Wheeler J. North Ecological Studies

at

Diablo Canyon Power Plant

FINAL REPORT

1969-1987

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PROJECT OBJECTIVES AND RATIONALE

The primary objective of our studies was to define characteristics and extent of ecological effects that may have arisen from power plant operations.

The term "ecological effects" was defined to include:

- Changes in species composition
- Changes in species abundances (both increases and decreases)
- Changes in spatial distributions
- Changes in community structure
- Changes in prevalence of moribund or diseased organisms
- Changes in the physical/chemical environment as related to the above

Considerable variations in these ecological characteristics were known to occur from natural causes, based on our 19 years of background studies prior to power plant startup. It was necessary to identify and separate naturally-caused changes from any that may have arisen from power plant operations.

Our operating rationale involved comparisons between preoperational and operational conditions, as established by field studies. Our field studies included periodic surveys at fixed sites within Diablo Cove and at control stations, as well as reconnaissance surveys to establish whether results from our fixed stations were representative of general conditions elsewhere.

STUDY AREA DESCRIPTION

Diablo Cove and the surrounding shoreline are representative of central California exposed rocky habitat. The ocean floor here slopes fairly steeply to seaward. Consequently, deep water occurs fairly close to shore. Important seasonal cycles included three oceanographic periods, the Oceanic (mid-July through October), The Davidson Current (November through February) and Upwelling (March to July). Winds were important factors controlling the oceanography. The

Oceanic Period was characterized by appearance close to shore of the southerly-trending California Current. The Davidson Current is a northerly-trending flow of water normally at deep levels but surfacing nearshore during winter. Upwelling involved offshore transport by surface water which was replaced nearshore by deep cold water.

The marine fauna and flora of the Diablo Canyon region included "cold-water" species characteristic of coastlines lying to the north. There were also "warm-water" species represented, which were organisms occurring far to the south. We were interested in the Davidson Current as a possible mechanism for introducing additional warm-water species from the south to the mildly-warm environment of Diablo Cove during operational years.

HISTORY

Our survey work in the Diablo Canyon region began in November 1966. The site was judged to be in pristine condition, probably because of severely-restricted access to the location. A highly diverse and generally abundant marine biota existed both intertidally and subtidally. There were large subtidal areas, however, dominated by urchins. Grazing by urchins greatly reduced vegetation in these areas and faunal abundances may also have been affected. Such deteriorated areas are known as urchin "barrens".

A number of minor changes occurred during our 22 year study, most of them temporary disturbances associated with power plant construction. A major permanent alteration was caused by breakwater installation at Intake Cove, converting an exposed wave-swept shoreline to a protected baylike environment.

Two very important natural disturbances also occurred that affected our studies during subsequent years:

- Sea otters returned to the Diablo Canyon region around 1974, after an absence of many decades. Their feeding activities reduced urchin densities almost to nil during the next 3 or 4 years. Vegetation was able to recolonize the former urchin barrens. Some animal species were benefited by appearance of new vegetation and relief from urchin domination. Other animals such as abalone declined, however, due to predation from otters. The otter-dominated ecosystems prevailed until the end of our studies in December 1987.
- A climatic disturbance, El Niño, occurred from 1982 to 1984. Disruptive events included a series of powerful storms and enhancement of northerly-flowing ocean currents. The northerly currents led to import of larvae of southern species, abnormally high water temperatures, and low dissolved nutrients. Effects from this El Niño persisted into the operational period, influencing our studies to a certain extent.

Power plant operations commenced during fall 1984 when power ascension testing began of Diablo Canyon Power Plant (DCPP) Unit I. Full-scale commercial operation of Unit I began in May 1985. Similar full-scale operation for Unit II began in March 1986.

POTENTIAL IMPACTS ON MARINE BIOTA FROM DCPP

We considered four possible mechanisms whereby DCPP operations might impact marine biota: heated effluent, scouring, secondary wastes, and indirect ecological effects. Our plans for assessing each of these types of potential impact were as follows.

Elevated water temperatures would probably affect species composition and abundances of sensitive species (including both enhancement and depressive effects). We were able to characterize many of the indigenous species by their known geographical distributions. Organisms also occurring in warm habitats far south of the study site were presumed to be broadly tolerant of surrounding temperatures. Cold-loving species with narrow temperature tolerances would be found primarily northward (although some occurred in deep cold water at southern locations).

Scouring might also influence species composition, leaving only organisms characteristic of very exposed, high-energy habitats (e.g., barnacles, mussels).

Harmful components of secondary wastes might be manifested by appearances of diseased or moribund organisms, particularly among those species expected to tolerate other influences such as heated effluent. These species might even disappear from the immediate vicinity, if impacts were large.

Indirect ecological effects might arise when changes in abundance of a sensitive species affect other associated species that might be insensitive to direct impacts. Such changes can be subtle and may require continuing observation by qualified investigators to detect them and explain their causes.

EXPERIMENTAL DESIGN

Activities consisted of four types of biological field investigations as well as a computational effort to characterize background ocean temperatures.

- Intertidal surveys involved quantitative estimates of all organisms falling within one m^2 quadrats lying along permanent vertical line transects.
- Subtidal transect surveys involved recording presence of macroscopic organisms in the vicinity of permanent vertical-horizontal transects.
- Subtidal Phaeophyta studies involved quantitative abundance estimates of macroscopic Brown Algae (Phaeophyta) in selected permanent sampling areas.
- Subtidal solid substrate analyses involved recording presence of small and microscopic encrusting invertebrates on samples of cobbles and debris collected near our subtidal transects.
- Temperature analyses involved processing data gathered by colleagues. The analysis provided a "standard background temperature" (i.e., the ten-year mean) for each day of the year. The standard served as a calibration point for classifying an actual temperature as high, average, or low on a given day. The technique proved most useful for characterizing periods of many days (i.e., an unusually warm summer or cold spring).

We also conducted reconnaissance surveys (shorewalks and swimthroughs) to assess general conditions and compare them to results from our fixed stations and permanent transects.

STATION LAYOUT

Primary intertidal survey activity centered around four permanent transects on rocky substrate, spanning the intertidal zone. Two of the transects were located at the north and south extremes within Diablo Cove, a third lay centrally within the Cove (about 150 m [650 ft] north of the discharge structure), and the fourth was situated about 1.2 km [0.75] miles) northwest of the Cove, serving as a control. The deployment within the Cove served to detect gradients in any changes as well as any north-south differences that might become manifest. Transect lengths ranged from about 25 to 50 m (82 to 165 ft).

The three subtidal transects included a 100 m (330 ft) line centrally within Diablo Cove beneath the plume from the discharge structure, a 30 m (100 ft) line in the Cove entrance, and a 30 m (100 ft) control transect about 1.3 km (0.8 miles) northwest from the Cove. The two 30 m lines extended up the sides of small islands, to the sea surface. The 100 m line commenced at a depth of about 3 m (10 ft). All the transects terminated in horizontal sections at depths of 8 to 9 m (26 to 30 ft). These outer ends usually lay well below the thermocline and were free from exposure to heated effluent. We could thus determine changes and gradients as a function of depth and distance from the point of discharge. The 100 m line tested for near-field effects of the discharge. The transect in the Cove entrance assessed effects farther away, near the edge of the far field.

Our five Phaeophyta sampling areas were situated near the shallow and deep ends of the subtidal transects. We were thus able to assess effects on Brown Algae of nearness to the discharge structure and of water depth. We also used these sampling areas for collecting cobbles and debris used in our solid substrate analyses.

Shorewalks were conducted annually around the periphery of Diablo Cove, from April 1982 onward. Swimthroughs were accomplished thrice yearly (weather permitting), commencing in May 1985. They followed along the 3 m (10 ft) depth contours from the north channel to the south shore of the Cove.

OVERVIEW OF INTERTIDAL RESULTS

We selected 32 plant and 34 animal species for detailed analysis from our master listing of 179 intertidal plants and 373 intertidal animals. The selected species were those organisms occurring with sufficient frequency and abundance to support analytical studies. We defined "affected" species as those members of the select group displaying increases or declines during the three operational years. We classified 26 plants as affected (4 were enhanced, 22 were depressed), while 19 of the animal species were affected (2 depressed, 17 enhanced). Classifications were generally but not always similar between stations. Response by the flora to the operational environment was thus markedly different compared to response by the fauna. Floral regression was quite apparent throughout Diablo Cove during our shorewalks. Coverage by various foliose seaweeds had formerly been dense in most of the lower and mid-intertidal zones. Foliose algae of the mid-intertidal dwindled markedly in 1986 and 1987, leaving crustose forms as the dominant coverage. Red Algae were overwhelmingly the dominant algal Division remaining in the Diablo Cove intertidal at the end of 1987. While Brown Algae had rarely been prominent in preoperational times, only three species persisted during operational times (the rockweeds *Pelvetia* and *Hesperophycus*, and the crustose species, *Ralfsia*).

A number of intertidal species were impacted by El Niño in 1983-84 and populations were often still depressed by the time DCPP became operational. In some cases we were able to derive conclusions by comparing performances by a species in Diablo Cove with that by counterparts at the control transect. Thus a species affected by El Niño at both locations would be classified as an affected organism if it subsequently recovered at the control but not in Diablo Cove.

Changes were usually greatest at the transect closest to the discharge structure, becoming smaller for the two transects at either end of Diablo Cove. Changes were larger in the northern part of the Cove than in the southern portion. Intertidal changes appeared to be confined to Diablo Cove. Some algal species apparently survived in the elevated water temperatures, but were seemingly unable to endure the double stress of warm water and subaerial exposures during low tides. In such cases, upper parts of distributions disappeared while populations survived or even flourished at lower levels. In some cases the distribution center and/or lower limit shifted downward.

OVERVIEW OF SUBTIDAL RESULTS

Our documentation of subtidal biota, except for Brown Algae, did not involve quantitative methods. We relied primarily on frequencies of survey occurrences for selecting affected species. We also compared survey occurrences at shallow depths with presence beneath the thermocline. A species that disappeared above but not below the thermocline suggested sensitivity to heated effluent because the plume maintained a near-surface distribution.

By far the greatest change recorded was a marked decline in abundances of two short-statured palm kelps (*Laminaria* and *Pterygophora*) for depths lying above the thermocline. Palm kelps had been the dominant subtidal vegetation in Diablo Cove during latter preoperational times. They formed dense populations that produced a scrub-forest type of environment. The blade crowns created a fairly coherent substory canopy that probably controlled underlying vegetation by shading. The thick stipes (stems) of the palm kelps may have reduced wave surge near the bottom. The overall plant structures may have provided food, shelter, and settling substrates for certain animals. *Laminaria* proved to be a more sensitive organism than *Pterygophora*. Loss of shallow palm kelp forests extended out into the north channel, but they survived well in the southwest channel.

As of the end of 1987, only one species of Brown Algae, bladder-chain kelp *Cystoseira*, appeared to be surviving in the subtidal shallows near the discharge structure. Remaining *Cystoseira* were small and appeared to be severely grazed by turban snails. *Cystoseira* far away from the discharge structure (near the ends of the Cove) appeared healthy.

The palm-kelp forest was replaced by several Red Algal species, most of which had tough structures that could withstand the violent water motion characterizing these shallow depths. In spite of their strong tissues, storms typically removed most of this algal biomass during fall and winter, leaving the shallow bottom fairly barren except for crustose algae. Thus the stable structure of the former palm-kelp forest was superseded by a seasonally unstable carpet of short seaweeds. The new flora apparently sustained high productivity during spring and summer and produced large amounts of drift in fall and winter. Transported drift weeds may have influenced areas beyond the zone where they formerly grew (i.e., providing organic matter over a wider area than that sustaining the productivity).

Macroscopic subtidal animals generally showed few changes during operational years. Fishes were an exception. Numerous species were apparently attracted to the vicinity of the plume. Of special interest were a few non-indigenous southern species that were probably introduced as larvae into the region during the 1983-84 El Niño. They lingered in Diablo Cove, where they have grown to adulthood. The heated effluent also apparently attracted a common small shark (*Triakis*) and bat ray (*Myliobatis*). Both are wide-ranging species and their occurrences at Diablo Cove did not represent advent of exotic animals.

An ill-defined aggregate of small and microscopic encrusting invertebrates, known collectively as invertebrate turf, was judged to have declined substantially in Diablo Cove within the past few years. An important part of these losses occurred during the El Niño years. Invertebrate turf has since recovered at our control station and at deep levels in Diablo Cove, but not in the Cove shallows. Our solid subtrate analyses indicated that many encrusting invertebrates species still remained in the Cove shallows. Arborescent Bryozoans, certain colonial Tunicates, and some cold-loving Sponges were the principal members of the turf that failed to return to the Diablo Cove shallows during operational times.

INDICATOR ORGANISMS

We defined indicator organisms as those affected species considered most likely to have been impacted by exposure to heated effluent. Our criterion for designating a species as an indicator organism was that the distribution displayed a gradient in abundance in relation to distance from the discharge structure. We also required that the organism be a common species, to facilitate quantitative studies of its distribution.

We selected the iridescent seaweed, *Iridaea flaccida*, and a coralline alga, *Corallina vancouveriensis*, as good indicator organisms for the intertidal. *I. flaccida* was considered a better indicator than *Corallina* because effects on the latter may have been indirect. The two palm kelps, *Laminaria* and *Pterygophora*, appeared as the best subtidal indicator organisms within Diablo Cove. *Laminaria* was the most sensitive of the two. We also discussed several other Brown Algae as possible good indicators. Bull kelp, *Nereocystis*, was too sparse in the Diablo Cove shallows to be a good indicator. The dense bull kelp canopies overlying deep water outside the Cove were considered as excellent indicators of effects or of lack-of-effects.

EXOTIC WARM-WATER SPECIES

We had anticipated that replacement communities in Diablo Cove might contain substantial numbers of exotic warm-water species some time after DCPP became operational. The principal source would probably be the Southern California Bight, lying a scant 80 km (50 miles) to the southeast. The northward-flowing Davidson Current might serve to transport larvae of these species to the vicinity of Diablo Cove where they might be attracted by the operational environment. Only one species considered likely to be a warm-water exotic, however, appeared during the three operational years encompassed by our study (a small white Sponge, *Leucetta*, which lasted only a few months). Possibly strong northerly currents during major El Niños would provide better transport mechanisms than the normal Davidson Current regime. Abilities of exotic warm-water organisms to maintain populations in Diablo Cove seems questionable, even if they were somehow to arrive there. Dimensions of the plume-affected area are minuscule compared to dispersal distances associated with natural transport mechanisms that would scatter eggs and larvae produced by resident species inside the Cove. It seems likely that replacement communities in Diablo Cove will continue to consist primarily of indigenous warm-water species.

UNANTICIPATED FINDINGS

Most results from our studies agreed with expectations, but a few findings were not anticipated or clearly disagreed with our prior predictions. We found eight plant and nine animal species that did not conform with our presumptions that they would prove to be warm-water- or cold-water tolerant. Almost complete disappearance of Brown Algae raised the possibility that the concept of warm-water species may require re-evaluation, at least for this group of seaweeds. Possibly warm-water and cold-water strains can occur within a single species as a result of stable local conditions over long periods.

Declines among populations of sensitive species in Diablo Cove seemed to occur intermittently, associated with the latter part of each year during the operational period. The sporadic declines would not be reconstituted at other times of the year. The following year would witness a spreading of the decline into new territory. This phenomenon was termed "intermittently spreading disturbances" and was still occurring during latter 1987. The process was probably caused by seasonal warming associated with the oceanographic regimes.

In spite of these unanticipated findings, it appeared that a large majority of the changes we observed in the Diablo Cove biota arose as expected, either directly from exposure to elevated water temperatures or indirectly through altered ecological relationships.

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Chapter 1

GENERAL INTRODUCTION

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DESCRIPTION OF THE STUDY AREA

Diablo Canyon (35° 12' 44" N. Lat., 120° 51' 23" W. Long.) is the site of a small freshwater creek entering the sea on the central California coast, about 9.6 km (6 miles) northwesterly from Point San Luis and 4.8 km (3 miles) southeast of Point Buchon. The site is about 80 km (50 miles) northwesterly from an oceanographically important location, Point Conception (Figure 1-1).

Most of the surrounding shoreline between Point San Luis and Point Buchon is rocky and bordered by sheer vertical cliffs and therefore not easily accessible from land. The sea floor slopes rather steeply, especially toward the north, so that the ten and twenty fathom (1 fathom = 1.8 m = 6 ft) bottom contours lie unusually close to shore (about 0.8 km and 1.6 km respectively). Bottoms are highly irregular, mostly rocky, and there are many small islets, pinnacles, and washrocks throughout the rugged nearshore. Onshore, a narrow coastal terrace is backed by the steep slopes of the Irish Hills, rising to maximal elevations of about 425 to 485 m (1400 to 1600 ft).

The Diablo Canyon Power Plant (DCPP), owned by Pacific Gas and Electric Company (PG&E) lies on the south side of Diablo Creek, facing an inlet which, through common usage, is now known as Diablo Cove. Diablo Cove is about 550 m (1800 ft) wide, 400 m (1300 ft) from the central shore to the open sea, and embraces about 16 hectares (40 acres) at low tide. Common usage has also created names for two downcoast inlets (South Cove and Intake Cove) and the inlet immediately upcoast (Field's Cove). Intake Cove derived its name from location along the northwest part of the Cove of the intake structure that supplies cooling water to DCPP. Protection for the intake structure was provided by construction of two breakwaters in 1970. The breakwaters block wave action along about 600 m (2000 ft) of formerly highly exposed coastline. Cooling water from DCPP is discharged centrally into Diablo Cove as a surface jet. The jet plume exits Diablo Cove to the open sea via two channels lying on either side of a large pinnacle, Diablo Rock, that dominates the outer part of the Cove.

Substrate throughout Diablo Cove is predominantly rocky, although sandy patches do occur both intertidally and subtidally (TERA, 1982). Intertidal bedrock exposures occur in several locations around the Cove's periphery. Some exposures are flat terraces, others are rounded projections, low ledges, ridges, and pinnacles. The majority of the bedrock, however, is overlain by cobble and boulder, the latter ranging up to one or two meters (3 to 7 ft) in longest dimension. Small patches of sand and gravel occur throughout the intertidal but most are unstable. Substantial amounts of coarse sand and gravel frequently occur in the upper intertidal near the north and south ends of the Cove, just where the coastline turns seaward to form headlands.

The shallow subtidal at 3 to 4 m (10 to 13 ft) depths is largely irregular bedrock with accumulations of cobble and boulders in the low areas. Patches of coarse sand do occur in the south part of the Cove at 2 to 3 m (7 to 10 ft) depths. A small cliff occurs about 5 m (16 ft) deep in the central part of the Cove, about 200 m (60 ft) from the beach. Beyond the cliff, small patches of sand and gravel fill depressions and low-lying areas at depths of 6 to 7 m (20 to 23 ft) or more. Even these deeper parts of the Cove are highly irregular, with large boulders strewn across the bottom, and bedrock projections occurring commonly, sometimes forming pinnacles 3 to 5 m (10 to 17 ft) high or more. A few of these projections emerge from the sea surface as washrocks. Cobble and boulder piles usually surround bases of the pinnacles and islets (such as Diablo Rock), resulting from erosion of the subaerial parts of these formations. A large group of washrocks lies just beyond the north entrance, offering some protection to the north part of the Cove from westerly swell. Diablo Rock also provides some breakwater effects for the north and central Cove. Washrocks and shoals extend westerly and northwesterly from the south headland, shielding the southern part of the Cove from westerly and southwesterly swell and current. In spite of these protective offshore formations, all parts of the Cove are subject to violent water motion during storms and the entire shoreline would be classified as exposed open coast. The northern 2/3 of Diablo Cove tends to be lashed by surf somewhat more vigorously than the southern 1/3. Possibly deep water off the south shore focuses wave fronts in a northeasterly direction, explaining the more direction, explaining the more turbulent conditions in this part of the Cove. Circulation within the Cove is driven by tidal action and the inshore current system, augmented by mixing due to winds (PG&E, 1971; TERA, 1982). Within-Cove circulation patterns were modeled for various conditions of coastal currents (Kendall, 1983).

Annual water temperatures at 3 to 5 m (10 to 17 ft) depths in or near the Cove for the nine-year period 1978-86 ranged from 12°C (53.6°F) in 1985 to 14.3°C (57.7°F) in 1983 (James et al., 1987). Minimum temperature for the nine year period was 8.5°C (47.3°F) in 1980, maximum was 22.0°C (71.6°F) in 1983 (an El Niño year). These are temperatures characteristic of coastal waters off central California. Dissolved oxygen ranged from about 6 to 9 ppm, salinity between 33 and 34 °/oo (White, 1986 and earlier reports). Macronutrient concentrations were not routinely determined, but should generally lie in the range of 5 to 20 μM for nitrate and 0.5 to 2 μM for phosphate if temperature-nutrient relationships at Diablo Cove are similar to those in southern California waters (Zimmerman, 1983; Kamykowski, 1972). These are relatively high values and we would not expect any growth limitation among seaweeds due to inadequate supplies of macronutrients, except perhaps during severe El Niño events.

Summarizing, the varied and irregular topography and variety of substrates within Diablo Cove has provided a highly heterogeneous environment for colonization by marine organisms. Water circulation and chemistry here also favor richness of life. One might thus expect to find highly diverse plant and animal assemblages in the many different habitats of the Cove. The extensive species lists provided by various investigators confirm this expectation. For example, Gotshall et al. (1984) list 83 species of Red and Green Algae and 111 invertebrates as occurring in their random 0.25 m^2 subtidal stations; Kelly (1984) published a master species list for Diablo Canyon studies that contained 2487 entries; a list of genera recorded within the Thermal Effects Monitoring Program (TEMP) included 110 plants and 413 animals; a similar list from our own studies amounted to 126 plants and 316 animals.

OCEAN CURRENT SYSTEMS

Oceanographic conditions have been routinely measured at 24 open water stations and three sites near or within Diablo Cove, thrice yearly since 1972 (temperature profiles, dissolved oxygen, and salinity; White 1986). Currents were measured by drogues and by a continuously monitoring meter (ENDECO, Model 105). Flows were predominantly parallel to shore with average velocities in the range 0.2 to 0.3 knots (10 to 15 $cm \cdot s^{-1}$). Upcoast flows predominated from late summer through winter and became downcoast during spring and early summer (Meek, 1986). Results of the many years of oceanographic monitoring have been published annually in the series of reports *Environmental Investigations at Diablo Canyon* issued by PG&E (cf bibliographies by Warrick and Behrens, 1982, 1985).

The various investigators have found a high degree of variability in nearshore currents and oceanographic parameters. Results were not always in agreement with the generally accepted notions of current patterns for this region (cf Reid et al., 1958). For example, Gosink and Weigel (1979) analyzed the current data collected from 1972 to 1976 and concluded:

> "The currents are quite complex and variable and it is sometimes difficult to assign the currents measured at a particular time to one of the current regimes (Oceanic, Davidson, and Upwelling), but they all appear at the site .... Upwelling is most closely associated with strong WNW winds in spring or early summer .... The Oceanic period appears to exist from about mid-August through October, and it might occur during early spring. During each winter, there exist sufficient data in which the presence of a current flowing towards the NW (the Davidson Current) can be noted. The strength and persistence of the current varies from winter to winter with apparently little dependence upon the strength of the locally measured winds."

There have been no subsequent attempts to relate local oceanographic data gathered near Diablo Canyon to broad scale classical current patterns. Existence of these classical patterns has nonetheless been confirmed by recent work. Thus, Chelton et al. (1987) found well-developed northwesterly (i.e., poleward) flows in February 1984 and even stronger currents during January 1985, along nearshore central California. They also reported extensive poleward flow in July 1984, reverting to an equatorward current in October 1984. Drifter trajectories suggested that current patterns in the region from Point Conception to Point Buchon were more complex than farther northward or southward. They suggested that this complexity might arise from influence of the Santa Barbara Channel on currents moving poleward or equatorward. As we shall see below, interactions off the Santa Barbara Channel entrance are of special interest to studies at Diablo Canyon.

Brink and Muench (1986) conducted an intensive review of data gathered by two investigative programs (OPUS and SAIC) from April to July in 1983. The objective was to develop information regarding currents and circulation patterns within the Santa Barbara Channel and off the western Channel entrance (i.e., San Miguel Island to Point Arguello, see Figure 1-1). They determined that a "concentrated energetic jet flowed westward out of the north side of the Santa Barbara Channel and into the area just off Point Conception". The westward jet was considered a persistent feature of the general circulation patterns in the region. The coastal region between Point Conception and Point Arguello was dominated by locally wind-driven upwelling with super-imposed alongshore currents that were apparently remotely forced (prominence of upwelling may have been influenced by season and might be less evident at other times of the year). An eastward flow into the Channel was found on the southern side of the west entrance (i.e., just north of San Miguel Island). The authors suggested that a "gyre-like pattern" may exist here in the Channel mouth. Presumably some of the water leaving the Channel along the north side might be reintroduced along the south side, depending on strength and direction of the poleward-equatorward flow west of Point Conception. Jackson (1986) mentions that studies using drifters indicate that substantial amounts of outgoing water from the Channel eventually return to the Southern California Bight.

It is clear that coastal current patterns between the west entrance to the Santa Barbara Channel and Point Buchon are complex and variable. Their characteristics and driving forces are not completely understood. Their importance to our studies arises from the potential of some of

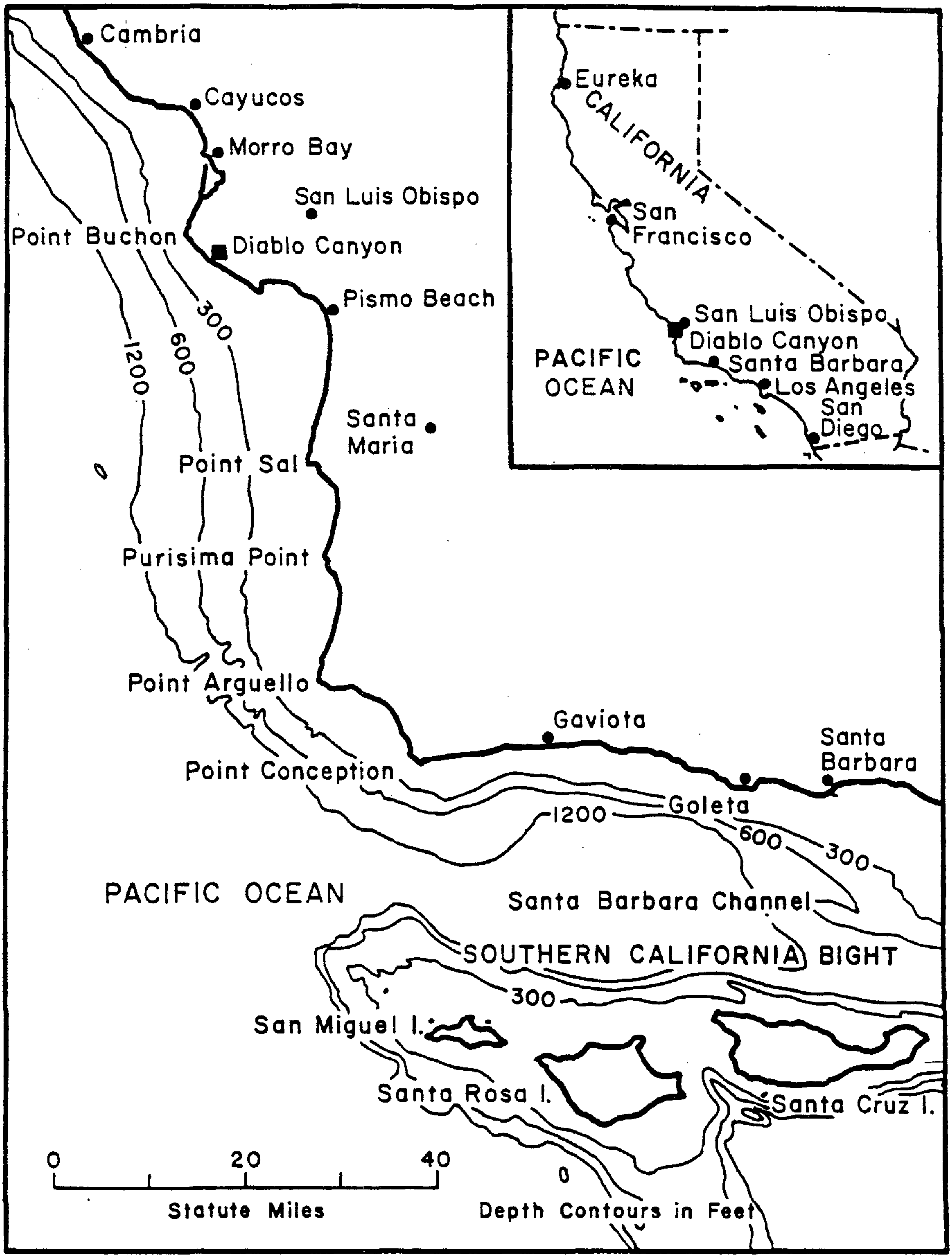

Figure 1-1. Chart of the California coast, Cambria to Santa Barbara.

these currents to serve as a link between Diablo Cove and the large reservoir of warm-water species that exist in the Southern California Bight.

Naylor (1965) noted that thermal discharges into freshwater and marine environments tended to shift species composition toward forms able to tolerate elevated temperatures (so-called warm water species). He used the term "replacement fauna" to designate such assemblages. Naylor observed both indigenous and exotic species in the replacement faunal assemblages he studied. The indigenous biota of Diablo Cove included many species found in the Southern California Bight (presumably warm-tolerant forms). Any appearances of new warm-tolerant species in Diablo Cove after operations at DCPP commence would be of great theoretical as well as practical interest. We might glean information on current systems as well as capabilities among propagules (spores, eggs, larvae, etc) for negotiating long distances in the sea to establish new populations.

As noted above, most planktonic propagules of southern origin that move upcoast past Point Conception will likely emerge from the Southern California Bight via the west entrance to the Santa Barbara Channel. Significant poleward transport is most probable during seasonal occurrences of the Davidson Current or during El Niño episodes.

The Davidson Current is believed to be a surface manifestation of a poleward flow of equatorial water extending at least from the tip of Baja California to Vancouver Island (Chelton, 1982; Newberger, 1982; McLain and Thomas, 1983). It is also known as the California Countercurrent and the California Undercurrent, the latter because it remains at depths below 200 m (660 ft) for most of the year. Quoting from Jones (1971), "The earth's rotation requires a deceleration in the peripheral speed of this current as it moves north, thus producing a tendency to build up against the coast". The California Undercurrent penetrates into the Southern California Bight at least as far as about 33° 00' N. Lat. (i.e., off Del Mar) but was weak or undetectable farther north off Oceanside, Dana Point, and Newport Beach (Tsuchiya, 1976; Barcelona et al., 1982). In any case, the California Undercurrent does not appear to manifest itself as a surface phenomenon within the Bight and is probably not a mechanism for transporting propagules of warm water species, either within the Bight or for exporting them to other regions.

That portion of the California Undercurrent not entering the Bight but flowing peripherally west of the Santa Rosa-Cortez Ridge, bypasses the Bight and presumably reaches the vicinity of Point Conception (Sverdrup and Fleming, 1941; see Figure 1-1). Here it may surface inshore of the California Current when northerly winds weaken or disappear in fall and winter (Reid et al., 1958). Chelton et al. (1987) noted that the Davidson Current in 1984 and 1985 was about 50 km (30 miles) wide. Geostrophic velocities for 1985 were about twice those for 1984 (i.e., 45 $cm \cdot s^{-1}$ vs 25 $cm \cdot s^{-1}$ for near-surface depths about 10 to 20 km [6.2 to 12.5 miles] offshore from Point Buchon). At a steady velocity of 20 $cm \cdot s^{-1}$, a suspended particle would require about five days to be transported from the Santa Barbara Channel entrance to Diablo Cove. Once the direct transport was completed, a propagule would somehow need to move inshore to shallow water, encountering all the vagaries of the nearshore current systems, before it found suitable settling substrate. Larval development time may be temperature dependent. The Davidson is a relatively warm current, which would enhance larval growth rates. Nonetheless, travel time of a week or two seems sufficiently short so that transport of many larval species from the northwest part of the Southern California Bight seems feasible, provided there were strong poleward currents flowing. Durations of larval development range from minutes or hours for some tunicates (Millar, 1971) to several months for some crustaceans such as sand crabs and lobster (Johnson, 1957, 1960). Tegner and Butler (1985) presented interesting studies relating larval existence spans to dispersal capabilities among abalone.

Flow velocities during El Niño events appear to be poorly documented for the Point Conception to Point Buchon region. Schwarzlose (1963) observed strong poleward flows north of Point Conception in November 1957, during a major El Niño, based on movement by drift bottles. He derived velocity estimates of 0.3 knots (i.e., about 15 $cm \cdot s^{-1}$). These estimates were for very long trajectories (greater than 700 km) and might underestimate velocities that could occur over short distances and times such as from Point Conception to Diablo Cove. McLain et al. (1985) note that poleward flows of undercurrents near the continental shelf are intensified during "warm" periods (i.e., El Niños). They cited data indicating that poleward flow of the California Undercurrent off Oregon during winter 1982-83 (another major El Niño) averaged 13 $cm \cdot s^{-1}$, almost twice the average of values measured from other years. These were 93-day determinations and again are not necessarily indicative of short term velocities that might occur between Point Conception and Diablo Cove. We simply cite these works as indicating that poleward flows during El Niño events may be better developed than at other times. McLain and Thomas (1983) and McLain et al. (1985) review theoretical aspects of influences on the California Current System from northward propagation of El Niños.

Appearance of southern species far north of their usual ranges during major El Niños has been well-documented and known for many years (cf Sette and Isaacs, 1960). Major El Niños may last a year or more whereas the Davidson Current usually endures for only a few months during fall and winter. El Niños might thus bring in propagules that appear only during spring and summer, when the Davidson Current lies too deep to be an effective transport mechanism for propagules of shallow-dwelling species.

Thus long term biological studies in the region of Diablo Canyon may furnish information useful in clarifying the difficult physical oceanographic problems of this nearshore region, as well as adding to our knowledge of dispersion processes among shallow water benthic marine organisms.

OVERVIEW OF THE PROJECT

This report describes a group of ecological studies that commenced with a general reconnaissance of Diablo Cove, undertaken on a part-time consulting basis, on November 5, 6, 11 and 12 in 1966. The objectives, scope, and methods of our studies shifted as time passed. We initially sought to develop a descriptive account of the biota and their distributions, which would assist PG&E in hearings before the California Public Utilities Commission. The Company was seeking approval from the Commission for construction and operation of an electrical generating station on the terrace overlooking Diablo Cove. Additional hearings before other regulatory bodies followed, requiring further input regarding status of the Cove and of nearby areas (for example, the adjacent shoreline downcoast where construction of facilities were planned for intake of cooling water). These early studies continued to be largely descriptive and occurred irregularly. We were primarily concerned with ascertaining whether conditions at Diablo Cove remained essentially as first observed by us in 1966 (or noting any changes that may have occurred).

The regulatory climate was obviously becoming more stringent during these first 2 to 3 years of our work. In response to criticism, we modified our methods to include some quantitative sampling and we established permanent intertidal and subtidal stations within the Cove as well as at control sites outside the Cove. In 1970, a second team of ecologists led by Richard T. Burge and Steven A. Schultz from the California Department of Fish and Game (CDF&G), commenced a series of regular and intensive studies of the region. PG&E management envisioned that CDF&G personnel would concentrate on species of commercial and sports-fishing importance while our investigations would encompass general ecology without regard to practical interests. Our periodic surveys were still conducted somewhat irregularly. Our study team was separated so it was sometimes difficult to assemble at Diablo Cove, particularly during times of gasoline shortages. Furthermore, ecological conditions showed little change within the Cove and there did not appear to be a compelling need for increasing the frequency of our visits or the intensity of our studies. No intertidal or subtidal studies were conducted by us at Diablo Cove in 1971 or 1973. Considerable information was being gathered at the Cove by the CDF&G project and our group became involved assisting PG&E staff in preliminary surveys at sites off Point Arena and Davenport. Construction of plant facilities at Diablo Canyon was well underway at this time but full-scale operation was not imminent.

Important ecological changes began occurring with appearance in 1974 of substantial numbers of sea otters in Diablo Cove. We therefore endeavored to perform at least one intertidal and subtidal survey yearly from 1974 onward. Frequency of our intertidal surveys was increased to three per year, beginning in 1977. Subtidal surveys were usually conducted near the end of each year. A major set of new biological investigations, the 316(a) Demonstration Studies, (later changed to the Thermal Effects Monitoring Program - TEMP) were launched in 1976 in response to requirements imposed by the State Water Quality Control Board, Central Coast Region (SWQCB,CCR) as mandated by the United States Environmental Protection Agency.

Bad weather during December in 1978 and 1980 forced us to postpone the subtidal surveys by one month (so two subtidal surveys were performed in 1979 and 1981). We increased our activities from late 1982 onward in anticipation of power plant startup with discharge of heated effluent into Diablo Cove. Quantitative surveys of large subtidal Phaeophyta (kelps) were initiated in December 1982 and performed thrice yearly thereafter. A third intertidal station within Diablo Cove was added in 1982. Yearly shorewalks around the entire Diablo Cove periphery were initiated in March 1983. Shorewalks were continued to the end of the study. Swimthroughs along the 3 m (10 ft) depth contour within the Cove began in May 1985 at about the time Unit I of DCPP became fully operational.

Thus the methodology and intensity of our studies changed substantially over the twenty-one years encompassed by our activities at Diablo Cove, responding to needs of PG&E, the regulatory agencies, and to avoid undue duplication of activities carried out by other research groups that came into existence as time passed. In presenting our findings, we will draw on results from the entire study period. Emphasis, however, will be placed on data from the past ten years. This recent ten-year span represents the "new regime" that developed as a result of the otter return in 1974. It is also a period where frequency and methodology of our surveys became more uniform. We will also utilize findings from the extensive data gathered by our colleagues in the overall Diablo Canyon research effort. These companion programs have been very useful for filling gaps in our own records, allowing us to provide a more complete description of ecological changes we have observed, and possible relationships to both natural and human-caused events.

OTHER STUDY GROUPS

Physical, chemical, and biological characteristics of the marine environment near Diablo Canyon have been studied by many individuals from 1966 onward. Some of these investigations were peripheral to our interests and objectives. Others are closely related to our investigations and some lie in-between. We will here describe briefly the closely-related studies plus those investigations from the intermediate group that were most meaningful to our own work. We have categorized them below according to the primary organization or agency responsible for the study.

CDF&G Studies, 1966-82

Of the various studies described in this section, this group of investigations, plus the TEMP project, were the most similar to our own work. Some of the CDF&G investigations were not relevant to our primary interests (e.g., their studies at the Intake Cove cofferdam and analyses of commercial and sportfishing statistics). Their quantitative intertidal and subtidal samplings, however, were of considerable assistance, particularly for completing informational gaps in our own records. Otter observations and counts were initiated by this group, then continued later by a former group member (S.V. Benech).

Thermal Effects Monitoring Program, 1976-87

This program was initiated in 1976 under section 316(a) of the Federal Water Pollution Control Act Amendments of 1972 and was called the 316(a) Demonstration Study. The name of the program was changed to Thermal Effects Monitoring Program (TEMP) to reflect changes in the requirement for the studies. This large program included two major efforts: laboratory assessment of thermal tolerances and other parameters associated with temperature for 8 plant and 29 animal species, plus a long series of intertidal and subtidal field studies. TEMP has quantitatively monitored ten permanent intertidal and nine permanent subtidal stations in Diablo Cove and at control sites to the north and south since 1978 (more stations were studied from 1976 to 1978). Pre-survey design studies had indicated that sampling at randomly selected locations would likely yield unsatisfactory results because of high variances in species abundances (TERA, 1982). Thus the principal investigators opted for studies at permanently-fixed sites and acquiring large numbers of data points. As for the CDF&G investigations, certain of the TEMP activities were of minimal interest to us (e.g., settling plate, sedimentation, and crab-trapping studies).

PG&E Studies, 1966-87

This category includes a large number of separate projects, some conducted in close association with other organizations (for example, plume description and modeling and power plant ascension studies). Rather than treating these cooperative activities separately, we have lumped them all together as PG&E investigations. For the sake of simplicity, we will merely list the topics of greatest interest and forgo dates and descriptions:

- Thermal tolerances of red abalone and bull kelp
- Kelp canopy distribution by aerial photography
- Algal-faunal associations
- Physical oceanography (especially determinations of water temperatures)
- Plume description, modeling, and power ascension studies
- NPDES monitoring and toxicity studies

Studies by Other Consultants and Investigators

Suzanne V. Benech continued otter studies initiated within the CDF&G group. Dr. Richard A. Pimentel and Rosemary C. Bowker of California Polytechnic State University, San Luis Obispo, performed a useful statistical analysis of a portion of our intertidal data.

OBJECTIVES AND RATIONALE

The primary objective of our studies was to define characteristics and extent of ecological effects that may have arisen from power plant operations. Our rationale involved collecting a long time series of preoperational observations and quantitative data to furnish a comparative basis for identifying changes occurring during the operational period. "Ecological effects" covers a broad spectrum of topics which include:

- Changes in species composition
- Disappearance of pre-existing species
- Appearance of new species
- Changes in abundance (increases or decreases)
- Changes in distributional patterns
- Changes in community structure
- Shifts among dominant species
- Disruption of trophic relationships
- Alterations of competitive relationships
- Modifications of physical relationships (i.e., shading, hydrodynamic effects, etc.)
- Alterations among reproductive patterns and age distributions within populations
- Changes in prevalence of moribund or diseased organisms
- Changes in pertinent physical or chemical characteristics of the environment

This seems like a formidable list and resembles a table of contents from a textbook on ecology. In fact, many of the topics are supportive of each other and changes in one may be accompanied or followed by modifications in others. Patterns or syndromes arise which are extremely helpful for interpreting cause and effect relationships. The largest single problem we faced in evaluating possible influences from power plant operations was separating any such effects from the often large variations known to occur naturally. Thus even a large change in a single parameter may leave uncertainty as to cause if historical data indicate the parameter fluctuates widely. Concurrent shifts in several parameters, however, may provide convincing evidence that a major or unusual disruption has occurred.

Identifying changes directly or indirectly caused by power plant operations requires a broad approach, examining temporal changes in abundances and distributions of many species over appropriate time periods. One of us (WJN) was once queried by an examiner at a hearing as to the usefulness and significance of quantitative data: "isn't it important whether there are one or ten anemones in one of your quadrats?" The appropriate answer depends on the objective of the investigation.

In terms of understanding local biological activities at a given point in time and space, it is obviously important to know composition of the biota in as much detail as possible. Our data revealed, however, that large and abrupt changes were common in the intertidal and shallow subtidal of Diablo Cove. Thus a quadrat might contain ten individuals of species X at a given survey but yield only one specimen during our next visit. In terms of understanding long term effects of DCPP operations, the relevant question was: did species X continue to exhibit the patterns of abundances and distributions that characterized peroperational times? Whether one or ten individuals occurred was useful information only in helping to define the broad-scale pattern of occurrences.

Presence/absence data were often just about as useful as quantitative observations for documenting changes considered outside the range of normality. Most of our subtidal studies utilized presence/absence data. Many helpful insights were also provided simply by observations conducted during shorewalks and reconnaissance diving (swimthroughs).

Changes in distributional patterns were considered especially useful for our purposes. Such changes in areas known to receive exposure to discharged effluents are persuasive of a cause and effect relationship.

Very little was known about ecological effects from across-the-beach thermal discharges on California cold water marine biota at the time we began our investigations in 1966. We gathered important information as to what we might expect from studies at the Morro Bay and Humboldt Bay discharge facilities (North, 1969; Devinny, 1975). Discharge influences did not extend over large areas, however, so it was questionable whether the plumes at these two sites would be very effective in creating suitable habitat for replacement communities (sensu Naylor, 1965). It appeared that studies by ourselves and others at Diablo Canyon might uncover unanticipated results simply because the scale of operations at DCPP was much larger than at Morro Bay or Humboldt Bay. A broad-scope investigative program was needed. We adopted a strategy of undertaking intensive quantitative studies at presumably critical locations (based on predictions of plume behavior), coupled with observational work over as broad an area as possible.

DOCUMENTATION, REPORTING, AND PUBLICATIONS

The various research programs and projects focusing on Diablo Cove and conducted by PG&E staff, Company consultants, and outside investigators have produced a voluminous literature. A great deal of the material has been conveniently assembled in a continuing series of annual reports, *Environmental Investigations at Diablo Canyon*, covering the period 1969 to 1987. The Company has also issued reports on special topics such as extensive descriptions of plume characteristics during power ascension testing. There have also been publications in scientific journals, conference proceedings, and graduate-level theses. Two bibliographies of pertinent reports, publications, and presentations through 1984 were assembled by Warrick and Behrens (1982, 1985). Updating these bibliographies to the present time is beyond the scope of our objectives. We will confine our discussion to material issuing from our own project.

Except for the earliest work, our intertidal surveys have always included an individual with primary responsibility for recording data and observations. The subtidal activities involved in situ recording of species and quantitative information on data sheets, with general observations written down from memory as soon as practicable following a day of diving. Data and observations were summarized in our annual contributions to the *Environmental Investigations at Diablo Canyon* series. Copies of raw data and photographs taken were also submitted to PG&E for their files. In response to a Company request, short survey reports were prepared for each study, beginning in 1983. The initial intent was simply to list activities and accomplishments. The reports proved to be very useful to us and we expanded them to include our field notes describing impressions of the stations and areas visited. Copies of these survey reports have also been included in our annual publications. A list of our reports and publications relating to our studies at Diablo Canyon follows:

North, Wheeler J., 1966. An evaluation of the marine fauna and flora in the vicinity of Diablo Cove, California. Marine Advisers, La Jolla, 38 pp.

Cayot, Raymond F., and Wheeler J. North, 1967. Oceanographic background study, Diablo Canyon Nuclear Power Plant site, 1967. PG&E, D.E.R. Report No. 6242.4-68.

Cayot, Raymond F., and Wheeler J. North, 1968. Oceanographic background study, Diablo Canyon Nuclear Power Plant site, 1968. PG&E, D.E.R. Report No. 7331-69, 71 pp.

North, Wheeler J., 1969. Biological effects of a heated water discharge at Morro Bay, California. Proc. VIth Intl. Seaweed Symp., 1969. Subsecretaria de la Marina Mercante, Direccion General de Pesca Maritima, Madrid. pp. 275-286.

North, Wheeler J., and James R. Adams, 1969. The status of thermal discharges on the Pacific coast. Chesapeake Sci., 10:39-144.

North, Wheeler J., 1972. Marine ecology. Chap. 3 in *Marine Environmental Investigations at the Diablo Canyon Units 1 and 2 Nuclear Power Plant Site, 1969-1971*. J.R. Adams (Ed), PG&E, San Ramon, pp. 23-99.

Abbott, Isabella A., and Wheeler J. North, 1972. Temperature influences on floral composition in California coastal waters. Proc. VIIth Intl. Seaweed Symp., Univ. Tokyo Press, pp. 72-79.

North, Wheeler J., and Einar K. Anderson, 1973. Anticipated biological effects from heated effluents at Diablo Cove. PG&E, San Ramon, 134 pp.

North, Wheeler J., Einar K. Anderson, and Faylla A. Chapman, 1975. Marine ecological transect studies. Chap. 6 in *Environmental Investigations at Diablo Canyon, 1974*. J.R. Adams and B.J. Anderson (Eds), PG&E, San Ramon, 15 pp.

North, Wheeler J., Faylla A. Chapman, and Einar K. Anderson, 1979. Marine ecological transect studies. Chap. 13 in *Environmental Investigations at Diablo Canyon, 1975-1977*. Vol. 1. J.W. Warrick and E.A. Banuet-Hutton (Eds), PG&E, San Ramon, 53 pp.

North, Wheeler J., Einar K. Anderson, and Faylla A. Chapman, 1981a. W.J. North marine ecological transect studies. Chap. 8 in *Environmental Investigations at Diablo Canyon, 1978*. D.W. Behrens and E.A. Banuet-Hutton (Eds), PG&E, San Ramon, 7 pp.

North, Wheeler J., Einar K. Anderson, and Faylla A. Chapman, 1981b. W.J. North marine ecological transect studies. Chap. 10 in *Environmental Investigations at Diablo Canyon, 1979*. D.W. Behrens (Ed), PG&E, San Ramon, 33 pp.

North, Wheeler J., Einar K. Anderson, and Faylla A. Chapman, 1982. W.J. North marine ecological studies: 1980, 1981. Chap. 11 in *Environmental Investigations at Diablo Canyon, 1981*. D.W. Behrens (Ed), PG&E, San Ramon, 49 pp.

North, Wheeler J., Faylla A. Chapman, and Einar K. Anderson, 1983. W.J. North marine ecological transects: 1982. Chap 10 in *Environmental Investigations at Diablo Canyon, 1982*. D.W. Behrens (Ed), PG&E, San Ramon, 46 pp.

North, Wheeler J., Einar K. Anderson, and Faylla A. Chapman, 1984. W.J. North marine ecological transects: 1983. Chap 7 in *Environmental Investigations at Diablo Canyon, 1983*. D.W. Behrens and C.O. White, (Eds), PG&E, San Ramon, 65 pp.

North, Wheeler J., Einar K. Anderson, and Faylla A. Chapman, 1985. Wheeler J. North ecological studies: 1984. Chap. 6 in *Environmental Investigations at Diablo Canyon, 1984*. D.W. Behrens (Ed), PG&E, San Ramon, 84 pp.

North, Wheeler J., Faylla A. Chapman, and Einar K. Anderson, 1986. W.J. North marine ecological investigations: 1985. Chap. 1 in *Environmental Investigations at Diablo Canyon, 1985*. D.W. Behrens (Ed), PG&E, San Ramon, 117 pp.

Chapman, Faylla A., Wheeler J. North, and Einar K. Anderson, 1987. W.J. North marine ecological investigations: 1986. Chap 1 in *Environmental Investigations at Diablo Canyon, 1986*. Vol 1. D.W. Behrens (Ed), PG&E, San Ramon, 240 pp.

Chapter 2

ECOLOGICAL HISTORY of MARINE BIOTA and of DISRUPTIVE EFFECTS at DIABLO CANYON

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INTRODUCTION

The first ecological survey in the Diablo Canyon region occurred in May 1966 under the leadership of Earl E. Ebert of the California Department of Fish and Game (CDF&G). Numerous individuals and organizations have since examined intensively the physical, chemical, and biological characteristics of this rugged stretch of central California coastline. Accumulated data are now voluminous, requiring sophisticated processing techniques to extract comprehendible information.

A major problem associated with data analysis has involved separating effects caused by natural disturbances from those arising from human activities. This narrative history is designed to familiarize readers with major perturbations we have seen between 1966 and 1987 and describe observed responses by the marine fauna and flora. Our objective is to provide a suitable background to aid the reader in understanding the analytical sections which follow in our report.

Gotshall et al. (1984) discussed disruptive events for the Diablo Canyon region up through 1978. Their discussion divided these events into two categories, natural and artificially-caused. This is a convenient classification which we will follow. The various perturbations are easily identified but their consequences frequently overlap and are difficult to separate.

The primary insight revealed by our historical treatment lies in the dynamic nature of the marine environment off Diablo Canyon and of the fauna and flora inhabiting these waters. The ever-changing character of the biota will become even more apparent in the analytical sections of this report. Species abundances fluctuate constantly, responding to seasonal or longer-term changes or to ephemeral perturbations such as storms. Some species may disappear altogether for a while, then return without apparent reason. Our primary concern in this historical treatment, however, is not with the details of population dynamics, but with major forces and events that have influenced many populations of the entire region or of significant areas therein. The investigator must be fully aware of both natural and artificial processes of the recent past and somehow take them into account when attempting to explain the status quo. Such an accounting is of paramount importance when we seek to pinpoint specific effects from a continuing and complex perturbation such as the operation of a power plant.

CHANGES DUE TO NATURAL CAUSES

Diablo Canyon lies near the boundary of two large private ranches, about 11 km (7 mi) northwesterly from Avila Beach in San Luis Obispo County. Access was by dirt road when the author first visited the site in November 1966, and a four-wheel drive vehicle was a necessity for the journey. Remoteness of the location and difficulty of access led us to infer that marine communities here were probably in as pristine a condition as might be found anywhere along the California coast. Lack of human influences was evidenced by presence of numerous abalone exposed in the intertidal and shallow subtidal. Large intertidal ledges in Intake Cove, Diablo Cove, and Field's Cove sometimes harbored dozens of abalone, occasionally stacked atop one another. The heterogeneous rocky intertidal and shallow subtidal habitats were richly carpeted with seaweeds and numerous animal species. We compiled a species list for the area during these brief early visits for use in some of the upcoming public hearings (North, 1966). We focused our attention primarily on larger organisms, so the list was undoubtedly far from complete. Even so, it was clear that the region was populated by a very diverse biota and both broad temperature- and narrow temperature-tolerance species were present.

Rocky bottoms deeper than about 3 m (10 ft) in the Diablo Canyon region were largely dominated by hordes of red and purple sea urchins. This condition was quite common along the California coast in the 1950s and 60s. Hard substrates in the urchin-dominated territories supported encrusting corallines and bits of stubble from articulated corallines but not much other vegetation. There were, however, substantial patches of foliose vegetation here and there in Diablo Cove (usually dominated by short-statured palm kelps), but dense clusters of urchins usually surrounded the periphery of these patches, attacking holdfasts or climbing stipes to reach the blade crowns. Presumably these patches were ephemeral populations that would soon be eliminated by intensive grazing. We do not know how stable these mini-kelp forests may have been because their interactions with, and relations to, surrounding urchins were never studied. One kelp patch occurred a short distance in from the southwest channel and a second existed along the lee side of Diablo Rock and toward the north. Undoubtedly, drift material broken loose from the kelp forests by wave action nourished urchins and other herbivores out in the barren territories. These so-called "urchin barrens" actually harbored moderate amounts of invertebrates and fishes. Lack of vegetative cover probably made animals in the barrens more conspicuous than in the kelp forests. Crevices, ledges and pinnacle tops and sides often supported thick and diverse assemblages of encrusting invertebrates. Shallow pinnacle tops and other rocky bottom shallower than 3 m (10 ft) were usually free from urchins (probably wave surge removed urchins moving up shallower than 3 m). Little "islands" of kelp forest plus rich invertebrate turf occurred on the shallow pinnacle tops. Our first surveys identified twelve plant genera as probably being the most important producers (based on abundances) in the Diablo Cove subtidal. Listed in approximate order of importance, these genera were: *Pterygophora, Nereocystis, Laminaria, Botryoglossum, Gigartina* (*exasperata* and *corymbifera* complex), *Phyllospadix, Egregia, Prionitis* (primarily *P. lanceolata*), *Dictyoneurum, Desmarestia,* and *Iridaea* (primarily *I. cordata*). All of these genera are still important producers in the Diablo Canyon region, although ecological influences within Diablo Cove may have changed. In spite of urchin barrens, Diablo Cove was a biologically pristine location in 1966.

The barren deep subtidal and luxuriant shallow subtidal and intertidal described above persisted for about seven to eight years. In January 1973, seasonal aides Larry Wade and Lesley Thomas of CDF&G sighted rafting sea otters off Coon Creek, just north of Point Buchon and about 6 km (4 miles) upcoast from Diablo Cove. Otter were observed rafting in Diablo Cove in June 1974 (Benech and Colson, 1978; Gotshall et al., 1984). Otter have moved in and out of Diablo

Cove ever since and numbers were variable throughout the region. Foraging effects from this key species soon became evident everywhere in the subtidal. For example, red urchin abundances in Diablo Cove declined drastically between 1974 and 1978 as shown in monitoring by Gotshall et al. (ibid., Table 72 and Figures 187 and 188). Similar declines occurred in the local commercial fisheries for abalone and urchins after 1974 (ibid., Tables 130 and 132). Otter were observed consuming urchins and abalone in Diablo Cove. Gotshall et al. (ibid.) calculated that the herd ate 50 to 70 abalone and about 150 red urchins per day. There was no perceptible effect, however, on intertidal animals. Otter also consume other common invertebrates such as purple urchins, crab, gumboot chitons, and various snail species. Some of these prey species are now quite rare subtidally in the Diablo Canyon region.

Removal of urchins from the subtidal barren areas had profound effects on the flora. Reductions in grazing pressure permitted colonization of these areas by seaweeds. The biomass and numbers of Red Algae and of palm kelps in Diablo Cove increased dramatically between 1974 and 1976 according to Gotshall et al. (ibid., Tables 31 and 38). Our own observations along fixed subtidal transects within Diablo Cove and near Pup Rock confirmed these findings. One of the most visible effects from return of the otter was a widespread bloom of bull kelp (*Nereocystis*). Gotshall et al. (ibid., Table 133) show annual tallies of bull kelp within Diablo Cove by CDF&G staff. Prior to 1974, about 4000 to 5000 plants were counted each year. Tallies rose dramatically as urchin populations became controlled by otter predation. The estimated tally for the peak year, 1975, was 4.6×10^4 plants, roughly a tenfold increase above the background abundance. The entire Cove seemed filled with the bulbs and upper stipe portions of a vast bull kelp canopy. Quite unexpectedly, 1975 was the peak year and population numbers declined during the next three years, returning approximately to the pre-otter abundances. The bottom during these three years became dominated by palm kelps. Apparently their dense substory canopies shaded the bottom sufficiently to interfere with recruitment by bull kelp. Palm kelp lifespans probably extend over many years at subtidal depths greater than 3 m (Dayton et al., 1984). Bull kelp, however, is primarily an annual. Only a small portion of the population survives winter storms. Once the main population of bull kelp was lost to storms of the 1975-76 winter, the young palm kelps present were apparently able to produce a substory canopy that prevented normal recovery by *Nereocystis* the following spring. This behavior contrasts with competitive relationships between palm kelps and giant kelp (*Macrocystis*). Giant kelp is a perennial. Once *Macrocystis* canopies form, the species can successfully hold territories for many years and reduce biomass of subcanopy vegetation (including palm kelps) to very low levels (North, 1963).

Scattered *Nereocystis* plants continued to occur in Diablo Cove after the population explosion of 1974-75 subsided, but the inlet became largely dominated by dense stands of palm kelps that persisted throughout the preoperational period. A few specimens of giant kelp appeared in the central part of the Cove from 1977 onward (Gotshall et al., 1986, Table 7-1). Young *Macrocystis* have also been observed occasionally in other parts of the Cove but sooner or later disappear. Except for the persistent small population in the Cove's center, giant kelp does not seem able to establish itself throughout this inlet. Probably most of the Cove is too exposed for survival by this species. Storms rip plants out once they develop substantial foliage in midwater. Protected areas within Intake Cove and in the lee of Lion Rock, however, appear to be excellent habitats for giant kelp.

Although palm kelps interfered with development by bull kelp, certain other seaweed species and many invertebrates flourished in the expanded kelp forest that dominated most of Diablo Cove from about 1976 onward. The shallow inshore bottom beneath the kelp substory canopies frequently supported dense tangles of articulated corallines, primarily *Calliarthron*, but also at times containing *Corallina* and *Bossiella*. Diverse assemblages of encrusting invertebrates continued to occur on the undersides of ledges and on steep slopes of pinnacles. Occasional small open spaces permitted luxurious growths of foliose Red Algae. Larger invertebrates not subject to otter predation (i.e., sea stars, cucumbers, anemones, corals, sea squirts, Bryozoan colonies, small mollusks and crustaceans) were present in normal abundances. Animals consumed by otter (i.e., red and purple urchins, abalone, larger gastropods, crabs, gumboot chitons) were seen infrequently far back in crevices or in very shallow water. The new post-otter equilibrium persisted during the latter 1970s and early 1980s. Subtidally, conditions within the kelp forests seemed quite stable. Possibly the dense stands of palm kelps ameliorated destructive effects from wave surge, maintaining a quasi-equilibrium.

This stable condition was violently disrupted during the 1982-83 winter by a series of eleven powerful storms heralding onset of the largest El Niño episode of our century (Dayton and Tegner, 1984). In a tabulation of eighteen extreme wave episodes along the California coast between 1900 and 1984, representing instances when wave heights exceeded 6 m (20 ft), six of the storms listed occurred in the three months between December 1 1982 and March 1 1983 (Seymour et al., 1984). Two additional storms on the list occurred during the winter of 1983-84. From eyewitness accounts, the most damaging of these storms in the vicinity of Diablo Canyon occurred on February 29-March 1 1983. El Niño events (called ENSOs by physical oceanographers; this is an acronym for El Niño-Southern Oscillation) are widespread disturbances originating in equatorial waters, then extending their influences northward and southward. There are anecdotal accounts in the literature establishing that El Niños have occurred for at least the past 450 years (Quinn et al., 1987). The major El Niños affect world climate as well as oceanographic conditions. The 1982-83 EL Niño raised sea surface temperatures (SST) by 5°C (41°F) above normal near the Galapagos Islands by October 1982 (Cane, 1983). Presence of unusually warm ocean temperatures was also recorded off central California (Granite Canyon) during autumn 1982, eventually reaching a peak anomaly of almost 2.8°C (3.7°F) for SST values in March 1983 (Rienecker and Mooers, 1986). Temperature records from 3 m (10 ft) depths in Diablo Cove indicated most values ranged only one or two degrees above the nine-year mean from autumn 1982 through July 1983 (James et al., 1987). Evidently spring and early summer upwelling prevented temperatures from rising above 16°C (60.8°F) for most of this period. Values above 16°C became the norm in mid-July, lasting until mid-October. Measurements ranged from 18 to 22°C

(64.4 to 71.6°F) during August and September 1983 (i.e., from three to eight degrees above normal as measured against the nine-year mean). A few moderately high temperatures were also recorded from July to October 1984, but rarely exceeded 18°C (64.4°F) (record SST values in southern California occurred during September 1984; El Niño warming here was more severe and long-lasting than in central California; North et al., 1984).

The 1982-83 storms had varying effects on different parts of the Cove. Some sections of the intertidal were obliterated by landslides, wave action, and deposits of rubble. Subtidally, palm kelps and other vegetation were torn loose from highly exposed locations and very large boulders were overturned. Extensive stacks of drift weeds littered the upper shoreline. Some locations within the Cove experienced very little damage from the storm surge. Blades of various algae may have been somewhat tattered but the populations seemed relatively intact. Recovery from the storm damage also varied widely. Some highly impacted areas showed little recovery during the ensuing four years (this was especially true for intertidal areas buried by landslides or rubble deposits). Other sites recovered quickly and by summer of 1983 displayed few residual effects.

The most noticeable effect associated with elevated water temperatures during summer 1983 was paling among Red Algae in Diablo Cove. Color changes in seaweeds may reflect inadequate supplies of nutrients, especially nitrogen and phosphorus. Ocean temperatures and concentrations of macronutrients are typically inversely correlated for temperatures greater than 15.5°C (59.9°F) (Zimmerman, 1983). Gerard (1982) reported that nitrate concentrations in the San Pedro Basin are usually below one micromolar for water temperatures greater than 15°C (59°F). If similar relationships occur in the Diablo Canyon region, the temperatures recorded in the Cove during summer and fall 1983 indicate that nutritional stresses might be expected for algae of the region during this period. Because there was coincidence between paling among algae and appearance of high temperatures here at the height of El Niño, it appears that lack of macronutrients and nutritional stresses occurred then. We saw no obvious nutritional stress symptoms among Brown Algae in Diablo Cove during summer-fall 1983, nor in 1984.

Temperatures declined in latter 1983 and seaweed colorations soon returned to normal. Red Algae did not display paling during summer 1984. Beds of bull kelp and giant kelp were greatly reduced at this time, judging from canopy distributions, but this may have resulted from storm losses during the preceding winter.

Thus it appears that the most obvious effect on algae and invertebrates from the 1982-83 El Niño was physical disruption due to the great storms during the early phases of this event. More subtle effects on spores and larvae which might have affected recruitment were not studied by us. Several species of warm water fishes were noted in the Cove during El Niño. These may have been transported into central California by northerly flowing currents which become stronger during El Niño events. Elk kelp (*Pelagophycus*) was found growing on a deep reef near Pecho Rock (5.8 km [3.5 mi] south of Diablo Cove) after El Niño. It is a southern California and Baja California species. Its presence in central California suggests that some transport of exotic algal species did occur as a result of El Niño.

Power plant operations at Diablo Canyon began in latter 1984, complicating any attempts to assess processes of recovery from El Niño. A minor El Niño occurred during the 1986-87 winter. Otherwise background conditions of the operational years seemed to lie within the normal range of variability.

CHANGES DUE TO ARTIFICIAL EVENTS

During preoperational years, marine communities near Diablo Canyon were exposed to several kinds of human-associated perturbations:

- Discharge structure construction in Diablo Cove (7/70-2/74)
- Breakwater construction in Intake Cove (summer 1970)
- Intake structure construction in Intake Cove (1971-73)
- Siltation in Intake Cove (11/71-3/74)
- Accidental copper release during pump testing (7/74)

- Partial elimination of harbor seal haul-out area (6/70)
- Breakwater repairs (1975, 1982, 1983-84)
- Foam generation in Diablo Cove (1974 onward)
- Scouring in front of the discharge structure (1974 onward)

Some of these disruptions were either temporary (e.g., breakwater repair) or caused only minor ecological effects (e.g., foam generation). Where adverse effects could be predicted or became known, mitigative or corrective measures were often undertaken (e.g., removal of abalone from areas subject to burial by construction activities; replacement of copper-nickel condenser tubing with titanium). The only known permanent loss of habitat resulted from placement of construction materials over the intertidal and subtidal during production of the breakwaters. These losses were to some extent compensated by the solid surfaces created by these structures.

Probably the largest ecological change resulted from the altered environment in Intake Cove after breakwater installation. Serious siltation problems arose initially, associated with construction of the intake structure. Burge and Schultz (1973, pp. 222-228) provided a detailed summary of the early siltation problem. The long term change, however, has been conversion of a highly-exposed, wave-swept coastal indentation to a semiprotected embayment. Some species remain, others have disappeared, and some appeared that were not present previously. Light siltation consisting of 0.5 to 2 mm thick fine deposits presently cover most of the rocky surfaces. This seems to affect species diversity in the innermost parts of Intake Cove where deposits are thickest. Nonetheless, the little embayment is a highly productive area. Continual removal of kelp canopies is necessary to avoid interference with supplies of cooling water to the power plant, from clogging by excess drift. Intake Cove is used by otters for resting and feeding.

Where transient disruptions occurred (e.g., construction of cofferdams and subsequent removal; mortalities due to release of copper), effects were believed to be localized. Colonization by similar or alternate species followed after the disruptive influence disappeared.

Flows from the discharge structure commenced in June 1974 with initial pump testing. They have since continued intermittently but with increasing frequency and duration. Concern was expressed regarding possibility of loss of biota due to scouring immediately in front of the discharge (Gotshall et al., 1984). These investigators inspected the bottom outward from the discharge structure on June 21 1976 (Gotshall et al., 1979). They reported scouring effects for a 60 m (200 ft) distance from shore. A dense colony of palm kelps populated the lower intertidal in front of the discharge prior to power generation in late 1984. The inshore edge of the palm kelp thickets were perhaps 30 to 47 m (100 to 155 ft) from the discharge structure. Thus a portion of the scoured area observed in 1976 by Gotshall and his colleagues may have been recolonized by palm kelps.

Immediately following the first large scale flows from the discharge structure in July 1974, a release of copper caused deaths of an estimated 2000 to 3000 red abalone, 2000 to 10,000 black abalone (Warrick et al., 1975) and possibly other invertebrates such as red urchins. Large amounts of foam were also associated with the plume. The toxicity problem was solved by replacing the copper-nickel condenser tubes with titanium in 1975. Foam distribution and composition were studied extensively (Wyman, 1979; Gotshall et al., 1979). Ecological effects, if any, were never established.

None of the artificial disruptive influences described above caused identifiable changes in our study areas. We will, therefore, refrain from detailed discussions of these incidents. Complete descriptions are presented by the investigators cited above. Suffice it to say in conclusion that these artificial disturbances of the preoperational years were mostly minor compared to some of the perturbations arising from natural causes (cf. Gotshall et al., 1984, p. 39).

There is no precisely identifiable time when ecologically significant amounts of waste heat began to be introduced to Diablo Cove via the power plant cooling stream. Unit I went "critical" on April 29 1984. Low power testing commenced at Unit I on October 18 1984. Full scale commercial generation commenced at 0230 hrs on May 7 1985. Low power testing of Unit II began in October 1985, building up to full scale operations in March 1986. Unit I power generation was cut back from June through August 1986, ceasing entirely until the end of December to permit refueling.

Discharge temperatures have fluctuated according to amounts of power generated. Total heat emitted varied according to whether one or both units were operational. During 1986, for example, discharge temperatures were usually in the range 20 to 25°C (68 to 77°F), providing delta-t values of 7 to 11°C (12.6 to 19.8°F) (Thermal Effects Monitoring Program, 1987).

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Chapter 3

CHARACTERISTICS of the POWER PLANT and ITS OPERATIONS

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GENERAL DESCRIPTION

DCPP consists of two 3250 megawatt (thermal), four loop, pressurized water nuclear reactors with a combined electrical output of 2120 megawatts (PG&E, 1971). The reactors are housed in two domelike containment structures adjacent to a large turbine building and the overall facility includes related structures such as fuel-handling, administrative, warehouse, and laboratory buildings, plus switchyards, parking lot areas, fuel oil tanks, water storage reservoirs, a small sewage treatment facility, etc. Spent steam from the turbines is cooled by transferring heat across the titanium walls of condenser tubing to a flowing stream of seawater. Seawater for the cooling function is drawn from Intake Cove, the small stretch of shoreline immediately downcoast from Diablo Cove. The intake opening extends vertically from about 2.3 m down to 9.6 m (7.5 to 31.5 ft) below mean sea level (MSL). The prime moving force driving the cooling water stream is two 65.7 $m^3 \cdot s^{-1}$ (2330 $ft^3 \cdot s^{-1}$) circulating pumps per unit (i.e., four main pumps for DCPP). The water moves about 460 m (1500 ft) from Intake Cove to the power station about 40 m (132 ft) above. Heated seawater flows from the plant by gravity about 120 m (400 ft) to the discharge structure at the edge of Diablo Cove. Total transit time for the water is about 4.5 min. The discharge structure dissipates some of the force of the 20 m (65 ft) head by passing the flow over four cascading steps. The floor of the final step lies at 2.3 m (7.6 ft) below MSL. Discharged water, as it enters the sea, passes over a 1.3 m (4.3 ft) weir on the floor of the final step. There is thus a relationship between tidal height and cross-sectional area available to the flow at this point.

Differences between temperatures of the inflowing and outflowing streams (delta-t) vary according to power generated, but typically reach maximal levels of 10 to 11°C (18 to 20°F) (TERA, 1986). The average discharge velocity is about 4.6 $m \cdot s^{-1}$ (Tu et al., 1986). The 5.5°C (10°F) isotherm for delta-t at the sea surface off Diablo Cove embraces from 2 to 20 hectares (5 to 50 acres) with a single unit operating (Leighton et al., 1986). Maximum plume depths vary from 4.6 m to 10.7 m (15 to 35 ft), depending on wave action. As much as 6 hectares (15 acres) of the bottom within Diablo Cove may experience temperature elevations reaching half of the delta-t values in the discharged effluent.

The remote location of DCPP precludes use of a municipal sewerage system for liquid waste disposal. The facility therefore depends on the large dilution capability of the cooling water stream to remove and render harmless the various products resulting from plant operations. There are two 0.042 $m^3 \cdot s^{-1}$ (1.47 $ft^3 \cdot s^{-1}$) auxiliary pumps that supply cooling water for the component cooling water heat exchangers, and they also provide dilution for these liquid wastes during periods when the main pumps are shut down. Flows by the auxiliary pumping system are variable. Monthly volumes pumped in 1982 ranged from 5.4×10^5 to 2.235×10^6 m^3 (1.9×10^7 to 7.4×10^7 ft^3; Behrens, 1983). Table 3-1 provides information on relative volumes involved for some of the minor discharges.

Table 3-1: Summary of liquid discharge volumes (m^3/month) from DCPP for 1982.

Month	001 Main Circ Cooling (10^{-6})	001A Fire Flush (10^{-3})	001B Aux. Salt Water (10^{-6})	001C Mu H_2O Makeup (10^{-3})	001D Liq. Rad Waste (10^{-3})	001E Service Cooling (10^{-3})	001F Turbine OWS (10^{-3})
Jan	0	0	1.86	0.09	0.16	0	1.54
Feb	0	0.66	1.68	0.087	0.18	0	2.01
Mar	0	0	1.84	0.63	0.22	1.32	0.53
Apr	0	0.20	1.75	0.76	0.25	0	1.19
May	5.08	0	1.78	0.37	0.23	1.32	1.32
Jun	1.71	0	1.74	0	0.16	0	1.65
Jul	0	0.29	1.46	0.62	0.20	0	0.87
Aug	0	0	1.59	0.48	0.17	0	0.25
Sep	0	0.35	1.71	0.17	0.10	45.20	0.53
Oct	0	0.30	0.45	0	0.24	0	0.10
Nov	0	0	0.61	0	0.05	0	0.098
Dec	0	0	1.61	0	0.21	0.87	0.28

001G discharge (Reverse osmosis blow down) was 0 for the year.

A self-monitoring program established under the National Pollution Discharge Elimination System (NPDES), and regulated by RWQCB,CCR, involves periodic sampling of the main influent and effluent streams, as well as the various small inputs from various sources (Behrens, 1983). The main stream and separate inputs are identified by letters and numbers as follows:

- 001 Main circulation, once-through cooling
- 001A Firewater flush
- 001B Auxiliary seawater
- 001C Municipal water waste, makeup water system
- 001D Liquid radwaste system
- 001E Service cooling water
- 001F Turbine building sump, oily waste separator
- 001G Reverse osmosis blowdown
- 001H Condenser, seawater demineralizer
- 001I Sea evaporator blowdown
- 001J Condenser pump discharge
- 001K Condenser tube leak detector
- 001L Steam generator blowdown
- 002 Intake sump building drains
- 003 Screen wash intake
- 004 Thermal effects laboratory
- 005 Yard storm drains

Examples of reports from routine monitoring were presented by Behrens (1983, 1984) and Kelly (1985). Ninety-six hour static bioassays are conducted monthly on-site at DCPP for samples from 001 and other discharges (primarily 001B). PG&E participates in the mussel-watch program, part of a state-wide effort conducted by CDF&G and the State Water Resources Control Board. Special research tasks have evaluated toxicities of various materials such as chlorine, titanium, plastics, sea-foam, etc. (see bibliographies by Warrick and Behrens, 1982, 1985 for references to these studies).

MODELING AND EVALUATING PLUME BEHAVIOR

Predictions from numerical models of plume behavior were available to us at the beginning of our studies in 1966 and have figured importantly in decisions about design of our investigations.

Further modeling work has continued ever since, incorporating new information from the ongoing oceanographic work. We were able to utilize some revisions in the modeling for modifying our survey methodology from time to time.

PG&E staff and several collaborating organizations initiated a major field program in latter 1984 during power ascension testing of Unit I. The program also operated during latter 1985 and 1986 in the early operational phases of the Unit II reactor. Objectives of this field program were verification of the hydraulic model and quantifying effects from the many factors that influence plume behavior. The model was also tested for the specialized conditions that arise during heat treatments (flow patterns are altered in the cooling water conduits in order to raise and maintain temperatures of about 38°C (100°F) in the intake system for one to several hours to control biofouling; cf Summerville, 1986). Specific details of the field studies are presented in Tu et al. (1986), Leighton et al. (1986), Ryan et al. (1986), and in the various annual reports, *Environmental Investigations at Diablo Canyon*, published by PG&E. The combined studies were exhaustive and it is far beyond the scope of this brief review to describe the activities and findings in detail. We will discuss only those results that have particular relevance to our own investigations.

The discharge occurs primarily as a buoyant, near-surface plume, spreading laterally as it moves seaward. Plume depths and water temperatures were influenced by location (i.e., distance from the discharge), wave height, wind, and tide. Plume depth ranged from 4.6 to 10.7 m (15 to 35 ft). Entrainment of surrounding water within the moving plume was an important factor in reducing temperature in the near field region. Entrainment during high tides began near the point of discharge, then moved seaward as tidal levels fell, extending as far as 400 m (1320 ft) offshore during extreme low tides. Plume stratification was strongest during calm seas and became less defined as wave heights increased. The overall dilution factor was 3 to 5 at the Cove exits, with greatest values at low tide (this seems counter-intuitive but may represent differences in initial mixing which tends to occur in the shallow inshore during high tide but centrally in the deep cove during low tide: J. Doyle, personal communication). Path of the plume was related to tide, wind, and waves. Under some conditions, most of the flow passed through the southwest channel. Bifurcation of the flow became pronounced under other conditions and portions of the flow exited the Cove from both the southwest and north. As much as 80 percent of the heat flux from Diablo Cove occurred through the southwest channel. Both Units I and II influenced temperatures within the southwest exit but Unit I was primarily responsible for temperature elevations in the north exit. Heat treatment produced smaller plume areas within the Cove than found from full power operation of either one or both units, but actual areas contained within specific isotherms during heat treatments were not determined. The sampling did not extend into most shallow areas peripherally around the Cove (probably to avoid hazards from washrocks and surf). Data were taken near Diablo Rock and Tu et al. (1986) noted that warmest subtidal temperatures were encountered on the landward side of this islet.

Summarizing, plume behavior within Diablo Cove was complex and dynamic. There are probably shallow locations within the Cove that receive constant or nearly constant exposure to plume waters (e.g., the landward side of Diablo Rock, or inshore bottom shallower than 3 m (10 ft) and immediately in front of the discharge structure). With these few exceptions, plume exposure is probably variable for most of the shallow subtidal. No fixed or stable distributional pattern was found for the plume, from which one could estimate degree of exposure at a location of particular interest such as a biological sampling site.

POTENTIAL FOR ECOLOGICAL INFLUENCES

The description of power plant operations given above suggests that biota within parts of Diablo Cove might be influenced by five general processes:

- Release of primary cooling water
- Heat treatments
- Bottom scouring in the high velocity portion of the jet
- Secondary releases of liquid wastes
- Ecological adjustments and imbalances

We would not expect that effects from the five categories listed above would be equivalent or similar throughout the Cove. Scouring, for example, might only occur close to shore immediately in front of the discharge structure. If scouring completely removed all organisms close to shore, there would be no other ecological effects at this location even though potential for effects was maximal. Areas exposed to scouring would be quite small. At the other extreme, areas exposed to elevated water temperatures would probably encompass most, if not all, shallow bottom within the Cove. Topography undoubtedly influences degree of exposure (e.g., along the landward side of Diablo Rock). It may not always be possible to separate effects from two or more processes in areas where their influences might overlap. We will discuss special characteristics of each of the five processes listed above, that may be useful in detecting their influences.

Temperature-Related Effects

Biota of Diablo Cove consist of a mixture of species characteristic of cold water environments to the north and warm water habitats occurring to the south. Water temperature is believed to be influential in determining distributions of many marine organisms (Hubbs, 1960). Presumably warm-tolerant species of Diablo Cove would be able to survive in those areas where temperatures are elevated substantially above background due to exposure to primary cooling water (this hypothesis presumes that local members of a warm-tolerant species maintain the genetic capabilities of coping with elevated temperatures). Cold water species might disappear from such areas. Previously unrecorded warm-tolerant species might appear as immigrants from the south. Thus shifts in species composition would provide evidence of temperature-related effects. A reliable temperature record from a specific study site would, of course, be helpful for documenting cause of the presumed effect. Scouring and secondary wastes would probably not cause shifts toward warm-tolerant species, but heat treatments would have a pronounced influence. A temperature record would indicate whether heat treatment effects may have extended to a given location.

Scouring Effects

Influence of large velocities characteristic of plume waters close by the discharge might also be detected through species composition. One might expect highest survival among species characteristic of very exposed shorelines (e.g., mussels, barnacles, and encrusting algae). Delicate biota would disappear, as would cold water species.

Effects From Secondary Wastes

Very high dilutions are theoretically achieved when small amounts of liquid wastes are injected into the huge volume of the primary cooling water stream. Intense mixing as the flow passes through the discharge structure almost certainly ensures that the calculated dilutions are achieved. Dilutions remain high when only the auxiliary pumping system is operating at near-capacity. Nonetheless, we do not know sensitivity of the hundreds of species present in Diablo Cove to all the compounds that may occur in trace amounts in the DCPP effluent (Table 3-2 lists elements and compounds monitored by PG&E under terms of their NPDES permit). One must be alert to the possibility of some kind of influence, however remote the likelihood of its occurrence. This type of effect might be manifested as diseased or moribund organisms among sensitive species and in areas where no alternative explanation exists for the observed condition. Likewise, unusually low abundances or complete absence of a common species (especially one classed as warm-tolerant) from an area where it might be expected to occur abundantly, might lead to suspicion of effects from components of secondary wastes. This kind of evidence is tenuous at best, and should be supported by additional experimentation before even preliminary conclusions are drawn.

Ecological Adjustments and Imbalances

Assuming that certain species are encouraged by operational environmental conditions in Diablo Cove, their populations may increase and such changes might affect processes such as competition, recruitment, and trophic relationships. Opposite effects might result from reductions in abundances of species adversely impacted by the operational environment. These ecological

Table 3-2: NPDES monitoring requirements as specified in the WQCB,CCR Monitoring and Reporting Program No. 82-24, adopted October 7, 1982. Data from Behrens (1983).

Parameter Sampled	In	Out	Method	Discharge Sampled
Temperature	x	x	metered	001
Flow		x	pump data	001
Turbidity	x	x	grab	001
pH	x	x	grab/continuous	001 monthly *
Grease & oil	x	x	grab	001, 001F
Grease & oil		x	grab	001C,D,G,H,I,J, K,L, 002,005
Tot Non-filterable Residue.		x	grab	001,001C,D,F,G, 001H,I,J,K,L
Arsenic (As)	x	x	grab	001
Total. Chromium (Cr)	x	x	grab	001
Copper (Cu)	x	x	grab	001
Copper		x	composite	001D,F,I,L
Lead (Pb)	x	x	grab	001
Mercury (Hg)	x	x	grab	001
Nickel (Ni)	x	x	grab	001
Silver (Ag)	x	x	grab	001
Zinc (Zn)	x	x	grab	001
Cyanide	x	x	grab	001
Phenolic compounds	x	x	grab	001
Tot chlorine residual		x	grab	001
Chlorine used		x	amount used	001
Ammonia (NH_3)	x	x	grab	001
Toxicity		x	grab	001
Total chlorinated pesticides		x	grab	001, 005
PCBs		x	grab	001, 005
Iron (Fe)		x	composite	001D,F,I,L
Titanium (Ti)		x	grab	001
Boron (B)		x	grab	001
Dissolved Oxygen (O_2)		x	grab	001
Lithium (Li), Boron, Hydrazine		x	grab	001D
Hydrazine		x	grab	001
Cadmium (Cd), Cr, Cu, Pb, Hg, Ni, Tin (Sn), Zn		x	quarterly composite	001D,H,L
Cd, Cr, Pb, Cu, Hg, Ni, Sn, Zn		x	weekly composite	001F

* daily when discharging from 001C, D, H, I, J, K, otherwise monthly.

changes may have spreading influences that indirectly impact other species which might otherwise be unaffected by exposure to plume waters. As a hypothetical example, suppose giant kelp proliferated within Diablo Cove during operational years. Shading by kelp canopies might reduce abundances of understory seaweeds but favor colonization by encrusting animals (North, 1963). Such changes in benthos may bear little or no relationship to operations by DCPP. Comprehending and identifying ecological imbalances and adjustments is often difficult. It requires continuing observation by qualified staff and possibly additional supporting research to test proposed hypotheses.

VERY LONG-TERM CONSEQUENCES

Concern was expressed during early public hearings that ecological effects from operations at DCPP might persist long after the power plant's operational lifetime. North and Anderson (1973) pointed out that many processes in the ocean affect water temperature. The time-span associated with the several kinds of temperature fluctuations varies according to the process causing the change. Thus internal waves may cause temperature cycling measured in minutes. At the other end of the temporal spectrum, very long cycles are known to occur measured in terms of centuries and millennia. The very long-term changes are associated with major climatic alterations. Nine hundred years ago, for example, marine fauna near the tip of Baja California resembled the present-day cold-water communities of Monterey Bay (Hubbs, 1960). Tropical assemblages such as coral now dominate shallow water bottoms around the tip of Baja California. The temperature changes measured in Diablo Cove due to DCPP operations are relatively mild compared to the long-term fluctuations arising from major climatic variation. Our Pacific coast marine fauna and flora have necessarily adjusted to these large long- term changes.

It seems logical that reversion to the preoperational status by local biota after DCPP ceases functioning should be a simple and rapid process.

OPERATIONAL HISTORY OF DCPP

Construction activities with effects on marine biota commenced at Diablo Canyon in mid-1970 with construction of two breakwaters off Intake Cove and a cofferdam for the discharge structure in Diablo Cove. These activities are discussed in our historical account of ecological changes occurring in Diablo Cove. Our primary concern in this section is with history of flows produced by the main circulating pumps and temperature alterations in the cooling water due to operations of Units I and II.

Flow History

The two Unit I main circulating pumps first became operational on June 28 1974 (Warrick et al., 1975). They were operated intermittently through October 24 of that year (ibid., Table II-1). Pumps were not operated for more than a year thereafter because copper-nickel condenser tubes were being replaced by titanium tubing to avoid possible toxicity problems. Operations were variable after startup in late 1975 and monthly flows were generally low through September 1984 (, Figure 3-1a). Flows increased thereafter and Unit I commenced power ascension testing on October 18 1984. Commercial generation began on May 7 1985. Low power testing for Unit II began May 7 1985, followed by full scale commercial operations on March 13 1986. The TEMP 1986 annual report showed graphs of daily power level and flow volume for 1986 (TERA, 1986, Figure 2-1). Figures 3-1a, 3-1b, and 3-1c are presented here showing 1983-1987 flow volume and discharged heat. The auxiliary seawater pumps were first tested on March 4 1975 (Warrick et al., 1975).

Table 3-3: Monthly discharge volumes ($m^3\ month^{-1} \times 10^{-6}$) for the main circulating pumps (Effluent 001) at the Diablo Canyon Power Plant.

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	-	-	-	-	-	10.2	81.5	77.9	221.4	1.3	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	146.5
1976	140.0	104.4	0.9	-	-	-	-	-	-	-	-	-
1977	49.3	107.1	75.1	72.6	70.1	6.4	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	22.8	4.4	-
1979	-	29.2	62.5	1.8	1.4	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	20.5	72.4	7.8	1.9
1981	1.8	1.7	1.8	1.8	2.8	1.7	1.8	1.8	1.7	1.8	1.8	1.9
1982	-	-	-	-	5.1	1.7	-	-	-	-	-	-
1983	1.8	1.6	1.9	1.7	1.7	1.7	2.4	3.1	1.8	2.8	3.6	24.7
1984	28.6	69.3	73.0	51.3	67.2	79.3	73.1	93.9	78.2	103.0	144.2	204.2
1985	48.1	96.6	230.0	36.3	126.0	134.0	173.8	226.6	145.0	231.5	219.3	227.8
1986	187.3	183.4	269.8	261.0	280.9	264.6	259.6	278.2	135.7	146.3	182.8	212.1
1987	276.8	254.4	247.5	154.3	131.2	179.8	264.5	286.6	280.6	285.9	265.3	274.8

Intake and Discharge Temperatures

NPDES requirements include monitoring cooling water temperatures at the intake and discharge structures. We present daily values of both parameters for the period 1983-1987 as reported by PG&E to the WQCB,CCR (Figures 3-2a, 3-2b, 3-2c; Appendices 3-1 and 3-2). Values of delta-t (the differences between discharge and intake values) for 1986, were graphed by TEMP (TERA, 1986; Figure 2-2).

We also included measurements of influent temperature (Figure 3-2a; Appendix 3-1a) during 1983 to illustrate the elevated background values prevailing during this year because of a major El Niño. There was also a minor El Niño during winter 1986-87 and its effects can be seen as temperatures greater than 15.6°C (60°F) in December 1986 (Appendix 3-1b). The highest reading for an influent temperature was 20°C (68°F) on August 10 and October 14 to 16, 1983. Unusually high temperatures continued until latter November 1983. The record of effluent temperatures (Figures 3-2a, 3-2b, 3-2c; Appendix 3-2) showed that waste heat was discharged even before the Unit I reactor became operational in latter 1984 (for example, January 29 to February 6 1984). The maximum effluent temperature recorded was 26.4°C (79.5°F) on October 28 1987, representing a 9.7°C (17.5°F) delta-t. Highest effluent temperatures tended to occur during fall and winter (October to February), probably reflecting seasonal influences from the Davidson Current. There was a well-developed tendency for background temperatures during fall and winter to be at least 1.1 to 2.2°C (2 to 4°F) above spring-summer values. Short-term warm periods of an additional 1.6 to 3.3°C (3 to 6°F), lasting a week or two, were superimposed on the broad seasonal elevation of fall-winter. Highest discharge temperatures prevailed whenever one of these short-term warming periods appeared.

Additional temperature monitoring was conducted using recorders situated at various intertidal and subtidal locations inside Diablo Cove and at control sites to the north and south. Results from this environmental monitoring will be discussed elsewhere.

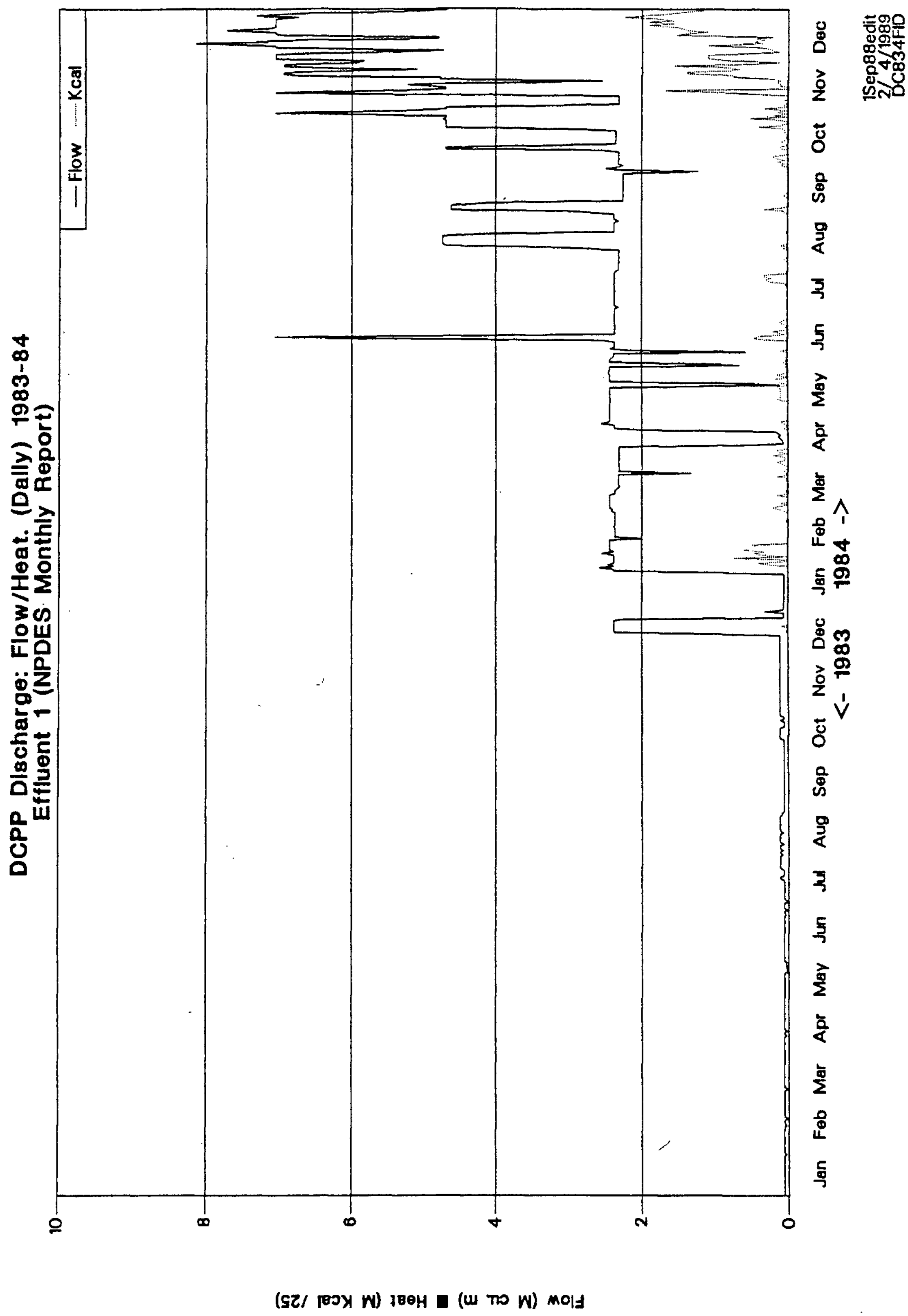


Figure 3-1a. Graph of daily discharge flow and heat for 1983-1984.

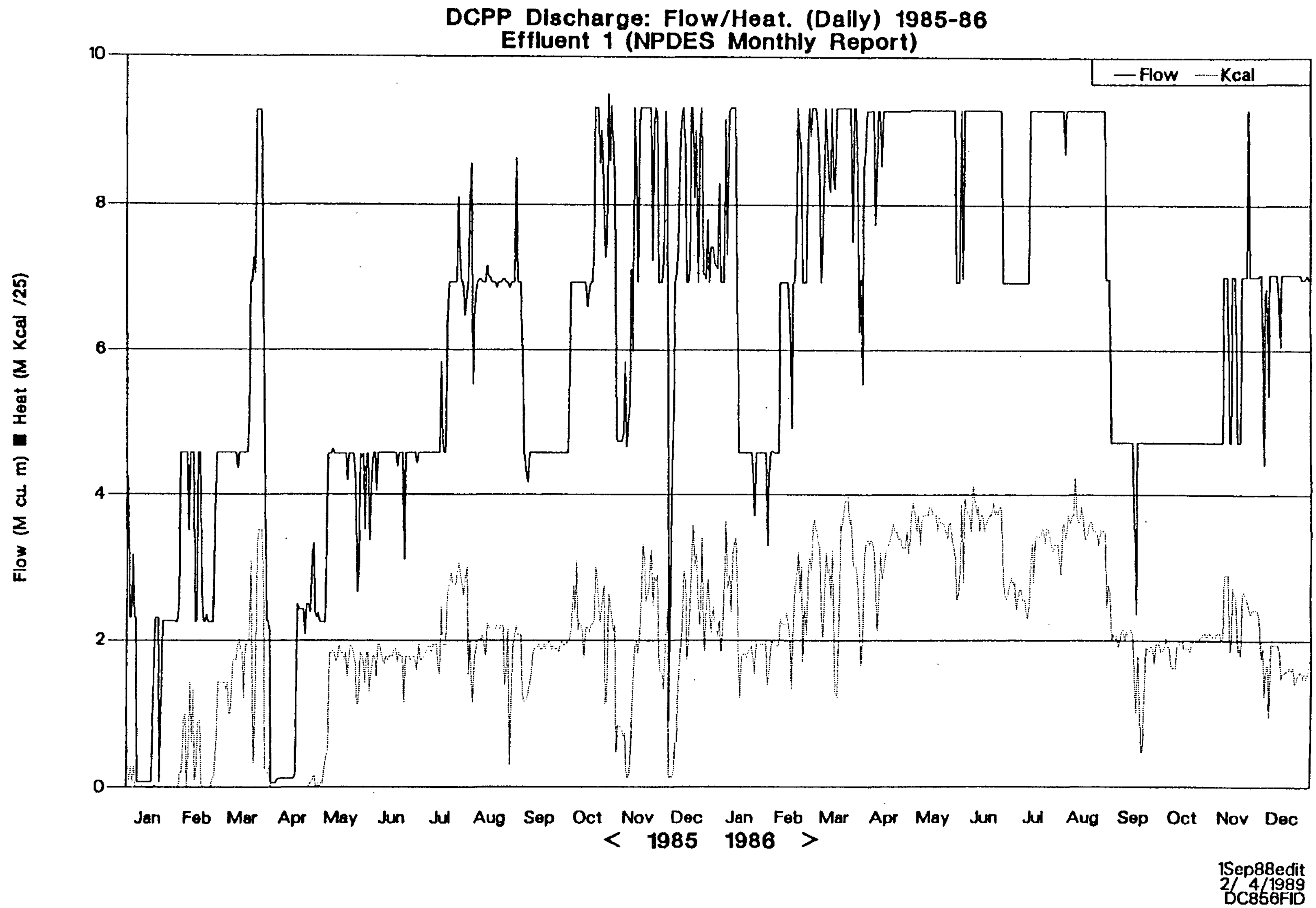


Figure 3-1b. Graph of daily discharge flow and heat for 1985-1986.

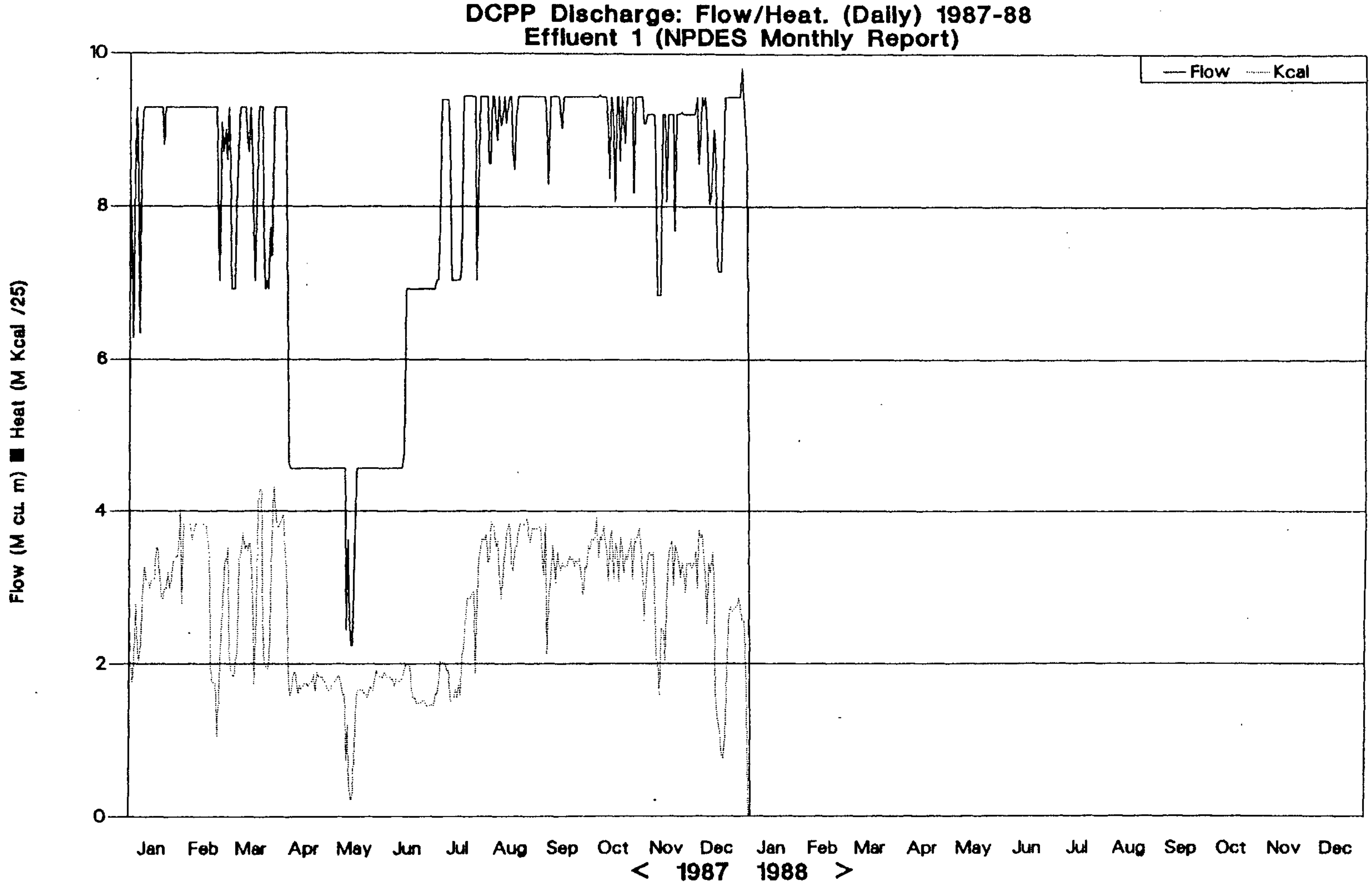
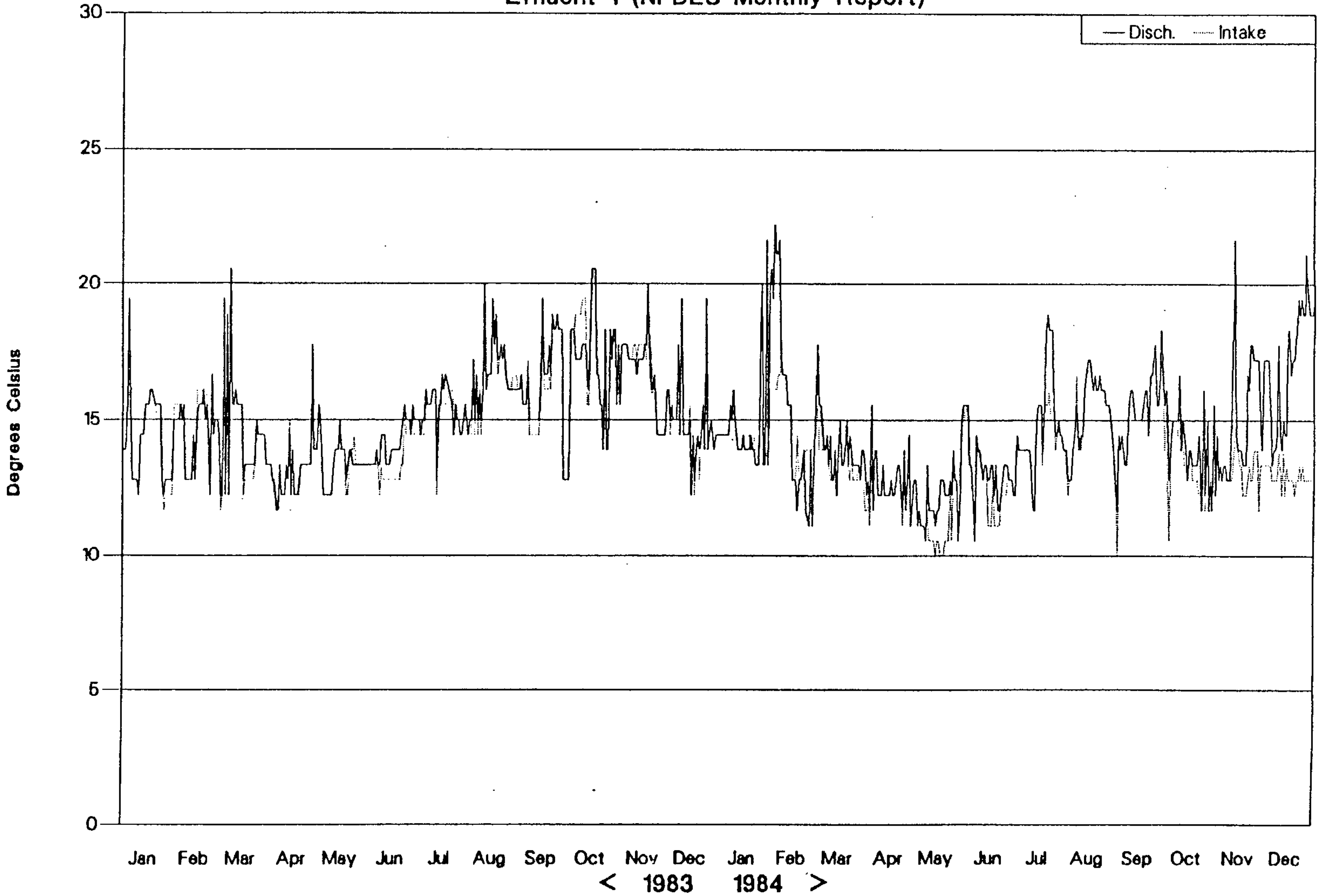


Figure 3-1c. Graph of daily discharge flow and heat for 1987.

DCPP Intake/Discharge: Temperatures (Daily) 1983-84
Effluent 1 (NPDES Monthly Report)



1Sep88edit
3/29/1989
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Figure 3-2a. Graph of daily intake and effluent temperatures for 1983-1984.

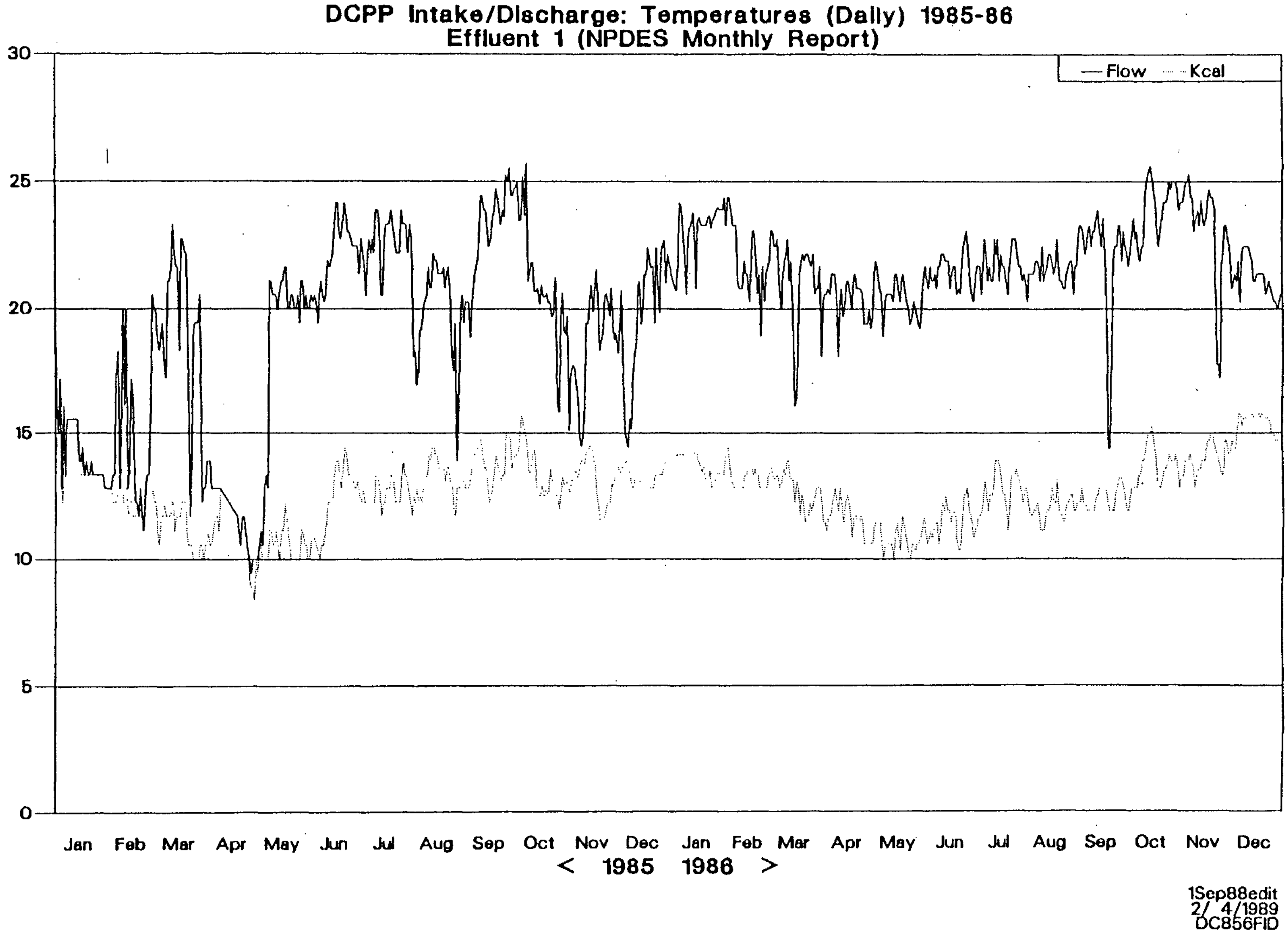
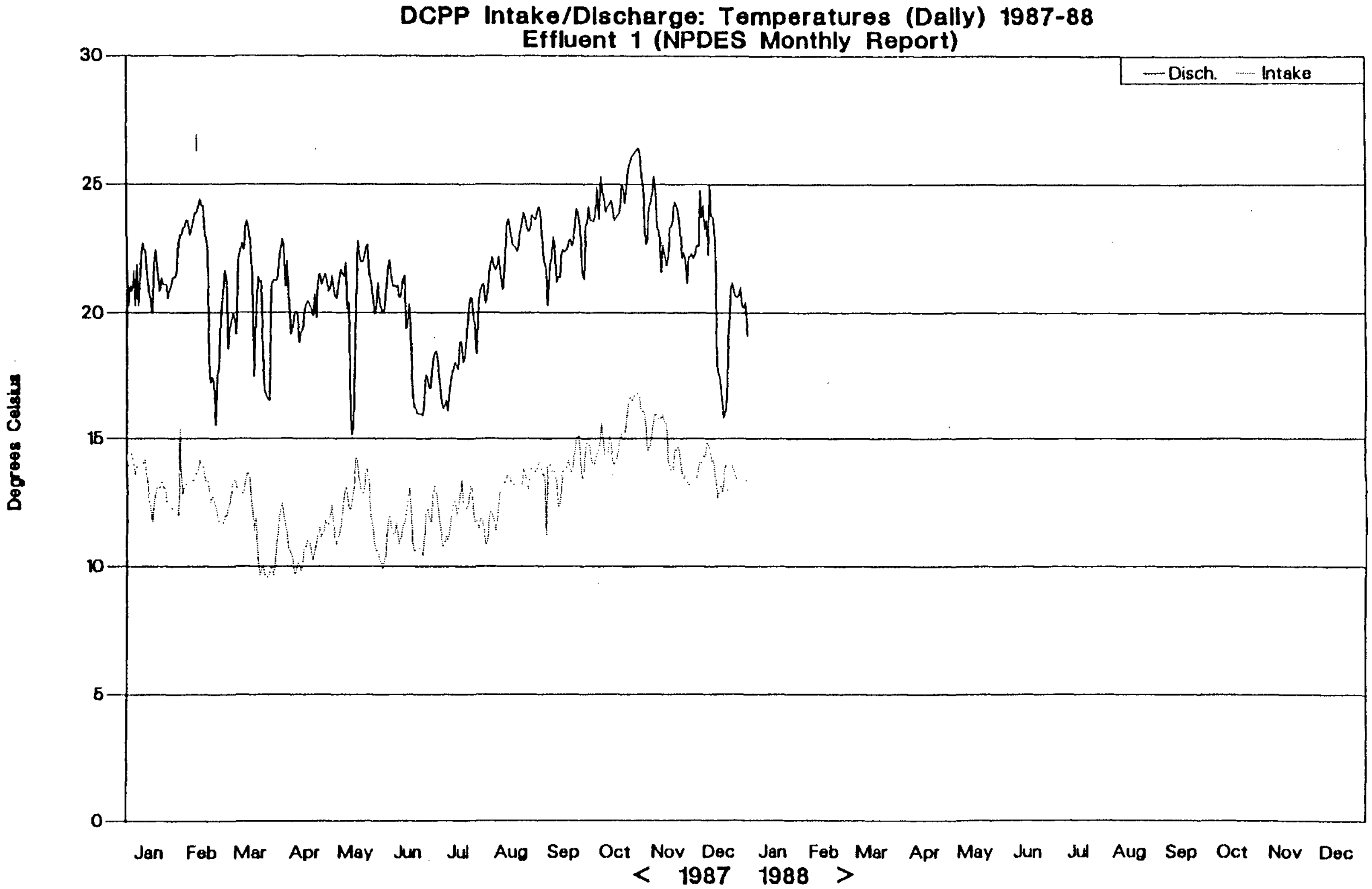


Figure 3-2b. Graph of daily intake and effluent temperatures for 1985-1986.



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2/ 4/1989
DC878FID

Figure 3-2c. Graph of daily intake and effluent temperatures for 1987.

Appendix 3-1a: Seawater temperatures (°C), measured within the INFLUENT stream of cooling water of Diablo Canyon Power Plant in 1983 and 1984. Data from the "Discharger Self-Monitoring Report" as submitted to the CCRWQCB.

Day	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983												
01	15.0	15.6	11.7	13.3	15.0	13.3	14.4	15.6	16.7	18.3	17.8	14.4
02	15.0	15.6	12.2	12.8	13.9	13.3	14.4	14.4	15.6	18.3	17.8	15.6
03	15.0	15.6	17.2	12.2	12.2	13.3	14.4	16.7	15.6	18.3	17.8	15.0
04	15.6	15.6	12.2	12.2	12.2	13.3	14.4	14.4	15.6	18.9	17.8	15.0
05	16.1	15.6	16.7	11.7	12.2	13.3	15.6	16.7	17.2	18.9	17.2	15.0
06	15.6	15.6	12.2	13.3	12.2	13.3	15.6	14.4	14.4	18.9	17.2	17.8
07	12.8	15.6	17.2	12.2	12.2	12.2	15.6	15.6	14.4	18.9	17.2	14.4
08	12.8	12.8	16.1	12.2	12.2	13.3	15.6	14.4	14.4	19.4	17.8	19.4
09	12.8	12.8	15.6	12.2	13.3	12.8	16.1	16.1	14.4	19.4	17.8	14.4
10	12.8	12.8	15.6	13.3	13.9	12.8	16.1	20.0	14.4	19.4	17.2	14.4
11	12.2	12.8	15.6	12.8	13.9	12.8	16.1	16.1	14.4	15.6	17.8	14.4
12	14.4	12.8	15.6	15.0	13.9	12.8	12.2	16.7	14.4	15.6	17.8	14.4
13	14.4	14.4	15.6	12.2	13.9	12.8	14.4	16.7	16.1	17.8	17.8	15.6
14	14.4	12.8	15.6	13.9	13.9	12.8	15.6	16.7	18.9	20.0	17.8	12.2
15	15.6	16.1	12.2	12.2	13.9	12.8	15.6	19.4	16.1	20.0	17.8	14.4
16	15.6	16.1	12.8	12.2	13.9	12.8	15.6	17.8	16.1	20.0	17.2	12.2
17	15.6	16.1	12.8	12.2	12.2	12.8	15.6	17.8	16.1	16.7	19.4	14.4
18	15.6	16.1	12.8	12.2	12.2	12.8		16.7	16.7	16.7	17.2	14.4
19	15.6	15.6	12.8	13.3	13.3	12.8		17.2	16.1	15.6	17.8	12.8
20		15.6	12.8	13.3	13.9	13.3		17.8	18.9	15.6	16.1	14.4
21	15.6	16.1	12.8	13.3	13.9	13.3	16.1	17.2	18.3	13.9	16.7	15.6
22	15.0	14.4	13.3	13.3	14.4	15.0	15.6	17.8	18.3	17.2	15.6	13.9
23	15.0	12.2	15.0	13.3	13.3	14.4	15.6	16.7	18.3	13.9	14.4	19.4
24	15.0	16.7	14.4	13.3	13.3	15.0	15.6	16.7	18.3	13.9	14.4	13.9
25	12.8	15.0	14.4	13.3	13.3	15.0	15.0	16.7	18.3	18.3	14.4	
26	11.7	15.0	14.4	16.1	13.3	14.4	15.0	16.1	18.3	17.2	14.4	15.0
27	12.2	15.6	14.4	13.9	13.3	15.0	15.0	16.7	12.8	18.3	14.4	14.4
28	12.2	15.0	14.4	14.4	13.3	14.4	15.0	16.7	12.8	18.3	14.4	13.9
29	12.2		13.3	13.9	13.3	14.4	15.6	16.7	12.8	15.6	16.1	14.4
30	12.2		13.3	15.6	13.3	14.4	15.6	16.1	12.8	17.8	16.1	14.4
31	12.2		13.3		13.3		15.6	16.1		15.6		14.4
1984												
01	14.4	16.1	15.6	12.2	11.1	15.0	14.4	13.3	10.0	15.6	12.8	13.3
02	14.4	16.1	13.9	11.1	11.7	13.3	13.9	12.2	13.9	12.8	12.8	13.3
03	14.4	16.1	15.6	13.3	11.1	13.3	13.9	12.8	13.9	10.6	12.8	13.3
04	14.4	16.1	13.9	12.2	11.1	12.2	13.9	12.8	14.4	13.9	12.8	13.3
05	14.4	16.7	13.9	12.2	11.1	11.1	13.9	13.9	13.9	15.0	12.8	12.8
06	15.6	16.7	14.4	12.2	10.6	13.3	13.9	14.4	13.3	15.0	12.8	12.8
07	15.0	17.2	14.4	12.2	11.7	13.9	13.9	16.7	13.3	15.0	12.8	12.8
08	15.0	16.7	13.3	12.2	10.6	13.9	13.9	13.9	15.6	14.4	12.8	12.8
09	15.0	16.7	12.8	12.2	10.6	13.3	13.9	14.4	15.6	16.1	12.8	13.9
10	14.4	16.7	12.8	12.2	10.6	12.8	13.3	13.9	15.6	13.9	12.8	13.3
11	13.9	15.6	12.8	12.2	10.6	13.3	11.7	14.4	15.6	14.4	13.3	12.2
12	13.9	15.6	13.3	12.2	10.0	13.3	11.7	16.1	15.0	13.3	14.4	13.9
13	13.9	15.6	12.2	12.2	10.6	11.1	15.0	16.7	15.0	13.3	14.4	12.2
14	14.4	12.8	13.9	12.2	10.6	11.1	15.6	17.2	15.0	12.8	13.9	13.3
15	13.9	12.8	15.0	12.8	10.0	11.1	15.6	17.2	15.0	13.3	13.3	12.8
16	13.9	12.8	13.3	12.2	10.0	12.8	15.6	16.7	15.0	13.9	13.3	12.8
17	14.4	14.4	13.3	12.2	10.0	11.1	13.3	16.1	15.6	12.8	12.2	12.8
18	14.4	12.8	13.9	12.8	10.6	11.1	16.1	16.1	16.1	12.8	12.2	12.8
19	13.9	12.8	14.4	12.8	10.6	11.1	15.6	16.1	16.1	12.8	12.2	12.2
20	13.9		13.3	12.8	10.6	11.1	15.6	16.1	14.4	12.8	12.8	12.8
21	14.4	13.3	12.8		12.8	12.2	16.1	16.7	16.7	12.2	13.3	12.8
22	13.9	13.9	13.9	11.1	10.6	12.2	15.0	16.1	16.7	12.8	12.8	13.3
23	13.9		12.8	12.8	13.3	12.2	15.0	16.1	17.2	11.7	12.8	12.8
24	13.3	13.9	12.8	11.7	12.8	12.2	15.6	16.1	17.8	16.1	13.9	13.3
25	15.6	13.9	12.8	12.8	12.8	12.8	13.9	15.6	15.6	11.7	13.9	12.8
26	15.6	13.9	13.3	14.4	10.6	12.8	14.4	15.6	15.6	12.2	13.9	12.8
27	13.3		12.8	11.1	11.7	12.8	15.0	15.6	16.7	11.7	11.7	12.8
28	13.3	14.4	13.3		12.8	12.8	14.4	15.0	17.2	11.7	13.3	12.8
29	13.9	13.9	12.8	12.8	15.6	12.2	14.4	14.4	16.1	11.7	13.3	12.8
30	13.3		11.7	12.8	15.0	12.2	13.9	13.3	13.9	15.0	13.3	12.8
31	16.1		11.7		15.6		13.9	12.2		12.2		12.8

Appendix 3-1b: Seawater temperatures (°C), measured within the INFLUENT stream of cooling water of Diablo Canyon Power Plant in 1985 and 1986. Data from the "Discharger Self-Monitoring Report" as submitted to the CCRWQCB.

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985												
01	13.3	12.8	12.2	11.1	10.6	10.8	12.2	12.5	12.8	14.1	12.6	13.3
02	15.0	12.8	11.1	10.6	10.6	10.8	12.8	12.2	12.8	14.2	12.9	13.5
03	13.9	12.8	10.6	10.6	10.0	10.8	12.2	12.8	12.8	14.7	13.3	13.8
04	13.9	12.2	11.7	11.1	10.0	10.6		12.2	13.3	15.8	13.4	13.8
05	12.2	12.2	11.7	11.7	10.0	10.3		12.5	13.9	15.3	13.4	13.9
06	12.8	12.2	12.2	11.7	10.0	10.0		12.2	14.2	15.1	13.2	13.7
07	13.3	12.8	11.7	11.1	11.1	10.6		12.8	14.2	14.6	13.7	13.4
08	13.3	12.8	11.7	12.8	11.1	10.6	12.2	13.1	14.4	13.4	13.9	13.0
09	13.3	12.8	11.7		10.6	10.8	12.2	13.3	14.7	13.4	13.9	12.8
10	13.3	12.2	12.2		10.6	11.4	13.3	14.2	14.7	13.9	13.8	13.1
11	13.3	12.8	12.2		11.1	12.2	13.3	13.9	14.2	14.2	14.3	12.8
12	13.3	12.8	11.1		10.6	12.2	12.8	14.4	13.6	14.3	14.3	12.9
13	13.3	11.7	11.7		10.0	12.2	11.7	14.4	13.6	12.8	14.5	13.1
14	13.3	12.2	11.7		11.1	12.5	12.2	14.2	12.8	12.6	14.4	13.1
15	13.3	12.2	11.7		11.1	13.6	12.2	14.2	12.2	12.4	14.1	13.0
16	13.3	11.7	12.2		12.2	13.9	12.8	13.6	12.5	12.9	13.7	12.8
17	13.9	11.7	12.2		11.7	13.9	12.8	13.6	13.1	12.4	12.7	12.8
18	13.3	12.2	12.2	11.7	11.1	13.3	12.8	13.6	13.6	12.7	12.1	12.8
19	13.3	11.7	11.1	11.1	10.6	12.8	13.3	13.6	14.2	12.5	11.6	12.8
20	13.3	12.8	10.6	10.6	10.0	13.6	13.3	13.1	13.6	12.7	11.6	12.8
21	13.3	11.7	10.6	11.7	10.0	14.4	12.2	13.6	13.3	13.7	11.5	12.8
22	13.3	11.1	10.6	11.7	10.0	14.2	12.2	13.6	13.1	13.1	11.8	13.3
23	13.3	12.8	10.0	11.1	10.0	13.3	12.2	13.1	13.3	12.8	12.1	13.3
24	13.3	12.2	10.0	10.6	10.0	13.3	12.2	13.1	13.3	12.7	12.3	13.3
25	13.3	12.2	10.0	9.4	10.0	13.1	13.3	11.9	15.0	12.3	12.2	13.3
26	13.3	12.2	10.0	8.9	11.1	13.1	13.9	11.7	15.0	11.9	12.9	13.3
27	13.3	12.8	10.6	8.9	11.1	12.8	13.3	12.8	15.0	12.7	12.9	13.5
28	13.3	12.2	10.6	8.3	10.6	12.8	13.3	12.8	13.6	13.3	13.2	13.8
29	13.3		10.0	10.0	10.6	13.1	12.8	13.1	13.9	12.9	13.4	13.9
30	12.8		10.6	9.4	10.0	12.5	12.2	13.1	14.2	12.9	13.7	13.9
31	12.8		10.6		10.0		11.7	13.1		13.1		14.0
1986												
01	13.9	13.9	13.6	11.4	11.4	10.6	11.4	12.5	12.2	11.9	13.3	14.7
02	14.1	14.4	13.3	11.4	11.4	10.8	11.7	11.9	12.2	12.5	13.3	14.4
03	14.1	14.4	13.1	11.1	11.4	11.1	11.7	11.7	12.8	12.8	13.9	14.4
04	14.2	13.6	13.3	11.7	11.4	10.8	11.9	11.7	12.2	12.8	13.9	15.0
05	14.1	13.3	13.3	11.7	10.6	11.1	12.5	11.9	12.2	12.8	13.9	15.8
06	14.2	12.8	12.8	12.2	10.0	11.4	13.1	11.9	11.9	12.8	14.2	15.8
07	14.1	12.8	13.1	12.5	10.6	11.4	12.5	12.2	11.9	13.3	13.9	15.3
08	14.2	12.8	13.6	12.8	10.6	10.6	11.9	11.7	11.9	13.3	13.6	15.6
09	14.2	12.8	13.3	12.2	10.6	11.1	12.5	11.1	11.9	13.9	12.8	15.6
10	14.2	12.8	13.9	11.9	10.6	12.2	12.5	11.1	11.9	13.9	13.3	15.6
11	14.2	12.8	13.9	12.8	10.6	11.9	12.8	11.1	12.2	14.2	13.6	15.6
12	14.2	12.8	13.3	12.2	10.0	12.5	13.9	11.7	12.5	14.7	13.6	15.6
13	14.2	13.3	13.1	11.4	11.1	11.9	13.9	11.9	12.5	15.0	13.9	15.8
14	14.2	13.3	13.1	12.2	11.4	11.9	13.9	11.9	12.8	15.0	13.9	15.6
15	14.2	13.6	12.2	12.5	10.8	11.4	13.6	12.2	12.8	15.3	13.9	15.6
16	13.9	13.6	13.1	12.2	10.3	11.7	13.1	12.8	12.8	14.7	14.4	15.8
17	13.7	13.6	12.8	11.7	11.7	11.9	12.5	12.2	12.8	14.2	14.7	15.8
18	13.4	13.3	11.7	10.8	11.4	11.7	12.5	12.2	12.5	13.1	14.7	15.6
19	13.7	13.6	12.5	11.7	11.1	10.6	11.9	13.1	11.9	12.8	15.0	15.8
20	13.2	13.3	12.2	11.7	10.6	10.3	11.1	11.9	11.7	12.8	15.0	15.6
21	13.1	13.3	11.4	11.4	10.3	10.6	12.2	11.7	11.9	13.1	14.4	15.6
22	13.2	12.8	11.7	11.4	10.0	11.7	13.3	11.7	11.9	13.6		15.6
23	13.5	12.8	11.7	11.7	10.6	12.5	13.3	11.4	12.5	13.6		15.6
24	12.8	12.8	12.2	11.4	10.6	12.5	13.3	11.9	12.8	13.9		15.3
25	12.9	12.8	11.9	10.6	10.3	12.8	13.6	12.2	13.1	14.2	13.3	15.0
26	13.0	12.8	12.2	10.6	10.6	11.9	13.3	12.2	13.3	13.9	13.6	15.0
27	13.3	13.3	12.5	10.6	10.6	11.7	13.1	12.5	13.1	13.9	14.7	14.7
28	13.4	13.6	12.8	10.6	10.8	11.4	12.8	12.5	12.8	13.9	14.7	14.7
29	13.3		12.8	10.6	11.1	10.8	12.2	11.9	12.2	14.2	14.2	14.7
30	13.3		12.8	10.6	11.7	11.1	12.5	11.9	11.9	13.6	14.2	14.4
31	13.3		12.2		11.1		12.8	12.2		12.8		14.4

Appendix 3-1c: Seawater temperatures (°C), measured within the INFLUENT stream of cooling water of Diablo Canyon Power Plant in 1987. Data from the "Discharger Self-Monitoring Report" as submitted to the CCRWQCB.

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987												
01	14.2	15.6	12.2	12.5	11.6	10.4	12.8	11.9	13.9	14.0	15.7	13.4
02	13.9	12.8	12.5	11.9	11.1	11.8	12.2	12.2	13.6	14.0	14.5	13.9
03	14.2	13.1	13.1	11.6	10.8	12.0	11.6	12.0	13.6	14.2	14.7	14.1
04	14.4	13.1	13.3	11.3	11.1	11.4	11.2	11.8	11.2	14.5	15.0	14.1
05	14.2	13.3	13.3	10.7	11.6	11.2	10.7	11.4	13.8	14.7	15.5	14.3
06	13.6	13.3	13.1	10.5	12.1	11.2	10.9	11.9	14.1	15.6	15.9	14.3
07	13.9	13.3	13.1	10.3	12.7	11.7	11.2	12.7	13.8	15.1	15.9	14.9
08	13.9	13.3	13.1	9.7	13.2	11.3	11.0	13.0	13.6	14.3	15.8	14.7
09	13.9	13.3	12.8	9.7	12.7	10.9	11.4	13.2	13.8	14.3	15.8	14.6
10	13.9	13.6	13.1	10.2	12.2	11.0	12.0	13.3	13.1	14.4	15.8	14.1
11	14.2	13.6	13.3	10.1	12.2	11.5	12.4	13.3	12.3	15.1	16.0	14.1
12	14.2	13.9	13.6	9.8	12.6	11.7	12.6	13.6	12.4	14.8	15.7	13.4
13	13.3	14.2	13.6	10.2	13.1	12.2	12.0	13.5	13.4	14.0	15.6	12.6
14	12.5	13.9	12.8	10.7	14.3	12.6	12.3	13.3	13.7	14.0	14.1	12.9
15	12.2	13.9	12.2	10.8	14.2	13.2	12.7	13.3	13.7	14.2	13.9	13.2
16	11.7	13.3	11.4	11.1	13.3	12.2	13.4	13.1	13.8	14.7	13.7	12.9
17	12.5	13.3	11.9	10.9	12.9	11.0	12.4	12.9	14.1	15.0	13.8	13.4
18	13.1	12.8	10.3	10.6	12.8	10.6	12.4	13.1	13.8	15.2	14.6	13.9
19	13.1	12.5	9.7	10.2	13.2	10.6	12.2	12.9	13.7	15.2	14.6	13.9
20	13.1	12.8	9.8	10.6	13.7	10.7	12.5	13.1	13.9	15.3	14.7	13.9
21	13.3	12.5	10.1	10.9	13.9	10.7	13.1	13.4	14.7	15.8	14.4	13.9
22	13.1	12.2	9.7	11.2	13.1	10.6	13.0	13.8	15.2	16.6	13.7	13.9
23	13.1	11.9	9.7	11.5	11.9	10.4	12.1	13.5	15.1	16.6	13.4	13.8
24	12.5	11.7	9.6	11.1	11.4	11.1	11.7	13.0	14.4	16.5	13.6	13.5
25	12.5	11.7	9.8	11.4	10.9	12.2	11.8	13.3	13.4	16.7	13.2	13.3
26	12.5	11.7	10.0	11.8	10.6	12.2	11.4	13.8	13.7	16.7	13.2	13.4
27	12.2	11.9	9.7	11.6	10.7	11.8	11.8	13.8	14.8	16.8	13.2	13.4
28	12.2	11.9	10.3	11.6	10.3	11.7	11.8	13.7	14.9	16.7	13.3	13.4
29	12.2		11.0	12.0	10.2	12.8	11.5	13.7	14.8	16.2	13.3	13.4
30	12.2		11.8	12.4	9.9	13.2	10.8	13.9	14.3	16.1	13.3	13.3
31	11.9		12.2		10.2		10.9	14.1		16.1		13.3

Appendix 3-2a: Seawater temperatures (°C), measured within the EFFLUENT stream of cooling water of Diablo Canyon Power Plant in 1983 and 1984. Data from the "Discharger Self-Monitoring Report" as submitted to the CCRWQCB.

						Month						
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983												
01					15.0	13.3	15.0	15.0	16.7	18.3	17.8	15.0
02					13.9	13.3	14.4	15.0	15.6	18.3	17.8	15.6
03					12.2	13.3	15.0	17.2	15.6	18.3	17.8	15.0
04					12.2	13.3	15.0	15.0	15.6	17.2	17.8	15.0
05					12.2	13.9	16.1	16.7	16.7	17.2	17.2	15.0
06					12.2	13.3	15.6	15.0	15.0	17.2	17.2	17.8
07					12.2	13.3	15.6	16.1	15.0	17.2	17.2	14.4
08					12.2	14.4	15.6	15.0	15.0	17.8	17.2	19.4
09					13.3	14.4	16.1	16.1	15.0	17.8	17.2	14.4
10					13.9	14.4	16.1	20.0	15.0	17.8	16.7	14.4
11					13.9	13.3	16.1	16.1	15.0	16.7	17.2	14.4
12					13.9	13.3	12.8	16.7	15.0	16.1	17.2	14.4
13					15.0	13.3	15.6	16.7	16.7	18.3	17.2	15.0
14					13.9	13.9	15.6	16.7	19.4	20.6	17.2	12.2
15					13.9	13.9	16.7	19.4	16.7	20.6	17.8	14.4
16					13.9	13.9	16.1	17.8	16.7	20.6	17.8	12.8
17					12.8	13.9	16.7	18.9	16.7	16.7	20.0	13.9
18					13.3	13.9		17.2	17.8	16.7	17.8	14.4
19					13.9	13.9		17.2	16.7	15.6	16.1	13.9
20					13.9	14.4		17.8	18.9	15.6	16.1	14.4
21					13.3	15.0	15.6	17.2	18.3	13.9	16.7	15.6
22					13.3	15.6	14.4	17.8	18.3	18.3	15.6	13.9
23					13.3	15.0	15.6	16.7	18.9	13.9	14.4	19.4
24					13.3	15.0	15.0	16.1	18.3	13.9	14.4	13.9
25					13.3	15.0	15.0	16.1	18.3	18.3	14.4	
26					13.3	14.4	14.4	16.1	18.3	17.2	14.4	15.0
27					13.3	15.6	14.4	16.1	12.8	18.3	14.4	14.4
28					13.3	15.0	15.0	16.1	12.8	18.3	14.4	13.9
29					13.3	15.0	15.6	16.1	12.8	15.6	16.1	14.4
30					13.3	15.0	15.0	16.1	12.8	17.8	16.1	14.4
31					13.3		14.4	16.1		15.6		14.4
1984												
01	14.4	20.6	17.8	12.8	11.1	15.6	14.4	13.9	11.7	16.1	14.4	17.2
02	14.4	19.4	15.6	11.7	11.7	13.3	13.9	12.8	14.4	14.4	12.8	17.2
3	14.4	22.2	15.6	15.6	11.1	13.3	13.9	12.8	13.9	12.8	13.3	17.2
04	14.4	21.1	15.0	11.7	11.1	12.2	13.9	12.8	14.4	14.4	12.8	15.6
05	14.4	21.1	13.9	13.9	11.1	10.6	13.9	13.9	13.9	15.0	13.3	13.3
06	15.6	21.7	13.9	13.9	10.6	14.4	13.9	14.4	13.3	15.0	13.3	13.9
07	15.0	17.2	14.4	12.2	13.3	13.9	13.9	15.6	13.3	15.0	12.8	13.9
08	16.1	16.7	13.3	12.2	11.7	13.9	13.9	14.4	15.6	15.0	12.8	14.4
09	15.0	16.7	14.4	12.2	11.7	13.3	13.9	13.9	16.1	16.7	12.8	17.8
10	14.4	16.7	12.8	13.3	11.7	12.8	13.3	14.4	16.1	13.9	15.0	14.4
11	13.9	15.6	12.8	12.2	11.7	13.3	11.7	14.4	15.6	15.0	17.2	13.9
12	13.9	15.6	13.9	12.2	11.1	13.3	11.7	16.1	15.0	14.4	21.7	15.0
13	13.9	15.6	12.2	12.2	11.7	12.8	15.0	16.7	15.0	13.9	14.4	14.4
14	14.4	12.8	13.9	12.2	11.7	12.8	15.6	17.2	15.0	12.8	13.9	14.4
15	13.9	12.8	15.0	12.8	12.8	13.3	15.6	17.2	15.0	13.9	13.9	18.3
16	13.9	12.8	13.3	12.2	12.8	13.3	15.6	16.7	15.0	13.9	13.9	17.8
17	13.9	11.7	13.3	12.2	12.8	12.2	13.9	16.1	15.6	13.3	13.3	16.7
18	13.9	12.8	13.9	12.8	12.2	13.3	15.6	16.7	16.1	13.3	13.3	17.2
19	14.4	12.8	15.0	13.3	12.2	11.7	18.3	16.1	16.1	13.3	13.3	17.2
20	13.9		13.3	13.3	12.2	11.7	18.9	16.1	14.4	13.3	16.7	18.3
21	13.9	13.9	14.4		12.8	12.2	18.3	16.7	16.7	14.4	16.1	19.4
22	13.3	11.7	13.9	11.7	12.2	12.8	18.3	16.1	16.7	13.3	17.8	18.9
23	13.3		13.3	13.9	13.9	13.3	18.3	16.1	17.2	11.7	17.8	19.4
24	13.3	11.1	13.3	11.7	12.8	13.3	15.6	16.1	17.8	16.1	17.2	18.9
25	18.3	13.9	13.3	12.8	12.8	13.3	14.4	15.6	15.6	12.2	17.2	18.9
26	20.0	11.1	13.3	14.4	10.6	12.8	14.4	15.6	15.6	15.0	17.2	21.1
27	13.3		12.8	11.1	11.7	12.8	15.0	15.6	16.7	11.7	17.2	19.4
28	13.3	15.6	13.9		15.0	12.8	14.4	15.0	18.3	12.8	15.0	18.9
29	21.7	15.6	13.9	12.8	15.6	12.2	14.4	14.4	16.7	11.7	13.9	18.9
30	13.3		13.3	12.8	15.6	12.2	13.9	13.9	15.6	15.6	17.2	18.9
31	20.0		12.2		15.6		13.9	12.8		12.2		19.4

Appendix 3-2b: Seawater temperatures (°C), measured within the EFFLUENT stream of cooling water of Diablo Canyon Power Plant in 1985 and 1986. Data from the "Discharger Self-Monitoring Report" as submitted to the CCRWQCB.

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985												
01	18.9	12.8	20.0	13.9	10.6	20.6	22.8	18.1	20.3	24.8	15.1	18.9
02	16.1	12.8	18.9	13.9	11.1	20.3	22.2	18.3	20.3	25.0	17.4	20.7
03	15.0	12.8	18.3	12.8	10.6	20.6	21.7	16.9	20.3	23.5	17.7	17.2
04	17.2	13.3	18.9	12.8	12.8	20.3	20.6	17.5	18.9	23.6	17.6	15.2
05	12.8	13.3	19.4	12.8	13.3	19.4	22.2	19.2	20.3	25.2	17.1	14.7
06	16.1	17.2	17.8	12.8	12.8	20.6	22.8	19.2	21.1	23.7	16.4	14.4
07	13.3	18.3	17.2	12.8	21.1	21.1	22.2	20.0	21.7	25.8	14.9	15.6
08	15.6	12.8	21.1	12.8	21.1	20.6	22.8	20.3	21.9	21.1	14.5	15.2
09	15.6	16.1	21.1		20.6	20.3	22.2	20.6	22.8	21.4	14.8	17.4
10	15.6	20.0	21.7		20.6	20.6	23.9	21.7	24.4	21.8	16.2	18.2
11	15.6	16.1	23.3		20.6	21.9	23.9	20.8	24.4	21.8	19.4	18.7
12	15.6	20.0	22.2		20.0	21.7	23.3	20.8	23.9	20.7	19.4	20.9
13	15.6	12.8	21.7		20.6	21.9	20.6	22.2	23.9	20.7	20.4	21.1
14	15.6	13.9	21.7		21.1	22.2	20.6	21.9	23.3	20.8	20.9	19.4
15	13.9	17.2	18.3		21.1	23.3	22.8	21.9	22.5	20.2	19.9	20.1
16	13.9	16.7	22.8		21.7	24.2	23.3	21.4	22.8	20.9	20.7	21.4
17	14.4	12.2	22.8		21.7	24.2	23.3	21.4	23.6	20.4	21.6	21.3
18	13.3	12.2	22.2	11.7	20.0	23.1	23.3	21.4	23.9	20.4	20.5	22.4
19	13.9	11.7	22.2	11.1	20.0	22.8	23.9	21.7	24.7	20.6	18.3	22.1
20	13.3	12.8	16.7	10.6	20.6	23.3	23.3	20.8	24.4	20.2	18.7	21.6
21	13.3	11.7	11.7	11.7	20.6	24.2	22.8	21.4	23.9	20.3	18.9	21.7
22	13.9	11.1	13.9	11.7	20.0	23.6	22.2	21.7	23.3	19.7	20.5	19.4
23	13.3	12.8	18.9	11.1	20.0	23.1	22.2	20.8	23.9	19.8	20.6	22.4
24	13.3	13.3	19.4	10.6	20.6	23.1	22.2	18.1	23.6	21.2	20.2	21.1
25	13.3	13.3	19.4	10.0	19.4	22.8	23.9	17.5	25.3	16.2	19.7	19.8
26	13.3	16.1	19.4	9.4	21.1	22.5	23.3	19.4	25.0	15.8	20.8	22.3
27	13.3	20.6	20.6	10.0	21.1	22.5	23.3	13.9	25.6	19.6	19.3	22.6
28	13.3	20.0	12.2	10.0	20.0	22.5	23.3	16.9	24.4	20.6	18.8	22.7
29	13.3		12.8	10.0	20.6	22.5	22.2	20.0	24.4	19.2	19.1	21.0
30	12.8		12.8	10.0	20.0	21.4	23.3	20.6	24.7	19.0	18.2	22.2
31	12.8		13.9		20.0		22.8	19.4		19.7		21.7
1986												
01	21.1	24.4	23.1	20.3	21.4	21.1	21.7	20.3	22.8	21.7	24.2	20.8
02	20.9	23.3	23.1	20.6	21.9	20.8	21.7	21.4	23.3	22.2	24.2	21.1
03	20.7	24.4	22.5	20.6	21.4	21.7	21.7	21.4	23.3	22.8	24.7	21.4
04	21.8	24.4	22.5	20.8	20.8	21.1	20.6	21.4	23.1	23.6	25.0	21.1
05	24.2	23.9	22.8	20.6	20.6	21.1	21.7	21.4	22.2	22.8	25.0	21.9
06	24.1	23.3	21.1	21.4	18.9	21.4	22.8	21.9	22.5	23.1	25.3	20.3
07	23.3	23.3	20.0	21.4	20.3	20.8	22.2	21.9	23.1	22.2	24.4	22.2
08	22.0	23.3	21.4	21.4	20.6	21.7	21.1	21.7	23.3	21.9	24.4	22.5
09	20.6	21.1	21.9	20.6	20.6	21.7	21.7	21.1	22.5	22.5	23.1	22.5
10	22.8	20.8	22.2	18.1	20.6	22.2	21.1	22.5	23.1	22.5	23.6	22.5
11	23.2	20.8	22.8	20.0	20.6	22.2	21.1	21.1	23.1	24.4	23.9	22.5
12	23.3	20.8	21.1	20.8	20.3	21.9	22.8	21.4	23.6	25.0	23.3	22.2
13	23.8	21.9	21.9	19.7	21.4	21.9	22.2	21.7	23.9	25.3	24.3	21.9
14	23.1	21.4	20.0	20.3	21.4	21.9	22.8	22.2	23.3	25.6	23.6	21.1
15	20.8	21.4	16.1	21.1	20.8	20.8	21.1	22.2	22.5	25.3	23.3	21.1
16	23.5	20.3	16.4	21.1	20.3	21.4	22.2	21.9	23.6	24.7	23.6	21.4
17	23.6	21.7	18.9	20.6	21.1	21.7	21.7	21.4	22.2	24.2	24.4	21.4
18	23.3	23.1	21.4	20.0	21.4	21.7	21.7	21.7	18.9	23.1	24.7	21.4
19	23.3	23.1	21.9	21.1	20.8	20.6	21.1	22.8	14.4	22.5	24.4	21.4
20	23.3	21.9	22.2	21.4	20.3	20.8	20.6	21.7	14.4	23.1	24.4	21.4
21	23.3	20.6	21.9	20.8	20.0	20.6	21.7	21.1	18.3	23.6	23.9	20.6
22	23.6	21.4	22.2	20.8	19.4	21.9	22.2	21.1	21.9	24.2		20.8
23	23.7	18.9	22.2	20.8	19.7	22.5	22.8	20.8	22.5	24.2		21.1
24	23.2	21.7	21.9	20.6	20.3	22.8	22.8	20.8	22.5	24.4		20.8
25	23.5	20.3	21.7	19.4	20.0	23.1	22.8	21.4	23.3	25.0	21.7	20.6
26	23.6	21.4	22.2	19.4	19.7	22.2	22.2	21.7	23.3	24.7	22.2	20.3
27	23.9	21.7	20.6	19.4	19.4	21.1	21.7	21.9	21.9	25.0	23.3	20.3
28	24.0	21.9	20.8	20.0	19.2	20.6	21.7	21.9	23.1	25.0	23.3	20.0
29	23.9		20.8	19.2	20.3	20.3	21.1	20.6	22.5	25.0	22.8	20.3
30	23.9		21.7	19.7	21.1	21.1	21.4	21.7	22.2	24.7	22.5	20.6
31	23.9		18.1		21.7		21.1	21.7		23.9		20.6

Appendix 3-2c: Seawater temperatures (°C), measured within the EFFLUENT stream of cooling water of Diablo Canyon Power Plant in 1987. Data from the "Discharger Self-Monitoring Report" as submitted to the CCRWQCB.

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987												
01	21.9	23.1	18.6	22.9	21.0	20.8	18.5	21.6	23.9	23.6	22.7	22.7
02	20.3	23.1	19.4	22.6	20.7	21.8	17.9	21.9	22.7	23.6	22.8	22.6
03	21.1	23.3	19.7	21.1	20.6	22.1	17.3	22.2	22.0	23.9	24.1	24.8
04	20.8	23.3	20.0	22.1	21.2	21.4	16.6	21.9	21.8	24.9	24.3	23.7
05	21.7	23.6	19.7	20.8	21.7	21.1	16.2	21.7	20.3	23.7	24.8	24.2
06	20.3	23.6	19.2	19.2	21.6	21.1	16.3	21.9	21.9	25.3	25.3	23.3
07	21.9	23.1	22.1	19.4	21.4	21.0	16.6	22.2	22.1	24.7	24.7	23.7
08	20.3	23.3	22.5	19.9	22.0	21.1	16.1	21.6	23.0	24.4	23.3	22.3
09	21.9	23.6	22.8	20.1	20.2	20.6	16.8	20.9	22.6	23.9	23.2	25.0
10	22.8	23.9	22.5	19.9	20.4	20.7	17.3	21.7	21.2	24.1	21.6	23.8
11	22.5	23.9	23.3	18.8	16.2	21.3	17.8	22.8	21.4	24.2	22.7	23.7
12	22.5	24.2	23.6	19.2	15.2	21.5	18.1	23.6	21.4	24.4	22.3	22.4
13	21.4	24.4	23.3	19.3	15.6	19.4	17.9	23.7	22.3	24.2	21.9	17.9
14	20.8	24.2	22.5	20.1	20.3	19.7	17.8	23.3	22.5	23.6	22.2	17.6
15	20.6	24.2	21.4	20.4	22.8	20.4	18.9	22.7	22.4	23.7	23.3	17.3
16	20.0	23.1	17.5	20.5	22.3	19.3	18.9	22.6	22.5	23.8	23.4	16.6
17	21.9	22.5	19.7	20.3	22.0	16.9	18.1	22.6	22.8	23.9	23.6	15.8
18	22.5	18.1	21.4	20.2	22.0	16.2	18.2	22.4	22.9	24.9	24.3	16.0
19	21.4	17.2	21.2	19.9	22.2	16.2	18.9	22.9	22.6	24.9	24.2	16.6
20	20.8	17.5	21.3	20.8	22.6	16.0	20.1	23.2	22.9	24.3	24.1	18.9
21	21.4	17.2	18.4	19.8	22.7	16.0	20.6	23.6	23.3	24.9	23.6	21.1
22	21.1	15.6	16.9	21.5	21.6	15.9	20.6	23.9	24.1	25.5	22.2	21.2
23	21.1	17.5	16.7	21.6	21.3	15.9	19.8	23.7	23.9	25.8	22.4	20.9
24	21.1	17.8	16.6	21.1	20.7	16.6	19.5	23.3	23.4	26.1	22.1	20.7
25	20.6	19.7	16.5	21.4	19.9	17.6	18.4	23.2	21.6	26.2	21.2	20.6
26	20.8	20.8	21.1	21.6	20.2	17.4	20.3	23.3	21.3	26.3	22.2	20.7
27	21.1	21.7	21.3	21.2	21.2	17.0	20.8	23.8	23.4	26.3	22.2	21.1
28	21.4	21.4	21.3	20.8	20.5	17.0	21.1	23.7	23.5	26.4	22.3	20.3
29	21.4		21.3	21.0	20.2	18.1	21.2	23.6	24.2	26.2	22.2	20.2
30	21.7		22.0	21.5	20.0	18.4	20.4	23.9	23.6	25.3	22.3	20.4
31	22.8		22.6		20.1		20.8	24.1		24.8		19.1

Chapter 4

EXPERIMENTAL DESIGN

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Tables

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INTRODUCTORY PERSPECTIVE

We have noted above that the nearshore environment at Diablo Cove is extremely heterogeneous and the intertidal and subtidal support a luxuriant and diverse biota. Our task involved characterizing these complex biotic assemblages in sufficient detail to allow clear definition of any changes that might be associated with discharged effluent from DCPP during operational years. Identifying components of the various communities at any point in time was straightforward, but defining their "normal status" was frequently difficult. Abundances and distributions often changed radically and unpredictably. Quoting from the TERA (1982) report: "In order to detect numerical population changes attributable to the DCPP discharge, or any other effect, it is necessary to measure and define the natural population changes and separate them from the total changes observed". The strategy adopted by the TEMP group involved intensive sampling at fixed stations with the objective of building up a large data base to define background conditions adequately. Our intertidal studies followed the same general strategy.

The effort mounted by our survey team was modest compared to that of the TEMP group and it was not feasible for us to accumulate a large data base at numerous stations. We initially studied only three intertidal and three subtidal locations at a rather low frequency. Work at the intertidal sites involved annual quantitative estimates of abundances. At the subtidal stations, we simply tallied species present. We increased frequencies of our intertidal visits in 1977 and added a fourth station in 1982. We also subdivided our subtidal transects in latter 1982 into five subsections for thrice yearly quantitative sampling of Phaeophyta. Prior to December 1982, all our subtidal studies were qualitative and conducted annually.

We increased the effort devoted to qualitative observations as the time drew near for commencement of operations by Unit I. We initiated shorewalks around the periphery of Diablo Cove in December 1982. We began comparable traverses ("swimthroughs") subtidally, following the 3 m (10 ft) depth contours in May 1985, just as Unit I began commercial power generation.

The purpose of the shorewalks and swimthroughs was to increase the size of the territories studied by us. The areas covered by our quantitative studies were minuscule compared to the total intertidal and subtidal areas receiving exposure to plume waters. It was important to expand our coverage to determine how representative our findings from the intensively-sampled stations might be in relation to the remainder of Diablo Cove. We also wanted to establish the limits to which ecological effects from plume exposure might extend. Our quantitative work provided clues as to what effects we should look for elsewhere. The shorewalks and swimthroughs applied this information in a generalized way to other parts of the Cove.

SELECTION OF STATION LOCATIONS

We selected our permanent intertidal stations (see Figure 5-1) at a time when there was controversy regarding the distance to which ecological effects from the DCPP effluent might extend. Special concern existed as to whether effects might be felt beyond the confines of Diablo Cove. We therefore selected two locations near the Cove extremities. The sites would presumably signal whether effects were apparent in these farthest-away positions. If effects were found, they would tell us what indications and symptoms to seek at even greater distances.

We did not locate the two stations precisely at the extreme ends of the Cove because these outermost limits are steep wave-swept headlands where work could be accomplished only during calm seas. We therefore chose study sites at short distances inside the headlands, where shore slopes were fairly gentle and nearby topography furnished some protection from pounding surf. Both locations consisted of similar boulder-cobble habitat. We established transects perpendicular to the shoreline more or less along the highest region of the boulder-cobble patches at both sites. Our objective was to select similar habitats to facilitate inter-transect comparisons. The transects were named North Diablo Intertidal Transect (NDIX) and South Diablo Intertidal Transect (SDIX).

We also established a control intertidal transect at a site about 1.2 km (0.75 mi) northwest from Diablo Canyon. The site was the only nearby location with reasonably safe access down the steep terrain to the shoreline. A major headland to the north and offshore islands (Lion Rock and Pup Rock) offered protection from swell. The site was also being used as a control area by CDF&G investigators R. Burge and S. Schultz. Substrate here was primarily exposed bedrock with very large boulders in the upper intertidal. The habitat thus differed moderately from NDIX and SDIX and the slope was slightly steeper. The rocky terrain was nonetheless highly irregular and we established our control transect here in spite of the differences compared to Diablo Cove. Taking all factors into consideration, the spot seemed to be the best available. We labeled the location Lionrock Control Intertidal Transect (LCIX). LCIX was situated on a minor rocky point and the transect line ran more or less perpendicular to the general trend of the shoreline here, although it intersected the waterline at an oblique angle because of the point. The point was a rocky ridge extending seaward about 50 m (165 ft). The outer terminus of LCIX was a vertical 1 to 2 m (3 to 6 ft) drop down to the sea surface, not a sloping gradient as at NDIX and SDIX,.

At the time we selected our intertidal stations, the hydraulic model predicted that the DCPP plume would exit through the southwest channel of Diablo Cove. It was anticipated that an eddy would form on the left side (looking downstream), diverting some heat into the southern part of the Cove. Little, if any, warming was predicted for the north part of the Cove. We thus presumed that of our three transects, SDIX would receive the greatest exposure, NDIX little if any exposure, and LCIX none.

The hydraulic model in its intermediate stages predicted that the extreme north part of Diablo Cove would experience no heat whatsoever. It appeared that NDIX would be a control station similar to LCIX. We thus elected in latter 1982 to cut back on our sampling at LCIX to once per year and establish a fourth intertidal transect close by the discharge within Diablo Cove. The fourth transect was named Central Diablo Intertidal Transect (CDIX). CDIX was situated just north of Diablo Creek where the nearest bedrock-boulder-cobble habitat to the discharge structure occurred. We anticipated that CDIX and SDIX would receive similar exposures to plume waters while NDIX and LCIX would receive none.

The hydraulic model also predicted that the plume would separate or lift off from the bottom at about 5 m (17 ft) depths. Any subtidal transects would thus need to extend into shallow water to obtain information on plume-related effects. We needed to know if any such effects developed and we also wished to determine correctness of the model prediction as to lift-off depth.

Our primary subtidal transect was 100 m (330 ft) long, extending more or less beneath the predicted plume path from depths of 3 m (10 ft) to 8 m (26 ft) in the central part of Diablo Cove (see Figure 5-1). The line was named Diablo Cove Subtidal Transect (DCSX). We did not attempt to study bottoms shallower than 3 m here because of strong water movements from wave surge and the jet stream formed by the plume. The bottom sloped gently downward for the inshore 65 m (215 ft) of DCSX and water depth increased from 3 m to 5 m (10 to 17 ft) along this part of the line. We thus expected that most of the inshore 65 m of the transect would receive maximal exposure to plume waters. A small cliff occurred at about 65 m (215 ft) and water depth increased abruptly to 8 m (26 ft). The last 30 m (100 ft) of the line should thus receive little or no exposure to the plume. This transect was thus located to provide information on possible ecological effects along the inshore region and define the lift-off depth farther out, perhaps near the cliff at 65 m (215 ft).

Within the subtidal, only the inshore region along DCSX would receive exposure to plume waters if the hydraulic model was correct, except possibly for the tops of wash rocks or other shoal areas situated in or near the southwest channel. We speculated that possibly wisps from the plume would reach the landward side of Diablo Rock. We thus established a second transect extending from the central shoreward-facing part of Diablo Rock to test whether ecological effects would indeed be confined within the Cove. The transect began at the water's edge at a place where the face of Diablo Rock drops almost vertically to a depth of about 6 m (20 ft). Thus the first part of the transect lay on a steep gradient. The final 18 m (60 ft) of the transect extended shoreward, following the 7 m (23 ft) depth contour. The bottom here sloped downward from north to south. Consequently this shoreward part of the line ran horizontally along a moderately steep slope. We named the line Diablo Rock Subtidal Transect (DRSX). As for DCSX, a part of DRSX lay in shallow water and the rest was in deeper water where no plume-related effects were anticipated.

Our control subtidal transect was similar to DRSX in that it was positioned on the landward side of a small islet, directly offshore from our intertidal control, LCIX. We named the subtidal control Lion Rock Subtidal Transect (LRSX) because the islet had no name at the time we established this station (the islet was subsequently designated as Pup Rock). A small flat terrace about 3 m (10 ft) deep extended out from the shoreline at Pup Rock for a distance of 5 to 10 m (17 to 33 ft). A cliff occurred at this point, dropping vertically to about 8 m (26 ft) depths. The transect ran down the side of the cliff, then horizontally another 15 m (50 ft) toward shore. Wave surge was usually so strong that routine survey work was difficult or impossible at 3 m (10 ft) depths up on the terrace.

As for the intertidal stations, we anticipated that one subtidal transect, DCSX, would receive maximal exposure to plume waters, one line, DRSX, would receive little or no exposure, and the control, LRSX, would receive no exposure. Most of the rocky bottom at the subtidal stations was dominated by urchins at the time we established the transects in 1969. Urchins all but vanished after otter reappeared in the region in the mid-1970s. Eventually our subtidal transects supported dense populations of two palm kelp species (*Laminaria dentigera* and *Pterygophora californica*). The kelp populations appeared to be very stable and it seemed likely that they might be affected by the thermal discharge because both palm kelps were cold water species. We therefore began measuring their abundances in latter 1982, extending the study to other kelp species in 1983. We sampled these Phaeophyta in shallow and deep water at the DCSX transect (both at the inshore and offshore ends of the line), at DRSX (a shallow spot north and a deep spot south of the line) and in deep water only at LRSX (along the outer horizontal part of the transect).

A dense population of palm kelps occurred at 3 m (10 ft) depths on the terrace at the top of LRSX, but the area was too surgy to permit routine sampling of abundances.

SAMPLING RATIONALE

Intertidal Stations

The primary purpose of our quantitative intertidal surveys was to determine what species were consistently present and where they occurred in the intertidal. We were also concerned with other characteristics of the biota, listed below in approximate order of importance:

- Presence-Absence
- Vertical distribution
- Persistence and stability
- Abundance
- Sensitivity to environmental change
- Seasonality
- Relative importance in the community

To define all these characteristics for even one species would obviously involve considerable effort. Assessing all the characteristics carefully for all species was out of the question, given the existing constraints on our time. Our first decision required assigning priorities to the categories listed above and deciding how much effort we could feasibly devote to each.

An elementary calculation will illustrate the magnitude of the problem. To simplify the calculation, let us consider only the task of determining abundances of all species along a single band transect one meter wide, running from the spray zone to the lower intertidal. We will assume that survey work involved laying a one m^2 quadrat successively along the transect until the entire line had been quantified. We further assume there was considerable value in having the various quadrat tallies as synoptic as possible. A given transect should thus be surveyed during a single low tide (i.e., a period lasting three to four hours).

Sampling along an intertidal band transect would involve estimating abundances of plants and animals in from twenty to fifty quadrats during the low tide period. Taking the NDIX transect as an example, the mean number of species per quadrat for all our preoperational surveys from 1975 to 1984 ranged from 14.4 to 27.8 separate values (Table 4-1). The averages showed an increasing trend as time passed.

Table 4-1. Mean values of combined plant plus animal species tallied for various preoperational surveys along the NDIX transect, averaged over all quadrats studied for each survey.

Survey Date	No. of Quadrats	Species/ Quadrat	Survey Date	No. of Quadrats	Species/ Quadrat
Jan 1975	26	14.8	May 1981	28	21.9
Apr 1976	32	18.3	Oct 1981	25	23.0
Feb 1977	27	14.4	Jan 1982	33	25.5
May 1977	33	16.6	Apr 1982	32	27.0
Oct 1977	32	21.0	Sep 1982	25	24.9
Mar 1978	25	17.5	Dec 1982	29	26.4
May 1978	33	18.6	Apr 1983	29	22.7
Oct 1978	27	18.7	Sep 1983	28	21.0
Dec 1978	32	21.0	Dec 1983	32	21.8
May 1979	27	20.9	Dec 1983	32	21.8
Sep 1979	23	19.2	Apr 1984	24	20.8
Dec 1979	28	18.4	Apr 1984	24	20.8
May 1980	23	19.7	Aug 1984	28	27.0
Aug 1980	27	22.5	Dec 1984	29	27.8
Dec 1980	27	17.8			
May 1981	28	21.9			

In addition to species, we also estimated coverages by various substrate types (i.e., sand, gravel, cobble, etc.) in each quadrat. Assuming that an average quadrat required performing 25 estimates of abundance, an entire transect would involve making 500 to 1250 abundance estimates in a period of 180 to 240 minutes. We thus usually needed to average between two and seven estimates per minute in order to complete a transect during a single low tide. While there were several instances when we did not succeed in finishing a transect during a single tide and we returned on another day, the need for a high rate of producing estimates was clear. This requirement limited the techniques we could use to determine abundances. Time-consuming methods such as the random point contact technique were eliminated from consideration. We chose to estimate percent cover by eye for attached and encrusting forms such as seaweeds, barnacles, worm tubes, substrate type, etc. We counted individual animals and some plants (e.g., kelps) where totals did not exceed about ten specimens. We usually estimated totals when numbers exceeded ten except that exact counts were made for important or large species such as abalone, urchins, anemones, and kelps. Estimating percent cover by eye and total numbers above ten by factors of ten obviously reduced accuracies of our estimates. We described certain difficult species simply as "present" (i.e., spirorbids, gammarids, small gastropods) without regard to abundances.

The size of the task, coupled with our time constraints, required that we prioritize our objectives. We believed it was more important to obtain approximations for abundances of all species present rather than determine accurate estimates for a few species. Quoting from Pielou's (1984) extracted citation from Goodall (1980): "in highly heterogeneous communities, 'quantitative measures add little useful information' to that yielded by a simple species list for each quadrat". This is not to say that we would do well to abandon altogether our efforts towards obtaining quantitative data. We merely assigned this task a lower priority than presence/absence determinations although we expected to derive benefits from quantitative abundance estimates. In fact, in another publication, Goodall (1982) acknowledges that "many workers have expressed the view that quantitative measures add appreciably to the useful information about vegetation samples contained in species lists". The magnitude of effort required to collect precise information on species abundances would have limited us to working with only a few species. We opted instead for methods yielding approximate estimates for most species. We also undertook special studies to evaluate quality of our percent cover estimates and accuracy of our abilities to detect presence of species in the quadrats.

We utilized permanently located band transects running perpendicular to shoreline as our basic method for sampling the intertidal. Vertical distributions of organisms along the transect lines were assessed by estimating abundances in quadrats laid successively down the lines. Seasonal and other changes were assessed by repeating the surveys at different times of the year, corresponding generally with the three widely-recognized oceanographic periods in this region (i.e., upwelling, oceanic, and Davidson) as discussed in Chapter 1. We also conducted observations beyond the bounds of the band transects (yearly shorewalks around Diablo Cove) to assess how representative our transects were of general conditions within the Cove.

A third decision involved selection of quadrat size. Guidelines for this kind of decision have been summarized by Whittaker (1982):

> "1. The sample should be large enough in area, or should include counts of a sufficient number of plants, to represent effectively the composition of the plant community.
>
> 2. The sample should be homogeneous - there should be no trend of change in community composition or structure from one edge of the sample to another.
>
> 3. The sample should be efficient. Since considerable numbers of samples may be needed, the samples should be designed to obtain and record rapidly the kinds of information regarded as important.
>
> 4. The sample should be appropriate. Among the many kinds of information that might be gathered on a plant community, some are more interesting or significant, appropriate to the character of the community, and informative in relation to time spent and the purpose of gradient analysis than others."

Whittaker's suggestions also apply to sampling of sessile or slow-moving invertebrates. Obviously all these characteristics cannot be fulfilled optimally for an area as heterogeneous as the Diablo Cove intertidal. Some compromise is necessary. The size range of organisms along our transects ranged from less than one mm for some snails, barnacles, and amphipods, to several meters for the largest plants such as feather-boa kelp. We chose a one m^2 quadrat as constituting an intermediate size that would likely include practically all species in the vicinity of a line. One m^2 was often far too large for estimating abundances of small aggregating animals such as barnacles. For such cases, however, we simply estimated percent coverage or approximate total numbers. A smaller size quadrat would not have sampled adequately many of the large and important plant species. A large quadrat size would have blurred to some extent the vertical zonation patterns.

Subtidal Stations

Subtidal communities of Diablo Cove, like their intertidal counterparts, displayed considerable temporal and spatial variability. During the first ten years of our studies, community variability resulting from grazing by urchins was followed by the ecological disruptions associated with reappearances of otter, all adding to the background variability. We did not attempt any quantitative subtidal work during these early years because of insufficient time available. Instead, we simply tallied species seen along our three subtidal transects during the routine annual surveys.

An apparently stable stand of palm kelps eventually dominated the sea floor in Diablo Cove some two or three years after the otter return. The dense kelp canopies shaded the bottom quite effectively, controlling numbers and kinds of substory plants. It appeared that palm kelp populations could be rather easily evaluated quantitatively since temporal variability appeared to be low. Such studies might be quite relevant to some of our objectives because palm kelps were considered to be cold water species that might be affected by exposure to heated effluent. We commenced quantitative sampling during the annual subtidal survey of 1982 and continued the study up to the end of the program. We soon realized other kelp species were present and could easily be tallied, so we extended the study to include all large Phaeophyta.

Even though we would not be able to use inferential statistics to compare pre-and operational results, we nonetheless employed haphazard sampling (an approximation to a true random sampling design). This would allow use of tests of significance involving the preoperational data only. The palm kelp populations appeared to be quite stable and it seemed worthwhile to establish this presumption if it were true. A valid demonstration of preoperational stability would be useful information if population abundances declined or fluctuated widely during operational years.

We chose a circular quadrat of one m radius (3.14 m^2 area). The quadrat boundaries could be easily delineated within the dense kelp stands by swinging a short rope in a circle around a fixed point. It would have been extremely difficult to use a conventional rigid quadrat, trying to force it down through the kelp canopies and between the nonflexible stipes of *Laminaria* and *Pterygophora*. The 3.14 m^2 size proved satisfactory for estimating palm kelp densities but was too small for adequate determinations of most other Phaeophyta. Our primary interest, however, lay with palm kelps so we did not utilize a second larger size quadrat for other Phaeophyta.

ANALYSES OF QUANTITATIVE DATA

Although our primary interest was concerned with comparing conditions between pre-and operational periods, our data also contained information of purely scientific value (i.e., effects of El Niño and definition of background conditions from our long historical records). Our analyses must necessarily deal with the entire data base, so results will have both theoretical and applied usefulness. Because of the nature of conditions and events (i.e., the fixed location of the powerplant and discharge structure), we were unable to assign "treatments" randomly among our various sampling units. Hurlbert (1984) suggests: "the best one can do in such a situation is develop graphs and tables that clearly show both the approximate mean values and the variability of the data on which they are based". Stewart-Oaten et al. (1986) proposed a technique for overcoming Hurlbert's objections. A long series of sequential sampling is conducted at both control and impacted sites (to include periods before and after an impact has occurred). If both sites displayed similar fluctuations for the beforehand period but differed substantially during the afterward period, one can assess significance of the changed behavior by a BACI analysis (Before-After Control Impact). We therefore used graphs and tables to describe our findings but we also compared our preoperational data for control and "treatment" sites to determine if they were sufficiently similar to allow usage of BACI analyses.

BACI analyses did not seem to be appropriate and our conclusions relied on tables and graphs as suggested by Hurlbert (1984). We were, however, able to provide additional objectivity to conclusions from the quantitative intertidal data by a modified classification analysis. Data from all surveys were segregated according to species, transect, and position along the transect line. Quantitative data for selected species were converted to presence-absence notation. The analyses yielded dendrograms showing affinities among the various surveys. A dendrogram that showed a well-defined grouping of all preoperational surveys which was distinct from the operational surveys would be considered as indicative of demonstrating an effect from DCPP operations. Dendrograms from sites in Diablo Cove were compared to those from the control station. Clustering analyses using quantitative data were conducted for certain species difficult to classify. All available information was utilized to draw final conclusions as to responses by the selected species to operations by DCPP.

The subtidal quantitative data on Phaeophyta abundances suffered from the same difficulties that affected our intertidal data (i.e., inability to assign "treatments" randomly to the sampling units). Our experimental design nonetheless did allow us to test some of the preoperational data for significance of any changes in abundances. We used this information to assess stability of the populations and suitability of the data for BACI analyses. We then compared pre-and operational results by means of tables and graphs.

ANALYSES OF QUALITATIVE DATA

Much of the qualitative intertidal and subtidal data consisted of descriptive information accumulated from our shorewalks and swimthroughs. We have attempted to relate this voluminous material to findings from analyses of the quantitative data (i.e., how representative of the entire Cove were conditions along the transects). Furthermore, the shorewalks and swimthroughs clearly indicated that "special" locations occurred within the Cove, harboring species not found elsewhere. We deemed it important to describe how these atypical locations fared during the operational period.

A large body of qualitative data existed for the subtidal transects in the form of species lists tabulated from the annual surveys. We simply compared presences and absences of the various species throughout the years and noted changes during the operational period. Any changes were considered in the light of general observations while swimming the transects and related to conditions noted elsewhere during our swimthroughs.

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Chapter 5

STATION DESCRIPTIONS

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INTRODUCTION

Our studies in the Diablo Canyon region involved concentrated activities at four intertidal and eight subtidal locations, as well as observational surveys along the shoreline and shallow subtidal. All study areas differed from each other in various ways. We have described the principal characteristics of these sites in the sections below, as an aid to understanding important factors influencing resident biota of the stations. The station array is somewhat complex (Figure 5-1), so we have listed the various stations, their locations, and their purposes, as an organizational aid for

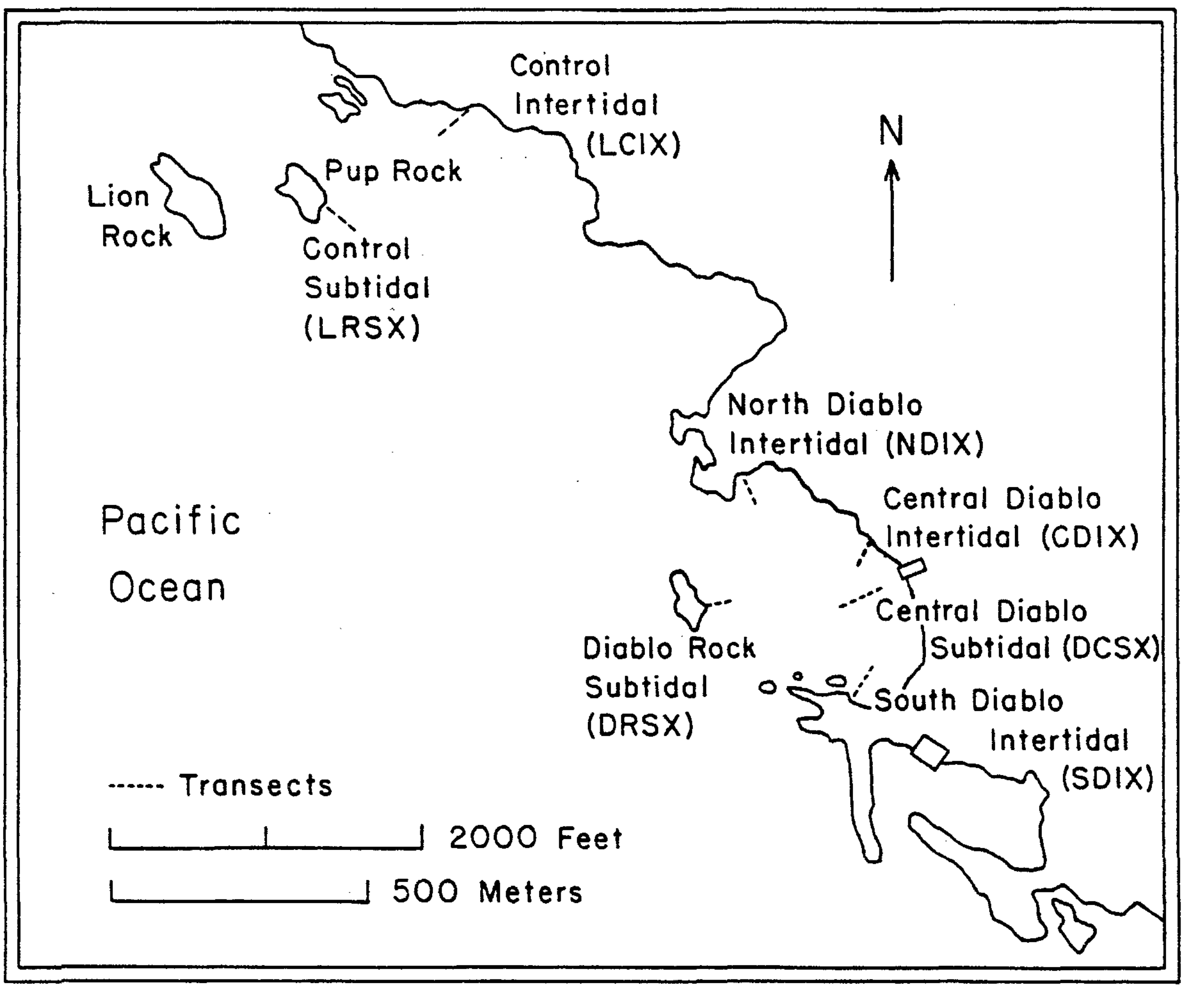


Figure 5-1. Diablo Canyon regional chart, showing transect locations.

the reader (Table 5-1). The "purpose" shown in Table 5-1 presents the original rationale for selecting a given site. In some cases, however, the original purpose may have been changed or partially invalidated as a result of unforeseen events. For example, the great storms during the 1982-83 winter produced disruptions that impacted many of our stations and studies, thereby affecting the underlying design and intent of certain activities. Major disruptions from natural

Table 5-1: Listing of our various transects, sampling sites, and observational areas, grouped according to the type of study involved. We also show the purpose served by each location, to provide insight regarding general design of the project and the overall sampling pattern.

Study Type	Site Identity	Facility Description	Purpose
Permanent Intertidal Quantitative Transects	SDIX	50m length	Assess changes in south Diablo Cove
	SCDIX	40m length	Assess changes in central Diablo Cove just south of discharge structure
	CDIX	40m length	Assess changes in central Diablo Cove, approx. 200m north of discharge structure
	NDIX	30m length	Assess changes in north Diablo Cove
	LCIX	20m length	Control transect, approx. 1km north of discharge
Subtidal Qualitative Transects and Solid Substrate Collections	DCSX	100m length	Assess nearfield changes as a function of depth
	DRSX	30m length	Assess farfield conditions as a function of depth
	LRSX	30m length	Control transect, approx. 1km north of discharge
Subtidal Phaeophyta and Solid Substrate Collections	DCSX3m	600m^2 Area	Assess nearfield kelp abundance changes at shallow depths
	DCSX8m	600m^2 Area	Assess nearfield kelp abundance changes below plume depth
	DRSX3m	600m^2 Area	Assess farfield kelp abundance changes at shallow depths
	DRSX8m	600m^2 Area	Assess farfield kelp abundance changes below plume depth
	LRSX8m	600m^2 Area	Control area assessing kelp abundance changes
Intertidal	Shore-Walk	600m traverse	Assess representativeness of permanent intertidal transects
Subtidal	Swim-through	600m traverse	Assess representativeness of permanent subtidal transect and extent of DCPP operational changes

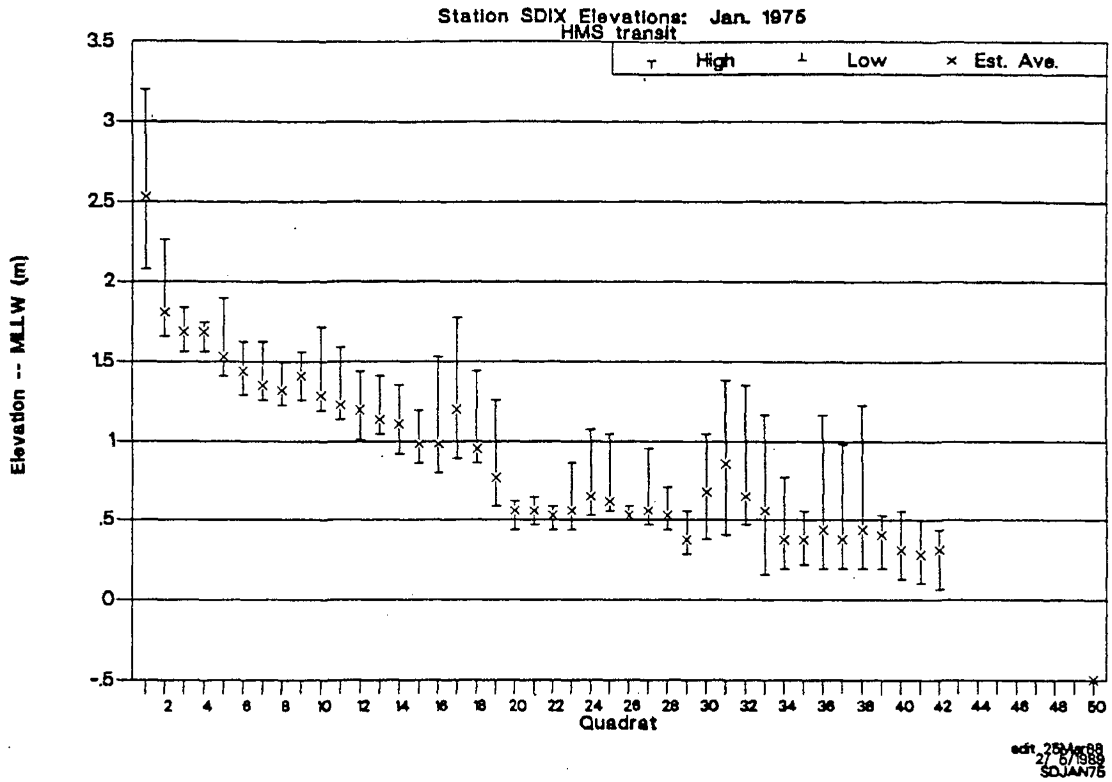
causes are to be expected during any long-term study of a high-energy environment such as the Diablo Canyon nearshore region. We had no choice but to attempt to cope with these disruptions, adjusting to changes as best we could. We have discussed susceptibility to natural forces in the station descriptions given below, as well as some effects experienced during the course of our studies and their impacts on our experimental design.

PHYSICAL ASPECTS OF THE INTERTIDAL TRANSECTS

The South Diablo Intertidal Transect (SDIX)

The intertidal area in the easterly half of the south border of Diablo Cove has gentle slopes. Low tides expose 50 m (165 ft) or more of substrate (Figure 5-2). Pavement rock occurred in the upper intertidal, but most of the substrate consisted of piles of gravel, cobble, and boulders. Small rocky ridges were scattered here and there, running more or less parallel to shore. One such ridge intersected the transect at m16 to m18.

The transect lay near the southernmost boundary of the flat part of the shoreline, about 15 m (50 ft) easterly from a massive pinnacle projecting some 15 m (50 ft) above the intertidal. The transect originated at a stainless steel spike driven into the cliff base, about 1.6 m (5 ft) above the upper beach level. The uppermost two meters of the transect lay on basement rock near the bottom of the steeply sloping cliff that rims most of Diablo Cove. The next twelve meters traversed an unstable area of cobble and boulders which were usually buried to varying extents by sand and gravel. A bedrock exposure which included a sharp ridge about 1 m (3 ft) high, followed. Substrate for the remainder of the line consisted of aggregates of sand, gravel, cobble, and boulders in varying amounts. Sand and gravel predominated from about m18 to m22. Cobble was prominent thereafter for 3 to 5 m (10 to 17 ft). Boulders dominated the transect from about m30 outward. Stones smaller than 0.3 to 0.6 m (1 to 2 ft) in diameter were frequently unstable and



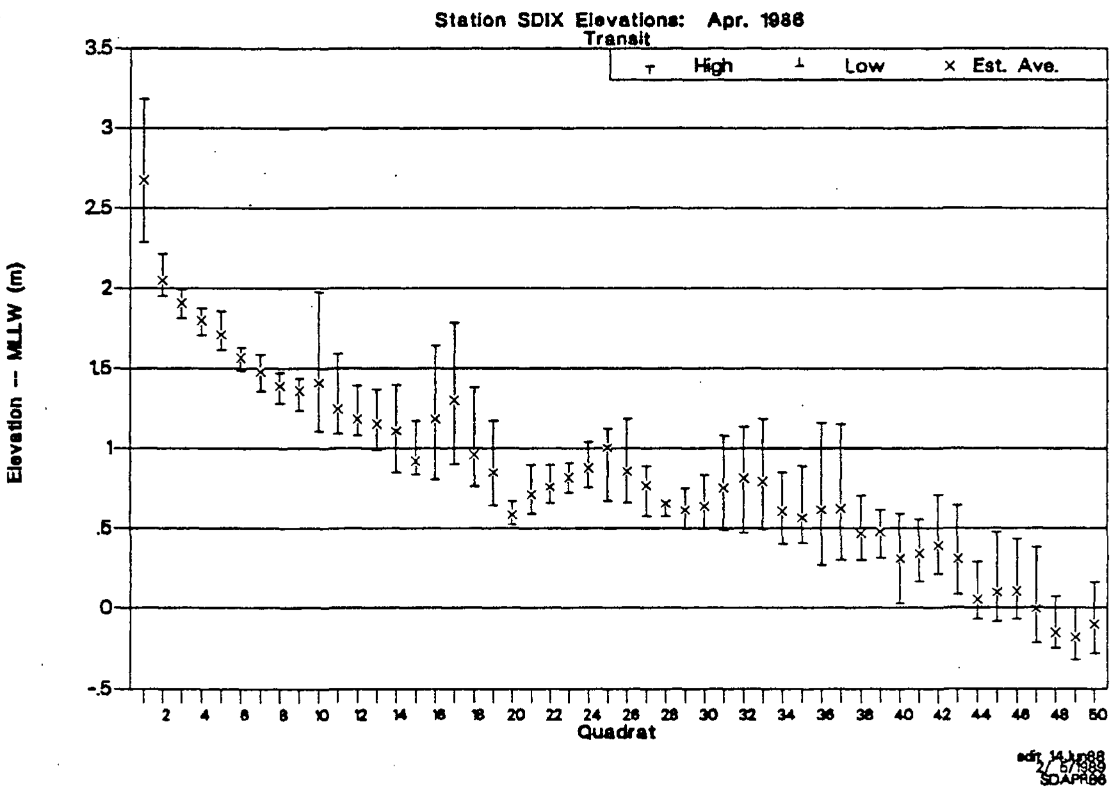


Figure 5-2. SDIX profile, 1975 and 1986.

shifted during storms. The instability undoubtedly contributed importantly to changes in biota we observed along the SDIX transect. The transect was representative of boulder-strewn beach in this part of the Cove but not of pavement rock. The boulder aggregates, however, supported more diverse habitat such as crevice environments. Zonation patterns tended to be similar for both types of substrate.

Large drifting debris (logs, remains of bull kelp, dead sea lions, and assorted seaweed aggregates) tended to accumulate on the upper beaches at the south end of the Cove. Apparently wind and currents moved surface material in this direction. We occasionally experienced difficulties with our surveys at SDIX from thick deposits of sea foam in the lower intertidal.

Compared to our other stations, effects from wave action were minimal at SDIX. Swell entering Diablo Cove from the southwest channel was attenuated by refraction as well as by the pinnacles and wash rocks strewn along the south shore of the Cove. Distance and offshore shoals offered some protection from swell entering the Cove through the north channel. In spite of the protected location, SDIX suffered considerable damage during the great storms of the 1982-83 winter. This damage was of an indirect nature, however, and resulted from collapse of a section of cliff on the large pinnacle lying just west of SDIX. Rubble from this landslide was carried easterly and buried much of SDIX from about m20 outward. Cobbles and boulders in the rubble were unstable through the end of 1987. Plants and animals had difficulty colonizing these shifting substrates. A topographic survey in 1986 (i.e., 3 years after the great storms) showed presence of some fill remaining between m20 and m40, when compared to a similar survey conducted in 1975 (Figure 5-2). The 1982-83 storms also moved some of the large boulders bearing epoxy markers used for relocating the transect line, along the outer part of SDIX. It was necessary to install new markers.

The South Central Diablo Intertidal Transect (SCDIX)

This transect lay centrally in Diablo Cove, about 30 m (100 ft) south of the discharge structure. The backshore here was terminated by a steep cliff. The cliff base followed a fairly straight line in this part of the Cove except for an abrupt jog seaward for a distance of about 3 m (10 ft). The base of the jog had been eroded, creating a small bedrock shelf. Origin of SCDIX was on the cliff at the point where it jutted out. South of the jog, the beach sloped gently downward away from the cliff, supporting a stretch of unstable cobbles. The cobbles displayed no resident organisms, presumably because cobble movements in the surf crush any small organisms entering this hostile environment. The remainder of the transect consisted of flat bedrock exposures, interrupted occasionally by irregular crevices running transversely across the transect line. There were also more or less continuous small grooves or channels running parallel to each other and perpendicular to shore. The flat, smooth, terrace-like formation extended about 40 m (132 ft) seaward from the cobble aggregate at the cliff base.

The transect terminated at the seaward edge of the flat terrace. A small vertical drop-off here led down to water about 0.3 m (1 ft) deep at low tide where the substrate changed to boulder-cobble aggregate. We did not install any epoxy markers along SCDIX. The outer end of the line bisected the most seaward-reaching part of the terrace while the inner end was fixed by the jog in the cliff. These were two stable and easily relocated landmarks. We surveyed SCDIX only twice during the project (November 12 1966 and May 15 1987), noting only the ranges of occurrence along the transect for each species. It was thus not necessary to relocate the line with the high degree of precision used on our other intertidal transects, where we needed to position our quadrats in the same location survey after survey.

The Central Diablo Intertidal Transect (CDIX)

CDIX was also located centrally within Diablo Cove at a point about 150 m (500 ft) north from the discharge structure, just beyond the immediate influence of Diablo Creek (Figure 5-1). The transect followed along a set of rocky ridges formed by layers of hard rock running almost perpendicular to shore and sloping down toward the north. Tops of the ridges were eroded by wave action so that the line had a generally downward sloping trend, looking seaward from the origin (Figure 5-3). Differential rates of erosion along the ridges produced irregular high areas

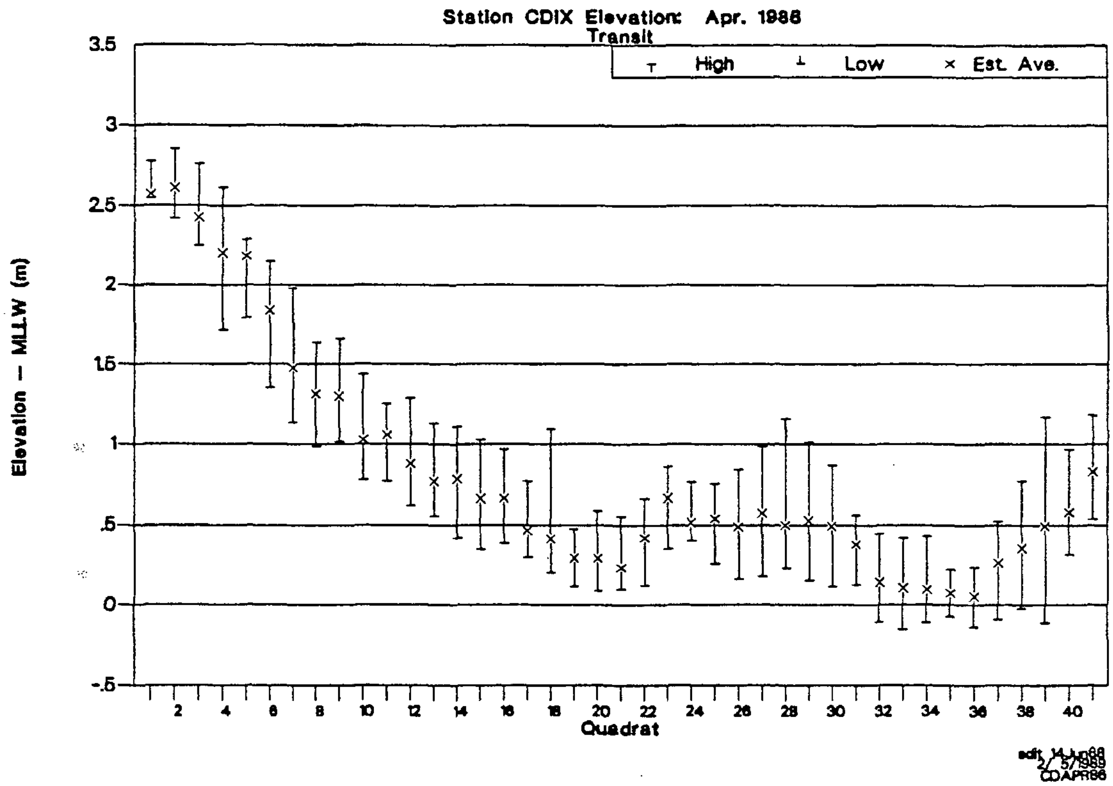


Figure 5-3. CDIX profile, 1986.

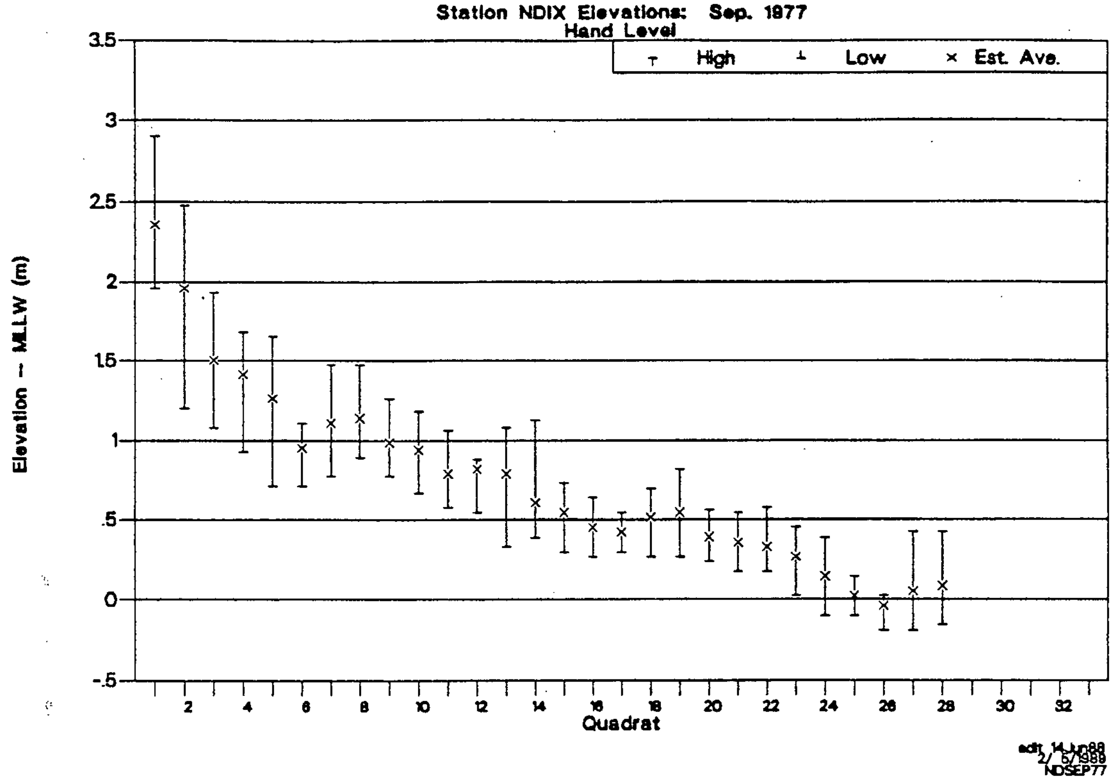
along the transect, causing the level to rise at about m28 and again at m39 (near the outermost end). Elongate depressions between the high regions contained boulders, cobble, and small patches of sand and gravel. Two substantial-sized tidepools were nestled in enclosed hollows formed within the bedrock ridges at m20 and m36. The profile of CDIX thus differed from the more or less uniformly-sloping patterns seen among our other intertidal transects. CDIX was somewhat undulatory with alternating rises and depressions.

Wave exposure at CDIX was usually intermediate between the high energy condition at NDIX and the relatively low energy shore at SDIX and varied with swell direction. The rock ridges that were so prominent along CDIX extended seaward beyond the end of the line for about 150 m (500 ft) as a series of pinnacles and washrocks. The resulting reef provided substantial protection from northwesterly swell entering Diablo Cove through the north channel. Physical effects from the great storms of the 1982-83 winter were much less at CDIX than at our other intertidal transects, but there were some changes due to boulders shifting in the area above m15. Relative scarcity of boulder and cobble along the outer part of CDIX lessened damage from moving rocks at this station.

The North Diablo Intertidal Transect (NDIX)

Substrate along our intertidal transect at the north end of Diablo Cove was similar to the line at the south end. Both transects originated on bedrock of the backshore cliff and passed over similar sized boulders. Both had small bedrock ridges a short distance beyond the transect origins. Both had unstable areas of boulder and cobble behind the ridges that were periodically buried by sand and gravel deposits. Slope, however, was steeper at NDIX, and exposure to wave action was greater. NDIX was only about half the length of SDIX, due to the steeper slope. Some shifting of boulders along outer NDIX led to a degree of community instability but the effect seemed less than at SDIX.

The NDIX transect (see Figure 5-1) originated at a stainless steel stake driven into a crevice in the cliff, about 1.2 m (4 ft) above the upper beach level. The uppermost three meters of the line passed over the bedrock base of the cliff, with a small depression at m2-m3 containing a tidepool. The unstable section, subject to sedimentary burial, occupied m3 to m6. A low bedrock ridge occurred from m7 to m8. The remainder of the line displayed an irregular profile and consisted primarily of boulders 0.6 to 1.2 m (2 to 4 ft) in longest dimension with cobble and gravel in the hollows and depressions (Figure 5-4). The extreme northern part of Diablo Cove was primarily a boulder-strewn beach. The only relief from boulder aggregates was a stretch of flat pavement rock, about 50 m (160 ft) wide, at the base of the north headland to the Cove. Thus our NDIX transect was considered as representative of the principal shoreline habitat in this part of the Cove.



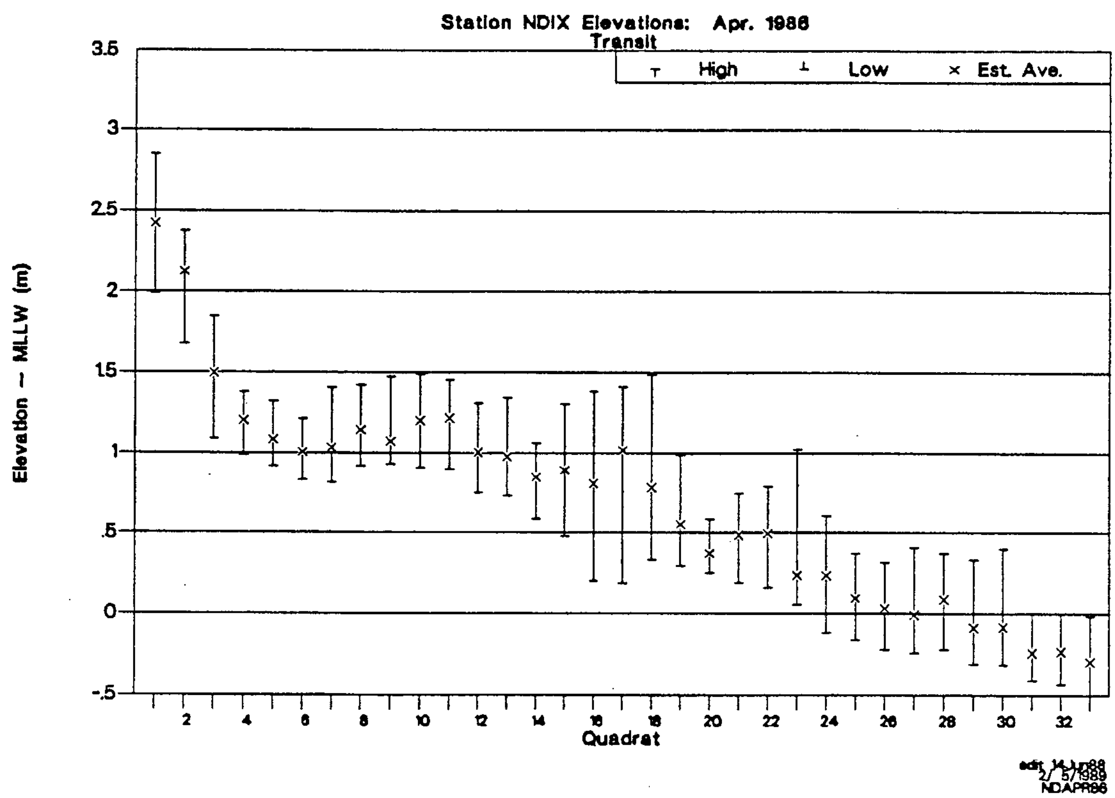


Figure 5-4. NDIX profile, 1977 and 1986.

Wave exposure at NDIX was usually greater than for any of our other intertidal transects within Diablo Cove. The north headland provided considerable protection from northwesterly swell, but deep water lies relatively close to shore in this area. Proximity to deep water allowed waves to refract around the north headland with minimal attenuation from a shoaling bottom. Large changes in substrate at NDIX resulted from the great storms of the 1982-83 winter. Boulders 1 to 2 m (3 to 7 ft) in longest dimension were transported from the low intertidal and deposited along mid-intertidal parts of the transect, along with considerable rubble. The larger boulders remained in place, raising the transect profile permanently between m9 and m22 (Figure 5-4). This portion of the transect became an irregular ridgelike formation, constituting the high point or crest of the boulder pile. Thus NDIX was no longer strictly similar to the surrounding shoreline. We nonetheless continued surveying the line because of the long historical record accumulated for the transect. The main effect from the new boulders was conversion of a portion of the line from lower mid-intertidal to higher mid-intertidal. The change must be kept in mind as it influenced distributions of certain species.

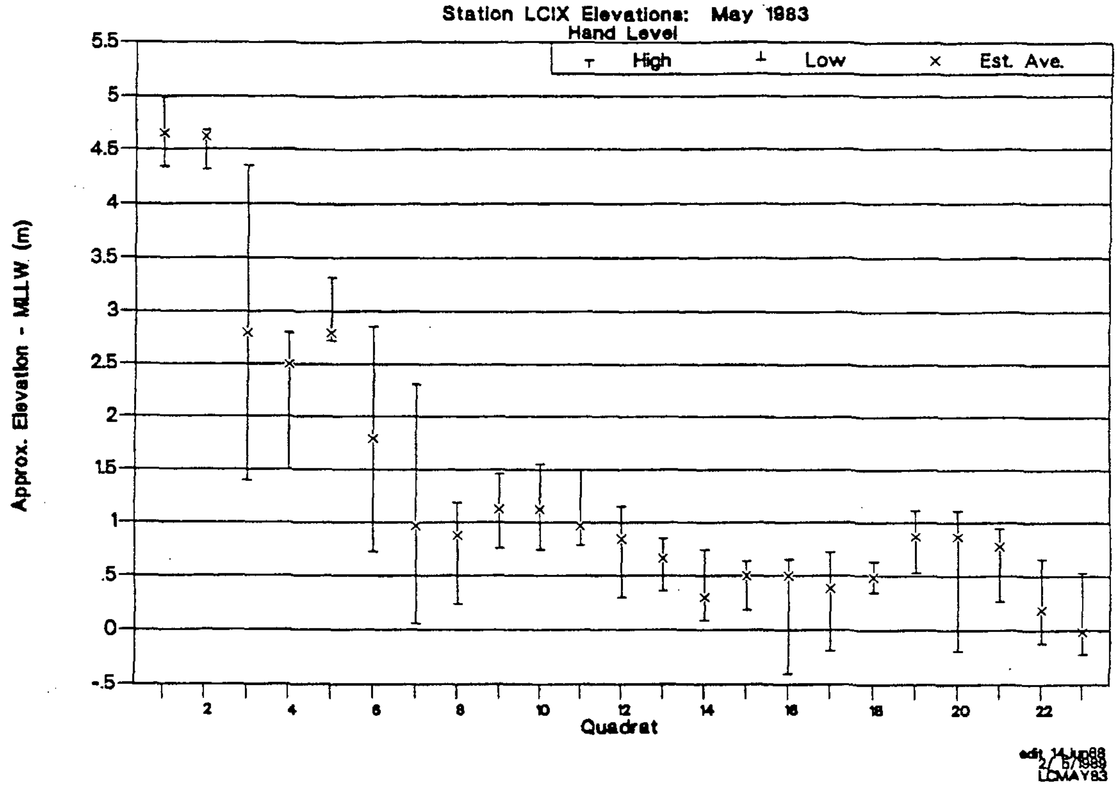
The Lion Rock Control Intertidal Transect (LCIX)

The control intertidal transect lay at the tip of a rocky promontory about 1.2 km (0.75 mi) northwesterly from Diablo Cove and in the lee of Lion Rock and Pup Rock (Figure 5-1). The general site was originally selected by Burge and Schultz of CDF&G as a control site for their studies. The location provided about the only beach access within reasonable distance from Diablo Cove. Our transect line, however, did not coincide with the CDF&G study area, although there was some overlap. A CDF&G marker near the outer end of LCIX was initially used to orient our line. We later installed additional epoxy markers and fasteners to aid in relocation of the line, after the CDF&G marker disappeared.

The first 6 m (20 ft) of LCIX traversed a transitional region between solid bedrock forming the cliff here and a flat bedrock shelf characterizing the outer three quarters of the transect. The transition area contained deep fissures separating large sections of cliff or huge boulders in the process of breaking away from the cliff. The transect originated at a stainless steel stake driven into cliff bedrock about 3 to 4 m (10 to 13 ft) above the tidal flats (Figure 5-5). The line dropped steeply down to a small pool at m7, nestled against the base of the huge rocks. A small ridge ensued, then the line descended gently across bedrock slopes with crisscrossing ledges some 0.6 to 0.9 m (2 to 3 ft) high. The line passed next to a large depression at m16 containing another tidepool, passed over a large boulder at m17-m18, and then rose up across a bedrock ridge at m19-m21. The substrate fell abruptly at m21 to a narrow ledge, then plunged vertically into the sea at m22.

Most of LCIX ran across bedrock or very large (i.e., automobile-size) boulders. Hence effects from shifting substrates was minimal along this transect. Slope was greatest at this transect and small-scale relief was high. The boulder and bedrock surfaces below m8 had been sculptured by biological activity that produced a "swiss cheese" effect. Rocky surfaces were widely pitted with small concavities and holes. The sculpturing probably resulted from activities of rock-boring mollusks and sea urchins. There were also deep crevices and overhangs scattered throughout the transect. All these irregularities yielded an extremely heterogeneous physical environment.

LCIX was the most exposed site of all our intertidal transects. Lion Rock, Pup Rock, and a promontory to the northwest provided some protection from northwesterly swell. The area was completely exposed to swell from the west and southwest. Very large (i.e., automobile-size) boulders in the lower and upper intertidal at LCIX shifted during the great storms of the 1982- 83 winter, but overall elevation changes were minor (Figure 5-5). The outer three quadrats were lost when a part of the seaward ridge disappeared in late 1987. The scarcity of boulders, cobble and small rubble at LCIX greatly reduced damage to biota arising from crushing by these materials as they were tossed about in the storm surf. This type of damage was common at our intertidal transects in Diablo Cove following the great storms of the 1982-83 winter.



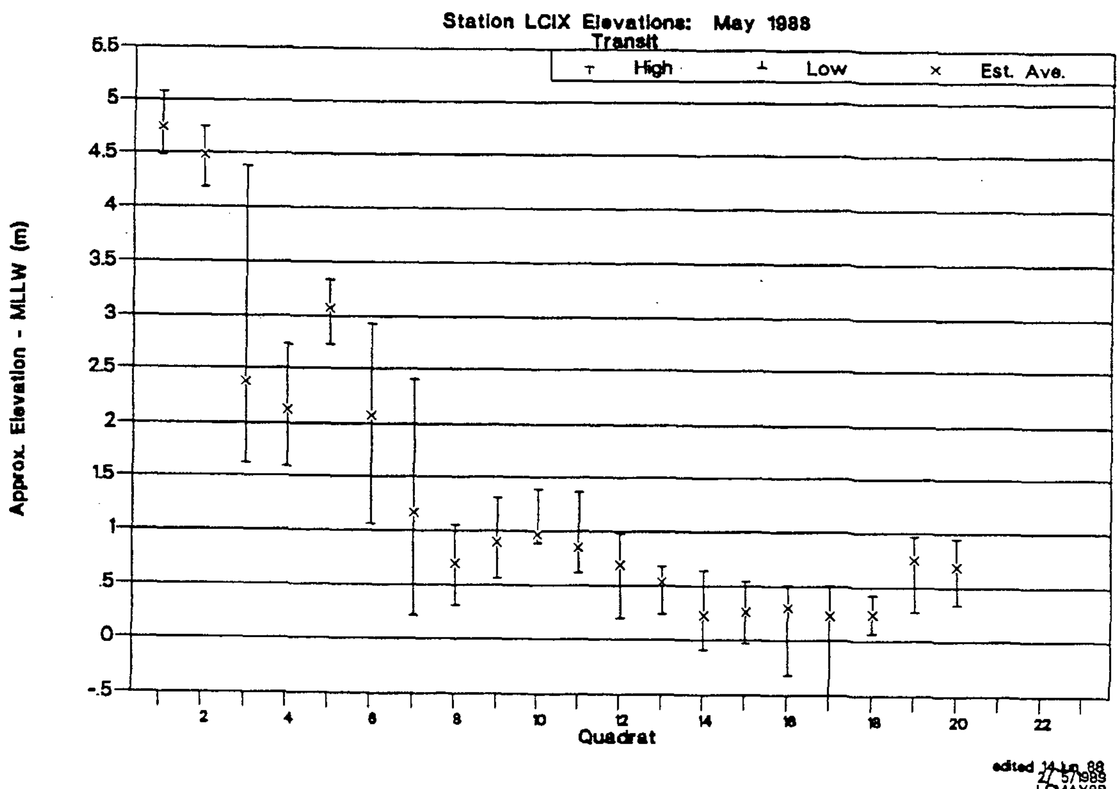


Figure 5-5. LCIX profile, 1983 and 1988.

Shorewalks

Our earliest surveys in 1966 and 1967 included shorewalks encompassing the entire Diablo Cove intertidal. We simply tallied species as they were encountered but made no effort to chart their locations or describe their distributions, nor did we attempt to distinguish the varied habitats occurring within the Cove. We established permanent intertidal transects for quantitative study of biota in the Cove during 1969-70. Our entire effort became directed toward analyzing conditions along the transects and we discontinued the shorewalks. We resumed conducting the shorewalks in December 1982 because full scale operations at DCPP were scheduled to commence shortly. The transects provided detailed information about conditions for boulder-cobble habitat at fairly restricted locations. We wished to assess, if only qualitatively, how representative these results might be of similar or differing habitats elsewhere within the Cove and describe any important differences we might observe.

Our initial shorewalk for the later period occurred December 30 1982. We attempted to categorize the major habitats within Diablo Cove and we charted their approximate distributions. This produced a scheme involving eight primary habitats (Figure 5-6):

A. Stable boulders up to 1 to 2 m (3 to 6 ft) in greatest dimension with underlying cobble and occasional bedrock.

B. Unstable sand and cobble backshore, stable flat pavement rock from mid to low intertidal.

C. Stable boulders up to 1 to 2 m (3 to 6 ft) in greatest dimension, dispersed among occasional bedrock ridges or irregular outcrops.

D. Unstable cobble and boulders up to 0.5 m (1.5 ft) in greatest dimension (a special habitat at the mouth of Diablo Creek).

E. High relief bedrock ridges with an unstable small boulder-cobble mix between the ridges.

F. Backshore of unstable cobble, flat bedrock in upper to low intertidal, tidepools in depressions.

G. Unstable cobble in backshore, very heterogeneous at lower levels (stable boulders, bedrock pinnacles, ridges, channels, and flat areas).

H. Unstable sand, cobble, small boulder backshore, fairly stable boulder-cobble from upper to lower intertidal.

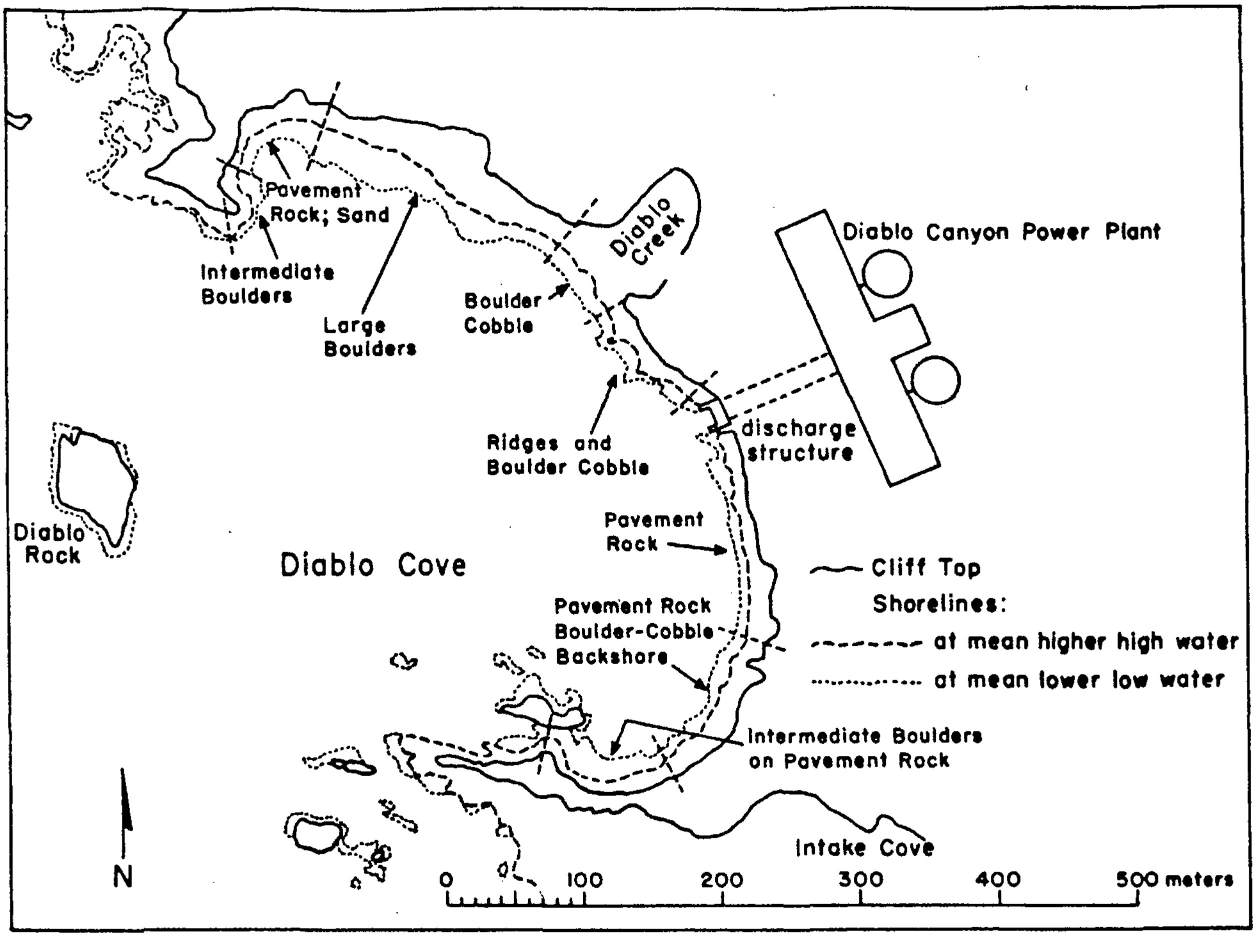


Figure 5-6. Major intertidal habitats, Diablo Cove.

These major domains were also present in our earliest shorewalks of 1966-67, much as they appeared in latter 1982. The great storms of 1982-83 caused important substrate changes at A, E, and G, but most of the other habitats or sub-areas received only minor impacts. Sub-area E subsequently recovered to its former status after about a year. Deposits of rubble and boulders in sub-areas A and G remained in place. These two sub-areas were the sites of our NDIX and SDIX intertidal transects. We described above the changes wrought by the great storms at these two locations.

For purposes of documenting our survey results, several of the eight subareas were too large for conveniently describing conditions of the resident biota. We therefore subdivided these larger habitats into smaller parcels which were designated as "sectors" (see Figure 5-7).

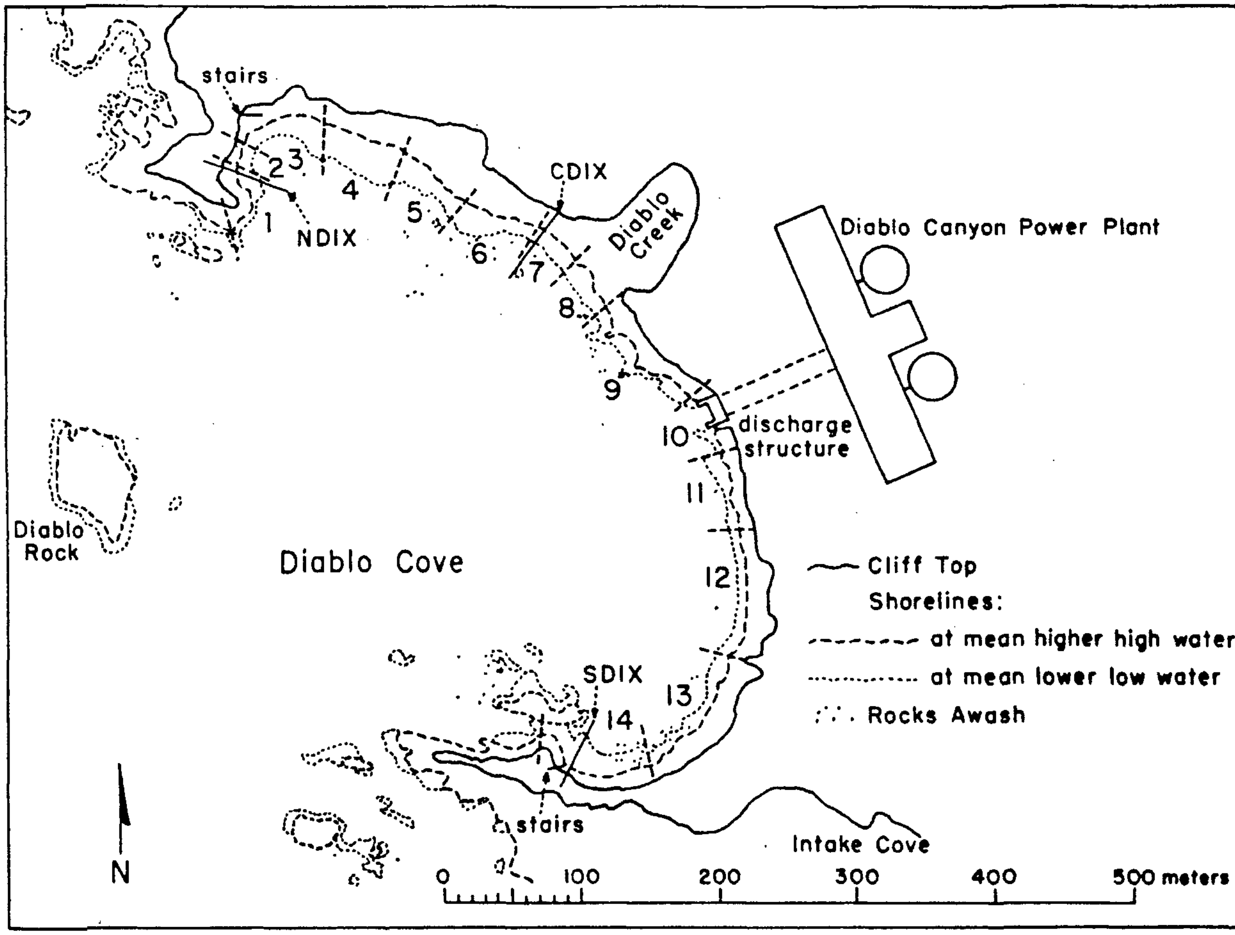


Figure 5-7. Shorewalk sector map, Diablo Cove.

PHYSICAL ASPECTS OF THE SUBTIDAL TRANSECTS

The Diablo Cove Central Subtidal Transect (DCSX)

This subtidal transect, running perpendicular to shore in the Cove's center, began at a depth of 3 m (10 ft) about 60 m (200 ft) off the north side of the discharge structure (see Figure 5-1). The transect was 100 m (330 ft) long, terminating at a depth of about 8 m (26 ft).

The first 40 m (132 ft) of the transect traversed uneven bedrock, with relief usually about 1 m (3 ft) due to channels and ridges sculpturing the fairly flat bedrock (Figure 5-8). Occasional massive outcrops rose some 2 m (6 to 7 ft) above the surrounding bottom. A few cobbles aggregated at the bottom of channels and depressions but very little gravel and no sand was present in any of the low areas. Terrain northerly of this part of DCSX was similar but rocky bottom immediately south consisted of a large high-relief reef running alongside the transect path. Depth increased gradually in a seaward direction to about 4.5 m (15 ft) at m40 on the line. A broad depression at m40 to m50 contained cobble and boulders at depths of about 6 to 7 m (20 to 23 ft). The reef formation immediately south still displayed pinnacle tops only 2 to 3 m (6 to 9 ft) deep. Large, almost vertical rock faces were thus common along the south side of DCSX in this mid-section portion. A massive shoulder of the reef intersected the line at about m50. The transect penetrated the reef for about 20 m (66 ft) at this point, threading a tortuous pathway through crevasses and across ridges. The reef terminated in a cliff or steep slope at about m65. The transect line descended sharply here, following a vertical rock face down to a depth of 8 m (26 ft) at m70. Sediment and rocky rubble extended outward from the cliff base for the next 20 m (66 ft). Rocky outcrops and steep pinnacles projected up out of the sandy bottom for the final 10 m (33 ft) of the transect.

Location of DCSX was marked by laying 9.5 mm (3/8 in) steel chain along the bottom. Corrosion required chain replacement about every four to five years.

All parts of DCSX may have received some exposure to the thermal plume but portions at 4 to 4.5 m (12 to 15 ft) depths usually marked the plume's lower boundary. The massive and highly irregular reef at the south side of DCSX produced very complex distributions of cold and warm water on the bottom. Tops of the rock outcrops were typically swept by the warm plume flows. Hollows and depressions might contain warm or cold water. Presumably the temperature characteristic of a given depression was a more or less permanent feature of that pocket. We would find cold water species surviving in "cold water depressions" long after they had

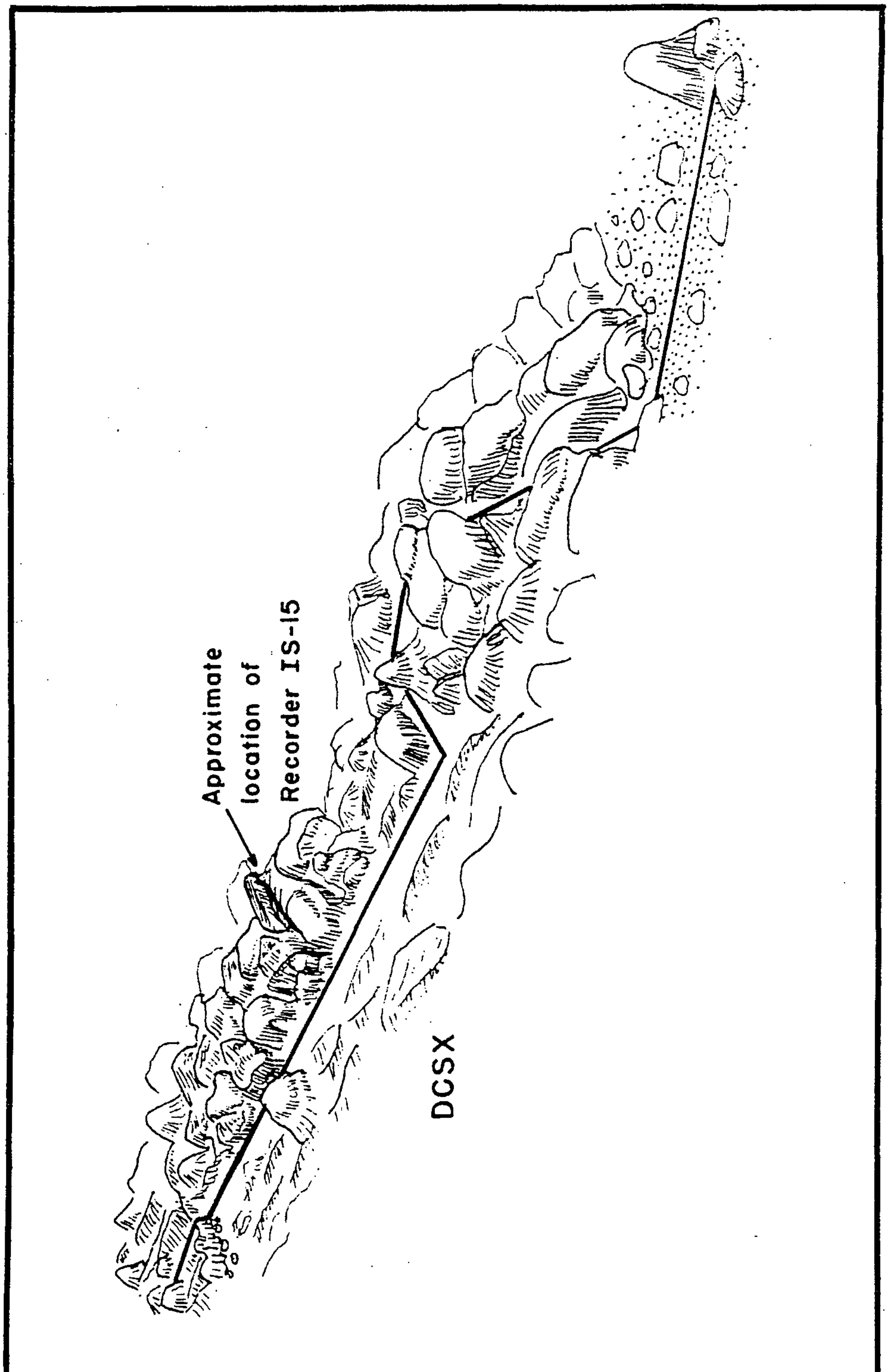


Figure 5-8. Sketch of the DCSX transect in central Diablo Cove, lying directly off the north edge of the DCPP discharge structure.

disappeared from adjacent territory. The Sea Data recorder at Station IS-15, for example, was located in a cold water pocket. Two cold water kelps, *Laminaria* and *Pterygophora*, were flourishing in this hollow during latter 1987, about a year after they had completely disappeared from comparable depths on the flat bottom of the DCSX transect.

Wave exposure was relatively moderate along most parts of DCSX. The high rocky outcrops of the adjacent reef probably offered some protection from wave surge, particularly the outer portion of the reef between m50 and m60 which formed a shoal athwart the transect. Whenever we surveyed DCSX, wave surge was always much higher at m50 to m60 than for areas lying farther inshore. About the only indication at DCSX of effects from the great storms of 1982-83 was a few overturned boulders here and there in the channels and depressions. A dense cover of mature palm kelps apparently survived these storms with no detectable losses, even in the shallows near the transect origin. This kelp forest may have lessened wave surge near the bottom during storms, to some extent protecting underlying biota from these powerful forces.

The Diablo Rock Subtidal Transect (DRSX)

A small vertical crevasse down the east face of Diablo Rock marked the location of this transect (Figure 5-9). The transect originated in the intertidal about 1 m (3 ft) above low water. Consequently, we recorded a few intertidal species along this transect whenever sea conditions were sufficiently calm to permit inspection of the shallows (a rather rare situation). The line ran nearly vertically downward from the origin to a depth of about 6 m (20 ft). This was the base of Diablo Rock. A rock rubble bottom intersected the cliff at this point. The rubble pile sloped downward from north to south. The transect, however, was oriented in an east-west direction so it ran shoreward from Diablo Rock along a uniform depth contour of the rock pile at approximately 7 m (23 ft) below the surface. This horizontal portion of the transect was 10 m (33 ft) long. Total transect length was about 17 m (56 ft).

The portion of DRSX at m5 to m6 (at the base of Diablo Rock) was an unusual microhabitat, not found elsewhere along any of our subtidal transects. A large boulder about 3 m

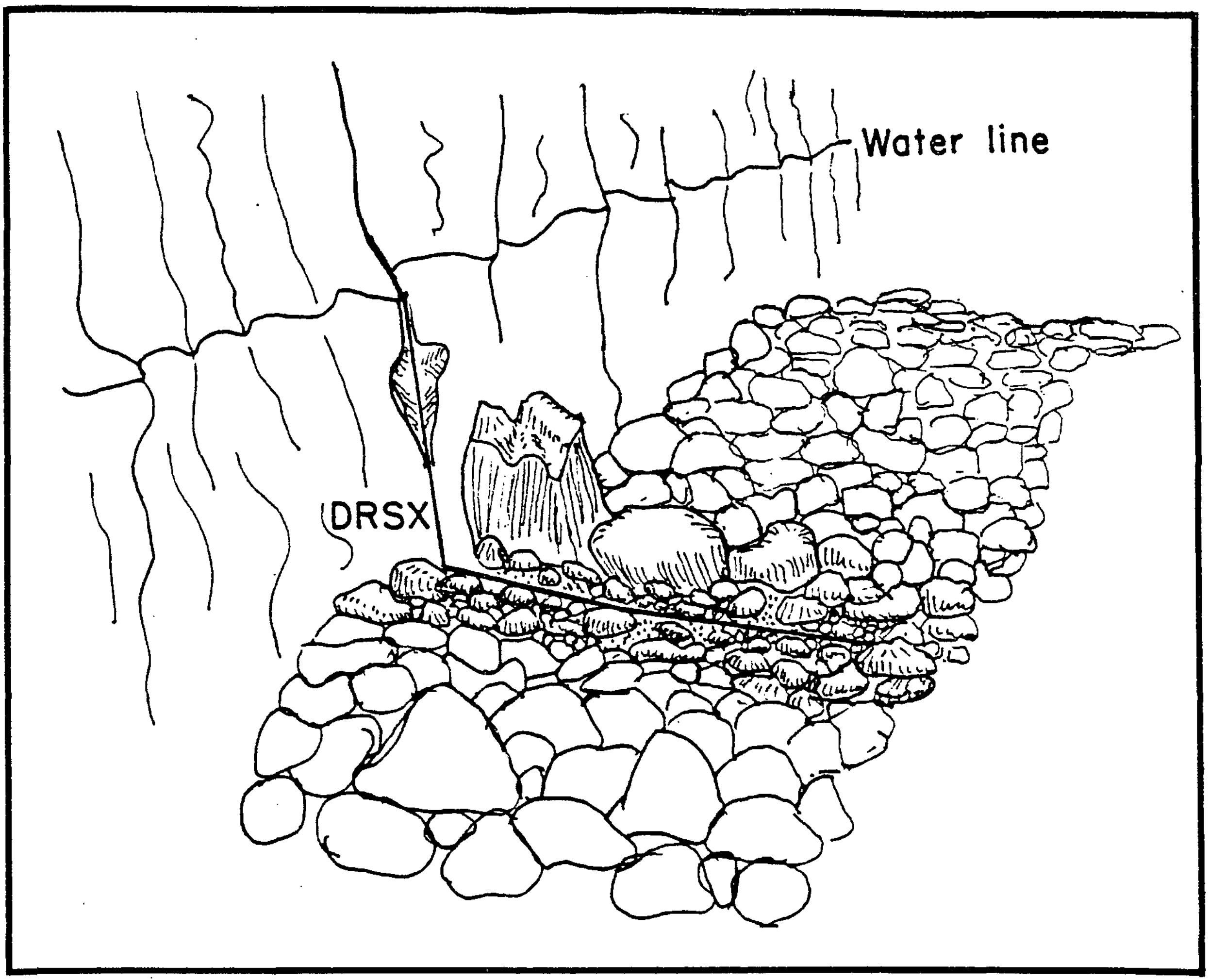


Figure 5-9. Sketch of the DRSX transect in outer Diablo Cove, running down the east face of Diablo Rock, thence horizontally towards shore.

(8 ft) tall rested against the cliff face at a slight angle, forming an enclosed crevice or tunnel. A second large boulder or bedrock outcrop occurred on the upslope (north) side of the line at m9 to m10. The remainder of the transect traversed boulders about 0.3 to 1 m (1 to 3 ft) in longest dimension.

The large boulder pile in the lee of Diablo Rock had a truncated top, forming an irregularly flat area about 3 m (10 ft) deep and beginning at about 10 m (33 ft) north of the DRSX line. Two massive rocky outcrops about 21 m (70 ft) downslope (south) from DRSX interrupted the deepening trend by trapping boulders and creating an irregular flat area. One of the pinnacles broke the surface and formed a wash rock. Except for these anomalies, the bottom continued a downward trend to a depth of about 14 m (45 ft) where the horizontal flat floor of the southwest channel began, about 60 m (200 ft) south of DRSX.

Proximity to deep water of the southwest channel was apparently conducive to high wave exposure for DRSX. Although Diablo Rock prevented direct impingement by incoming wave trains from the west, deep water nearby allowed wave refraction without attenuation from shoals. Wave surge at DRSX was usually greater than for any of our other subtidal study areas. More damage to biota was observed at DRSX following the great storms of 1982-83 than at our other subtidal transects. Shallow parts of the transect were stripped of vegetation and encrusting animals. Large overturned boulders were strewn in abundance along horizontal parts of the transect. Palm kelp populations upslope from DRSX were almost totally obliterated.

The Lion Rock Control Subtidal Transect (LRSX)

Although designated by the term "Lion Rock", this transect actually occurred inshore from that island, off a smaller, at first unnamed, islet that later became known as Pup Rock (see Figure 5-1). We chose the location expecting that the site would be quite protected from wave action and could be surveyed at times when conditions were too rough to operate effectively at Lion Rock. The transect was positioned off a small cusp on the east side of Pup Rock. The east side of Pup Rock falls steeply to the water's edge but then slopes fairly gently for a distance of about 15 m (50 ft), creating a shallow subsurface shelf (Figure 5-10). The shallow shelf ended abruptly at a depth of about 3 m (10 ft). An uneven cliff edge here fell another 1 to 2 m (3 to 6 ft) to a narrow ledge, thence steeply to the cliff base at about 9 m (30 ft) deep. A mixture of fine sand and small rubble formed a gently sloping bottom leading away from the cliff base for about 2 m (6 ft) to the bottom of a small gully. Beyond the gully, various-sized rock outcroppings projected up out of flat sandy bottom. Apparently sand moved in and out of this flat area because proportions of sand to rock varied from about 1:1 to 2:1 from one visit to the next.

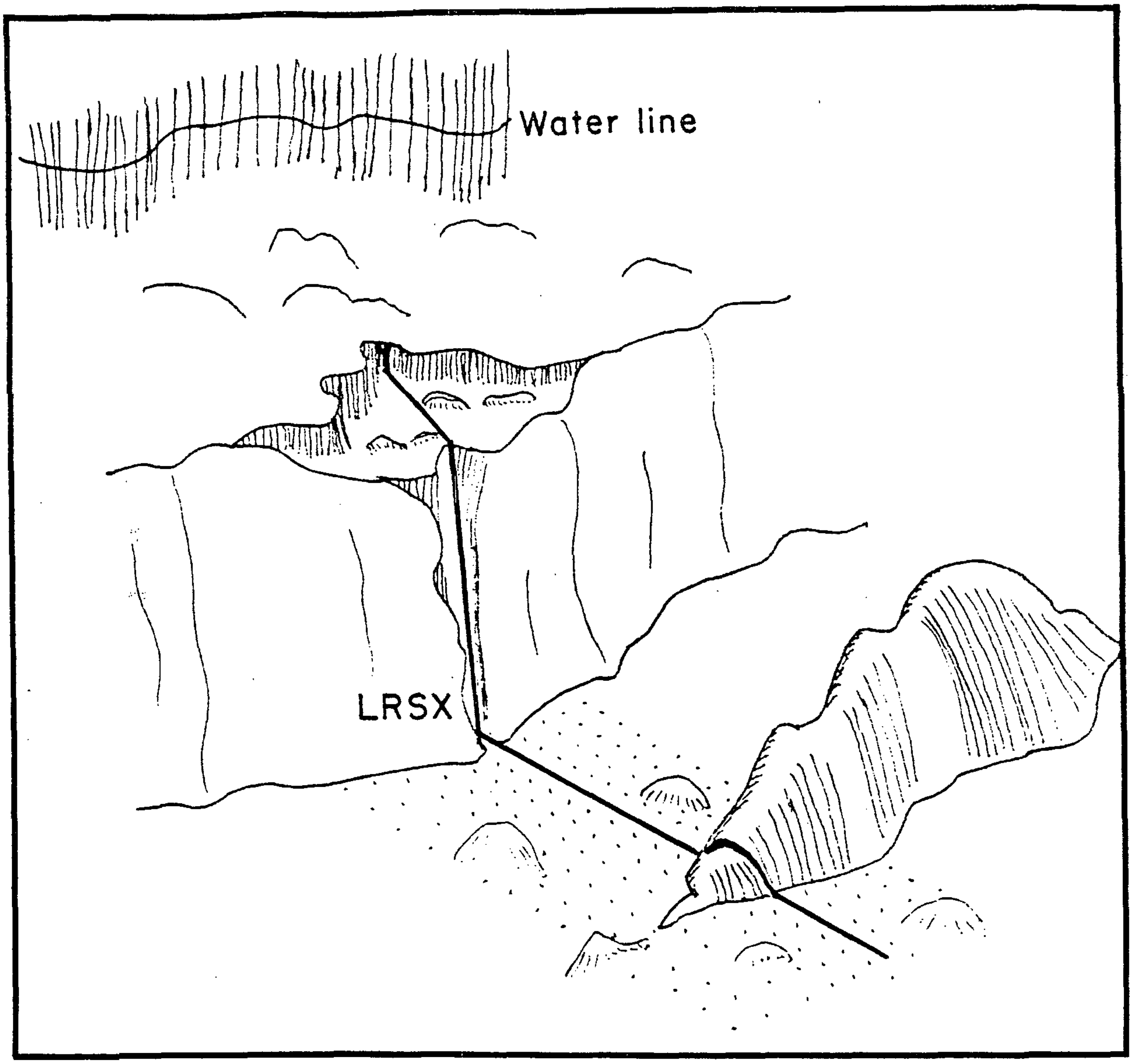


Figure 5-10. Sketch of the LRSX transect, running down a submerged cliff bordering southeast Pup Rock, thence horizontally toward the southeast.

Like DRSX, the cliff off Pup Rock had a small crevasse extending from top to bottom . We chose this feature as the site of the LRSX transect to save the trouble of installing landmarks. The transect originated at the top of the cliff at a depth of 3 m (10 ft). The line descended vertically down the crevasse, thence outward approximately horizontally for 10 m (33 ft). We had hoped to be able to include the shallow shelf off Pup Rock in the LRSX transect. Wave surge proved to be exceptionally forceful on this shelf. We were only able to examine shallow biota here carefully on one out of eighteen surveys (i.e., on April 15 1972). We were able on all our visits to study the cliff and deep horizontal bottom without difficulty. The LRSX transect thus displayed a marked vertical gradient in forcefulness of wave surge. Although organisms on the shallow shelf experienced strong water motion almost constantly, they were apparently adapted to such conditions. The only effects seen from the great storms of 1982-83 were confined to the deep horizontal part of the transect. The sedimentary level dropped, exposing more rocky substrate and a few boulders were overturned.

At the time we selected the LRSX site we did not expect that any portion of this transect would ever encounter temperature changes due to presence of the thermal plume from DCPP. Judging from distribution of foam and water temperatures during Fall 1987 (i.e., the season for the Davidson Current regime), diluted plume waters may extend this far to the northwest. It was thus unfortunate that we did not have a good background of intertidal observations from LRSX.

Swimthroughs

Like the shorewalks, swimthroughs were primarily observational activities intended to assess conditions throughout the shallow subtidal in Diablo Cove and compare any findings to the status prevailing along our permanent transects. We did tally species observed during the swimthroughs and we noted approximately where they occurred. Our first swimthrough took place in May 1985. We examined only shallow water north of the discharge structure. Subsequent swimthroughs also included scans of territory south of the discharge structure. Our swimthroughs in 1985 and 1986 stayed within the confines of Diablo Cove. We extended these surveys outward into the north channel in 1987 to ascertain whether ecological effects were manifest beyond the limits of the Cove.

We attempted to remain between the 3 and 4.5 m (10 ft and 15 ft) depth contours during our swimthroughs as this was considered to be the transition zone where plume exposures were variable and influenced by tidal heights. The highly irregular topography of the sea floor in some parts of Diablo Cove made it difficult to remain within the desired depth range. At times we had to swim over ridges and pinnacles or traverse hollows and depressions, but usually we were able to thread our way around these irregularities. Occasional pinnacles or hollows were helpful in providing us small-scale samples of conditions above or below our prescribed zone of study. We could thus evaluate status of the biota over a broader vertical range.

The highest-relief bottom tended to occur at the extreme ends of the swimthroughs (i.e., the north channel and the long east-west trending shoreline formed by the south headland (Figure 5-11). There were two additional areas of moderately high relief within the Cove produced by aggregates of rock outcrops creating massive reef formations. The two reefs straddled Diablo Creek, one lying on the seaward bulge in the 3 m (10 ft) depth contour just off Diablo Creek, the

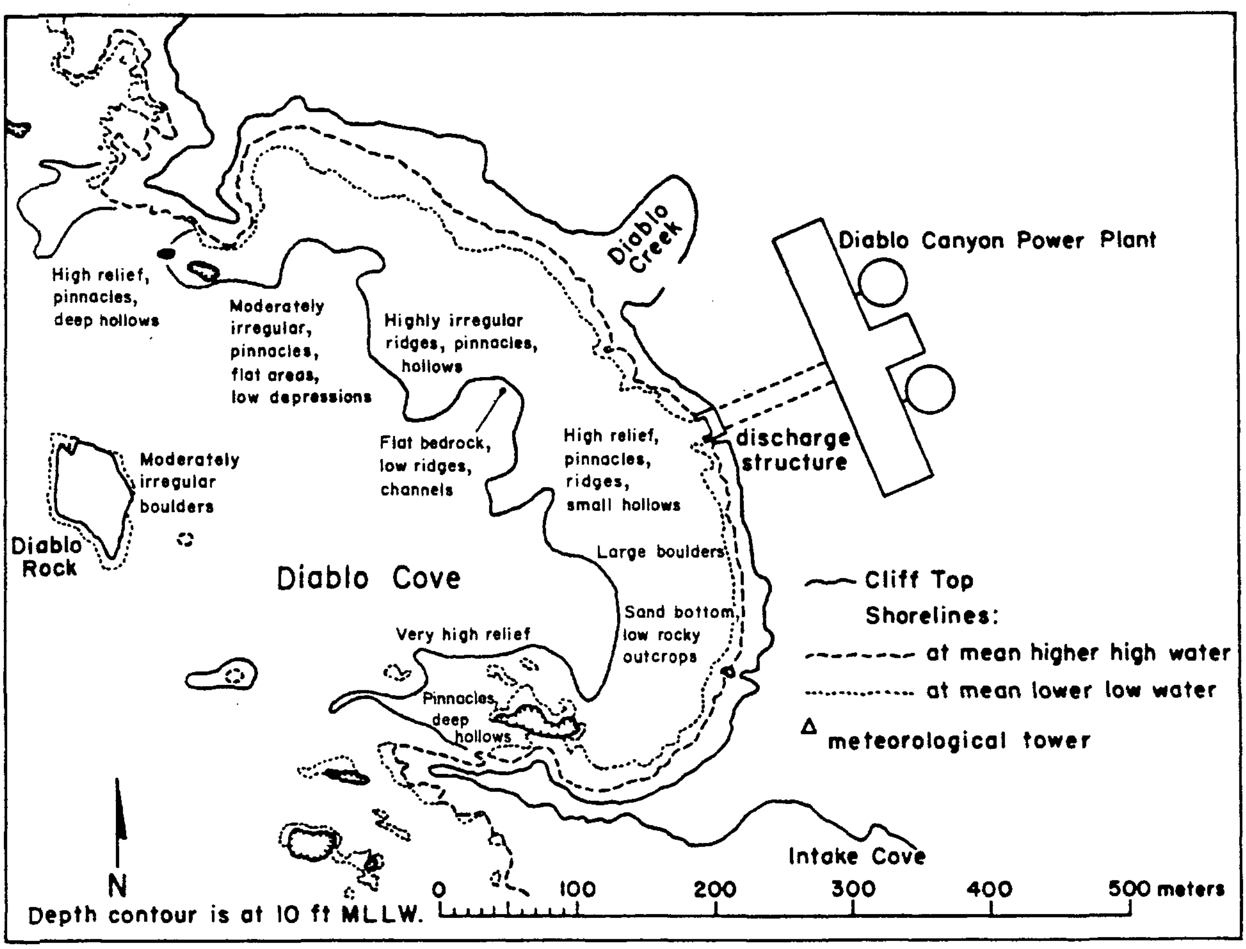


Figure 5-11. Major subtidal habitats, Diablo Cove.

other located in a similar bulge off the discharge structure. Relatively flat bottom occurred directly off Diablo Creek, between the two bulges. Flat bottom also prevailed in the south part of Diablo Cove. This was usually the calmest area within the Cove. Deposits of coarse sand filled the broad depressions here. Small rocky ridges and tops of isolated rocks projected up to about 0.5 m (1 to 2 ft) above the flat sandy floor here.

A small shoal also occurred on the leeward side of Diablo Rock. This was largely an accumulation of boulders up to 1 m (3 to 4 ft) in longest dimension, probably representing material eroded from Diablo Rock. The top of the boulder pile stretched for about 30 m (100 ft) in a north-south direction and lay about 3 m (10 ft) deep. The top was irregularly flat but abrupt downward slopes occurred at the north and south ends where protection from Diablo Rock ended. Slope off the eastern border of the boulder pile was more gentle. Relief on the horizontal top of the boulder pile was about 1 m (3 to 4 ft) between boulder tops and bases of the crevices. This shoal was used as one of our Phaeophyta sampling areas (DRSX 3m).

Most of the territory covered by our swimthroughs consisted of bedrock or of fairly large boulders. These substrates were highly stable and remained unaffected by passage of storms. Even the sand flats in the south part of the Cove appeared to be little affected by large swell and surf. We occasionally saw freshly overturned boulders and cobble, but these were infrequent occurrences along the shallow shoreline. Overturned cobbles and small boulders were more common on the shoal behind Diablo Rock. Even large boulders were tumbled around here during the extremely large storm of February 28 - March 1 1983. With the exception of this shoal, substrate within Diablo Cove seemed stable. This was perhaps surprising because of the exposed location, regularly experiencing large swell and surf. Most of the unstable material on the sea floor here appears to have been transported out to deep water so that the remaining substrate generally exhibited a high degree of stability.

PHYSICAL ASPECTS OF THE PHAEOPHYTA SAMPLING AREAS

Our five Phaeophyta sampling stations were located on or close by the three permanent subtidal transects, DCSX, DRSX, and LRSX (Figure 5-12). Phaeophyta sampling began in December 1982, about thirteen years after we had established the permanent transects. Positioning our Phaeophyta sampling sites next to the transects thus provided us with long histories of conditions prior to initiation of the Phaeophyta studies. The Phaeophyta studies examined status of this ecologically important group of plants as influenced by depth and proximity to the discharge structure. We needed sampling sites with dense populations of Brown

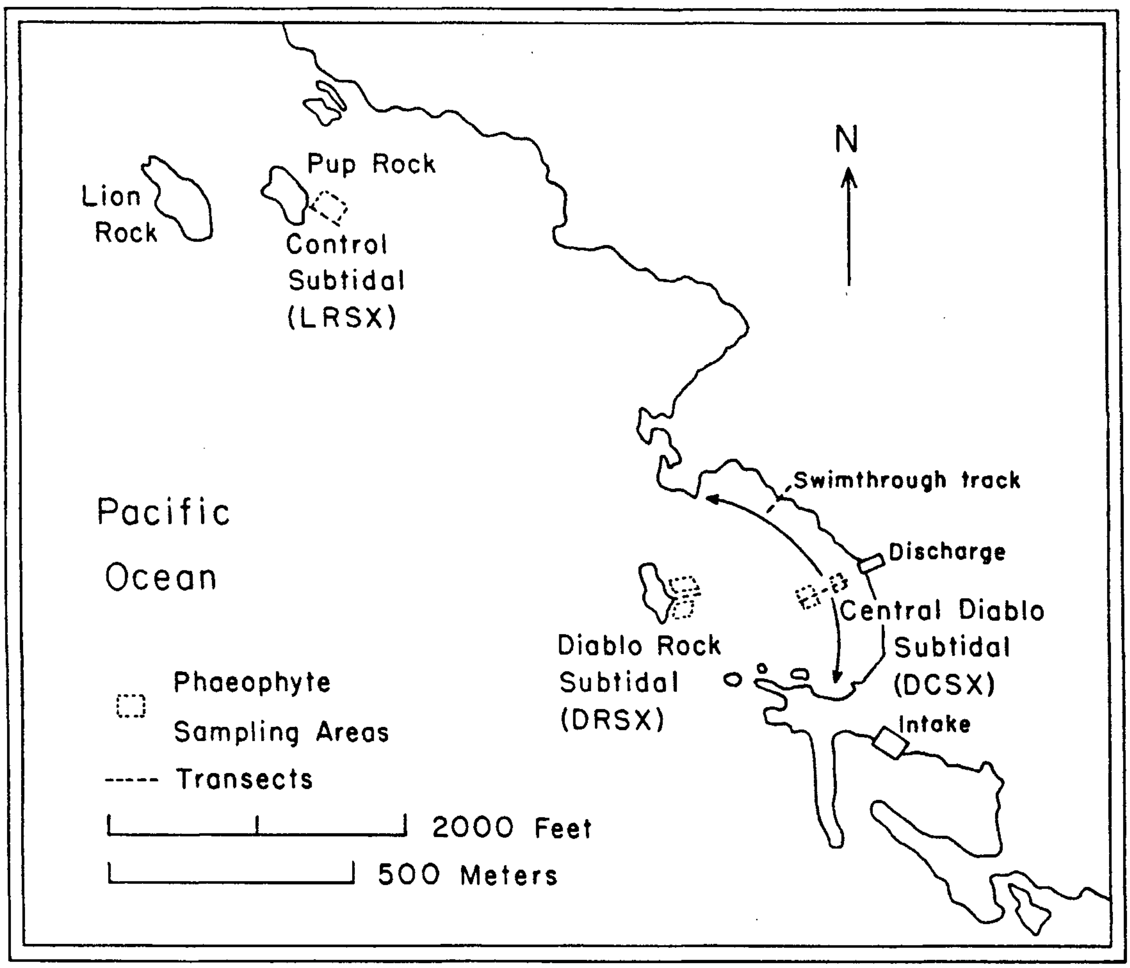


Figure 5-12. Chart of the subtidal Phaeophyta sampling sites.

Algae, reasonably horizontal bottom (to ensure uniform depths), reasonably uniform conditions throughout the sampling area, and appropriate depths and distances from the discharge structure, commensurate with our experimental design. We chose two different depths for routine sampling: 3 m (10 ft) as a depth almost always occurring within the plume and near its deepest boundary, and 8 m (26 ft) as almost always occurring below the lower plume boundary. Each sampling station was identified by the name of its nearby transect and by the depth in meters (e.g., DCSX3m and DCSX8m occurred respectively athwart the shallow and deep ends of the DCSX transect). We also used the Phaeophyta sampling areas for observations and collections where we wanted to distinguish between shallow and deepwater habitats (for example, some of the solid substrate collections).

The Shallow Nearshore Sampling Site, DCSX3m

This sampling station lay about 110 m (360 ft) offshore, just north of the discharge structure, lying along the north side of the inshore 20 m (66 ft) of the DCSX transect. The bottom was predominantly bedrock but cobbles and small boulders occurred in the shallow channels and depressions. Low-to-moderate relief topography lay north of the inshore part of the DCSX transect here and with one or two exceptions, most steep pinnacles were confined to the transect's south side. Relief in the DCSX3m sampling area was mostly in the range of 0.3 to 0.9 m (1 to 3 ft). A few pinnacles and ridges in the inshore part of the sampling area extended up about 1 to 2 m (4 to 6 ft) above the lowest points in the surrounding lowlands. Wave surge was nearly always forceful at DCSX3m but we were able to operate here during times when work at DRSX3m (behind Diablo Rock) was very difficult. Seaward-flowing current from the plume was strong except for occasional visits when the plume was situated slightly north of the DCSX transect. Underwater visibility in the sampling area was frequently seriously impaired by swirls bringing large numbers of tiny bubbles from the sea surface downward, sometimes all the way to the bottom.

The Deep Nearshore Sampling Site, DCSX8m

DCSX8m occupied m70 to m100 on the south side of the DCSX transect. Large boulders and a pinnacle occurred between m90 and m100, but most of the bottom shoreward from m75 to m90 was gravel and small cobble with only a few scattered and half-buried boulders. Large boulders and bedrock outcrops at m70 to m75 formed the base of the small cliff occurring at about m70. The best substrate for the larger Phaeophyta was thus located near the inshore and offshore borders of the sampling area. We often found juvenile and young plants growing on small rocks in the relatively open areas around m80 to m95. Presumably shading from substory canopies was reduced in this zone, but the small rocks did not support the young foliage satisfactorily after it had developed to a point where drag during wave surge caused movement by the underlying pieces of gravel or cobble.

Considerable algal drift accumulated on the flatland between m75 and m90, following storms. Thickness of this loose material was frequently 0.3 to 0.6 m (1 to 2 ft) and prevented detection of any short-statured plants within the swirling masses of debris. We were only able to sample elevated substrates at the end of DCSX or near m70 (not the flatlands in between) during periods when drift was abundant. Problems from drift were minor prior to about 1986 but posed considerable difficulties thereafter.

Wave surge was usually moderate at DCSX8m except during storms and periods of large swell. We never felt warm swirls at this station and presumably it received little or no exposure to plume waters.

The Shallow Offshore Sampling Site, DRSX3m

This Phaeophyta sampling station was situated on the roughly horizontal pile of boulders just north of DRSX, in the lee of Diablo Rock, and mentioned above in the section describing terrain encountered during our swimthroughs (see Figures 5-9 and 5-12). The boulders probably represented material torn loose or eroded from Diablo Rock. Sizes ranged up to about 1 m (3 to 4 ft) in longest dimension. The largest boulders appeared to be stable but we observed overturned stones that were about 0.6 m (2 ft) or less wide, nearly every year following the winter storm season.

Wave surge was more forceful at DRSX3m than at any of the other four Phaeophyta stations. Changes in direction of the surge were frequently very abrupt. Waves usually approached Diablo Rock from a northwesterly direction and would refract around both sides. The water column behind Diablo Rock (and over DRSX3m) thus experienced waves coming from both the north and the south, essentially doubling the frequency for a given wave train impinging on the coast. Suspended material and drift weeds were minimal here and underwater visibility was usually as good or better than elsewhere within Diablo Cove. Elevated temperatures during operational years indicated that plume exposure at DRSX3m was only slightly less compared to the status at DCSX3m.

The Offshore Deepwater Sampling Site, DRSX8m

We noted above that the horizontal portion of DRSX ran along the 7 m (23 ft) depth contour along the south side of the slope formed by the boulder pile in the lee of Diablo Rock (see Figure 5-9). DRSX3m began at the top of this slope, north of DRSX, while DRSX8m was downslope on the south side of the transect, in an approximately horizontal area where boulders were trapped by a pinnacle and a wash rock just southeast from Diablo Rock. Substrate and topography at DRSX8m were thus similar to conditions at DRSX3m. Relief was greater, however, because of occasional bedrock outcroppings projecting up out of the boulder aggregate. Small patches of sand and gravel occasionally accumulated in protected holes and crevices here.

Wave surge at DRSX8m was much more forceful than at a similar depth at DCSX8m, even though the former site lay in the lee of Diablo Rock, guarded by a slope to the north and by a washrock from the south. Some seaweed debris was usually present but never so much that it obscured the bottom as at DCSX8m. Underwater visibility was generally good but slightly poorer than at DRSX3m, where no drift could accumulate. Water temperature was usually cold and close to background at DRSX8m. Traces of slightly warm swirls were occasionally present.

The Control Sampling Site, LRSX8m

This Phaeophyta station served as the primary control for the Phaeophyta survey series. The sampling area lay on a gently sloping bottom, just north of the horizontal portion of the LRSX transect (see Figures 5-10 and 5-12). The bottom somewhat resembled DCSX8m, consisting of boulders and bedrock outcroppings projecting up out of surrounding flat sedimentary substrate (sand at LRSX8m, gravel at DCSX8m). Relief was substantial, ranging from about 0.3 to 2.4 m (1 to 8 ft). The sand level varied somewhat (possibly 0.25 m [10 in.] or so). This variation did not usually lead to permanent large changes in amounts of rocky substrate available for colonization by Phaeophyta. Changes probably occurred with sufficient frequency to prevent colonization by small sporophytes, which require several months for establishment. All available rocky substrate was usually fully covered by plant and animal life, indicating little, if any, influence from the surrounding sand as causing scour or burial. Worm tubes occurred in the sandy areas and served as attachment sites for algae and some animals.

LRSX8m had the calmest sea state conditions of all our Phaeophyta stations. We were able to assess kelp populations here when all the other stations were unworkable because of surge. The site was protected to the west and north by Pup Rock, Lion Rock, and a nearby headland. Curiously, wave surge was extremely forceful at 3 m (10 ft) depths on the shelf abutting the water's edge at Pup Rock. We would have liked to establish a shallow Phaeophyta sampling station here (i.e., LRSX3m) as a control, but surge on the shelf at Pup Rock would simply not have allowed any routine surveying.

We usually found considerable drift and disintegrating material in the vicinity of LRSX8m. Underwater visibility was generally only moderate or poor here near the bottom. Bottom temperatures were always cold and equivalent to background.

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Chapter 6

FIELD and LABORATORY PROCEDURES, DATA PROCESSING

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INTRODUCTION

Sampling design is influenced by objectives of the study as well as by characteristics of the target populations (i.e., organism size, abundance, frequency, distributions, mobility, etc). No single sampling design or method would suffice to collect the desired information on all the species of interest occurring in the Diablo Canyon region. We employed several sampling procedures, each oriented toward collecting as much data as possible with reasonable efficiency, recognizing that some species would be oversampled while others would be undersampled. The differing sampling methods obviously required different approaches to data analysis.

The several sampling methods utilized were directed toward gathering presence/absence and/or abundance information from four major groupings of organisms:

- Intertidal macroflora and fauna (quantitative quadrat sampling)
- Subtidal macroflora and fauna (occurrence along transects)
- Subtidal Phaeophyta (quantitative quadrat sampling)
- Subtidal encrusting biota (collections of solid substrates)

All of this sampling activity occurred at fixed locations or stations (see Table 5-1). We also scanned considerable territory beyond the immediate sampling areas to ascertain whether findings from the stations were representative of conditions elsewhere.

INTERTIDAL FIELD PROCEDURES

Intertidal Transects

Each intertidal survey began by paying out a pre-stretched 6 mm (1/4 in.) diameter polypropylene line across the intertidal zone, precisely aligned by stakes and markers permanently installed for that purpose. The line was fitted with numbered tags at meter intervals. The entire path along the line was scrutinized a meter at a time by at least two investigators (usually WJN and

EKA). A recorder (usually FAC) noted information called by the investigators. The recorder also assisted with observational work.

We sampled the communities quantitatively with a square quadrat, one meter on a side. The quadrat was successively positioned at each meter number along the transect line. One side of the quadrat coincided with the line and the corners were placed directly beneath numbered tags on the line. Transects were usually surveyed from the seaward end shoreward. For most transects the quadrat was positioned on only one side of the line. We shifted sides for some quadrat locations at CDIX and LCIX to accommodate local problems caused by terrain.

The quadrat was subdivided into 0.25 m^2 sections by cross rods to provide reference areas as an aid to estimating coverages. We also used a white plastic card during later surveys, showing squares to depict reference areas of 1, 2, 3, 5, and 10 percent of a m^2. We did not attempt to estimate percent coverages for values less than one percent. We simply recorded an entry of P (present) for the species on the data sheet.

We tallied all macroscopic plants and animals accessible to view or to feeling underneath rocks, without moving any of the boulders or cobbles. Percent cover of each plant and encrusting animal species was estimated by eye within each quadrat. Numbers of individuals were tallied for non-encrusting animals and larger plants such as kelps. When a species was numerous (i.e., more than about 10), total number was merely estimated. Presence was also noted of very small organisms such as Spirorbids, Bryozoans, and juveniles of species easily identifiable as adults. Samples of organisms not identifiable in the field were usually collected for laboratory analysis at a later time. Difficult taxonomic problems were referred to specialists. Percent coverage was also estimated for bedrock, boulder, cobble, gravel, and sand. All intertidal quadrats were individually photographed during or near each winter survey. Boulders and cobbles were normally not moved during surveys, to avoid disturbances. However, in occasional quadrats, two or three easily-moved cobbles were turned over temporarily during a survey to tally organisms underneath. Taxonomic information from beneath rocks was identified by the letter U in our data entries.

A reference collection of representative plants was established at the PG&E Biology Lab at the Diablo Canyon site. In situ identifications and enumerations within quadrats were made by all members of the survey party. Other occasional activities in connection with our transect studies included photographing quadrats, determining upper and lower limits at which species occurred, and performing one-time studies such as charting dimensions of the beach profile.

Only every fifth or tenth quadrat along the transects was examined prior to our survey of November 1970 (except for LCIX on February 5 1970, which was completely analyzed by E. K. Anderson and C. T. Mitchell). All quadrats along the transects from the upper shore to the workable lower limit at water level have been studied from November 1970 onward.

Shorewalks

Our shorewalks involved traversing the entire intertidal shoreline of Diablo Cove from the accessible but steep slopes of the north headland to the base of the elongated promontory forming the Cove's southern edge (Figure 5-7). We examined all areas easily accessible by foot without wading or swimming. A typical shorewalk required about two hours for completion and covered about 900 m (3000 ft) of shoreline (500 m north of the discharge structure and 400 m south). We concentrated our observations on dominant organisms, particularly the cold water species considered most likely to demonstrate changed abundances or distributions from exposure to DCPP effluent (examples were the Red Algae *Iridaea flaccida* and *Gastroclonium coulteri*). We recorded health status and densities in qualitative terms and distributions with respect to elevation of these species above low water. We also noted condition of special situations or unusual populations (e.g., urchins and abalone in a high tidepool on the outer north headland).

For purposes of efficient data recording, we subdivided the Diablo Cove shoreline into 14 major sectors, using easily identifiable landmarks to denote boundaries between sectors (Figure 5-7). Many of the boundaries coincided with locations of the naturally-occurring transitions in major habitats and substrate types (see Figure 5-6). We usually recorded average conditions for an entire sector without attempting to define detailed circumstances on a small scale such as tidepools or similar defined minor habitats. We occasionally photographed interesting assemblages or conditions. A recorder (FAC) wrote down all on-the-spot observations described by the investigators (WJN and EKA). Observations in some instances were recorded on magnetic tape for later transcription to typed notes.

LABORATORY PROCEDURES FOR INTERTIDAL AND SUBTIDAL TRANSECT SAMPLES

Invertebrate Specimens

Invertebrates collected for laboratory identification were processed in three different ways during the course of the study. At first all collections were rinsed in seawater over a 1 mm screen. All trapped material was preserved. Only very small copepods, gastropods, and nematodes were lost. We subsequently eliminated screening, selectively picking obvious invertebrates from the algal samples but probably missing some small well-hidden animals. We ultimately collected and identified only single invertebrates of interest. We ceased picking over algal specimens except for intertidal and subtidal algal and rock substrates supporting encrusting organisms such as bryozoans.

All samples were further processed similarly throughout the study. Sponges, tunicates, some worms, sipunculids, and chitons (if curled up) were segregated, placed in MS-222 (tricaine methanesulfonate, a relaxant) and seawater and refrigerated overnight. Twelve percent buffered formalin was slowly dripped into the container the next day until the relaxed animal no longer responded to probing and was considered dead.

Analyses involved identifying all invertebrates to the lowest possible taxon. Large and heterogeneous samples were first sorted to individual phyla under a dissecting microscope. Each phylum was then sorted to individual groups or species with results entered on standardized laboratory identification sheets (Figure 6-1).

LAB SHEET I of 1 2 3 4 5

Lab Date:________ Job:________ File #:________

LOCALITY:________

SAMPLE DATE:________ DEPTH:________ TYPE: DP SED or ________

STATION:________

GROSS SAMPLE DESCRIPTION:________

REMAINING CONTAINERS:

Rhodophyta Chloronhyta Phaophyta Protista Porifera Coelenterata
"worm-like" Brachiopoda Bryozoa Annelida Arthropoda Mollusca
Echinodermata Tunicata Vertebrata ________

SAVED	Group--Genus--species	Number	Comments
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

Figure 6-1. Sample of the standardized laboratory identification sheet.

Individual identified species or taxa were preserved in 70 percent alcohol with the appropriate labels. Laboratory identification sheets were stored with their related survey data sheets.

Non-identifiable specimens (primarily molluscs, but also annelids, bryozoans, and pagurids) were documented and sent to taxonomic experts. Returned samples received new labels identifying genus and species whenever possible. All invertebrates are either awaiting analysis, in storage with us, or are housed in the PG&E Biology Laboratory Museum at Diablo Canyon.

Algal Specimens

Algal samples were collected as unknowns or for voucher specimens. Unknowns were either preserved in three percent buffered formalin-seawater or taken fresh to our algal expert. Identified voucher samples were pressed, labelled, and stored at Hopkins Marine Station, Stanford University, in Pacific Grove, CA. All pressed algal specimens were transferred to the J. R. Adams Memorial Herbarium at PG&E's Biology Laboratory, Diablo Canyon, in 1980.

New algal unknowns and voucher specimens since 1980 have been identified in the fresh state, immediately pressed, and stored in the herbarium. Crustose corallines and non-coralline crustose algae were collected on rocks, dried, then stored in labelled boxes in the herbarium. Lists of identified algae were kept with the field notes for each survey.

SUBTIDAL FIELD PROCEDURES

Subtidal Transects

Our studies along the subtidal transects were much less detailed compared to work along the intertidal transects. Subtidal operations were inefficient because of wave surge, especially at depths less than 6 m (20 ft). We identified and collected subtidal species, but quantitative enumeration along an entire transect was never attempted. We did, however, evaluate abundances of Phaeophyta (Brown Algae) by haphazardly positioned quadrats, beginning with our survey of December 1982 (see below).

During the early subtidal transect surveys, a nylon transect line with numbered markings every meter, was usually laid out at the start of a survey, as close as possible to previous deployments. We then proceeded along the line, usually from shallow to deep, recording the meter tag where a species was first observed. We tabulated sessile or slowly-moving organisms lying within one meter on either side of the transect line. We recorded presence of motile organisms such as fishes out to the limit of visibility on either side of the line. We also noted presence of any extra-limital organisms of special significance (e.g., abalone, crab, bull kelp) as well as observations of particular interest (e.g., overturned rocks, unhealthy specimens). Surface and bottom temperatures, underwater visibilities, depth of the bottom and the thermocline (if any), and estimates of wave heights and periods were also recorded. Wherever possible, samples of unidentifiable organisms were gathered extra-limitally as needed for laboratory study. Other members of the survey party also assisted by compiling species lists, taking underwater photographs, determining ranges of species, conducting extra-limital observations, and determining bottom profiles.

The DRSX and LRSX transects had well-defined and easily remembered landmarks so that the nylon line could be laid out very close to the same location survey after survey. The DCSX transect was much more complex and we were unable always to restore the nylon line to the same location. We therefore installed a 100 m (330 ft) length of 9.5 mm (3/8 in.) chain at DCSX to mark the transect and ensure that we returned to the same location time after time. We soon memorized the meter locations of various landmarks along the transects. This enabled us to dispense with laying out and recovering the transect line, a task that was time-consuming during rough weather. We established shallow and deep Phaeophyta sampling areas along the transects in 1982. These proved useful for simply identifying whether or not a species observed during a transect survey was occurring in areas exposed to plume waters. We dispensed with the practice of noting the meter number where a species was first observed and simply recorded whether the organism occurred in the shallows, or in deep water, or in both settings.

Rough seas seriously hampered or completely prevented work at one or more stations on a number of visits. At such times, species lists were compiled as best possible, but usually only large and obvious organisms could be observed. Results of any particular survey were thus greatly influenced by oceanic conditions, particularly at shallow depths. The environmental conditions of each survey were important factors to recall when reviewing findings from the survey series.

Phaeophyta Studies

Background Information

Because of their ecological importance in Diablo Cove, a special effort to assess abundances of palm kelps (*Laminaria dentigera* and *Pterygophora californica*) was initiated during our subtidal survey of December 1982 and was continued three times per year through October 1987 for a total of sixteen surveys. Observations along our subtidal transects revealed that dense populations of palm kelps developed on all rocky subtidal substrates around 1976 and 1977, following disappearance of urchins because of predation from sea otters. The palm kelp populations appeared to persist and exhibited great stability year in and year out. Both palm kelp species were considered as cold water forms (especially *Laminaria*), based on their geographic and vertical distributions. We expected that they would be good indicators of presence of heated effluent. Their ecological significance derived from their dominant status as dense stands throughout Diablo Cove and adjacent waters. These stands formed scrub forest habitat that provided shelter, settling substrate, and food for many animals. Canopies of the palm kelps effectively shaded much of the bottom and may have thereby controlled density and species composition of the associated short-statured vegetation. The solid palm kelp structures may have reduced the force of wave surge close to the bottom, enhancing survival by delicate encrusting species. We conjectured that abundances of palm kelp populations could be assessed with relative ease and small effort. A record of abundances at selected locations might be very helpful in assessing ecological effects from DCPP effluent during the operational years.

At first we only tallied occurrences of *Laminaria* and of *Pterygophora*. We soon found that the less-frequent kelps could also be included in the tallies with very little added effort. We thus began counting all species of Phaeophyta commencing with our survey of September 7 1983.

Station Selection Criteria

Five Phaeophyta sampling stations were established to define effluent effects and lack-of-effects in both the horizontal and vertical dimensions. We took advantage of our existing subtidal transects by locating the Phaeophyta stations on or close to these lines (Figure 5-12). Site selection also drew on information provided by the hydrodynamic model describing plume behavior. The model predicted that the plume would exist as a jet stream, exiting Diablo Cove through the southwest channel between Diablo Rock and the south headland. The model also predicted that the plume would lift off the bottom at a depth of 3.5 to 4.5 m (12 to 15 ft).

The shoreward end of our DCSX transect (about 3.5 m deep [11.5 ft]) lay directly in the plume path and was presumed to be a location receiving maximal exposure to effluent in the near field of dispersal. Any plume-related effects would presumably be greatest at this station. All other stations were anticipated as having little or no plume-exposure and were presumed to be controls.

The seaward end of our DCSX transect (8 m or about 26 ft deep) also lay in the near- field plume path but was situated well beneath the predicted lift-off depth. This station thus served as a control site inside Diablo Cove, testing for lack-of-effects, based on the predicted vertical distribution of the plume. Any comparisons between DCSX3m and DCSX8m would, of course, need to take account of the depth differences between the two locations as well as differences in exposure to effluent.

Our DRSX subtidal transect on the east face of Diablo Rock was presumed to lie outside the boundary of the plume just as it exits from Diablo Cove. We selected a shallow (3 m [10 ft] deep) flat area on the north side of our transect here as a control to DCSX3m. This station, DRSX3m, thus did not display the depth difference of our near field control, DCSX8m. DRSX3m thus tested for lack-of-effects based on horizontal features of the plume distribution.

A deep sampling station, DRSX8m, was established on the south side of the Diablo Rock subtidal transect. This station was also presumed as lying both outside and below the plume. Any differences between DRSX3m and DRSX8m would presumably reflect only effects from the depth differences. The comparison would presumably be useful for comparing results from DCSX3m and DCSX8m, where we might need to segregate depth influences from effects of plume exposure. DRSX8m thus tested for lack-of-effects and depth effects.

Our fifth Phaeophyta sampling station was situated about 1.3 km (0.8 mile) northwest from and outside of Diablo Cove. This station, LRSX8m, was located on the north side of our subtidal control transect where it runs easterly from Pup Rock. The sampling area consisted of boulders and ridges projecting up out of the surrounding sandy bottom. Sampling was restricted to rocky portions of the bottom. LRSX8m thus tested for lack-of-effects and depth effects. It served as a backup control to DRSX8m in case the plume did not behave as predicted.

Sampling Methodology

All our sampling stations were selected as displaying dense stands of palm kelps. Estimating abundances by using conventional rigid square quadrats would be very difficult because of physical interferences between the plants and the quadrat frame. We thus employed a technique commonly used for delineating sampling areas in thick kelp stands to avoid interference by the foliage. This alternative method employed a small metal weight subtending a rope one meter long. The weight was tossed to the bottom by blind casting and a full circle was swung with the line, delineating a sampling area of about 3.1 m^2. All Phaeophyta within one m of the weight were identified and counted. We recorded the tallies and repeated the cast until from nine to fourteen replicates (usually ten) had been taken. Plants were considered as lying within the sampling area if any part of the holdfast was included in the one m radius circle.

Studies of Solid Substrates

Encrusting organisms are important ecologically, serving as food for many small herbivores and intermediate carnivores and contributing very substantially to faunal diversity. Many members of the encrusting fauna are filter feeders. As such they depend on plankton productivity for their organic matter. A rich assemblage of encrusters thus provides a pathway that can channel substantial amounts of carbon, nutrients, and energy produced by phytoplankton into nearshore benthic food webs.

As mentioned above, our earliest surveys of Diablo Canyon revealed presence of dense and diverse aggregations of encrusting invertebrates, even during times when urchins dominated much of the bottom. Rich assemblages of encrusters persisted after urchins disappeared and palm kelps created large scrub forests dominating the bottom. Any assessment of these invertebrate assemblages would require considerable effort because of their complexity. From time to time we collected and analyzed fragments of invertebrate turf or encrusters on shells, algae, or stones, to provide some information as to species present. No routine effort, however, was attempted at characterizing the encrusting invertebrates until our subtidal survey of December 1982. At this time we had developed a somewhat crude but relatively simple method for analyzing encrusting organisms in southern California kelp beds. We decided to apply the methodology to our Diablo Cove studies because we obviously were neglecting an important segment of the marine community here. At first we simply sampled for encrusting invertebrates wherever dense aggregates were found along our subtidal transects without respect to depths of the collection sites. At that time we did not observe any important vertical differences in composition of the aggregates. The depth ranges involved were only 3 to 4.5 m (10 to 15 ft) between the shallowest and deepest collecting sites. Marked vertical differences began appearing during operational years, so we altered our sampling procedures. Instead of sampling along the full subtidal transects, we used the Phaeophyta sampling areas within Diablo Cove as collection sites. The Phaeophyta sampling areas provided a means for segregating shallow from deep collections. The control transect, LRSX, did not show any marked vertical difference in encrusting organisms during operational years. We therefore continued to sample the same portion of this transect throughout the survey series (a location about 3 to 6 m [10 to 20 ft] deep along the upper part of the cliff here).

Our sampling methodology was designed simply to establish presence or absence of the important (i.e., commonest) components of an encrusting assemblage. No attempt was made to quantify abundances or frequencies of occurrence of any encrusting species. A typical collection would bring in numerous colonies or individuals of the important encrusting species present. Analyses of a series of collections reveals presence of these common species in survey after survey. If a common species eventually disappears entirely as the survey series continue, this change becomes apparent in the long- term record.

The exact size of a given collection varied according to characteristics of the components and was not an overridingly important factor in the subsequent analysis. From experience, we attempted to gather enough material from each site (i.e., small cobbles, shells, fragments of turf, bits of seaweed, etc.) to require roughly four to six hours of effort for laboratory identification. In other words, processing effort determined our sample sizes. A reasonably diverse collection yielded about 50 to 100 species. All organisms seen were identified whenever possible. For common species such as those found among Bryozoans, Spirorbids, and Mollusca, dozens of occurrences would require separate identifications within material from one collection at one site.

A typical collection might include five to ten small cobbles plus a cupful of algal fragments, samples of arborescent species, sponges, hydroids, small crustaceans, and mollusks. The material was rinsed to remove loosely attached debris and sediment. The collection was spread out to dry for several days. Drying hindered or prevented identification of a few species (primarily Polychaeta), but most could be processed satisfactorily. Identifications were made with a low power (9X and 54X) stereoscopic microscope except for small structures such as sponge spicules that required a compound microscope for appropriate visualization.

TEMPERATURE ANALYSES

We selected a technique for graphing daily water temperatures that displayed each datum in conjunction with the ten-year mean value for that day. This display furnished a reference standard (the ten-year mean) that permitted an assessment of whether the actual temperature was high, low, or about average for that particular day (James et al., 1987). The technique has proven useful for identifying and characterizing anomalous conditions such as El Niños (North et al., 1984).

We selected those recording stations from the PG&E network of temperature recorders which gave the longest continuous temperature records. Data were obtained from records gathered at subtidal stations IS-15 in Diablo Cove, 19-10 in South Cove, and 01-10 north of Diablo Cove (Figure 6-2). Most of the preoperational data came from the recorder at IS-15 while 19-10 furnished most of our operational data (Table 6-1). Two different types of instruments were utilized for gathering data during the ten year period, with somewhat different characteristics (Table 6-2). We discontinued use of data from IS- 15 after 1982 because this station lay immediately offshore from the discharge structure and would presumably be affected by power plant ascension testing in 1984 and full-scale operations from 1985 onward. We switched to data from 19-10 as our primary source, depending on data from 01-10 to fill in gaps in the record.

Table 6-1: Summary of the temperature data sources and periods for which each source was utilized for developing our graphs of daily 0800 ocean temperatures in the Diablo Canyon region.

Station	Period	Instrument Type	Comments
IS-15	1977 to 1981	ENDECO Type 109	
IS-15 or 19-10	1982	ENDECO Sea Data	19-10 filled gaps in IS-15
19-10	1983 to 1985	Sea Data	
19-10 or 01-10	1986	Sea Data	01-10 filled gaps in 19-10

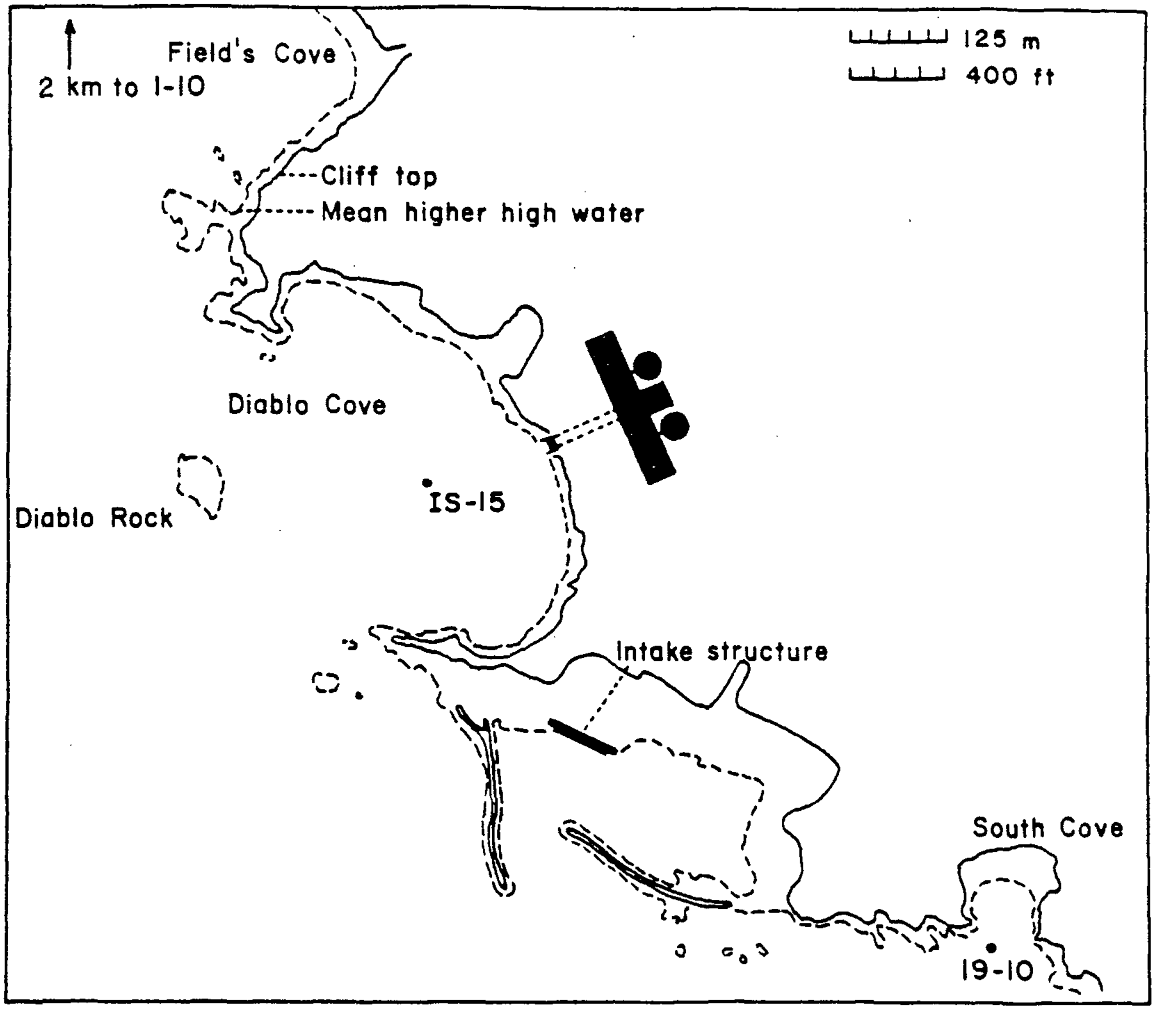

Figure 6-2. Diablo Cove chart showing location of temperature recording stations.

Table 6-2: Characteristics of the two types of temperature recording instruments providing data utilized for developing our graphs of daily 0800 background ocean temperatures in the Diablo Canyon region. (manufacturer's specifications).

Instrument	Accuracy	Resolution	Response Time	Recording Interval	Timing Accuracy
ENDECO	0.2 °C	0.10 °C	10 min.	60 min.	50 ppm
Sea Data	0.1 °C	0.01 °C	1 min.	20 min.	30 ppm

The automated recording units at these stations were periodically serviced and calibrated per standards traceable to the National Bureau of Standards. To facilitate comparisons with ocean temperature measurements from other sites along the Pacific coast, the daily 0800 values were extracted from records for each station. To fill gaps in the database, data from the three stations were combined as necessary according to the following procedures.

Mean temperatures were computed for each station for periods of between-station overlap. Because the IS-15 station yielded the largest fraction of the record, data from 19-10 which filled the IS-15 gaps were adjusted toward IS-15 values by the difference between computed overlap means if that difference exceeded 0.5°C. Data from 01-10 intended for filling gaps from 19-10 were adjusted toward 19-10 by identical methods. Daily long-term means were computed after the gaps were filled. Some gaps remained after patching. The years 1984, 1985, and 1986 had more than ten percent of the yearly record missing. The largest missing fraction occurred for 1985.

SPECIAL STUDIES

Opportunities arose from time to time to conduct a few small-scale studies to provide information helpful for interpreting results from our principal monitoring activities or to contribute additional data that would add to our understanding of the biological changes we were observing. We will briefly discuss the purposes of these special studies and the methodology involved in conducting them.

Shorewalk of Field's Cove

The purpose of this shorewalk was to compare by qualitative observations the status of intertidal biota in Field's Cove with similar populations in Diablo Cove. Field's Cove was an indentation about the same size as Diablo Cove and lying immediately adjacent thereto towards the northwest (Figure 6-1). The shorewalk occurred on May 16 1987 at a season when maximal foliage was usually displayed by many of the common algal species. We had observed substantial declines in abundances among some of these species in the Diablo Cove intertidal. We wished to determine if similar losses had developed in Field's Cove. Assuming that any losses were minor, we also intended to scrutinize the biota in Field's Cove for possible early indications of deterioration. This would tell us whether or not ecological effects from DCPP operations were confined to Diablo Cove. Methods used were similar to those described above for our shorewalks in Diablo Cove.

<u>Examining Life Stages of *Iridaea flaccida*</u>

Intertidal monitoring within Diablo Cove during 1986 and 1987 had indicated that abundances of a common Red Algal species, *Iridaea flaccida*, had noticeably decreased. Curiously, remaining plants continued to appear healthy. We wondered if perhaps effluent from DCPP was selectively affecting one or more life stages of *I. flaccida*. If so, the sensitive stage (or stages) may have disappeared but the sturdy stage(s) might have remained. We collected samples of about 20 adult *I. flaccida* plants from both Diablo Cove and the northern part of Field's Cove on May 16 1987. The collections were kept refrigerated for several days until we were able to examine them microscopically in the laboratory to determine relative proportions of the three life stages in the samples.

<u>Transplanting *Laminaria* Kelp</u>

The large palm kelp, *Laminaria dentigera*, was considered to be a cold water species and likely to be a good indicator of effects from exposure to heated effluent. Extensive investigations of thermal tolerances of a number of plant and animal species from Diablo Cove, including *Laminaria*, had been conducted by the Thermal Effects Monitoring Program (TEMP). These studies were performed under laboratory conditions, holding organisms at various constant temperatures. We extended the TEMP studies by transplanting four to five *Laminaria* plants to Newport Bay in southern California during the winters of 1985 and 1986. Water temperatures in Newport Bay range around 15°C (59°F) during winter, rising to 20 to 23°C (68 to 73°F) during summer (i.e., values probably tolerated by *Laminaria* during winter but very likely fatal during summer). Our transplant experiment thus repeated the TEMP studies in a field situation where temperatures gradually changed. This might allow some opportunity for accommodation to elevated temperatures by the test plants, if such a process were possible.

The transplants were collected from our subtidal stations in Diablo Cove during our regular December subtidal surveys. They were packed in ice chests for transport to Newport Bay. Plants were then placed in running seawater at the Kerckhoff Marine Laboratory until they could be outplanted to a location 3 m (10 ft) deep in the nearby bay. This site was the intake seawater pipe of the laboratory. Outplanting consisted of simply tying plant holdfasts to the pipe so that the stipes and blade crowns assumed a generally upright attitude. The transplants were inspected every few weeks and their status recorded. Plant healthiness was correlated with temperature by means of daily measurements of the laboratory running seawater system.

DATA PROCESSING

Intertidal Transects

Raw data were entered onto standardized waterproof sheets (Figure 6-3) as a survey proceeded. Each sheet represented a single quadrat from a given transect. Data sheets were reviewed following each survey, then photocopied, with copies transmitted to PG&E and to all investigators. Data were entered into computer data files, then verified. Computer listing by species or similar category, along with abundance estimates, location, and date of each particular datum were generated from the raw computer data files. The listing provided the basis for compiling species lists.

Based on our field experiences, we arbitrarily selected those species considered suitable for further analysis. Species selected were those recalled as being most common and frequent along the transects. This selection process yielded a second list of about 80 "commonest" species. Tables were compiled for each of these select species for each station, showing quadrat

Page ____ of ____ [Quadrat] Page ____ of ____ [Station]

Job: ______________________________ : Seq. #: ____________ Date: __________

Station: ______________________________ : Quadrat #: ____________ Time: __________

Persons: ______________________________ : Quadrat Size: ____________ [1 M ^{2} Standard]

Side of Transect Sampled [looking offshore]: Left Right || Photo Taken: [yes] [no]

Notes / Comments: ____

% Cover	PLANTS		Number	ANIMALS
- -		1	- -	-
- -		2	- -	-
- -		3	- -	-
- -		4	- -	-
- -		5	- -	-
- -		6	- -	-
- -		7	- -	-
- -		8	- -	-
- -		9	- -	-
- -		10	- -	-
- -		11	- -	-
- -		12	- -	-
- -		13	- -	-
- -		14	- -	-
- -		15	- -	-
- -		16	- -	-
- -		17	- -	-
- -		18	- -	-
- -		19	- -	-
- -		20	- -	-
- -		21	- -	-
- -		22		
- -		23		% SAND [< 0.3 cm.]
- -		24		% GRAVEL [< 6.5 cm.]
- -		25		% COBBLE [< 25.6 cm.] **
- -		26		% BARE ROCK [ONLY Types **]
- -		27		% BEDROCK [ ] **
		28	# %	# BOULDERS [> 25.6 cm.] **
	Total # Plant Entries			Total # Animal Entries

Seq. #

Copied ______

Figure 6-3. Sample of field data sheet for intertidal quadrat data.

number in the left column and survey data along the top row. There was a different table for each species. The estimated abundance for a species within a given quadrat was entered in each cell of the table (Figure 6-4). Each table thus provided a history of abundances and vertical distributions of a given select species. All the tables constituted a compendium of the commonest and presumably most important organisms at each station. Only 66 species yielded records with enough data entries to justify further analysis. It should be noted that this group did not include all species likely to be impacted by heated effluent because our selection process had removed "uncommon" species from consideration. We justify omitting the uncommon species on the premise that there were not sufficient data to decide whether a given organism in this category was or was not sensitive (i.e., behavior of abundance and distribution comparing pre-operational and operational). Some of the uncommon intertidal species such as *Laminaria* and *Pterygophora* were sufficiently abundant subtidally to allow assessment during operational years.

Data from the 66 selected species were analyzed on the PG&E mainframe computer system utilizing Release 5.61 of SAS (Statistical Analysis System, SAS Institute, Cary, NC). Raw data files were uploaded to the mainframe from diskettes under TSO. Data sets representing individual station/survey combinations were concatenated to form compiled station data sets. Mass storage thus involved four large raw data sets representing all data from each individual intertidal station. Magnetic tape backup copies of each were also archived.

All data analyses used custom-written SAS-based programs. A permanent SAS data set was created from all the intertidal data prior to analysis. This data set contained one observation for each datum in the original data set and was extremely large, encompassing more than 70,000 SAS observations. All analyses were performed on the permanent SAS data sets, which also corresponded to the individual intertidal stations. Species/survey tables were compiled for select species and cluster analyses yielded spatial distributions of select species through time at each station.

ABUNDANCE OF SELECT SPECIES ALONG THE LCIX TRANSECT 15:31 THURSDAY, MARCH 3, 1988 177
CA ONE KM NORTHWEST FROM THE DIABLO CANYON POWER PLANT.
QUADRATS WERE ONE METER SQUARE.
P DESIGNATES PRESENT.

SPECIES=IRIDAEA FLACCIDA

QUADRAT	FEB 77	MAY 77	OCT 77	MAR 78	MAY 78	OCT 78	DEC 78	MAY 79	SEP 79	DEC 79
4	.	.	2	.	.	1	.	1	1	P
5	.	.	.	.	P	.	.	.	.	.
6	P	.	1	.	1	4	1	P	.	1
7	.	.	5	.	2	2	P	2	20	2
8	30	20	50	5	20	30	10	70	50	30
9	40	60	50	15	60	30	30	60	78	60
10	30	50	50	20	50	40	40	40	72	60
11	30	70	60	20	40	40	40	60	72	60
12	30	50	50	20	40	30	50	70	62	80
13	40	80	50	20	70	30	60	70	69	40
14	10	20	20	5	20	.	10	30	47	.
15	10	20	20	1	15	.	10	20	31	.
16	10	50	40	5	40	.	30	40	47	.
17	20	20	3	1	20	.	5	5	12	.
18	10	10	8	P	5	.	5	10	8	.
19	10	20	8	5	15	.	10	10	22	.
20	.	80	56	30	50	.	50	60	66	.
21	.	P	8	.	20	.	5	.	.	.
22	.	.	.	.	10	.	5	.	.	.
23	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.

QUADRAT	MAY 80	AUG 80	DEC 80	MAY 81	OCT 81	JAN 82	APR 82	SEP 82	DEC 82
4	.	.	P	.	.	.	P	3	1
5	.	.	.	.	.	.	.	.	.
6	P	4	2	.	10	P	2	10	.
7	P	22	.	P	4	1	P	4	2
8	20	70	10	50	20	20	65	50	30
9	40	80	30	70	60	40	60	50	40
10	50	70	50	50	60	20	45	50	20
11	50	50	25	30	50	15	30	60	30
12	60	60	40	50	30	20	60	50	30
13	30	80	30	40	30	30	65	60	40
14	.	20	10	30	10	10	12	20	10
15	.	10	5	10	5	5	27	15	5
16	.	60	10	30	20	20	50	40	10
17	.	20	5	10	10	3	12	.	5
18	.	10	.	10	10	5	13	.	5
19	.	15	.	10	10	10	17	.	10
20	.	60	.	60	40	30	80	.	40
21	.	.	.	.	15	10	.	.	10
22	.	.	.	.	.	5	.	.	.
23	.	.	.	.	.	2	.	.	.
24	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.

QUADRAT	APR 83	DEC 83	DEC 84	AUG 85	DEC 85	APR 86	DEC 86	AUG 87	DEC 87
4	.	.	.	P	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.
6	P	.	P	P	P	P	.	1	.
7	.	1	P	4	P	.	P	1	P
8	10	5	20	60	10	20	20	50	20
9	30	10	30	90	20	20	20	60	30
10	20	15	30	50	10	15	30	60	30
11	20	10	20	40	20	15	20	40	10
12	40	20	30	60	50	30	40	70	15
13	30	20	40	50	30	30	30	70	20
14	5	15	10	30	15	.	10	10	10
15	2	3	5	20	3	.	15	20	5
16	20	10	10	30	10	.	20	50	10
17	10	10	5	30	15	.	20	40	10
18	P	1	5	20	15	.	15	30	10
19	30	15	20	40	20	.	30	60	10
20	40	40	30	60	60	.	30	60	20
21	10	.	10	20	20	.	.	.	.
22	.	.	P	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.

Figure 6-4. Sample of the tabular display developed for each of about 66 intertidal select species. The table format provided a display showing historical trends and vertical distributions for each select species along a given transect.

Species/station tables were produced from permanent SAS data sets using several variations on the SAS FREQ Procedure. Qualitative measures of abundance, such as "present" were converted to 0.1. This standardized the data and eliminated mixing of numeric and character variables in SAS.

Further analyses of our intertidal transect data utilized two approaches, one objective, the other subjective. The objective method involved examining the data for each selected species by clustering analysis. The resulting dendrograms were assessed for evidences of tight clustering by the operational surveys, producing a branching aggregate within the dendrogram that was clearly separate from preoperational surveys. The subjective approach involved reviewing the entire data set for each selected species and deciding whether large changes in abundances or in vertical distributions were associated with the operational years. Results from the two approaches are presented in Chapter 9. Any conflicting findings are either resolved or discussed in Chapters 9 and 13.

Cluster analyses of individual species distributions utilized a SAS program based largely on the procedures CLUSTER and TREE. Abundance data were transformed to presence/absence by converting all non-zero values to 1.0; all others remained at zero. The resulting data matrix was "zero-filled", permitting analysis in the absence of entries treated by SAS as "missing values". The distance measure was Euclidean Distance, largely due to properties of the presence/absence matrix. We treated several clustering algorithms in the final TREE Procedure and all produced comparable results. We selected nearest neighbor as the algorithm of final choice.

The SAS procedures and SAS data management techniques are documented in SAS Users Guide, Version 5 Edition (SAS Institute, Inc., Box 8000, Cary, NC 27511-8000).

Although the clustering analyses were objective procedures, interpretation of results involved a subjective element, namely deciding whether a given dendrogram represented substantial change, no change, or an intermediate status. We adopted a ranking scheme that classified the dendrograms into six categories (ranging from 0 = no change, to 5 = conclusive change; Table 6-3, Figures 6-5a to 6-5f). Where a conclusive change was indicated, however, the dendrogram provided no information on direction of the change (i.e., enhancement or depression of a species). Likewise the dendrograms did not identify causes of changes (i.e., vertical shifting of distributions, changes in abundances, disappearances or appearances within quadrats or zones of the intertidal). Our subjective reviews of the data identified causes and nature of any changes involved. Thus the two analytical methods complemented each other to a large extent, rather than acting competitively.

Table 6-3: Basis for rankings assigned to the cluster analyses for our selected intertidal species from the Diablo Canyon region.

Ranking	Meaning	Basis
	NO CHANGE DURING OPERATIONAL YEARS	
0	Positively no change	Random chronological ordering of surveys, no clustering relationships among later surveys
1	Probably no change	Clustering and chronological distributions of surveys fairly random
2	Slight trend, no change	Weak groupings and clustering among later years
	CHANGE DURING OPERATIONAL YEARS	
3	Slight trend, change	Some groupings of later surveys, no clear clustering relationships
4	Probably a change	1 or 2 groupings of later surveys, some chronological ordering, possibly weak clustering relationship
5	Positive change	Strong groupings of later years with chronological ordering and strong clustering relationships

Where conflicts between conclusions from the two methods occurred, data and analyses were reviewed carefully to identify causes of the disagreement. The commonest reason for conflicts involved those species undergoing large changes in abundances. Our initial clustering analyses utilized the data as presence/absence, not taking account of any variations in abundance. Problems also arose from data sets containing several surveys where a species did

BIOSTAT II: HIERARCHICAL CLUSTER ANALYSIS (VER. 2.2)

"Sta. LCIX: PETRO FRAN . Quant. Data

Quad Range USED 7 to 16 for Total of 10: Range WITH data 1 to 21
TOTAL Quads with Data = 347: # Dropped 130: 37.5%

Surveys 24 : Dropped 5 if < 0 Quads below 16
DROP Surveys =: S 8-7604: S14-7810: S18-7912: S19-8005: S37-8604

Audit: Prg CSVtoDEK: V. 1.6b: Date/Time 09-06-1988/05:24:51

NUMBER OF INDIVIDUALS = 24 NUMBER OF VARIABLES = 10

METHOD: GROUP AVERAGE (UNWEIGHTED PAIR GROUP METHOD USING ARITHMETIC AVERAGES)
ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST

PAIRING SEQUENCE:

ITEM	JOINS ITEM	AT DIST.	ITEM	JOINS ITEM	AT DIST.
3	22	109.544	5	7	114.017
3	15	125.483	5	9	128.443
11	20	129.615	11	13	166.075
12	14	178.885	3	8	180.941
11	21	186.313	17	23	198.242
16	19	203.961	5	11	212.976
12	18	229.927	3	5	232.064
3	12	255.098	4	6	271.477
3	17	301.183	10	24	315.753
3	4	321.494	10	16	386.593
3	10	403.791	2	3	476.731
1	2	530.139			

COPHENETIC CORRELATION COEFFICIENT = 0.673313

DENDROGRAM

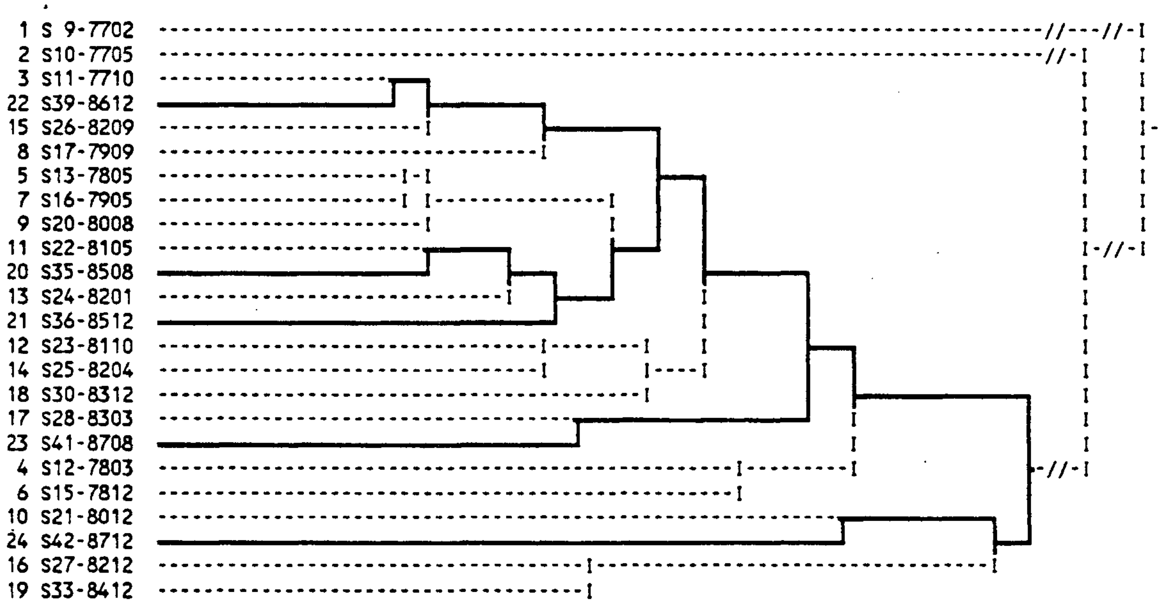

Figure 6-5a: RANK 0 dendrogram: Conclusively no evidence of clustering by surveys from the operational years. *Petrocelis franciscana* at LCIX

BIOSTAT II: HIERARCHICAL CLUSTER ANALYSIS (VER. 2.2)

"Sta. LCIX: IRIDAEA FLAC Quant. Data

Quad Range USED 4 to 17 for Total of 14: Range WITH data 4 to 23
TOTAL Quads with Data = 404: # Dropped 133: 32.9%

Surveys 23: Dropped 6 if < 0 Quads below 17
DROP Surveys =: S 8-7604: S14-7810: S18-7912: S19-8005: S26-8209: S37-8604

Audit: Prg CSVtoDEK: V. 1.6b: Date/Time 09-06-1988/05:20:49

NUMBER OF INDIVIDUALS = 23 NUMBER OF VARIABLES = 14

METHOD: NEAREST NEIGHBOR (SINGLE LINKAGE, MINIMUM)
ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST

PAIRING SEQUENCE:

ITEM	JOINS ITEM	AT DIST.	ITEM	JOINS ITEM	AT DIST.
1	15	250.831	4	17	258.147
1	18	282.092	13	23	309.903
1	13	319.556	16	20	325.632
1	16	328.030	1	21	346.906
1	4	375.920	1	10	380.584
2	5	490.000	11	19	506.908
3	7	546.000	14	22	546.180
3	14	559.124	1	6	579.607
1	2	582.979	3	11	588.833
1	12	621.858	1	3	655.613
1	9	672.000	1	8	699.440

COPHENETIC CORRELATION COEFFICIENT = 0.581109

DENDROGRAM

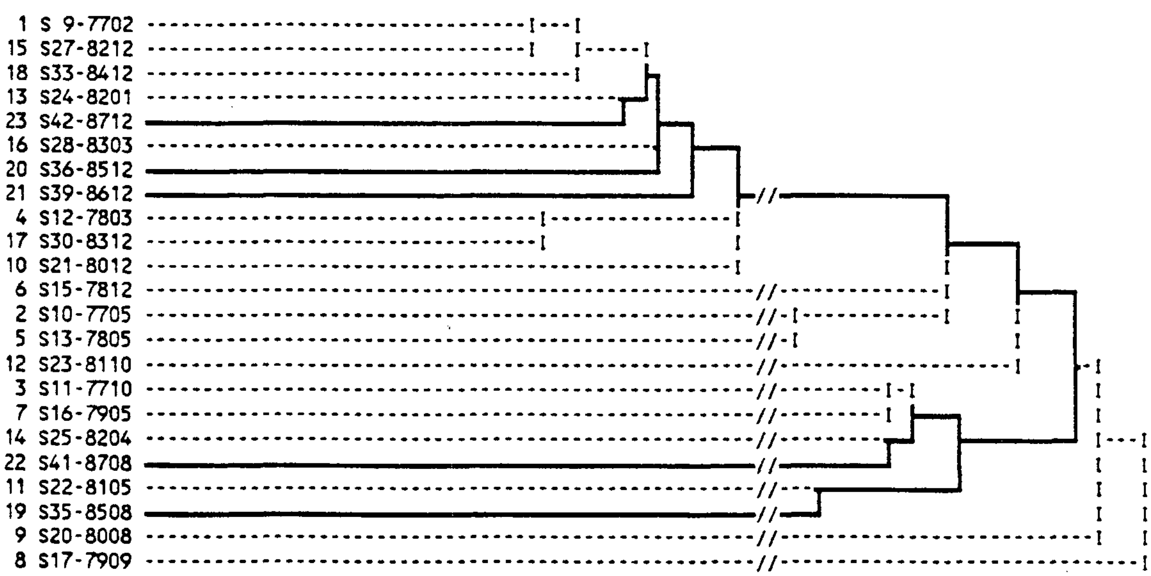

Figure 6-5b: RANK 1 dendrogram: No evidence of clustering among surveys from the operational years. *Iridaea flaccida* at LCIX.

```
BIOSTAT II:  HIERARCHICAL CLUSTER ANALYSIS (VER. 2.2)

"Sta. LCIX:  GASTRO COULT                                                    BINARY Data

Quad Range USED 7 to 17 for Total of 11:                   Range WITH data 7 to 19
   TOTAL Quads with Data = 139:                            # Dropped  23:      16.5%

# Surveys  23:      Dropped 6  if < 0  Quads below 17
DROP Surveys =:     S 8-7604: S14-7810: S18-7912: S19-8005: S26-8209: S37-8604

Audit: Prg CSVtoDEK: V.  1.6b:  Date/Time 09-06-1988/04:50:57

         NUMBER OF INDIVIDUALS =  23                       NUMBER OF VARIABLES =  11
         METHOD:  MINIMUM VARIANCE (WARD'S SUM OF SQUARES)
         ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST
```

PAIRING SEQUENCE:

ITEM	JOINS ITEM	AT DIST.	ITEM	JOINS ITEM	AT DIST.
3	7	0.000	9	12	0.000
6	13	0.000	10	14	0.000
1	16	0.000	1	17	0.000
6	20	0.000	19	21	0.000
19	23	0.000	2	5	11.000
4	15	11.000	8	9	14.667
3	18	14.667	11	22	15.556
2	10	21.056	4	8	22.622
2	11	24.906	2	6	28.233
1	3	30.223	4	19	39.433
2	4	44.265	1	2	56.560

COPHENETIC CORRELATION COEFFICIENT = 0.454144

DENDROGRAM

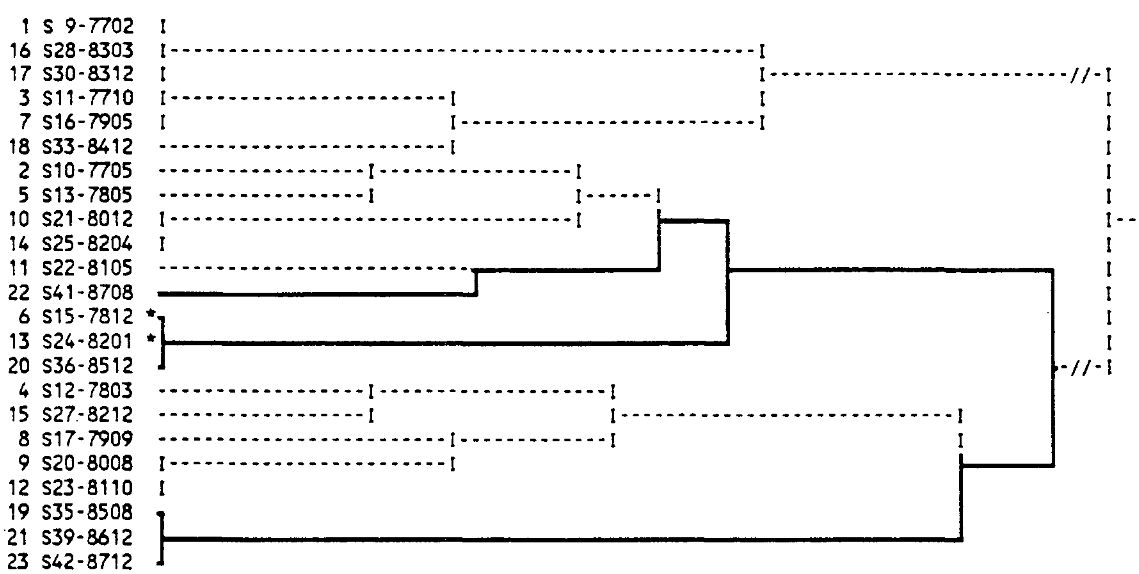

Figure 6-5c: RANK 2 dendrogram: Weak clustering by surveys for operational years, no chronological ordering. *Gastroclonium coulteri* at LCIX

BIOSTAT II: HIERARCHICAL CLUSTER ANALYSIS (VER. 2.2)

"Sta. SDIX: GASTRO COULT BINARY Data

Quad Range USED 27 to 42 for Total of 16:
TOTAL Quads with Data = 255:

Range WITH data 27 to 52
Dropped 150: 58.8%

Surveys 31: Dropped 4 if < 0 Quads below 42
DROP Surveys =: S 9-7702: S12-7803: S14-7810: S17-7909

Audit: Prg CSVtoDEK: V. 1.6a: Date/Time 09-06-1988/03:33:30

NUMBER OF INDIVIDUALS = 31 NUMBER OF VARIABLES = 16
METHOD: MINIMUM VARIANCE (WARD'S SUM OF SQUARES)
ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST

PAIRING SEQUENCE:

ITEM	JOINS ITEM	AT DIST.	ITEM	JOINS ITEM	AT DIST.
2	4	0.000	2	5	0.000
9	10	0.000	2	14	0.000
7	19	0.000	18	22	0.000
21	23	0.000	24	25	0.000
18	26	0.000	18	27	0.000
18	28	0.000	21	29	0.000
24	30	0.000	6	31	0.000
3	6	21.333	7	17	21.333
7	20	21.980	8	11	22.627
1	13	22.627	12	15	27.713
1	16	29.408	1	12	30.465
1	8	37.756	3	24	43.961
1	9	48.922	18	21	60.000
3	7	65.900	1	2	75.572
3	18	94.192	1	3	173.811

COPHENETIC CORRELATION COEFFICIENT = 0.547429

DENDROGRAM

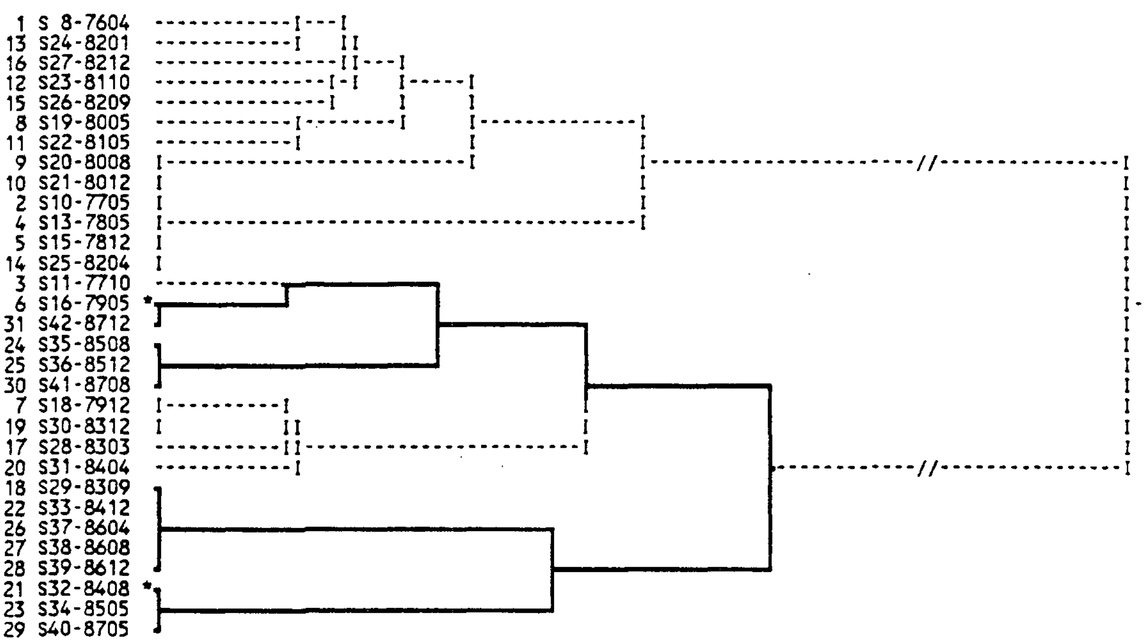

Figure 6-5d: RANK 3 dendrogram: Weak clustering by surveys for operational years, no chronological ordering. *Gastroclonium coulteri* at SDIX

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---------------------------------------------------------------------------
BIOSTAT II:  HIERARCHICAL CLUSTER ANALYSIS (VER. 2.2)
---------------------------------------------------------------------------

"Sta. CDIX:  GASTRO COULT                                                  BINARY Data

Quad Range USED 12 to 39 for Total of 28:               Range WITH data 12 to 39
         TOTAL Quads with Data = 88:                    # Dropped  0:       0.0%

# Surveys  16:     Dropped 0  if < 0  Quads below 39
DROP Surveys =     NONE

Audit: Prg CSVtoDEK: V.  1.6a:  Date/Time 09-06-1988/03:57:41

        NUMBER OF INDIVIDUALS =  16                     NUMBER OF VARIABLES =  28
        METHOD:  MINIMUM VARIANCE (WARD'S SUM OF SQUARES)
        ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST
```

PAIRING SEQUENCE:

ITEM	JOINS ITEM	AT DIST.	ITEM	JOINS ITEM	AT DIST.
2	4	0.000	2	7	0.000
2	8	0.000	2	9	0.000
2	10	0.000	11	14	0.000
11	16	0.000	1	3	28.000
12	15	28.000	2	6	48.000
1	5	49.397	12	13	49.397
11	12	68.498	1	2	99.556
1	11	220.921			

COPHENETIC CORRELATION COEFFICIENT = 0.670701

DENDROGRAM

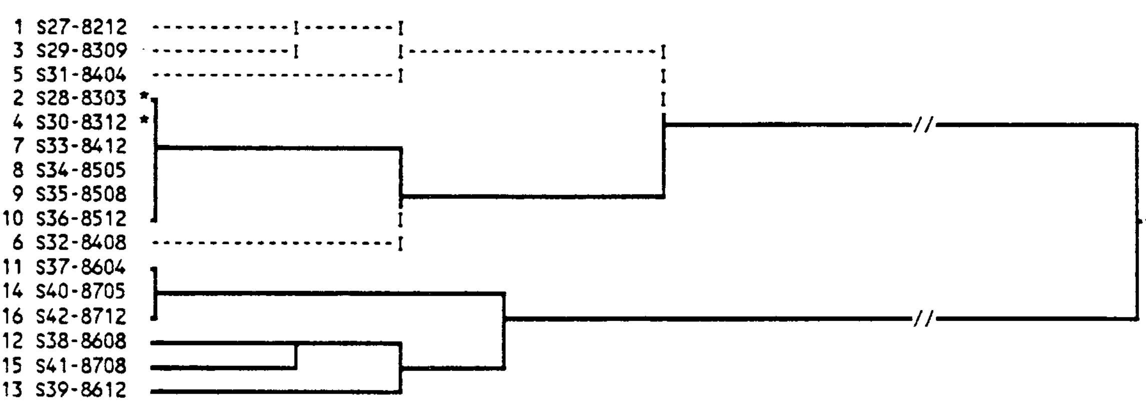

Figure 6-5e: RANK 4 dendrogram: Clustering of surveys for operational years, some chronological ordering, but some association with El Niño years. *Gastroclonium coulteri* at CDIX

```
BIOSTAT II: HIERARCHICAL CLUSTER ANALYSIS (VER. 2.2)

"Sta. NDIX:  GASTRO COULT                                                     BINARY Data

Quad Range USED 18 to 23 for Total of 6:                  Range WITH data 18 to 32
         TOTAL Quads with Data = 263:                     # Dropped  187:    71.1%

# Surveys  35 :    Dropped 0  if < 0  Quads below 23
DROP Surveys =     NONE

Audit: Prg CSVtoDEK: V.  1.6a:  Date/Time 09-06-1988/04:24:45

         NUMBER OF INDIVIDUALS =  35                      NUMBER OF VARIABLES =   6

         METHOD:  MINIMUM VARIANCE (WARD'S SUM OF SQUARES)
         ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST
```

PAIRING SEQUENCE:

ITEM	JOINS ITEM	AT DIST.	ITEM	JOINS ITEM	AT DIST.
4	5	0.000	4	6	0.000
4	10	0.000	8	11	0.000
4	12	0.000	4	13	0.000
7	14	0.000	15	16	0.000
15	17	0.000	7	19	0.000
7	20	0.000	7	21	0.000
7	22	0.000	7	24	0.000
7	25	0.000	15	26	0.000
27	28	0.000	27	29	0.000
30	31	0.000	27	32	0.000
30	33	0.000	30	34	0.000
30	35	0.000	8	9	8.000
1	3	8.485	18	23	8.485
2	15	9.600	7	18	12.412
1	8	15.125	1	27	20.940
2	4	30.202	1	30	31.404
1	7	45.191	1	2	62.018

COPHENETIC CORRELATION COEFFICIENT = 0.644736

DENDROGRAM

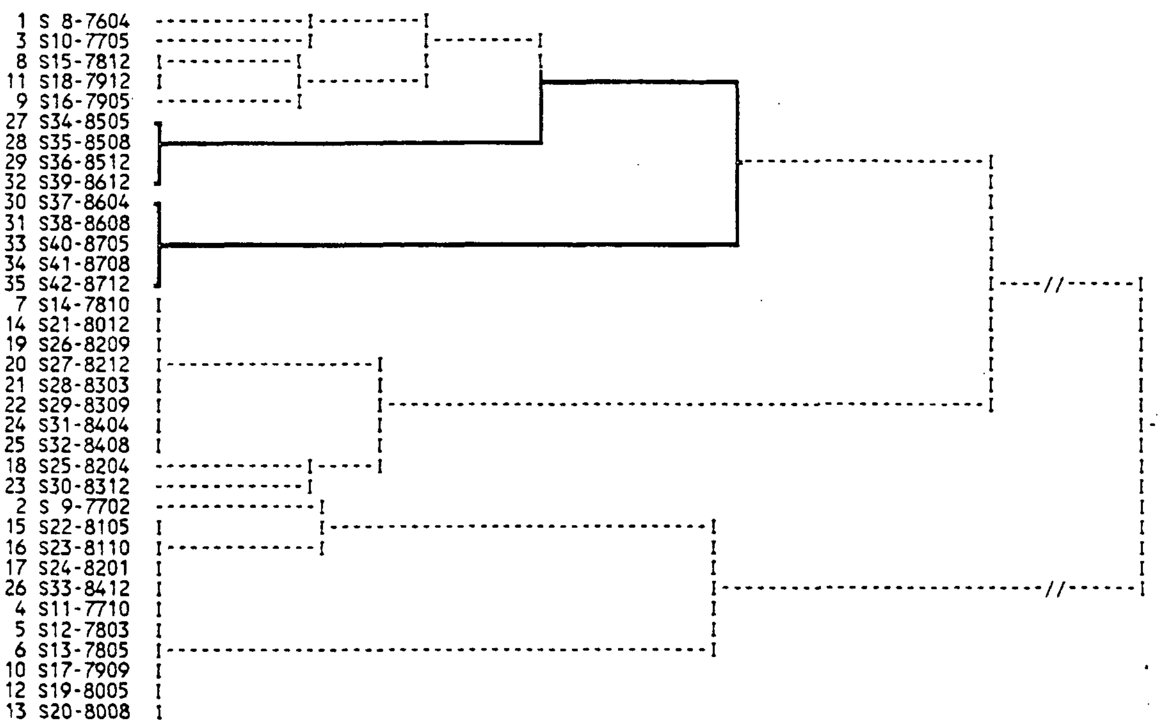

Figure 6-5f: RANK 5 dendrogram: Five later operational surveys tightly clustered, good separation from El Niño surveys. *Gastroclonium coulteri* at NDIX

not occur (so-called zero surveys). Zero surveys were most frequent among sparsely-distributed species. Zero surveys were not passed to the programs used for clustering analyses. The dendrograms were thus deficient for those species where zero surveys were common. Omission of zero surveys sometimes affected conclusions (for example, where an influence might be associated with disappearance of a species).

Dendrograms of species dwelling at low intertidal levels were sometimes affected by truncation of the lower part of the data base. Truncation was a process of assuring that the number of quadrats entering computations of a dendrogram remained constant from survey to survey (a prerequisite for this type of analysis). It may be recalled that the lowest quadrat examined along a transect varied from survey to survey because of differing tide levels and wave action. Truncation eliminated this source of variability. Effects from truncation on analysis of a species living in the low intertidal could be lessened by eliminating from the computations those few surveys that did not extend well down into the lowest regions of a transect. The optimum solution involved balancing loss of information from truncating against loss of information from eliminating surveys. Fortunately most of the surveys subject to elimination were from the preoperational period, where we had an abundance of data available.

We employed single-linkage clustering with Euclidean distance as our primary clustering methodology. Data were entered in a presence/absence (binary) format. We also tested other methodologies for selected taxa to compare performances and results, entering the data both in binary form and as quantitative abundance estimates. The methodologies tested were clustering by group average and minimum variance; principal component analysis; and, detrended reciprocal averaging. We found that the results from all methodologies were usually similar for those species showing extreme rankings (i.e., scores of 0-1 or 4-5 for the scheme given in Table 6-3). The additional methods were helpful for adding definition to a few species whose categorization was difficult for reasons cited above and for separating El Niño effects from changes occurring during the operational years.

Many species still remained in the uncertain classifications (i.e., scores between 1 and 4 in Table 6-3). Hopefully our follow-on studies will allow resolution of the status of a substantial fraction of these uncertain species.

A few of the dendrograms failed to separate El Niño from operational surveys although the combination may have been distinct from the pre-1983 surveys. This pattern presumably resulted from a sensitive species that was affected by El Niño, with effects persisting during the operational years. In such cases, we referred to the data table and dendrogram for that species from the control station, LCIX, in hopes of resolving the dilemma. If there were no El Niño effects or if only El Niño effects were apparent in the clustering pattern for a dendrogram from LCIX, we concluded that operations at DCPP may have affected that particular species.

Subtidal Transects

Presence of a given species observed during a subtidal survey was noted on a standardized data sheet (Figure 6-6) printed on waterproof paper (Nalgene Polypaper®). Each sheet represented a single field day. Station location was identified by a letter placed after the species name (A=DCSX, B=DRSX, C=LRSX). Species encountered but lacking preprinted names on the data sheet were written down in pencil in situ. All the field data sheets from a given survey were later combined into a master listing for that survey. Both the field sheets and the master listings were processed for data verification, then utilized to prepare a computer listing. This listing provided the basis for compiling species lists.

Summary tables were obtained from the computer listing showing presence or absence of each species for the entire survey series, segregated according to station. A secondary table was derived from the computer, listing the number of occurrences for each species and station during the pre-1983, 1983-84, and post-1984 periods. These numbers were reviewed to decide if there were indications that El Niño and/or DCPP operations had affected occurrence of a given species at a given station. Examples of specific analyses are shown in Table 6-4 to illustrate our processing method.

Bryopsis	Acarnus	Chaetop	Balanus	Anisotremus
Cladoph	Astylin	Dexio	Cancer	Atherinid
Codium	Axinella	Diopatr	Caprell	Brachvist
Ulva	Cliona	Dodeca	Crangon	Cheilotre
	Cyamon	Eudisty	Idothea	Chromis
Colpomen	Halichon	Eupomat	Loxorhy	Citharic
Cystose	Haliclo	Phragma	Lysmata	Coryphop
Desmares	Hymenam	Phylloch	Pagurid	Cymatogas
Dictyop	Isocion	Pista	Panulir	Damalic
Dictyot	Leucetta	Sabellid	Pugetti	Embiotoca
Ectocar	Leuconia	Salmaci	Scyra	Girella
Egregia	Leucosol	Serpulid		Gymnothor
Eisenia	Microcio	Telepsav	Astrome	Halichoer
Laminar	Plocamia		Astrope	Heterost
Macrocy	Plocamis	Acmaea	Cucumar	Hypsurus
Pachydic	Rhabdo	Aletes	Dendras	Hypsypops
Pterygop	Sphecio	Anisodor	Dermast	Medialuna
Sargass	Tedanio	Archidor	Henricia	Mola
Taonia	Tethya	Aplysia	Leptast	Ophiodon
Zonaria	Tetilla	Astraea	Lytechin	Oxyjulis
	Verongia	Burchia	Linckia	Oxylebius
Acrosor	Xestosp	Cadlina	Ophioder	Paralab c
Anisoclad		Calliost	Ophiothr	Paralab n
Botryocl	Aglaoph	Chama	Orthast	Paralic
Bossiel	Anthopl a	Chione	Parastic	Phanero
Calliar	Anthopl e	Conus	Pisast b	Rhacochi
Calloph	Anthopl x	Crepid	Pi gig	Scorpaena
"	Astrang	Cyanopl	Pi och	Scorpaeni
Coelosi	Balanoph	Dendrod	Pycnopod	Sebastes
Coral o	Cactoso	Dialula	Stron f	"
Coral v	Corynac	Fissur	Stron p	"
Cryptone	Epiactis	Flabell	**Patiria**	Semicoss
Cryptopl	Lophogor	Glossod	Amarou	Seriphus
Gelidium	Murice c	Haliot	Archid	Urobatis
"	Murice f	"	Boltenia	
Gigart	Pachycer	"	Chelysoma	
"	Paracy	Hermiss	Clavellina	
"	Pelagia	Hinnites	Cystodites	
Gloioph	Renilla	Jaton	Didemnum	
Gracill	Stylatu	Kelletia	Didemnid	
Laurencia	Tealia	Leptopec	Eudistoma	
"		Megathu	Euherdmania	
Leptocl	Antropo	Mitra	Metandrocarpa	
Lithoth	Aplousi	Mitrella	Pycnoclavella	
Microcla	Bugula	Norrisia	Pyura	
Neoagard	Cellaria	Octopus	Ritterella	
Neoptilo	Crisia	Olivella	Styela	
Opuntie	Costaz	Pholad	Trididemnum	
Pevsonn	Diapero	Polinices		
Plocamium	Hippodi	Pododesmus		
Polyneura	Hippopo	Tegula		
Polyopes	Lagenip	Zonaria		
Polysiph	Membran			
Prionitis	Phidolo			
"	Rhyncoz			
Pterocladia	Scrupoc			
Pterosiphonia	Thalamoporella			
Rhodymenia ca	Victorella			
Rhodymenia pa		Phyllospadix		

Figure 6-6. Sample of the standard sheet used for tallying species along our subtidal transects.

Table 6-4: Examples of occurrences of certain species along our subtidal transects, illustrating the basis for concluding whether or not an organism was affected by DCPP operations.

Species	Station	Percent of Occurrences pre-83	El Niño	post 84	Conclusions
Tethya	DCSX	100	100	100	
aurantia	DRSX	33	100	33	No effects at DCSX or LRSX
(sponge)	LRSX	91	100	67	
Astraea	DCSX	75	0	17	
gibberosa	DRSX	100	50	33	El Niño effect, possibly
(snail)	LRSX	82	0	33	some post-El Niño recovery
Dictyota sp.	DCSX	50	50	0	
(brown	DRSX	67	0	0	El Niño and DCPP depression at
seaweed)	LRSX	9	0	17	DRSX, DCPP depress. at DCSX
Oxyjulis	DCSX	17	50	50	
californicus	DRSX	8	100	83	El Niño, DCPP enhancement
(fish)	LRSX	0	100	17	
Leucetta	DCSX	0	0	17	
losangelensis	DRSX	0	0	33	DCPP enhancement at DCSX
(sponge)	LRSX	0	0	0	and DRSX during latter 1987

Shorewalks and Swimthroughs

Recorded observations from our shorewalks, as well as field notes prepared following swimthroughs, have all been presented in the report series *Environmental Investigations at Diablo Canyon*, published each year by D.E.R. of PG&E. We will not repeat all this material in the present report but will draw on descriptive information contained therein, as needed to explain or support findings and conclusions from our other studies.

Solid Substrate Analyses

Standardized data sheets were employed to receive species tallies from the preserved collections being processed in the laboratory (Figures 6-7a and 6-7b). Master listings for each station were compiled from the data sheets, showing all survey dates when a given species

Region______________ Station______________ Coll. Date __________ Anal. Date__________ Anal. Hrs.______

1. Aetea anguina
2. Aetea ligulata
3. Aetea recta
4. Aetea truncata
5. Antropora tincta
6. Aplousina sp
7. Arthropoma cecili
8. Bicellaria sp
9. Bugula sp
10. Callopora armata
11. Callopora circumclathrata
12. Callopora horrida
13. Caulibugula ciliata
14. Caulibugula sp
15. Cauloramphus spiniferum
16. Cauloramphus echinus
17. Cellaria mandibulata
18. Chapperia patula
19. Coleopora gigantea
20. Colletosia radiata
21. Costazia robertsoni
22. Costazia sp
23. Crisia maxima
24. Crisia occidentalis
25. Crisia sp
26. Crisulipora occidentalis
27. Diaporoecia californica
28. Disporella californica
29. Disporella sp
30. Electra crustulenta
31. Fasciculipora pacifica
32. Fenestrulina malusi
33. Filicrisia franciscana
34. Filicrisia geniculata
35. Filicrisia sp
36. Heteropora sp
37. Hincksina alba
38. Hincksina sp
39. Hincksina velata
40. Hippodiplosia insculpta
41. Hippopodina sp
42. Hippoporella gorgonensis
43. Hippoporella nitescens
44. Hippoporina porcellana
45. Hippothoa sp
46. Holoporella brunnea
47. Lagenipora punctulata
48. Lagenipora sp
49. Lichenopora novae-zealandi
50. Lichenopora sp
51. Lyrula hippocrepis
52. Membranipora fusca
53. Membranipora membranacea
54. Membranipora tuberculata
55. Membranipora villosa
56. Micropora coriacea
57. Microporella californica
58. Microporella ciliata
59. Microporella cribrosa
60. Microporella setiformis
61. Microporella umbonata
62. Microporella vibraculifera
63. Mucronella major
64. Parasmittina californica
65. Parasmittina collifera
66. Parasmittina sp
67. Parasmittina trispinosa
68. Pherusella brevituba
69. Plagioecia sarniensis
70. Plagioecia sp
71. Porella porifera
72. Puellina setosa
73. Retevirgula areolata
74. Rhyncozoon grandicella
75. Rhyncozoon rostratum
76. Rhyncozoon spicatum
77. Rhyncozoon tumulosum
78. Schizomavella auriculata
79. Schizoporella cornuta
80. Schizoporella linearis
81. Schizoporella sp
82. Schizoporellidae
83. Schizotheca fissurella
84. Scrupocellaria bertholetti
85. Scrupocellaria diegensis
86. Scrupocellaria sp
87. Scrupocellaria varians
88. Smittina cordata
89. Thalamoporella californica
90. Tricellaria sp
91. Tricellaria ternata
92. Tubulipora concinna
93. Tubulipora pacifica
94. Tubulipora sp
95. Tubulipora tuba
96. Unident. Ascophora
97. Veleroa veleronis
98. Victorella sp

Figure 6-7a. Sample of the standard sheet used for tallying Bryozoan species from our analyses of subtidal solid substrates.

Region ______	Station ______	Coll. Date ______	Anal. Date ______	Anal. Hrs. ______

1. Cladophora sp
2. Enteromorpha sp
3. Ulva sp
4. Unident. green nodule
5. Ectocarpus sp
6. Dictyota sp
7. Ralfsia sp
8. Acrosorium uncinatum
9. Antithamnion sp
10. Antithamnionella sp
11. Bossiella sp
12. Callithamnion sp
13. Centroceras clavulatum
14. Ceramium sp
15. Corallina sp
16. Haliptylon gracile
17. Heterosiphonia sp
18. Hildenbrandia occidentalis
19. Hildenbrandia sp
20. Lithothamnium sp
21. Peyssonellia sp
22. Platysiphonia sp
23. Platythamnion sp
24. Polysiphonia sp
25. Pterocladia media
26. Pterosiphonia dendroidea
27. Pterosiphonia pennata
28. Rhodoptilum plumosum
29. Rhodymenia californica
30. Rhodymenia sp
31. Tiffaniella snyderiae
32. Gromia oviformis
33. Unident. Foraminifera
34. Anaata sp
35. Cliona celata
36. Cyamon argon
37. Esperiopsis sp
38. Haliclona permollis
39. Haliclona sp
40. Hymedesmiidae
41. Leucandra heathi
42. Leucilla nuttingii
43. Leucosolenia eleanor
44. Leucosolenia macleyi
45. Leucosolenia nautilia
46. Leucosolenia sp
47. Myxilla sp
48. Ophlitaspongia pennata
49. Plocamia karykina
50. Prosuberites sisyrnus
51. Abietinaria sp
52. Aglaophenia sp
53. Balanophyllia elegans
54. Muricea sp
55. Paracyathus stearnsi
56. Plumularia sp
57. Sertularella sp
58. Sertularia sp
59. Unident. Hydroid
60. Eupomatus sp
61. Hydroides pacificus
62. Mesochaetopterus taylori
63. Paradexiospira vitrea
64. Phyllochaetopterus prolifica
65. Protolaeospira capensis
66. Serpulidae
67. Spirorbis bifurcata
68. Spirorbis rothlisbergi
69. Spirorbis spatulatus
70. Telepsavus costarum
71. Unident. Polynoidae
72. Acmaea sp
73. Basilochiton heathii
74. Callistochiton crassicostatus
75. Callistochiton palmatus
76. Crepidula sp
77. Crepipatella lingulata
78. Entodesma sp
79. Hiatella arctica
80. Ischnochiton sp
81. Kellia laperousi
82. Leptopecten latiauritus
83. Lepidozona sp
84. Petaloconchus compactus
85. Pseudochama exogyra
86. Serpulorbis squamigerus
87. Siliquaria sp
88. Spiroglyphis lituella
89. Unident. Chiton
90. Balanus sp
91. Tetraclita squamosa
92. Unident. Caprellid
93. Unident. Gammarid
94. Unident. Isopoda
95. Unident. Paguridae
96. Unident. Sphaeromidae
97. Unident. Tanaidacea
98. Ophiothrix spiculata
99. Unident. Ophiuroidea
100. Chelysoma producta
101. Didemnum carnulentum
102. Trididemnum opacum

Figure 6-7b. Sample of the standard sheet used for tallying encrusting species other than Bryozoans from our analyses of subtidal solid substrates.

occurred. We reviewed the master lists in similar fashion to the reviews of the summary tables, as described above for analyses of data from our subtidal transects (see Table 6-4).

Phaeophyta Analyses

Our Phaeophyta sampling studies yielded only nine species, so the data base was much simpler compared to material compiled from our other major studies. The data included abundance estimates, not just presence/absence information. This allowed us to conduct a more sophisticated analysis than was possible for our subtidal transect and solid substrate data bases.

We first reviewed the Phaeophyta data base to assess which species occurred with sufficient frequency and abundance to support further analytical studies. Two species (*Laminaria* and *Pterygophora*) provided good data bases at all stations, capable of supporting quantitative analyses. *Cystoseira* data were initially substantial at all stations except DCSX8m. We hoped, if possible, to use inferential statistics to assess stabilities and trends in the populations of these three species.

We began by examining characteristics of the numerical distributions for abundance data from these three species to determine if there were serious departures from normality. These assessments were carried out only on the preoperational portions of the data. Tests included the following:

- Kolmogorov-Smirnov test of goodness-of-fit to normality
- Tests for correlations between means and variances
- Bartlett's test of variance homogeneity
- One-way ANOVA test of population stability
- Examination of overall distributions for skewness and unimodality

Treatment of the complete data sets (i.e., including both pre-and-operational surveys) was accomplished by tabular and graphical presentations. Means and 95 percent confidence intervals were computed and plotted as a function of time.

Temperature Analyses

Prior to calculation, temperature data were multiplied by ten to eliminate the decimal point. Data for all February 29 readings were removed from the data base. Computations were then performed using a two-byte INTEGER format in PDP-FORTRAN/77 on a DEC PDP 11/24 minicomputer. Plots were generated with the California Institute of Technology plotting/analysis program MAGIC (authored by Dr. R.C.Y. Koh).

Chapter 7

QUALITY ASSURANCE and PROCEDURAL QUESTIONS

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Figures

Tables

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INTRODUCTION

We have noted that certain features of our investigations were modified as time progressed. The modifications were generally intended to improve quality of the studies or to solve problems not perceived initially, or in some cases arising from events beyond our control. We also initiated ancillary activities from time to time, oriented toward quality improvement or for quality assessment. These studies and topics form a heterogeneous assortment, usually with little or no common resemblances other than their connection to the necessity of ensuring optimal quality. They are discussed below without any particular ordering as to importance or priority.

SPECIES OVERSIGHTS AND REPEATABILITY OF COVERAGE ESTIMATES

Possibilities always exist that an investigator will fail to record one or more species present in a quadrat or along a transect, especially for complex environments crowded with a variety of organisms. The problem is more severe for underwater work where time is limited, communication with partners is restricted, and environmental conditions may interfere with or otherwise affect observations. One can only hope to improve one's capabilities to discern undersea organisms, by experience and diligence. We attempted to reduce species oversights in our intertidal studies by having at least three individuals scanning the quadrats. We investigated the likelihood of occurrence of oversights during one survey by repeating scanning of quadrats a few minutes after the initial perusal. Presumably this allowed sufficient time for the observer to forget the precise details of the quadrat contents. We did not attempt to identify all the species present on the second set of examinations. We concentrated only on two dominant Red Algae in the Diablo intertidal, *Gastroclonium* and *Iridaea flaccida*. One observer (WJN) failed to detect small amounts of the target species six times out of the 109 duplicate quadrats (i.e., 218 quadrat casts). With two observers (EKA and WJN), oversights fell to three for the 109 replicated quadrats.

We also investigated repeatability of our coverage estimates in this same experiment with duplicated quadrats. Identical coverage values were obtained from 46 of the 109 replicates (WJN observer). The mean difference between duplicates for all quadrats was slightly less than four percent. The maximum difference between duplicates was 20 percent (for example, estimates of 30 and 50 for percent covers from a pair of replicate quadrats). Differences as high as 20 percent occurred for only three quadrat pairs. Differences for 102 of the 109 were 10 percent or less. Comparisons between two observers (WJN and EKA) yielded a maximum difference of 15 percent for three of 102 quadrats duplicated and a mean difference of slightly more than four percent. Repeatability thus seemed satisfactory. We reduced possibilities for between-observer errors by having the same individual (WJN) primarily responsible for calling percent coverages for plants. Animal coverages were almost always estimated by two observers (WJN and EKA).

CALIBRATION OF PERCENT COVERAGE ESTIMATES

As noted elsewhere, we regularly estimated percent cover for many plant and animal species in our intertidal quadrats simply by viewing the populations and comparing their coverages to fixed areas of known dimensions (i.e., the one m^2 quadrat itself, or its two subdivisions of 0.5 m^2 and 0.25 m^2, and, in later surveys, to a card showing areas of 0.1, 0.05, 0.03, 0.02, and 0.01 m^2). We assessed possible errors in our methodology by performing similar areal estimates on irregularly shaped flat pieces of cardboard of known area. This calibration study was somewhat deficient in that many of the areas we estimated in our field studies were three dimensional (e.g., plant cover on rounded cobble/boulder), but the calibration study examined two dimensional objects. The latter study nonetheless provided indications as to whether our estimates contained large errors, whether we had a tendency to underestimate or overestimate areas, whether magnitude of any error was related to size of the estimated area, and if there were large differences between the two principal observers (EKA and WJN).

We undertook calibration studies on May 14 1987 and August 8 1987 at a flat spot on the NDIX transect at the 6m tag, to simulate the actual survey environment as closely as possible. Our standard quadrat was first positioned on the flat spot. Irregularly shaped pieces of white cardboard were sequentially placed in a haphazard order within the quadrat and their areas estimated by the two observers. One group of estimates was conducted before dawn, using flashlights for illumination (i.e., our normal surveying procedure during hours of darkness). We repeated the estimates after sunrise. Each observer recorded his estimate independently without informing the other. Areas of the cardboard pieces had been previously determined but neither observer knew the values. The largest single cardboard piece was 0.37 m^2 (Table 7-1a). We first used single pieces but later employed several pieces to produce areas greater than 0.4 m^2 (termed "multiples" in Tables 7-1b & 7-1c).

Both observers tended to overestimate moderately the areas of pieces, regardless of size. The patterns of values from illumination by flashlight (Figure 7-1) were similar to those obtained under sunlight (Figure 7-2). Calculated regression lines for each observer and illumination source were similar (Table 7-2). Correlation coefficients ranged from 0.990 (WJN combined sunlight studies) to 0.994 (EKA sunlight on May 14) for the several regressions. Variation of error size as a function of cardboard size depended on the way errors were computed. We defined "relative" error as a percentage value (error divided by cardboard size times 100). "Absolute" error was simply the error value (estimated area minus actual area of a cardboard). Small cardboard pieces often yielded very high relative errors but never large absolute errors (i.e., an 0.01 m^2 cardboard estimated as being 0.02 m^2 would have a relative error of 100 percent but an absolute error of only 0.01 m^2). Alternatively, large cardboard pieces were sometimes associated with high absolute errors but never with substantial relative errors (i.e., an 0.3 m^2 cardboard estimated as being 0.35 m^2 would have a relative error of 17 percent and an absolute error of 0.05 m^2.

Table 7-1a: Areal estimates by two observers for single odd-shaped pieces of white cardboard under two conditions of illumination (sunlight and flashlight) at m-6, a flat spot, on our NDIX transect. Pieces were set within an one m^2 quadrat in an haphazard order. Numbers indicate percent of the quadrat that was covered by the cardboard. Actual = true area of cardboard: Obs. = estimated as recorded by the observer: p = estimated as present at <1%.

	Flashlight		Sunlight			Flashlight		Sunlight	
Actual	WJN Obs.	eka Obs.	WJN Obs.	eka Obs.	Actual	WJN Obs.	eka Obs.	WJN Obs.	eka Obs.
0.3	p	0.3	p	0.3	0.6	0.5	0.9	0.5	0.7
0.6	p	0.7	p	0.6	0.7	0.5	0.9	p	0.6
0.9	p	0.6	p	0.5	0.9	0.5	0.5	p	0.7
1.1	1	p	p	0.5	1.1	1	0.8	1	1
1.2	1	0.9	1	0.9	1.3	1	1	1	0.8
1.5	1	1.7	1	1.4	1.5	1	1.8	1	1.1
1.5	1	1.3	1	0.8	1.6	2	1.7	1	1.1
1.6	1	2	1	0.9	1.7	1	1	2	1.2
1.7	1	1.4	1	1.1	1.7	1	1.2	1	1.8
1.8	1	1.8	1	1.2	1.9	2	2.7	2	1.8
2.0	1	2.5	2	1.9	2.1	3	1.8	2	1.3
2.1	1	2.5	2	2	2.3	2	4.1	3	2.4
2.4	3	4	2	2	2.6	2	2.8	3	2.3
2.7	3	2.1	2	2.1	2.8	2	3	4	2.2
3.0	3	4.6	5	2.3	3.0	5	4.1	3	2.1
3.1	2	4	3	2.7	3.1	5	7	3	3
3.3	5	6	5	3.2	3.4	5	6	5	2.5
3.4	3	4	5	3	3.5	3	4	5	2.6
3.6	5	7	5	5	3.6	3	7	5	3
3.9	5	5	3	4	3.9	5	5	5	2.8
3.9	5	5	5	3.8	4.0	3	7	5	4.5
4.3	5	8	5	4	4.5	5	8	5	4.1
4.5	5	8	5	6	4.6	5	7	5	5
4.6	5	4.7	7	5	5.2	5	9	7	5.1
5.3	5	9	5	6	5.3	10	9	5	5
5.4	10	8	10	6	5.6	10	9	5	5
5.6	5	8	5	3.2	5.8	5	9	5	5
5.9	5	9.7	7	6	6.0	5	7	5	5.2
6.6	5	11	7	8	7.0	10	9.8	7	6
7.7	10	11	5	8	7.9	10	10	10	9
8.1	10	13	5	8	8.8	10	10	10	9
9.1	10	14	10	10	9.1	10	12	10	11
9.1	10	15	10	12	9.5	10	12	10	10
9.6	10	11	10	12	9.9	15	14	15	11
10.0	15	13	10	12	10.1	10	13	10	11
10.2	10	13	10	11	11.3	15	12	10	10
11.7	15	18	10	15	12.2	15	18	15	11
12.3	20	22	15	16	12.4	15	17	12	13
14.0	20	19	15	13	14.5	20	20	20	18
15.0	15	19	15	12	15.6	20	23	20	17
16.7	25	25	20	21	16.8	25	20	20	19
16.8	20	18	20	20	18.4	25	22	20	18
19.7	25	24	25	18	20.1	20	23	20	23
20.3	20	27	25	22	22.0	25	24	25	23
23.3	30	33	25	26	29.8	30	40	25	31
33.0	30	39	30	44	36.8	40	44	40	42
37.2	40	47	40	42					

Table 7-1b: Areal estimates by two observers for multiple odd-shaped pieces of white cardboard under two conditions of illumination (sunlight and flashlight) at m-6, a flat spot, on our NDIX transect. Pieces were set within an one m^2 quadrat in an haphazard order. Numbers indicate percent of the quadrat that was covered by the cardboard. Actual = true area of cardboard: Obs. = estimated as recorded by the observer.

	Flashlight		Sunlight			Flashlight		Sunlight	
Actual	WJN Obs.	eka Obs.	WJN Obs.	eka Obs.	Actual	WJN Obs.	eka Obs.	WJN Obs.	eka Obs.
13.1			20	18	40.8	50	49		
45.4	50	48			47.4			50	51
49.0	50	61			53.3			60	59
54.2	60	68			56.2	50	58		
57.1	60	70			57.8	60	56		
58.8			70	62	58.8	60	60		
61.0	70	65			65.1	80	71		
66.0	80	72							

PHOTOGRAPHY

35 mm color photographs were taken of each intertidal quadrat during the winter surveys. The photographs provided a means for visually checking on past conditions in case questions arose regarding species identifications or percent coverages or we wished to apply new methods of assessing the status quo. Originals of the slides were delivered to the Department of Engineering and Research of PG&E. Duplicate slides were retained by the responsible investigator (EKA).

TAXONOMIC PROBLEMS

Difficult or questionable identifications were resolved by referring sample specimens to specialists (Table 7-3). Voucher specimens were placed in the reference collection of PG&E's Diablo Canyon Biological Laboratory.

A number of populations encountered in the field consisted of closely similar species that either required laboratory work for proper identification or careful scrutiny involving considerable effort if numerous individuals were involved. For most such cases we simply recorded the genus

Table 7-1c: Areal estimates by two observers for multiple odd-shaped pieces of white cardboard under sunlight illumination near the stairway at north Diablo Cove on 8 August 1987. Pieces were set within an one m^2 quadrat in an haphazard order. Numbers indicate percent of the quadrat that was covered by the cardboard. Actual = true area of cardboard: Obs. = estimated as recorded by the observer: Del. = error of actual - observed.

	WJN->		EKA->			WJN->		EKA->	
Actual	Obs.	Del.	Obs.	Del.	Actual	Obs.	Del.	Obs.	Del.
24.3	25.0	.7	28.0	3.7	24.8	25.0	.2	22.0	-2.8
25.0	25.0	.0	25.0	.0	26.6	30.0	3.4	26.0	-.6
27.4	35.0	7.6	19.0	-8.4	29.0	35.0	6.0	33.0	4.0
29.6	40.0	10.4	30.0	.4	29.7	40.0	10.3	44.0	14.3
29.9	40.0	10.1	30.0	.1	30.4	35.0	4.6	30.0	-.4
32.0	30.0	-2.0	35.0	3.0	32.1	35.0	2.9	33.0	.9
32.9	40.0	7.1	40.0	7.1	32.9	45.0	12.1	30.0	-2.9
32.9	35.0	2.1	38.0	5.1	33.3	30.0	-3.3	35.0	1.7
35.1	50.0	14.9	38.0	2.9	35.5	45.0	9.5	28.0	-7.5
35.8	40.0	4.2	45.0	9.2	35.9	40.0	4.1	45.0	9.1
36.0	50.0	14.0	45.0	9.0	36.1	40.0	3.9	41.0	4.9
36.3	40.0	3.7	38.0	1.7	36.4	35.0	-1.4	40.0	3.6
37.2	45.0	7.8	34.0	-3.2	37.6	40.0	2.4	40.0	2.4
37.8	60.0	22.2	40.0	2.2	37.8	35.0	-2.8	38.0	.2
38.1	35.0	-3.1	38.0	-.1	39.0	35.0	-4.0	40.0	1.0
39.1	35.0	-4.1	38.0	-1.1	39.2	40.0	.8	42.0	2.8
39.4	40.0	.6	44.0	4.6	39.6	40.0	.4	38.0	-1.6
39.9	40.0	.1	40.0	.1	40.0	40.0	.0	45.0	5.0
41.0	40.0	-1.0	44.0	3.0	41.8	40.0	-1.8	45.0	3.2
42.8	40.0	-2.8	55.0	12.2	43.9	50.0	6.1	49.0	5.1
44.3	50.0	5.7	50.0	5.7	44.7	45.0	.3	50.0	5.3
45.1	45.0	-.1	44.0	-1.1	45.5	70.0	24.5	45.0	-.5
45.6	55.0	9.4	55.0	9.4	46.2	60.0	13.8	60.0	13.8
47.3	50.0	2.7	55.0	7.7	47.4	60.0	12.6	65.0	17.6
47.6	60.0	12.4	53.0	5.4	48.6	60.0	11.4	55.0	6.4
49.5	45.0	-4.5	48.0	-1.5	49.7	45.0	-4.7	60.0	10.3
50.3	60.0	9.7	47.0	-3.3	50.3	50.0	-.3	55.0	4.7
50.9	50.0	-.9	50.0	-.9	51.0	60.0	9.0	55.0	4.0
51.2	50.0	-1.2	55.0	3.8	51.5	55.0	3.5	60.0	8.5
51.7	60.0	8.3	65.0	13.3	52.1	70.0	17.9	65.0	12.9
52.4	70.0	17.6	60.0	7.6	52.9	60.0	7.1	63.0	10.1
53.5	60.0	6.5	55.0	1.5	55.4	70.0	14.6	70.0	14.6
57.0	60.0	3.0	70.0	13.0	57.6	55.0	-2.6	65.0	7.4
57.7	70.0	12.3	70.0	12.3	59.0	60.0	1.0	76.0	17.0
60.4	70.0	9.6	70.0	9.6	60.5	70.0	9.5	72.0	11.5
60.6	75.0	14.4	60.0	-.6	62.6	70.0	7.4	70.0	7.4
64.7	80.0	15.3	80.0	15.3	68.5	80.0	11.5	80.0	11.5
69.5	70.0	.5	80.0	10.5	71.5	80.0	8.5	82.0	10.5

because we were unable to mount the field effort needed to distinguish the species involved. Common examples were hermit crabs and some barnacles. Most of these problem populations consisted primarily of one species with perhaps a few representatives of a second similar species. A few groups of organisms such as crustose corallines could not be correctly and consistently identified to species in the field and would have required considerable effort for laboratory identification. We simply lumped these species into loose categories (i.e., crustose corallines) for our analyses. There were a few species that were easily distinguished when full-grown and intact (i.e., *Gelidium coulteri* and *G. pusillum*, *Bossiella* spp. and *Calliarthron*), but were difficult to separate when pruned down or eroded during storms. We consequently combined these into inclusive categories. The "select" group of about 70 intertidal species used for our analyses contained nine plant and eight animal groupings considered as problem populations (Table 7-4).

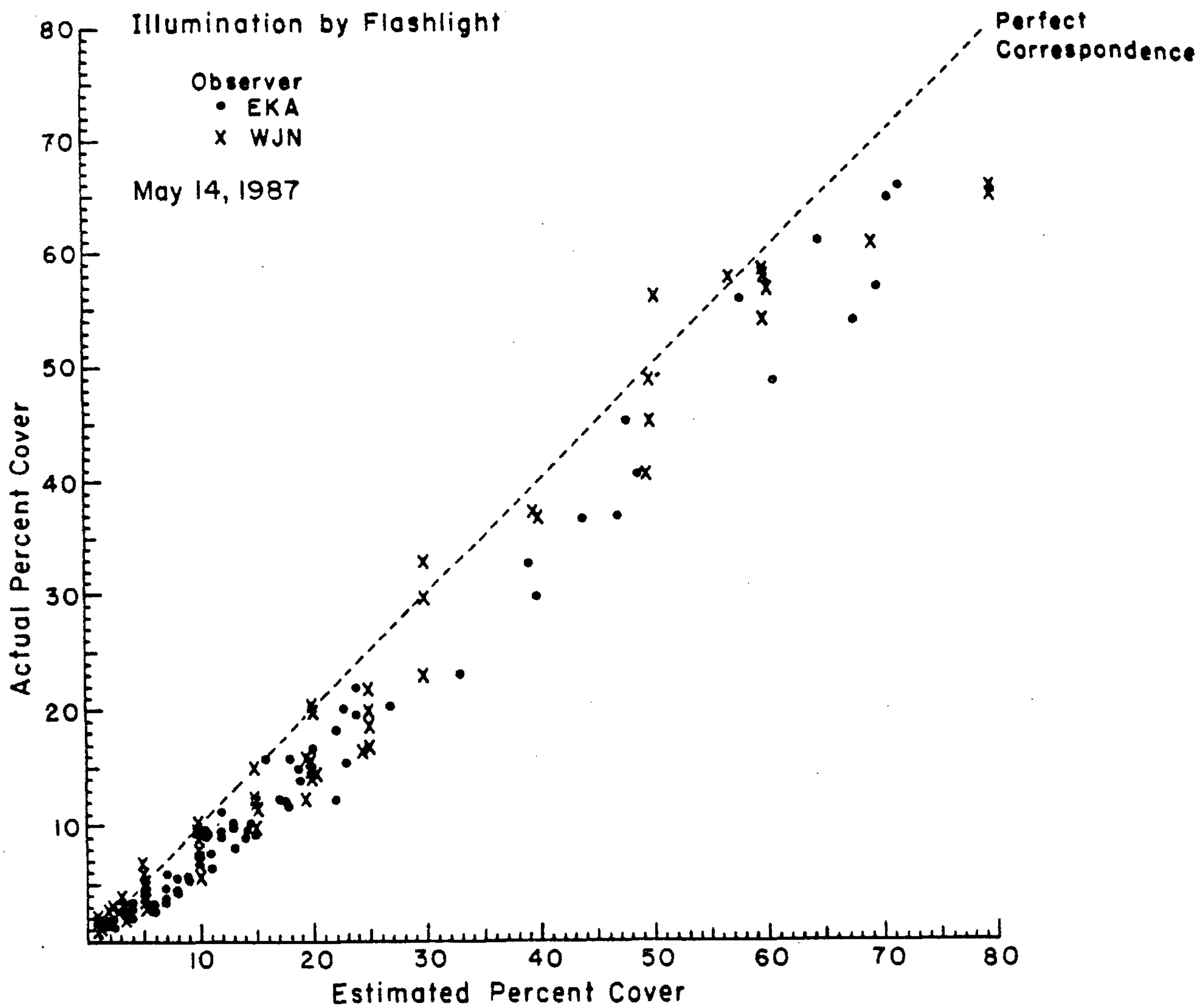

Figure 7-1. Graph of percent cover by cardboards vs estimated areas, flashlight.

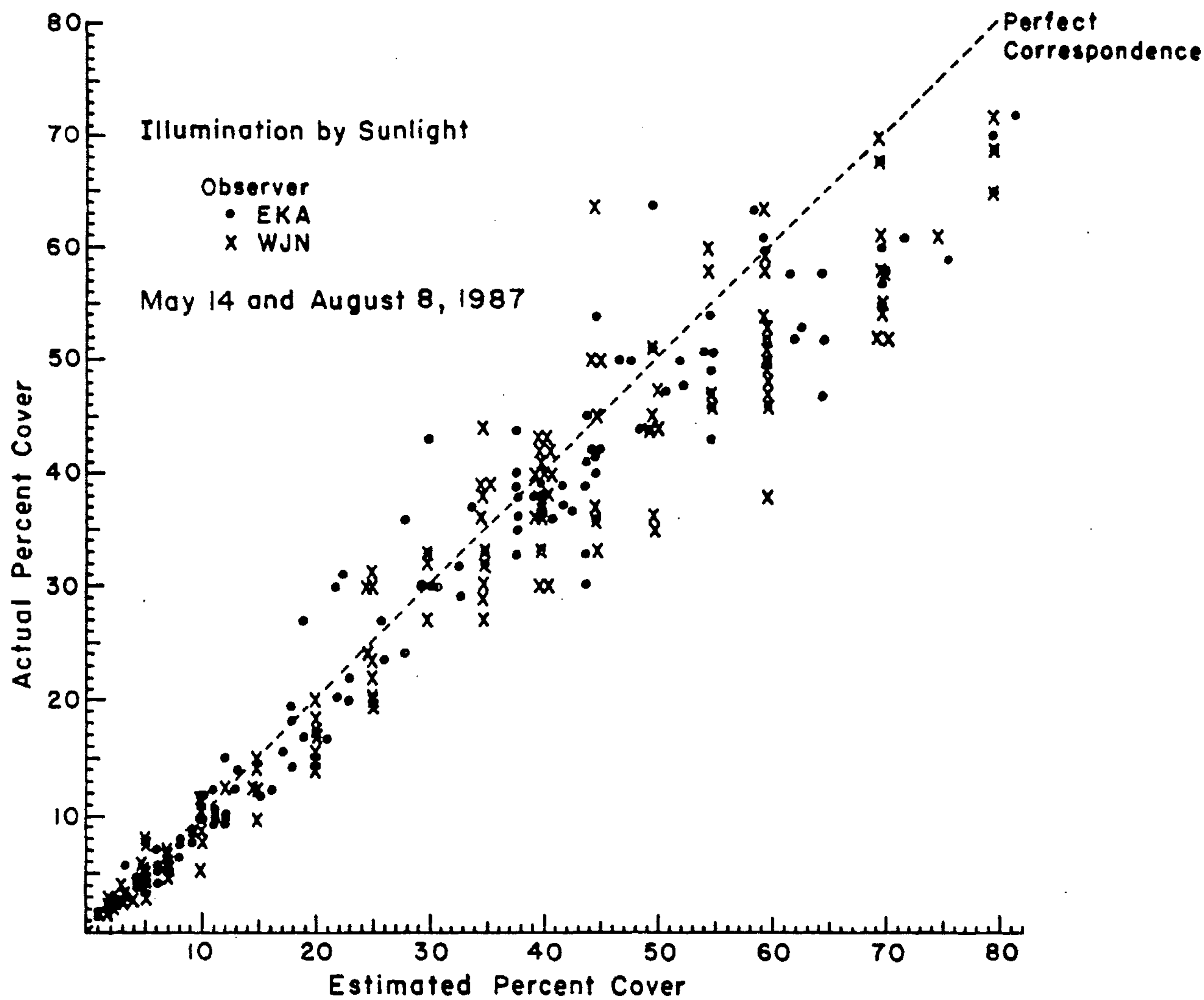

Figure 7-2. Graph of percent cover by cardboards vs estimated areas, sunlight.

Table 7-2: Equations for lines of best fit for estimates of cardboard areas by E.K. Anderson and W.J. North. Sampling was conducted under sunlight illumination on 14 May and 8 August 1987 on or near the NDIX transect. Y=actual area (independent variable), X=estimated area (dependent variable).

Observer	14 May 87	8 Aug 87	14 May + 8 Aug
EKA	X=1.075Y-0.173	X=1.203Y-5.327	X=1.103Y-0.619
WJN	X=1.059Y+0.266	X=1.065Y+1.33	X=1.087Y+0.165

Table 7-3: Taxonomic specialists assisting with identifications of selected taxa.

Taxonomic Group	Specialist	Affiliation
Algae	Dr. Isabella A. Abbott	Hopkins Marine Station, Stanford Univ.
Bryozoa	Dr. Penelope A. Morris-Smith	University of Southern California
Annelida	Dr. Donald J. Reish	California State University Long Beach
Mollusca	Dr. James H. McLean	Southern California Academy of Sciences
Crustacea	Dr. Janet Haig	University of Southern California
Crustacea	Dr. Mary Wickstein	University of Southern California

PROCEDURAL CHANGES

Several minor procedural changes occurred during the initial years of our monitoring to improve our methodology. Our first intertidal transect line was made of cotton. We simply paid it out from a permanent stainless steel stake marking the origin, across one or two landmarks used for proper orientation. We soon found that the line shrunk about 7%. We replaced the cotton with polypropylene line to reduce shrinking and we installed permanent stainless steel tubes and epoxy markers at 5 to 10 m (16-33 ft) intervals along the transects. Tie lines were incorporated into the line, permitting attachment at that point to an appropriate tube in an epoxy marker. This modified procedure ensured close tolerances when we positioned a quadrat along the line.

A continuing problem during our earliest surveys was lack of complete familiarity with the highly diverse biota present both intertidally and subtidally. The difficulty was largely remedied by referring specimens to specialists, but the learning process required several years. The quality of our earlier intertidal surveys was thus below that of surveys from about 1977 onward. Interchanges with specialists continued throughout the project, but by 1977 we were familiar with all the

Table 7-4: Taxa occurring among inclusive categorizations employed for combining taxa that were difficult to identify separately under field conditions.

Group	Major Genus or Species	Minor Genus or Species
	PLANTS	
Bossiella spp./ *Calliarthron* spp.	*B. plumosa* *C. cheliosporioides*	*B. californica* *B. orbigniana* *C. tuberculosum*
Coralline Crusts	*Lithothamnium* spp. *Mesophyllum* spp. *Lithophyllum* spp.	*Melobesia* spp.
Cryptopleura/Hymenena	*C. lobulifera* *C. violacea*	*H. flabelligera* *H. multiloba*
Fucus/Hesperophycus	*F. distichus*	*H. harveyanus*
Gelidium spp.	*G. coulteri* *G. pusillum*	
Gigartina exasperata/ Gigartina corymbifera	*G. exasperata*	*G. corymbifera*
Hildenbrandia spp./ *Calothrix* spp.	*H. prototypus*	*H. occidentalis* *Calothrix* spp.
Laurencia spp.	*L. spectabilis*	*L. blinksii*
Petrocelis franciscana	*P. franciscana*	*Ralfsia* spp.
	ANIMALS	
Balanus spp	*B. glandula*	*B. cariosus*
Chthamalus spp.	*C. fissus*	*C. dalli*
Cyanoplax spp.	*C. hartwegii*	*C. dentiens*
Hemigrapsus spp.	*H. nudus*	*H. oregonensis*
Mopalia spp.	*M. ciliata* *M. muscosa*	*M. hindsii* *M. lignosa*
Mytilus spp.	*M. californianus*	*M. edulis*
Unid. Pagurids	*P. granosimanus* *P. hemphilli* *P. hirsutiusculus* *P. samuelis*	
Petrolisthes spp.	*P. cinctipes* *P. eriomerus*	

important species that were central to the analyses we will describe in Chapters 9 and 10. The intertidal analyses deal only with surveys from 1977 onward, to avoid any difficulties arising from failure to recognize certain species during the early surveys. Variation in identifications was not a problem for our solid substrate studies. All laboratory analyses of solid substrates were either accomplished in latter 1987 or reviewed then, for those analyses performed earlier.

Our choice of survey stations was based on preliminary predictions of plume behavior, yielded by modeling studies. Revisions in these predictions led us to establish a new intertidal station, CDIX, in latter 1982 and reduce frequency of our visits to the control station, LCIX. At that point in time, it appeared that NDIX might receive little or no plume exposure and could serve as a suitable control. The CDIX station would presumably supply information on any ecological effects occurring north of the discharge structure. This fulfilled the role we had intended for NDIX.

Our earlier intertidal surveys revealed that substantial survey-to-survey variation was occurring in substrate composition for certain of our intertidal quadrats. Substrate stability and instability might figure importantly in explaining presence or absence of certain species in the quadrats. We began estimating percent coverages by bedrock, boulder, cobble, gravel, and sand in each quadrat from the survey of February 1977 onward. These data provide a basis for assessing degrees of substrate stability in the quadrats. They also were useful for documenting major substrate alterations caused by the extreme storms of the 1982-83 winter.

Intertidal surveys prior to November 1970 examined quadrats only at five or ten meter intervals along the transect lines. A need for more detailed quantitative information became apparent at that time. We began analyzing every quadrat from the 1970 survey series onward.

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Chapter 8

ANALYSIS of BACKGROUND OCEAN TEMPERATURES

by

David E. James, John R. Steinbeck,
Einar K. Anderson, Wheeler J. North

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INTRODUCTION

Methodology and instrumentation involved in collecting and processing the background ocean temperature data were described in Chapter 6. This chapter presents results of our analyses. For the main historical treatment, we used temperature values occurring at 0800 each day. This will facilitate comparison with a great many other published temperature records for points along the California coast, which are presented as 0800 values. The PG&E data base, however, contained 72 temperature measurements per day per station. In the final sections of this chapter, we compare the 0800 measurements from 1987 with the means of the full complement of 72 daily determinations.

YEAR- BY- YEAR COMPARISONS

We first compiled yearly means, maximum and minimum temperatures, and other statistical information for the ten year period 1978 to 1987 (Table 8-1). We omitted 1977 from Table 8-1 because much of the record for that year was missing. Because of missing data points throughout the entire period, the largest number (N) of temperatures available for calculating a mean was 10. Minimum N was 8. The great majority of N values came to 10, so we have referred to our means as representing 10 years of data.

To provide a basis for comparing any daily 0800 temperature with a "standard" for that day, we next computed the ten-year means and standard deviations for each day of the year, using all available data from 1977 to 1987 (Tables 8-2 and 8-3, Figure 8-1). The graph clearly showed that a minimum occurred in late spring while maximal values centered in late summer. The maximum mean daily temperature was 14.5°C (58.1°F) and the minimum was 10.3°C (50.4°F). The average of all 365 daily mean temperatures was 12.6°C (54.7°F).

Table 8-1: Summary of 0800 daily temperature data used in the ten year analysis of background ocean temperatures at Diablo Canyon.

Year	Annual Mean Temp. °C	Deviation From 10 yr Mean (°C)	Max. Temp. °C	Min. Temp. °C	Temp. Range °C	Data Points Used	Data Points Missing
1978	12.47	-0.16	15.3	9.4	5.9	358	7
1979	12.14	-0.49	15.5	9.1	6.4	364	1
1980	12.31	-0.32	15.1	8.5	6.6	359	6
1981	12.64	0.01	14.8	9.8	5.0	365	0
1982	12.47	-0.16	16.6	9.9	6.7	365	0
1983	14.49	1.86	18.2	10.0	8.2	268	97
1984	12.76	0.13	17.9	8.7	9.2	317	48
1985	11.97	-0.66	15.4	8.8	6.6	287	78
1986	12.63	0.00	15.5	9.7	5.8	326	39
1987	12.69	0.06	16.8	9.6	7.2	365	0

The graph of daily mean temperatures was utilized by plotting it in conjunction with daily actual temperatures for each year from 1978 to 1987 (Figures 8-2 to 8-11, following the text). The 0800 daily readings were depicted by x's superimposed on a plot of the ten year means. We again omitted 1977 because much of the record for that year was missing. All available data from 1977 were nonetheless used in computing the ten year means.

A major El Niño episode occurred in 1982-84 and a minor event followed during the 1986-87 winter. Anomalous (> 1°C) warm water conditions of substantial duration (> 30 days) were apparent in our graphs for early 1978, early 1981, late 1982, most of 1983, mid-1984, late 1986, and early and late 1987 (Table 8-4). Most of these events lay beyond the 95 percent confidence limits for their respective daily means and could be considered as significant from a statistical viewpoint. Thus with means constructed from only ten years of data, one can identify presence of El Niños and other anomalies in the Diablo Canyon region. One can also perceive upwelling events and determine their relative magnitudes. The technique demonstrated seasonal temperature changes that appeared with regularity year after year. Consequently this methodology (developed by the Food Chain Research Group of the University of California) was applicable to the Diablo Canyon region and provided useful insight into physical changes of biological interest in local waters.

Table 8-2: Mean Temperatures (°C) for each day of the year. Data from 1977 - 1987 using 0800 daily temperatures.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01	13.2	12.8	12.5	11.5	10.8	11.3	11.8	12.7	13.0	13.8	13.9	13.0
02	13.1	12.8	12.3	11.1	10.7	11.7	11.8	12.6	13.2	13.8	13.7	12.9
03	13.1	12.9	12.1	10.9	10.8	11.5	11.7	12.6	13.2	14.2	13.7	12.8
04	13.2	13.0	12.3	11.0	10.7	11.1	11.7	12.5	13.3	14.4	13.8	12.9
05	13.4	13.0	12.2	11.1	10.7	10.8	11.5	12.6	13.2	14.4	13.8	13.2
06	13.3	13.0	12.2	11.3	10.9	10.9	12.0	12.6	13.6	14.5	13.8	13.0
07	13.3	12.9	12.6	11.1	10.7	11.5	12.0	13.0	13.7	14.3	13.8	12.9
08	13.4	13.0	12.6	10.9	10.7	11.2	12.2	13.2	13.8	14.0	13.9	12.9
09	13.4	13.0	12.6	11.0	10.6	11.0	12.1	12.9	13.7	14.0	13.9	13.0
10	13.4	13.0	12.7	10.9	10.5	11.2	12.2	13.0	13.6	14.2	13.9	13.2
11	13.5	13.2	12.5	10.8	10.6	11.2	12.3	13.2	13.8	14.4	14.2	13.3
12	13.6	12.9	12.5	10.7	10.7	11.2	12.3	13.5	14.0	14.2	14.1	13.1
13	13.6	13.2	12.1	10.7	10.8	11.2	11.8	13.6	14.0	13.9	14.3	13.0
14	13.4	13.1	12.1	11.2	11.0	11.3	12.2	13.7	14.2	13.6	14.1	13.0
15	13.6	13.1	11.7	11.5	10.9	11.3	12.6	13.6	14.3	13.4	14.0	13.1
16	13.5	13.0	11.7	11.2	10.7	11.3	12.7	13.7	14.2	13.4	13.9	13.1
17	13.4	12.6	11.8	11.2	10.8	11.5	12.7	13.7	14.4	13.2	14.2	13.3
18	13.5	12.6	11.6	10.7	10.9	11.3	12.6	13.4	14.5	13.1	13.8	13.5
19	13.4	12.7	11.6	10.7	10.7	11.1	12.4	13.7	14.0	13.4	13.5	13.5
20	13.2	12.6	11.7	10.7	11.0	11.4	12.3	13.5	13.7	13.5	13.6	13.3
21	13.2	12.5	11.6	10.8	11.2	11.5	12.5	13.6	13.7	13.6	13.2	13.3
22	13.2	12.5	11.4	10.7	11.4	11.9	12.6	13.3	13.8	13.5	13.2	13.3
23	13.2	12.5	11.4	10.8	11.1	12.0	12.7	12.9	13.9	13.5	13.6	13.2
24	12.9	12.2	11.5	10.7	10.7	11.8	12.6	12.9	14.2	13.6	13.6	13.1
25	12.9	12.3	11.1	10.7	10.7	12.1	12.7	12.9	14.3	13.8	13.1	13.1
26	12.9	12.2	11.1	10.5	10.8	11.9	12.5	12.8	14.4	13.4	12.8	13.1
27	13.0	12.3	11.1	10.4	11.0	11.8	12.6	12.9	14.0	13.8	13.0	13.1
28	13.0	12.5	11.2	10.7	11.0	11.8	12.5	12.8	13.8	13.8	13.3	13.1
29	12.8		11.3	10.3	11.1	11.7	12.6	13.0	14.0	13.7	13.3	13.0
30	12.7		11.4	10.6	11.1	11.7	12.5	12.7	14.2	14.0	13.3	13.1
31	12.7		11.5		11.1		12.4	12.8		13.8		13.0
Avg	13.2	12.8	11.9	10.9	10.9	11.4	12.3	13.1	13.9	13.8	13.7	13.1
Std.	0.3	0.3	0.5	0.3	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.2

The graph of the ten-year mean temperature curve (Figure 8-1) showed that lowest ambient values occurred in April and May (i.e., coinciding with the upwelling period as described in the oceanographic literature). Maximal temperatures tended to occur as separated peaks from latter August through November (i.e., the oceanic period). The baseline temperatures of the oceanic period persisted throughout the Davidson Current period (December to March) but excursions to peak values were absent. The absence of unusually high temperatures during winter suggested that the Davidson Current was not bringing significant amounts of surface water from

Table 8-3: Standard Deviations in °C for each day of the year. Averaged over 1977 - 1987 using 0800 daily temperatures.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
01	0.8	1.1	0.9	1.1	0.8	1.1	1.2	0.9	1.1	1.5	1.8	0.7
02	0.8	1.0	1.1	1.0	0.8	0.9	1.2	0.7	0.6	1.4	1.6	0.7
03	1.0	0.9	1.2	0.8	0.7	0.8	1.2	0.9	0.6	1.1	1.4	0.8
04	0.9	0.9	1.1	0.9	0.7	0.9	1.1	1.0	0.7	1.2	1.3	0.8
05	0.9	0.9	1.2	0.7	0.9	0.7	0.9	0.9	0.9	1.3	1.1	0.9
06	0.8	0.9	1.2	0.5	1.0	1.0	1.1	0.8	0.9	1.4	1.3	1.2
07	0.8	0.9	1.1	0.7	0.9	1.2	1.0	0.9	0.9	1.5	1.1	1.2
08	0.9	1.0	1.0	0.7	0.7	1.0	0.9	0.9	0.5	1.5	0.8	1.1
09	0.8	1.0	1.1	0.7	0.8	1.4	1.2	0.9	0.7	1.5	1.1	1.1
10	0.8	1.0	1.1	0.8	0.6	1.3	0.8	1.0	1.1	1.4	1.2	1.0
11	0.8	0.7	0.9	0.8	0.6	1.2	1.0	1.2	1.3	1.1	1.2	1.1
12	0.8	0.8	1.1	1.0	0.8	1.0	0.9	1.3	1.6	1.1	1.1	1.1
13	0.9	0.8	0.7	0.8	0.9	0.9	1.1	1.3	1.6	0.9	1.1	1.1
14	1.0	0.6	0.5	0.9	1.1	0.9	1.0	1.3	1.6	0.9	1.2	1.0
15	1.0	0.6	0.7	0.9	1.2	1.1	1.3	1.3	1.8	0.9	1.3	1.1
16	1.4	0.8	0.8	0.9	1.2	1.1	1.2	1.4	1.9	1.2	1.4	1.1
17	1.3	0.9	0.7	0.7	1.0	1.1	1.3	1.2	1.7	1.0	1.5	1.1
18	1.0	1.0	0.7	0.7	0.9	1.1	1.2	1.5	1.8	0.9	1.6	0.8
19	1.1	0.9	1.0	0.6	0.9	0.9	1.4	1.4	1.9	0.8	1.6	0.9
20	1.0	0.9	1.3	0.8	1.1	0.9	1.3	1.4	1.7	1.0	1.4	0.8
21	1.0	1.1	1.2	0.6	1.2	1.2	1.2	1.5	1.8	1.3	1.3	0.9
22	1.0	1.0	1.4	0.5	1.1	1.4	1.0	1.4	1.9	1.4	1.1	0.8
23	1.2	1.1	1.3	0.6	0.8	1.3	1.0	1.2	1.7	1.4	0.7	1.0
24	1.2	0.9	1.2	0.6	0.7	1.3	1.0	1.0	1.5	1.3	0.9	0.9
25	0.9	1.0	1.0	0.8	0.7	1.1	0.9	1.0	1.4	1.3	1.1	0.9
26	0.9	1.1	1.1	1.1	1.1	1.1	0.9	1.1	1.5	1.4	1.2	0.8
27	1.1	1.1	1.1	1.0	1.1	1.3	1.1	1.2	1.2	1.3	1.2	0.8
28	1.1	1.2	0.8	0.9	0.8	1.2	1.2	1.3	1.3	1.4	1.3	0.9
29	1.2		1.2	0.8	1.1	1.3	1.1	1.3	1.6	1.7	1.2	0.9
30	1.1		1.0	1.0	1.2	1.1	1.2	1.0	1.9	1.6	1.1	0.8
31	0.9		1.1		1.2		1.1	0.9		1.7		0.9
Avg	1.0	0.9	1.0	0.8	0.9	1.1	1.1	1.1	1.4	1.3	1.2	0.9
Std.	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.4	0.2	0.2	0.1

the Southern California Bight into the nearshore region around Diablo Canyon. Examination of records for individual years revealed that isolated high temperature peaks have occurred in occasional winters (examples: January 1978 and 1981, February 1980). A sustained plateau of 14 to 15°C (57.2 to 59.0°F) occurred in January and February 1983 (an El Niño year). Several non-indigenous fish species appeared as juveniles in Diablo Cove during this El Niño episode. The precise timing of larval introductions, however, and the role of the Davidson Current in their transport, remain unknown.

Patterns of anomalously high ocean temperatures during 1983 and 1984 resulted from a major El Niño, but differed from patterns observed within the Southern California Bight (compare Figures 8-7 and 8-8 with graphs for 1983 and 1984 shown in North et al., 1985). The El Niño was manifested in Diablo Cove as excursions to levels well above average temperatures for periods of a few weeks to a few months. 1983 was more anomalous than 1984. Duration of substantially elevated water temperature in southern California lasted for five months in 1983 and eleven months in 1984. 1984 was more anomalous than 1983 in southern California waters.

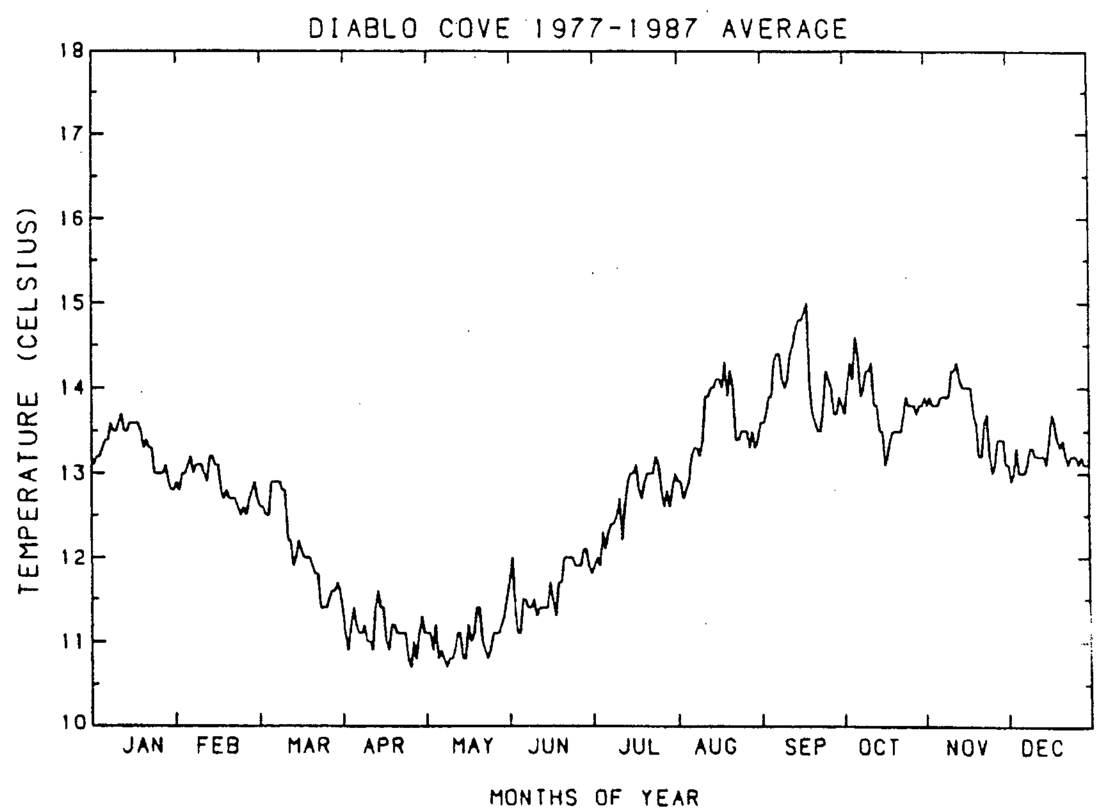

Figure 8-1. Plot of 0800 ten-year mean temperatures versus day of the year.

Table 8-4: Extended periods (more than 30 days) of 0800 background ocean temperatures continuously above daily ten-year mean values by more than 1 °C occurring in the Diablo Canyon region between 1978 and 1987.

Year	Starting Date	Duration In Days	Average Dev. °C	Maximum Dev. °C	Date of Max. Temp.
1978	05 Mar.	37	1.6	2.8	12 Mar.
1981	01 Jan.	31	1.0	1.7	24 Jan.
1982	29 Oct.	33	1.6	3.1	26 Nov.
1983	11 Jan.	44	1.5	2.2	30 Jan.
1983	27 July	122	2.4	4.4	20 Sept.
1984	02 July	31	1.7	3.7	18 July
1986	27 Nov.	35	1.5	2.5	06 Dec.
1987	22 Apr.	33	1.7	3.6	15 May

COMPARISONS BETWEEN 0800 AND ALL DAILY TEMPERATURE DETERMINATIONS

As mentioned above, the daily mean temperatures used for computing the ten-year means were values recorded at 0800 each day. Each sensor, however, provided temperature determinations every 20 minutes, yielding a record of 72 values per day. We also utilized the full data base for 1987 to compute daily means and compare results with the 0800 values.

The 1987 yearly display, showing daily means versus the ten year mean record, was very similar to the corresponding graph depicting 0800 daily values (Figure 8-12, compare to Figure 8-11). We also plotted individual 0800 values for 1987 against corresponding averages from all daily determinations (Figure 8-13). Only a few of the 0800 values were slightly greater than their corresponding daily average. Means, standard deviations, yearly maximal and minimal values were very similar for the two data sets (Table 8-5).

The range spanned by daily temperature fluctuations varied from 0 to 2.7°C (Table 8-6). Largest fluctuations tended to occur during the upwelling season. The smallest daily ranges were associated with the Davidson Current period (Figure 8-14). Similar associations were established for the standard deviations of the 72 daily temperature determinations (Figure 8-15). The

Table 8-5: Comparison of statistical parameters for 1987 data between 0800 readings and the average of 72 daily readings of background oceanic temperatures in the Diablo Canyon vicinity.

Parameter	0800 Temperature °C	Daily Average of 72 measurements °C
Mean	12.7	13.0
Standard deviation	1.5	1.4
Maximum value	16.8	16.8
Minimum value	9.6	10.0

Table 8-6: Comparison of computed statistical parameters between daily diurnal temperature range and daily standard deviation for 1987.

Parameter	Diurnal Range(°C)	Standard Deviation(°C)
Mean	1.05	0.30
Standard deviation	0.46	0.16
Maximum	2.70	0.90
Minimum	0.00	0.00

maximum standard deviation of 0.9 occurred in June 1987 and again in July. It appeared that for purposes of identifying extended periods of anomalously warm or cold water, the simple technique of using 0800 temperatures served about as well as mean values derived from 72 determinations. The complete sets of determinations were useful for establishing daily temperature ranges and seasonal differences in these ranges.

DAILY VARIATIONS IN TEMPERATURE

Superimposed on long-term seasonal changes in temperature are short period fluctuations occurring within a time frame of hours. Some short term changes result in characteristic patterns that we have classified as daily variation. There was considerable irregularity in this pattern, comparing one day with another, but we examined data from all of 1987 and concluded that solar heating leads to small daytime temperature increases (i.e., daily variation) for most days of the year.

To illustrate the characteristics of daily variation, we present results from the 72 temperature determinations recorded for January 1 1987, a day when the local environment was apparently free from substantial very short term perturbations (Figure 8-16). The most prominent feature of this record is a gentle temperature rise that commenced at about 0600 and peaked at about noon where it stood at about 0.3°C (0.5°F) above the mean value for the day. Water temperature then declined for about seven hours, forming a fairly symmetrical pattern. The timing of the rise and fall in temperature on this day suggested a relationship to input of solar energy. Obviously such a conclusion needs to be based on more than a single day's record to guard against the possibility that the temporal relationship between changes in water temperature and solar input on January 1 1987 was not simply fortuitous.

A five day record of water temperatures near Diablo Cove for the period January 1 to 5 1987 illustrated some of the irregularities that frequently appear in documentations lasting for several days (Figure 8-17). There was a downward shift below the overall mean, lasting a day and a half (possibly an influence from upwelling). This was followed by an approximately two day period when temperatures mostly hovered above the mean. In spite of these major shifts, late morning rises in temperature occurred on all five days and afternoon declines were present on four days. The daily variation pattern could thus be discerned and the temporal relation to solar input was maintained. It thus seemed worthwhile to examine data for the entire year of 1987.

We have already displayed in Figure 8-13 a plot of all of the 1987 0800 temperatures against corresponding averages from the 72 daily measurements for each day of the year. Only 21 of the 0800 measurements exceeded their daily averages. If we examine a similar plot but perform the comparisons for temperatures later in the day (for example, 1400 hours), we find that only 11 determinations in 1987 fell below the corresponding daily averages (Figure 8-18). Thus data from an entire year supported the hypothesis that cyclical daily temperature changes occur in shallow coastal waters, caused by the fluctuating solar input.

Examining temporal distributions of the differences between the 0800 and 1400 temperatures and their daily averages, there did not appear to be any seasonal clustering of either large differentials or small differentials (Figures 8-19 and 8-20). Factors such as cloudiness, fog, and wind apparently introduce sufficient randomness to the differentials to obscure any influences caused by season on solar warming of the near-surface layers.

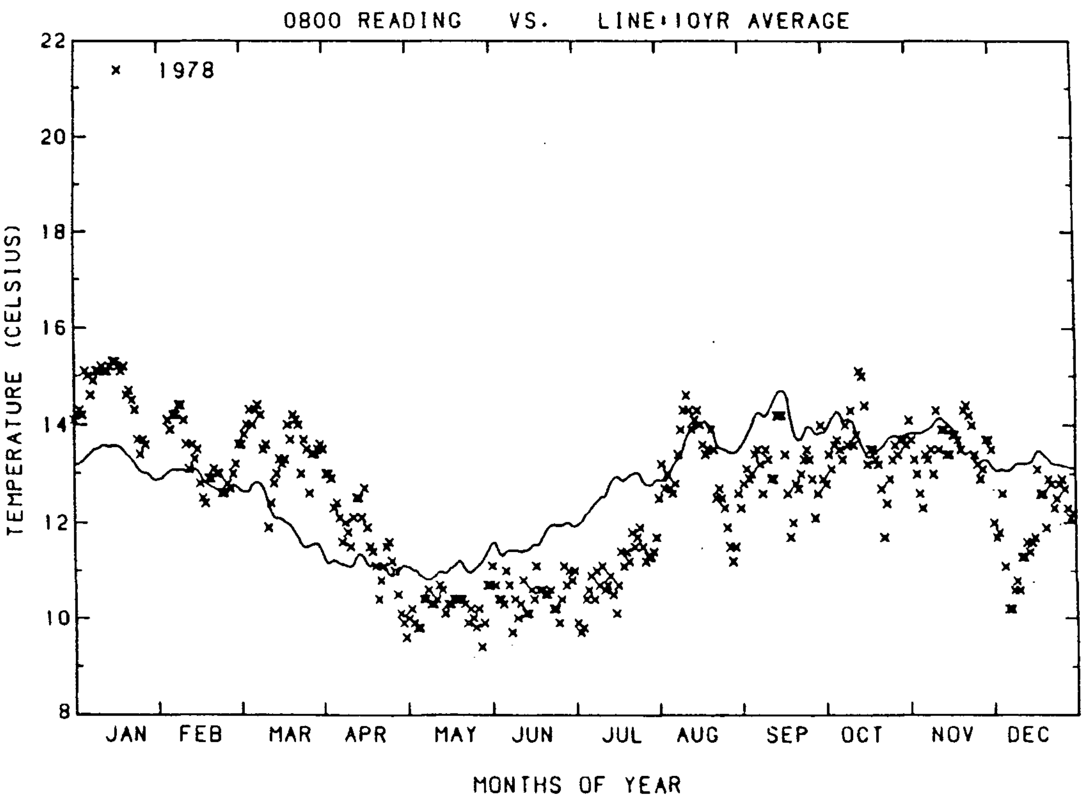

Figure 8-2. Plot of 1978 0800 temperatures compared to graph of ten-year mean.

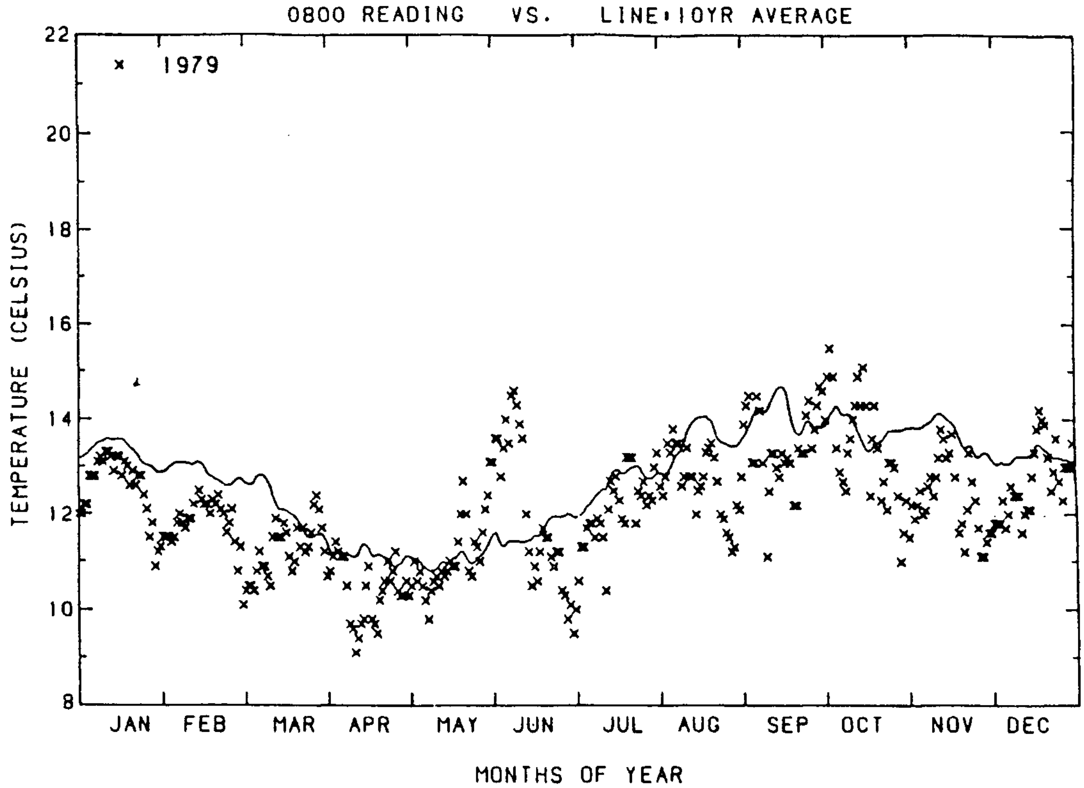

Figure 8-3. Plot of 1979 0800 temperatures compared to graph of ten-year mean.

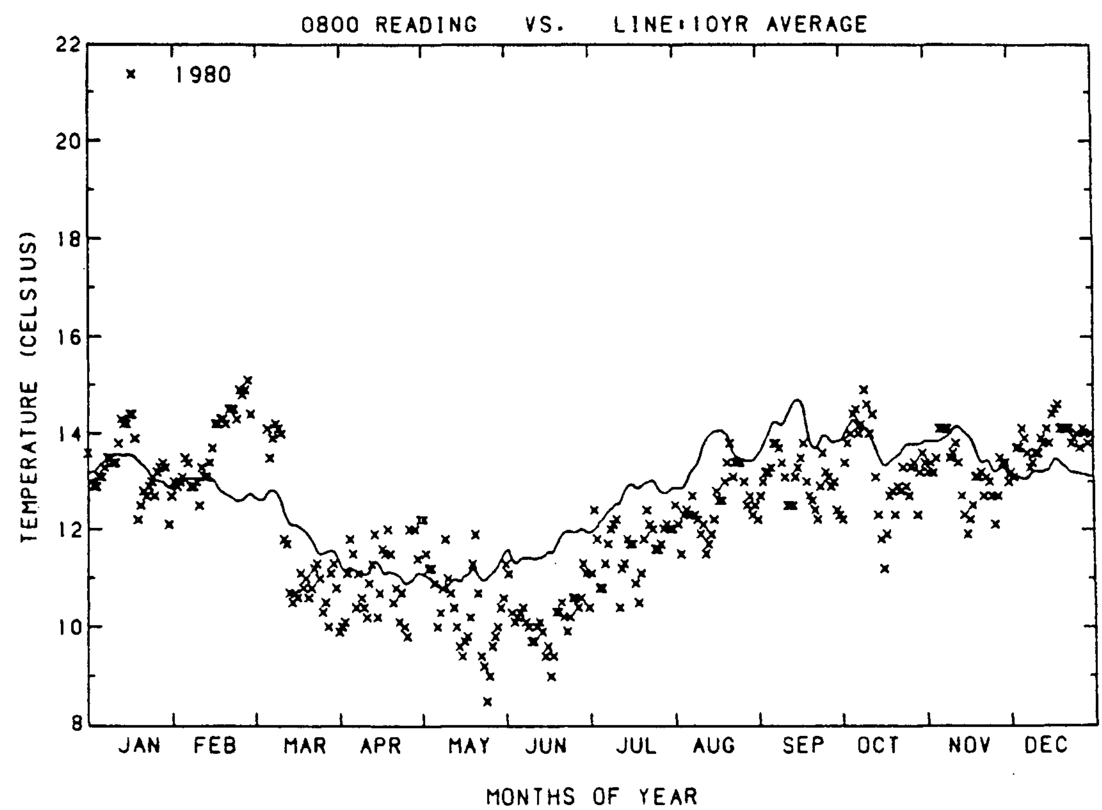

Figure 8-4. Plot of 1980 0800 temperatures compared to graph of ten-year mean.

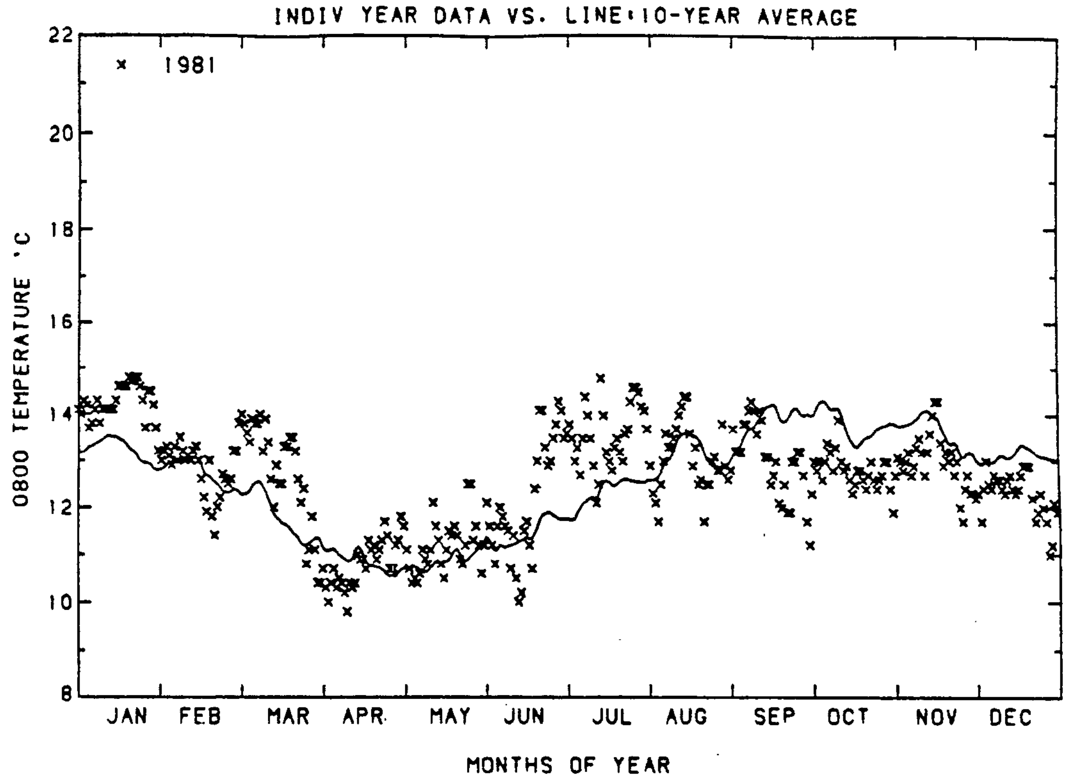

Figure 8-5. Plot of 1981 0800 temperatures compared to graph of ten-year mean.

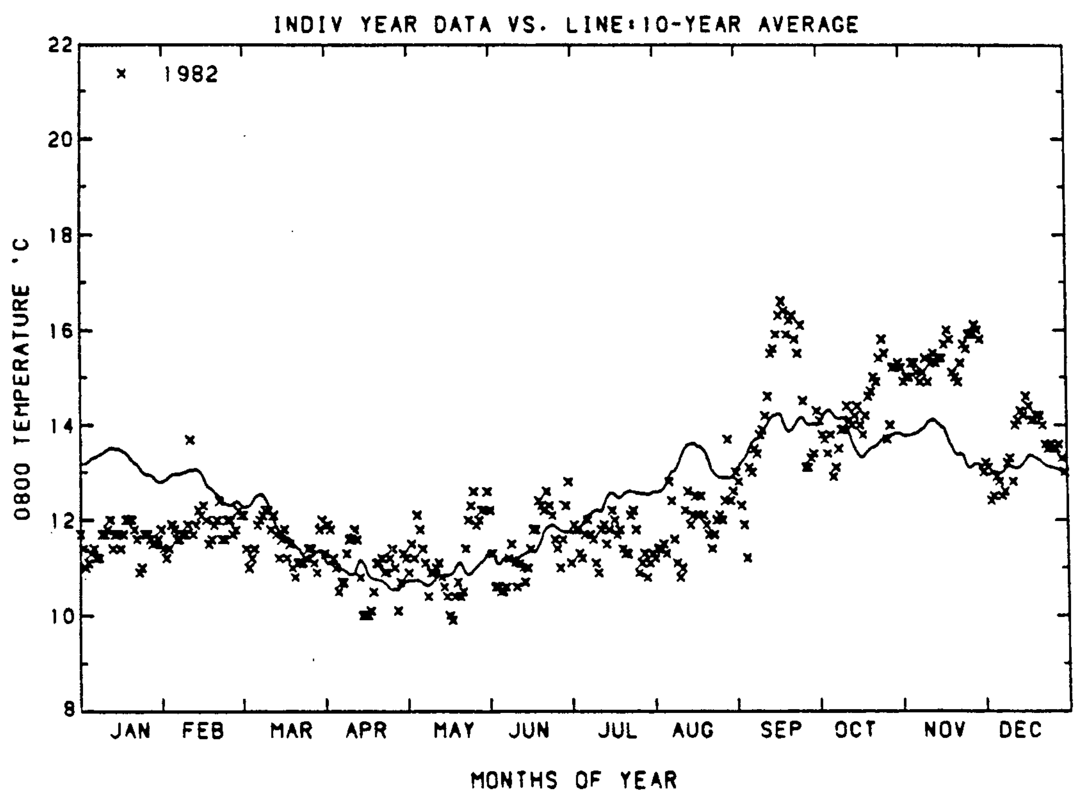

Figure 8-6. Plot of 1982 0800 temperatures compared to graph of ten-year mean.

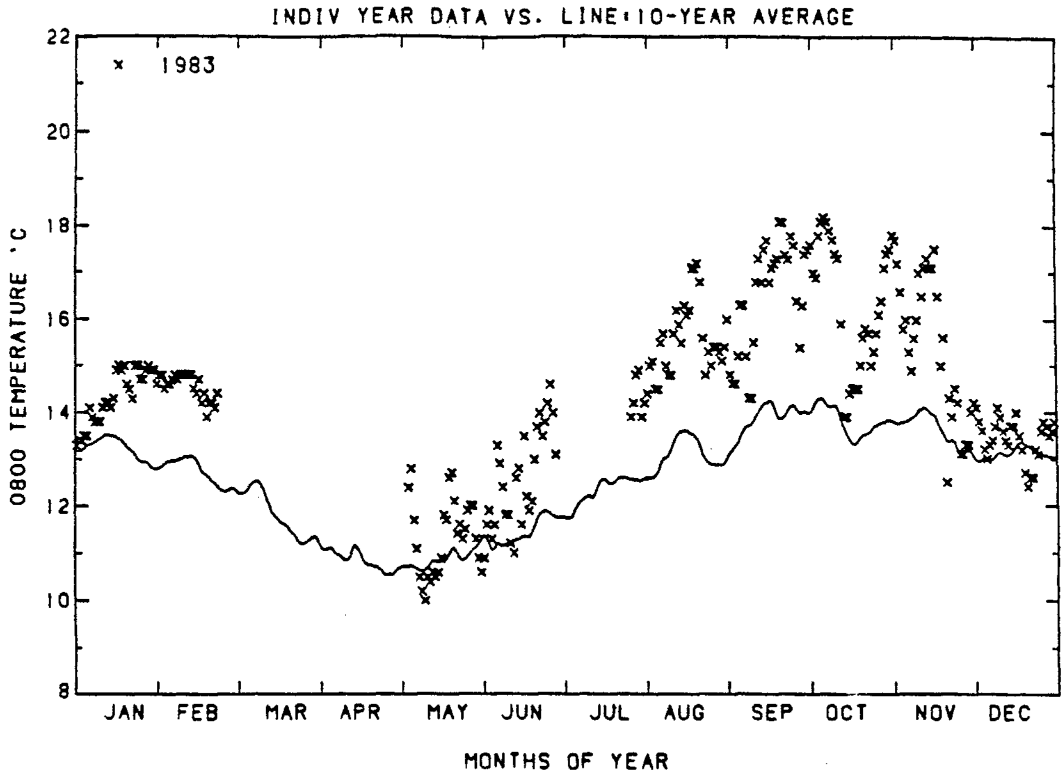

Figure 8-7. Plot of 1983 0800 temperatures compared to graph of ten-year mean.

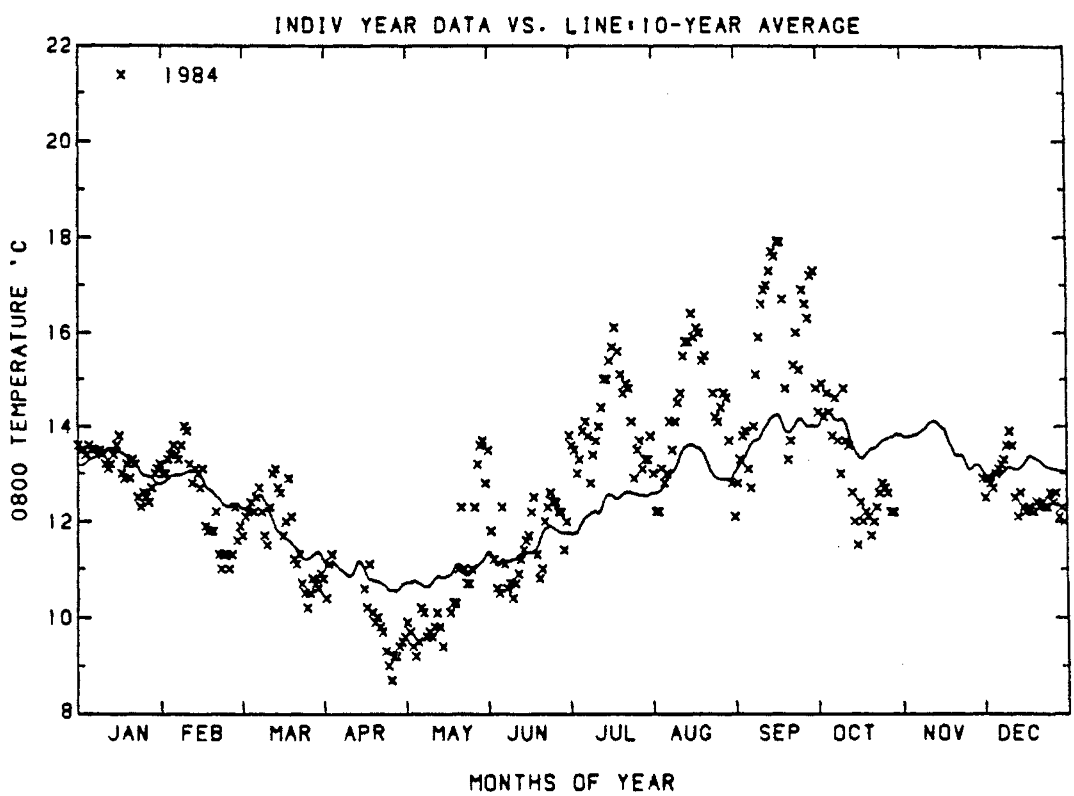

Figure 8-8. Plot of 1984 0800 temperatures compared to graph of ten-year mean.

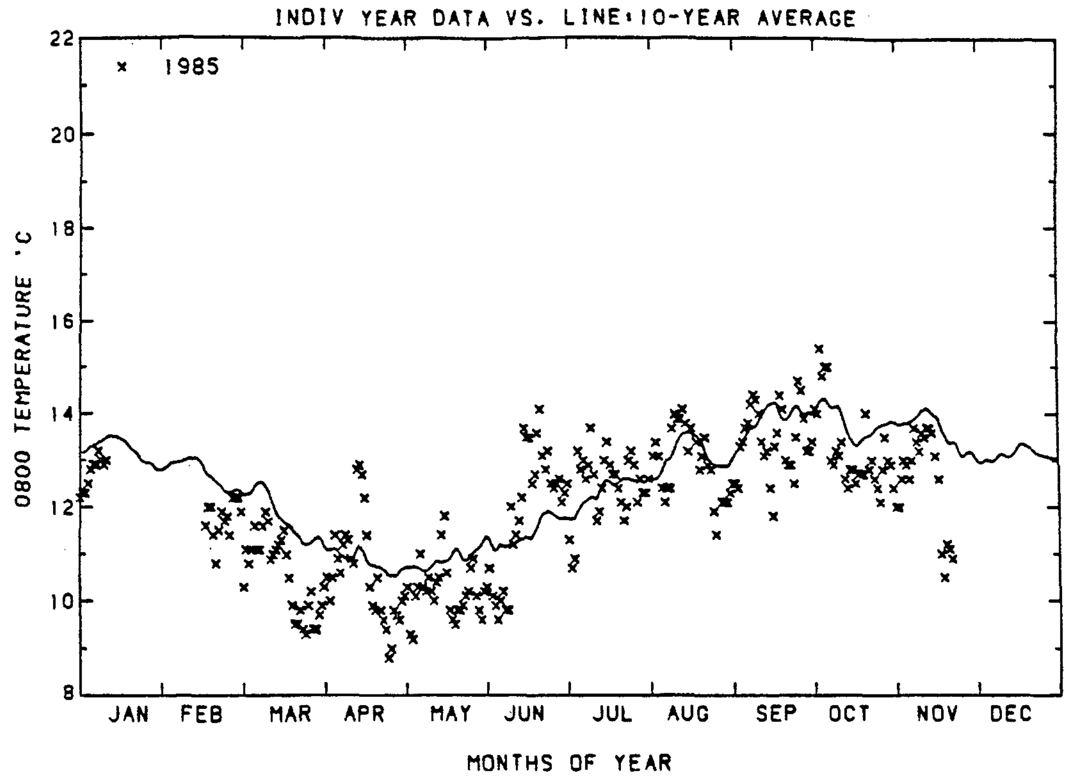

Figure 8-9. Plot of 1985 0800 temperatures compared to graph of ten-year mean.

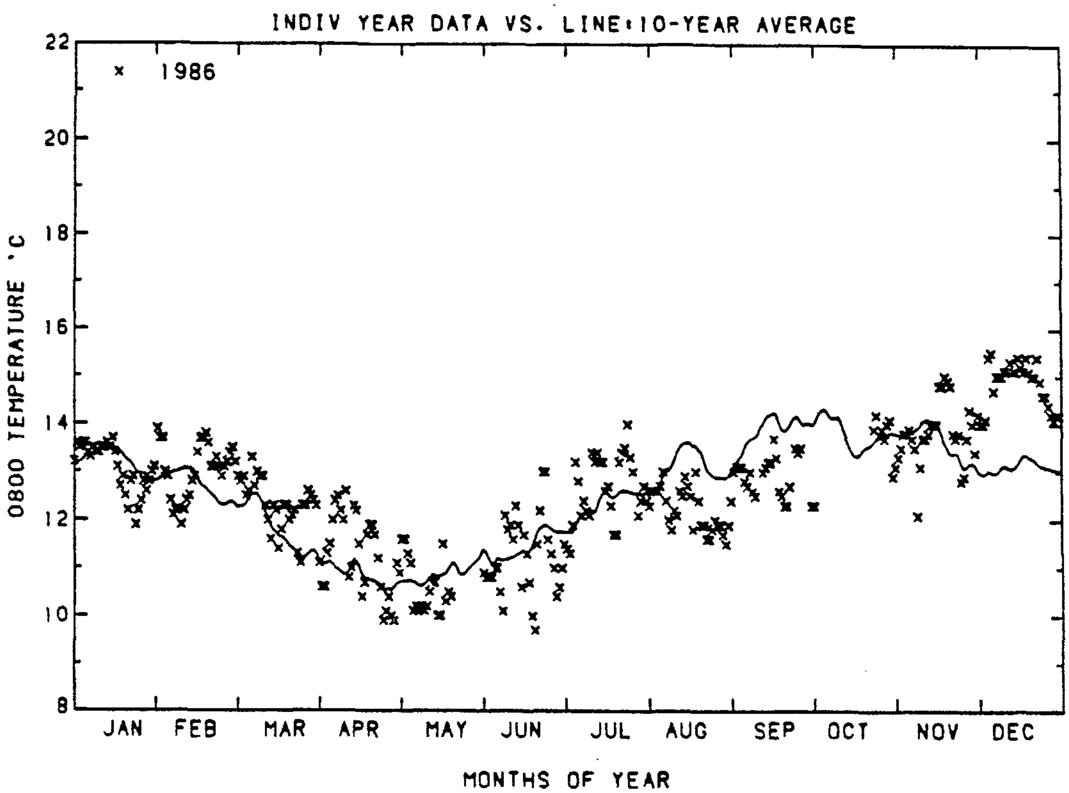

Figure 8-10. Plot of 1986 0800 temperatures compared to graph of ten-year mean.

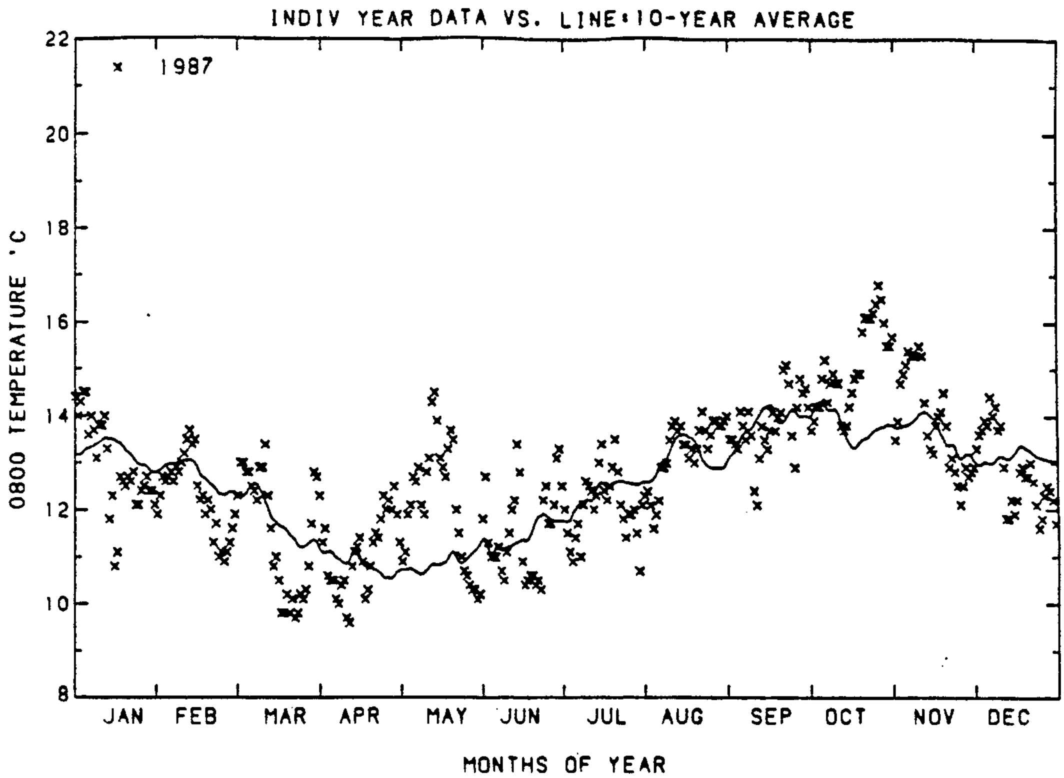

Figure 8-11. Plot of 1987 0800 temperatures compared to graph of ten-year mean.

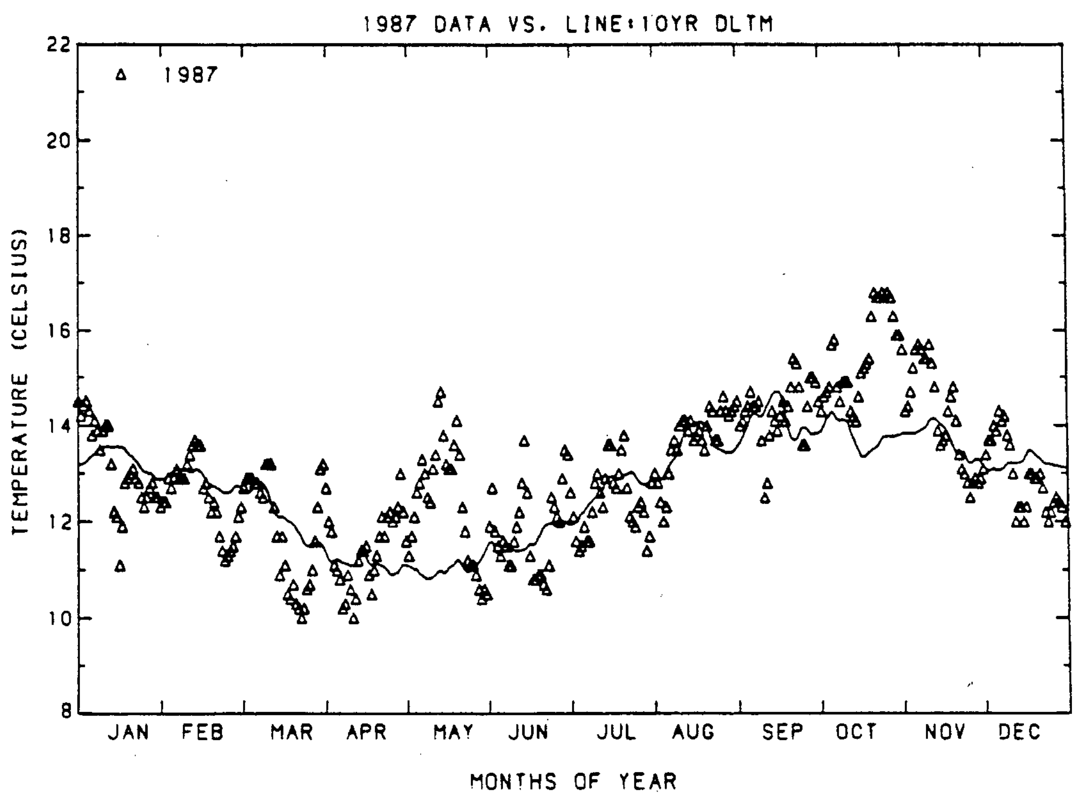

Figure 8-12. Plot of 1987 daily temperature means (N = 72) compared to graph of ten-year means.

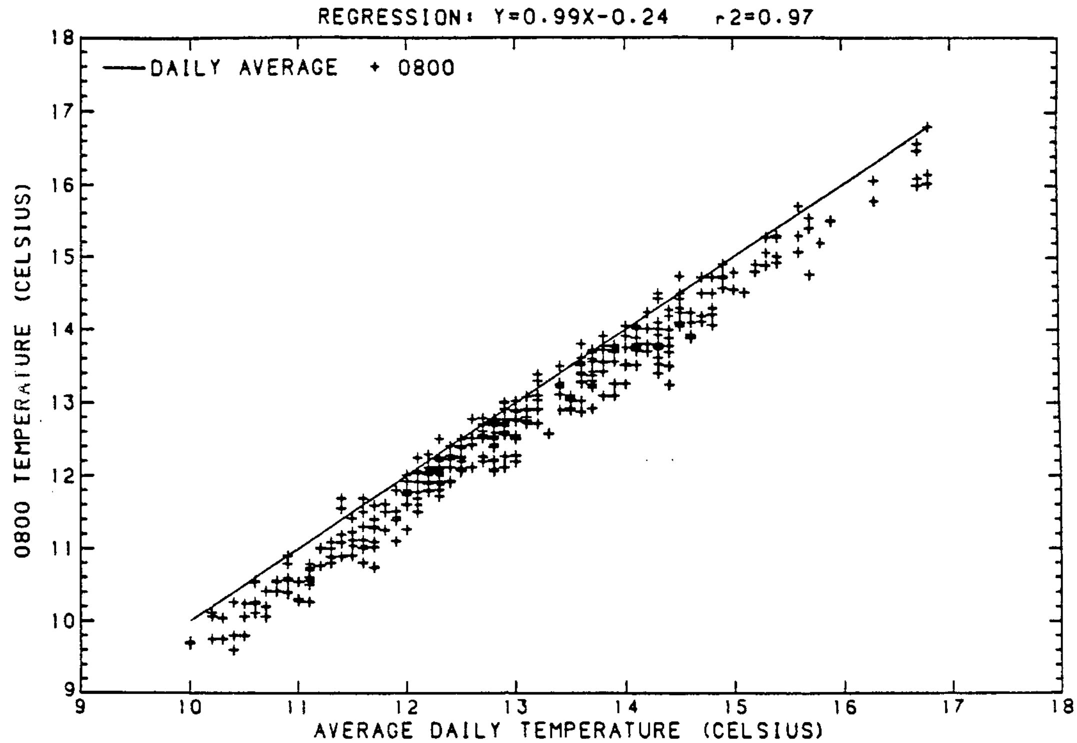

Figure 8-13. Plot of 1987 0800 temperatures vs their corresponding daily means (straight line).

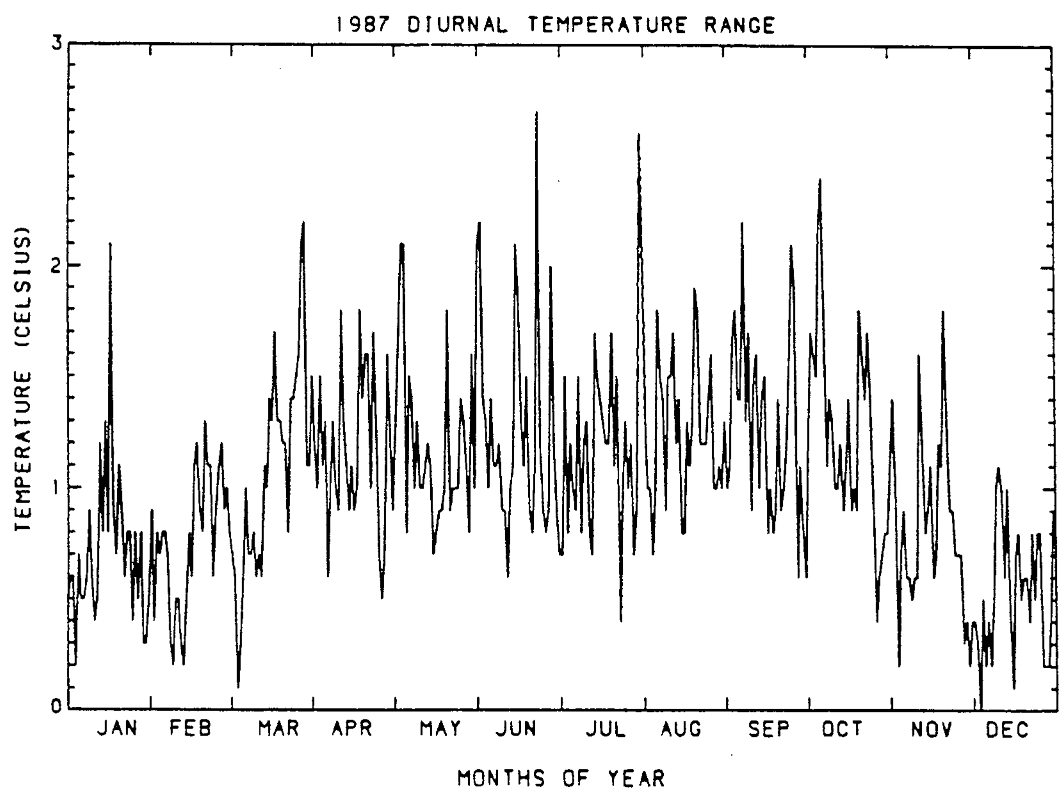

Figure 8-14. Ranges of daily temperature fluctuations throughout 1987.

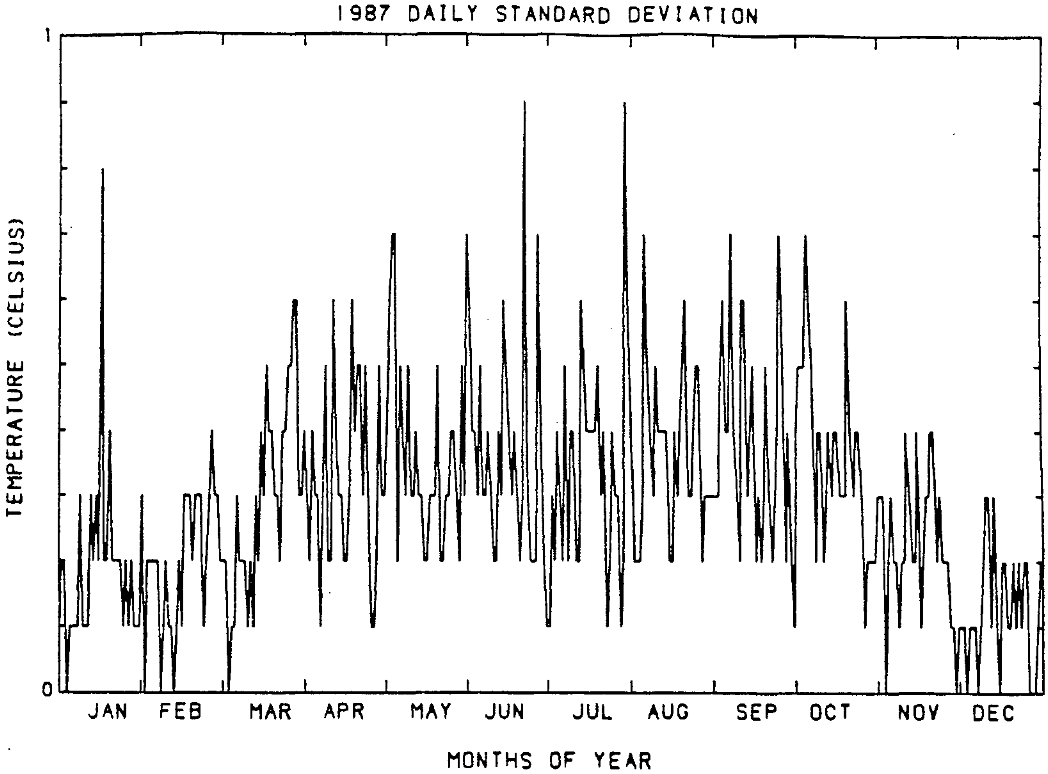

Figure 8-15. Standard deviations of the daily temperature means (N=72) throughout 1987.

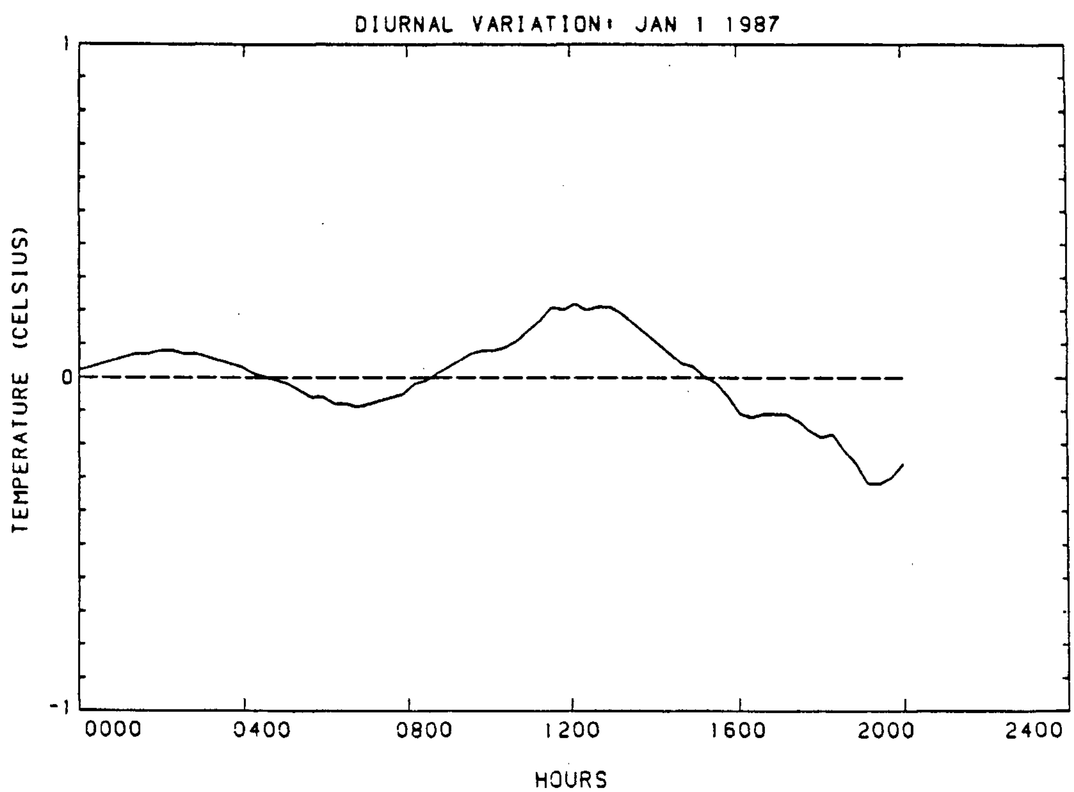

Figure 8-16. Record from 60 ocean temperature measurements on January 1 1987, depth 3 m.

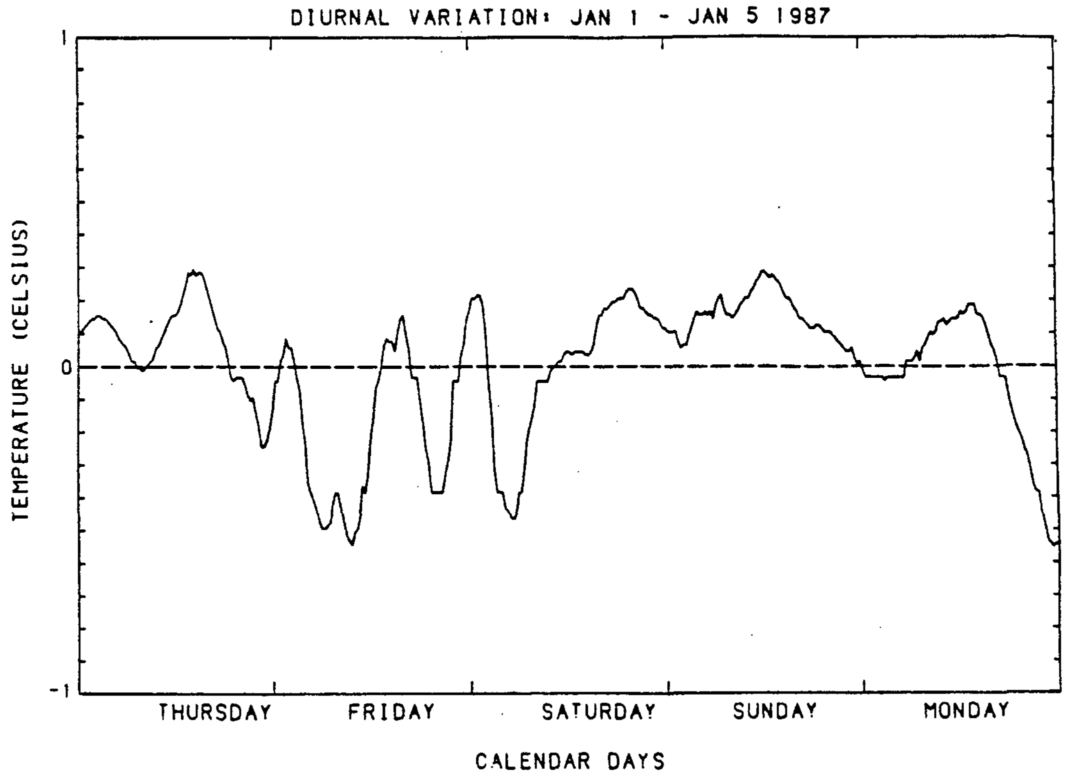

Figure 8-17. Five day record of ocean temperatures, January 1-5 1987, depth 3 m.

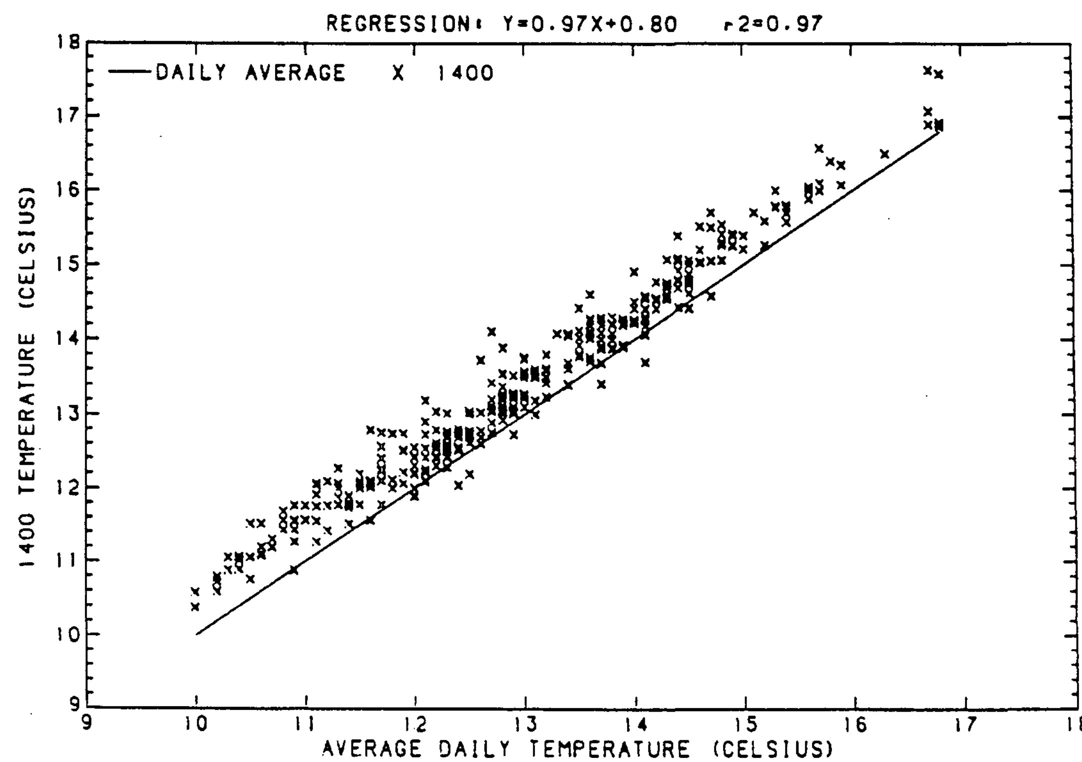

Figure 8-18. Plot of 1987 1400 temperatures vs their corresponding daily means (straight line).

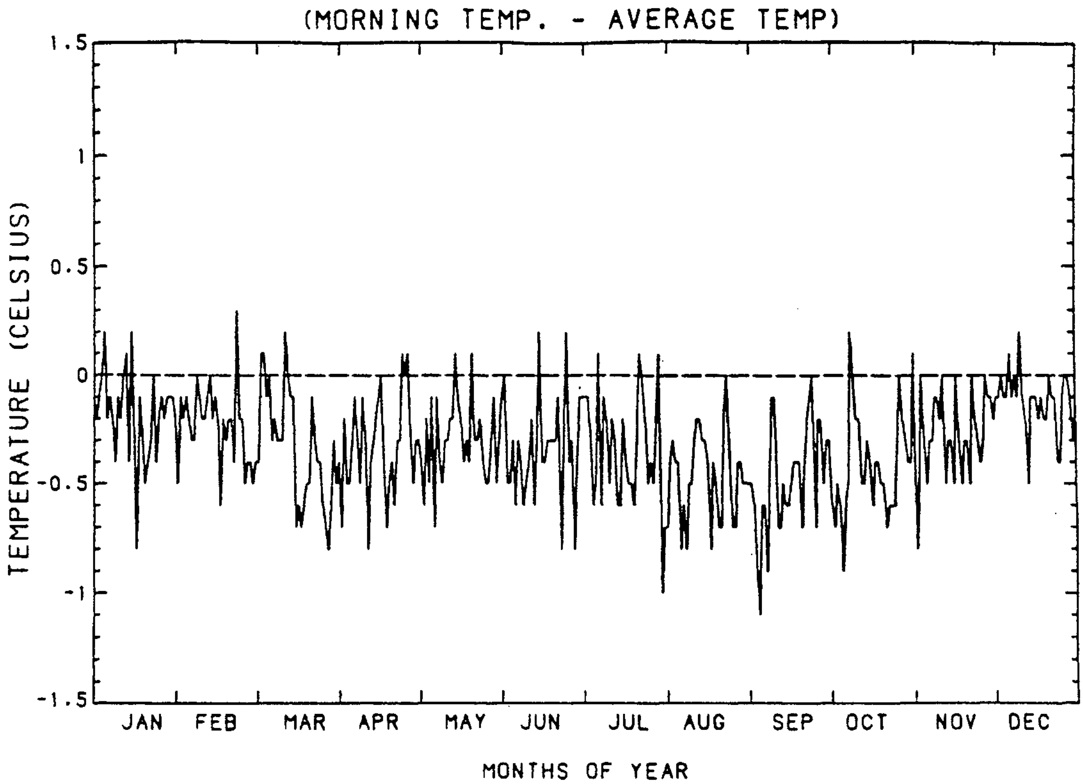

Figure 8-19. Temporal distribution of differences between 0800 and daily mean temperatures,1987.

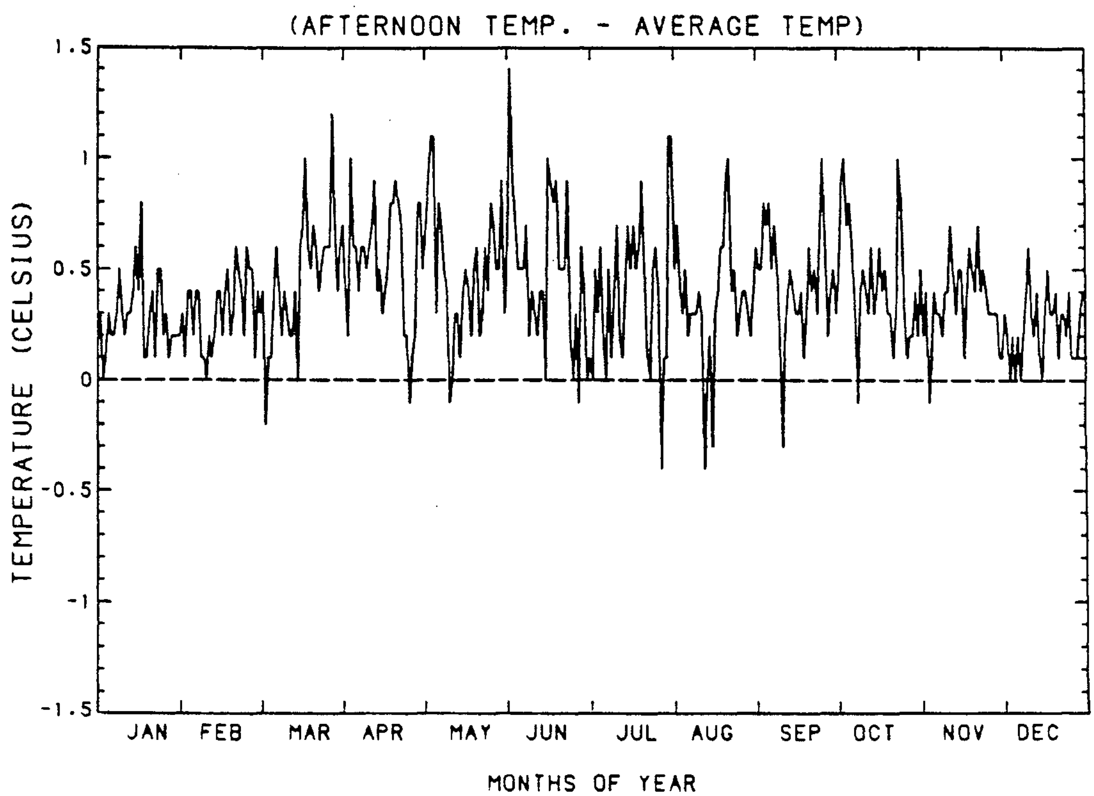

Figure 8-20. Temporal distribution of differences between 1400 and daily mean temperatures,1987.

Chapter 9

INTERTIDAL RESULTS

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Tables

Appendix
(Follows the chapter text material)

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INTRODUCTION

Our experimental design for the quantitative intertidal investigations involved periodic determinations of plant and animal abundances along permanent vertical transects spanning the intertidal zone. Successive samples were thus not independent, precluding usage of inferential statistics. This was not considered as an important and avoidable deficiency in our experimental design because a conventional random sampling design would still have constituted pseudoreplication, also precluding usage of inferential statistics (Hurlbert, 1984). Our fixed transect design, however, did provide some important advantages. While we were not able to define an "average" condition for any of our sampling areas, we were able to identify changes at fixed locations with a degree of certainty beyond that provided by estimates of mean values derived from random sampling. We were also able to define vertical distributions of the populations, and any changes therein, along our transects.

Our analyses were greatly complicated by occurrence of a major El Niño event during the two years immediately preceding startup of operations at DCPP. El Niño effects differed at the various stations. Diablo Cove received greater impacts than our control station to the northwest (see Figure 5-1 for station locations). Within Diablo Cove, the transects at either end were affected more severely than in the center. Differences in effects somewhat hampered our abilities to compare results among transects.

While our fixed transect studies commenced in 1969, we did not begin surveying the lines on a regularly scheduled basis until 1977 (Table 9-1). By then we had become familiar with the various species so that consistencies of our identifications were high. We consequently chose 1977 as the starting point for our quantitative analyses, bypassing any irregularities associated with data from the earlier years. While some information was thereby sacrificed, we believe that the increase in overall quality of the data base justified this course of action. We considered pre-1977 information for compiling species lists.

Table 9-1: Dates of our surveys along four intertidal transects in the Diablo Canyon region. If an '*' in Survey Number, information for the survey was excluded from most data analyses.

Year	Survey Number	Station SDIX	NDIX	CDIX	LCIX
1966	* *	12 Nov			
1969	* *	18 Jan	18 Jan		5 Jun
1970	* *	04 Feb	04 Feb		05 Feb
	5*	11 Nov	13 Nov		12 Nov
1971					
1972	* *	17 Dec	17 Dec		17-18 Dec
1973					
1974	* *		18-19 Jan, 5 Feb		06 Feb
1975	7*	25 Jan	25 Jan		26 Jan
1976	8	16 Apr	16 Apr		17 Apr
1977	9	03 Feb	03 Feb		03 Feb
	10	05-06 May	05 May		05 May
	11	13 Oct, 13 Nov	14 Oct, 14 Nov		13 Oct, 12 Nov
1978	12	08-09 Mar	07-08 Mar		07 Mar
	13	23 May	23, 27 May		24 May
	14	09-10 Oct	09-10 Oct		10 Oct
	15	28 Dec	29-30 Dec		28 Dec
1979	16	16-17 May	16 May		16 May
	17	06, 18 Sep	07, 18 Sep		07, 18 Sep
	18	19 Dec	20 Dec		19 Dec
1980	19	01, 02 May	01 May		01 May
	20	26 Aug	26 Aug		27 Aug
	21	23 Dec	22 Dec		22 Dec
1981	22	06 May	06 May		07 May
	23	13 Oct	13 Oct		14 Oct
1982	24	07 Jan	07-08 Jan		08 Jan
	25	25 Apr	26, 28 Apr		27 Apr
	26	15 Sep	15 Sep		16 Sep
	27	29 Dec	29-30 Dec	28 Dec, 1 Jan	31 Dec
1983	28	11 Mar, 16 Apr	11-12 Mar	12 Mar	15 Apr
	29	07 Sep	07-08 Sep	08 Sep	n.d.
	30	21 Dec	19 Dec	19-20 Dec	20 Dec
1984	31	12 Apr	11 Apr	11-12 Apr	n.d.
	32	25-26 Aug	25-26 Aug	24, 26 Aug	n.d.
	33	23 Dec, 3 Jan	23-24 Dec	19, 24 Dec	21 Dec, 04 Jan
1985	34	09 May	08, 10 May	08, 10 May	n.d.
	35	28, 31 Aug	27, 30 Aug	27, 30 Aug	29 Aug
	36	12 Dec	09-10 Dec	09-10 Dec	11 Dec
1986	37	04 Apr, 23 May	03 Apr, 23 May	02 Apr	04 Apr
	38	18 Aug	20 Aug	19 Aug	n.d.
	39	28 Dec	27, 30 Dec	27, 30 Dec	29 Dec
1987	40	17 Apr, 15 May	16 Apr, 14 May	15 Apr	n.d.
	41	09 Aug	07 Aug	08 Aug	10 Aug
	42	19, 22 Dec	20 Dec	18, 24 Dec	20, 23 Dec

SPECIES OF THE INTERTIDAL TRANSECTS

The four transects yielded combined totals of 179 plant and 373 animal species (or similar taxa) for the seventeen year study period (Table 9-2). The great majority of entries in Table 9-2 represented actual species, but there were 8 "inclusive" listings among the plants and 61 such listings included in the animal section (i.e., "unident. brown blade", "unident. colonial tunicates", etc., see Tables 9-3 and 9-4).

CDIX in central Diablo Cove yielded substantially fewer species than any of the other three stations. Fewer totals from CDIX probably resulted in part from the circumstance that the data base for this station was derived from only 16 surveys compared to 31 for LCIX and 37 each for SDIX and NDIX. Species totals at CDIX, however, were so much lower than elsewhere that it seems likely that this station was species-poor in relation to the others. Possibly there was an impact here from presence of Diablo Creek, about 30 m (100 ft) south of the transect. We accordingly omitted CDIX from our first analysis comparing species totals among the stations, but examined it separately later.

Comparing the three stations with approximately equal numbers of surveys, we noted that flora at LCIX was substantially more diverse than at SDIX or NDIX, but numbers of faunal species were similar at all three areas (taking account of the slightly fewer numbers of surveys accomplished at LCIX). Superiority among plant species at LCIX resulted from the large total for Rhodophyta (Red Algae) at this site. The three transects were similar as regards species totals for Chlorophyta and Phaeophyta (Green and Brown Algae). SDIX and NDIX were very similar with respect to all three of these major floral Divisions.

NDIX and SDIX also yielded very similar species totals for most major animal Phyla. Totals of Bryozoa and Annelida, however, differed substantially between these two stations. The differences probably arose from the more intensive effort devoted to laboratory identifications of collected substrates from SDIX versus NDIX.

Table 9-2: Total numbers of species within Phyla or other major taxa, recorded from four intertidal stations in the Diablo Canyon region between 1970 and 1987. Includes lab identifications.

Phylum	SDIX	NDIX	CDIX	LCIX	Total
			PLANTS		
Cyanophyta	1	1	1	1	1
Chrysophyta	1	1	1	1	1
Lichens	1	0	0	0	1
Chlorophyta	9	6	8	10	10
Phaeophyta	16	15	7	13	23
Rhodophyta	81	87	57	119	141
Spermatophyta	1	2	1	1	2
Total Plants	110	112	75	145	179
			ANIMALS		
Protozoa	1	1	1	1	1
Porifera	9	11	5	18	23
Cnidaria	8	9	4	17	19
Platyhelminthes	2	2	1	1	2
Nemertea	1	2	1	1	2
Aschelminthes	1	1	0	1	1
Bryozoa	28	12	3	15	37
Entoprocta	0	0	0	1	1
Sipunculoida	2	1	1	2	3
Annelida	24	18	11	32	41
Mollusca	103	104	50	68	138
Arthropoda	47	46	22	37	64
Echinodermata	14	16	8	7	20
Chordata-Tunicata	8	8	4	10	15
Chordata-Pisces	4	6	1	2	6
Total Animals	252	237	112	213	373
Total Plants + Animals	362	349	187	358	552
Number of Surveys for Station	37	37	16	31	**

Comparing LCIX to NDIX and SDIX, there were substantially greater species numbers of Porifera, Cnidaria, and Annelida at LCIX but fewer Mollusca, Echinodermata, and Pisces. The differences in totals (including the large discrepancy in Rhodophyta), suggested that there may have been important biological differences between NDIX-SDIX and LCIX. If so, we should be aware of the problem and exercise caution when utilizing LCIX as a control site. We will discuss the question in greater detail in the next section. First we need to establish relative importances of the various species at each of the stations.

We chose frequency of occurrence at each station as a criterion for initially evaluating and comparing relative importances of the species. The resulting tabulation yielded a full range of possible survey occurrences (i.e., one-time occurrences to continuous encounters) at all of the stations (Tables 9-3 and 9-4). Although it was a simple parameter, survey occurrence usually proved to be a reliable and useful indicator of relative importance. Most organisms that appeared on only a few surveys were rare or minor components of the biota. Species yielding high values of survey occurrences were mostly those plants and animals that our repeated and routine observations identified as being the dominants. A few species that were clearly not dominants also displayed high survey occurrences. These were usually organisms that existed at a particular location on one or more transects and persisted there for most of the study period (some might be dominants at that spot but not elsewhere along the line). The species was perhaps long-lived and/or the particular location was highly favorable so that successive generations flourished there. One such example was *Laurencia blinksii*, which was found in 23 out of 32 surveys at LCIX. When present, this unusual Red Alga nearly always occurred at quadrats 18 and 19 which fell on top of a large flat-topped boulder in the low intertidal, well-washed by waves but semi-protected by a ridge lying immediately seaward.

Table 9-3: Number of surveys (#S) that the indicated plant species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
CYANOPHYTA				
Callothrix sp.	35	30	9	16
CHLOROPHYTA (P)				
Bryopsis sp.				4
Bryopsis corticulans				1
Cladophora sp.	36	35	16	29
Chaetomorpha sp.			1	1
Codium setchellii	2	37	16	5
Enteromorpha sp.	1	1	4	2
Enteromorpha linza			1	
Derbesia marina				2
Spongomorpha sp.	15	3	4	4
Spongomorpha mertensii	1			
Unicellular green algae (GATGORE)	37	37	16	30
Ulva sp.	33	33	15	31
Ulva expansa	1			
Ulva lobata	1			
PHAEOPHYTA (P)				
Alaria marginata				1
Analipus japonicus	7	10	10	18
Colpomenia sp.	19	1		11
Cystoseira osmundacea	6			4
Cylindrocarpus rugosus	3	9	10	6
Desmarestia ligulata var. *ligulata*		1		13
Dictyoneurum californicum	1			
Egregia menziesii	12	15	6	17
Fucus distichus ssp. *edentatus*	37	23		2
Haplogloia andersonii	1			
Hesperophycus harveyanus	28	28		
Laminaria sp.				1
Laminaria dentigera	16	8	1	18
Nereocystis luetkeana				1
Pelvetia fastigiata	37	37	14	23
Phaeostrophion irregulare		1		
Pterygophora californica	6			
Ralfsia sp.	25	10	11	4
Ralfsia pacifica	1	1	1	
Scytosiphon sp.		2		
Scytosiphon dotyi		1		
Unid. brown blade	1	2		
Unid. fucales	4			
RHODOPHYTA (P)				
Neoagardhiella gaudichaudii	28	32	13	7
Bangia sp.			1	
Bangia fusco-purpurea	3		9	1
Bossiella sp.	32	34	16	31
Bossiella californica		1		1
Bossiella orbigniana ssp. *dichotoma*	1	1		1
Bossiella plumosa				1

Table 9-3: Number of surveys (#S) that the indicated plant species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
RHODOPHYTA (cont.)				
Botryocladia sp.				1
Botryoglossum farlowianum	13	27	8	24
Calliarthron sp.	31	25	15	32
Calliarthron cheilosporioides		1		2
Calliarthron tuberculosum	1	1		1
Callithamnion sp.				2
Callithamnion acutum				2
Callithamnion pikeanum	8	22	9	23
Callithamnion rupicolum		18	10	27
Callophyllis sp.	2	1		3
Callophyllis crenulata				1
Callophyllis firma	1	9		5
Callophyllis flabellulata	1	1		3
Callophyllis violacea	6	23	2	22
Centroceras sp.				5
Centroceras clavulatum				2
Ceramium sp.		5	5	20
Ceramium californicum				1
Ceramium eatonianum				2
Ceramium sinicola				1
Clathromorphum sp.				2
Clathromorphum parcum		1		1
Chondria decipiens	6			
Corallina sp.	3	2	1	1
Corallina officinalis var. *chilensis*	21	34	11	24
Corallina vancouveriensis	35	37	16	32
Cryptonemia sp.		1		
Cryptonemia ovalifolia	1	1		
Cryptopleura sp.	1			6
Cryptopleura corallinara		1		1
Cryptopleura lobulifera		1		7
Cryptopleura violacea	28	36	16	27
Cryptosiphonia woodii	24	12		3
Cumagloia andersonii		17	6	
Endocladia muricata	37	37	16	31
Erythrophyllum delesserioides		7		22
Fauchea laciniata				1
Farlowia compressa		2		
Farlowia mollis	1	1	1	1
Gastroclonium coulteri	37	37	16	31
Gelidium sp.	5	3		3
Gelidium coulteri	35	36	16	30
Gelidium purpurascens	1			
Gelidium pusillum	33	34	16	20
Gelidium robustum		2	3	6
Gigartina sp.		1		
Gigartina agardhii	34	37	16	30
Gigartina canaliculata	37	37	16	31
Gigartina corymbifera	11	14	3	4
Gigartina exasperata	28	35	10	28
Gigartina harveyana	1	1		1

Table 9-3: Number of surveys (#S) that the indicated plant species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
RHODOPHYTA (cont.)				
Gigartina leptorhynchos	34	15	15	1
Gigartina papillata	37	37	16	31
Gigartina spinosa				1
Gigartina volans	2	2		
Grateloupia sp.	4	6	4	1
Griffithsia pacifica				1
Gymnogongrus platyphyllus				2
Halosaccion glandiforme	13	3		19
Halymenia sp.				1
Halymenia californica	1			1
Halymenia coccinea	1			
Halymenia schizymenioides	14	12	2	3
Herposiphonia sp.				1
Herposiphonia plumula				1
Herposiphonia verticillata		2		8
Hildenbrandia sp.	36	36	16	30
Hildenbrandia occidentalis	1			
Hymenena sp.	1	1		25
Hymenena flabelligera	1	1		1
Hymenena multiloba				1
Iridaea sp.	1	1		
Iridaea cordata	27	33	8	23
Iridaea cordata var. *cordata*	1			1
Iridaea cordata var. *splendens*				1
Iridaea flaccida	37	37	15	32
Iridaea heterocarpa	35	36	15	24
Iridaea lineare				5
Laurencia sp.				1
Laurencia blinksii				23
Laurencia spectabilis	32	37	13	26
Lithophyllum sp.	29	22	8	22
Lithophyllum grumosum				1
Lithothamnium sp.	34	32	12	25
Lithothamnium pacificum		1		1
Lithothrix aspergillum	1			
Membranoptera sp.				1
Melobesia sp.	8	21	7	1
Mesophyllum conchatum				3
Mesophyllum lamellatum	29	24	16	24
Microcladia borealis	3	1		23
Microcladia californica		1		
Microcladia coulteri	32	32	8	25
Neoptilota sp.		1		
Neoptilota densa	4			1
Petrocelis franciscana	36	36	16	31
Peyssonellia sp.	15	24	1	14
Peyssonellia meridionalis	18	16	11	10
Pikea sp.	4			7
Pikea californica	1			2
Plocamium cartilagineum				1
Plocamium violaceum	1	1	11	9

Table 9-3: Number of surveys (#S) that the indicated plant species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
RHODOPHYTA (cont.)				
Polyneura latissima			4	4
Polysiphonia sp.		2		23
Polysiphonia hendryi		1		2
Polysiphonia pacifica				1
Polysiphonia paniculata				1
Porphyra sp.	30	33	16	26
Porphyra perforata			1	1
Prionitis angusta	1			
Prionitis australis				1
Prionitis lanceolata	36	37	16	32
Prionitis linearis		1		
Prionitis lyallii	3	2	12	
Pseudolithophyllum neofarlowii	36	36	16	30
Pterocladia media		1		
Pterosiphonia sp.	1		1	8
Pterosiphonia baileyi				22
Pterosiphonia bipinnata				1
Pterosiphonia dendroidea				1
Ptilota sp.				1
Rhodochorton purpureum	1			10
Rhodoglossum affine	34	35	16	18
Rhodoglossum californicum	4	2		1
Rhodoglossum roseum	7	11	2	3
Rhodomela larix				3
Rhodymenia sp.	2	7		2
Rhodymenia californica	1			1
Rhodymenia pacifica		3		1
Schizymenia pacifica	9	10	5	3
Smithora naiadum	14	19	2	
Unid. coralline (white)	6	8	5	3
Unid. coralline (stubs)	6	2	4	
Unid. red blade	11	6	8	6
LICHENS (P)				
Unid. lichens (num. of types)	33			
SPERMATOPHYTA (P)				
Phyllospadix sp.	19	34	16	14
Phyllospadix scouleri		1		
CHRYSOPHYTA (P)				
Unid. diatoms	13	12	15	9
Taxa Listed	117	119	82	153
# of Taxa	111	113	76	147
# of Taxa LabO	0	0	0	0
# of Quads	1750	1090	650	590
# of Surveys	37	37	16	32

Table 9-4: Number of surveys (#S) that the indicated animal species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX = 37, CDIX = 16, LCIX = 31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
PORIFERA (P)				
Acarnus erithacus				10
Axocielita originalis		1	1	1
Cliona celata	1			1
Gellius textapatina		1		
Halichondria panicea				1
Haliclona sp.	3	7	4	6
Haliclona permollis		1		
Isociona lithophoenix				2
Leucilla nuttingi				7
Leuconia sp.	2	4		4
Leuconia heathi				1
Leucosolenia sp.	2	1		6
Leucosolenia eleanor				1
Clathrina blanca	1			
Leucosolenia nautila				1
Lissodendoryx sp.				1
Lissodendoryx firma		1		8
Microciona sp.				2
Myxilla sp.		1		1
Ophlitaspongia pennata	1	1	1	
Plocamia sp.	8	11	2	19
Plocamia karykina	1			
Unid. sponges	15	20	12	23
CNIDARIA (P)				
Abietinaria abietina				1
Aglaophenia sp.				21
Anthopleura sp.	2	5		9
Anthopleura elegantissima	37	36	16	31
Anthopleura xanthogrammica	34	36	2	30
Astrangia lajollanensis		1		
Campanularia sp.				1
Corynactis californica	3	6		26
Epiactis prolifera	23	30	14	15
Eudendrium sp.				1
Metridium sp.				1
Perigonimus sp.				1
Plumularia sp.				1
Sertularella sp.				2
Tealia sp.		1		
Unid. hydroids	1			4
Unid. hydroids thecate	3	2		12
Unid. actinarians	4	3	1	3
Unid. ceriantharians				1
PLATYHELMINTHES (P)				
Unid. turbellarians	1	1		
Unid. polyclads	18	10	1	1

Table 9-4: Number of surveys (#S) that the indicated animal species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX = 37, CDIX = 16, LCIX = 31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
NEMERTINEA (P)				
Unid. nemerteans	15	20	13	22
Unid. hoplonemerteans		1		
ASCHELMINTHES COMPLEX (P)				
Unid. nematodes	1	1		1
ENTOPROCTA (P)				
Unid. entoprocts				1
BRYOZOA (P)				
Alcyonidium sp.	1	1		
Callopora sp.				1
Callopora armata				1
Cauloramphus sp.	1	1		
Cauloramphus spiniferum	2			1
Costazia sp.		1		1
Costazia costazi	1	2		
Crisia sp.	1			1
Crisia occidentalis				1
Eurystomella bilabiata	24	24	2	11
Fenestrulina malusi	1			
Flustrella sp.				1
Hippodiplosia sp.	1			
Hippodiplosia insculpta	2			
Hippoporella gorgonensis	1			
Hippothoa sp.	2	2		1
Hippothoa hyalina	1	1		1
Hippothoa sp. 2	1			
Hippothoa sp. 3	1			
Lagenipora hippocrepis	1			
Microporella sp.	1			
Microporella californica	1	1		
Microporella ciliata	1			
Microporella cribrosa	1			
Mucronella major	1			
Rhynchozoon sp.	11	14	1	4
Rhynchozoon grandicella	1			
Rhynchozoon rostratum	1			
Rhynchozoon spicatum	2			
Schizoporella cornuta	1			
Scrupocellaria californica		1		1
Smittina sp.	1			
Stomachetosella cruenta	1			
Victorella sp.				2
Unid. cheilostomatans	28	24	9	16
Unid. cyclostomatans burrowing		1		
Unid. ctenostomatans				1

Table 9-4: Number of surveys (#S) that the indicated animal species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
MOLLUSCA (P)				
Acanthina sp.	35	31	9	
Acmaea mitra	29	25	12	15
Amphissa sp.	9	8		1
Amphissa versicolor	1	2		1
Anisodoris nobilis	1		1	
Archidoris montereyensis	1			
Astraea gibberosa	9	2		
Barleeia sp.	12	4	6	
Barleeia acuta	1			
Barleeia haliotiphila	1	1		
Barleeia subtenuis		1		
Bittium sp.	15	6	5	
Bittium attenuatum		1		
Bittium eschrichti	1			
Cadlina sp.	2			
Caecum dalli	1			
Calliostoma sp.	7	17	3	11
Calliostoma ligatum		1		1
Callistochiton palmulatus	1			
Chama sp.		2		
Collisella sp.	1	1		1
Collisella asmi	32	32	15	5
Collisella digitalis	37	37	16	31
Collisella limatula	37	37	16	31
Collisella ochracea	1	1		
Collisella pelta	37	37	16	32
Collisella scabra	37	37	16	31
Collisella strigatella	2	1		
Collisella triangularis				1
Conus californicus	9			
Cryptochiton stelleri		1		
Crepidula sp.	34	34	14	
Crepidula adunca	1	1		
Crepidula perforans	1	1		
Crepipatella sp.	1			
Cyanoplax sp.	32	31	14	13
Cyanoplax dentiens	1	1		
Cyanoplax hartwegii	2	2	1	
Cyanoplax sp. 1	1	1		
Cymakra gracilor		1		
Dendrodoris sp.	2	4	2	8
Dendropoma sp.		1		
Diaulula sandiegensis	2	1	1	
Diodora aspera	2	5		4
Entodesma pictum				1
Entodesma saxicola				1
Epitonium sp.	4	4		
Eubranchus sp.				1
Fissurella volcano	34	36	16	14

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Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
MOLLUSCA (cont.)				
Fusinus sp.		1		
Haliotis sp.	1	2	1	6
Haliotis cracherodii	32	36	16	32
Haliotis rufescens	4	7		3
Hermissenda crassicornis	2	4	2	
Hiatella sp.	4	4		1
Hiatella arctica				1
Hinnites multirugosus	1	4		
Homalopoma sp.	29	27	8	2
Homalopoma luridum	1	1		1
Hopkinsia sp.	3	6		1
Katharina tunicata		1		14
Kellia sp.				1
Lacuna sp.	25	30	11	14
Lacuna marmorata	1	2		1
Lacuna porrecta				1
Lacuna unifasciata	1	1		1
Lepidochitona keepiana	1	1		
Lepidozona sp.	6	2	1	
Lepidozona cooperi	1	1		
Lepidozona mertensi		1		
Lepidozona sinudentata	1	1		
Lirularia succincta		1		
Littorina sp.	3	1		
Littorina planaxis	37	37	16	31
Littorina scutulata	37	37	16	30
Lottia gigantea	1	3	5	8
Margarites sp.		1		
Margarites pupillus salmoneus		1		
Megatebennus bimaculatus		2		
Mitra idae	3			
Mitrella sp.	20	19	5	3
Mitrella aurantiaca	1			
Mitrella carinata	31	27	10	2
Mitrella tuberosa	1	1		
Mitromorpha sp.		1		
Modiolus sp.	1	1		
Mopalia sp.	26	23	15	15
Mopalia acuta	1			
Mopalia hindsii				1
Mopalia lowei		1		1
Mopalia lignosa		1		
Mytilimeria sp.				1
Mytilus sp.	13	11	16	31
Mytilus californianus				3
Notoacmea fenestrata	1	1		1
Notoacmea insessa		1		
Notoacmea persona			2	
Notoacmea scutum	36	36	16	29

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Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
MOLLUSCA (cont.)				
Nucella sp.	7	3	5	26
Nucella emarginata				1
Nuttallina sp.	21	19	16	30
Nuttallina californica	1			1
Nuttallina fluxa				1
Ocenebra sp.	7	3	5	4
Ocenebra circumtexta	33	35	16	18
Ocenebra interfossa	20	12	2	
Ocenebra lurida	7	14		4
Ocenebra subangulata	1			
Onchidella sp.	1	7	1	
Phidiana pugnax	3			
Pododesmus cepio	4	2		
Polinices sp.				1
Pseudomelatoma sp.	7	6		
Pseudomelatoma penecillata	2			
Pseudomelatoma torosa	2			
Rostanga sp.		1		
Serpulorbis squamigerus	15	18	4	27
Stenoplax sp.	1			
Stenoplax heathiana	1	1		
Tegula sp.	26	24	8	1
Tegula brunnea	36	37	14	30
Tegula funebralis	37	37	16	31
Tegula montereyi		1		
Tegula pulligo	1	1		
Tonicella lineata	11	19	5	20
Tricolia sp.	12	11	5	2
Tricolia pulloides	1	1		
Williamia peltoides		1		
Unid. acmaeids	37	34	16	30
Unid. gastropods neopic	1			1
Unid. pelecypods	3	2	1	1
Unid. mytilids	1	1		1
Unid. gastropod eggcases	6	4	3	3
Unid. aeolids	2			
Unid. dorids	1	2	1	
Unid. pholads	5	11	2	20
Unid. gastropods	1	3		
Unid. chitons	36	33	11	27
SIPUNCULIDA (P)				
Phascolosoma sp.	6	3	6	7
Phascolosoma agassizi				1
Unid. sipunculids	1			

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Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
ANNELIDA (P)				
Anaitides sp.				1
Boccardia sp.	1			
Brania limbata	1			1
Janua sp.		1		1
Diopatra sp.	12	3		1
Dodecaceria sp.			2	26
Eteone sp.				1
Eudistylia polymorpha				1
Halosydna brevisetosa		1		1
Haplosyllis spongicola				1
Nereis grubei	1	1		1
Odontosyllis parva	1			
Paleanotus bellis		1		
Perinereis montera				1
Pherusa papillata	1			
Phragmatopoma sp.	35	35	16	32
Phragmatopoma californica				1
Pista sp.	28	10	10	14
Polydora pygidialis				1
Sabellaria cementarium	1	1		1
Salmacina sp.	7	16	3	19
Serpula vermicularis				1
Sphaerosyllis pirifera	1			
Spirobranchis spinosus	19	18	13	14
Spirorbis sp.				1
Spirorbis spirillum	1	1		
Typosyllis sp.	1			1
Typosyllis alternata	1			1
Typosyllis armillaris				1
Typosyllis fasciata	1	1		1
Typosyllis variegata	1			
Unid. nereids	10	7	5	3
Unid. phyllodocids				1
Unid. chaetopterids	3	6	4	4
Unid. sabellids	9	6		7
Unid. serpulids	15	19	11	19
Unid. spionids			2	
Unid. spirorbinids	35	34	15	16
Unid. terebellids				1
Unid. oligochaetes	1			
Unid. polychaete	3	6	5	6
ARTHROPODA (P)				
Balanus sp.	34	30	14	32
Balanus glandula	1			1
Balanus nubilis				1
Cancer sp.	15	7		11
Caprella sp.				1
Caprella angusta				1
Caprella verucosa				1
Chthamalus sp.	37	37	16	31

Table 9-4: Number of surveys (#S) that the indicated animal species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
ARTHROPODA (cont.)				
Cirolana sp.	6	1		
Cirolana harfordi	1	1		
Alpheus sp. (Old-*Crangon*)	1	2		
Cryptolithodes sp.	2			
Cryptolithodes sitchensis	1			
Exosphaeroma amplicauda	1			
Hapalogaster cavicauda		1		
Hemigrapsus sp.	36	30	12	7
Hemigrapsus nudus		1		
Idotea sp.	7	6		12
Idotea schmitti				1
Jaeropsis sp.	1			
Ligia sp.	2	3	2	3
Lophopanopeus sp.		3		
Lophopanopeus leucomanus heathi	1	1		
Mimulus sp.		1		
Munna sp.	1			1
Pachycheles sp.	3	2	1	
Pachycheles pubescens				1
Pachygrapsus crassipes	31	33	15	29
Pagurus sp.		1		
Pagurus granosimanus	1	1		
Pagurus hirsutiusculus		1		
Pagurus samuelis	1	1		
Petrolisthes sp.	34	25	9	8
Petrolisthes cinctipes		1		
Pollicipes polymerus	2	3	12	31
Pugettia sp.	5	5	5	3
Pugettia producta	34	31	9	18
Pugettia richii	12	16		2
Scyra acutifrons	1			
Spirontocaris sp.	13	20	7	1
Spirontocaris picta (*Heptacarpus*)		1		
Spirontocaris taylori (*Heptacarpus*)	1			
Synapseudes sp.				1
Tetraclita sp.	1	1		
Tetraclita squamosa var. *rubescens*	37	35	16	31
Unid. caprellids	1	1	1	1
Unid. gammarid spp.	29	34	15	24
Unid. brachyuran juveniles	4			1
Unid. pycnogonids	1	2	2	1
Unid. anthurideans				1
Unid. asellotans	1	1		
Unid. flabelliferans	1	1		
Unid. cirolanid	2	1	1	
Unid. grapsoid	19	17	15	13
Unid. copepods	7	18	4	20
Unid. copepods harpacticoid	1	1		1
Unid. isopod		1		

Table 9-4: Number of surveys (#S) that the indicated animal species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
ARTHROPODA (P)				
Unid. halacarids	19	21	13	6
Unid. cheliferans	1			1
Unid. pagurids	37	37	16	29
Unid. majiid	5	8	4	1
Unid. sphaeromids	4	3		
Unid. barnacles balanomorpha	9	3	2	6
Unid. ostracods	1	1		1
ECHINODERMATA (P)				
Axiognathus sp.		1		
Henricia sp.	4	3	1	4
Leptasterias sp.	26	27	14	28
Leptasterias pusilla		1		
Leptosynapta sp.		1		
Lissothuria nutriens	7	6	3	
Ophiothrix sp.	1			
Ophiothrix spiculata		1		
Orthasterias sp.	1			
Patiria miniata	23	32		5
Pisaster brevispinus		1		
Pisaster giganteus	2			
Pisaster ochraceus	16	17	8	32
Pycnopodia helianthoides	4	11	3	
Strongylocentrotus sp.	3	6	3	
Strongylocentrotus franciscanus	1			
Strongylocentrotus purpuratus	19	19	11	32
Unid. holothuroids		1		
Unid. asteroids	6	9	6	3
Unid. ophiuroids	11	10		1
TUNICATA (P)				
Clavelina sp.	17	23	2	2
Cnemidocarpa finmarkiensis				1
Cystodytes sp.		2		
Didemnum sp.	10	9		4
Distaplia sp.	1			
Archidistoma sp.	3	9	1	20
Archidistoma psammion				1
Euherdmania sp.	2			4
Euherdmania claviformis				1
Metandrocarpa sp.	4	7		
Ritterella pulchra	1	2		
Styela sp.	5	2		7
Styela montereyensis				1
Synoicum parfustis		1	1	
Unid. tunicates, colonial	34	30	14	25

Table 9-4: Number of surveys (#S) that the indicated animal species (or similar taxon) occurred along our intertidal transects in the Diablo Canyon region from 1970 to 1987. Table includes laboratory identifications. Totals surveys for each station: SDIX = 37, NDIX =37, CDIX = 16, LCIX =31.

Taxon Name	SDIX #S	NDIX #S	CDIX #S	LCIX #S
VERTEBRATA (P)				
Artedius lateralis		1		
Gibbonsia sp.		1		
Unid. blennidae	1	3		
Unid. cottidae	11	12		6
Unid. gobiesocidae	2	4		
Unid. stichaeidae	22	17	5	2
PROTOZOA (P)				
Gromia sp.	7	3	1	5
MINERAL (K)				
Boulders (#)	33	34	16	25
Taxa Listed	254	239	113	214
# of Taxa	253	238	112	213
# of Taxa LabO	0	0	0	0
# of Quads /10	1750	1090	650	590
# of Surveys	37	37	16	32

SIMILARITIES AMONG STATIONS

As noted above, comparisons of species per Phylum between the stations suggested that biological differences might exist between LCIX and SDIX-NDIX. This was considered an important finding, if valid, because it might affect the usefulness of LCIX as a control station. We investigated possibilities of existence of any such difference by extending our analyses to the species level, comparing similarities and differences among the stations.

We separated the listings of Tables 9-3 and 9-4 into groups corresponding to those species occurring only at a single station (unique species) and those observed at two or at all three stations (shared species). We did not include CDIX in this first analysis, but will discuss it subsequently in relation to the other three stations.

Less than ten percent of the plant species at SDIX and NDIX were unique to these stations (Table 9-5). Almost a third of the plants at LCIX were absent from the two Diablo Cove stations. Approximately 50 to 70 percent of the plant species at each station were shared with both other stations. Relatively small proportions of plants occurred at two but not at three stations.

Distributions of animal species among the three stations differed slightly from patterns shown by the flora. Unique animal species ranged from 20 to 30 percent of the totals at each station. About 50 to 60 percent of the totals were species occurring at all three stations (i.e., values similar to "plants shared by all stations"). Relatively few species were shared between LCIX and only one of the Diablo Cove stations. Roughly a quarter, however, of the animals at SDIX and NDIX were shared with each other but not with LCIX, suggesting within-Cove similarities.

The statistics thus indicated that a half or somewhat greater proportion of the intertidal species occurred at all three stations. The high proportions of unique plants at LCIX, and of animals shared only between SDIX and NDIX, stood out as differences that were possibly important and deserved further inquiry.

Table 9-5: Numbers of intertidal species (or similar taxa) grouped according to Phylum, showing occurrences per station as well as numbers of species unique to or shared with other stations. Includes laboratory identifications.

	SDIX				NDIX				LCIX				Site	
Phylum	Total species for Station	Unique species for Station	Species shared with NDIX only	Species shared with LCIX only	Total species for Station	Unique species for Station	Species shared with SDIX only	Species shared with LCIX only	Total species for Station	Unique species for Station	Species shared with SDIX only	Species shared with NDIX only	Species occurring at all 3 Stations	Total Species per Phylum
						PLANTS								
Four Minor Phyla	4	1	0	0	4	1	0	0	3	0	0	0	3	5
CHLOROPHYTA	9	3	0	0	6	0	0	0	10	4	0	0	6	10
PHAEOPHYTA	16	4	3	1	15	3	3	1	13	3	1	1	8	23
RHODOPHYTA	81	6	6	9	87	8	6	13	119	37	9	13	60	141
Total Plants	110	14	9	10	112	12	9	14	145	44	10	14	77	179
						ANIMAL								
Five Minor Phyla	6	1	1	0	6	1	1	0	6	2	0	0	4	9
PROTOZOA	1	0	0	0	1	0	0	0	1	0	0	0	1	1
PORIFERA	9	2	1	1	11	2	1	3	18	9	1	3	5	23
CNIDARIA	8	0	0	1	9	2	0	0	17	9	1	0	7	19
BRYOZOA	28	17	4	2	12	1	4	2	15	6	2	2	5	37
ANNELIDA	24	6	1	3	18	1	1	2	32	13	3	2	14	41
MOLLUSCA	103	18	33	2	104	18	33	3	68	13	2	3	50	138
ARTHROPODA	47	6	12	4	46	9	12	0	37	8	4	0	25	64
ECHINODERMATA	14	4	3	0	16	6	3	0	7	0	0	0	7	20
CHORDATA-TUNICATA	8	1	2	1	8	2	2	0	10	5	1	0	4	15
CHORDATA-PISCES	4	0	2	0	6	2	2	0	2	0	0	0	2	6
Total Animals	252	55	59	14	237	44	59	10	213	65	14	10	124	373
Total Plants + Animals	362	69	68	24	349	56	68	24	358	109	24	24	201	552

Examining the category of unique plants at LCIX, 42 of the 44 unique species occurred on only five surveys or less (29 of these species were single-time occurrences). Two plants did occur fairly frequently: *Pterosiphonia baileyi* on 22 surveys, *Laurencia blinksii* on 23 surveys. Thus it appeared that a great majority of the unique plants at LCIX were uncommon or rare species that appeared irregularly from time to time. We concluded that LCIX was not consistently harboring a flora considerably more diverse than that found in Diablo Cove. One might still suspect, however, that subtle environmental differences at LCIX favored ephemeral occurrences of uncommon plants.

Among the 65 unique animals at LCIX, 61 occurred four times or less (54 were only single occurrences). The four animals that were unique and occurred fairly frequently were: *Axocielita originalis*, 10 surveys; *Leucilla nuttingi*, 7 surveys; *Aglaophenia* sp., 21 surveys; *Dodecaceria fewkesi*, 26 surveys. All four of the frequently-occurring unique animals as well as the two plants, were lower intertidal species. None were considered to be dominants in the few quadrats where they were found. It appeared that possibly specialized conditions in the lower intertidal at LCIX did allow occurrence of some species that were not present in Diablo Cove, but the primary biota along all three transects was similar.

Among unique species at SDIX and NDIX, the overwhelming majority resulted from plants and animals that were encountered only once or twice during the surveys. They were thus not likely to be significant in the community structures, nor influential as to relationships with other species, nor indicative of important environmental differences between these two stations. Four unique plants and no unique animals occurred at survey frequencies exceeding two for NDIX and SDIX. These were: at SDIX - *Pterygophora*, 4 surveys; *Chondria*, 6 surveys, and Lichens, 33 surveys; at NDIX - *Cumagloia*, 17 surveys. None of these four plants was considered to be an important component of the intertidal flora.

Turning to species shared only between SDIX and NDIX, 45 of the 59 animals involved occurred at survey frequencies of four per station or less (27 were at frequencies of one). Six of the nine shared plants occurred at frequencies of three or less per station (three were single occurrences). Frequently-occurring shared plants were: *Hesperophycus*, 28 surveys for both SDIX and NDIX, *Smithora* at 14/19 occurrences, and unid. corallines at 6/2. Frequently-occurring shared animals were: *Acanthina*, 35/31; *Astraea*, 9/2; *Barleeia* sp., 12/4; *Bittium* sp., 15/6; *Crepidula* sp., 34/34; *Epitonium*, 4/4; *Lepidozona* sp., 6/2; *Ocenebra interfossa*, 20/12; *Onchidella* sp., 1/7; *Pseudomelatoma* sp., 7/6; *Lissothuria*, 7/6; *Pycnopodia*, 4/11, *Strongylocentrotus* sp., 3/6; and *Metandrocarpa*, 4/7. A few of these organisms (*Hesperophycus*, *Smithora*, *Acanthina*, *Ocenebra*, and *Pycnopodia*) might conceivably have had some ecologically significant influence at particular times or locations. We concluded that biological similarities between the three stations far outweighed the dissimilarities. Species shared by all three stations included all of the obviously dominant plants and animals. The unique species consisted primarily of rare or uncommon organisms that occurred rather infrequently or at specialized locations along a particular transect. There were, however, a few species of possible ecological importance that occurred in Diablo Cove but not at the control station. Furthermore, LCIX apparently favored occasional appearances of unusual biota.

Taken in its entirety, the evidence suggested that rather subtle environmental differences probably existed between Diablo Cove and our control station, especially as regards the lower intertidal. Whether these differences led to significant influences on dominant organisms was uncertain. We proceeded with further analyses under the assumption that any such differences caused little or no effect on the dominants, but with the reservation that comparisons between LCIX and other transects should be viewed with some small degree of caution.

We drew up a separate similarity tabulation to analyze relationships between CDIX and the other stations (Table 9-6). Only two plants (*Enteromorpha linza* and *Bangia* sp., both semimicroscopic forms that produce slippery films on boulders in the high intertidal) and two animals (*Notoacmea persona* and Unident. Spionids, a small limpet and a group of tiny worms) were unique to CDIX. None of the four were encountered on more than two surveys, so were not considered as ecologically important at the station. About 80 percent of the species observed at CDIX also occurred at the other three stations and 96 percent of the CDIX biota also occurred at SDIX, or at NDIX, or at both stations. CDIX was thus unusual only in possibly being somewhat deficient with regard to species totals.

Table 9-6: Numbers of intertidal species (or similar taxon) grouped according to Phylum, showing occurences per station as well as numbers of species unique to or shared with other stations. (Includes laboratory identifications)

Phylum	CDIX Total species for Station	Unique species for Station	Species shared with SDIX,NDIX, LCIX	Species shared with SDIX And NDIX	Species shared with SDIX and LCIX	Species shared with NDIX and LCIX	Shared with SDIX only	Shared with NDIX only	Shared with LCIX only
				PLANTS					
Four Minor Phyla	3	0	3	3	0	0	0	0	0
CHLOROPHYTA	8	1	6	6	0	0	0	0	1
PHAEOPHYTA	7	0	6	7	0	0	0	0	0
RHODOPHYTA	57	1	48	51	1	1	0	1	1
Total Plants	75	2	63	67	1	1	0	1	2
				ANIMAL					
Five Minor Phyla	3	0	3	0	0	0	0	0	0
PROTOZOA	1	0	1	0	0	0	0	0	0
PORIFERA	5	0	3	1	1	0	0	0	0
CNIDARIA	4	0	4	0	0	0	0	0	0
BRYOZOA	3	0	3	0	0	0	0	0	0
ANNELIDA	11	1	9	0	0	0	0	0	1
MOLLUSCA	50	1	37	48	0	0	1	0	0
ARTHROPODA	22	0	20	22	0	0	0	0	0
ECHINODERMATA	8	0	5	8	0	0	0	0	0
CHORDATA-TUNICATA	4	0	3	0	0	0	0	1	0
CHORDATA-PISCES	1	0	1	0	0	0	0	0	0
Total Animals	112	2	88	78	1	1	1	1	1
Total Plants + Animals	187	4	151	146	2	2	1	2	4

CATEGORIZATION OF SELECTED INTERTIDAL SPECIES

We selected 32 plant and 34 animal species as being the most important along the intertidal transects or as having special interest for our studies, based on their survey occurrences (see Tables 9-3 and 9-4) as well as our recollections of their abundances and degree of dominance at the stations. These 66 organisms were analyzed further as described in Chapter 6 to identify any changes in abundances or distributions associated with occurrence of the 1983-84 El Niño or during the operational period. Appendix 9-1 contains detailed information on these 66 species and their abundances and distributions at all intertidal stations.

Our subjective reviews of the data tables categorized plants and animals according to whether there were obvious changes in abundances or distributions during the 1983-84 El Niño, as well as from 1985 to 1987, the operational years (Tables 9-7 and 9-8). We have also listed scores for these species derived from the clustering analyses. We initially used single-linkage clustering and binary data. There were disagreements between decisions from the two methods for about 10 percent of the cases. We repeated the clustering analyses for 19 plant and 10 animal species, using minimum variance or group average methods and entering the data in full quantitative format for the plants. The final result was five conflicts, or about two percent of the determinations. Three of the conflicts arose from artifacts caused by truncating the data bases (*Gigartina exasperata/corymbifera* at NDIX, *Tegula brunnea* at LCIX, and *Tetraclita* at SDIX). The other two conflicts resulted from physical disruptions remaining after the 1983-84 El Niño (*Corallina officinalis* at LCIX and *Notoacmea scutum* at SDIX).

The most noteworthy generalization derived from these analyses was that animals as a group appeared to be unchanged during operational years or displayed increased abundances. Plants as a group tended to be either unchanged or incurred decreases in abundances. We found no animal species whose abundances or occurrences decreased at all stations (*Tegula brunnea* may have decreased at CDIX, our station closest to the DCPP discharge). Nine plants are believed

Table 9-7: Categorization of selected intertidal plants of the Diablo Canyon region, based on subjective reviews of transect data and from single linkage or group average* or minimum variance** cluster analyses (cluster scoring was 0 = no change up to 5 = conclusive change, see Table 6-3). N = NDIX, C = CDIX, S = SDIX, L = LCIX, ? = uncertain, i = insufficient data, X = disappeared during later years. El Niño effects were E = clearcut, e = possible.

	El Niño		Subjective Review: Operational Abundance						Subjective Review: Distrib. Shift			Cluster Analysis (Station)
			Lower		No Chg		Higher		Down		Up	
	E	e	Yes	?	Yes	?	Yes	?	Yes	?	Yes	N C S L
CHLOROPHYTA												
*Codium setchellii**	C		NC		L							3 5 i i
Ulva sp.*	NC	S	S	C	L	N						3 4 4 1
PHAEOPHYTA												
Egregia menziesii	NC			S			L					X X X 4
Fucus/Hesperophycus	S	N	S	N					S			3 i 4 i
Pelvetia fastigiata	N		L	NS		C			S		N	4 3 4 X
RHODOPHYTA												
Bossiella spp./ *Calliarthron* spp.			S			NCL			NS			3 1 5 3
Corallina officinalis	L	CN	NCS		L							4 i X 3
Corallina vancouveriensis	NS		C	NS	L				N	S		4 4 4 2
Coralline crust			C		SL	N			N			1 3 1 2
Cryptopleura/Hymenena	S	NC	C		NL		S		N			4 5 3 1
*Endocladia muricata**		CS	NCS		L				N			5 5 5 1
*Gastroclonium coulteri***	S	N	NC	S	L				NS			5 4 3 2
*Gelidium coult./pus.***		NCS		NCS		L						4 2 3 1
Gigartina agardhii	SL	NC	NCS		L				S			5 5 4 1
*Gigartina canaliculata**	NS		NCS			L			S			5 5 5 0
Gigartina corymb./exasp.	S	L	C	N	L			S	S			4 5 X 1
Gigartina leptorhynchos	S	N			S			NC				4 4 0 i
Gigartina papillata	NS	C	NS	CL					S	NC		3 2 4 2
Hildenbrandia/Calothrix	C	S			LC	NS						3 2 3 0
Iridaea cordata		S			L	C		NS		N		i X i 1
*Iridaea flaccida**	NS	C	NCS		L				S			5 5 4 1
Iridaea heterocarpa	NS	C	NC			L			S			5 4 4 1
Laurencia blink./spectab.	S		C			NSL						3 4 4 1
Microcladia coulteri	NSL	C	C	N	L	S				S		2 X 4 1
Neoagardhiella baileyi		NCS				NS						1 4 3 i
*Petrocelis/Ralfsia**				S	L	N		C		N		4 4 4 0
*Porphyra perforata**	NS	CL	S	NC	L							3 3 3 1
*Prionitis lanceolata**	L	S		L		C		NS	S			3 2 5 5
Prionitis lyallii						C						i 3 i i
*Pseudolithophyllum neofarlowii**	N	LC		C	L	NS				NS		4 4 4 2
*Rhodoglossum affine**		NCS	S	NC		L			NS			4 4 4 2
SPERMATOPHYTA												
Phyllospadix scouleri	SL			C	N							3 3 X X

Table 9-8: Categorization of selected intertidal animals of the Diablo Canyon region, based on subjective reviews of transect data and from single linkage or group average* or minimum variance** cluster analyses (cluster scoring was 0 = no change up to 5 = conclusive change, see Table 6-3). N = NDIX, C = CDIX, S = SDIX, L = LCIX, ? = uncertain, i = insufficient data, X = disappeared during later years. El Niño effects were E = clearcut, e = possible.

	El Niño		Subjective Review: Operational Abundance						Distrib. Shift			Cluster Analysis (Station)			
			Lower		No Chg		Higher		Down		Up				
	E	e	Yes	?	Yes	?	Yes	?	Yes	?	Yes	N	C	S	L
Cnidaria															
Anthopleura elegantissima	NS			S	NL			C	N			4	4	4	2
Corynactis californica					NL							i	i	i	1
Bryozoa															
Eurystomella bilabiata	S			S	N		L					0	i	3	i
Annelida															
Phragmatopoma californica	L	C			L		NS	C	S		C	4	3	4	1
Pista elongata		S			NSL			C				i	3	3	i
Mollusca															
Acmaea mitra	NS	C		C	NS		L					3	4	1	3
Collisella digitalis	NS				SL		NC		NC			4	4	2	0
*Collisella limatula***	NS	L			L		S	NC	NC	S		3	3	3	1
Collisella pelta	NSL				N	C	S	L	N	S		4	2	3	4
Collisella scabra	NCS				S		NC	L	NCS			4	4	4	3
Cyanoplax spp.					L		NCS					5	5	3	i
Fissurella volcano							NL	CS				3	2	3	3
*Haliotis cracherodii**	NS		NS		C	L				C		4	1	4	3
Littorina planaxis	C				NCL	S				N		3	1	2	1
Littorina scutulata	NS				SL			CN	N	S		3	4	4	0
Mopalia spp.	NCS	L		S			NCL					3	3	i	3
Mytilus spp.		C			L		NC	S				4	5	i	1
*Notoacmea scutum***	NCL	S		CSL	N				N	CS		2	3	0	2
Nuttalina californica	N	C			L		N	CS				4	4	2	1
Ocenebra circumtexta	NC					L	NCS					4	4	4	2
*Serpulorbis squamigerus**							NSL					4	i	4	3
*Tegula brunnea**	C			C	L		N	S	NS			4	3	3	3
Tegula funebralis	S				NL	C		S	NS			1	2	4	1
Arthropoda															
Balanus spp.	C				CL	S	N				C	3	2	2	2
Chthamalus spp.**		S			L		NCS		NC			3	3	4	1
Hemigrapsus spp.		C		C	S	NL						2	2	0	i
Pachygrapsus crassipes	NC	S			L		C	NS				3	4	3	1
Petrolisthes spp.	NS				SL	NC						2	i	3	i
Pollicipes polymerus		L				SL	C	N				i	4	i	3
*Tetraclita squamosa rubescens**	NS				C		NSL		NS			4	2	1	3
Unident. Paguridae	L				CSL		N					1	2	2	0
Echinodermata															
Patiria miniata	NS			N		S						3	i	i	i
*Pisaster ochraceus**		L		C	NSL							i	i	i	1
Strongylocentrotus purpuratus					L		C	NS				i	4	3	1

to have decreased at all Diablo Cove stations where they occurred in preoperational times (*Fucus/Hesperophycus*, *Corallina officinalis*, *C. vancouveriensis*, *Endocladia*, *Gigartina agardhii*, *G. canaliculata*, *G. papillata*, *Iridaea flaccida*, and *Porphyra*).

We found that 6 intertidal plants and 24 animals gave some indications of enhanced populations during the operational period at one or more Diablo Cove stations (Tables 9-7 and 9-8). Trends of decreased abundances and downward distributions during this final period of our study were shown by 28 plants and 21 animals. A number of these trends were not clearly defined and the uncertainty associated with their category was shown in the tables by question marks. Some of these uncertainties may become resolved with the passage of time. Sixteen plants and 20 animals were classed as neither encouraged or discouraged during the operational environment at one or more of our Diablo Cove stations. Some organisms were shown as occurring in two or three of the classifications when their responses differed at the various stations.

Two intertidal plants, *Cryptopleura/Hymenena* and *Gigartina corymbifera/exasperata*, deserve special discussion. *Cryptopleura violacea* and *Gigartina exasperata* displayed abundant and seemingly healthy populations in the shallow subtidal, proliferating throughout much of Diablo Cove. Both *Cryptopleura/Hymenena* and *G. corymbifera/exasperata* displayed enhanced abundances at SDIX, neutral behavior at NDIX, and decreased abundances at CDIX. Distribution of the *G. corymbifera/exasperata* population at SDIX displayed a downward shift and a similar response was seen for *Cryptopleura/Hymenena* at NDIX. The degree of changes occurring during the operational period in Diablo Cove (based on observed condition of many of the plant species) was regarded as SDIX < NDIX < CDIX. It may be significant that responses by *Cryptopleura/Hymenena* and *G. corymbifera/exasperata* to the operational environment (as indicated by their classifications: flourishing at SDIX, unchanged at NDIX, and declining at CDIX), followed the same ranking pattern, SDIX < NDIX < CDIX. Possibly the threshold for these two species was very narrow so that they were able to flourish at SDIX, survive at NDIX, but could not tolerate conditions at CDIX.

We also encountered a few intertidal species at the origins of two of our subtidal transects (DRSX and LRSX). The DRSX transect received direct exposure to diluted effluent discharged from DCPP. We noted that *Egregia*, *Laminaria*, *Endocladia*, *Gigartina papillata*, and *Iridaea flaccida* all disappeared from the intertidal portions of DRSX during the operational period. *Laminaria* was not included as one of our select species for our intertidal analyses because it occurred sparsely and infrequently along our transects. It nonetheless occurred elsewhere in the Diablo Cove intertidal (sometimes as very dense stands) during preoperational times but vanished completely by the end of 1987. The other four intertidal plants that disappeared from the intertidal part of DRSX, also fared poorly along our intertidal transects.

Results thus suggested that more declines occurred among intertidal plants than among animals and more intertidal animals than plants were encouraged by the operational environment. A number of these select intertidal species also occurred subtidally and their responses will be further discussed in the next chapter. We note here, however, that status of subtidal *Bossiella*, *Gigartina exasperata*, *Iridaea cordata*, *Neoagardhiella*, *Prionitis lanceolata*, *Anthopleura elegantissima*, and *Tegula brunnea* (species common in both the intertidal and shallow subtidal) was classed as either encouraged (E) or neutral (N).

WARM WATER SPECIES

We had made predictions as to which species were most likely to flourish in the operational environment in testimony at various hearings during early phases of construction of DCPP. Our predictions were based on the known geographical distributions of species indigenous to the Diablo Canyon region, as well as abilities of some of them to colonize warm water habitat. We were interested in determining how well our predictions were borne out by the status quo in Diablo Cove during latter 1987, after three years of operations by DCPP. We were concerned not only with which species appeared to be enhanced, but also with those which should have been encouraged but were not, and possible reasons for failure to respond as expected.

To provide an up-to-date evaluation of intertidal species growing in warm water environments, we tallied species during December 1987 at three intertidal sites in southern California, La Jolla Bay, Little Corona State Beach, and near Point Fermin. These locations characteristically display water temperatures equivalent to, or possibly greater than, those occurring in operational times at Diablo Cove. We found 26 plant and 32 animal species at our three warm water sites that also occur or were recently present in Diablo Cove (Table 9-9a & 9-9b). Most of these species fell in the encouraged (E) classifications in Tables 9-7 and 9-8. They apparently tolerated the water temperatures of the operational environment. A few of the plants present in southern California that should be doing well at Diablo Cove, seemed to be having difficulty maintaining populations in the changed environment there (i.e., *Dictyota*, *Egregia*, *Endocladia*, *Gigartina canaliculata*, and *Rhodymenia californica*). One possible explanation for these anomalies might be that the five species are subdivided into strains with differing temperature tolerances. Perhaps a warm-water strain inhabits intertidal sites in southern California and a cold water strain developed along central California. A rise in average water temperature in Diablo Cove would thus impact the local population even though the species was able to tolerate elevated temperatures elsewhere. We were able to test this hypothesis to some extent by examining responses by these five plants to the anomalously high ocean temperatures that prevailed during the 1983-84 El Niño around Diablo Canyon (see Figures 8-7 and 8-8). We will discuss the plants separately because each has special features requiring consideration.

<u>*Dictyota* sp.</u>

This Brown Alga was plentiful throughout the southern California intertidal sites and was even dominant in some areas. One might expect it to occur intertidally at Diablo Cove, but it was encountered only subtidally, especially at the subtidal DRSX transect (see Chapters 10 and 12). *Dictyota* is a moderately delicate plant and perhaps did not tolerate rough conditions of the wave-

Table 9-9a: Plant species observed intertidally at La Jolla on December 3 1987 (A), Little Corona State Beach on December 4 1987 (B), and Point Fermin on December 17 1987 (C).

Plant Organism	Station A	B	C	Plant Organism	Station A	B	C
CHLOROPHYTA & CYANOPHYTA				RHODOPHYTA (cont.)			
Bryopsis hypnoides		x		*Corallina officinalis*	x	x	x
BATGOR		x		*Corallina vancouveriensis*	x	x	x
Callothrix scopulorum	x	x		*Endocladia muricata*	x		
Cladophora sp.	x	x		*Gelidium coulteri*	x	x	x
Codium fragile	x	x		*Gelidium nudifrons*	x		
GATGOR	x	x	x	*Gelidium pusillum*	x	x	x
Ulva sp.	x	x	x	*Gelidium robustum*		x	
				Gigartina canaliculata	x	x	x
PHAEOPHYTA				*Haliptylon gracilis*	x	x	x
				Hildenbrandia occidentalis		x	
Colpomenia sinuosa	x	x		*Hildenbrandia* sp.	x	x	
Cystoseira osmundacea	x	x		*Jania crassa*	x		
Dictyota sp.	x	x		*Jania tenella*	x		
Dictyopteris undulata	x			*Laurencia lajolla*	x		
Ectocarpus sp.	x			*Laurencia* sp.	x	x	
Egregia menziesii	x	x	x	*Lithothamnium* sp.	x	x	
Eisenia arborea	x	x		*Lithothrix aspergillum*		x	x
Pelvetia fastigiata	x			*Melobesia mediocris*	x	x	
Ralfsia sp.	x	x	x	Non-coralline crust	x	x	
Sargassum agardhianum	x	x	x	*Petrocelis fransicana*	x	x	x
Scytosiphon dotyi	x	x		*Peyssonellia* sp.	x	x	
Zonaria farlowii	x	x		*Plocamium pacificum*	x		
				Polysiphonia sp.	x	x	
RHODOPHYTA				*Pseudolithophyllum neofarlowii*	x	x	x
				Pterocladia capillacea	x	x	x
Acrosorium uncinatum	x	x		*Rhodymenia californica*	x		
Bossiella orbigniana	x	x	x				
Bossiella plumosa	x	x	x	SPERMATOPHYTA			
Ceramium eatonium	x		x				
Ceramium sp.		x		*Phyllospadix torreyi*	x	x	x

swept intertidal flats in Diablo Cove. *Dictyota* was observed on two subtidal surveys during El Niño (December 1983 at DRSX8m and December 1984 at DCSX). It occurred only once during the operational period (August 1986 at DRSX8m). We have not observed *Dictyota* at Pup Rock, South Cove, or Intake Cove after 1983. We conducted a special survey at Pup Rock and Intake Cove on December 21 1987, looking specifically for *Dictyota*, but without success. The protected waters of Intake Cove were presumed to be an ideal location for this delicate species. *Dictyota* was, however, observed and collected from South Cove during 1987 (J. Carroll, pers. comm). It

Table 9-9b: Animal species observed intertidally at La Jolla on December 3 1987 (A), Little Corona State Beach on December 4 1987 (B), and Point Fermin on December 17 1987 (C).

Animal Organism	Station A	Station B	Station C
PORIFERA			
Astylinifer-like	x		
Esperiopsis-like	x		
Leucosolenia macleayi-like	x		
Verongia thione	x		
CNIDARIA			
Anthopleura elegantissima	x	x	x
ANNELIDA			
Hydroides-like		x	x
Phragmatopoma californica	x	x	
Sabellaria cementarium			x
Spirorbinidae	x	x	
MOLLUSCA			
Astraea undosa		x	
Collisella digitalis	x	x	x
Collisella limatula	x		x
Collisella pelta	x	x	x
Collisella scabra	x	x	x
Collisella strigatella	x		
Crepidula sp.	x	x	
Cyanoplax hartwegii	x	x	
Fissurella volcano	x	x	
Haliotis fulgens	x		
Jaton festivus	x		
Ischnochiton sp.	x		
Littorina planaxis	x	x	x
Littorina scutulata	x	x	x
Lottia gigantea	x		x
Mytilus californianus	x	x	x
Navanax inermis	x		
Norrisia norrisi	x	x	
Notoacmea fenestrata	x	x	
Notoacmea insessa		x	
Notoacmea persona		x	
Notoacmea scutum	x	x	x
MOLLUSCA (cont.)			
Nuttalina californica	x	x	x
Ocenebra interfossa			x
Petaloconchus compactus	x	x	x
Pseudochama exogyra		x	
Serpulorbis squamigerus	x	x	
Tegula aureotincta		x	
Tegula funebralis		x	x
Tegula gallina		x	
Tegula ligulata	x	x	x
ARTHROPODA			
Balanus glandula		x	
Balanus tintinnabulum	x		
Chthamalus fissus	x	x	x
Crangon dentipes		x	
Gammaridae		x	x
Lygia occidentalis	x		
Pachygrapsus crassipes	x		x
Paguridae	x	x	x
Petrolisthes eriomerus		x	
Pollicipes polymerus	x	x	
Tetraclita squamosa rubescens	x	x	x
ECHINODERMATA			
Strongylocentrotus franciscanus			x
Strongylocentrotus purpuratus		x	x
CHORDATA-TUNICATA			
Euherdmania claviformis	x		
Trididemnum opacum		x	
Unident. colonial (tan)	x		
CHORDATA-PISCES			
Arbaciosa rhessodon		x	
Blennidae		x	
Girella nigricans	x	x	

appeared to be scarce or absent elsewhere as of the end of 1987. In spite of sporadic occurrences by *Dictyota* both during and after El Niño, the primary disappearances of this once fairly common species appeared to be associated with advent of El Niño. There was thus uncertainty regarding its response to the operational environment.

Egregia menziesii

This large kelp species formerly occurred consistently at certain locations in the Diablo Canyon region and we always found it present in the intertidal portion of the DRSX transect (one of our three subtidal transects) whenever seas were sufficiently calm to permit inspection there. *Egregia* occurred only sporadically at our intertidal transects during the pre-El Niño period. It became common in the low intertidal at NDIX and CDIX during summer 1983 (Table 9-10) and also increased at LCIX at some point during El Niño (we were only visiting LCIX once per year at that time). *Egregia* subsequently disappeared from all our Diablo Cove stations but has persisted at the control intertidal station, LCIX. Thus we probably cannot ascribe the operational disappearance of *Egregia* in Diablo Cove to sensitivity by a cold water strain to warm water.

Endocladia muricata

This small member of the Rhodophyta or Red Algae was a dominant plant in the upper part of the mid-intertidal throughout the Diablo Canyon region. We only found it in southern California as very small and isolated plants on a sea wall at the east side of La Jolla Bay (nonetheless, a decidedly warm water environment). We listed *Endocladia* as discouraged by El Niño in Table 9-7 because of abundance declines at SDIX, commencing in December 1983 and continuing thereafter. No effects were seen at the other three stations. Effects on *Endocladia* at SDIX may have resulted from a highly disturbed substrate in the mid-intertidal at this station, shifting during winter storms in latter 1983. There was thus uncertainty as to whether *Endocladia* at Diablo Cove was truly sensitive to elevated water temperatures.

Gigartina canaliculata

This moderately-sized Red Alga was common in the algal turf at all our southern California sampling sites. It clearly withstood these warm water environments. It did not appear to be affected by El Niño at NDIX and LCIX, but abundances declined abruptly at SDIX and CDIX in

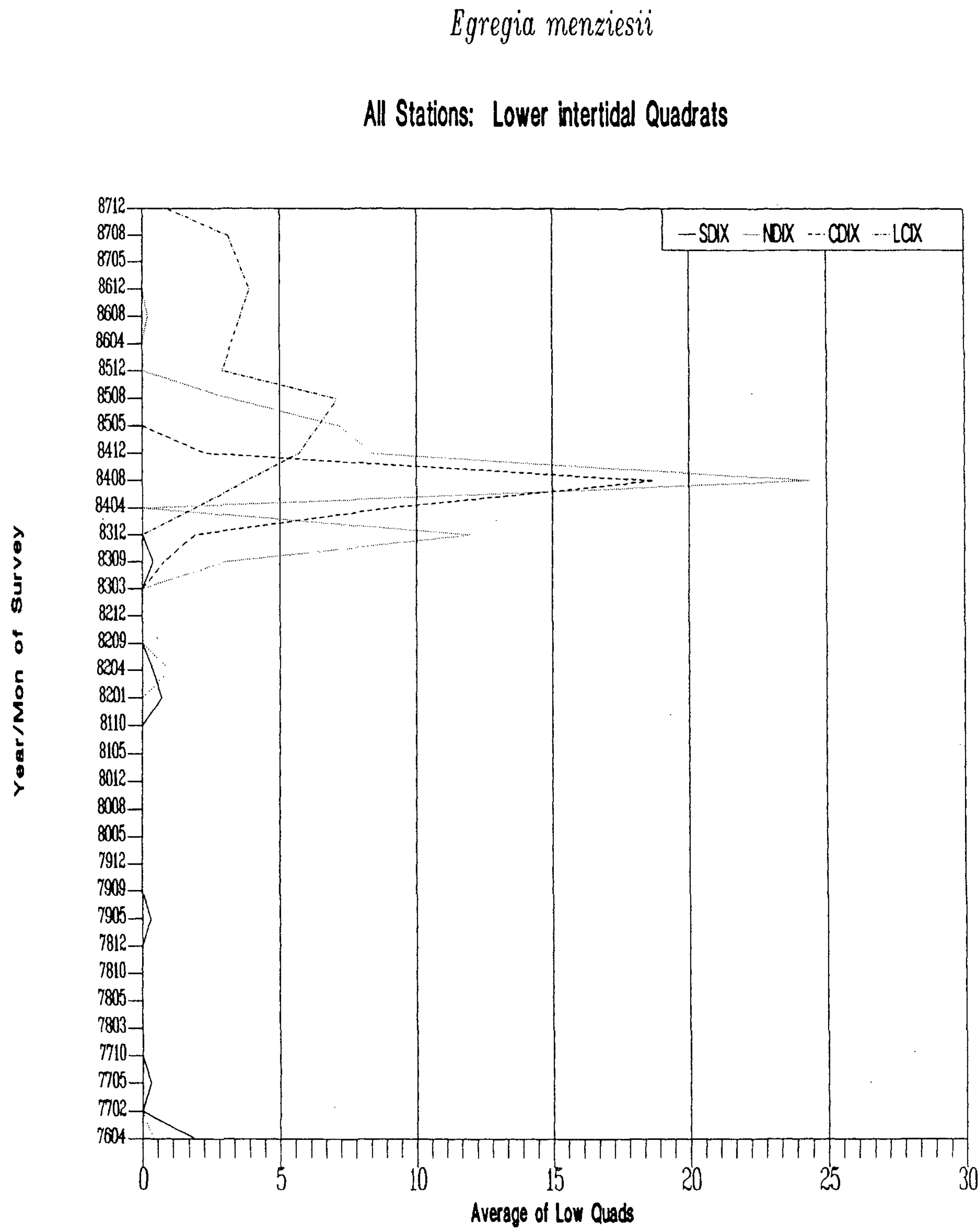

Figure 9-1. History of vertical distributions by *Egregia menziesii* along the four intertidal transects. Note increased abundances associated with onset of or during El Niño.

March 1983. The populations at SDIX and CDIX recovered during 1983-1984. The El Niño impacts were thus associated with large storms during the initial phases and not with warm water conditions which appeared later. The evidence thus suggested that *G. canaliculata* at Diablo Canyon was probably not a cold- water strain. A second decline was documented for 1986-1987. The later decline led us to classify it as discouraged (Table 9-7).

Rhodymenia californica

This small Red Alga was moderately common in the low intertidal of La Jolla Bay, which was the warmest of the three intertidal sites we surveyed in southern California. *Rhodymenia californica* was formerly common in the shallow subtidal of Diablo Cove but only appeared in the low intertidal once at SDIX. We were thus not able to assess its response to El Niño from our intertidal data, but we classed it as an encouraged species for the subtidal during El Niño (see Table 10-8). The local strains of *R. californica* in the Diablo Canyon region thus did not appear to be cold-water forms. One might have expected it to do well in the operational environment and perhaps occur more frequently in the low intertidal compared to the preoperational period. In fact, it all but disappeared from the shallow subtidal (we found one sickly specimen at DRSX during our October 1987 survey) and was never recorded from the intertidal during the operational period.

Discussion

The co-occurrence in southern California and the Diablo Canyon region of these five plant species identified as discouraged by the operational environment, posed something of a mystery as regards *Egregia*, *Endocladia*, *Gigartina canaliculata*, and *Rhodymenia californica*. El Niño responses indicated that local populations were probably warm-water organisms, in agreement with their distributions in the southern California intertidal. Explanations other than presence of elevated water temperatures are needed to define causes of declines by these four species in Diablo Cove. Possibly ecological relationships involving predation or competition have changed, leading to abundance declines among these four plants. Physiological requirements of the microscopic stages in the life histories may not be fulfilled in the new operational environment. Additional studies will probably be needed to clarify the uncertainties involved.

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Appendix 9-1

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Appendix Introduction

This Appendix contains information on the 66 selected species or groups (plant and animal). The information was used, along with other data, to develop Tables 9-7 and 9-8 (pages 9-25 and 9-26).

Throughout this Appendix the terms **species**, **taxon** (plural **taxa**), **group**, or **category** are used somewhat inter-changeably, and **taxon** is not necessarily used in the strict Linnean sense, but can include individual species as well as lumped species or genera and non-biological entities such as substrates (i.e., boulder, cobble, etc.).

Before presenting the descriptions and data for each of the 66 species, we have general introductions to each of the types of information presented. These introductory sections explain how we interpreted the data to develop the information, and the format used for presenting the information. The introductory sections are:

- Introduction to Taxon Information Sheets
- Introduction to Shaded Plot Sheets
- Introduction to Cluster Dendrogram Sheets

After the introductory sections, the information is presented for each of the 66 taxa arranged in the same order as presented in Tables 9-7 and 9-8, for the plants and animals respectively. Then information on the substrates is included. Each individual taxon section is set up as follows:

« Taxon Information Sheet		1 page
« Shaded Plot Sheets	2 Stations/Page	2 pages
« Cluster Dendrogram Sheets	2 Stations/Page	2 pages

The information is arranged so that the reader can conveniently compare each species at all four stations at once, first for the plots and then for the cluster diagrams.

Raw data representing station quadrats by survey for each species are presented in Volume 2: "DCPP-WJN Final Report, Data Appendices.

Introduction to Taxon Information Sheets

General introduction to terms and conventions used for taxon information pages. The style is compact for the sake of brevity. Boxed areas describe the information presented for a given section; the paragraph above explains terms or conventions used.

Shaded plot sheets were reviewed for each taxon to develop contents of these information sheets.

Species/Group Name Section: The **Scientific Name** used is from the indicated **reference** and may not reflect the latest name changes. Major lumped categories in the **scientific name** location, are not italicized and reflect our usual term for the group as used in the main text. If there is no generally accepted **Common Name**, then that area is left blank. **Describer** information uses zoological taxonomic conventions (plant taxonomists follow a different convention). In some cases, the second line has another scientific name at the extreme left indicating a superseding name that has gained wide acceptance among field biologists.

> *Scientific Name* (Common Name). Describer, Date. Reference.
> (Optional *Scientific Name*) **Phylum** Name: **Class** Name:

Principal references for the above information:

Algae: Abbott and Hollenberg, "Marine Algae of California", Stanford Univ. Press. 1976.

Phyllospadix: P. A. Munz, "A California Flora", UC Press. 1959.

Animals: Morris, Abbott, and Haderlie, "Intertidal Invertebrates of California", Stanford Univ. Press. 1980.

The description of the group or taxon usually uses normal scientific nomenclature for anatomical structures for the group being described. Sizes indicated are for individuals field-identified in our study area (**approximate** conversions are: 1 mm = 1/25 inch, 1 cm = 1/3 inch, and 1 m = 3 feet). Parenthetical information following size, refers to maximum size cited in the **reference** if appreciably different than found in our study area.

> **Description:** Brief description of the taxon usually including information on shape, color, and size.

The distribution (both geographic and vertically within the intertidal) of the group or taxon (and relative abundances for plants) and, where applicable a preferred habitat, is usually paraphrased from the cited reference, sometimes modified by the authors' personal observations. Warm-water-tolerance (group or taxon is known to occur above the thermocline from Point Conception southward) was usually determined by author's (WJN personal) observations. See section **Intertidal Levels** below for tidal level definitions.

> **Distribution:** A brief description of the known geographical range, range within the intertidal or subtidal, and notes as to relative abundance and habitat preference. Whether considered a warm-tolerant taxon or not.

For the Diablo area, the group's or taxon's relative abundance, followed by percent occurrence (based on approximately 3500 quadrats) and maximum percent cover or estimated number for all intertidal transects observed from 1976 to 1987. Relative abundance terms used from high to low were: **Abundant**, occurring over wide areas in larges patches or numbers; **Common**, occurring over relative wide areas but usually not as large patches or in large numbers; **Rare**, usually as scattered individuals in restricted areas. These terms can be modified by adjectives such as "moderately, fairly", etc. Whether the group was considered ephemeral or persistent was noted as applicable.

Habitat preference was usually indicated and included: type(s) of areas found (e.g. sandy, or on rocks); where within area (e.g. on tops and sides of rocks); and intertidal range if it differed from or augmented information presented in **Distribution** section.

> **Diablo Area Specific Information:** Relative abundance, percent occurrence, and maximum number or area cover observed.
> **Habitat:** As found in the Diablo intertidal region along our transects.

This section outlines problems associated with observing or quantifying the group in the field. Some terms that are used: **Quadrat boundary errors** refer to groups where individuals can occur near the edge of the quadrat and it is difficult to determine whether to call such individuals in or out of the quadrat. **Dense algal mat** can obscure underlying organisms or organisms nestled within the mat. Morph variation, coloration, grazing, etc. can cause mis-identifications. Confusion with other taxa are mentioned and then discussed in greater detail in **Field Identification Problems Section.** Estimates of **missed observations** are presented, if applicable. Percent values were usually estimated from counts of zero occurrences for a specific quadrat when the group occurred during preceding and following surveys for that quadrat.

> **Observational Errors:** Major factors contributing to missed or incorrect observations.

This section describes problems with field-identification of the group, either in general or for specific stations and follows this format:

> **Field Identification Problems**
> **General:** Lists known problems with reliable identification of this taxon in our intertidal study area.
> **Station Specific:** If problems were not applicable to all of our stations.

This section can contain any information considered pertinent, including station specific comments, etc.

> **General Comments:**

Impacts to Taxon Section: This entire section uses moderately abbreviated sentences with following terms defined as follows:

Extend, extending, etc., refers to situations where group's range in intertidal expanded either upwards or downwards.

Level(s) often used instead of the longer and more correct form "intertidal level"; thus, "at lower levels" translates to "at lower intertidal levels".

Lower usually used to state that the organism was found at lower intertidal levels than previously, not necessarily in the lower intertidal.

Occurrences refer to number of quadrats occupied by the group for survey(s).

Numbers refer to numbers of individuals present in quadrats.

Shifting refers to changes of distribution within the intertidal.

Sporadic refers to changes that are not continuous, i.e., interval discussed has reversals, but overall changes follow indicated trend.

Any station identification followed by a "?" (e.g. "CDIX?") indicates that the conclusions may be tenuous. Normal conditions at CDIX impossible to determine, because only one survey prior to El Niño and DCPP operation.

El Niño: 1982-83 winter storm: Briefly describes and discusses changes in taxon for March 1983 survey. Impacts to group for each station are summarized.

Winter storms of 1982-1983 swept all stations with moderate to severe wave action just prior to March 1983.

Major physical changes observed after these storms for each station are summarized here:

SDIX: collapse of nearby cliff covered the mid and lower intertidal areas with new cobble burying much of the existing biota. Several large boulders removed from the transect and one new boulder was introduced.

NDIX: several large, high-relief boulders were introduced into what used to be the mid intertidal, and there was moderate shifting of existing boulders in the mid to lower intertidal.

CDIX: some movement of boulders in the mid intertidal, and some scouring from cobble movement in this area. Note that this transect is mainly bedrock.

LCIX: removal of one boulder and breaking away of b*edrock (possibly extending through 1984). One quadrat was relocated to the opposite side of the transect because of bedrock removal at its old location.

El Niño: 1983-1984: Discusses changes in taxon from Sept. 1983 to December 1984.

During the period 1983-1984, stations' substrates still changing as follows:

SDIX: new cobble being removed from area, but still shifting. Cobble introduced in mid intertidal, not being removed.

NDIX: large, introduced, high-relief boulders in mid-intertidal stable, with some colonized by upper intertidal organisms; organisms introduced with (on) them, typically declining.

CDIX and **LCIX:** little change.

Diablo DCPP Operation: Discusses changes in taxon from May 1985 to end of study in December 1987 and compares to pre-El Niño conditions.

During the period 1985-1987, stations' substrates changed relatively little.

Intertidal Levels: Normally accepted Pacific Coast biotic intertidal levels referenced to Mean Lower Low Water (MLLW) are: **Upper**, Splash zone > +2 to +1.5 m (>7 to +5 ft); **High**, +1.5 to +0.8 m (+5 to +2.5 ft); **Mid**, +0.8 to 0.0 m (+2.5 to 0.0 ft); and **Low**, 0.0 to -0.6 m (0.0 to -1.8 ft). These data criteria adapted from Ricketts, Calvin, and Hedgpeth: "Between Pacific Tides", (1985).

During much of our study in the Diablo Canyon area, these zones were probably displaced upward as much as 0.2 m (0.6 ft) because of the relatively exposed coastline here.

Table of intertidal ranges and approximate quadrats included for each station. (Note: the same quadrat can be assigned to more than one range).

Station	Tidal Range El Niño	Upper > ~0.8 m	Mid ~0.8-> ~0.0	Low < ~0.0
SDIX	Pre-	1->19,31->33,36->38	19->40	~35->
	Post	1->25,31->33,36,37 (41->43?)	27->40	~35->
NDIX	Pre-	1->14	5,6,11->23	~22->
	Post	1->18,23	~14->24	~24->
CDIX	Pre-	1->14,40,41	11->31	26->39
	Post		as above	
LCIX	Pre-	1->7	6->14	7,8,13?,14->
	Post		as above	

Introduction to Shaded Plot Sheets

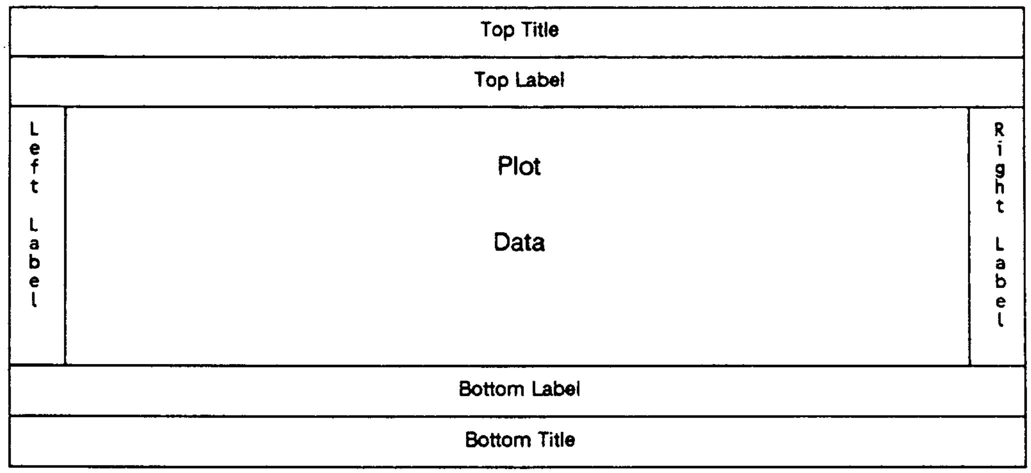
See facing page for example of information discussed.

We briefly explain the format and contents and the plot pages. Data processing was accomplished by a specially written program that read the taxon's CSV (comma separated values) data files for all stations, and output them to a single data file with a special format that was then output to a printer. Two stations were plotted on each page and the stations were arranged as CDIX (central Diablo Cove, station closest to DCPP discharge), NDIX (northern Diablo Cove), SDIX (southern Diablo Cove), and LCIX (on open coast north of Diablo Cove and inshore from Lion Rock). The pages were divided into sections (see figure) and included the following information in each section:

Top Title: Line 1, Running head; Line 2, Taxon name [notes on type of quantification if non-standard]. Standard quantification for plants was percent cover and for animals was number per quadrat; Line 3, Options used to select data for plot (discussed below in greater detail).

Top Label: Line 1, Left title heading (in part), and centered "Survey Number"; Line 2, Left title heading (in part), and column headings of decade of survey number for plotted data; Line 3, column headings of unit of survey number for plotted data.

Left Label: First row for each NEW Station, has station identification and then to left for each row, quadrat numbers for plotted data.



Right Label: Topmost row: number following "N=" is the sum of all plotted values within the Options used values for this page (NOT for taxon). Arranged vertically below are scale identification sections formatted as follows:

##-##:	Range of data values for this shade of plot. 'P' = present.
▒:	Shade used in plotted data section for above values
##%:	Percent of data values (for THIS page), within above range.

Bottom Label: Lines 1-4, year and month of survey dates arranged vertically under plotted data columns. Line 5, identifies assigned time phases.

Bottom Title: Plotted data's transect study termination note (i.e., if '_' appears in survey column, that quadrat and following quadrats were not observed for the survey; Line 2, starting with "Audit:" is audit trail information including program name and version (as 'V.#.#') generating plotted data, data file name for FIRST file read (NOTE: if "Key in" appears on this line, then program was operated via keyboard rather than from a driver file and date and time does NOT apply), and date and time program created plotted data.

Detailed information for Options Used (Line 3 of **Top Title**):

Quad. Range: Part. or Auto. indicates that full data set was not plotted. Most if not all of the plots, were plotted in "part" mode, i.e., starting and ending quadrat numbers were set to fixed values.

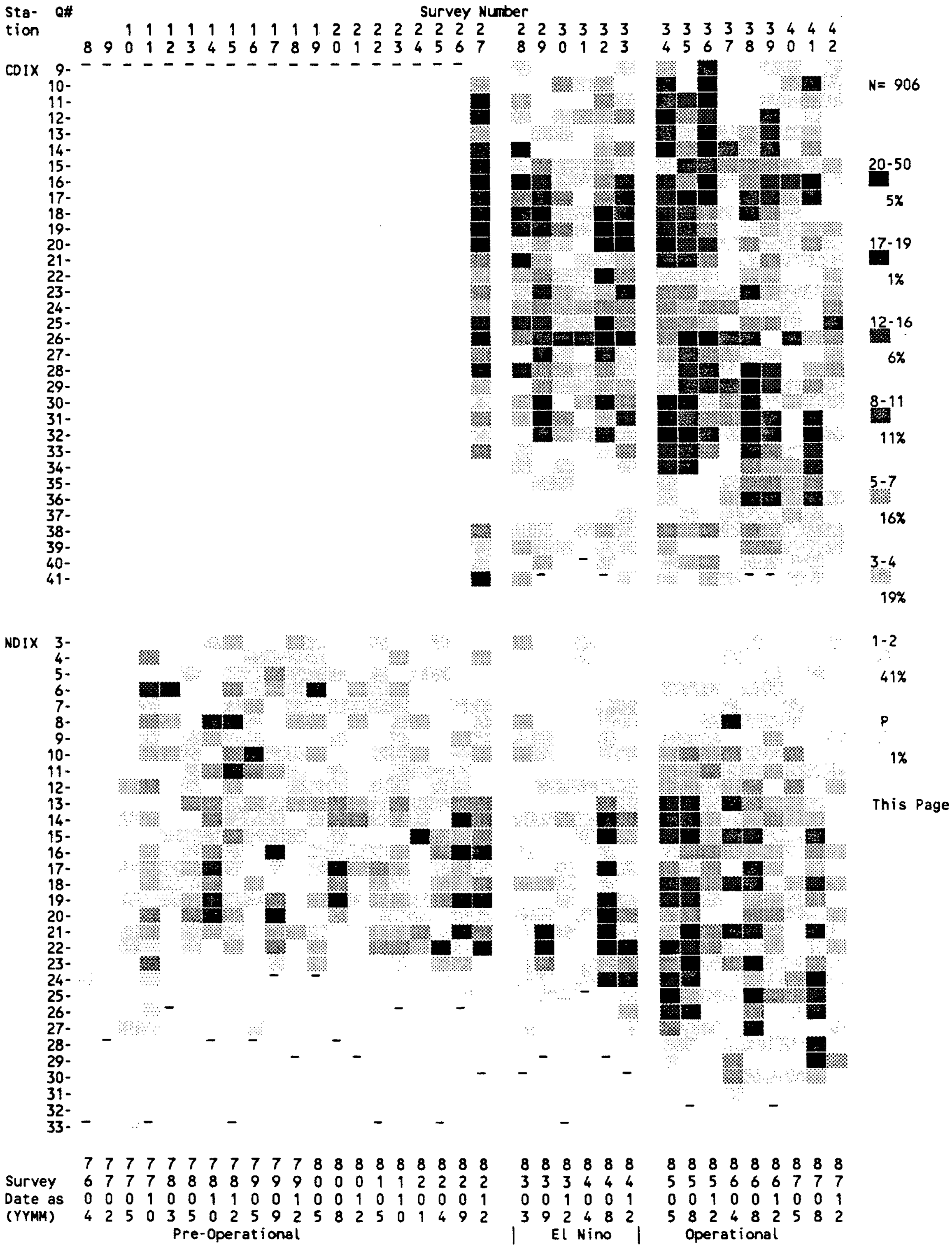
Data Scaled: Indicates that the plotted values were scaled based on the taxon's maximum and minimum values. Not scaled, means that an absolute value of 50 was always assigned the same shade for the plot.

Data Values: Indicates the data value range included in the plots, i.e., if this part of the title does NOT read "Data Values P to Max.", data outside of the indicated range were NOT plotted.

DCPP-WJN Final Report: Chapter 9: Intertidal Results: Appendix 9-AI-7:

Taxon or Category: Notoacmea scutum [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for NOTSCU CSV 6138 3-29-88 8:00a 04-15-1989 06:30

Introduction to Cluster Dendrogram Sheets

See facing page for example of information discussed.

Two stations' data are included on each page and the stations are arranged as CDIX (central Diablo Cove, station closest to DCPP discharge), NDIX (northern Diablo Cove), SDIX (southern Diablo Cove), and LCIX (on open coast north of Diablo Cove and inshore from Lion Rock). The pages are divided into sections (see figure) and include the following information in each section:

Top Title: Line 1, Running head.

Audit Label: Programs generating the data, run dates and times, options and type of data processed.

Line 1, Program name and version merging output files generated by following programs (Line 2).

Line 2, Driver program name and version that generated driver data files from raw CSV data files, and date and time of run; followed by the BIOSTAT program name, title, and version that processed driver data files to clustered output data files.

Line 3, BIOSTAT method of clustering and type of association matrix used; followed by type of data used for input, "Quantitative data" or "<< BINARY data >>" (i.e., presence =1, absence =0).

Station n or n+1 Label: Identify station, taxon, taxon's data characteristics, data included in cluster data deck, and some of the results of the clustering process.

Line 1, Station, followed by taxon name, notes, and "TOTAL Quads with data =" followed by the number of quadrats that had data for this taxon for Surveys 8-42.
May be followed by another line (not counted as a separate line here) that begins "Abrev. taxa name(s)", which is printed only if all files processed did not include the same taxa. This should only occur for groups that contain more than one taxa and indicates which taxa occurred at that station.

Line 2, "Quad Range USED" indicates range of quadrats included in cluster analysis, followed by "for Total of" for number of within the range, followed by "Range WITH data" indicating quadrat range containing data for this taxon (Surveys 8-42), followed by "# Dropped" indicating number of "TOTAL Quads with Data" that were NOT included in our cluster data base for this taxon, followed by percent this represents. See discussion below section describing "Criteria for Dropping Data".

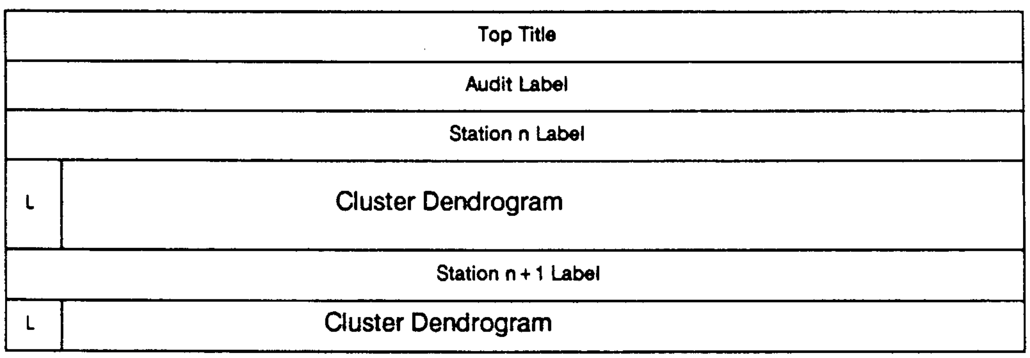
Line 3, "Surveys", indicates number of surveys considered for inclusion in data processing, "Dropped" indicates number of surveys that were EXCLUDED from the cluster data deck because "quads sampled" were less than the number indicated.

Line 4, identifies results of clustering "correlation coefficient" and the maximum linkage distance (i.e., rightmost vertical column of "1 "'s represent the numeric value indicated.

Cluster Dendrogram and Left Label: Each row of this section represents a single survey.

Left Label: Each row is preceded by a Survey Label starting with an 'S##' which indicates the survey number, followed by '-####' which indicates the year, followed by the month. If surveys were dropped, they are listed on succeeding rows until the last one which is labeled "<- End Dropped Surveys". If only one survey was dropped, the row is simply labeled "<-Start Dropped Surveys".

Cluster Dendrogram: Output for each row labeled by a survey number and presentation follows normal conventions for this type of data presentation. However see information below on interpreting closely clustered segments.



Audit: CLUMRG2P: V.1.2: for SNOTSCUB CLU 6581 4-23-89 6:40a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:37:12 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Notoacmea scutum [Mixed P/#]: TOTAL Quads with Data = 434

Quad Range USED 10 to 39 for Total of 30 : Range WITH data 4 to 41: : # Dropped 51 : 11.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.620203: Maximum Distance = 15

```
S27-8212  --------------------I-----I
S32-8408  --------------------I     I------------------I
S36-8512  --------------------------I                  I-------I
S33-8412  --------------------------------I------------I       I
S35-8508  --------------------------------I                    I--------I
S34-8505  --------------------------------------I--I           I        I
S39-8612  --------------------------------------I  I-----------I        I----------I
S38-8608  -----------------------------------------I                    I          I----------I
S28-8303  --------------------------------------------------------------I          I          I
S29-8309  ----------------------------------------------------------I--------------I          I-----I
S30-8312  ----------------------------------------------------------I                         I     I
S40-8705  ------------------------------------------------------------------------I-----------I     I---------I
S41-8708  ------------------------------------------------------------------------I                 I         I
S31-8404  -----------------------------------------------------------------I------------------------I         I------
S42-8712  -----------------------------------------------------------------I                                  I
S37-8604  ----------------------------------------------------------------------------------------------------I
```

Station: NDIX: Notoacmea scutum [Mixed P/#]: TOTAL Quads with Data = 498

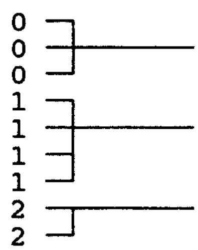
Quad Range USED 3 to 25 for Total of 23 : Range WITH data 3 to 33: : # Dropped 74 : 14.9%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.611434: Maximum Distance = 13

```
S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End   Dropped Surveys
S 8-7604  -------I-----------------------------------------------I
S 9-7702  -------I                                               I------I
S10-7705  ----------------------I--------------------------------I      I---I
S30-8312  ----------------------I                                       I   I---------------------------------I
S12-7803  --------------------------------------------------------------I   I                                 I
S21-8012  ------------------------------------------------------------------I                                 I
S11-7710  ----------------------I---------------I                                                             I
S23-8110  ----------------------I               I--------------I                                              I
S27-8212  ------------------------------I-------I              I                                              I
S32-8408  ------------------------------I                      I                                              I
S26-8209  ----------------------I--I                           I-----I                                        I
S34-8505  I---------------------I  I----I                      I     I                                        I
S35-8508  I                        I    I                      I     I                                        I
S36-8512  -------------------------I    I----------------------I     I--------I                               I
S38-8608  ------------------------------I                            I        I                               I------
S39-8612  ------------------------------I                            I        I                               I
S33-8412  ---------------------------------------------------I-------I        I                               I
S37-8604  --------------------------------------I------------I                I--------------I                I
S40-8705  --------------------------------------I                             I              I                I
S13-7805  ------------------------------I---------------I                     I              I                I
S20-8008  ------------------------------I               I------------I        I              I                I
S14-7810  ----------------------------------------------I            I------I I              I                I
S25-8204  --------------------------------------I--------------------I      I-I              I---------I      I
S41-8708  --------------------------------------I                           I                I         I      I
S15-7812  ----------------------------------------------I-------------------I                I         I      I
S22-8105  ----------------------------------------------I                                    I         I      I
S28-8303  ----------------------------------------------I                                    I         I------I
S29-8309  ----------------------------------------------I------------------------------------I         I
S42-8712  ----------------------------------------------I                                              I
S16-7905  -------------------------------------------------------I----------I                          I
S18-7912  -------------------------------------------------------I          I--------------------------I
S24-8201  ------------------------------------------------------------------I
```

Criteria for Dropping data: Dropping data was necessary because clustering methodology required that data for each survey embraced the same quadrats utilized from other surveys. We achieved this uniformity either by eliminating occasional "outliers" where a species occurred well outside of its usual vertical range, or by eliminating an entire survey (where the full range of quadrats were not observed because of a poor tide or similar reason). The entire process was conducted so as to minimize information excluded from data presentation.

Interpreting Closely Clustered Areas: Space was not available on the Dendrogram sheets to include the pairing sequence information table. If clusters are tightly packed, it may be difficult to determine where linkages occur. Guidelines for determining linkages follow:

```
0 -I
0 -I------ odd # links, right '-' is centered
0 -I
1 -I
1 -I------ even # links, right '-' atop center pair
1 -I
1 -I
2 -I------ even # links, right '-' atop of center pair
2 -I
```



above is equivalent to this

Codium setchellii Gardner, 1919. Ref. AH 1976, p 118.
Phylum Chlorophyta: **Class** Codiales:

Description: Dark green, prostrate mat, thick (to 1.5 cm), to 25 cm broad.

Distribution: Sitka (Alaska) to Punta Baja (Baja California). Frequent on exposed rocks, low intertidal. A warm-tolerant species.

Diablo Area Specific Information: Rare, but persistent, occurring in about 3% of our quadrats.

Habitat: On large boulders or bedrock, mostly on sides or under ledges, mid to lower intertidal.

Observational Errors: Quadrat boundary errors occur at NDIX, where small mats of this species occurred near the edges of two quadrats on each side of the main patch (for about 7% missed observations). At LCIX, there was a small frequently overlooked patch because it could be hidden by large *Anthopleura* or overhanging algae. Area estimates may be somewhat in error because of viewing angle, when under ledge.

Field Identification Problems:

General: Might possibly be confused with *Codium hubbsii*, (a southern species), but this taxon has not been found in the Diablo area.

Station Specific: n.a.

General Comments: Occurrence at SDIX extremely rare (never an established species there), and at LCIX one small patch in recent surveys (1982 onward) often missed.

Impacts to Taxon:

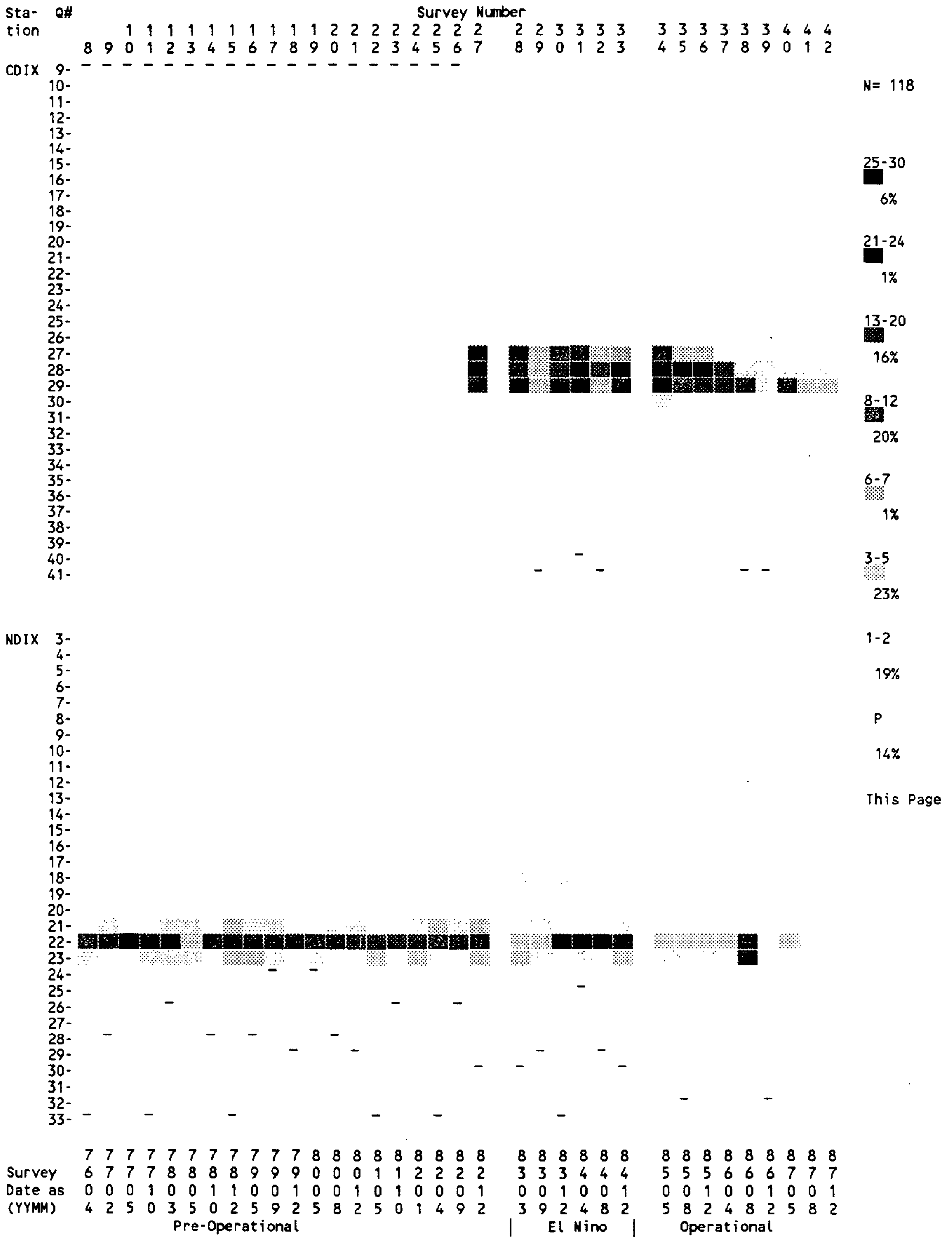
El Niño: 1982-83 winter storm: NDIX with a small patch washed in on a boulder and small reduction in area cover for the existing patch at quadrat 22. CDIX with no apparent change. LCIX and SDIX insufficient occurrences to evaluate.

El Niño: 1983-1984: CDIX possibly with slight increase in area cover in one quadrat, NDIX relatively unchanged (i.e. number of occurrences mainly affected by quadrat boundary errors). LCIX and SDIX insufficient data.

Diablo DCPP Operation: At NDIX and CDIX, slow decline in occurrences and area cover with patches occasionally noted as containing bleached areas. LCIX and SDIX insufficient data to evaluate.

Taxon or Category: Codium setchellii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

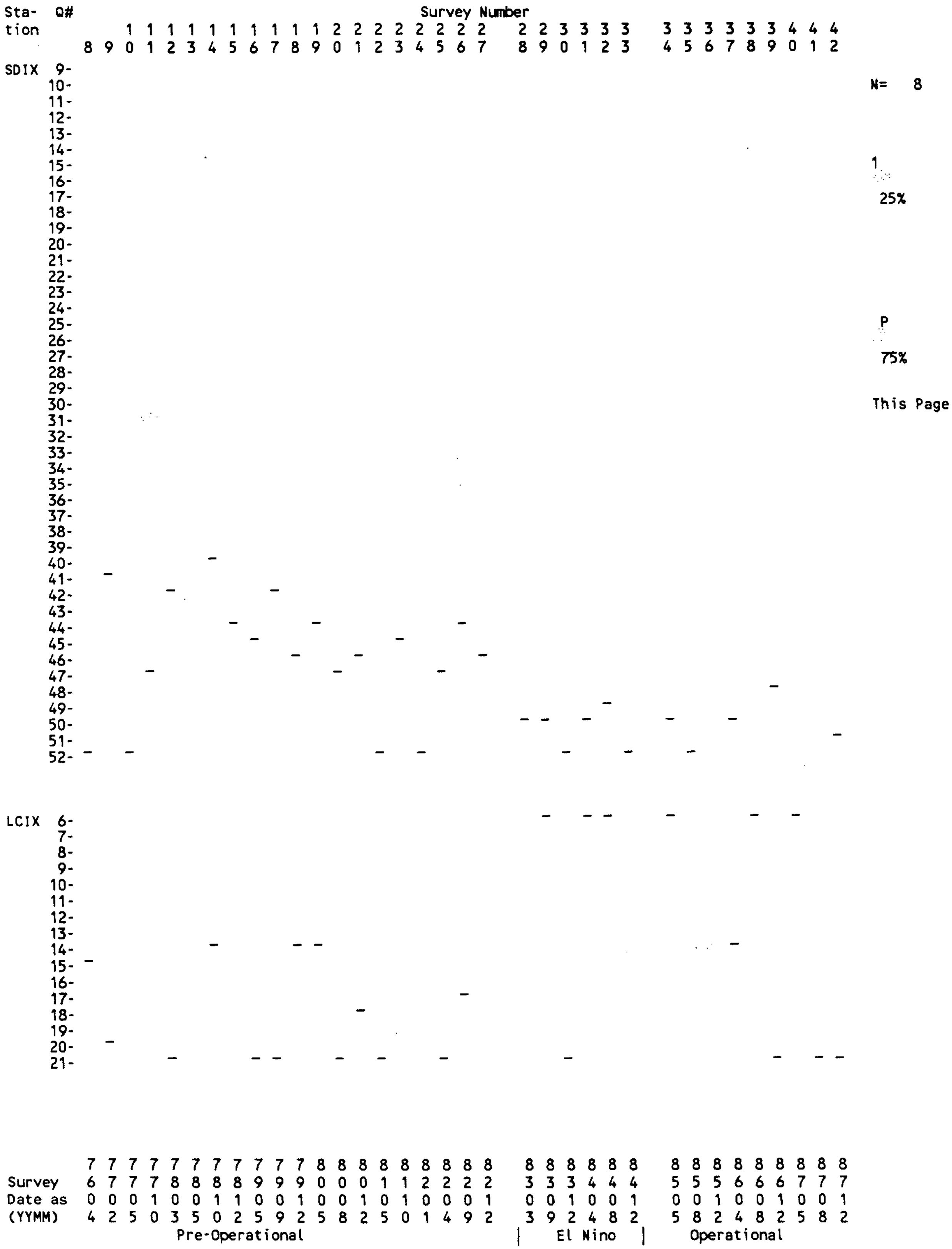


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CODSET CSV 5205 3-29-88 7:26a 04-14-1989 09:07

Taxon or Category: Codium setchellii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CODSET CSV 5205 3-29-88 7:26a 04-14-1989 09:07

Audit: CLUMRG2P: V.1.2: for SCODSET CLU 7249 4-22-89 7:06a: 04-28-1989/07:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:02:43 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Codium setchellii: TOTAL Quads with Data = 43

Quad Range USED 27 to 30 for Total of 4 : Range WITH data 27 to 30: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 30
COPHENETIC CORRELATION COEFFICIENT = 0.690083: Maximum Distance = 106

```
S27-8212 -----------------------------------I
S28-8303 I-----------------------I          I-------I
S30-8312 I                       I----------I       I------------------I
S32-8408 ------------------------I                  I                  I
S31-8404 --------------------------------I----------I                  I----------------------------------I
S33-8412 -------I------------------------I                             I                                  I
S35-8508 -------I                                                      I                                  I
S34-8505 -----------------------------------------------------I--------I                                  I------
S36-8512 ---------------------------------------I-------------I                                           I
S37-8604 ---------------------------------------I                                                         I
S29-8309 ------------------------------I                                                                  I
S38-8608 ---I------------------I       I------------------------------------------------------------------I
S40-8705 ---I                  I-------I
S39-8612 -----------I----------I
S41-8708 -------I---I
S42-8712 -------I
```

Station: NDIX: Codium setchellii: TOTAL Quads with Data = 75

Quad Range USED 21 to 23 for Total of 3 : Range WITH data 18 to 29: : # Dropped 5 : 6.7%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.660353: Maximum Distance = 34

```
S 8-7604 I-------I
S30-8312 I       I---I
S14-7810 I-------I   I-------I
S32-8408 I           I       I
S19-8005 I-----------I       I---------------I
S31-8404 I                   I               I
S 9-7702 -----------------I--I               I-----I
S12-7803 -----------------I                  I     I
S25-8204 ------------------------------------I     I
S13-7805 I----------------I                        I----------------I
S29-8309 I                I                        I                I
S34-8505 I                I-------I                I                I
S35-8508 I-------I        I       I                I                I
S36-8512 I       I--------I       I----------------I                I------------I
S37-8604 --------I                I                                 I            I
S40-8705 -------------------------I                                 I            I
S28-8303 -----------------------------------I-----I                 I            I-------------------------I
S33-8412 -----------------------------------I     I-----------------I            I                         I
S38-8608 -----------------------------------------I                              I                         I
S39-8612 --------I---------------------------------------------------------------I                         I
S41-8708 I-------I                                                                                         I
S42-8712 I                                                                                                 I------
S10-7705 ----------------------------------------------------------------------------------------I         I
S11-7710 ------------------I--------I                                                            I         I
S16-7905 --------I---------I        I-------I                                                    I         I
S22-8105 --------I                  I       I------------I                                       I         I
S24-8201 ---------------------------I       I            I                                       I---------I
S17-7909 ---------------------I-------------I            I--------------------------I            I
S20-8008 ---------------------I                          I                          I            I
S18-7912 I----------------I                              I                          I            I
S23-8110 I                I------------------------------I                          I------------I
S21-8012 I----------------I                                                         I
S26-8209 I                                                                          I
S15-7812 ---------------------------------------------------I-----------------------I
S27-8212 ---------------------------------------------------I
```

Station: SDIX: Codium setchellii: : No data for this station

```
                                       NO DATA
                                 NO DATA
                           NO DATA
                     NO DATA
               NO DATA
         NO DATA
   NO DATA
NO DATA
NO DATA
   NO DATA
         NO DATA
               NO DATA
                     NO DATA
                           NO DATA
                                 NO DATA
                                       NO DATA
```

Station: LCIX: Codium setchellii: TOTAL Quads with Data = 6:**** Prob. INSUFFICIENT Data ****

Quad Range USED 8 to 14 for Total of 7 : Range WITH data 8 to 14: : # Dropped 0 : 0.0%
Surveys 25 : Dropped 4 Surveys if quads sampled < 14
COPHENETIC CORRELATION COEFFICIENT = 0.935994: Maximum Distance = 11

```
S14-7810:  <-Start Dropped Surveys
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 8-7604  I
S10-7705  I
S11-7710  I
S12-7803  I
S13-7805  I
S15-7812  I
S16-7905  I
S17-7909  I
S20-8008  I
S21-8012  I-------------------------------------------------------------I
S22-8105  I                                                             I
S23-8110  I                                                             I
S24-8201  I                                                             I
S26-8209  I                                                             I
S27-8212  I                                                             I-------------------------------------I
S28-8303  I                                                             I                                     I
S30-8312  I                                                             I                                     I
S39-8612  I                                                             I                                     I
S41-8708  I                                                             I                                     I------
S42-8712  I                                                             I                                     I
S 9-7702  --------------------------------------------------------------I                                     I
S25-8204  --------------------------------------------------------------I------------I                        I
S33-8412  --------------------------------------------------------------I            I------------------------I
S35-8508  I--------------------------------------------------------------------------I
S36-8512  I
```

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Ulva spp. (Sea Lettuce). Linnaeus, 1753. Ref. AH 1976, p 77ff.
Phylum Chlorophyta: **Class** Ulotrichales:

Description: Grass to pale green, thin blades to >1 m in length, but often as small short (<0.3 cm) ruffles.

Distribution: See below for species of this taxon identified from our intertidal studies. A warm-tolerant group.

Diablo Area Specific Information: Common, but sporadic in its range of occurrence and cover, occurring in about 20% of our quadrats.

Habitat: On rocks and epiphytic on algae, can occur as short ruffles (in small crevices or epiphytic) or sporadically as large blades, mid (occasionally upper) to lower intertidal.

Observational Errors: Dense algal cover can hide the short ruffles on rock or such ruffles may be so eroded by sand that they are not identifiable as this group. No estimate of missed observations (or mis-identifications) is available for this group.

Field Identification Problems:

General: Ruffle form can be confused with almost any of the lettucy green alga, most likely with *Enteromorpha* spp.

Station Specific: n.a.

General Comments: Ruffled turf (either epiphytic or on rock) is the more common form, with sporadic "blooms" of large blades occurring over much of a transect. Pre-operational phase with large fluctuations in number of occurrences, from about 0 to many for the Cove stations; LCIX the only station with relatively stable number of occurrences through the years.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX with almost complete loss of this group, probably due to burial by cobble from nearby cliff collapse. NDIX with removal at low tidal levels. CDIX possibly with increased occurrences (only 1 survey prior to storm). LCIX probably normal.

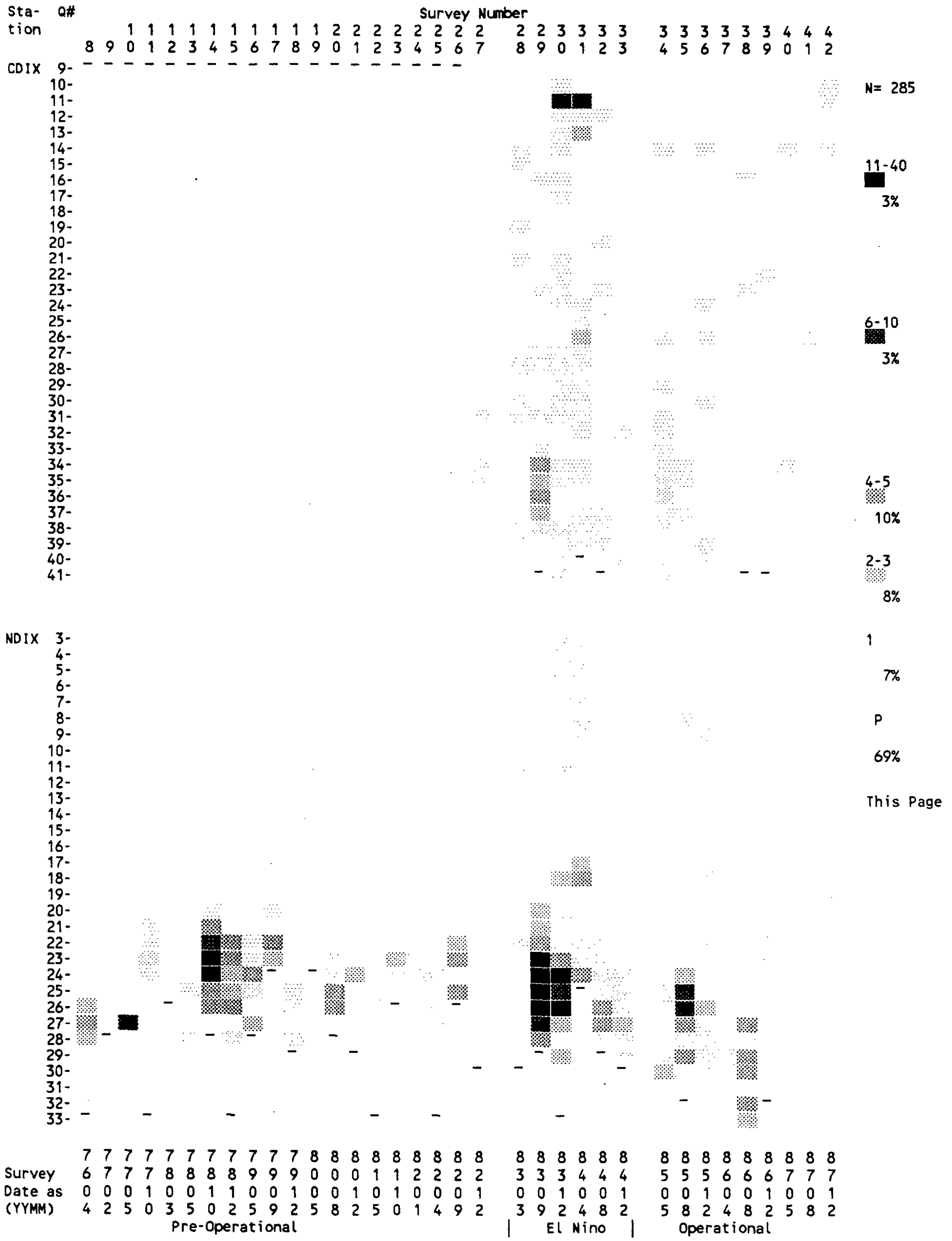
El Niño: 1983-1984: SDIX developed dense covers in the low intertidal for Autumn surveys (somewhat similar to what occurred in late 1978). NDIX similar to SDIX. CDIX with moderate covers, but extending into the upper-mid intertidal. LCIX with moderate (winter) covers somewhat similar to what was observed there in 1980.

Diablo DCPP Operation: All Cove stations declining in occurrences and covers (to <10% of maximum for station) during 1987, which may be abnormal because these stations usually had Autumn-Winter blooms of this group. NDIX, however, has often lacked a well defined bloom, and CDIX with insufficient pre-El Niño data. LCIX normal in occurrences with covers low.

Ulva expansa: South British Columbia to Baja California, common, lower intertidal and subtidal.
Ulva lobata: Oregon to Guerrero (Mexico) and to Ecuador and Chile, common intertidally in central California, mid to subtidal.

Taxon or Category: Ulva sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

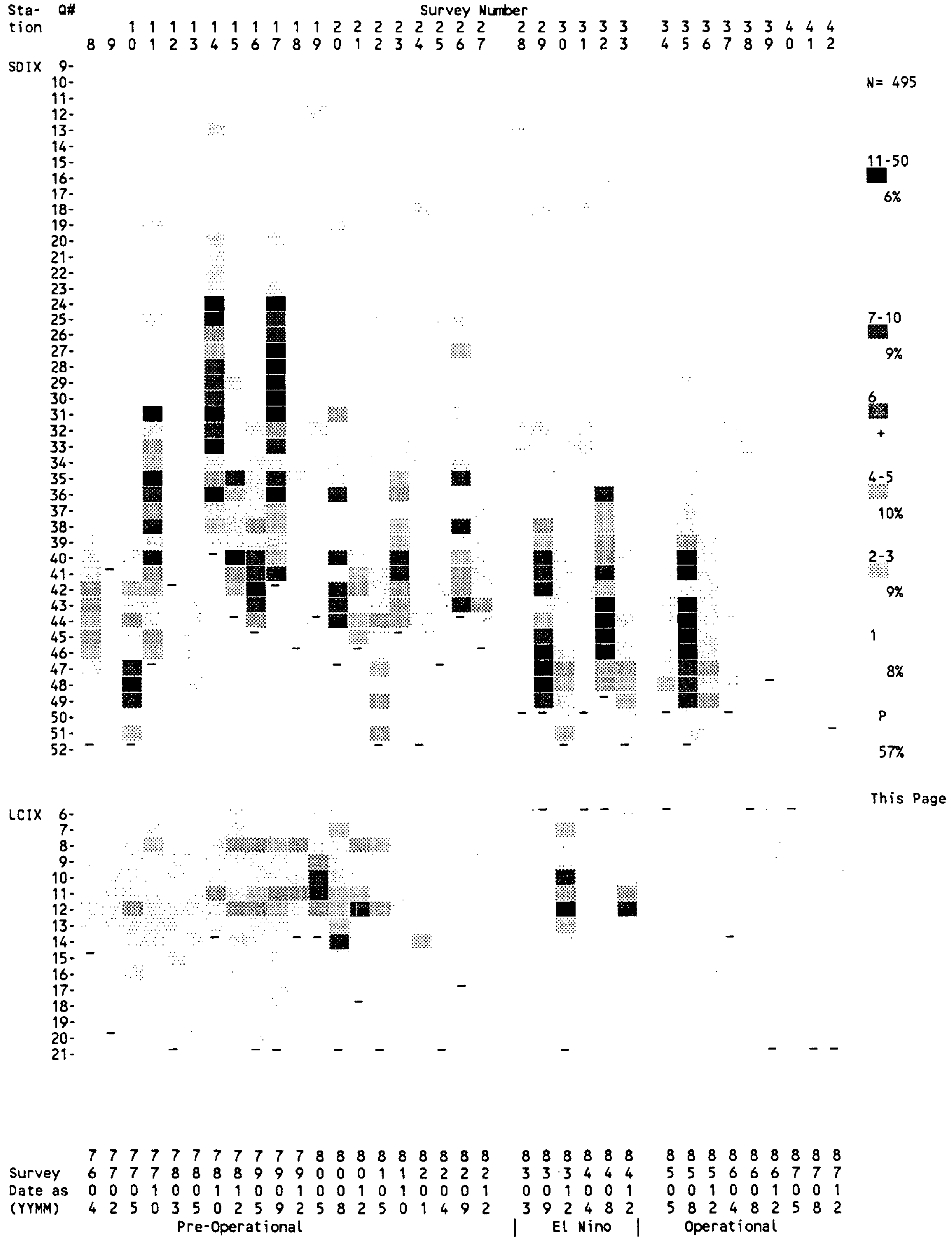


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ULVASP CSV 5680 3-29-88 7:41a 04-14-1989 10:52

Taxon or Category: Ulva sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ULVASP CSV 5680 3-29-88 7:41a 04-14-1989 10:52

```
Audit: CLUMRG2P: V.1.2: for SULVASP CLU     6163  4-22-89  10:36a:  04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:32:05 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
      METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used
```

```
Station: CDIX:  Ulva sp.:  TOTAL Quads with Data = 109

      Quad Range USED 5 to 39 for Total of 35 :  Range WITH data 4 to 41:  : # Dropped  9 :   8.3%
      Surveys  16 :  Dropped  0 Surveys if quads sampled < 39
      COPHENETIC CORRELATION COEFFICIENT = 0.902782:                          Maximum Distance = 663

S27-8212  --------I-I
S35-8508  --------I I
S33-8412  ----II    I
S37-8604  ----III   I-I
S39-8612  -----II-I I I
S41-8708  ------I III I
S38-8608  --------III II
S40-8705  --------II  II
S42-8712  ---------I  II--I
S36-8512  ------------II  I----I
S32-8408  -------------I  I    I---------------------------I
S28-8303  ----------------I    I                           I-----------------------------------------------I
S34-8505  ---------------------I                           I                                               I------
S29-8309  -------------------------------------------------I                                               I
S30-8312  -------------------------------------------------------I-----------------------------------------I
S31-8404  -------------------------------------------------------I
```

```
Station: NDIX:  Ulva sp.:  TOTAL Quads with Data = 181

      Quad Range USED 3 to 27 for Total of 25 :  Range WITH data 3 to 33:  : # Dropped  64 :   35.4%
      Surveys  29 :  Dropped  6 Surveys if quads sampled < 27
      COPHENETIC CORRELATION COEFFICIENT = 0.924455:                          Maximum Distance = 1256

S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End  Dropped Surveys
S 8-7604  ---I----I
S38-8608  ---I    I---I
S10-7705  --------I   I-I
S32-8408  ------------I I
S 9-7702  I             I
S37-8604  II            I
S40-8705  III           I
S41-8708  III           I
S13-7805  -III          I
S18-7912  --II          I
S42-8712  --II          I---I
S22-8105  --II          I   I
S24-8201  --III         I   I
S39-8612  --III         I   I
S25-8204  --IIII        I   I
S27-8212  --IIII        I   I
S34-8505  ---III-I      I   I--------I
S36-8512  ----II I      I   I        I
S11-7710  -----I I--I   I   I        I
S33-8412  -----I I  I---I   I        I
S28-8303  -------I  I       I        I----------------------I
S16-7905  ------I---I       I        I                      I
S21-8012  ------I           I        I                      I
S15-7812  --------------I--I         I                      I------------------------------------------------I
S20-8008  --------------I            I                      I                                                I
S35-8508  ---------------------------I                      I                                                I------
S14-7810  --------------------------------------------------I                                                I
S29-8309  -------------------------------------------------------------------I-------------------------------I
S30-8312  -------------------------------------------------------------------I
```

Station: SDIX: Ulva sp.: TOTAL Quads with Data = 281

Quad Range USED 15 to 44 for Total of 30 : Range WITH data 6 to 55: : # Dropped 137 : 48.8%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.916397: Maximum Distance = 1163

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  ------------I-----I
S27-8212  ------------I     I
S10-7705  ----I----------I  I
S22-8105  ----I          I  I
S13-7805  --II           I  I
S34-8505  --III          I  I----------------------------------I
S25-8204  ---II          I  I                                  I
S18-7912  --I I          I  I                                  I
S39-8612  I I I          I  I                                  I
S40-8705  I-III          I  I                                  I
S41-8708  I IIII         I  I                                  I
S42-8712  I IIII         I--I                                  I
S38-8608  --IIII         I                                     I
S24-8201  ---IIII        I                                     I----------------------------------I
S37-8604  ---IIII        I                                     I                                  I
S28-8303  ----III--------I                                     I                                  I
S33-8412  -----II        I                                     I                                  I
S31-8404  -----II        I                                     I                                  I
S30-8312  -----II        I                                     I                                  I
S36-8512  -----I         I                                     I                                  I----------I
S21-8012  ---------------I                                     I                                  I          I
S16-7905  --------------------------------------I------I       I                                  I          I
S23-8110  ---------------------------I----------I      I-------I                                  I          I------
S29-8309  ---------------------------I                 I                                          I          I
S20-8008  ---------------------------------------------I                                          I          I
S11-7710  ----------------------------------------------------------------------------------------I          I
S32-8408  ------------------------------------------------------------------I--------------------------------I
S35-8508  ------------------------------------------------------------------I
```

Station: LCIX: Ulva sp.: TOTAL Quads with Data = 219

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 3 to 21: : # Dropped 39 : 17.8%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.890001: Maximum Distance = 244

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  -------I-I
S12-7803  -------I I-I
S27-8212  -----I---I I---I
S36-8512  -----I     I   I
S13-7805  -------I---I   I
S35-8508  -------I       I
S23-8110  -------------I I
S28-8303  ---------I-I IIII
S39-8612  ---------I I-IIII
S42-8712  -----------I  III
S25-8204  ------------I-III--------------------I
S41-8708  ------------I  II                    I
S24-8201  ---------------II                    I-------------------I
S11-7710  ----------------I                    I                   I
S10-7705  ---------------------------I--I      I                   I
S17-7909  ---------------------------I  I------I                   I--------I
S15-7812  -----------------I-I          I                          I        I
S16-7905  -----------------I I----------I                          I        I--------------------------------I
S22-8105  -------------------I                                     I        I                                I
S33-8412  ---------------------------------------------------------I        I                                I------
S20-8008  ------------------------------------------------------------------I                                I
S30-8312  ---------------------------------------------------------------------------------------------------I
```

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Egregia menziesii (Feather-boa Ribbon Kelp). (Turner, 1808). Ref. AH 1976, p 244.
Phylum Phaeophyta: **Class** Laminariales:

Description: Brown, with long (to 15 m) flattened stipes (to 3.5 cm wide) bearing densely packed broad to linear blades (to 8 cm long) at edges. Holdfast conical, up to 25 cm diameter.

Distribution: Alaska to Punta Eugenio (Baja California). Common on protected to moderately exposed rocks, mid intertidal to subtidal (20 m). A warm-tolerant species.

Diablo Area Specific Information: Rare, but long-lived holdfast, occurring in about 3% of our quadrats. Persistent occurrences at certain subtidal locations.

Habitat: On large boulders or bedrock, mostly on tops and sides, mid (at LCIX) to lower intertidal.

Observational Errors: Data presented includes observations of fronds (holdfast extralimital) within a quadrat as well as holdfast + fronds, which is not our usual methodology. Earlier surveys (prior to about 1978) were not consistent for calling extralimital fronds and some of the data represented number of plants rather than area cover.

Small or eroded individuals can be missed when under algal mats. When stipeless holdfast is found, may be difficult to assess viability.

Field Identification Problems:

General: Small individuals (<5 cm) that might be this species are identified in the field as "unid. laminarian, juveniles" to avoid possible confusion with other Laminariales.

Station Specific: n.a.

General Comments: When occurring during the pre-El Niño period, this taxon was usually at the extreme lower limit of the observed transect except for 1976 at SDIX where it was moderately common.

Stipes often removed by grazing or storm damage, leaving just the holdfast with tiny rosette of stipe.

Impacts to Taxon:

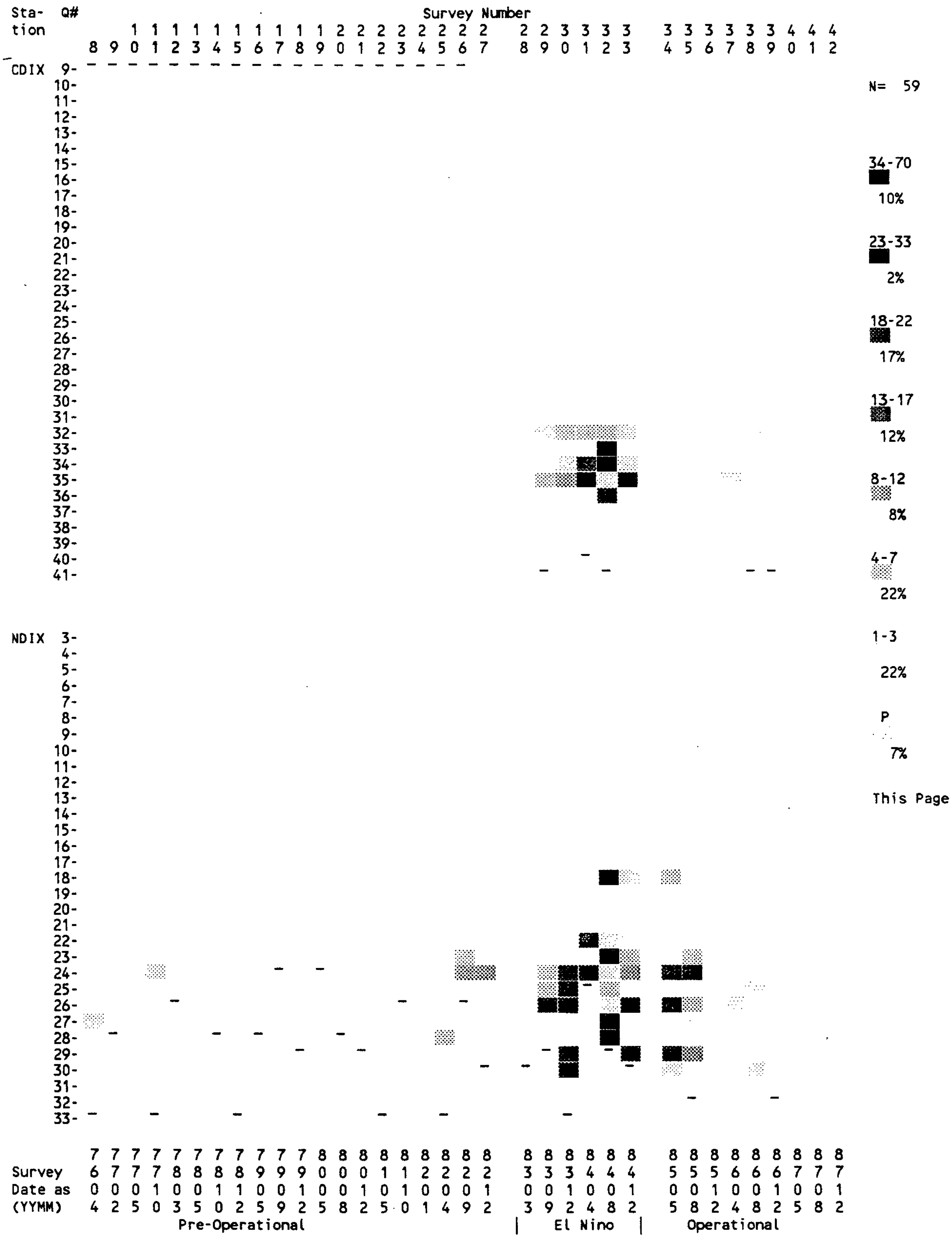
El Niño: 1982-83 winter storm: NDIX with one occurrence just prior to storms and none just afterwards. CDIX and SDIX with no occurrences just prior or after storms. LCIX with no immediate change but only 1 occurrence.

El Niño: 1983-1984: NDIX and CDIX with large increase in occurrence and cover (NDIX above normal). SDIX with 1 occurrence for 1 survey. This station had moderate number of occurrences in 1976. Possibly the cobble overlay or some other factor was inhibiting *Egregia* at SDIX. LCIX increased by two occurrences, but only at the end of 1984.

Diablo DCPP Operation: Moderately rapid decline in occurrences and area cover at NDIX with disappearance by the end of 1986. CDIX as NDIX but much more rapid, i.e., by mid 1985 all individuals had vanished. LCIX slightly expanding number of occurrences, possibly with declining covers by winter 1987, but well above normal.

Taxon or Category: Egregia menziesii (fronds ONLY OR holdfast AND fronds)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

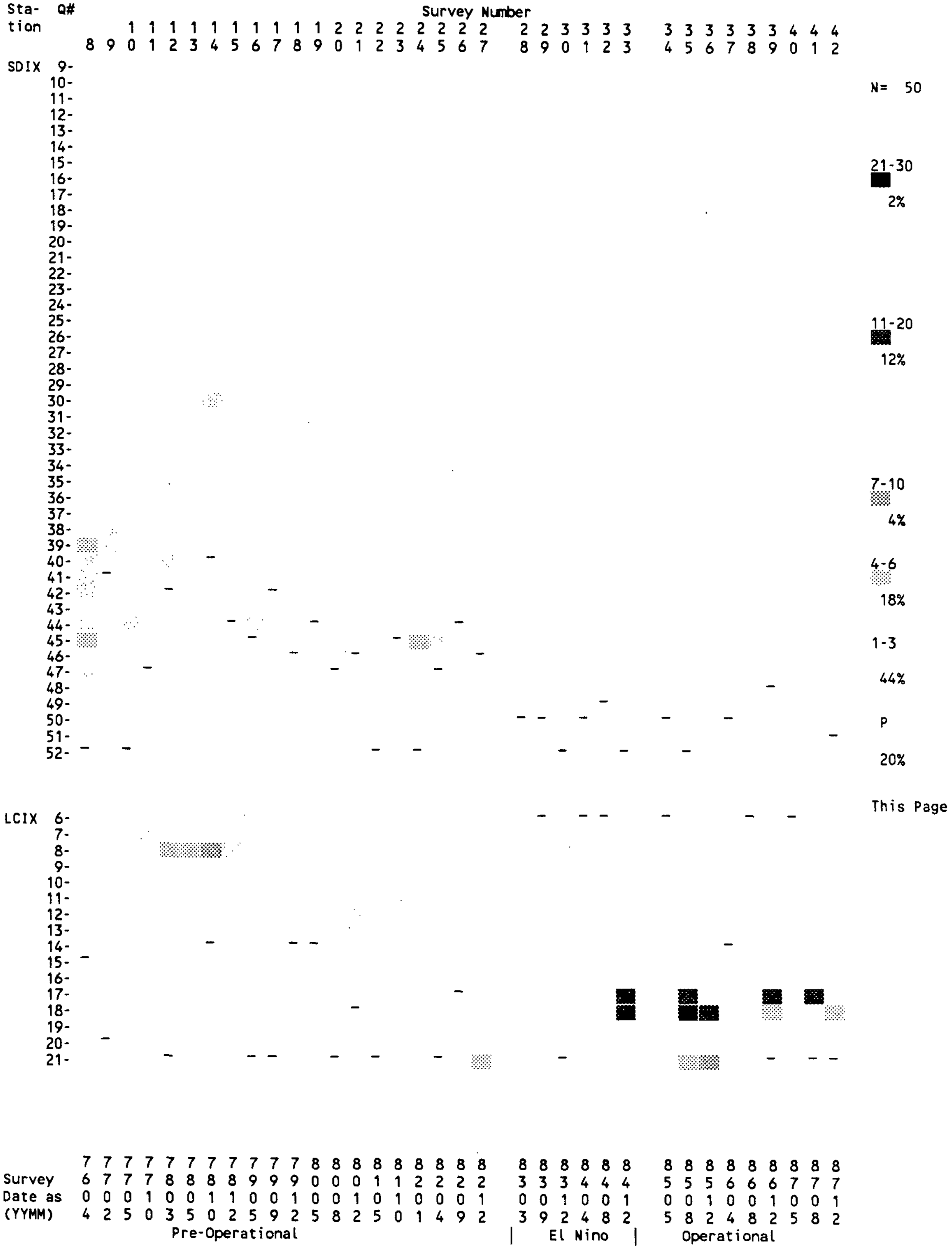


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for EGRMEN CSV 5220 3-29-88 7:28a 04-14-1989 09:38

Taxon or Category: Egregia menziesii (fronds ONLY OR holdfast AND fronds)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for EGRMEN CSV 5220 3-29-88 7:28a 04-14-1989 09:38

Audit: CLUMRG2P: V.1.2: for SEGRMEN CLU 6163 4-22-89 7:51a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:47:59 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Egregia menziesii (fronds ONLY OR holdfast AND fronds): TOTAL Quads with Data = 17

Quad Range USED 32 to 36 for Total of 5 : Range WITH data 32 to 36: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 36
COPHENETIC CORRELATION COEFFICIENT = 0.969232: Maximum Distance = 507

```
S27-8212  I
S28-8303  I
S34-8505  I
S35-8508  I
S36-8512  I
S38-8608  I-------I
S39-8612  I       I
S40-8705  I       I
S41-8708  I       I-------I
S42-8712  I       I       I
S37-8604  I       I       I---------------------------------------I
S29-8309  -----I--I       I                                       I
S30-8312  -----I          I                                       I--------------------------------------I
S33-8412  ----------------I                                       I                                      I------
S31-8404  --------------------------------------------------------I                                      I
S32-8408  -----------------------------------------------------------------------------------------------I
```

Station: NDIX: Egregia menziesii (fronds ONLY OR holdfast AND fronds): TOTAL Quads with Data = 42

Quad Range USED 18 to 27 for Total of 10 : Range WITH data 18 to 30: : # Dropped 13 : 31.0%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.979106: Maximum Distance = 731

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  --I
S 9-7702  I I
S10-7705  I I
S13-7805  I I
S14-7810  I I
S15-7812  I I
S16-7905  I I
S18-7912  I I
S20-8008  I I
S21-8012  I I
S22-8105  I-I----------I
S24-8201  I I          I
S25-8204  I I          I
S28-8303  I I          I
S36-8512  I I          I
S39-8612  I I          I
S40-8705  I I          I--------------I
S41-8708  I I          I              I
S42-8712  I I          I              I
S37-8604  I I          I              I
S38-8608  I I          I              I---------------I
S11-7710  --I          I              I               I
S27-8212  -------------I              I               I
S29-8309  ----------------I---I       I               I--------------------------------------------------I
S33-8412  -------------I--I   I-------I               I                                                  I
S34-8505  -------------I      I                       I                                                  I------
S35-8508  --------------------I                       I                                                  I
S30-8312  --------------------------------------------I                                                  I
S32-8408  -----------------------------------------------------------------------------------------------I
```

Station: SDIX: Egregia menziesii (fronds ONLY OR holdfast AND fronds): TOTAL Quads with Data = 17

Quad Range USED 38 to 44 for Total of 7 : Range WITH data 30 to 47: : # Dropped 11 : 64.7%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.993894: Maximum Distance = 51

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604   ----------------------------------------------------------------------------------------------------I
S10-7705   I-------------------------I                                                                         I
S16-7905   I                         I                                                                         I
S11-7710   I                         I                                                                         I
S13-7805   I                         I                                                                         I------
S18-7912   I                         I                                                                         I
S20-8008   I                         I                                                                         I
S21-8012   I                         I                                                                         I
S22-8105   I                         I-------------------------------------------------------------------------I
S23-8110   I                         I
S24-8201   I                         I
S25-8204   I                         I
S27-8212   I                         I
S28-8303   I                         I
S29-8309   I                         I
S30-8312   I-------------------------I
S31-8404   I
S32-8408   I
S33-8412   I
S34-8505   I
S35-8508   I
S36-8512   I
S37-8604   I
S38-8608   I
S39-8612   I
S40-8705   I
S41-8708   I
S42-8712   I
```

Station: LCIX: Egregia menziesii (fronds ONLY OR holdfast AND fronds): TOTAL Quads with Data = 33

Quad Range USED 8 to 19 for Total of 12 : Range WITH data 7 to 21: : # Dropped 10 : 30.3%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.932889: Maximum Distance = 364

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702   I
S10-7705   I
S11-7710   I
S16-7905   I
S17-7909   I-----I
S20-8008   I     I
S22-8105   I     I
S25-8204   I     II
S27-8212   I     II
S28-8303   I     II--------I
S23-8110   I-----II        I
S24-8201   I      I        I----I
S30-8312   -------I        I    I
S12-7803   I-----I         I    I-------------------------------------------I
S13-7805   I     I---------I    I                                           I
S15-7812   ------I              I                                           I---I
S42-8712   ---------------------I                                           I   I------------------------------I
S36-8512   -----------------------------------------------------------------I   I                              I
S39-8612   --------------I------------------------------------------------------I                              I------
S41-8708   --------------I                                                                                     I
S33-8412   ----------------------------------I-----------------------------------------------------------------I
S35-8508   ----------------------------------I
```

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Fucus/Hesperophycus (Rock weed). Ref. AH 1976, p 261 & 266.
Phylum Phaeophyta: **Class** Fucales:

Description: Olive brown to dark brown (*Fucus*) to yellowish brown (*Hesperophycus*), branched flattened blades to 0.5 m long, tips often swollen and lumpy. Holdfast disk-shaped.

Distribution: See below. A mixed warm-tolerant/intolerant group.

Diablo Area Specific Information: Moderately common, persistent, occurring in about 15% of our quadrats.

Habitat: On large boulders or bedrock, mostly on tops and sides, upper to mid intertidal. Usually in moderately open areas free from other algal species.

Observational Errors: *Hesperophycus* is distinguished from *Fucus* in the field by small pale hairs in lines on the blades but hairs not always present or if present are scattered.

Collections of field identified members of each taxon were laboratory identified and yielded about 50% correct field identifications. Consequently, we combined both taxa although only one was warm-tolerant.

Quadrat boundary errors occurred (i.e. holdfast of specimen near the quadrat edge, so may be counted as in or out of a quadrat for a survey) and probably account for about 2% of all observations. Other missed observations might involve missing small individuals in areas with dense algal mats, although this should rarely occur.

Field Identification Problems:

General: Small individuals (<1.5 cm) that might be this species, were field-identified as "unid. fucoid, juveniles" to avoid possible confusion with the other common fucoid, *Pelvetia*. Occasionally, eroded stipes were either this group or *Pelvetia*. We either ignored (i.e., probably non-viable) or identified them as "unid. fucoid".

Station Specific: n.a.

General Comments: Occurs only at SDIX and NDIX (1 occurrence at LCIX in 1977).

Impacts to Taxon:

El Niño: 1982-83 winter storm: At both SDIX and NDIX several boulders supporting this group were removed in the mid to lower intertidal.

El Niño: 1983-1984: This group quickly re-established at SDIX in the mid to upper-low intertidal levels where new large boulders had been introduced by 1982-83 winter storms. Number of occurrences increased at NDIX more slowly and only at the upper tidal levels. LCIX and CDIX still with no occurrences.

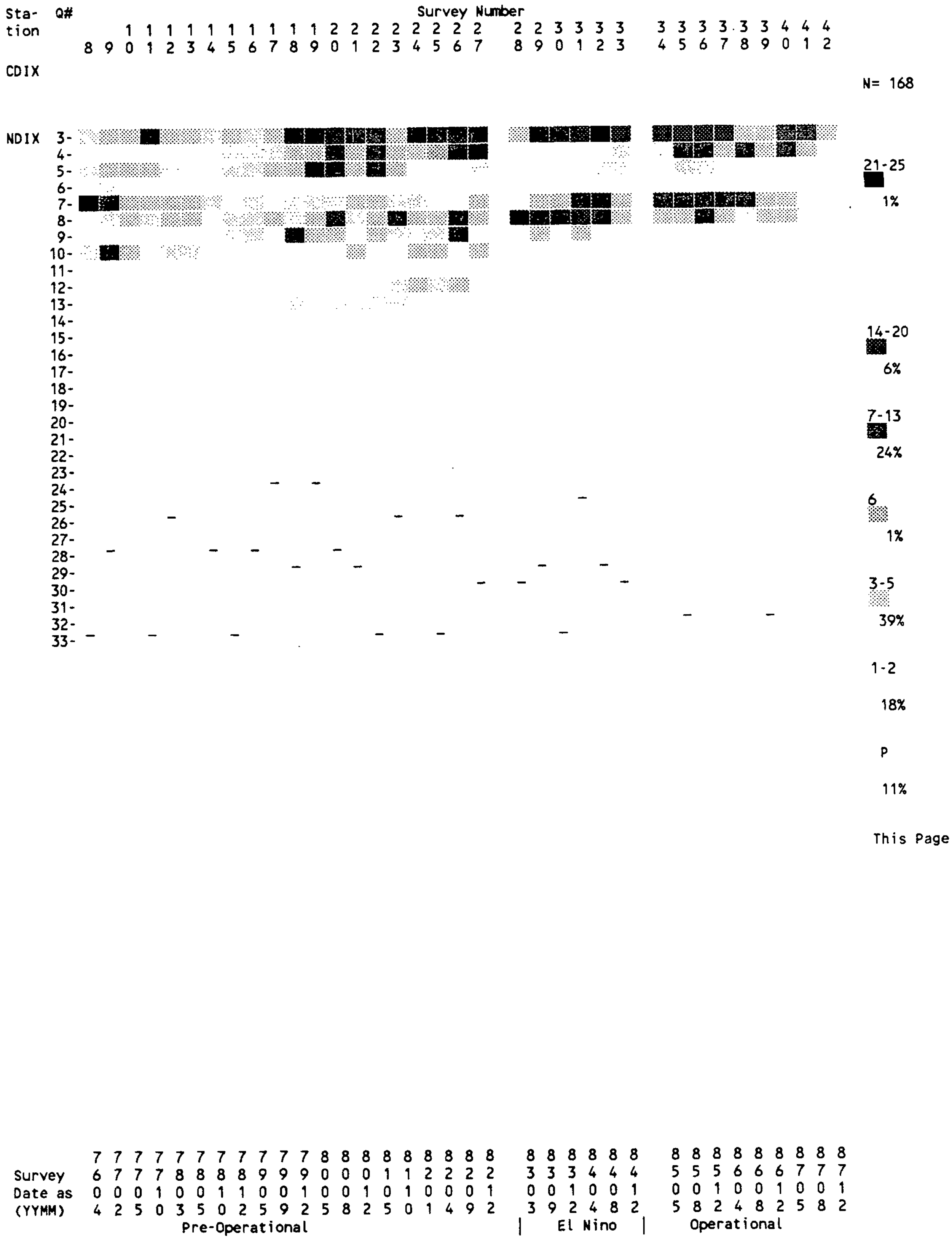
Diablo DCPP Operation: There was an abrupt decline in occurrences at SDIX at all tidal levels from about 16 quadrats to only 2 to 3 quadrats (in the upper and mid tide range) beginning with winter of 1986 and complete by spring of 1987. NDIX with a slower decline, from 5 to 2 quadrats by end of 1987.

Fucus distichus ssp. *edentatus*: Northern Washington to Point Conception (California), locally common in upper to mid intertidal. Not a warm-tolerant species.

Hesperophycus harveyanus: Santa Cruz (California) to Isla San Benito (Baja California), locally abundant upper intertidal. A warm-tolerant species.

Taxa or Category: Fucus distichus +Hesperophycus harveyanus

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

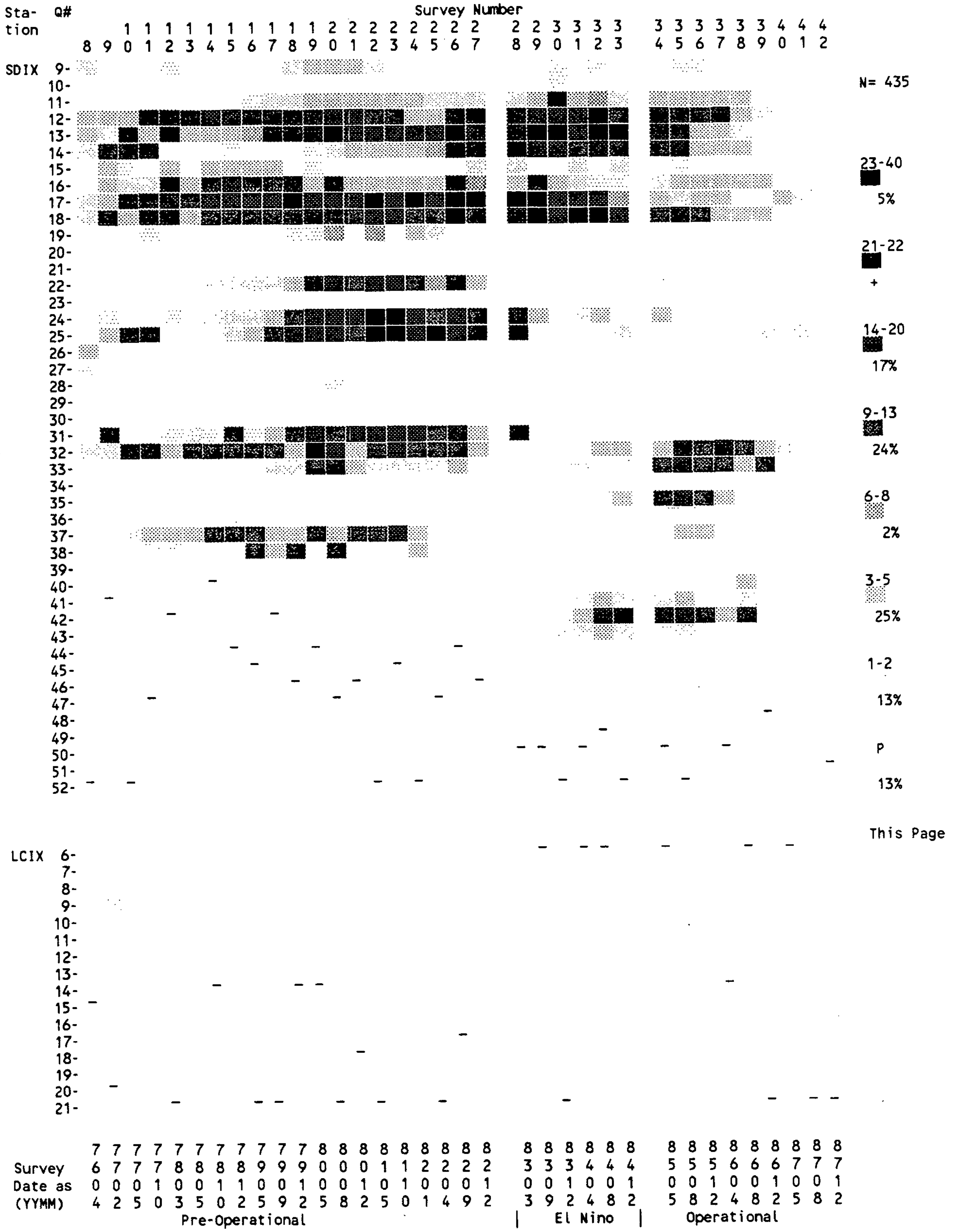


' _ ' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for FUCHES CSV 5951 9-30-88 7:37a 04-14-1989 09:41

Taxa or Category: Fucus distichus +Hesperophycus harveyanus

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for FUCHES CSV 5951 9-30-88 7:37a 04-14-1989 09:42

Audit: CLUMRG2P: V.1.2: for SFUCHES CLU 6581 4-22-89 8:08a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:09:06 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Fucus distichus +Hesperophycus harveyanus: : No data for this station
Abrev. taxon name(s): FUCUS DIST +HESPERO HARV Quant. Data

```
                                                NO DATA
                                          NO DATA
                                    NO DATA
                              NO DATA
                        NO DATA
                  NO DATA
            NO DATA
      NO DATA
      NO DATA
            NO DATA
                  NO DATA
                        NO DATA
                              NO DATA
                                    NO DATA
                                          NO DATA
                                                NO DATA
```

Station: NDIX: Fucus distichus +Hesperophycus harveyanus: TOTAL Quads with Data = 169
Abrev. taxon name(s): FUCUS DIST +HESPERO HARV Quant. Data

Quad Range USED 2 to 13 for Total of 12 : Range WITH data 2 to 13: : # Dropped 0 : 0.0%
Surveys 35 : Dropped 0 Surveys if quads sampled < 13
COPHENETIC CORRELATION COEFFICIENT = 0.689587: Maximum Distance = 312

```
S 8-7604  --------------------------------------------------------------------------------------------------I
S 9-7702  -----------------------------------I------------I                                                 I
S21-8012  -----------------------------------I            I                                                 I
S10-7705  -------------------------I----I                 I                                                 I
S12-7803  ---I---------------------I    I----I            I                                                 I
S13-7805  ---I                          I    I            I                                                 I
S11-7710  ------------------------------I    I----I       I                                                 I
S14-7810  --------------I--I                 I    I       I-I                                               I
S15-7812  -----------I--I  I--------I        I    I       I I                                               I
S16-7905  -----------I     I        I--------I    I---I   I I                                               I
S42-8712  -----------------I        I             I   I   I I                                               I
S17-7909  --------------------------I             I   I   I I                                               I
S28-8303  -------------------------------I--------I   I   I I                                               I
S29-8309  ----------------------I--------I            I---I I                                               I------
S30-8312  ----------------------I                     I     I                                               I
S24-8201  -------------I--------------I               I     I---------------I                               I
S25-8204  -------------I              I-------I       I     I               I                               I
S41-8708  ----------------------------I       I       I     I               I                               I
S27-8212  ---------------I-------I            I-------I     I               I                               I
S40-8705  ---------------I       I-----I      I             I               I                               I
S39-8612  -----------------------I     I------I             I               I                               I
S38-8608  -----------------------------I                    I               I--------I                      I
S18-7912  ---------------------------------------I          I               I        I                      I
S19-8005  -----------------------I---------I     I----------I               I        I                      I
S22-8105  -----------------------I         I-----I                          I        I                      I
S23-8110  ---------------------------------I                                I        I                      I
S31-8404  -------------------------------------------------------------I    I        I                      I
S32-8408  ------------------------------------------I                  I----I        I----------------------I
S33-8412  -----------------------I                  I------------------I             I
S37-8604  -----------------------I---------I        I                                I
S34-8505  -----------------------I         I--------I                                I
S35-8508  ---------------I-----------------I                                         I
S36-8512  ---------------I                                                           I
S20-8008  -----------------------------------------------I---------------------------I
S26-8209  -----------------------------------------------I
```

Station: SDIX: Fucus distichus +Hesperophycus harveyanus: TOTAL Quads with Data = 438
Abrev. taxon name(s): FUCUS DIST +HESPERO HARV Quant. Data

Quad Range USED 9 to 43 for Total of 35 : Range WITH data 7 to 43: : # Dropped 53 : 12.1%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.584776: Maximum Distance = 1572

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604 ---------------------I----------I
S40-8705 -----------I---------I          I
S41-8708 --I--------I                    I---------------I
S42-8712 --I                             I               I
S39-8612 --------------------------------I               I---------I
S10-7705 -----------------I------------------I           I         I
S11-7710 -----------------I                  I-----------I         I-------------------------I
S13-7805 ------------------------------------I                     I                         I
S34-8505 --------------------------------------------------I       I                         I
S36-8512 -----------------------------I-------I            I-------I                         I-------I
S37-8604 -----------------------------I       I------------I                                 I       I
S38-8608 -------------------------------------I                                              I       I--------I
S35-8508 ------------------------------------------------------------------------------------I       I        I
S29-8309 ------------------------------------------I---------I                                       I        I
S30-8312 ------------------------------------I-----I         I---------------------------------------I        I
S31-8404 ------------------------------------I               I                                                I
S32-8408 -------------------------------------------------I--I                                                I
S33-8412 -------------------------------------------------I                                                   I------
S15-7812 -----------------------------------------I-------------------------I                                 I
S16-7905 -----------------------------------------I                         I--------I                        I
S18-7912 ------------------------------------------------------I--I         I        I                        I
S25-8204 ------------------------------------------------------I  I---------I        I                        I
S21-8012 --------------------------------------------------I------I                  I                        I
S27-8212 ----------------------------------I---------------I                         I------------------------I
S28-8303 ----------------------------------I                                         I
S19-8005 -------------------------------------------I-------------I                  I
S20-8008 -------------------------------------------I             I---------------I  I
S22-8105 ----------------------------------------I-------I        I               I  I
S24-8201 ----------------------------------------I       I--------I               I--I
S23-8110 ------------------------------------------------I                        I
S26-8209 -------------------------------------------------------------------------I
```

Station: LCIX: Fucus distichus +Hesperophycus harveyanus: TOTAL Quads with Data = 1:**** Prob. INSUFFICIENT Dat
Abrev. taxon name(s): FUCUS DIST Quant. Data

Quad Range USED 9 to 9 for Total of 1 : Range WITH data 9 to 9: : # Dropped 0 : 0.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 9
COPHENETIC CORRELATION COEFFICIENT = 0.997365: Maximum Distance = 2

```
S 8-7604 I
S10-7705 I
S11-7710 I
S12-7803 I
S13-7805 I
S14-7810 I
S15-7812 I
S16-7905 I
S17-7909 I
S18-7912 I
S19-8005 I
S20-8008 I
S21-8012 I
S22-8105 I----------------------------------------------------------------------------------------------------I
S23-8110 I                                                                                                    I
S24-8201 I                                                                                                    I
S25-8204 I                                                                                                    I
S26-8209 I                                                                                                    I
S27-8212 I                                                                                                    I
S28-8303 I                                                                                                    I
S30-8312 I                                                                                                    I------
S33-8412 I                                                                                                    I
S35-8508 I                                                                                                    I
S36-8512 I                                                                                                    I
S37-8604 I                                                                                                    I
S39-8612 I                                                                                                    I
S41-8708 I                                                                                                    I
S42-8712 I                                                                                                    I
S 9-7702 -----------------------------------------------------------------------------------------------------I
```

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Pelvetia fastigiata (Rock weed). (J. Agardh, 1841) Ref. AH 1976, p 261.
Phylum Phaeophyta: **Class** Fucales:

Description: Dark greenish-olive to yellowish-brown, branched sub-cylindrical to flattened blades to 0.9 m long, tips often swollen and lumpy. Holdfast small, disk-shaped.

Distribution: Horswell Channel (British Columbia) to Punta Baja (Baja California), locally abundant on rocks somewhat protected from open surf, mid intertidal. A warm-tolerant species.

Diablo Area Specific Information: Moderately common, persistent, occurring in about 20% of our quadrats in cover up to 60%.

Habitat: On large boulders or bedrock, mostly on tops and sides, upper to mid intertidal. Usually in moderately open areas free from other algal species. Small juveniles occasionally occurred in algal mats, but usually did not survive.

Observational Errors: Quadrat boundary errors occur (i.e., holdfast of specimen near the quadrat edge, so may be counted as in or out of a quadrat for a survey) and probably account for about 2% of all observations. Other missed observations could be from missing small individuals in areas with dense algal mats, although this should rarely occur.

Field Identification Problems:

General: Small individuals (<1.5 cm) that might be this species were field-identified as "unid. fucoid, juveniles" to avoid possible confusion with the other common fucoids, *Hesperophycus* and *Fucus*. Occasionally eroded stipes were either *Pelvetia* or the above fucoids and these we either ignored (i.e., probably non-viable) or identified as "unid. fucoid".

Station Specific: n.a.

General Comments: Limited occurrences at LCIX (in one to two quadrats at low covers prior to 1984). Not occurring at CDIX for the one survey prior to El Niño.

Impacts to Taxon:

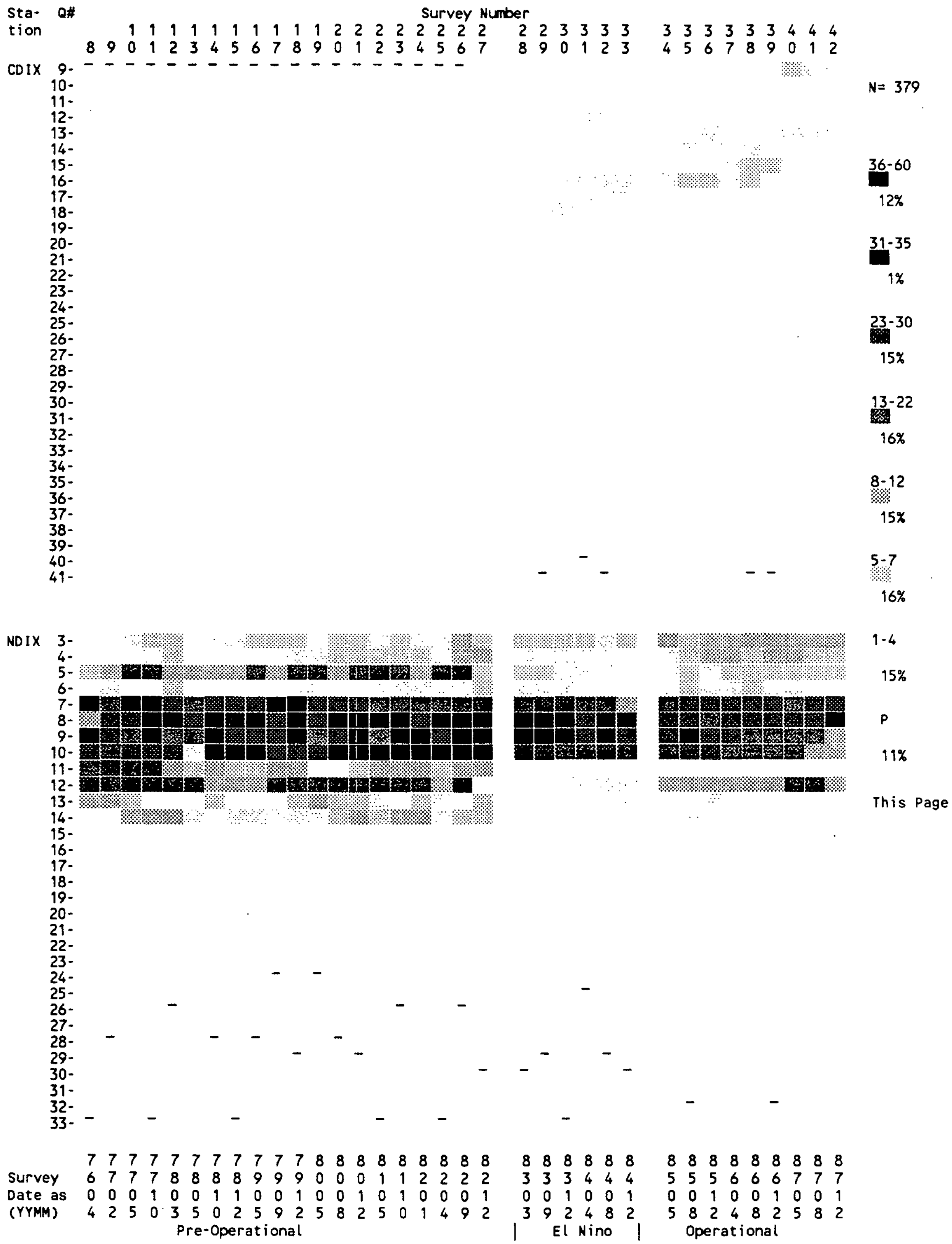
El Niño: 1982-83 winter storm: Several boulders which supported this taxon were removed from the mid intertidal at NDIX. Little to no effect at other stations.

El Niño: 1983-1984: At SDIX this species sporadically recruited juveniles in the lower and upper intertidal ranges, with existing plants remaining normal. At NDIX plants surviving remained normal, with some recruitment in the mid tidal levels (where plants had been removed). CDIX began to develop a small population but never with much cover. LCIX lost this species early in 1984 (only 1 quadrat).

Diablo DCPP Operation: At SDIX about mid 1987, lost gains made in occurrences during El Niño with possible decrease in covers except at mid tidal levels, but probably within normal range of fluctuation (*Pelvetia* occurrences were always somewhat sporadic at SDIX in the upper tidal ranges). NDIX also losing occurrences, but only in the lower part of the intertidal, and possibly declining in coverage (note here that boulder removal at quadrats 13 and 14 during 1983-84 storm caused habitat loss for this species). CDIX losing occurrences in the lower range and gaining at upper end, but no occurrences here prior to El Niño. Taxon only listed as present, not with any well-developed plants with substantial coverage.

Taxon or Category: Pelvetia fastigiata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

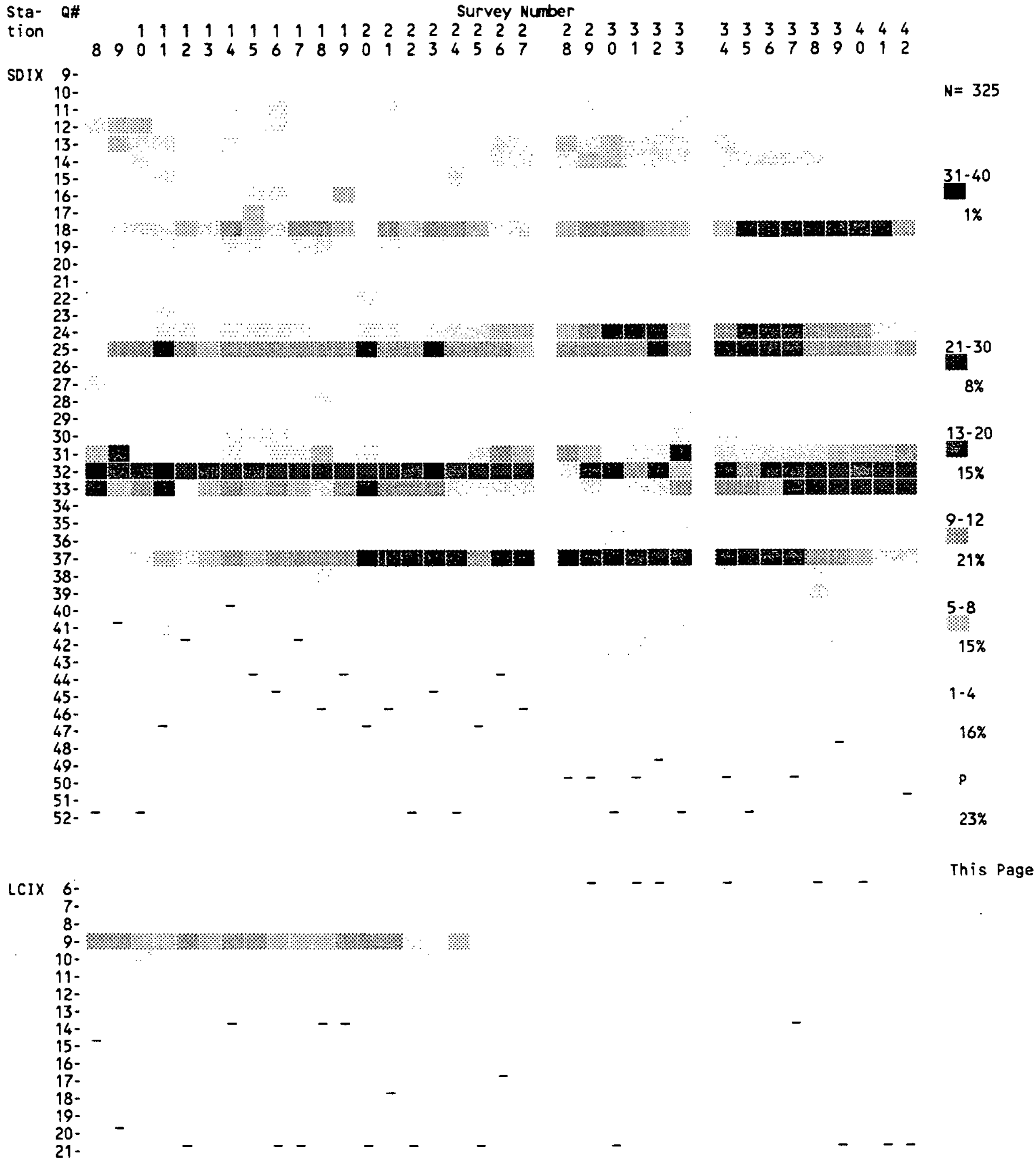


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PELFAS CSV 5723 3-29-88 7:36a 04-14-1989 10:46

Taxon or Category: Pelvetia fastigiata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Survey Date as (YYMM)	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: CLUMRG2P: V.1.2: for SPELFAS CLU 7249 4-22-89 9:52a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:48:49 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Pelvetia fastigiata: TOTAL Quads with Data = 35

Quad Range USED 9 to 24 for Total of 16 : Range WITH data 9 to 26: : # Dropped 1 : 2.9%
Surveys 16 : Dropped 0 Surveys if quads sampled < 24
COPHENETIC CORRELATION COEFFICIENT = 0.765635: Maximum Distance = 122

```
S27-8212 I----------I
S28-8303 I          I-------------I
S29-8309 -----------I             I
S30-8312 ---------------I         I--------I
S31-8404 -----------I--I   I--I   I        I
S32-8408 -----------I  I---I  I---I        I----I
S33-8412 --------------I      I            I    I
S34-8505 ---------------------I            I    I--------------------------I
S37-8604 ----------------------------------I    I                          I
S41-8708 --------------------------I------------I                          I-----------------I
S42-8712 --------------------------I                                       I                 I
S35-8508 --------------------------I---------------------------------------I                 I-------I
S36-8512 --------------------------I                                                         I       I
S38-8608 ----------------------------------------------------------------------------I-------I       I------
S39-8612 ----------------------------------------------------------------------------I               I
S40-8705 --------------------------------------------------------------------------------------------I
```

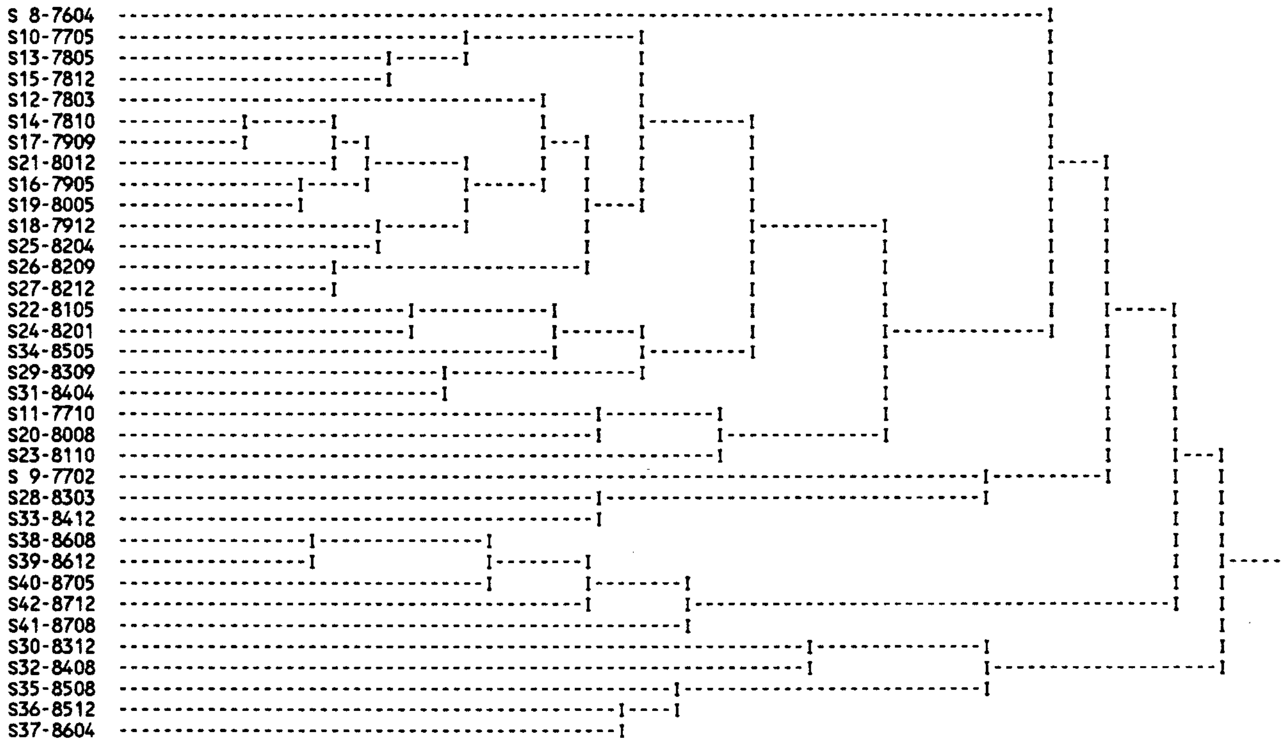
Station: NDIX: Pelvetia fastigiata: TOTAL Quads with Data = 347

Quad Range USED 3 to 14 for Total of 12 : Range WITH data 2 to 25: : # Dropped 8 : 2.3%
Surveys 35 : Dropped 0 Surveys if quads sampled < 14
COPHENETIC CORRELATION COEFFICIENT = 0.576392: Maximum Distance = 600

```
S 8-7604 --------------------------------------------------------------------------------------------I
S 9-7702 ---------------------------------------------------------------I------I                     I
S10-7705 ------------------------------------------------------I--------I      I                     I
S11-7710 ----------------------------------------I-------------I               I                     I
S18-7912 ----------------------------------------I                             I                     I
S12-7803 -----------------------------------I------I                           I                     I
S22-8105 -----------------------------------I      I---I                       I                     I
S19-8005 ------------------------------------------I   I                       I                     I
S14-7810 ----------------------------I-------I         I---I                   I                     I
S15-7812 -----------------------I----I       I------I  I   I                   I                     I
S16-7905 -----------------------I            I      I  I   I                   I--I                  I------
S20-8008 -------------------------------I----I      I--I   I-----I             I  I                  I
S21-8012 -------------------------------I           I      I     I             I  I                  I
S24-8201 -------------------------------------------I      I     I             I  I                  I
S17-7909 -----------------------------------------I--------I     I---I         I  I                  I
S36-8512 -----------------------------------------I              I   I         I  I                  I
S27-8212 ---------------------------------------------------I    I   I         I  I                  I
S28-8303 -----------------I----I                            I    I   I         I  I                  I
S32-8408 -----------------I    I--------I                   I----I   I         I  I                  I
S29-8309 ----------------------I        I---I               I        I---------I  I                  I
S30-8312 -------------------------------I   I---------------I        I            I                  I
S35-8508 -----------------------------------I                        I            I------------------I
S13-7805 --------------------------------------------I               I            I
S31-8404 ------------------I-----I                   I               I            I
S34-8505 ------------------I     I-----I             I---------------I            I
S37-8604 ------------------------I     I--------I    I                            I
S33-8412 ------------------------------I        I    I                            I
S38-8608 ----------------I-----I                I----I                            I
S39-8612 ----------------I     I---I            I                                 I
S41-8708 ----------------------I   I---I        I                                 I
S40-8705 --------------------------I   I--------I                                 I
S42-8712 ------------------------------I                                          I
S23-8110 -----------------------------I-------------------I                       I
S26-8209 -----------------------------I                   I-----------------------I
S25-8204 -------------------------------------------------I
```

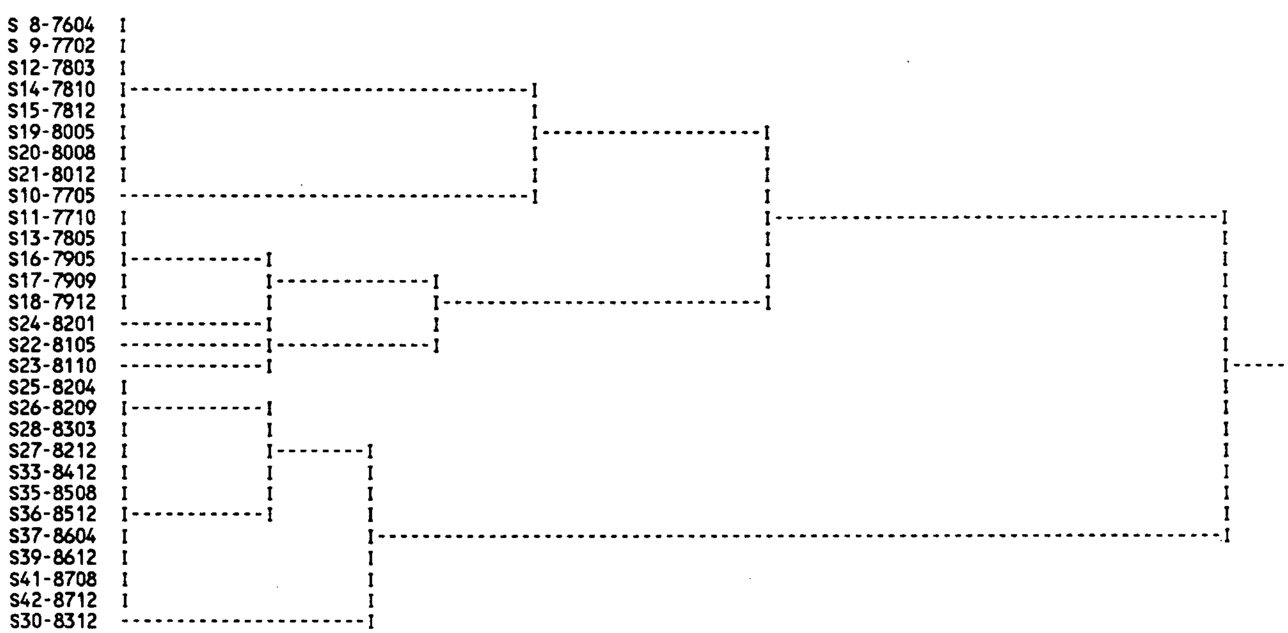
Station: SDIX: Pelvetia fastigiata: TOTAL Quads with Data = 301

Quad Range USED 12 to 38 for Total of 27 : Range WITH data 11 to 43: : # Dropped 19 : 6.3%
Surveys 35 : Dropped 0 Surveys if quads sampled < 38
COPHENETIC CORRELATION COEFFICIENT = 0.657400: Maximum Distance = 927



Station: LCIX: Pelvetia fastigiata: TOTAL Quads with Data = 25

Quad Range USED 4 to 10 for Total of 7 : Range WITH data 3 to 10: : # Dropped 1 : 4.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 10
COPHENETIC CORRELATION COEFFICIENT = 0.814696: Maximum Distance = 52



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Bossiella/Calliarthron spp. (Erect Coralline). Ref: AH 1976, p409-416.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Fan-like turf, pinkish, to 15 (30) cm tall.

Distribution: see below. A probable warm-tolerant group except that *Calliarthron* is usually not found in warm habitats in southern California.

Diablo Area Specific Information: Moderately common, persistent, occurring in about 20% of our quadrats with covers up to 60%.

Habitat: On rock, boulders, bedrock, rarely cobble, mostly on sides, mid to low intertidal. Often in small tide pools, although small clumps occur in algal mats.

Observational Errors: This group was field identified as *Bossiella* spp. and *Calliarthron* spp., but upon analyzing the data we found that there may have been about 10% confusion between these taxa, so we consolidated them (see note below concerning *Corallina* spp. and coral crust). Missed observations occurred from overlooking small clumps in areas with dense algal mats, about 2% of the time.

Field Identification Problems:

General: When short or severely eroded, can be confused with similar *Corallina* spp., which probably occurs <7% of the time. When only basal crust (possibly with minor excrescences) is present, this group could be identified as nearly any of the coralline crusts. In later surveys we classified crust plus excrescences as "unid. coralline, stubs".

Station Specific: Quadrats 7 and 8 at LCIX (in the upper intertidal) contained clumps of erect corallines that were identified as *Bossiella/Calliarthron* or as *Corallina* spp. depending on their general appearances at the time.

General Comments: Most common and abundant at our outer coast station (LCIX). Populations possibly above normal in the mid intertidal at SDIX and NDIX just prior to El Niño.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Occurrence moderately reduced at SDIX (cobble overlay, and possibly removal), with possibly small to slight reduction at all other stations.

El Niño: 1983-1984: Occurrence at SDIX and NDIX declined sporadically (decreasing in the mid intertidal). CDIX possibly less affected. LCIX possibly with declines in occurrence and cover.

Diablo DCPP Operation: At SDIX the El Niño decline continued until late 1987 where occurrence and cover were well below normal. At NDIX the El Niño decline continued, but here possibly normal (see above concerning pre-El Niño conditions). CDIX with sporadic changes in occurrence; probably still normal by end of 1987, but covers possibly slightly reduced. At LCIX with normal occurrences, but reduced cover at the mid intertidal.

Bossiella californica ssp. *californica*: Bodega Head (Calif.) to Bahia Asuncion (Baja Calif.)

Bossiella orbigniana ssp. *orbigniana*: Oregon to South America.

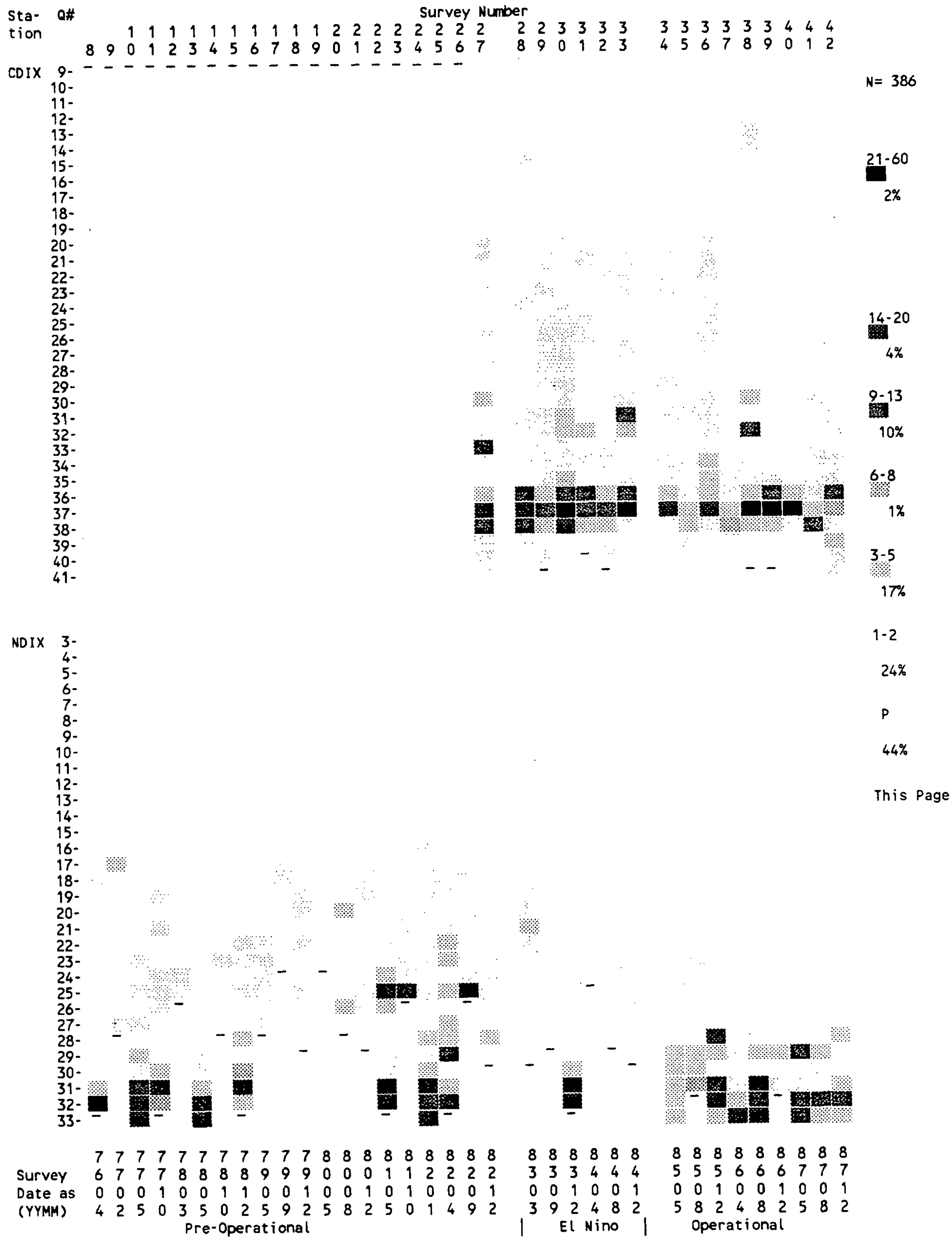
Bossiella plumosa: Alaska to Baja California.

Calliarthron cheilosporioides: Pacific Grove (Calif.) to Isla Cedros (Baja California).

Calliarthron tuberculosum: Alaska to Isla Cedros (Baja California).

Taxa or Category: Bossiella sp. +Calliarthron sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

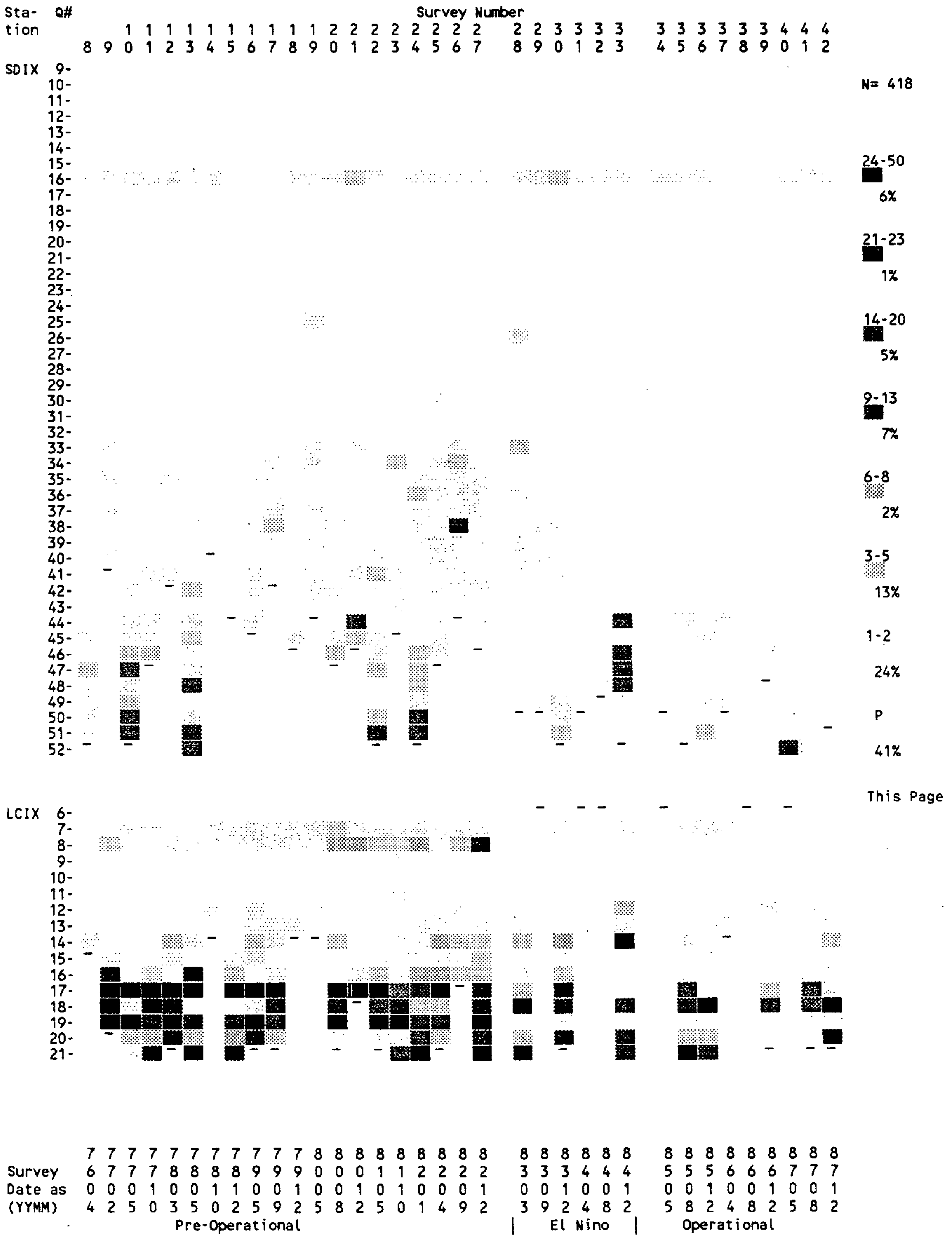


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for BOSCAL CSV 5563 9-30-88 7:32a 04-14-1989 09:05

Taxa or Category: Bossiella sp. +Calliarthron sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for BOSCAL CSV 5563 9-30-88 7:32a 04-14-1989 09:05

```
Audit: CLUMRG2P: V.1.2: for SBOSCAL CLU    6581   4-28-89   7:28a:   04-28-1989/07:34
Driver Prg. CSVtoDEK: V. 1.9 : Date/Time 04-28-1989/07:23:53 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
       METHOD:  GROUP AVERAGE:  ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST:  Quantitative Data Used


Station:  CDIX:   Bossiella sp. +Calliarthron sp.:   TOTAL Quads with Data = 172

        Quad Range USED 19 to 39 for Total of 21 :  Range WITH data 13 to 41:  :  # Dropped  11 :    6.4%
        Surveys  16 :  Dropped  0 Surveys if quads sampled < 39
        COPHENETIC CORRELATION COEFFICIENT = 0.600433:                          Maximum Distance = 543

S27-8212  ----------------------------------------------------------------I
S29-8309  ----------------------I------I                                  I
S32-8408  ----------------------I      I-------------I                    I--I
S35-8508  --------I------------I       I             I                    I  I
S37-8604  --------I            I-------I             I--------------------I  I
S41-8708  ---------------------I                     I                       I
S31-8404  ----------------------------------------I--I                       I------------------------------I
S42-8712  ----------------------------------------I                          I                              I
S28-8303  -----------------------------------------------I                   I                              I
S34-8505  ----------------------------------I-----I      I-------I           I                              I
S36-8512  ----------------------------------I     I------I       I-----------I                              I------
S40-8705  ----------------------------------------I              I                                          I
S33-8412  --------------------------------------------------I----I                                          I
S38-8608  --------------------------------------------------I                                               I
S30-8312  -------------------------------------------------------------I------------------------------------I
S39-8612  -------------------------------------------------------------I


Station:  NDIX:   Bossiella sp. +Calliarthron sp.:   TOTAL Quads with Data = 214

        Quad Range USED 17 to 27 for Total of 11 :  Range WITH data 10 to 33:  :  # Dropped  117 :   54.7%
        Surveys  29 :  Dropped  6 Surveys if quads sampled < 27
        COPHENETIC CORRELATION COEFFICIENT = 0.911020:                          Maximum Distance = 126

S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End  Dropped Surveys
S 8-7604  --------II
S37-8604  I-------II-I
S40-8705  I        I I
S13-7805  I--------I I--I
S41-8708  I          I  I
S36-8512  --------I--I  I-I
S39-8612  --------I     I I
S29-8309  I-------I     I I----I
S30-8312  I       I-----I I    I
S38-8608  --------I       I    II
S14-7810  -----------I----I    II
S42-8712  -----------I         II---I
S15-7812  ---------------------II   I
S10-7705  ----------------I---I I   I
S34-8505  ----------------I   I-I   I--I
S16-7905  --------------I--I  I     I  I
S33-8412  --------------I  I--I     I  II
S32-8408  -----------------I        I  II
S35-8508  --------------------------I  II
S18-7912  --------------------------I--II-----I
S21-8012  ------------------I-------I   I     I
S24-8201  ------------------I           I     I----------I
S11-7710  ------------------------------I     I          I--------I
S27-8212  ------------------------------------I          I        I-----I
S28-8303  -----------------------------------------------I        I     I---------------------I
S 9-7702  --------------------------------------------------------I     I                     I-------------I
S20-8008  --------------------------------------------------------------I                     I             I------
S25-8204  ------------------------------------------------------------------------------------I             I
S22-8105  --------------------------------------------------------------------------------------------------I
```

Station: SDIX: Bossiella sp. +Calliarthron sp.: TOTAL Quads with Data = 197

Quad Range USED 33 to 43 for Total of 11 : Range WITH data 16 to 55: : # Dropped 130 : 66.0%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.954434: Maximum Distance = 133

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  I
S15-7812  I
S18-7912  I
S31-8404  I
S32-8408  I
S33-8412  I
S34-8505  I------I
S35-8508  I      I
S37-8604  I      I
S38-8608  I      I
S39-8612  I      I-I
S40-8705  I      I I
S41-8708  I      I I-I
S42-8712  I      I I I
S10-7705  -------I I I
S30-8312  -------I-I I----I
S36-8512  -------I   I    I
S20-8008  -----------I    II
S29-8309  -----------I    II
S11-7710  -------I--------II--------------I
S21-8012  -------I         I              I-I
S16-7905  -----------------I              I I---I
S22-8105  --------------------------------I I   I
S19-8005  ----------------------------I-----I   I-I
S23-8110  ----------------------------I         I I
S24-8201  --------------------------------I-----I I---------I
S25-8204  -------------------------I------I       I         I
S27-8212  -------------------------I              I         I------------------------------------------------I
S28-8303  ----------------------------------------I         I                                                I------
S13-7805  --------------------------------------------------I                                                I
S26-8209  ---------------------------------------------------------------------------------------------------I
```

Station: LCIX: Bossiella sp. +Calliarthron sp.: TOTAL Quads with Data = 230

Quad Range USED 7 to 19 for Total of 13 : Range WITH data 6 to 24: : # Dropped 66 : 28.7%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.632257: Maximum Distance = 552

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ----------------------------------------------------------------------------I
S10-7705  ------------------------------I----------------I                            I
S16-7905  ------------------------------I                I-----I                      I
S20-8008  --------------------------I---------I          I     I                      I
S27-8212  --------------------------I         I----------I     I                      I-----------------------I
S22-8105  ------------------------------------I                I---------I            I                       I
S11-7710  -------------------------I-------I                   I         I            I                       I
S17-7909  -------------------------I       I----------I        I         I            I                       I
S12-7803  ---------------------------------I          I--------I         I------------I                       I
S15-7812  -----------------------I-------I            I                  I                                    I
S25-8204  -----------------------I       I------------I                  I                                    I------
S24-8201  -------------------------------I                               I                                    I
S13-7805  ---------------------------------------------------------------I                                    I
S23-8110  -------------------------------------------------------------I                                      I
S28-8303  ----------------------------I-------------------------I      I-------------------I                  I
S36-8512  -------------I--------------I                         I      I                   I                  I
S42-8712  -------------I                                        I------I                   I                  I
S30-8312  --------------------------------------I               I                          I------------------I
S35-8508  -----------I---I                      I---------------I                          I
S41-8708  -----------I   I----------------------I                                          I
S39-8612  ---------------I                                                                 I
S33-8412  ---------------------------------------------------------------------------------I
```

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Corallina officinalis var. *chilensis* (Erect Coralline) (Decaisne, 1847). Ref. AH, 1976. p 405.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Turf, whitish, pinkish to purplish, to 15 cm tall.

Distribution: Alaska to Chile. Common on rocks, low intertidal pools, to subtidal. A warm-tolerant species.

Diablo Area Specific Information: Fairly rare, occurring in about 10% of our quadrats in covers up to 40%.

Habitat: On rock mostly in areas that remain damp during low tides, lower-mid to low intertidal. Often in small tide pools, although clumps occur in algal mats.

Observational Errors: Probably about 5% mis-identification with the very similar *C. vancouveriensis* and some confusion with *Bossiella/Calliarthron spp.* and with any crustose coralline when eroded to basal crust. Missed observations occur from overlooking small clumps in areas with dense algal mats.

Field Identification Problems:

General: When short or severely eroded can be confused with similar *Bossiella/Calliarthron spp.* or with *C. vancouveriensis*. When only basal crust (possibly with minor excrescences) is present, this group could be identified as almost any of the coralline crusts, and in later surveys we have classified such material as "unid. coralline, stubs".

Station Specific: Quadrats 7 and 8 at LCIX (in the upper intertidal) contained clumps of erect corallines that were classified as this taxon or as *Bossiella/Calliarthron* spp. or as *C. vancouveriensis* depending on their general appearance at the time.

General Comments: More common and abundant at our Cove stations prior to El Niño. Changes between surveys probably arose from moderately high confusion with *C. vancouveriensis*. Assessment was considered adequate over long intervals.

Impacts to Taxon:

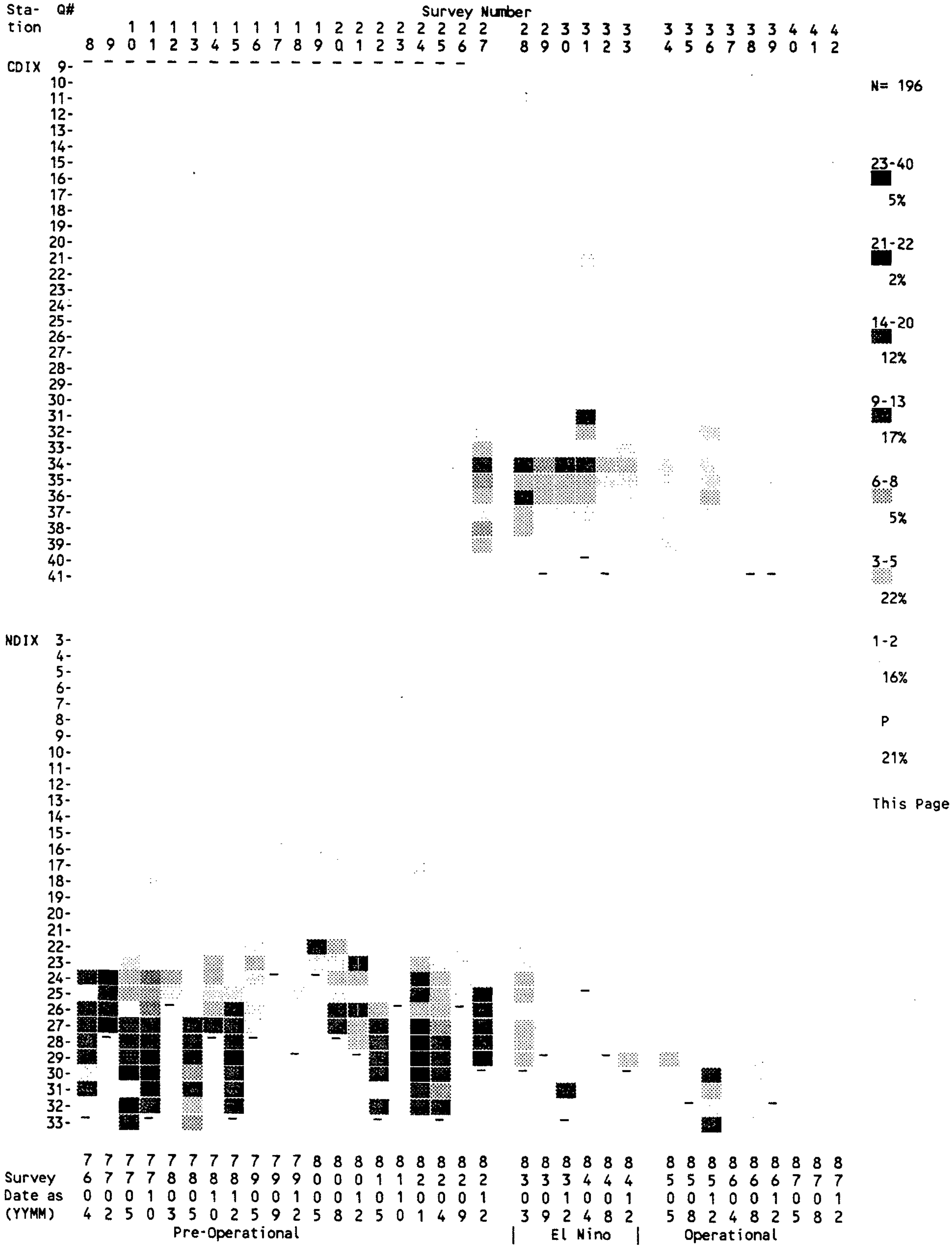
El Niño: 1982-83 winter storm: Reduced in occurrence at SDIX (cobble overlay, and possibly removal), with slight reduction to moderate reduction at other stations.

El Niño: 1983-1984: At SDIX all but disappeared by end of 1984, even at lowest tide levels which had little cobble overlay. NDIX with a general decline in occurrences and covers, but with moderate recovery towards end of 1984. CDIX declining in occurrences and cover compared to the one survey just prior to El Niño, and at end of 1984 at about 1/2 of prior occurrences. LCIX about normal.

Diablo DCPP Operation: Sporadically disappearing at all Cove stations beginning in the upper parts of the distribution, proceeding downward so that only zero to 1 occurrences here by end of 1987. At LCIX with scattered occurrences, possibly somewhat below normal.

Taxon or Category: Corallina officinalis

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

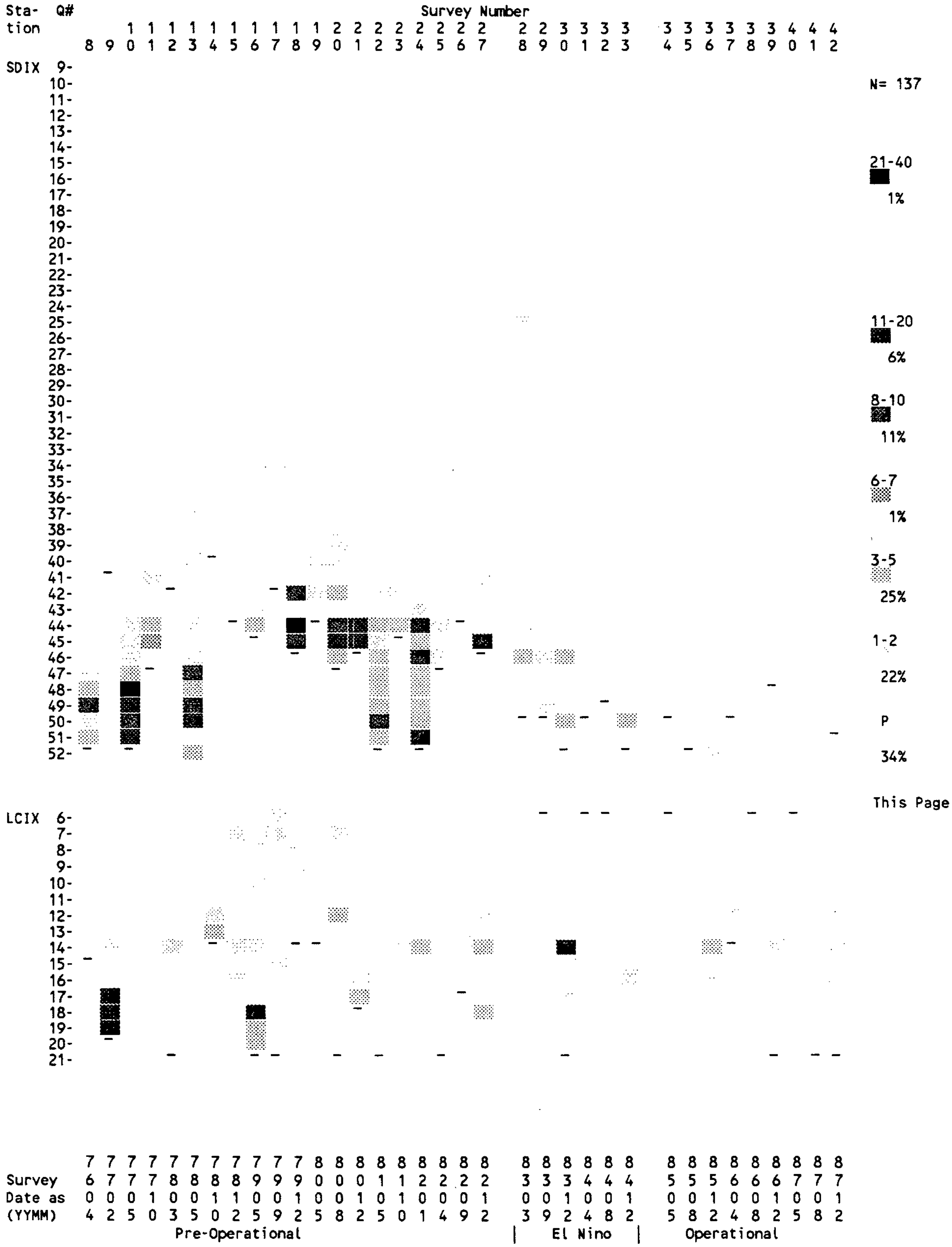


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COROFF CSV 5324 8-08-88 9:28a 04-14-1989 09:08

Taxon or Category: Corallina officinalis

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COROFF CSV 5324 8-08-88 9:28a 04-14-1989 09:08

Audit: CLUMRG2P: V.1.2: for SCOROFF CLU 6163 4-22-89 7:16a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:12:24 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Corallina officinalis: TOTAL Quads with Data = 44

Quad Range USED 28 to 39 for Total of 12 : Range WITH data 21 to 39: : # Dropped 1 : 2.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.872502: Maximum Distance = 258

```
S27-8212 ----------------------------------------------------------------------------------------------I--I
S28-8303 ----------------------------------------------------------------------------------------------I  I
S29-8309 ------------------I---------------------------I                                                  I
S30-8312 ------------------I                           I                                                  I
S32-8408 ------I--------------------I                  I                                                  I
S33-8412 ------I                    I                  I                                                  I------
S34-8505 ----------I                I---I              I---------------------I                            I
S35-8508 I         I                I   I              I                     I                            I
S37-8604 I         I----------------I   I              I                     I                            I
S38-8608 I---I     I                    I              I                     I                            I
S40-8705 I   I     I                    I--------------I                     I----------------------------I
S42-8712 I   I-----I                    I                                    I
S39-8612 ----I                          I                                    I
S41-8708 ----I                          I                                    I
S36-8512 -------------------------------I                                    I
S31-8404 --------------------------------------------------------------------I
```

Station: NDIX: Corallina officinalis: TOTAL Quads with Data = 152

Quad Range USED 20 to 27 for Total of 8 : Range WITH data 11 to 33: : # Dropped 84 : 55.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.887007: Maximum Distance = 310

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End  Dropped Surveys
S 8-7604 ----------------------------------------------I------------------I
S20-8008 ----------------------------------------------I                  I
S10-7705 ----------------------I---I                                      I
S11-7710 -------------------I--I   I-----I                                I
S14-7810 -------------------I      I     I----------I                     I
S22-8105 --------------------------I     I          I                     I--------------------------------I
S15-7812 --------------------I-----------I          I                     I                                I
S27-8212 --------------------I                      I                     I                                I
S13-7805 ----------------------I--I                 I                     I                                I
S25-8204 ----------------I-----I  I                 I                     I                                I
S28-8303 ----------------I        I                 I                     I                                I
S16-7905 ----------------I        I-----------I     I---------------------I                                I
S18-7912 --I             I        I           I     I                                                      I
S32-8408 I I             I        I           I     I                                                      I
S35-8508 I I             I        I           I     I                                                      I
S36-8512 I I             I--------I           I     I                                                      I
S37-8604 I-I-I           I                    I     I                                                      I------
S39-8612 I I I           I                    I     I                                                      I
S40-8705 I I I           I                    I-----I                                                      I
S41-8708 I I I-----------I                    I                                                            I
S42-8712 I I I                                I                                                            I
S38-8608 --I I                                I                                                            I
S29-8309 --I I                                I                                                            I
S30-8312 I-I-I                                I                                                            I
S34-8505 I I                                  I                                                            I
S33-8412 --I                                  I                                                            I
S21-8012 -------------------------------------I                                                            I
S 9-7702 -----------------------------------------------------I--------------------------------------------I
S24-8201 -----------------------------------------------------I
```

Station: SDIX: Corallina officinalis: TOTAL Quads with Data = 80

Quad Range USED 38 to 44 for Total of 7 : Range WITH data 25 to 55: : # Dropped 55 : 68.8%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.948004: Maximum Distance = 203

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  I
S29-8309  I
S30-8312  I
S31-8404  I
S32-8408  I
S33-8412  I
S34-8505  I
S35-8508  I-I
S36-8512  I I
S37-8604  I I
S38-8608  I I
S39-8612  I II
S40-8705  I II
S41-8708  I II--I
S42-8712  I II  I
S27-8212  --II  I-----------I
S28-8303  ---I  I           I
S10-7705  I-I   I           I-------------------------------I
S25-8204  I I---I           I                               I
S13-7805  --I               I                               I
S11-7710  ---------I--------I                               I-------------------------------------------------I
S16-7905  ----I----I                                        I                                                 I
S22-8105  --I-I                                             I                                                 I
S23-8110  --I                                               I                                                 I------
S20-8008  -----------------------------------I--------------I                                                 I
S21-8012  --------------I--------------------I                                                                I
S24-8201  --------------I                                                                                     I
S18-7912  ----------------------------------------------------------------------------------------------------I
```

Station: LCIX: Corallina officinalis: TOTAL Quads with Data = 59

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 6 to 20: : # Dropped 13 : 22.0%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.945181: Maximum Distance = 378

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ----------------------------------------------------------------------------------------------------I
S10-7705  I                                                                                                   I
S11-7710  I                                                                                                   I
S13-7805  I--I                                                                                                I
S22-8105  I  I---I                                                                                            I
S35-8508  I  I   II                                                                                           I
S28-8303  ---I   II                                                                                           I
S33-8412  ----I--III                                                                                          I
S41-8708  ----I   II                                                                                          I
S25-8204  --------II                                                                                          I------
S17-7909  ---------I------I                                                                                   I
S12-7803  ---I     I      I                                                                                   I
S23-8110  ---I---I I      I                                                                                   I
S39-8612  ---I   I-I      I----------I                                                                        I
S15-7812  -------I        I          I                                                                        I
S42-8712  -------I        I          I                                                                        I
S20-8008  ----------------I          I---------------I                                                        I
S24-8201  -----------I----I          I               I                                                        I
S36-8512  -----------I    I------I   I               I--------------------------------------------------------I
S30-8312  ----------------I      I---I               I
S27-8212  -----------------------I                   I
S16-7905  -------------------------------------------I
```

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Corallina vancouveriensis (Erect Coralline) Yendo, 1902. Ref. AH, 1976. p 405.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Turf, rose-pink to dark violet to purplish, to 15 cm tall.

Distribution: Aleutian Islands to Galapagos Islands. Extremely common on rocks, intertidal, to subtidal. A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 35% of our quadrats in cover up to 60%.

Habitat: On rock (often in areas that remain damp during low tides), upper-mid to low intertidal. Sometimes in small tide pools, but mostly intermingled with other species that form algal mats.

Observational Errors: Probably about 5% mis-identification with the very similar *C. officinalis* and some confusion with *Bossiella/Calliarthron spp.* and with any coral crust when eroded to basal crust. Missed observations occur from overlooking small clumps in areas with dense algal mats.

Field Identification Problems:

General: When short or severely eroded can be confused with similar *Bossiella/Calliarthron spp.* or with *C. officinalis*. When only basal crust (possibly with minor excrescences) is present, this group could be identified as nearly any of the coralline crusts. In later surveys we have classified such material as "unid. coralline, stubs".

Station Specific: Quadrats 7 and 8 at LCIX (in the upper intertidal) contained clumps of erect corallines that were classified as this taxon or as *Bossiella/Calliarthron* spp. *or as C. officinalis* depending on their general appearance at the time.

General Comments: The most common and abundant erect coralline at our stations. Changes between surveys, difficult to assess because of confusion with *C. officinalis*. Assessment was considered adequate over longer intervals.

Impacts to Taxon:

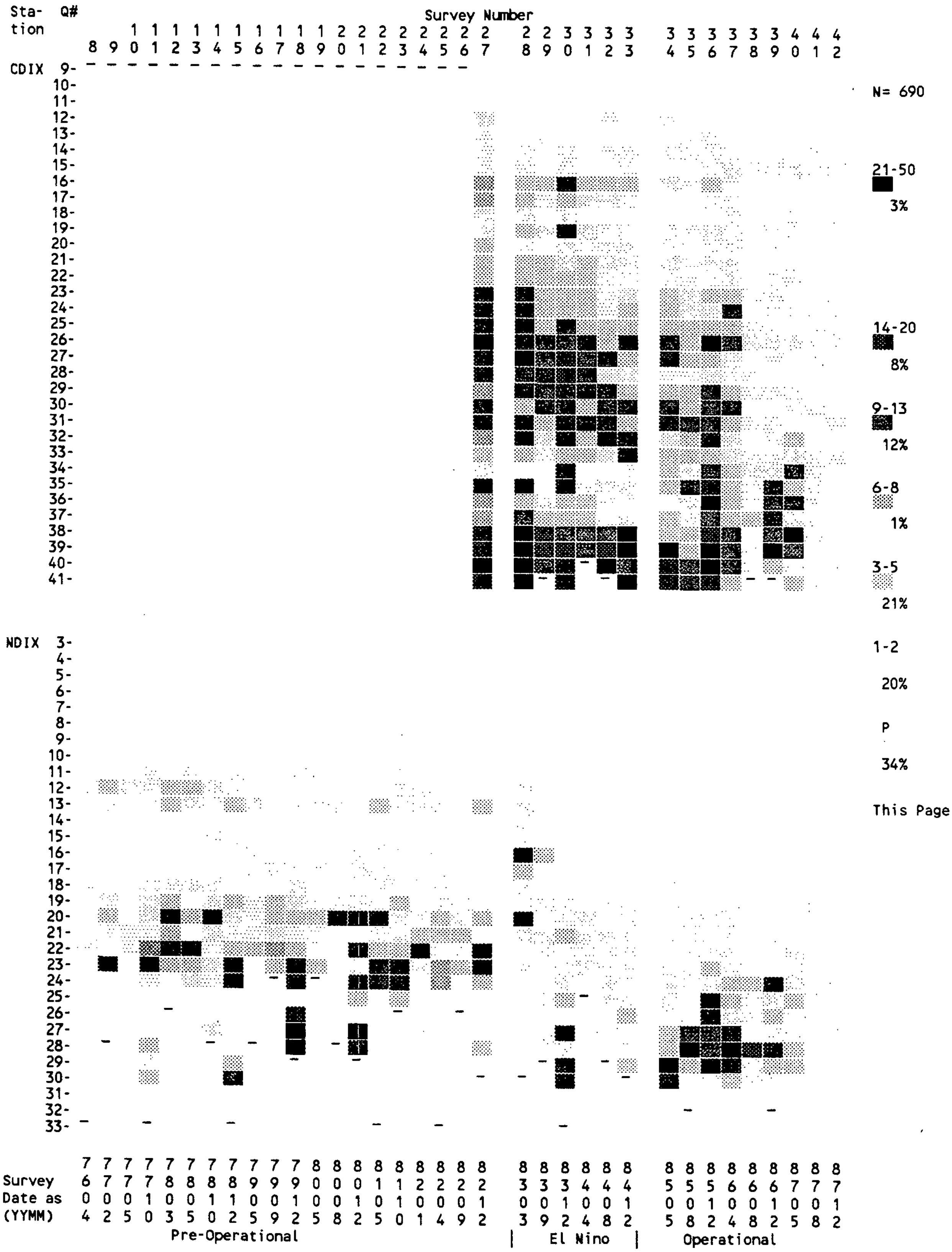
El Niño: 1982-83 winter storm: Somewhat reduced in occurrence at SDIX (cobble overlay, and possibly removal), NDIX with slight reduction at lower tidal levels, but introduced on new boulders in the mid-tidal areas so no overall decline. CDIX and LCIX with no apparent effect.

El Niño: 1983-1984: SDIX with decline in occurrences and covers, (zero occurrences in Autumn 1983, probably due to shifting of cobble), possibly shifting downward into the lower intertidal (at least when compared to surveys just prior to El Niño). NDIX moderately rapid loss of occurrences at the mid-intertidal, with extension into the lower intertidal (compared to surveys just prior to El Niño), with a decline in area cover. CDIX with occurrences about the same as one survey prior to El Niño, but with some decline in area cover. LCIX about normal for occurrences, but possibly with declining area cover in the upper-mid and mid-intertidal.

Diablo DCPP Operation: Occurrences at SDIX increased sporadically through 1986 (except for Autumn 1986, almost zero); cover increased in lower intertidal to about normal until end of 1986. Both cover and occurrence then declined sporadically to below normal, and with the population center much lower in the intertidal. NDIX unchanged from later part of El Niño but with sporadic increases in covers and some increase in occurrences until Winter of 1986. Occurrences and covers then declined far below normal, and the population shifted lower in the intertidal. CDIX moderately stable for occurrences and covers until Spring 1986, followed by an irregular trend of declining cover and occurrences ending in complete disappearance in the upper-mid intertidal. At LCIX retreated from the upper-mid intertidal in 1985, then slowly re-colonized to normal occurrences and covers by end of 1987.

Taxon or Category: Corallina vancouveriensis

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

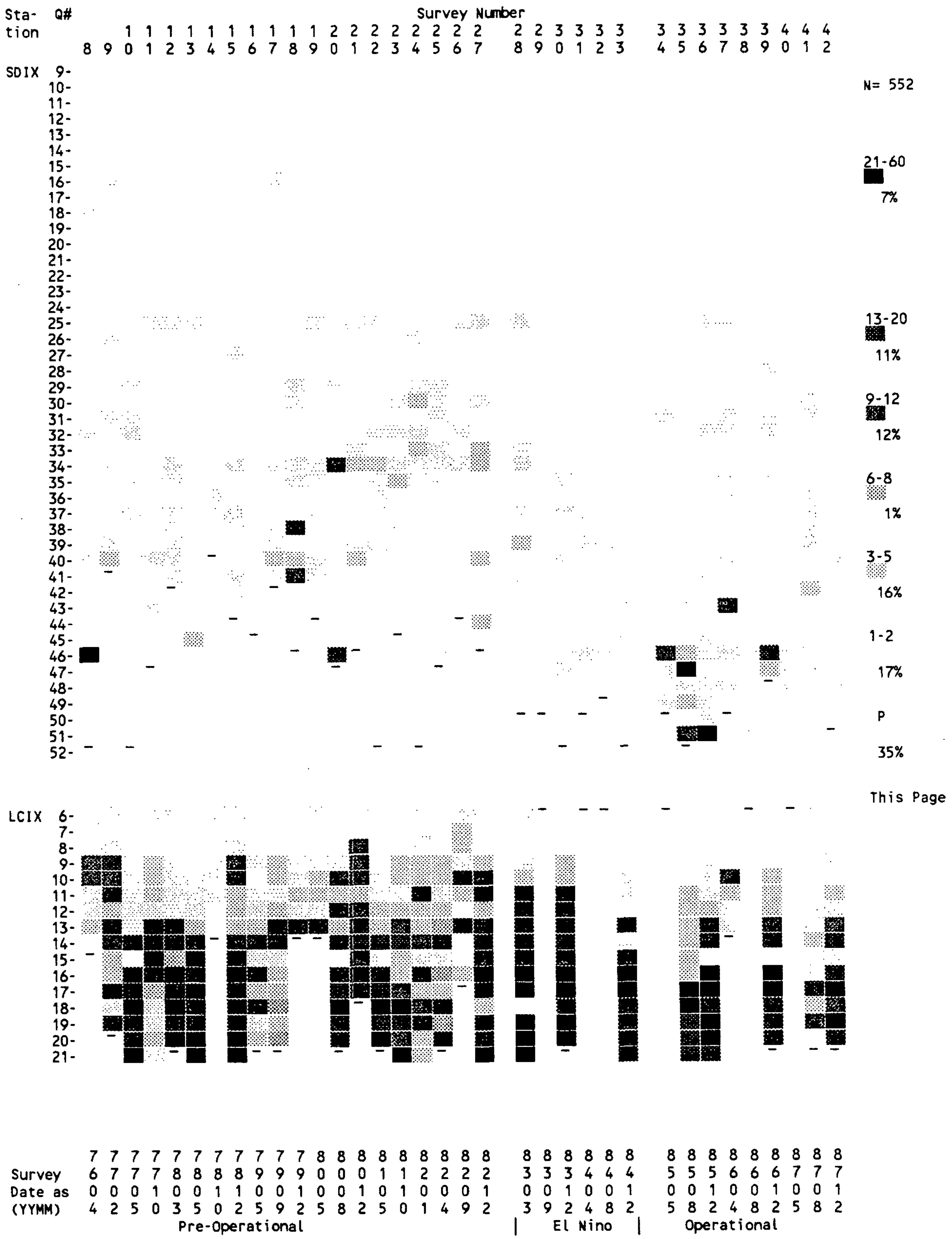


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CORVAN CSV 5588 3-29-88 7:27a 04-14-1989 09:08

Taxon or Category: Corallina vancouveriensis

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CORVAN CSV 5588 3-29-88 7:27a 04-14-1989 09:09

Audit: CLUMRG2P: V.1.2: for SCORVAN CLU   6581   4-22-89   7:23a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:19:43 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Corallina vancouveriensis: TOTAL Quads with Data = 375

Quad Range USED 12 to 39 for Total of 28 : Range WITH data 4 to 41: : # Dropped 26 :   6.9%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.635581:   Maximum Distance = 1743

```
S27-8212 -----------------------------------------------------I------------------I
S30-8312 -----------------------------------------------------I                  I
S29-8309 -----------------------------I-------I                                  I
S31-8404 -----------------------------I       I-----I                            I
S32-8408 --------------------------------I----I     I                            I
S35-8508 --------------------------I-----I          I--I                         I----------------------I
S37-8604 --------------------------I                I  I------I                  I                      I
S34-8505 -------------------------------------------I  I      I                  I                      I
S33-8412 ----------------------------------------------I      I-I                I                      I
S38-8608 ---------I--------------------------------------I    I I                I                      I------
S41-8708 -----I---I                                      I----I I----------------I                      I
S42-8712 -----I                                          I      I                                       I
S40-8705 ------------------------------------------------I      I                                       I
S39-8612 -------------------------------------------------------I                                       I
S28-8303 -------------------------------------------------------------------------------------I---------I
S36-8512 -------------------------------------------------------------------------------------I
```

Station: NDIX: Corallina vancouveriensis: TOTAL Quads with Data = 319

Quad Range USED 11 to 27 for Total of 17 : Range WITH data 2 to 33: : # Dropped 97 :   30.4%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.847573:   Maximum Distance = 683

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 ---I--I
S10-7705 ---I  I--I
S41-8708 -----II  I--I
S42-8712 -----I   I  I-I
S32-8408 ---------I  I II
S33-8412 ------------I II-I
S38-8608 --------------II I
S40-8705 ---------------I I------I
S16-7905 -----------------I      I---I
S29-8309 -----------------I      I   I
S30-8312 -------------------I----I   I---------I
S34-8505 ------------I------I        I         I
S35-8508 ------------I               I         I
S39-8612 ----------------------------I         I---I
S13-7805 ---------------------I------I         I   I
S27-8212 ---------------------I      I------I  I   I
S24-8201 ----------------------------I      I--I   I----I
S15-7812 --------------------------------I--I      I    I
S25-8204 --------------------------------I         I    I--I
S28-8303 ------------------------------------------I    I  I
S36-8512 ------------------------------------I----------I  I----I
S37-8604 ------------------------------------I             I    I
S 9-7702 ------------------------I-------------------------I    I------------------------------------------I
S11-7710 ------------------------I                              I                                          I
S14-7810 -----------I-------------------------I                 I                                          I------
S20-8008 -----------I                         I-----------------I                                          I
S22-8105 -------------------------------------I                                                            I
S18-7912 ------------------------------------------------------------------------I-------------------------I
S21-8012 ------------------------------------------------------------------------I
```

Station: SDIX: Corallina vancouveriensis: TOTAL Quads with Data = 225

Quad Range USED 28 to 43 for Total of 16 : Range WITH data 16 to 52: : # Dropped 90 : 40.0%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.900880: Maximum Distance = 245

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  ----------I
S13-7805  I         I
S29-8309  I-----I   II
S38-8608  I     I-I II
S42-8712  ------I I-II
S16-7905  --------I  I
S34-8505  --------I  I--I
S33-8412  --------I--I  I
S35-8508  --------I  I  I
S31-8404  I-------I  I  I--I
S32-8408  I       I--I  I  I
S36-8512  --------I     I  II
S40-8705  --------------I  II
S11-7710  ---------------I-III
S30-8312  ---------------I  II-I
S39-8612  ------------------II I-----I
S10-7705  -------------------I I     I
S15-7812  ------------------I--I     I-------------I
S19-8005  ----------------I-I        I             I
S26-8209  ----------------I          I             I--I
S25-8204  ---------------------------I             I  I--I
S28-8303  -----------------------------------------I  I  I-------I
S23-8110  --------------------------------------------I  I       I
S41-8708  -----------------------------------------------I       I
S20-8008  ------------------------------------I------------------I--------------I
S22-8105  ------------------------------------I                  I              I
S21-8012  ----------------------------------------I-----------I  I              I---------------------------I
S27-8212  ----------------------------------------I           I--I              I                           I
S24-8201  ----------------------------------------------------I                 I                           I------
S37-8604  ----------------------------------------------------------------------I                           I
S18-7912  --------------------------------------------------------------------------------------------------I
```

Station: LCIX: Corallina vancouveriensis: TOTAL Quads with Data = 334

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 4 to 23: : # Dropped 85 : 25.4%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.563158: Maximum Distance = 727

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ----------------------------------------------------------I
S11-7710  ----------------------------------I                       I
S16-7905  ------------------I----I          I-I                     I---------------I
S17-7909  ------------------I    I----------I I------I              I               I
S25-8204  -----------------------I            I      I--------------I               I
S24-8201  ------------------------------------I      I                              I
S13-7805  --------------------------------------I----I                              I
S41-8708  --------------------------------------I                                   I
S10-7705  ---------------------I---------------------------I                        I------------------------I
S22-8105  ---------------------I                           I-------I                I                        I
S20-8008  --------------------------------I----------I     I       I                I                        I
S35-8508  --------------------------------I          I-----I       I--------------I I                        I
S23-8110  -------------------------------------------I             I              I I                        I
S12-7803  ---------------------------------------------------------I              I I                        I
S15-7812  ----------------------------I-----------------------I                   I-I                        I------
S27-8212  ----------------------------I                       I----I              I                          I
S36-8512  -----------------------------I---------I            I    I              I                          I
S39-8612  -----------------------------I         I------------I    I--------------I                          I
S42-8712  ---------------------------------------I                 I                                         I
S28-8303  ---------------------------------------------------------I                                         I
S30-8312  --------------------------------------------------------I------------------------------------------I
S33-8412  --------------------------------------------------------I
```

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Coralline crust (see below for included taxa) Ref. AH, 1976. p 381ff.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Crusts to 0.3 cm thick (sometimes with excrescences), deep rose-red, violet to purplish, to whitish, to 5+ cm diameter.

Distribution: see below. A mixed warm-tolerant/intolerant group.

Diablo Area Specific Information: Common, occurring in about 25% of our quadrats with covers up to 80%.

Habitat: On rock (bedrock to cobble), tops, sides, and underneath, mostly in areas that remain damp during low tides, mid to low intertidal. Often in small tide pools, and under algal mats.

Observational Errors: Probably about <5% mis-identification with the very similar *Pseudolithophyllum* and some confusion with eroded basal crusts of erect corallines. Missed observations occur about 5% of the time when occurrences of small clumps in areas with dense algal mats.

Identified in the field as *Mesophyllum lamellulatum, Lithophyllum* spp., and *Lithothamnium* spp., based on color, location in the intertidal, and morphology, but confusion among members of the group as high as 10-20%, so we have combined them. Correct identification requires microscopic study.

Field Identification Problems:

General: Confused with similar *Pseudolithophyllum*, and as noted above, with eroded basal portions of erect corallines.

Station Specific: n.a.

General Comments: Changes between surveys, sometimes difficult to assess because of moderate number of confusions with *Pseudolithophyllum*. Assessment was adequate over long intervals.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Somewhat reduced in occurrence at SDIX (cobble overlay, and possibly removal), NDIX with reduction at mid and upper tidal levels. CDIX and LCIX with no apparent changes.

El Niño: 1983-1984: At SDIX with sporadic increase in occurrences and covers at upper part of range, but both apparently declining in late 1984 (possibly somewhat confused by mis-identifications). NDIX as for SDIX, but possible decline in late 1984 less well defined. Any change at CDIX and LCIX probably masked by mis-identifications with *Pseudolithophyllum*.

Diablo DCPP Operation: SDIX and NDIX, about normal but perhaps with reduced occurrences in mid-intertidal (i.e., may have lost about 3 quadrats at upper edge of its range). CDIX with trend towards reduced covers and occurrences in upper parts of range, but somewhat irregular. At LCIX about normal, with possible trend towards reduction in cover at upper parts of range. All conclusions somewhat masked by mis-identifications and possibly missed observations (obscured by algal mats).

Laboratory identifications from intertidal transects include:

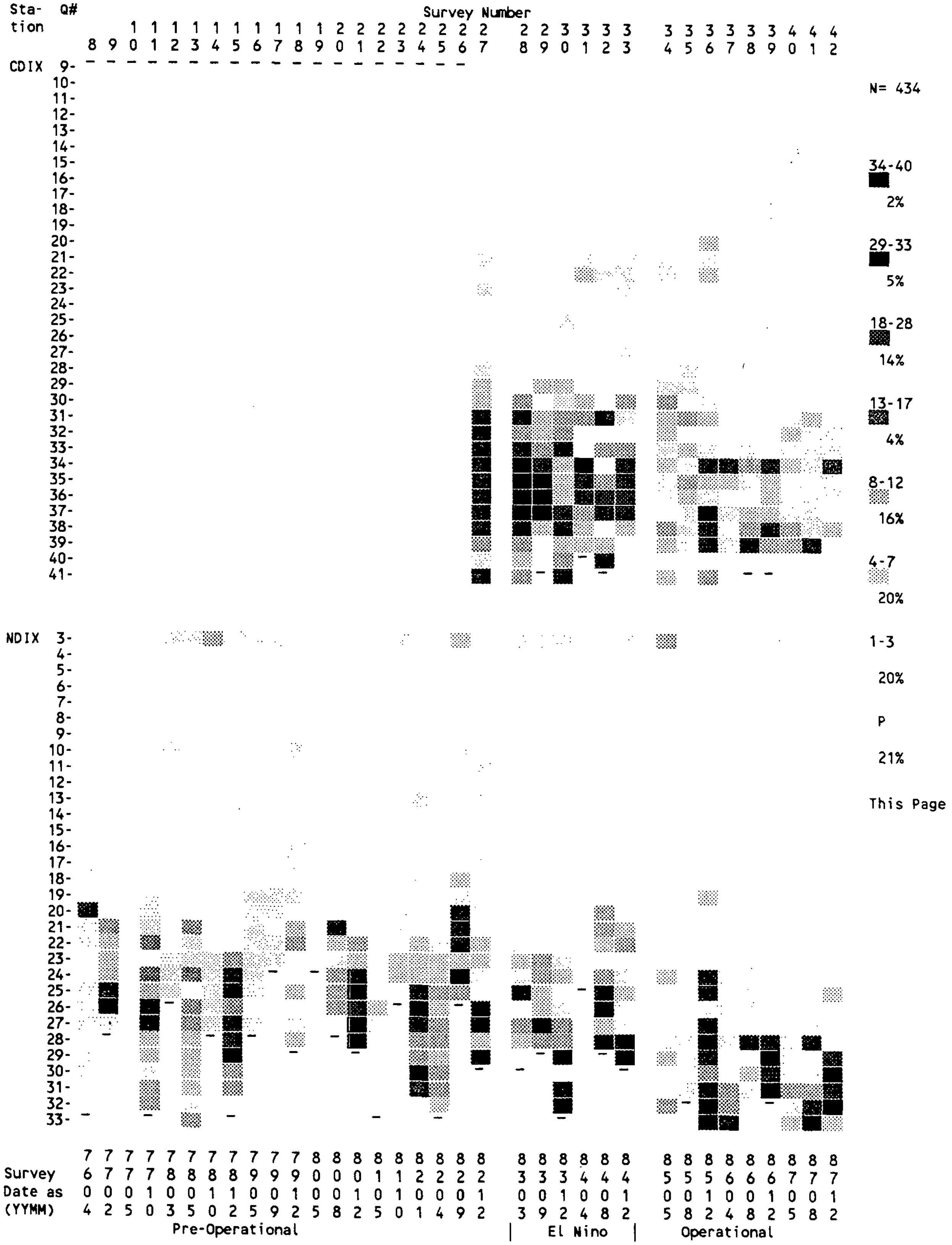
Lithothamnium pacificum: British Columbia to southern California.

Lithophyllum grumosum: Oregon to Baja California (mainly subtidal).

Mesophyllum lamellatum: Oregon to Baja California (subtidal from southern Calif. southward).

Taxa or Category: Mesophyllum +Lithothamnium +Lithophyllum

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

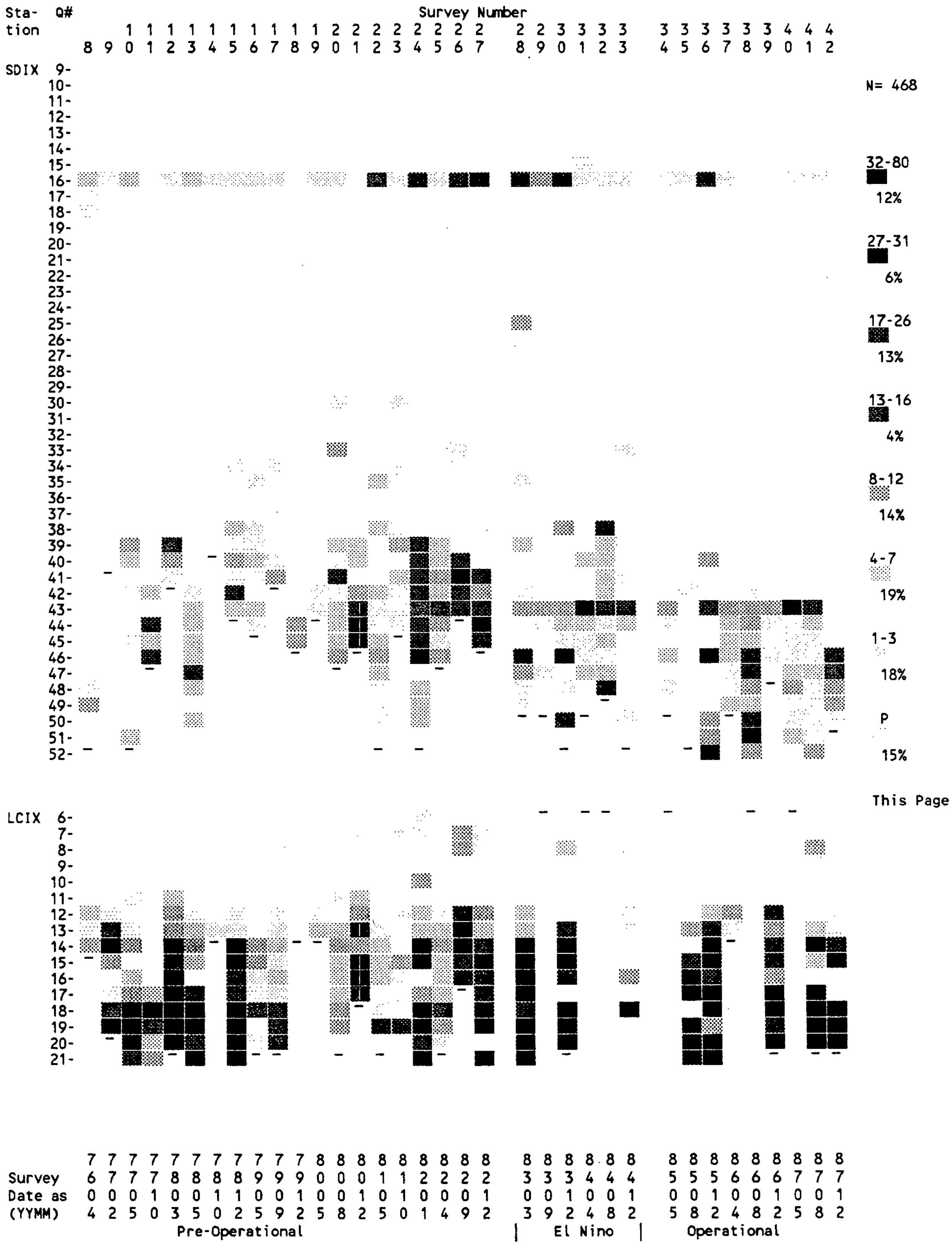


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CORCRX CSV 5638 9-30-88 7:35a 04-14-1989 09:07

Taxa or Category: Mesophyllum +Lithothamnium +Lithophyllum

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CORCRX CSV 5638 9-30-88 7:35a 04-14-1989 09:07

Audit: CLUMRG2P: V.1.2: for SCORCRX CLU 6163 4-22-89 7:31a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:26:45 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Mesophyllum +Lithothamnium +Lithophyllum: TOTAL Quads with Data = 168

Quad Range USED 21 to 39 for Total of 19 : Range WITH data 17 to 41: : # Dropped 13 : 7.7%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.622266: Maximum Distance = 1077

```
S27-8212  ------------------------------------------------I--------------I
S30-8312  ------------------------------------------------I              I---I
S36-8512  ---------------------------------------------------------------I   I
S31-8404  ---------------------------------------I------------------I        I
S33-8412  ---------------------------------------I                  I-----I  I--------------------------------I
S32-8408  ----------------------------------------------------------I     I  I                                I
S34-8505  ---------------------I--------I                                 I  I                                I
S40-8705  ---------------------I        I--------I                        I--I                                I
S38-8608  -----------------------I------I        I--I                     I                                   I
S41-8708  -----------------------I               I  I                     I                                   I------
S35-8508  ---------------------------------------I  I---------------------I                                   I
S37-8604  ----------------------I--------------I    I                                                         I
S42-8712  ----------------------I              I----I                                                         I
S39-8612  -------------------------------------I                                                              I
S28-8303  ----------------------------------------------------------I-----------------------------------------I
S29-8309  ----------------------------------------------------------I
```

Station: NDIX: Mesophyllum +Lithothamnium +Lithophyllum: TOTAL Quads with Data = 267

Quad Range USED 16 to 27 for Total of 12 : Range WITH data 2 to 33: : # Dropped 141 : 52.8%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.825022: Maximum Distance = 482

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------------I
S10-7705  II                                                 I
S35-8508  III                                                I
S39-8612  -II                                                I
S37-8604  -II--I                                             I
S40-8705  -II  I---I                                         I
S41-8708  --I  I   I                                         I---I
S38-8608  -----I   I----I                                    I   I
S14-7810  ---------I    I                                    I   I
S34-8505  ---------I    II                                   I   I
S16-7905  --------------II------------I                      I   I
S42-8712  --------------II            I---I                  I   I
S22-8105  ---------------I            I   I------------------I   I
S30-8312  ----------------------------I   I                      I-------I
S18-7912  ------------I-------------------I                      I       I
S33-8412  ------------I                                          I       I
S11-7710  ----------------------------------I--I                 I       I
S13-7805  ----------------------------------I  I--------I        I       I-------------------------I
S25-8204  --------------------I----------------I        I--------I       I                         I
S29-8309  --------------------I                         I        I       I                         I
S27-8212  ----------------------------------------------I        I       I                         I----------I
S28-8303  -------------------------------------------------------I       I                         I          I
S20-8008  ---------------------------------------------------------------I                         I          I
S 9-7702  ----------------------------------I------------------I                                   I          I------
S32-8408  ----------------------------------I                  I-----------------------------------I          I
S24-8201  -----------------------------------------------------I                                              I
S15-7812  -----------------------------------------I--------------------------I                               I
S36-8512  -----------------------------------------I                          I-------------------------------I
S21-8012  --------------------------------------------------------------------I
```

Station: SDIX: Mesophyllum +Lithothamnium +Lithophyllum: TOTAL Quads with Data = 250

Quad Range USED 34 to 44 for Total of 11 : Range WITH data 15 to 55: : # Dropped 159 : 63.6%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.803268: Maximum Distance = 424

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  I---I
S42-8712  I   I--------------------I
S35-8508  ----I                    I--I
S18-7912  -------------------------I  I
S13-7805  ------------I--I            I
S37-8604  ----------I-I  I            I-I
S38-8608  ----------I    I------I     I I
S29-8309  --I            I      I     I I
S34-8505  --I------------I      II    I I-I
S39-8612  --I                   II----I I I
S16-7905  ----------------------II      I I---I
S28-8303  -----------------------I      I I   I
S22-8105  ------------------------------I I   I---------------I
S30-8312  --------------------------------I   I               I
S10-7705  ------------------------I-----------I               II
S23-8110  ------------------------I                           II
S20-8008  ---------------------------------------I------------II--------I
S25-8204  ---------------------------------------I             I        I
S31-8404  ----------------------I--------I                     I        I
S40-8705  ----------------------I        I---------------------I        I----I
S33-8412  -----I----------------------I  I                              I    I
S41-8708  -----I                      I--I                              I    I-------------------------------I
S36-8512  ----------------------------I                                 I    I                               I
S11-7710  --------------------------------------------------------------I    I                               I------
S32-8408  -------------------------------------------------------------------I                               I
S21-8012  ----------------------------------------------------------I-----------------------------I          I
S27-8212  ----------------------------------------------------------I                             I----------I
S24-8201  ----------------------------------------------------------------------------------------I
```

Station: LCIX: Mesophyllum +Lithothamnium +Lithophyllum: TOTAL Quads with Data = 238

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 3 to 22: : # Dropped 74 : 31.1%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.601042: Maximum Distance = 1297

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  -------------------------------------------I---------------I
S27-8212  -------------------------------------------I               I
S10-7705  -------------------I------------I                          I-I
S13-7805  -------------------I            I------------I             I I
S11-7710  --------------------------------I            I             I I
S16-7905  -----------------I-----I                     I-------------I I
S17-7909  -------------I---I     I                     I               I-------------I
S20-8008  -------I-----I         I---------------------I               I             I
S25-8204  -------I               I                                     I             I
S22-8105  --------I--------------I                                     I             I
S23-8110  --------I                                                    I             I---I
S35-8508  -------------------------------------------------------------I             I   I
S15-7812  -------------------------------------------------I----------I              I   I
S24-8201  -----------------------------------I-------------I          I              I   I
S30-8312  ----------------------------I------I                        I--------I     I   I
S42-8712  ----------------------------I                               I        I-----I   I-------------------I
S41-8708  ------------------------------------------------------------I        I         I                   I
S28-8303  --------------------------------------------------------------I------I         I                   I
S36-8512  -----------------------------I--------------------------------I                I                   I------
S39-8612  -----------------------------I                                                 I                   I
S33-8412  -------------------------------------------------------------------------------I                   I
S12-7803  ---------------------------------------------------------------------------------------------------I
```

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Hymenena/Cryptopleura complex Ref. AH, 1976. p 660ff.
Phylum Rhodophyta: **Class** Ceramiales:

Description: Usually as ruffly dense blades, rose-red, to olive-brown, to 20+ cm tall.

Distribution: see below. A mixed warm-tolerant/intolerant group.

Diablo Area Specific Information: Common, occurring in about 20% of our quadrats in cover up to 90%.

Habitat: On rock (bedrock to cobble), tops, and sides, or on other algae (mainly erect corallines), mid to low intertidal. Often as part of the algal mat.

Observational Errors: Probably <1% mis-identification with taxa noted below. Missed observations occur infrequently when small tufts intermingled with dense algal mats.

Mostly identified in the field as to genus and species but at one point, we found that within quadrats at LCIX there was a mix of all members of this group that was not possible to separate (very similar in morphology and coloration), so we have combined them. Correct identification requires microscopic study and concurrence among algal taxonomists.

Field Identification Problems:

General: Can be confused with similar appearing small/young *Rhodoglossum affine*, *Gigartina papillata*, and *Botryglossum*.

Station Specific: *Hymenena* spp. was extremely rare except at LCIX (our outer coastal station), so for all Cove stations this group should be considered as predominantly *Cryptopleura violacea*, along with rarely occurring *C. corallinara*, and *C. lobulifera* and be classed as warm-tolerant.

General Comments: none.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Removed at SDIX (cobble overlay, and possibly removal). NDIX with 1/2 the occurrences of survey just prior to storms (boulders were removed, with possible plant removal also). CDIX with a reduction in covers. LCIX with loss of occurrences at the upper part of range.

El Niño: 1983-1984: At SDIX with occasional single occurrences (possibly affected by cobble movement). NDIX sporadic, about normal in covers but upper part of range lost, possibly due to substrate changes there. CDIX with possible irregular trend towards loss of occurrences and covers at upper parts of range. LCIX rapidly returned to normal from storm damage.

Diablo DCPP Operation: SDIX slowly increased in cover and occurrences until mid 1986 then sporadic extension into upper parts of its range, possibly with more occurrences than normal, but center of distribution may be lower in the intertidal than pre-El Niño. NDIX about normal in cover but with reduced occurrences in mid-intertidal(i.e., may have lost about 4 quadrats of upper edge of its range). CDIX with decreasing occurrences in upper parts of range, (Spring and Autumn of 1986 almost disappeared at the transect) and by end of 1987 was maintaining itself at lower tidal levels. LCIX normal, with possible trend towards increasing cover at upper parts of range.

Laboratory identifications from intertidal transects include:

Cryptopleura corallinara: Monterey (Calif.) to Isla Magdalena (Baja California).

Cryptopleura lobulifera: Washington to Baja California.

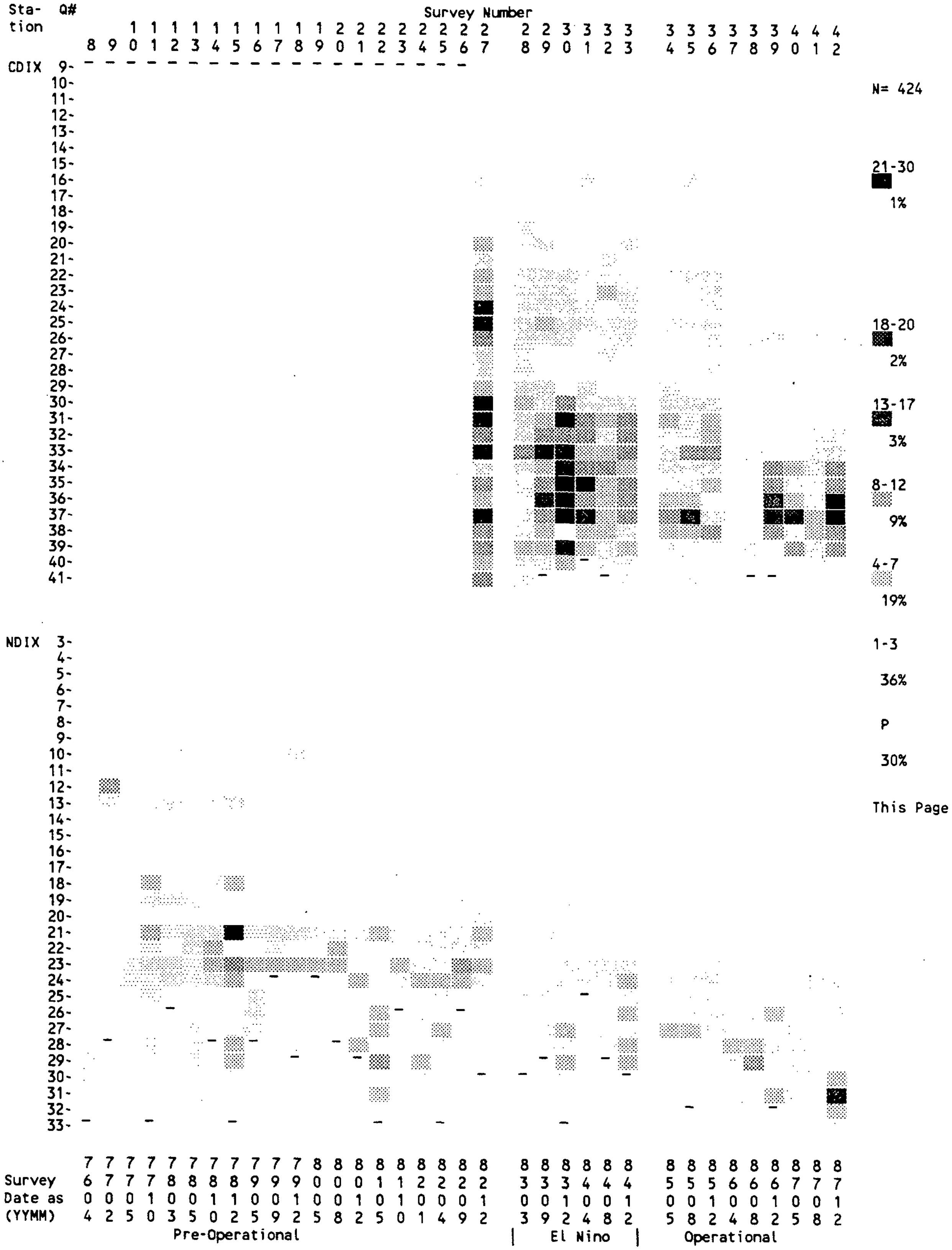
Cryptopleura violacea: Vancouver Island (British Columbia) to Isla Magdalena (Baja California).

Hymenena flabelligera: Vancouver Island (British Columbia) to San Luis Obispo Co. (California).

Hymenena multiloba: Northern British Columbia to San Luis Obispo Co. (California).

Taxa or Category: Hymenena spp. +Cryptopleura spp. (Mostly LCIX)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

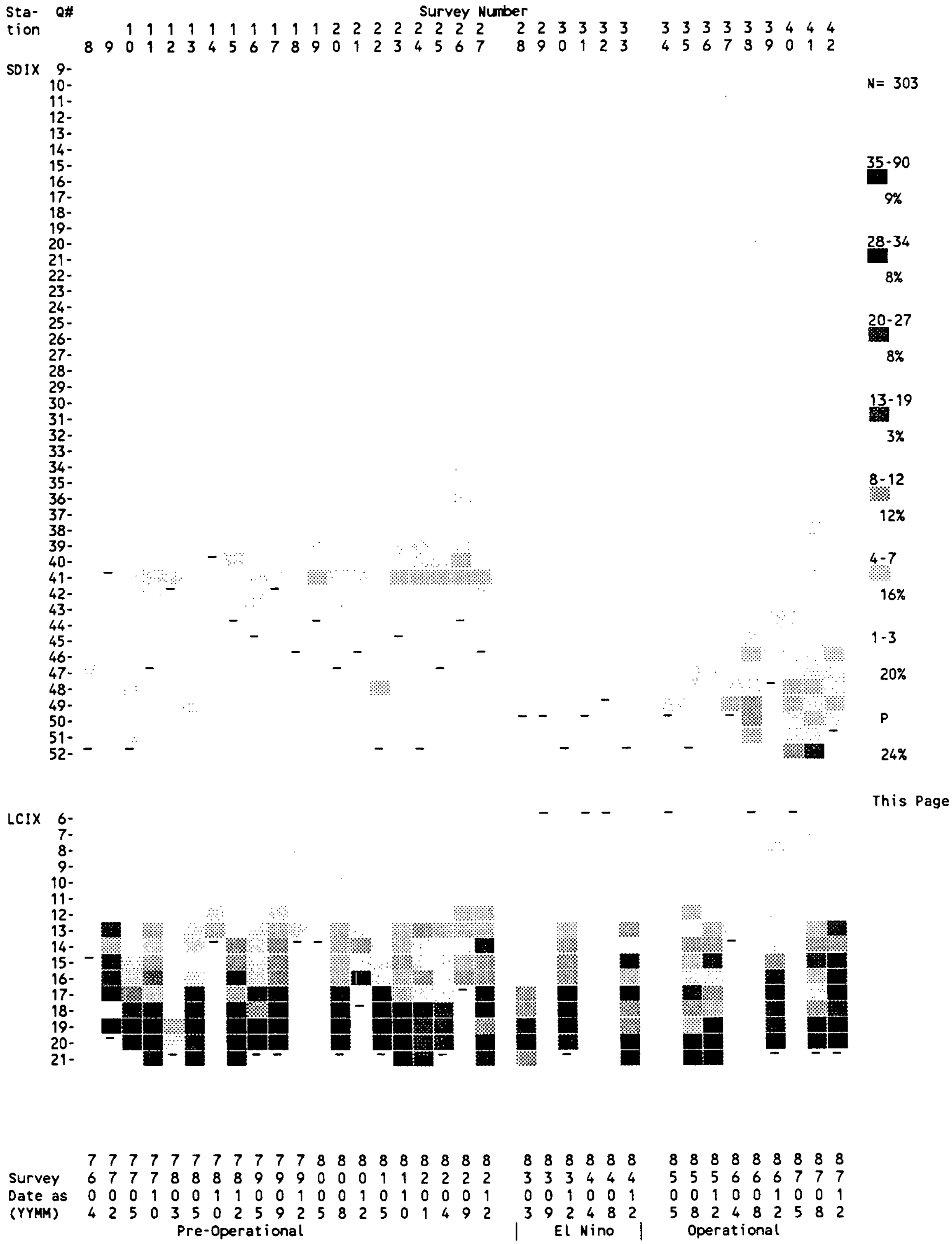


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HYMCRY CSV 5367 9-30-88 7:31a 04-14-1989 10:12

Taxa or Category: Hymenena spp. +Cryptopleura spp. (Mostly LCIX)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HYMCRY CSV 5367 9-30-88 7:31a 04-14-1989 10:12

Audit: CLUMRG2P: V.1.2: for SHYMCRY CLU 6581 4-22-89 7:38a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:33:56 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Hymenena spp. +Cryptopleura spp. (Mostly LCIX): TOTAL Quads with Data = 209
Abrev. taxon name(s): CRYPTOPL VIO Quant. Data

Quad Range USED 20 to 39 for Total of 20 : Range WITH data 16 to 41: : # Dropped 16 : 7.7%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.707972: Maximum Distance = 1020

```
S27-8212 -------------------------------------------------------------------------------------I
S28-8303 -----------------------------I-I                                                     I
S32-8408 --------------------------I--I I                                                     I
S36-8512 --------------------------I    I-----------I                                         I
S34-8505 ------------------I-----I      I           I                                         I
S41-8708 ------------------I     I------I           I                                         I
S37-8604 -----I------------------I                  I----I                                    I------------------I
S38-8608 -----I                                     I    I                                    I                  I
S35-8508 --------------------------------I----I     I    I------------------I                 I                  I
S40-8705 --------------------------------I    I-----I    I                  I                 I                  I
S39-8612 -------------------------------------I          I                  I------I          I                  I------
S29-8309 -----------------------------I------------------I                  I      I          I                  I
S33-8412 -----------------------------I                                     I      I----------I                  I
S31-8404 -------------------------------------------------------------------I      I                             I
S42-8712 --------------------------------------------------------------------------I                             I
S30-8312 --------------------------------------------------------------------------------------------------------I
```

Station: NDIX: Hymenena spp. +Cryptopleura spp. (Mostly LCIX): TOTAL Quads with Data = 215
Abrev. taxon name(s): CRYPTOPL VIO +HYMENENA SP Quant. Data

Quad Range USED 13 to 27 for Total of 15 : Range WITH data 10 to 33: : # Dropped 100 : 46.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.868863: Maximum Distance = 334

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End   Dropped Surveys
S 8-7604 -----I-I
S28-8303 -----I I--I
S10-7705 -------I  II
S 9-7702 ----------II-I
S37-8604 -------I---I I
S38-8608 ---I---I     I
S40-8705 ---I         I--I
S29-8309 -------------I  I
S36-8512 -----I---I   I  I-------I
S42-8712 -----I   I---I  I       I
S41-8708 ---------I      I       I--I
S13-7805 ----------------I       I  I-I
S39-8612 ------------------------I  I I
S18-7912 ----------------------I----I II
S32-8408 ----------------------I      II
S11-7710 -----------------------------II---I
S30-8312 -----I----------I             I   I
S34-8505 -----I          I-------------I   I----I
S35-8508 ----------------I                 I    I
S16-7905 ----------------------------------I    II
S14-7810 --------I---------------------I        II
S20-8008 --------I                     I--------II--I
S27-8212 ------------------------------I         I  I
S21-8012 -----------------------------I------I   I  I
S24-8201 -----------------------------I      I---I  I----------------------------------------------------------I
S25-8204 ----------------------------------I-I      I                                                          I
S33-8412 ----------------------------------I        I                                                          I------
S22-8105 -------------------------------------------I                                                          I
S15-7812 ------------------------------------------------------------------------------------------------------I
```

Station: SDIX: Hymenena spp. +Cryptopleura spp. (Mostly LCIX): TOTAL Quads with Data = 99
Abrev. taxon name(s): CRYPTOPL VIO +HYMENENA SP Quant. Data

Quad Range USED 38 to 43 for Total of 6 : Range WITH data 36 to 52: : # Dropped 61 : 61.6%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.906940: Maximum Distance = 46

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  I
S13-7805  I
S18-7912  I
S28-8303  I
S29-8309  I
S30-8312  I
S31-8404  I-----------I
S32-8408  I           I
S33-8412  I           I
S34-8505  I           I
S35-8508  I           II
S36-8512  I           II
S37-8604  I           II
S10-7705  ------------II-----------I
S38-8608  I           II           I
S39-8612  I-----------II           I
S40-8705  I            I           I--I
S42-8712  -------------I           I  I
S11-7710  ------------------I------I  I-----I
S16-7905  ------------------I      I  I     I
S41-8708  -------------------------I  I     I------------------------------------I
S15-7812  ----------------------------I     I                                    I
S20-8008  ----------------------------------I                                    I
S19-8005  ---------------------------I--I                                        I-----------------------------I
S23-8110  ----------------------I----I  I-----I                                  I                             I
S24-8201  ----------------------I       I     I-I                                I                             I
S25-8204  ------------------------------I     I I--------------------------------I                             I------
S27-8212  ------------------------------------I I                                                              I
S21-8012  I-------------------------------------I                                                              I
S22-8105  I                                                                                                    I
S26-8209  -----------------------------------------------------------------------------------------------------I
```

Station: LCIX: Hymenena spp. +Cryptopleura spp. (Mostly LCIX): TOTAL Quads with Data = 209
Abrev. taxon name(s): CRYPTOPL VIO +CRYPTOPL LOB +HYMENENA SP Quant. Data

Quad Range USED 12 to 19 for Total of 8 : Range WITH data 4 to 23: : # Dropped 63 : 30.1%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.649542: Maximum Distance = 572

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  --------------------------------------I----------------------------------I
S42-8712  --------------------------------------I                                  I
S10-7705  ------------------I-----I                                                I
S11-7710  ----------------I-I     I---I                                            I
S25-8204  ----------------I       I   I-------I                                    I
S28-8303  ------------------------I   I       I---------I                          I
S16-7905  ----------------------------I       I         I                          I---------------------------I
S36-8512  ------------------I-----------------I         I----I                     I                           I
S41-8708  ------------------I                           I    I                     I                           I
S12-7803  -------------------------------------I--------I    I                     I                           I
S35-8508  -------------------------------------I             I-----I               I                           I
S13-7805  --------------------I-----I                        I     I               I                           I
S20-8008  --------------------I     I-----I                  I     I               I                           I
S17-7909  --------------------------I     I-----------I      I     I---------------I                           I------
S22-8105  --------------------------------I           I------I     I                                           I
S23-8110  -------------------------------I------------I            I                                           I
S24-8201  -------------------------------I                         I                                           I
S27-8212  -----------------------------------------------I---------I                                           I
S30-8312  -------------------------------------------I---I                                                     I
S33-8412  ------------------------------------I------I                                                         I
S39-8612  ------------------------------------I                                                                I
S15-7812  -----------------------------------------------------------------------------------------------------I
```

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Endocladia muricata (Postels & Ruprecht, 1840). Ref. AH, 1976. p 422.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Densely bushy branches, wiry with minute spines, dark red, blackish-brown, to blackish, 4 - 8 cm tall.

Distribution: Alaska to Punta Santo Tomas (Baja California). Locally abundant on rocks, tops and sides, high to mid-intertidal. Most common alga in central California at the upper intertidal levels. A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 45% of our quadrats in cover up to 50%.

Habitat: On rock (bedrock to cobble), tops, and sides, upper to lower-mid intertidal. Usually as distinct patches excluding other algal species, but sometimes overlain by *Pelvetia*, *Fucus*, or *Gigartina papillata*.

Observational Errors: Not often mis-identified (see below). Missed observations occur about <3% of the time due to sand/gravel areas of SDIX and NDIX in the upper intertidal, quadrat boundary errors, and because of the commonness of this taxon, i.e., overlooked because always present.

Field Identification Problems:

General: Probably rarely confused with short, dried *Gelidium coulteri*, or with bladelets in crevices of *Gigartina papillata*.

Station Specific: n.a.

General Comments: Can trap moderate amounts of sand/gravel/shell debris and can harbor small animal nestlers.

Impacts to Taxon:

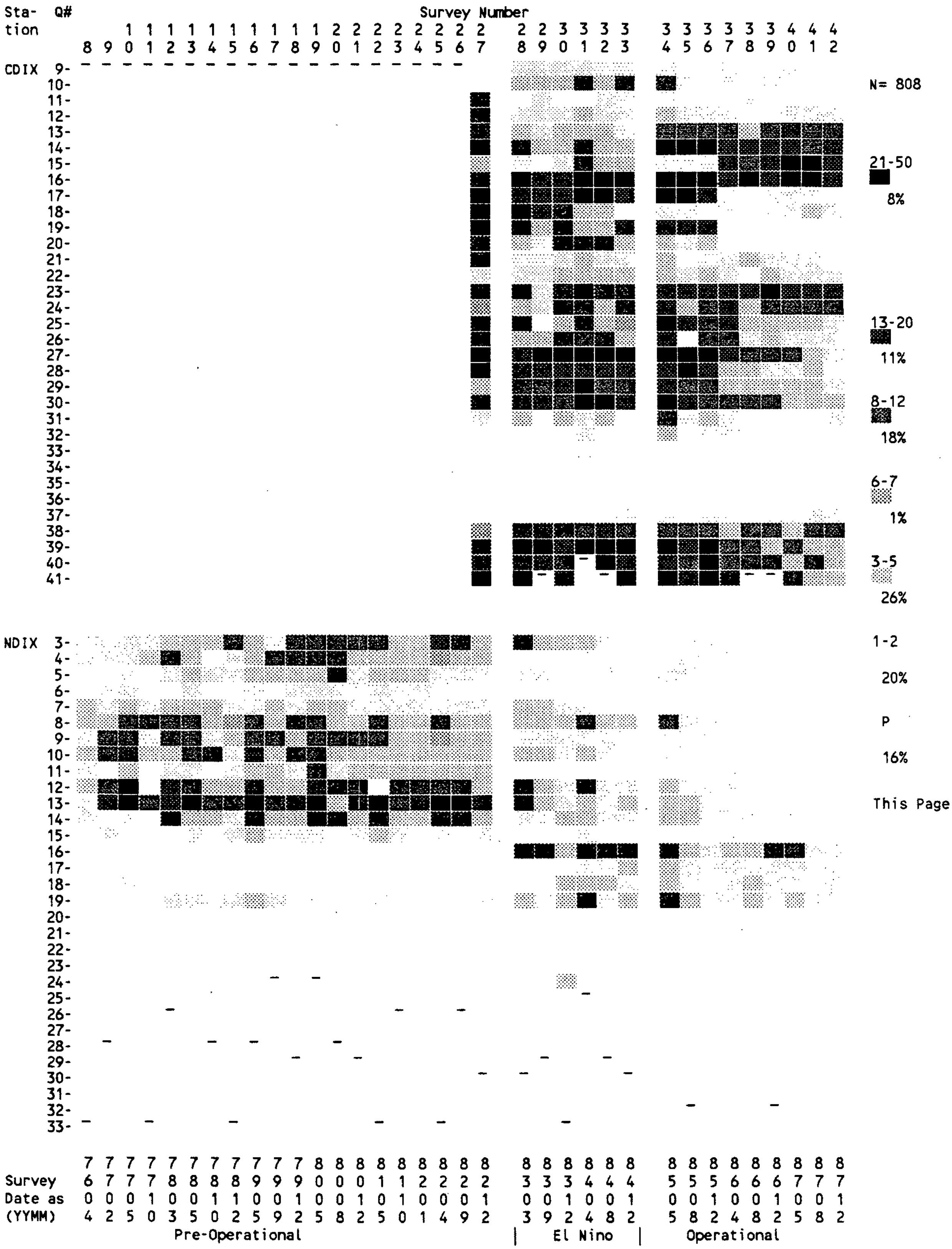
El Niño: 1982-83 winter storm: Reduction in occurrences at SDIX (cobble overlay, and removal of boulders). NDIX normal, but introduced in one quadrat on one new boulder. CDIX increased in occurrences (2 quadrats over an introduced boulder). LCIX with lost occurrence in only one quadrat, probably storm wave removal. Covers at all stations essentially normal.

El Niño: 1983-1984: Coverage at SDIX declining below normal at upper and probably mid-tidal levels, and slowly and sporadically recolonizing areas in the mid-lower levels. NDIX also with declining cover at upper to upper-mid tidal levels, but occurrences increasing slightly at the lower edge of range. CDIX with slight declines in covers in upper part of range, but occurrences unchanged. LCIX possibly losing one occurrence at extreme upper range.

Diablo DCPP Operation: SDIX slowly losing scattered occurrences at upper part of range, with covers there lower than normal, and with mid-lower areas remaining stable. NDIX much as El Niño period, but occurrences decreasing in the upper and upper-mid intertidal in Autumn 1986 and complete disappearance in these areas by Autumn 1987. Remaining covers lower than normal. CDIX very patchy, probably due to complex exposure patterns there. Occurrences declined on a moderately exposed bedrock shelf in the mid intertidal as well as in a cobble movement area higher in the intertidal. Cover thinned along most of the transect. LCIX apparently normal.

Taxon or Category: Endocladia muricata

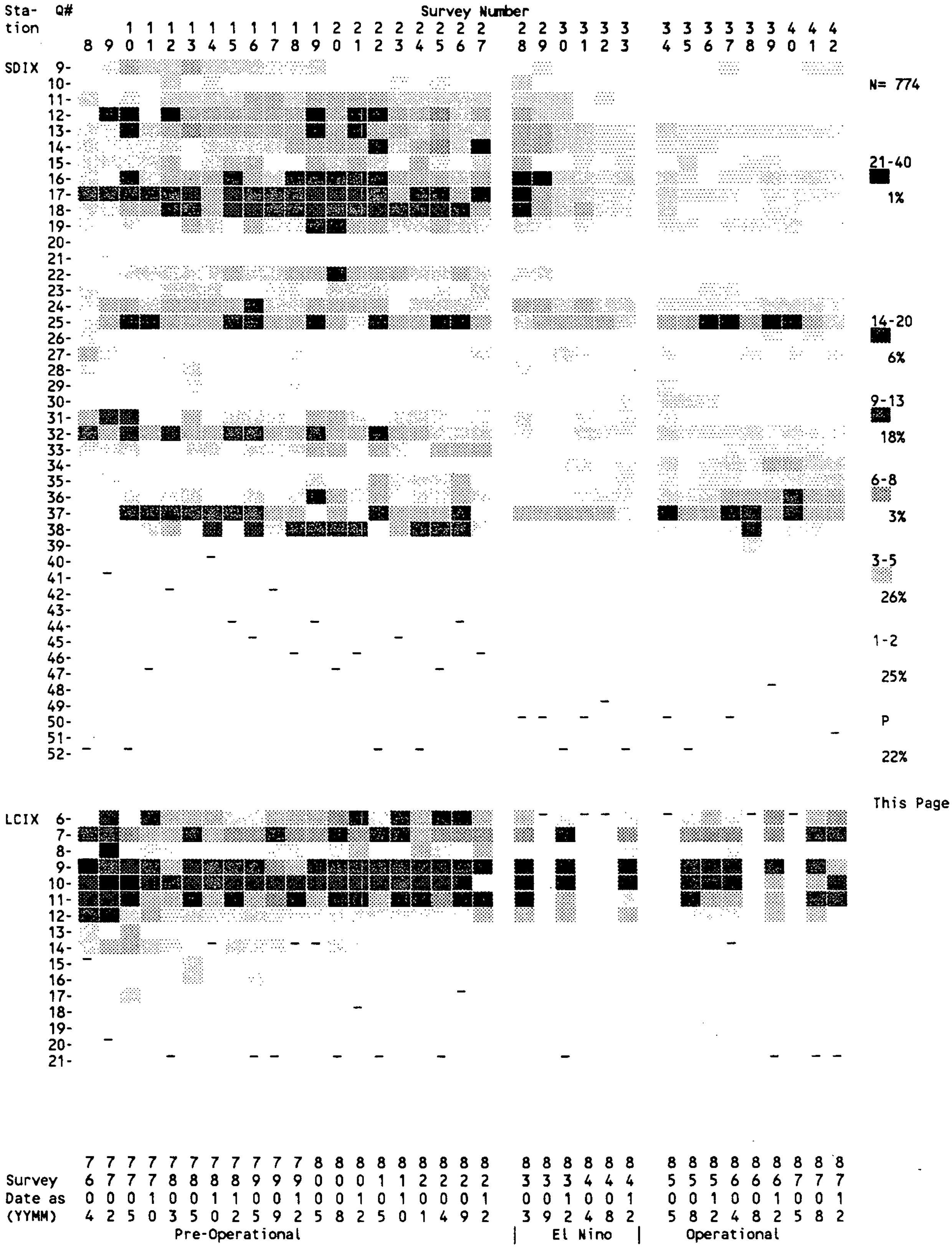
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for ENDMUR CSV 6070 3-29-88 7:28a 04-14-1989 09:38

Taxon or Category: *Endocladia muricata*

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ENDMUR CSV 6070 3-29-88 7:28a 04-14-1989 09:39

Audit: CLUMRG2P: V.1.2: for SENDMUR CLU 7249 4-22-89 8:01a: 04-27-1989/17:31
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/07:55:59 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Endocladia muricata: TOTAL Quads with Data = 430

Quad Range USED 6 to 39 for Total of 34 : Range WITH data 3 to 41: : # Dropped 44 : 10.2%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.572197: Maximum Distance = 2168

```
S27-8212 -----------------------------------------------------------------------------------------I
S28-8303 ----------------------------------------------I--------I                                 I
S29-8309 ----------------------------------------------I        I-------I                         I
S30-8312 --------------------------------------------------I----I       I                         I---------I
S32-8408 ----------------------------------------I---------I            I-------I                 I         I
S33-8412 ----------------------------------------I                      I       I                 I         I
S35-8508 --------------------------------------------I------------------I       I---------I       I         I
S36-8512 --------------------------------------------I                          I         I-------I         I------
S31-8404 -----------------------------------------------------------------------I         I                 I
S34-8505 ---------------------------------------------------------------------------------I                 I
S37-8604 ----------------------------------------I-I                                                        I
S38-8608 ---------------------------------I------I I                                                        I
S39-8612 ---------------------------I-----I        I--------------------------------------------------------I
S42-8712 ---------------------------I              I
S40-8705 ---------------------------I--------------I
S41-8708 ---------------------------I
```

Station: NDIX: Endocladia muricata: TOTAL Quads with Data = 432

Quad Range USED 3 to 23 for Total of 21 : Range WITH data 2 to 25: : # Dropped 11 : 2.5%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.669165: Maximum Distance = 646

```
S 8-7604 -------------------------------------I---I
S14-7810 -------------------------------------I   II
S11-7710 -----------------------------------------II----I
S15-7812 ------------------------------------------I    I-----I
S28-8303 ---------------------------I-------------------I     I-I
S29-8309 ---------------------------I                         I I
S 9-7702 -----------------------------------------------------I I-------I
S17-7909 -------------------------------I------I                I       I
S23-8110 -------------------------------I      I----------------I       I
S20-8008 --------------------------------------I                        I----------I
S30-8312 -----------------------I-----I                                 I          I
S32-8408 -----------------------I     I                                 I          I
S33-8412 ----------------------I------I                                 I          I
S35-8508 ----------------------I      I---------------------------------I          I
S36-8512 -------------I--I                                                         I
S41-8708 ----I--------I  I----I                                                    I------------------------I
S42-8712 ----I           I    I---I   I                                            I                        I
S37-8604 ----------------I    I   I---I                                            I                        I
S38-8608 ---------------------I   I                                                I                        I
S39-8612 --------------I----------I                                                I                        I
S40-8705 --------------I                                                           I                        I------
S31-8404 ----------------------------I---------------------------------------------I                        I
S34-8505 ----------------------------I                                                                      I
S10-7705 -----------------------------------------------------------------------------------------I         I
S12-7803 -----------------------------------------------I--------I                                I         I
S19-8005 -----------------------------------------------I        I-----I                          I---------I
S16-7905 --------------------------------------------------------I     I                          I
S13-7805 ------------------------------------------I--I                I                          I
S25-8204 --------------------------------I---------I  I----I           I--------------------------I
S26-8209 --------------------------------I            I    I           I
S18-7912 ------------------------------------I--------I    I           I
S21-8012 ------------------------I-----------I             I-----------I
S24-8201 --------------------I---I                         I
S27-8212 --------------------I                             I
S22-8105 --------------------------------------------------I
```

Station: SDIX: Endocladia muricata: TOTAL Quads with Data = 576

Quad Range USED 12 to 39 for Total of 28 : Range WITH data 6 to 41: : # Dropped 49 : 8.5%
Surveys 35 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.697890: Maximum Distance = 833

```
S 8-7604 ---------------------------------------------------------------I
S30-8312 --------------I---I                                            I
S31-8404 --------------I   I--I                                         I
S32-8408 ----------I-----I I  I                                         I
S35-8508 ----------I     I-I  I---I                                     I-I
S36-8512 ----------------I    I   I-------I                             I I
S34-8505 ---------------------I   I       I                             I I
S33-8412 -----------------------I-I       I                             I I
S41-8708 ------------------I----I         I-----------------------------I I
S42-8712 ------------------I              I                               I
S37-8604 ----------------I----I           I                               I
S39-8612 ----------------I    I-----------I                               I-------------I
S40-8705 ---------------------I                                           I             I
S11-7710 -----------------------------------I------------I                I             I
S17-7909 -----------------------------------I            I---I            I             I
S13-7805 ------------------------------------------------I   I            I             I
S18-7912 ------------------------------I-I                   I-I          I             I
S23-8110 ------------------------------I I--------I          I I          I             I----------I
S24-8201 --------------------------------I        I-----I    I I----------I             I          I
S25-8204 -----------------------------------------I     I----I I                        I          I
S26-8209 -----------------------------------------------I      I                        I          I
S27-8212 ---------------------------------------------I--------I                        I          I
S28-8303 -------------------------------------I-------I                                 I          I----------I
S29-8309 -------------------------------------I                                         I          I          I
S38-8608 -------------------------------------------------------------------------------I          I          I
S12-7803 --------------------------------------------------------------------I----------I          I          I
S14-7810 --------------------------------------------------I-----------------I          I          I          I
S16-7905 --------------------------------------------------I                            I----------I          I------
S15-7812 -------------------------------------------------------------I------------I    I                     I
S22-8105 -------------------------------------------------------------I            I----I                     I
S19-8005 ----------------------------------------------------I---------------------I                          I
S20-8008 ------------------------------------------------I---I                                                I
S21-8012 ------------------------------------------------I                                                    I
S 9-7702 -------------------------------------------------------------------------------I---------------------I
S10-7705 -------------------------------------------------------------------------------I
```

Station: LCIX: Endocladia muricata: TOTAL Quads with Data = 254

Quad Range USED 3 to 16 for Total of 14 : Range WITH data 3 to 19: : # Dropped 48 : 18.9%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.870533: Maximum Distance = 683

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 9-7702 ------------------------------------------------------------------------------------------------------I
S10-7705 ----------------------------------------------------I                                                 I
S11-7710 -----------------------I                            I                                                 I
S15-7812 ------------I-I        I                            I                                                 I------
S16-7905 -----I------I II       I---I                        I                                                 I
S22-8105 -----I        II--I    I   I                        I                                                 I
S24-8201 --------------II  I    I   I                        I                                                 I
S17-7909 -------I-------I  I----I   I                        I-------------------------------------------------I
S42-8712 -------I          I        I-----I                  I
S20-8008 ------------I-----I        I     I                  I
S21-8012 ------------I              I     I                  I
S12-7803 ----------------------I    I     I                  I
S23-8110 ------------I-----I   I----I     I                  I
S26-8209 ------------I     I---I          I------------------I
S35-8508 ------------I-I   I              I
S41-8708 ------------I I---I              I
S39-8612 --------------I                  I
S13-7805 --------------I----------------I I
S25-8204 --------------I                I-I
S27-8212 --------------------------I    I
S28-8303 --------------II          I----I
S30-8312 --------------II----------I
S33-8412 ----------I----I
S36-8512 ----------I
```

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Gastroclonium coulteri (Harvey, 1853). Ref. AH, 1976. p 422.
Phylum Rhodophyta: **Class** Rhodymeniales:

Description: Densely bushy, succulent, septate branches, reddish bases with greenish tops, 10 - 26 cm tall.

Distribution: Southern British Columbia to Baja California. Common on rocks, tops and sides, intertidal to subtidal (14 m). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 20% of our quadrats with covers to 70%.

Habitat: On rock (sometimes cobble), tops, and sides, lower-mid to low intertidal. Usually covering large areas, often mixed with *Gigartina canaliculata* and other algae, often overlain by *Iridaea* and other overstory algae.

Observational Errors: Not often mis-identified (see below). Missed observations occur about <3% of the time due to small isolated bladelets or small clumps mixed with *Gigartina canaliculata*, quadrat boundary errors.

Field Identification Problems:

General: When occurring as small bladelets possibly but probably rarely confused with *Gigartina canaliculata*.

Station Specific: n.a.

General Comments: Can trap moderate amounts of sand/gravel/shell debris and can harbor small animal nestlers.

Impacts to Taxon:

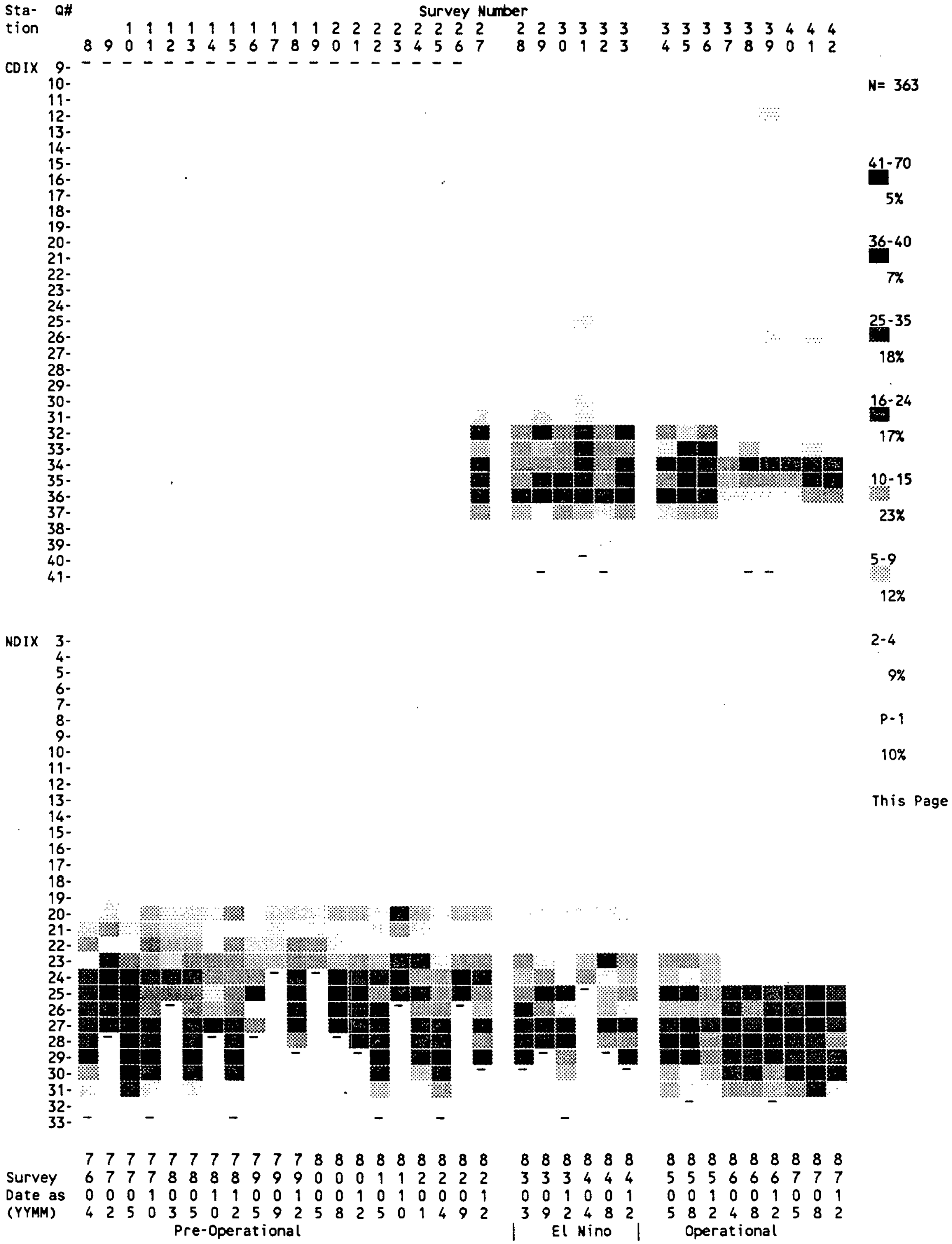
El Niño: 1982-83 winter storm: Reduction in occurrences and covers (to <5%) at SDIX (cobble overlay, and removal of growth and of boulders). NDIX and CDIX with normal occurrence, probably slight reduction of covers. LCIX with lost occurrence in only one quadrat, probably storm wave removal, with somewhat reduced covers overall.

El Niño: 1983-1984: SDIX declining in occurrences with covers below normal, but above those of survey just after storms. NDIX and CDIX probably normal by end of 1984. LCIX losing one occurrence at extreme upper range and covers declining.

Diablo DCPP Operation: SDIX with occurrences extending downward in the intertidal and not re-establishing occurrences at upper part of range, covers somewhat below normal. NDIX slowly losing 3-4 occurrences at upper part of range, but covers normal. Species always occurred to end of transect here. CDIX normal until May 1986 when 2 of a normal 7 were lost and covers declined. Occurrences did not recover by end of 1987 but covers recovered somewhat. LCIX re-colonized upper quadrats, never with substantial covers but otherwise close to normal.

Taxon or Category: Gastroclonium coulteri

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

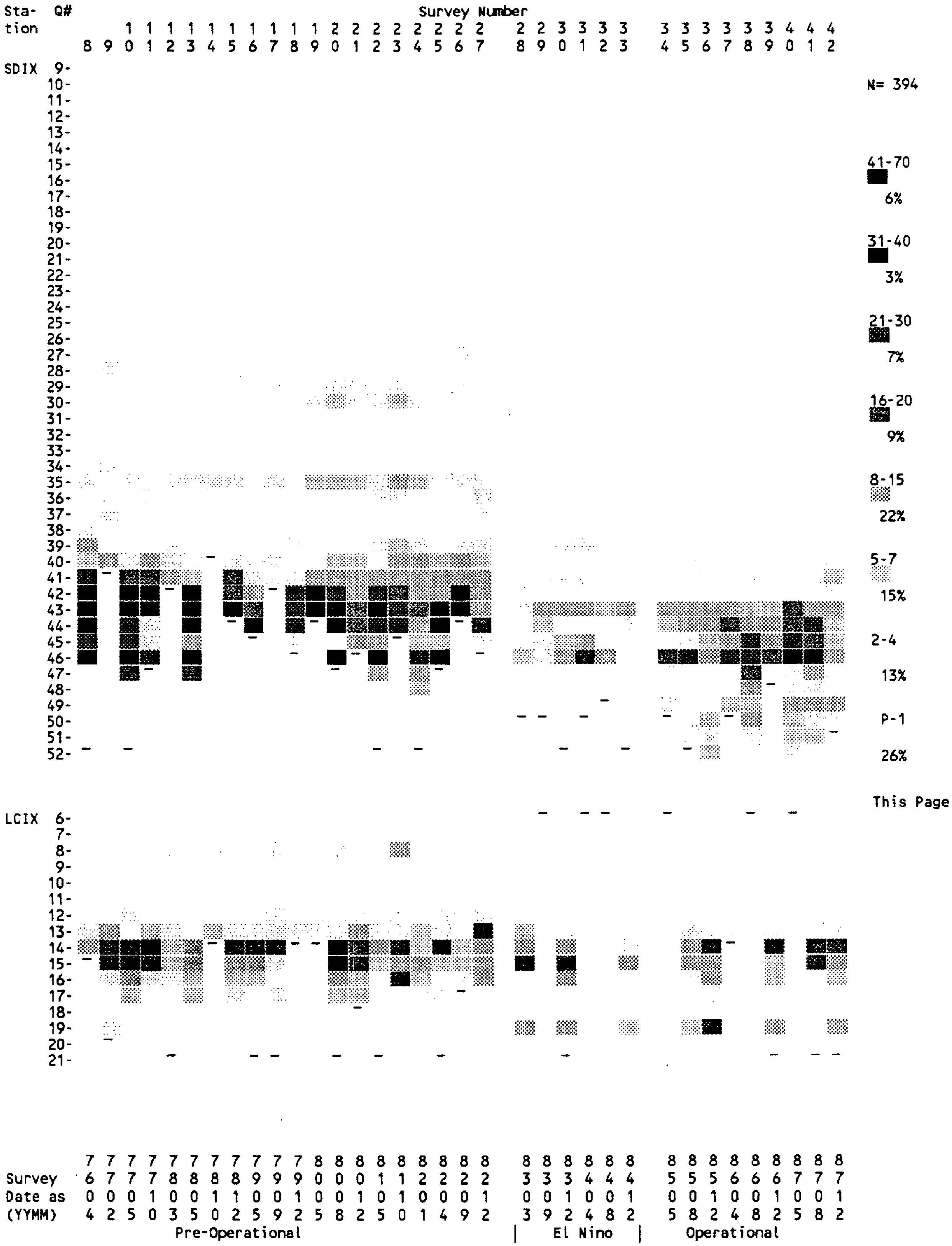


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GASCOU CSV 5631 3-29-88 7:29a 04-14-1989 09:42

Taxon or Category: Gastroclonium coulteri

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GASCOU CSV 5631 3-29-88 7:29a 04-14-1989 09:42

Audit: CLUMRG2P: V.1.2: for SGASCOU CLU 6163 4-22-89 8:14a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:11:09 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Gastroclonium coulteri: TOTAL Quads with Data = 88

Quad Range USED 30 to 39 for Total of 10 : Range WITH data 12 to 39: : # Dropped 4 : 4.5%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.576262: Maximum Distance = 437

```
S27-8212 ---------------------------------------------------------------I--I
S31-8404 ---------------------------------------I-----------------------I  I--------I
S36-8512 ---------------------------------------I                          I        I-----------------------I
S33-8412 ------------------------------------------------------------------I        I                       I
S35-8508 ---------------------------------------------------------------------------I                       I
S28-8303 --------------------------I------I                                                                 I
S32-8408 --------------------------I      I--------------I                                                  I------
S30-8312 ---------------------------------I              I------I                                           I
S34-8505 ------------------------------------------------I      I----------------I                          I
S29-8309 -------------------------------------------------------I                I                          I
S37-8604 ---------------------------I---I                                        I--------------------------I
S38-8608 -------------------I-------I   I                                        I
S39-8612 I------------------I           I-------------------I                    I
S40-8705 I                              I                   I--------------------I
S42-8712 -------------------------------I                   I
S41-8708 ---------------------------------------------------I
```

Station: NDIX: Gastroclonium coulteri: TOTAL Quads with Data = 275

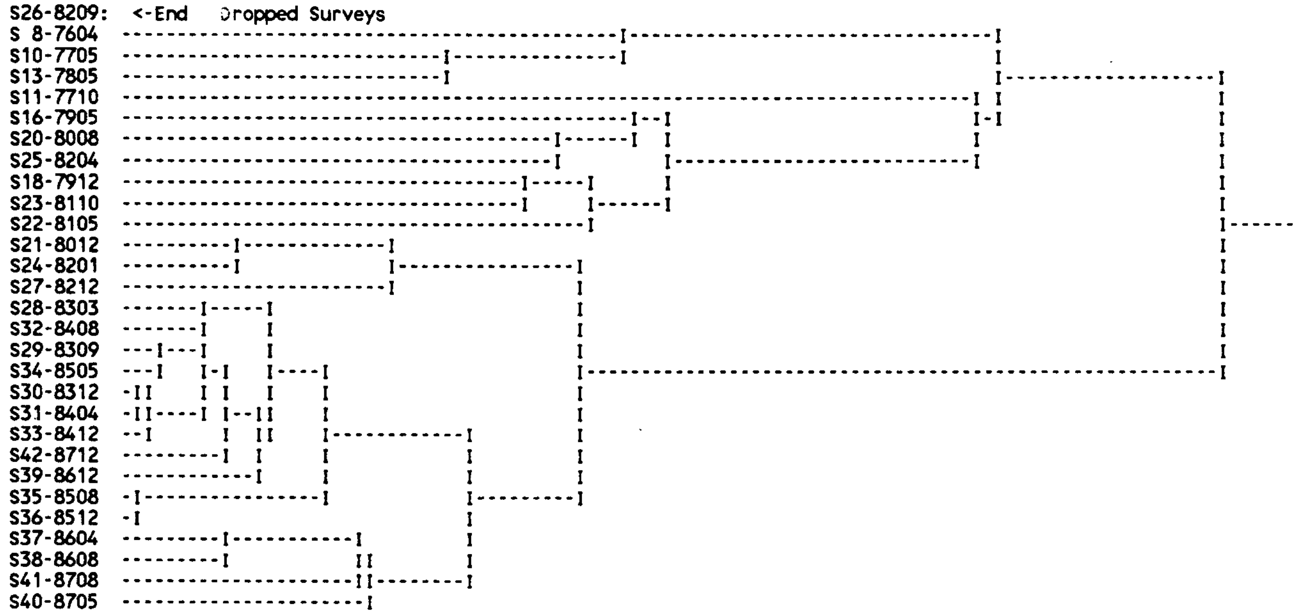
Quad Range USED 20 to 27 for Total of 8 : Range WITH data 18 to 32: : # Dropped 108 : 39.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.655514: Maximum Distance = 484

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 -----------------------------I----------------I
S22-8105 -----------------------------I                I-------------I
S 9-7702 ----------------------------------------I     I             I
S10-7705 -----------------------------I-----I    I-----I             I--------------I
S21-8012 -----------------------------I     I----I                   I              I
S18-7912 -----------------------------------I                        I              I
S20-8008 ------------------------------------------------------------I              I
S11-7710 ---------------------------I-----I                                         I
S27-8212 ---------------------------I     I                                         I
S13-7805 ----------------I---I            I--------I                                I
S25-8204 ----------------I   I-------I    I        I                                I
S14-7810 --------------------I       I--I I        I-I                              I------------------------I
S15-7812 ----------------------------I  I-I        I I                              I                        I
S16-7905 -------------------------------I          I I                              I                        I
S28-8303 -------------------------------------I----I I                              I                        I
S32-8408 -------------------------------------I      I                              I                        I
S24-8201 ---------------------I---I                  I--------------I               I                        I
S33-8412 ---------------------I   I-------I          I              I               I                        I
S29-8309 ----------------I--I     I       I          I              I               I                        I
S34-8505 ----------------I  I-----I       I----I     I              I               I                        I------
S36-8512 -------------------I             I    I     I              I---------------I                        I
S30-8312 -------------I-------------------I    I-----I              I                                        I
S38-8608 -------------I                        I                    I                                        I
S35-8508 --------------------------------------I                    I                                        I
S37-8604 -------------------I----------------------I                I                                        I
S39-8612 ----------------I--I                      I----------------I                                        I
S40-8705 ----------------I                         I                                                         I
S42-8712 ------------------------------------------I                                                         I
S41-8708 ----------------------------------------------------------------------------------------------------I
```

Station: SDIX: Gastroclonium coulteri: TOTAL Quads with Data = 255

Quad Range USED 29 to 44 for Total of 16 : Range WITH data 27 to 52: : # Dropped 112 : 43.9%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.778525: Maximum Distance = 912

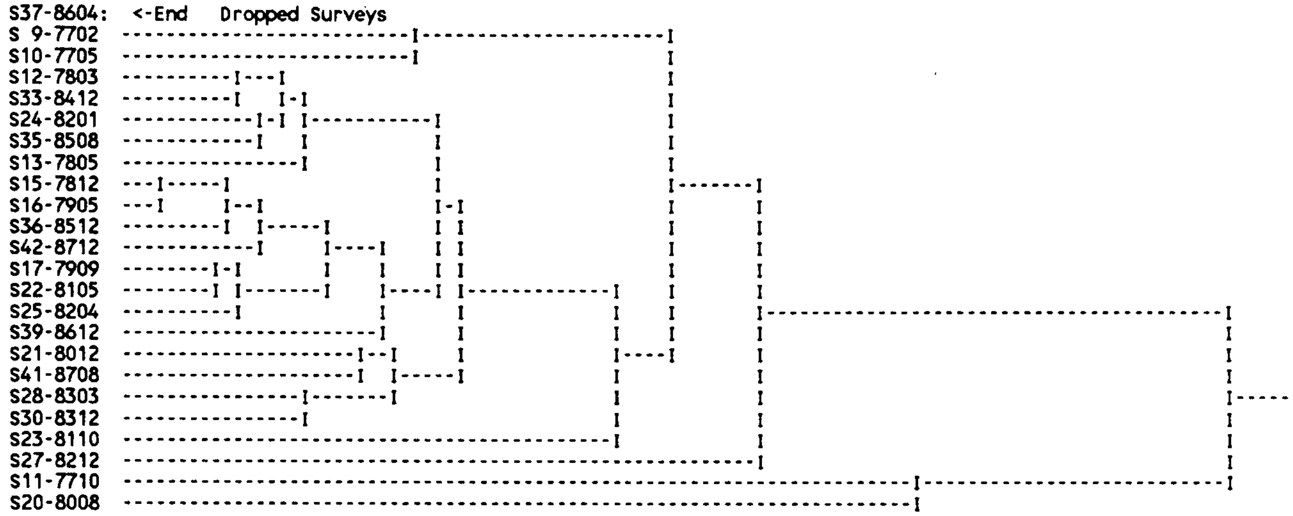
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209: <-End Dropped Surveys



Station: LCIX: Gastroclonium coulteri: TOTAL Quads with Data = 139

Quad Range USED 12 to 17 for Total of 6 : Range WITH data 7 to 19: : # Dropped 33 : 23.7%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.850845: Maximum Distance = 316

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604: <-End Dropped Surveys



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Gelidium coulteri/pusillum Ref. AH, 1976. p 344ff.

Phylum Rhodophyta: **Class** Nemaliales:

Description: Densely bushy clumps, or almost prostrate, reddish to almost black. 0.1 - 10+ cm tall.

Distribution: see below. A warm-tolerant group.

Diablo Area Specific Information: Common, occurring in about 50% of our quadrats with covers up to 30%.

Habitat: On rocks, cobbles, (sometimes epiphytic and epizoic), tops, and sides, upper to lower intertidal. Often mixed with other algae, but prostrate form (mostly *Gelidium pusillum*) often by itself or overlain by *Iridaea* and other overstory algae.

Observational Errors: Infrequently mis-identified (see below). Missed observations moderately common, occurring about <5% of the time due to small bladelets in crevasses, small clumps mixed with other algae, and when covered by algal mat. We did not field identify this group until mid 1977.

Field Identification Problems:

General: Possibly confused with *Gigartina papillata* when occurring as small bladelets in the upper intertidal. Other possible errors included confusion with *Pterocladia* (not known to be common at intertidal stations), rarely with *Endocladia muricata*.

Station Specific: n.a.

General Comments: We attempted to identify these two taxa separately in the field. We combined the two because substantial confusion was possible depending on growth form at time of observation.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Reduction in occurrences and covers at SDIX (cobble overlay, and removal of growth). NDIX and CDIX with slight reduction in occurrence, and at CDIX probably slight reduction of covers. LCIX with lost occurrences but possibly an artifact of missed observations, but with reduced covers.

El Niño: 1983-1984: SDIX with sporadic changes in occurrences and decreased covers in the upper parts of range, but coverages in lower intertidal about normal. NDIX with occurrences about normal, but with lower covers at upper parts of range, and with a cover increase to above normal for Winter 1983 and Spring 1984, then declining to normal cover by end of 1984. CDIX probably normal, but with covers thinning at upper quadrats. LCIX recovered from 1982-83 winter storms, but by end of 1984 covers below normal.

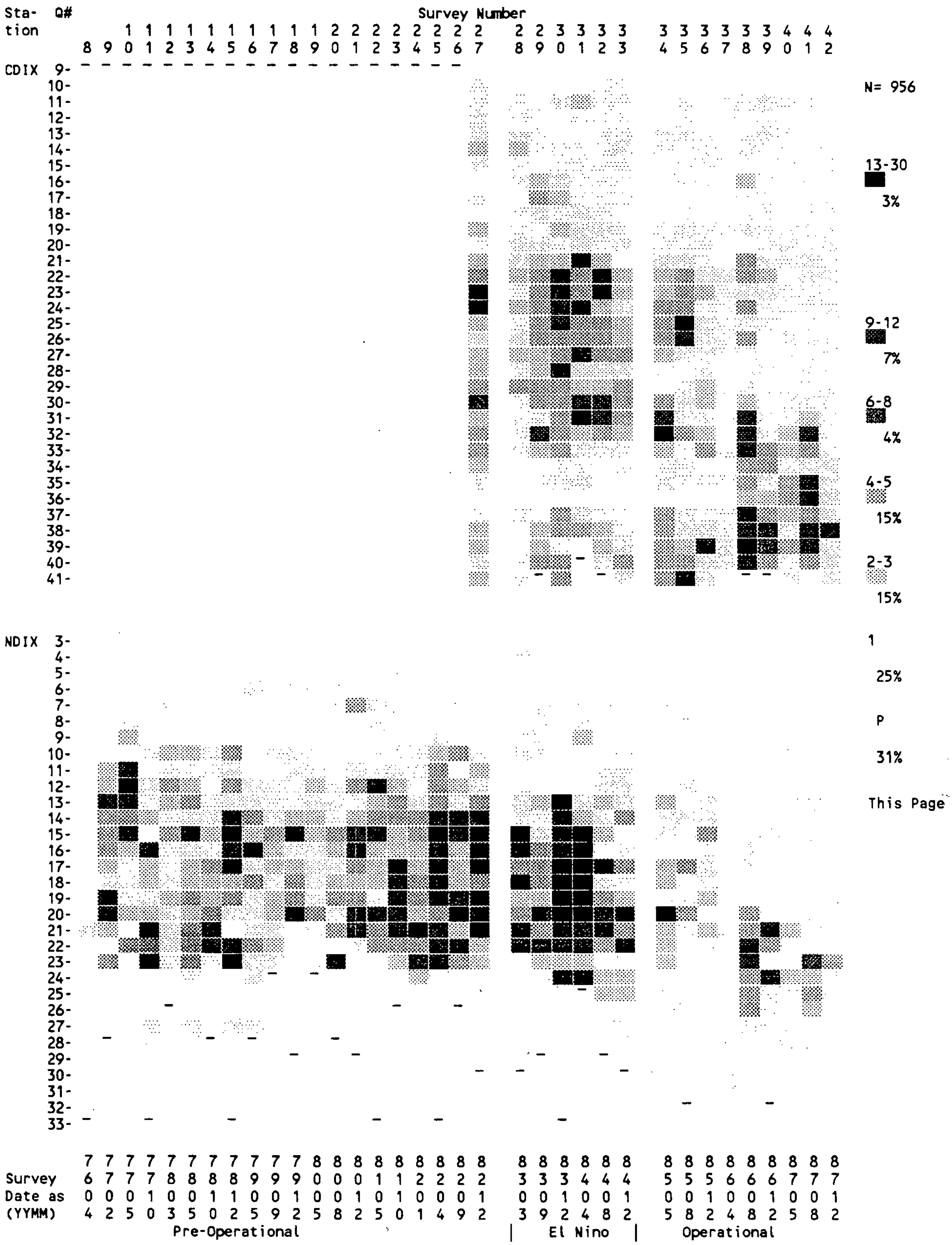
Diablo DCPP Operation: SDIX occurrences probably extending downward in the intertidal. Sporadic changes in occurrences in upper part of range. Covers throughout range below normal after mid 1986. NDIX about normal in occurrences but lower in covers until end of 1985, then with large decline in occurrences and covers, followed by resurgence but only in the lower parts of range. Range was about normal by end of 1987 but covers were reduced especially at upper quadrats. CDIX probably normal until May 1986 when covers declined sharply, but quickly recovered, followed by declining covers throughout range (not as pronounced at lowest tidal levels). LCIX remained low in covers and occurrences until late 1986, when recovered approximately to normal (possibly slightly low in area covered).

Gelidium coulteri: Washington to Punta Pequeña (Baja California).

Gelidium pusillum: British Columbia to Ecuador.

Taxa or Category: Gelidium coulteri +G. pusillum

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

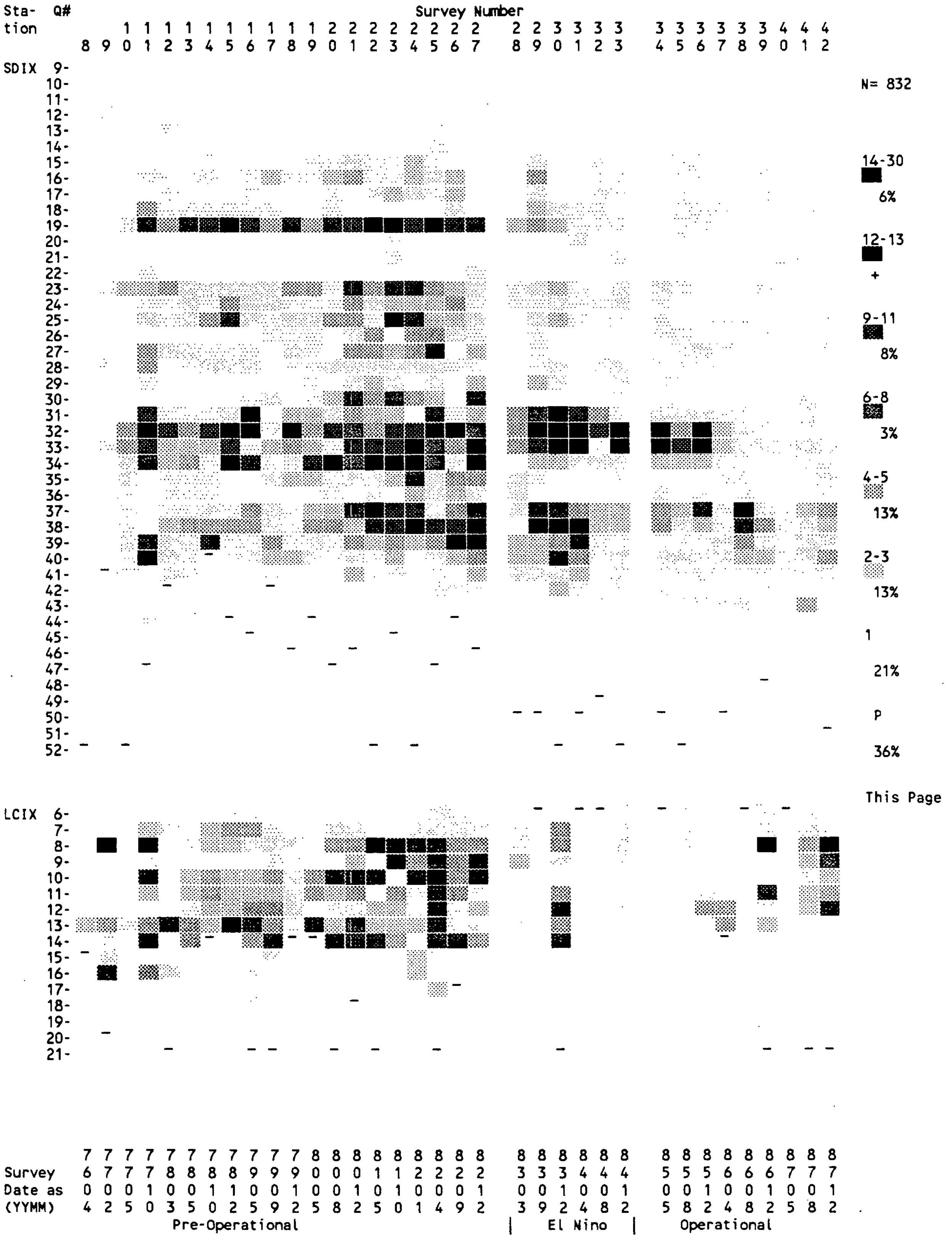


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GELCOP CSV 6418 9-30-88 7:32a 04-14-1989 09:43

Taxa or Category: Gelidium coulteri +G. pusillum

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GELCOP CSV 6418 9-30-88 7:32a 04-14-1989 09:43

```
Audit: CLUMRG2P: V.1.2: for SGELCOP CLU     6581   4-22-89   8:21a:   04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:17:26 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
       METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used


Station: CDIX: Gelidium coulteri +G. pusillum: TOTAL Quads with Data = 434

        Quad Range USED 9 to 39 for Total of 31 : Range WITH data 4 to 41: : # Dropped 29 :   6.7%
        Surveys 16 : Dropped 0 Surveys if quads sampled < 39
        COPHENETIC CORRELATION COEFFICIENT = 0.480210:                    Maximum Distance = 734

S27-8212  ----------------------------------------------I----I
S29-8309  ----------------------------------------------I    I--I
S32-8408  ---------------------------------------------------I  I---------I
S30-8312  ------------------------------------------------------I         I----I
S34-8505  ----------------------------------------------------------------I    I-----I
S35-8508  ---------------------------------------------------------------------I     I
S28-8303  ---------------------------------I--------I                                I---------------I
S37-8604  ---------------------------------I        I----------I                     I               I
S33-8412  ------------------------------------------I          I---------------------I               I
S36-8512  -----------------------------------------I------I    I                                     I-----I
S40-8705  -----------------------------------------I      I----I                                     I     I
S39-8612  -------------------------------------------I----I                                          I     I
S42-8712  -------------------------------------------I                                               I     I------
S38-8608  ----------------------------------------------------------------------I--------------------I     I
S41-8708  ----------------------------------------------------------------------I                          I
S31-8404  -------------------------------------------------------------------------------------------------I

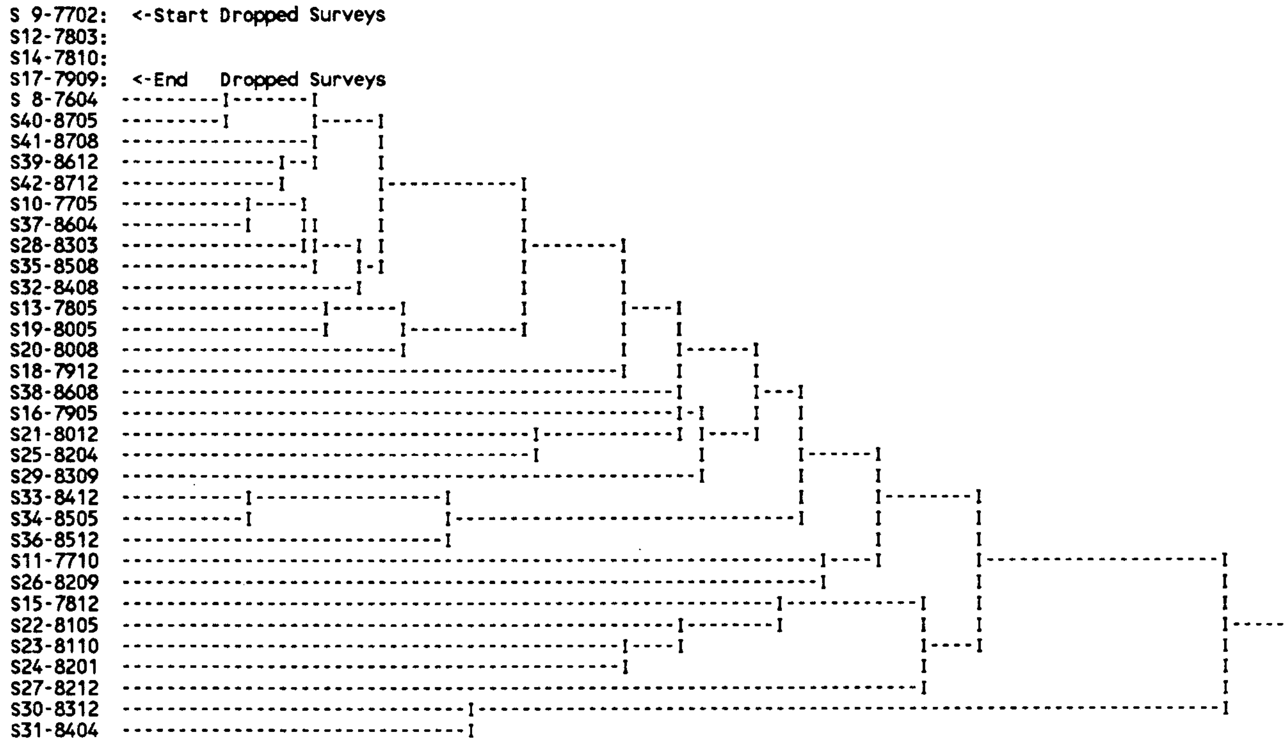

Station: NDIX: Gelidium coulteri +G. pusillum: TOTAL Quads with Data = 527

        Quad Range USED 10 to 27 for Total of 18 : Range WITH data 4 to 33: : # Dropped 170 :  32.3%
        Surveys 29 : Dropped 6 Surveys if quads sampled < 27
        COPHENETIC CORRELATION COEFFICIENT = 0.813391:                    Maximum Distance = 888

S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End  Dropped Surveys
S 8-7604  ----I-----I
S37-8604  ----I     I-----I
S40-8705  ----------I     I-I
S41-8708  -----------I----I I----I
S42-8712  -----------I      I    I
S35-8508  ----------------I-I    I----I
S36-8512  ----------------I      I    I--I
S39-8612  -----------------------I    I  I
S13-7805  -------------------I--------I  I--I
S20-8008  -------------------I           I  I
S11-7710  ----------------------I------I I  I
S16-7905  ----------------------I      I-I  I
S14-7810  --------------I------I       I    II
S29-8309  --------------I      I-------I    II
S32-8408  -----------------I---I            II
S33-8412  -----------------I                II
S38-8608  ----------------------------------II--------------I
S 9-7702  ------------------------------I----I              I
S18-7912  -------------------------I----I    I              I
S21-8012  --------------------I----I         I              I---I
S22-8105  --------------------I              I              I   I
S34-8505  -----------------------------------I              I   II
S24-8201  --------------------------------I-----------------I   II
S27-8212  --------------------------------I                     II
S15-7812  ---------------------------------------------I--------II-----------------------------------------I
S25-8204  ------------------------------------I--------I         I                                         I
S28-8303  ------------------------------------I                  I                                         I------
S10-7705  -------------------------------------------------------I                                         I
S30-8312  -------------------------------------------------------------------------------------------------I
```

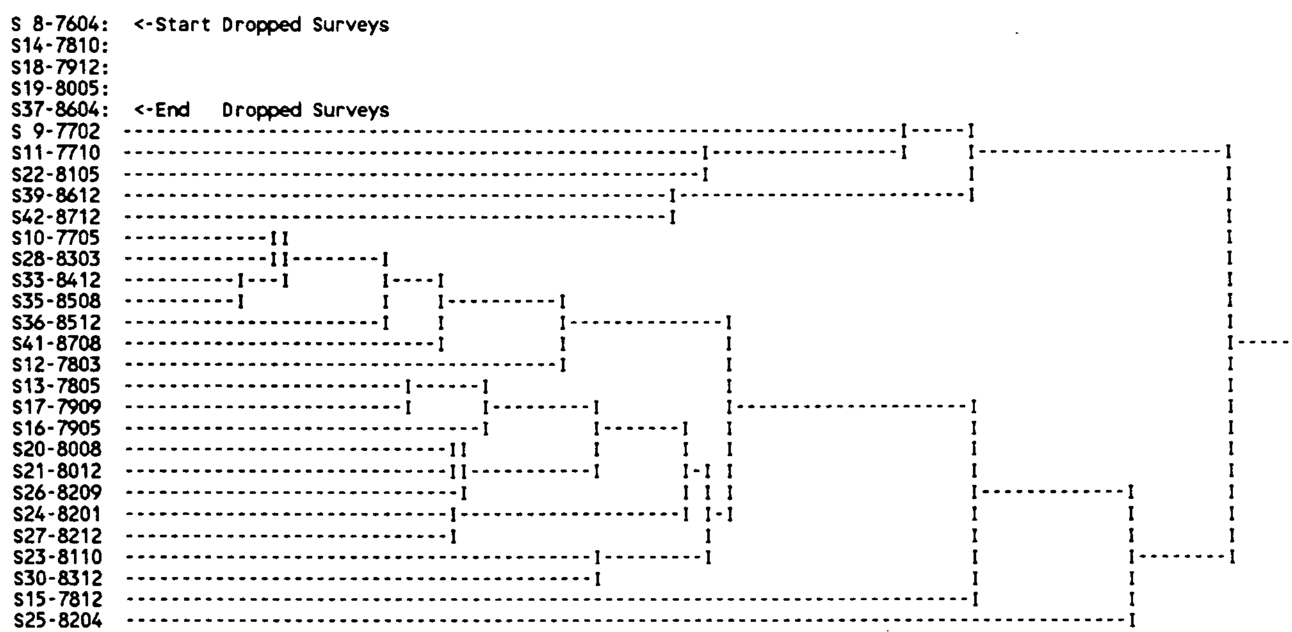
Station: SDIX: Gelidium coulteri +G. pusillum: TOTAL Quads with Data = 634

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 9 to 49: : # Dropped 86 : 13.6%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.749015: Maximum Distance = 1292



Station: LCIX: Gelidium coulteri +G. pusillum: TOTAL Quads with Data = 203

Quad Range USED 7 to 16 for Total of 10 : Range WITH data 3 to 19: : # Dropped 39 : 19.2%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.692926: Maximum Distance = 243



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Gigartina agardhii (Setchell & Gardner, 1933) Ref. AH, 1976. p 517.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Densely bushy clumps, stipes elongate and rounded, tips with papillae, reddish-brown to almost black. 5 - 10+ cm tall. (see also *Petrocelis franciscana*).

Distribution: Southern British Columbia to San Luis Obispo Co. (California). Frequent to common high to mid intertidal. Not a warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 25% of our quadrats in covers up to 40%.

Habitat: On rocks, tops, and sometimes sides, upper-mid to lower-mid intertidal. Often intermingled with other algae, mostly with *Gigartina papillata*.

Observational Errors: Mis-identified fairly frequently (see below). Missed observations moderately common, occurring about <7% mainly due to mis-identification. Quadrat boundary errors occurred.

Field identification of this taxon was not reliable until early 1978.

Field Identification Problems:

General: Most often confused with *Gigartina papillata* with which it sometimes grows as mixed stands. A crustose life-phase of this species (and other *Gigartina* spp.) was field identified as *Petrocelis franciscana*.

Station Specific: n.a.

General Comments: Separation of *G. agardhii* and *G. papillata* in the field was usually based on the primary stipe characteristics; thin and rounded (*agardhii*) versus broad and flattened (*papillata*).

Impacts to Taxon:

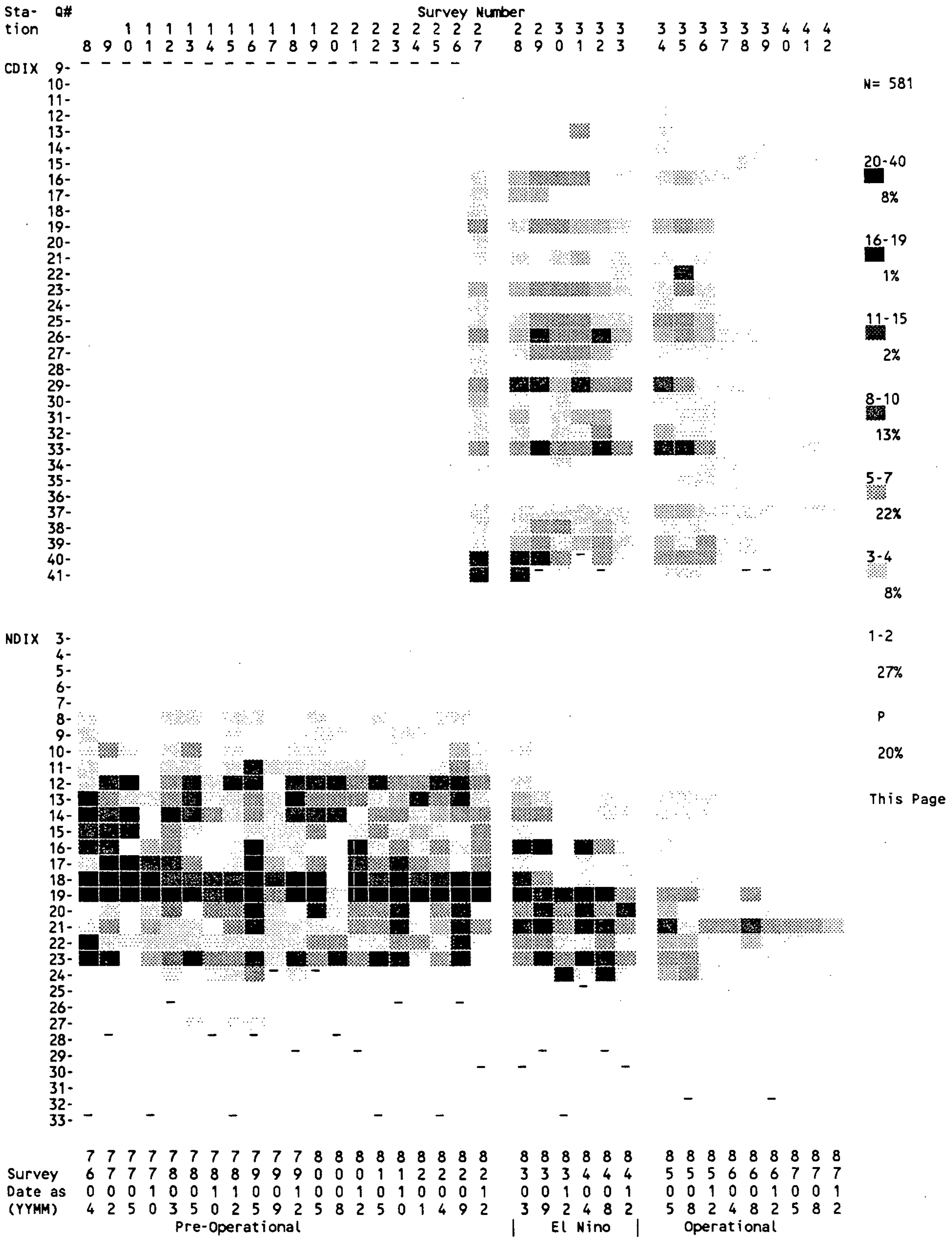
El Niño: 1982-83 winter storm: Reduction in occurrences and covers at SDIX (cobble overlay, and removal of growth) for upper quadrats of range. NDIX and CDIX with slight reduction in occurrence but apparently normal covers. LCIX normal.

El Niño: 1983-1984: SDIX with sporadic occurrences at upper part of range, (<50% of pre-El Niño storm conditions), and covers <1% in the quadrats, probably due to cobble overlay preventing colonization. NDIX with slow sporadic loss of occurrences in upper ranges, otherwise covers about normal. CDIX with slight sporadic loss of occurrences and with covers thinning at upper quadrats. LCIX within normal range of fluctuation.

Diablo DCPP Operation: SDIX with sporadic occurrences extending into lower intertidal, forming moderately stable low cover by end of 1986 . NDIX similar to El Niño conditions until May 86 when occurrences generally declined for upper parts of range. Occurrences were about 15% of normal and covers were much below normal by end of 1987. CDIX probably similar to El Niño until May 1986 when covers and occurrences declined with trend continuing until end of 1987. Losses here not restricted to definite tidal level. LCIX within normal range of fluctuation.

Taxon or Category: Gigartina agardhii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

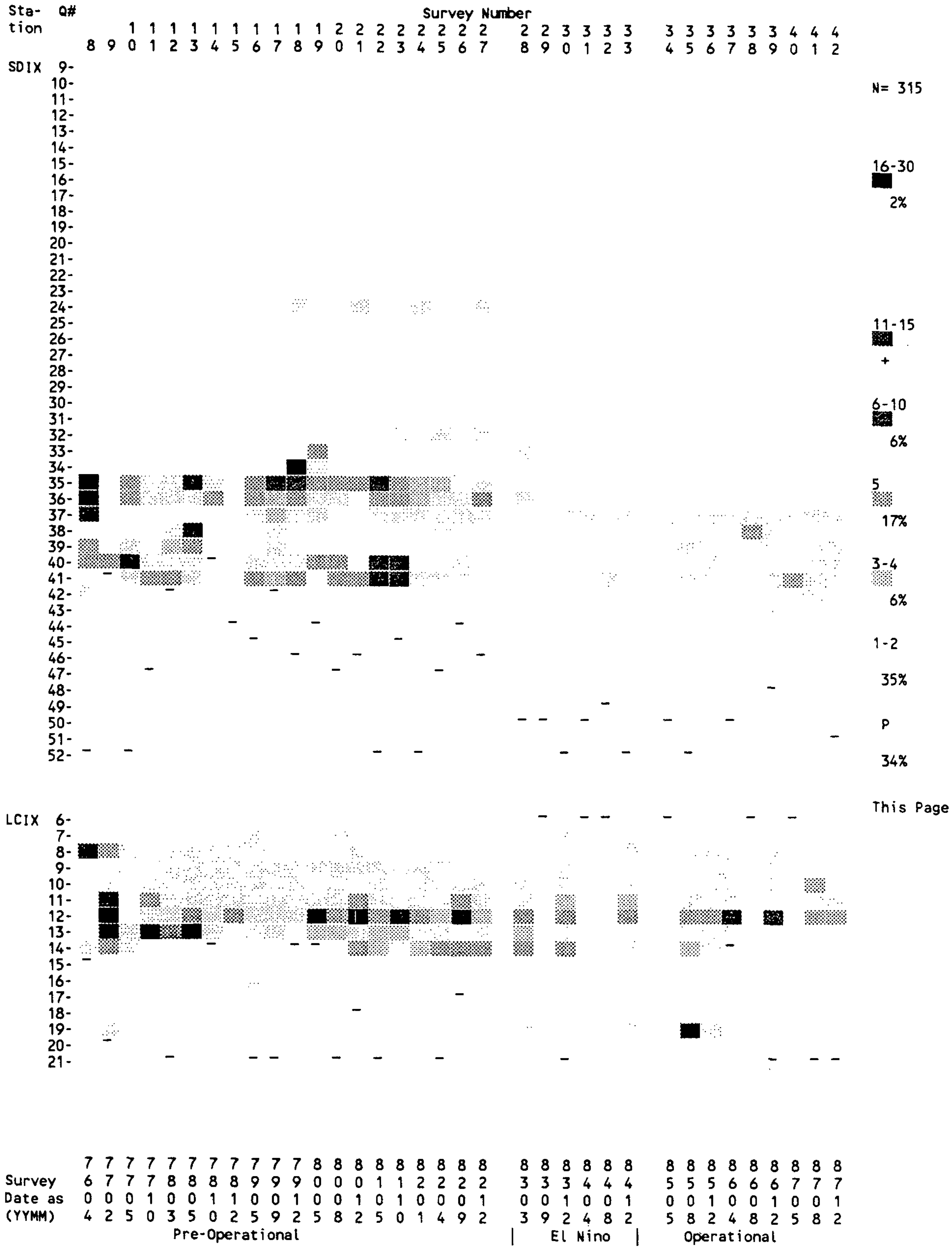


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGAGA CSV 5408 3-29-88 7:30a 04-14-1989 09:44

Taxon or Category: Gigartina agardhii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGAGA CSV 5408 3-29-88 7:30a 04-14-1989 09:44

Audit: CLUMRG2P: V.1.2: for SGIGAGA CLU 6581 4-22-89 8:38a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:25:57 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Gigartina agardhii: TOTAL Quads with Data = 204

Quad Range USED 12 to 39 for Total of 28 : Range WITH data 12 to 41: : # Dropped 21 : 10.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.643739: Maximum Distance = 477

```
S27-8212  -------------------------------------------------------II
S33-8412  ------------------------------------------I------------II---I
S36-8512  ------------------------------------------I             I   I-----I
S28-8303  --------------------------------------------------------I   I     I------I
S34-8505  ------------------------------------------------------------I     I      I--------I
S32-8408  ------------------------------------------------------------------I      I        I
S29-8309  -------------------------------------------------------------------I-----I        I----------------I
S30-8312  ---------------------------------------------------------------I---I              I                I
S31-8404  ---------------------------------------------------------------I                  I                I
S35-8508  ----------------------------------------------------------------------------------I                I------
S37-8604  -----------------I                                                                                 I
S39-8612  -------I         I-I                                                                               I
S40-8705  -------I-------I I I                                                                               I
S42-8712  -------I       I-I I-------------------------------------------------------------------------------I
S41-8708  ---------------I   I
S38-8608  -------------------I
```

Station: NDIX: Gigartina agardhii: TOTAL Quads with Data = 377

Quad Range USED 8 to 23 for Total of 16 : Range WITH data 5 to 27: : # Dropped 33 : 8.8%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.746126: Maximum Distance = 1009

```
S 8-7604  ---------------------------------------------------------------------------------------------------I
S 9-7702  --------------------------------I--I                                                               I
S12-7803  --------------------------------I  I                                                               I
S11-7710  ------------------I---I            I                                                               I
S27-8212  ------------------I   I------I     I---------I                                                     I
S15-7812  ---------------I-----II      I     I         I                                                     I
S25-8204  ---------------I     II      I--I  I         I                                                     I
S28-8303  ---------------------I       I  II I         I                                                     I
S24-8201  -----------------------------I  II-I         I--I                                                  I
S22-8105  --------------------------------II           I  I                                                  I
S13-7805  --------------------------I------I           I  I                                                  I
S18-7912  --------------------------I                  I  I-----I                                            I
S19-8005  ----------------------------------I----------I  I     I                                            I
S26-8209  ----------------------------------I             I     I                                            I------
S16-7905  ----------------------------------I-------------I     I                                            I
S21-8012  ---------------------------I------I                   I                                            I
S23-8110  ---------------------------I                          I                                            I
S14-7810  --------------I----------I                            I                                            I
S17-7909  --------------I          I                            I                                            I
S30-8312  ---------I--------I      I--------I                   I-----------I                                I
S33-8412  ---------I        I      I        I                   I           I                                I
S34-8505  -----------I--I   I      I        I                   I           I                                I
S38-8608  -----------I  I   I------I        I                   I           I                                I
S36-8512  --I           I   I               I                   I           I                                I
S37-8604  -II           I   I               I-------I           I           I                                I
S41-8708  -III          I---I               I       I           I           I                                I
S39-8612  -III----------I                   I       I           I           I--------------------------------I
S40-8705  --II          I                   I       I-----------I           I
S42-8712  ---I          I                   I       I                       I
S35-8508  --------------I                   I       I                       I
S20-8008  ----------------------------------I       I                       I
S29-8309  ---------------------------------I--------I                       I
S31-8404  --------------------I------------I                                I
S32-8408  --------------------I                                             I
S10-7705  ------------------------------------------------------------------I
```

Station: SDIX: Gigartina agardhii: TOTAL Quads with Data = 140

Quad Range USED 26 to 42 for Total of 17 : Range WITH data 24 to 46: : # Dropped 25 : 17.9%
Surveys 31 : Dropped 4 Surveys if quads sampled < 42
COPHENETIC CORRELATION COEFFICIENT = 0.938560: Maximum Distance = 548

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  ----------------------------------------------------------------------------------------I
S10-7705  ---------------------------I---------------I                                            I
S22-8105  ------------I--------------I               I                                            I
S23-8110  ------------I                              I                                            I
S11-7710  --------I--------I                         I                                            I
S40-8705  --------I        I                         I                                            I
S15-7812  I-I              I                         I                                            I
S29-8309  I II             I                         I                                            I
S30-8312  I-II             I                         I                                            I
S37-8604  I  I--I          I                         I                                            I
S31-8404  ---I  I          II                        I                                            I----------I
S33-8412  ---I  I-I        II                        I                                            I          I
S32-8408  ---II I I        II                        I                                            I          I
S39-8612  ---II I I        II                        I--I                                         I          I
S34-8505  --I-I-I II       II                        I  I                                         I          I
S36-8512  I-I I   II       II                        I  I                                         I          I
S42-8712  I   I   II       II-I                      I  I                                         I          I
S35-8508  ----I   II-------II I                      I  I                                         I          I
S26-8209  -------III        I I                      I  I                                         I          I
S28-8303  -------I I        I I                      I  I                                         I          I
S41-8708  ---------I        I I------I               I  I                                         I          I
S24-8201  ---------I--I     I I      I               I  I-----------------------------------------I          I------
S25-8204  ---------I  I-----I I      I               I  I                                                    I
S27-8212  ------------I       I      I----I          I  I                                                    I
S38-8608  --------------------I      I    I          I  I                                                    I
S16-7905  -----------------I-I       I    I----------I  I                                                    I
S20-8008  -----------------I I-------I    I             I                                                    I
S21-8012  -------------------I            I             I                                                    I
S19-8005  --------------------------------I             I                                                    I
S13-7805  ----------------------------------------------I                                                    I
S18-7912  ---------------------------------------------------------------------------------------------------I
```

Station: LCIX: Gigartina agardhii: TOTAL Quads with Data = 175

Quad Range USED 8 to 17 for Total of 10 : Range WITH data 7 to 19: : # Dropped 42 : 24.0%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.860769: Maximum Distance = 185

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ------------------------------------------------------I---------------------------------------------I
S21-8012  ------------------------------------------------------I                                             I
S10-7705  ------------------I-------I                                                                         I
S16-7905  -----------I------I       I----------I                                                              I
S17-7909  -----------I              I          I                                                              I
S12-7803  --------------------------I          I                                                              I
S15-7812  ----I--------------I                 I                                                              I
S42-8712  ----I              I--I              I                                                              I
S20-8008  -------------------I  I-----I        I                                                              I
S33-8412  ----------------I-----I     I        I------------------I                                           I------
S35-8508  --------------I-I           I-I      I                  I                                           I
S36-8512  --------------I             I I      I                  I                                           I
S23-8110  ---------------------I------I I      I                  I                                           I
S39-8612  ---------------------I        I-I    I                  I                                           I
S22-8105  ----------I--I                I I    I                  I                                           I
S24-8201  ----------I  I--I             I I    I                  I-----------------------------------------I I
S28-8303  -------------I  I-I           I I----I                  I                                         I I
S30-8312  ----------------I I-----------I I                       I                                         I I
S25-8204  --------I---------I             I                       I                                         I-I
S27-8212  --------I                       I                       I                                         I
S41-8708  --------------------------------I                       I                                         I
S11-7710  --------------------------------------------------------I                                         I
S13-7805  --------------------------------------------------------------------------------------------------I
```

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Gigartina canaliculata (Harvey, 1841) Ref. AH, 1976. p 518.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Densely bushy clumps, blades flattened and divided, reddish-brown, olive-green, green, to almost black when dry. 5 - 25+ cm tall.

Distribution: Southern Oregon to Isla Magdalena (Baja California). Locally abundant mid to lower intertidal. A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 30% of our quadrats in covers up to 90%.

Habitat: On rock (sometimes cobble), tops, and sides, mid to low intertidal. Usually covering large areas, often intermingled with *Gastroclonium coulteri*, and other algae; often overlain by *Iridaea* and other overstory algae.

Observational Errors: Infrequently mis-identified (see below). Missed observations occur about <3% of the time due to small isolated bladelets or small clumps mixed with *Gastroclonium coulteri*, and quadrat boundary errors.

Field Identification Problems:

General: When occurring as small bladelets possibly confused with *Gastroclonium coulteri*, or *Gigartina leptorhynchos*.

Station Specific: n.a.

General Comments: Can trap moderate amounts of sand/gravel/shell debris and can harbor small animal nestlers.

Impacts to Taxon:

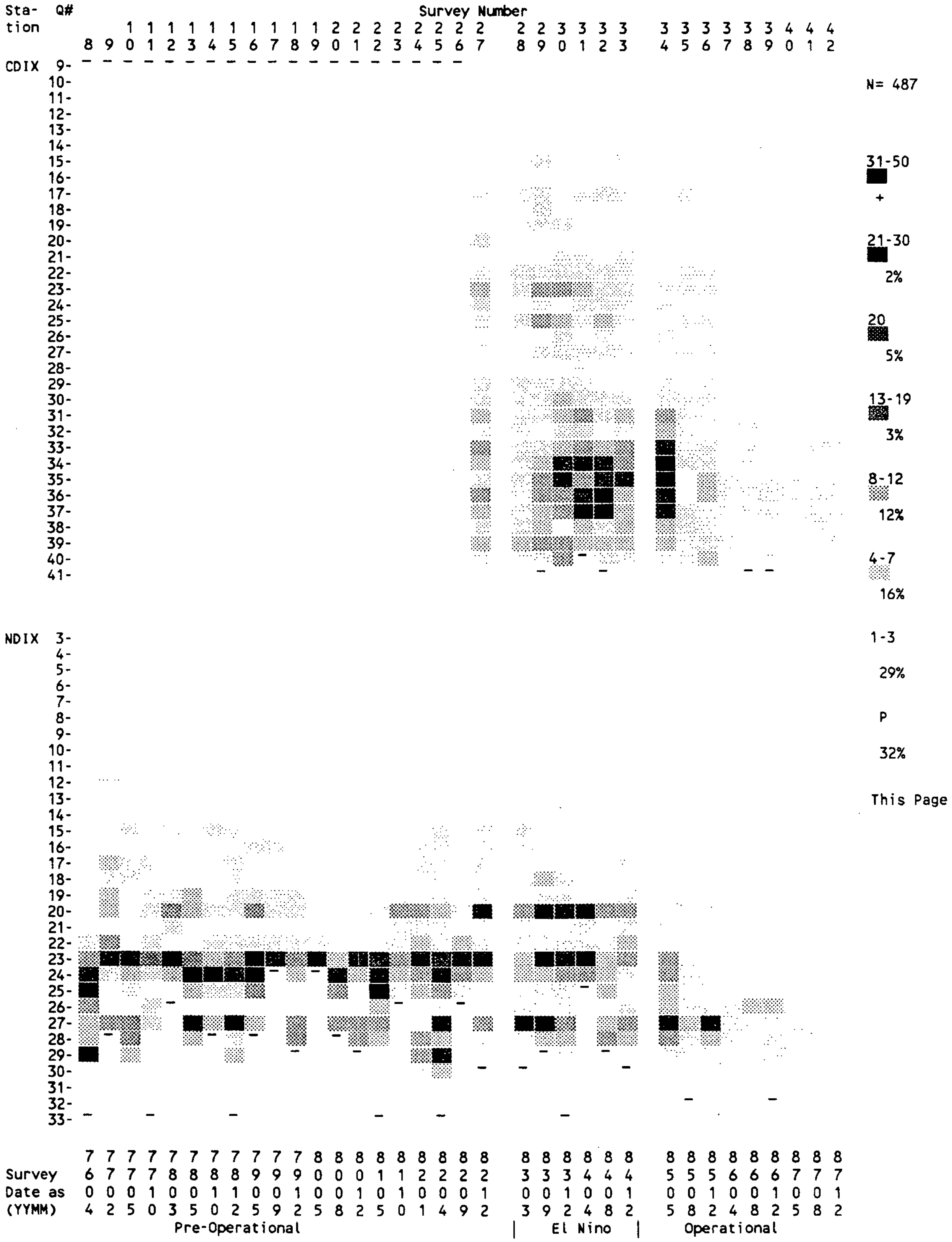
El Niño: 1982-83 winter storm: Reduction in occurrences (by 25%) and covers (to <5%) at SDIX (cobble overlay, and removal of growth and of boulders). NDIX and CDIX with normal occurrence, probably slight reduction of covers. LCIX with lost occurrence in only one quadrat, probably storm wave removal, with somewhat reduced covers in the upper part of its range.

El Niño: 1983-1984: SDIX recovered rapidly, covers began declining in Autumn 1984, especially at upper limit of range but remained within normal limits. NDIX similar to SDIX. CDIX similar to SDIX and NDIX, but covers in the lower ranges here were slowly increasing (above covers found in the single pre-El Niño survey). LCIX also with decreasing covers at the upper part of range and losing one occurrence there.

Diablo DCPP Operation: SDIX with occurrences extending downward in the intertidal (but only in covers <10%). Occurrences and covers at upper part of range declined from May 1986 onward. NDIX much as SDIX but upper range decline starting sooner (Autumn 1983). CDIX with increasing covers (as El Niño period), but abrupt decline in occurrences and covers in Autumn 1985, some recovery in Winter 1985, but with greatly reduced covers and occurrences from May 1986 onward, only present at the lowest levels. LCIX essentially normal, but covers at upper limits of range below pre-El Niño levels.

Taxon or Category: Gigartina canaliculata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

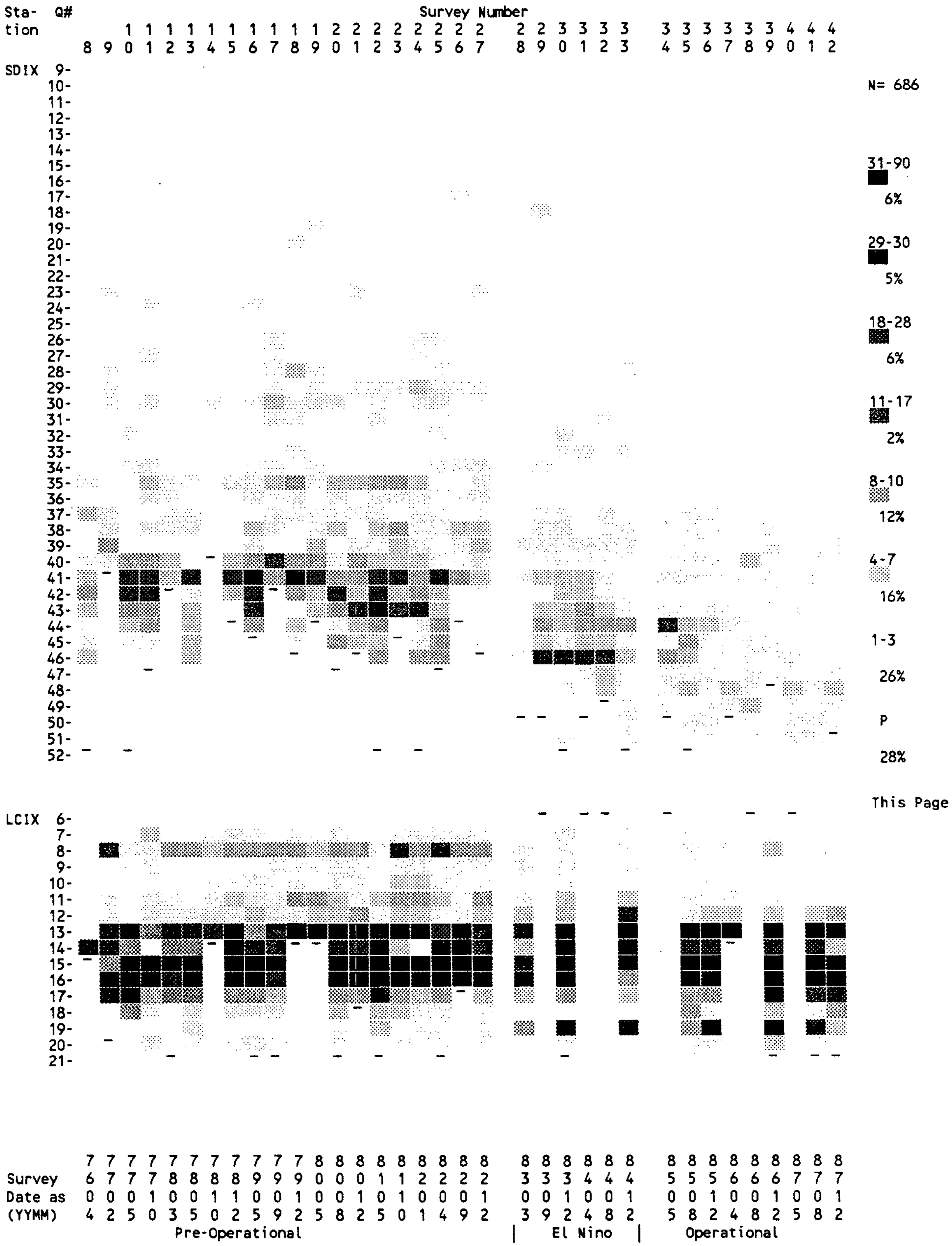


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGCAN CSV 5797 3-29-88 7:30a 04-14-1989 09:44

Taxon or Category: Gigartina canaliculata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGCAN CSV 5797 3-29-88 7:30a 04-14-1989 09:44

Audit: CLUMRG2P: V.1.2: for SGIGCAN CLU 6163 4-22-89 8:48a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:41:47 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Gigartina canaliculata: TOTAL Quads with Data = 204

Quad Range USED 17 to 39 for Total of 23 : Range WITH data 14 to 40: : # Dropped 14 : 6.9%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.779506: Maximum Distance = 959

```
S27-8212  -------------------------------------I-----------I
S29-8309  -------------------------------------I           I---------I
S30-8312  -----------------------------------------I-------I         I
S33-8412  -----------------------------------------I                 I-----------------------------------------I
S28-8303  --------------------I--I                                   I                                         I
S36-8512  --------------------I  I-----------------------------------I                                         I
S35-8508  -----------I           I                                                                             I
S37-8604  --I        I-----------I                                                                             I
S39-8612  --I-I      I                                                                                         I------
S40-8705  --I I------I                                                                                         I
S42-8712  ----I                                                                                                I
S38-8608  --I-I                                                                                                I
S41-8708  --I                                                                                                  I
S31-8404  ---------------------------------------------I------------------------------I                        I
S32-8408  ---------------------------------------------I                              I------------------------I
S34-8505  ----------------------------------------------------------------------------I
```

Station: NDIX: Gigartina canaliculata: TOTAL Quads with Data = 283

Quad Range USED 15 to 27 for Total of 13 : Range WITH data 12 to 31: : # Dropped 75 : 26.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.729200: Maximum Distance = 565

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------------I-------------------------------------------------I
S22-8105  ---------------------------------------------------I                                                 I
S 9-7702  --------------------------------I                                                                    I
S11-7710  -----------------------I-I      I--I                                                                 I
S18-7912  -----------------------I I------I  I                                                                 I
S32-8408  -----------------------I-I         I---I                                                             I
S33-8412  -----------------------I           I   I                                                             I
S10-7705  --------I--------------------------I   I---I                                                         I
S21-8012  --------I                              I   I                                                         I
S24-8201  ---------------------------------------I   I--I                                                      I
S15-7812  -------------------------I---------I       I  I                                                      I------
S34-8505  -------------------------I         I-------I  I                                                      I
S28-8303  ----------------------------I------I          I--------------I                                       I
S36-8512  ----------------------------I                 I              I                                       I
S35-8508  -------------I                                I              I                                       I
S37-8604  ---II        I--------------------------------I              I                                       I
S40-8705  -I-II------I I                                               I                                       I
S41-8708  -I  I      I-I                                               I------I                                I
S42-8712  ----I      I                                                 I      I                                I
S38-8608  -I---------I                                                 I      I                                I
S39-8612  -I                                                           I      I                                I
S27-8212  ----------------I--------------I                             I      I--------------------------------I
S30-8312  ----------------I              I-----------------------------I      I
S29-8309  -------------------------------I                                    I
S13-7805  ---------------------------------I-----I                            I
S14-7810  -------------------------------I-I     I-----------------I          I
S20-8008  -------------------------------I       I                 I----------I
S25-8204  ---------------------------------------I                 I
S16-7905  ---------------------------------------------------------I
```

Station: SDIX: Gigartina canaliculata: TOTAL Quads with Data = 374

Quad Range USED 28 to 44 for Total of 17 : Range WITH data 17 to 51: : # Dropped 157 : 42.0%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.744582: Maximum Distance = 476

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  -------------------------------------------------I
S27-8212  --------------------------------------I          I
S28-8303  --------II                            I          I
S39-8612  -----I--II                            I-I        I
S41-8708  ---I-I   I--I                         I I        I-------------------------------------------------I
S42-8712  ---I     I  I--------I                I I        I                                                 I
S37-8604  ---------I  I        I----------------I I        I                                                 I
S40-8705  ------------I        I                  I        I                                                 I
S38-8608  ---------------------I                  I--------I                                                 I
S29-8309  -----------------I-------I              I                                                          I
S32-8408  -----------------I       I-----I        I                                                          I
S33-8412  ----------------I--------I     I        I                                                          I
S35-8508  ------I---------I              I--I     I                                                          I
S36-8512  ------I                        I  I-----I                                                          I
S34-8505  -------------------------------I  I                                                                I------
S30-8312  ----------------------I-----------I                                                                I
S31-8404  ----------------------I                                                                            I
S10-7705  -------------------------I------------------------I                                                I
S11-7710  -------------------------I                        I--------------I                                 I
S16-7905  --------------------------------------------------I              I--------I                        I
S20-8008  -----------------------------------------------------------------I        I----------I             I
S13-7805  -------------------------------I---------------------------------------I  I          I             I
S25-8204  -------------------------------I                                       I--I          I             I
S21-8012  ---------------------------------I--------------------------I          I             I---I         I
S24-8201  ---------------------------------I                          I----------I             I   I         I
S23-8110  ------------------------------------------------------------I                        I   I---------I
S22-8105  -------------------------------------------------------------------------------------I   I
S18-7912  -----------------------------------------------------------------------------------------I
```

Station: LCIX: Gigartina canaliculata: TOTAL Quads with Data = 313

Quad Range USED 7 to 19 for Total of 13 : Range WITH data 6 to 22: : # Dropped 66 : 21.1%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.613255: Maximum Distance = 865

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ------------------------------------------------I-----I
S11-7710  ------------------------------------I-----------I     I
S12-7803  ------------------------------I-----I                 I
S28-8303  ------------------------------I                       I
S10-7705  -----------------------I-------I                      I------------I
S42-8712  -----------------------I       I-------I              I            I
S20-8008  -------------------------------I       I----I         I            I
S35-8508  ---------------------------------I-----I    I------I  I            I
S41-8708  ---------------------------------I          I      I  I            I
S23-8110  -------------------------------I------------I      I--I            I-----I
S24-8201  -------------------------------I                   I               I     I
S13-7805  --------------------------I----I                   I               I     I
S16-7905  --------------------------I    I-------------------I               I     I
S17-7909  -----------------I-------------I                                   I     I-------------------------I
S27-8212  -----------------I                                                 I     I                         I
S30-8312  ------------------------------------------------------I------------I     I                         I
S33-8412  ------------------------------------------------------I                  I                         I------
S15-7812  ------------------------------------------------------------I------------I                         I
S22-8105  ---------------------------------I--------------------------I                                      I
S25-8204  ---------------------------------I                                                                 I
S36-8512  -----------------------------------------------------------------------I---------------------------I
S39-8612  -----------------------------------------------------------------------I
```

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Gigartina exasperata/corymbifera (Turkish-towel alga). Ref. AH, 1976. p 518ff.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Large crisp blades, mature blade covered with papules on both sides, brownish-red to yellowish-pink, to 1+ m long and 0.3 m wide.

Distribution: (see below). Common, low intertidal to subtidal (20-30 m). A warm-tolerant group.

Diablo Area Specific Information: Moderately common, occurring in about 10% of our quadrats in covers up to 80%.

Habitat: On rock, tops, and sides, low intertidal (mid intertidal at LCIX). Occasionally covering large areas and, where abundant, usually not intermingled with other algae. Sometimes eroded to stubs.

Observational Errors: Infrequently mis-identified (see below). Missed observations occurred about <5% of the time when eroded to basal portions, or occurrences of small isolated bladelets or small clumps of plants mixed with algal mat, and because of quadrat boundary errors.

Field Identification Problems:

General: These two taxa were separately identified in the field, but the distinguishing characteristic was color difference (i.e., *G. corymbifera* is usually yellowish, while *G. exasperata* is usually much redder), but there were specimens with intermediate appearances. Juveniles of both appear similar in color and were usually identified as *G. exasperata*. We therefore combined the two species for our analysis.

Station Specific: n.a.

General Comments: none.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX with total removal (cobble overlay/or removal of growth). NDIX and CDIX with small reduction in occurrence, covers probably normal. LCIX with reduced occurrences (about 60% of normal) throughout range (one boulder removed and removal by storms) and with somewhat reduced covers for upper part of range.

El Niño: 1983-1984: SDIX with sharp recovery towards end of 1983, with above normal occurrences (extending downward in the intertidal and where dense covers occurred) followed by slowly declining covers except at lowest part of intertidal. NDIX rapidly returned to normal conditions (winter 1983 survey with 2 missing occurrences, possibly overlooked by us) then slowly declining in covers until end of 1984, possibly to below normal. CDIX probably normal. LCIX recovered rapidly, but then with reduced occurrences for winter of 1984 (possibly missed observations?).

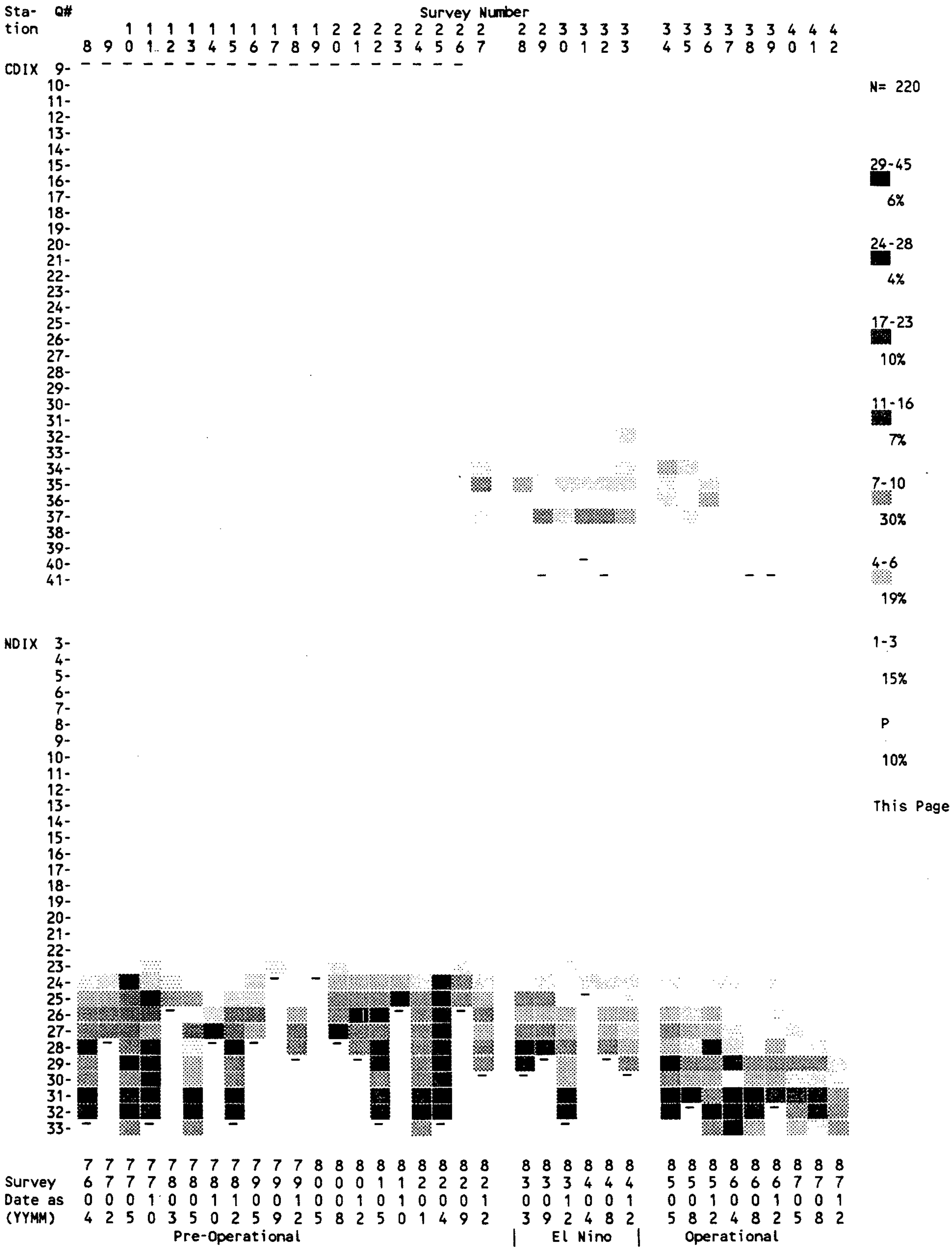
Diablo DCPP Operation: SDIX with occurrences gained in the lowest parts of range during El Niño remaining with high covers (possibly declining slightly towards end of 1987), but losing 3 occurrences at upper part of range. NDIX slowly losing occurrences at upper part of range (4 by end of 1987) and with below-normal covers in other quadrats (this group always extended to end of transect). CDIX with sporadic occurrences (possibly missed observations) but disappeared from transect by May 1986. LCIX losing occurrences (sporadic at upper parts of range) and possibly subnormal covers.

Gigartina corymbifera: Washington to Cabo San Quintin (Baja California).

Gigartina exasperata: Vancouver Island (British Columbia) to Punta Maria (Baja California).

Taxa or Category: Gigartina exasperata +G. corymbifera

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

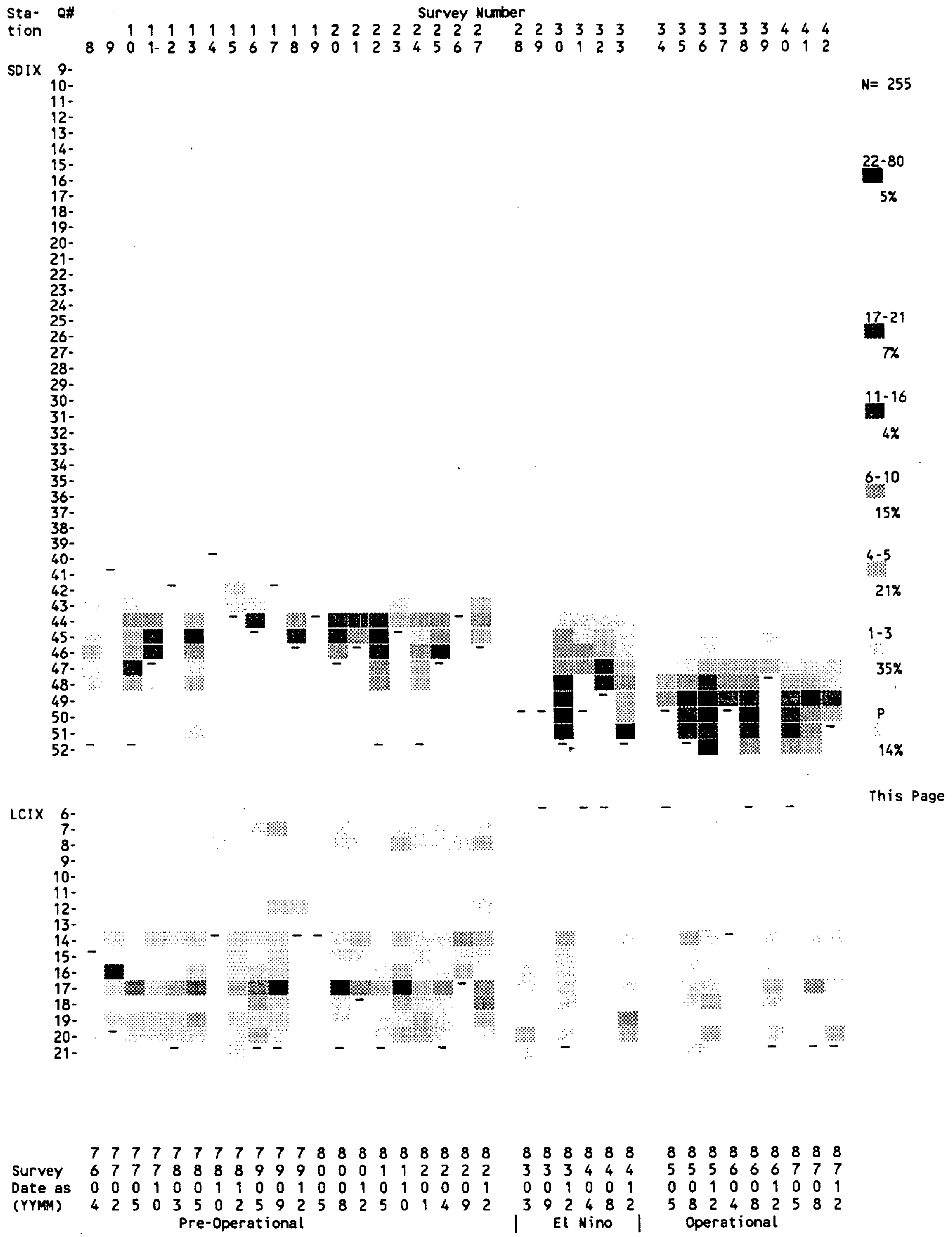


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGEAC CSV 5404 9-30-88 7:33a 04-14-1989 09:45

Taxa or Category: Gigartina exasperata +G. corymbifera

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGEAC CSV 5404 9-30-88 7:33a 04-14-1989 09:45

Audit: CLUMRG2P: V.1.2: for SGIGEAC CLU 5829 4-22-89 8:55a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:50:32 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Gigartina exasperata +G. corymbifera: TOTAL Quads with Data = 22

Quad Range USED 34 to 37 for Total of 4 : Range WITH data 32 to 37: : # Dropped 1 : 4.5%
Surveys 16 : Dropped 0 Surveys if quads sampled < 37
COPHENETIC CORRELATION COEFFICIENT = 0.765687: Maximum Distance = 37

```
S27-8212  ---------------------------------------------I---------------------------------------I
S28-8303  ---------------------------------------------I                                       I
S30-8312  ------------------------------I                                                      I
S35-8508  -----------------------I      I----------------------------------I                   I
S37-8604  I                      I------I                                  I                   I------------I
S38-8608  I                      I                                         I                   I            I
S39-8612  I----------------------I                                         I--I                I            I
S40-8705  I                                                                I  I                I            I
S41-8708  I                                                                I  I----------------I            I
S42-8712  I                                                                I  I                             I------
S34-8505  -----------------------------------------------------------------I  I                             I
S36-8512  --------------------------------------------------------------------I                             I
S29-8309  ------------------------------I-----I                                                             I
S31-8404  ------------------------------I     I--------I                                                    I
S32-8408  ------------------------------------I        I----------------------------------------------------I
S33-8412  ---------------------------------------------I
```

Station: NDIX: Gigartina exasperata +G. corymbifera: TOTAL Quads with Data = 198

Quad Range USED 23 to 27 for Total of 5 : Range WITH data 20 to 33: : # Dropped 114 : 57.6%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.845498: Maximum Distance = 185

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  --I---------I
S 9-7702  --I         II
S24-8201  ------------II--------I
S28-8303  -------I-----I        I
S29-8309  -------I              I
S15-7812  -------I----I         I---I
S18-7912  ----I--I    I         I   I
S34-8505  ----I       I---I     I   I
S30-8312  ----I-I     I   I     I   I
S32-8408  --I-I I-----I   I-----I   I---I
S36-8512  --I   I         I         I   I
S33-8412  ------I         I         I   I
S16-7905  ----------I-----I         I   I
S27-8212  ----------I               I   I-------------I
S13-7805  ------------------------I-I   I             I
S14-7810  ------------------------I     I             I
S35-8508  -------I----I                 I             I
S40-8705  -------I    I                 I             I
S37-8604  ---I        I-----------------I             I------------I
S38-8608  I  I        I                               I            I
S41-8708  I--I--------I                               I            I
S42-8712  I  I                                        I            I
S39-8612  ---I                                        I            I-----------------------------------------I
S11-7710  -----------------------------------I--------I            I                                         I
S20-8008  --------------------------------I--I                     I                                         I
S21-8012  I-------------------------------I                        I                                         I------
S22-8105  I                                                        I                                         I
S10-7705  ---------------------------------------------------------I                                         I
S25-8204  ---------------------------------------------------------------------------------------------------I
```

Station: SDIX: Gigartina exasperata +G. corymbifera: TOTAL Quads with Data = 117

Quad Range USED 43 to 45 for Total of 3 : Range WITH data 42 to 54: : # Dropped 84 : 71.8%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.859813: Maximum Distance = 72

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209: <-End   Dropped Surveys
S 8-7604 --------I
S28-8303 I       I
S29-8309 I       I
S34-8505 I       I-I
S35-8508 I       I I
S37-8604 I--I    I I
S38-8608 I  I    I I
S40-8705 I  I----I I---------I
S41-8708 I  I      I         I
S42-8712 I  I      I         I
S36-8512 I--I      I         I-------------------------I
S39-8612 I         I         I                         I
S33-8412 ----------I         I                         I
S31-8404 -------I------------I                         I
S32-8408 -------I                                      I-----------------------------------------------------I
S10-7705 --------I-------------I                       I                                                     I
S24-8201 --------I             I---I                   I                                                     I
S25-8204 ----------------------I   I-------------I     I                                                     I
S27-8212 --------------------------I             I-----I                                                     I------
S11-7710 -----------------------------I----------I                                                           I
S30-8312 -----------------------------I                                                                      I
S13-7805 ---------------------------------------------------I-I                                              I
S18-7912 ------------------------I--------------------------I I------------------I                           I
S20-8008 ------------------------I                            I                  I---------------------------I
S22-8105 -----------------------------------------------------I                  I
S21-8012 ------------------------------------------------------------------------I
```

Station: LCIX: Gigartina exasperata +G. corymbifera: TOTAL Quads with Data = 145

Quad Range USED 7 to 20 for Total of 14 : Range WITH data 7 to 24: : # Dropped 24 : 16.6%
Surveys 21 : Dropped 8 Surveys if quads sampled < 20
COPHENETIC CORRELATION COEFFICIENT = 0.706647: Maximum Distance = 225

```
S 8-7604: <-Start Dropped Surveys
S 9-7702:
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End   Dropped Surveys
S10-7705 --------------------I-----------I
S41-8708 --------------------I           I-----I
S13-7805 ----------------------I---------I     I
S25-8204 ----------------------I               I----------------I
S11-7710 -----------------------------I        I                I
S12-7803 ----------I-------I          I--------I                I
S22-8105 ----------I       I----I     I                         II
S15-7812 ------------------I    I-----I                         II
S39-8612 -----------------------I                               II----I
S16-7905 -------------------------------------------------------II    I
S28-8303 ---------------I----------------------------------I     I    I
S42-8712 ---------------I                                  I-----I    I---------------------------------------I
S30-8312 -------------------I----------------------I       I          I                                       I
S35-8508 -------------------I                      I-------I          I                                       I
S36-8512 ------------------------------------------I                  I                                       I
S24-8201 --------------------------------------------I----------------I                                       I------
S33-8412 --------------------------------------------I                                                        I
S17-7909 ----------------------------------------I---------------------------I                                I
S20-8008 ----------------------------------------I                           I------------------I             I
S23-8110 --------------------------------------------------------------------I                  I-------------I
S27-8212 ---------------------------------------------------------------------------------------I
```

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Gigartina leptorhynchos J. Agardh, 1885. Ref. AH, 1976. p 523.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Moderately slender blades often with dense fine papillae resulting in hirsute appearance, dark-brown to blackish. 10 to 15 + cm tall.

Distribution: Humboldt Co. (California) to Isla Cedros (Baja California). Locally common, lower-mid intertidal. A warm-tolerant species.

Diablo Area Specific Information: Fairly common, occurring in about 10% of our quadrats normally at covers <1%, rarely up to 20%. An ephemeral species.

Habitat: On rock and cobble, tops, and sides, mid to low intertidal.

Observational Errors: Infrequently mis-identified (see below). Missed observations not evaluated (ephemeral species) but could occur for small bladelets or small clumps plants mixed with algal mat.

Field Identification Problems:

General: Possibly juvenile plants of *Gigartina canaliculata*, *Gelidium coulteri*, and *Cryptosiphonia woodii* could possibly be mistaken for this species.

Station Specific: n.a.

General Comments: SDIX was the only station prior to El Niño where this taxon occurred frequently although sporadically.

Impacts to Taxon:

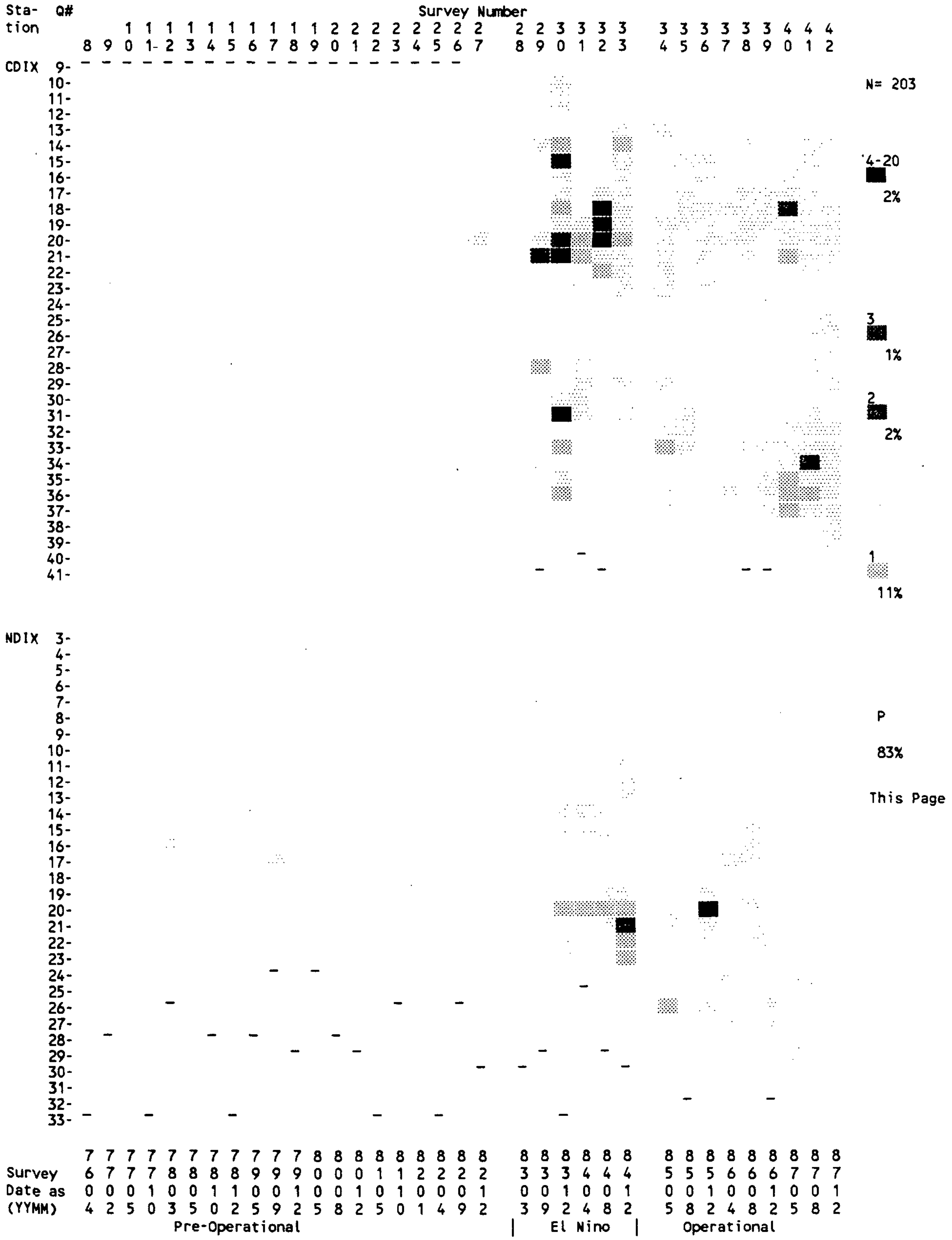
El Niño: 1982-83 winter storm: SDIX greatly reduced in occurrences compared to survey immediately preceding, but within normal limits. Not a normal part of the flora at other stations.

El Niño: 1983-1984: Within normal limits at mid tidal ranges at SDIX, but much higher than normal in occurrences and covers due to a large "bloom" at the lower intertidal. At NDIX and CDIX developing populations at mid and lower intertidal. LCIX normal.

Diablo DCPP Operation: SDIX with sporadic occurrences throughout range, covers declining from El Niño conditions rapidly back towards normal. NDIX much as SDIX, possibly returning to normal by December 1987 (i.e., very few occurrences). CDIX maintaining El Niño conditions and gaining a sporadic but perhaps stable population at lower tidal levels. Absent at LCIX, which was normal.

Taxon or Category: Gigartina leptorhynchos

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

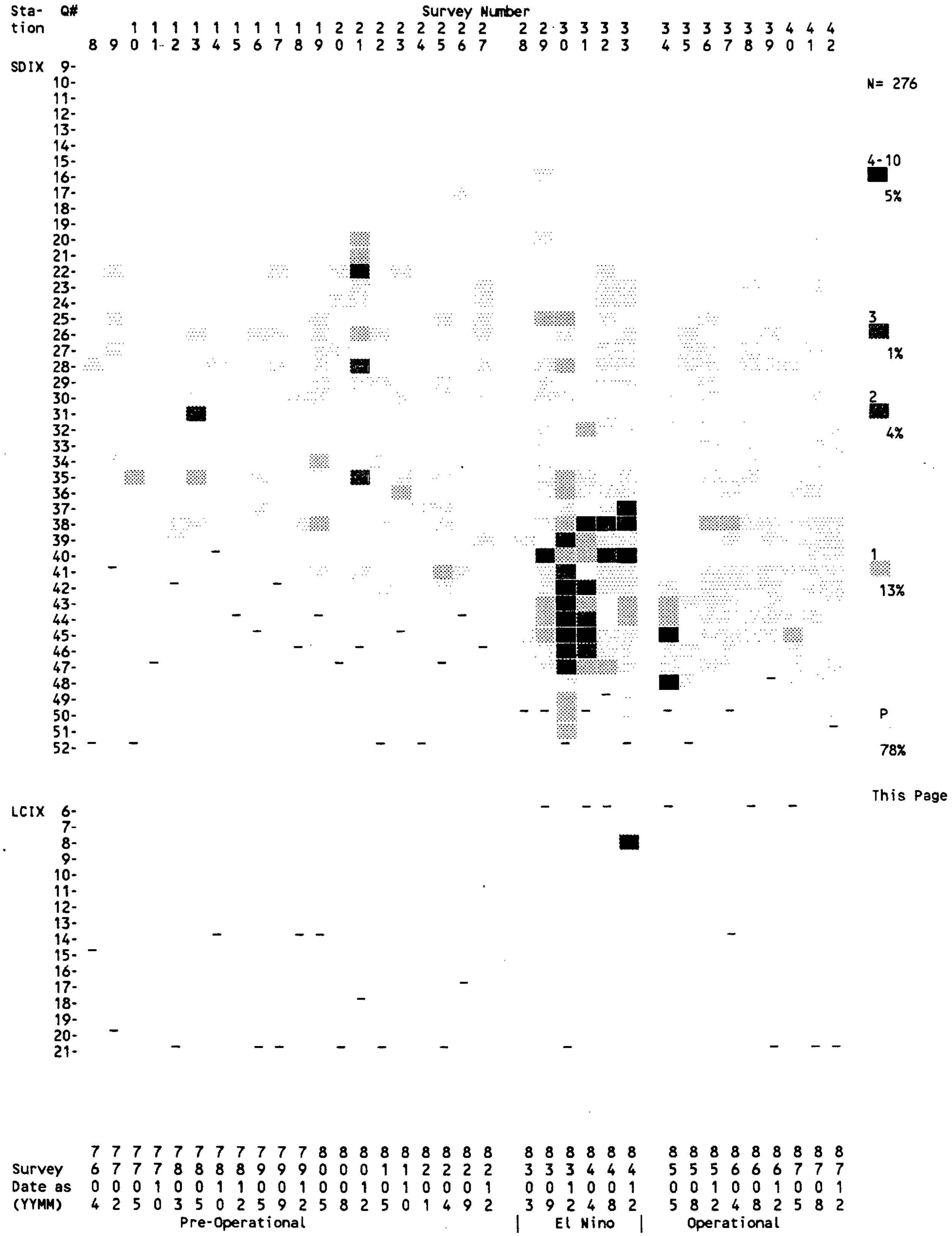


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGLEP CSV 5711 3-29-88 7:31a 04-14-1989 09:45

Taxon or Category: Gigartina leptorhynchos

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGLEP CSV 5711 3-29-88 7:31a 04-14-1989 09:46

Audit: CLUMRG2P: V.1.2: for SGIGLEP CLU 6163 4-22-89 9:01a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/08:57:46 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Gigartina leptorhynchos: TOTAL Quads with Data = 138

Quad Range USED 14 to 39 for Total of 26 : Range WITH data 10 to 39: : # Dropped 5 : 3.6%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.911737: Maximum Distance = 524

```
S27-8212  ----I--I
S28-8303  ----I  I---I
S37-8604  -------I   II
S36-8512  -----------III
S35-8508  -----------III--I
S38-8608  -----------I I  I-I
S39-8612  -------------I  I II
S34-8505  ----------------I II-I
S33-8412  ------------------II I
S41-8708  ----------------I--I I----I
S42-8712  ----------------I    I    I
S29-8309  ---------------I-----I    I--------------------I
S31-8404  ---------------I          I                    I-----------------------------------------------------I
S40-8705  --------------------------I                    I                                                     I------
S30-8312  -----------------------------------------------I                                                     I
S32-8408  -----------------------------------------------------------------------------------------------------I
```

Station: NDIX: Gigartina leptorhynchos: TOTAL Quads with Data = 65

Quad Range USED 14 to 27 for Total of 14 : Range WITH data 11 to 30: : # Dropped 12 : 18.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.951309: Maximum Distance = 83

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  I
S 9-7702  I
S10-7705  I
S11-7710  I
S13-7805  I
S14-7810  I
S15-7812  I
S16-7905  I
S18-7912  I---------------I
S20-8008  I               I
S21-8012  I               I
S22-8105  I               I
S24-8201  I               I-----------I
S25-8204  I               I           I
S27-8212  I               I           I
S28-8303  I               I           II
S35-8508  I               I           II
S29-8309  ----------------I           II----I
S39-8612  -----------------------I----II    I
S42-8712  -----------------------I     I    I-------I
S37-8604  -----------------------------I    I       I
S40-8705  ----------------I-----------------I       I---I
S41-8708  ----------------I                         I   I
S34-8505  ------------------------------------------I   I----------------------I
S30-8312  ---------------------------------I------I     I                      I
S32-8408  ---------------------------------I      I-----I                      I-----------------------------I
S38-8608  ----------------------------------------I                            I                             I------
S33-8412  ---------------------------------------------------------------------I                             I
S36-8512  ---------------------------------------------------------------------------------------------------I
```

Station: SDIX: Gigartina leptorhynchos: TOTAL Quads with Data = 275

Quad Range USED 20 to 44 for Total of 25 : Range WITH data 16 to 51: : # Dropped 70 : 25.5%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.916389: Maximum Distance = 341

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  ------I-I
S11-7710  ------I I--I
S24-8201  --------I  I--I
S28-8303  --------I  I  II
S18-7912  -----------I  II
S20-8008  --------------II--I
S10-7705  ------------I--I  I
S16-7905  ------------I  I  II
S35-8508  ---------------I  II-I
S22-8105  ------------------II I-I
S27-8212  -------------------I I I
S23-8110  ---------------------I II
S37-8604  --------------II       II
S40-8705  --------------II-----I II
S39-8612  ---------------I     I-II-I
S41-8708  --------------------II  I I
S42-8712  --------------------I   I I
S13-7805  ------------------------I I--------I
S25-8204  ---------------------I----I        I
S36-8512  -----------------I---I    I        I--I
S38-8608  -----------------I        I        I  I
S34-8505  --------------------------I        I  I--------------------------------------------I
S29-8309  -----------------------------------I  I                                            I
S21-8012  --------------------------------------I                                            I-------------I
S31-8404  -------------------------------------------------I----------I                      I             I
S32-8408  -------------------------------------------------I          I----------------------I             I------
S33-8412  ------------------------------------------------------------I                                    I
S30-8312  -------------------------------------------------------------------------------------------------I
```

Station: LCIX: Gigartina leptorhynchos: TOTAL Quads with Data = 1:**** Prob. INSUFFICIENT Data ****

Quad Range USED 8 to 8 for Total of 1 : Range WITH data 8 to 8: : # Dropped 0 : 0.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 8
COPHENETIC CORRELATION COEFFICIENT = 0.997365: Maximum Distance = 2

```
S 8-7604  I
S 9-7702  I
S10-7705  I
S11-7710  I
S12-7803  I
S13-7805  I
S14-7810  I
S15-7812  I
S16-7905  I
S17-7909  I
S18-7912  I
S19-8005  I
S20-8008  I
S21-8012  I------------------------------------------------------------------------------------------------I
S22-8105  I                                                                                                I
S23-8110  I                                                                                                I
S24-8201  I                                                                                                I
S25-8204  I                                                                                                I
S26-8209  I                                                                                                I
S27-8212  I                                                                                                I
S28-8303  I                                                                                                I------
S30-8312  I                                                                                                I
S35-8508  I                                                                                                I
S36-8512  I                                                                                                I
S37-8604  I                                                                                                I
S39-8612  I                                                                                                I
S41-8708  I                                                                                                I
S42-8712  I                                                                                                I
S33-8412  -------------------------------------------------------------------------------------------------I
```

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Gigartina papillata (C. Agardh, 1821) Ref. AH, 1976. p 523.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Foliose, usually papillated blades, highly variable, light rose to yellowish, to dark brown to almost black. 1 - 15+ cm tall. (see also *Petrocelis franciscana*).

Distribution: Alaska to Punta Baja (Baja California). Common high to mid-intertidal. A probable warm-tolerant species.

Diablo Area Specific Information: Abundant, occurring in about 80% of our quadrats with covers up to 70%.

Habitat: On rocks, tops, sides, upper to lower intertidal. In upper intertidal often as small bladelets in crevices, in mid intertidal as moderately pure stands often associated with *Endocladia*, in rest of range can be mixed with other algae.

Observational Errors: Mis-identified only when new growth developing, i.e., the plant is not in a usual form (see below). Missed observations fairly rare, occurring about <1% and usually in areas of intermittent sand/gravel cover or in dense algal cover areas. Field identification of this species may have included the similar species *Gigartina agardhii* until early 1978.

Field Identification Problems:

General: Depending on morphology and coloration of the specimen, could be confused with *Gigartina agardhii, Iridaea heterocarpa, Rhodoglossum affine,* or a few other species. A crustose life-phase of this species (and other *Gigartina* spp.) was field identified as *Petrocelis franciscana*.

Station Specific: n.a.

General Comments: The most common and wide-ranging macroscopic algal species at our intertidal Cove stations. Separation of *G. agardhii* and *G. papillata* in the field was based on stipe characteristics: thin and round (*agardhii*) versus broad and flattened (*papillata*).

Impacts to Taxon:

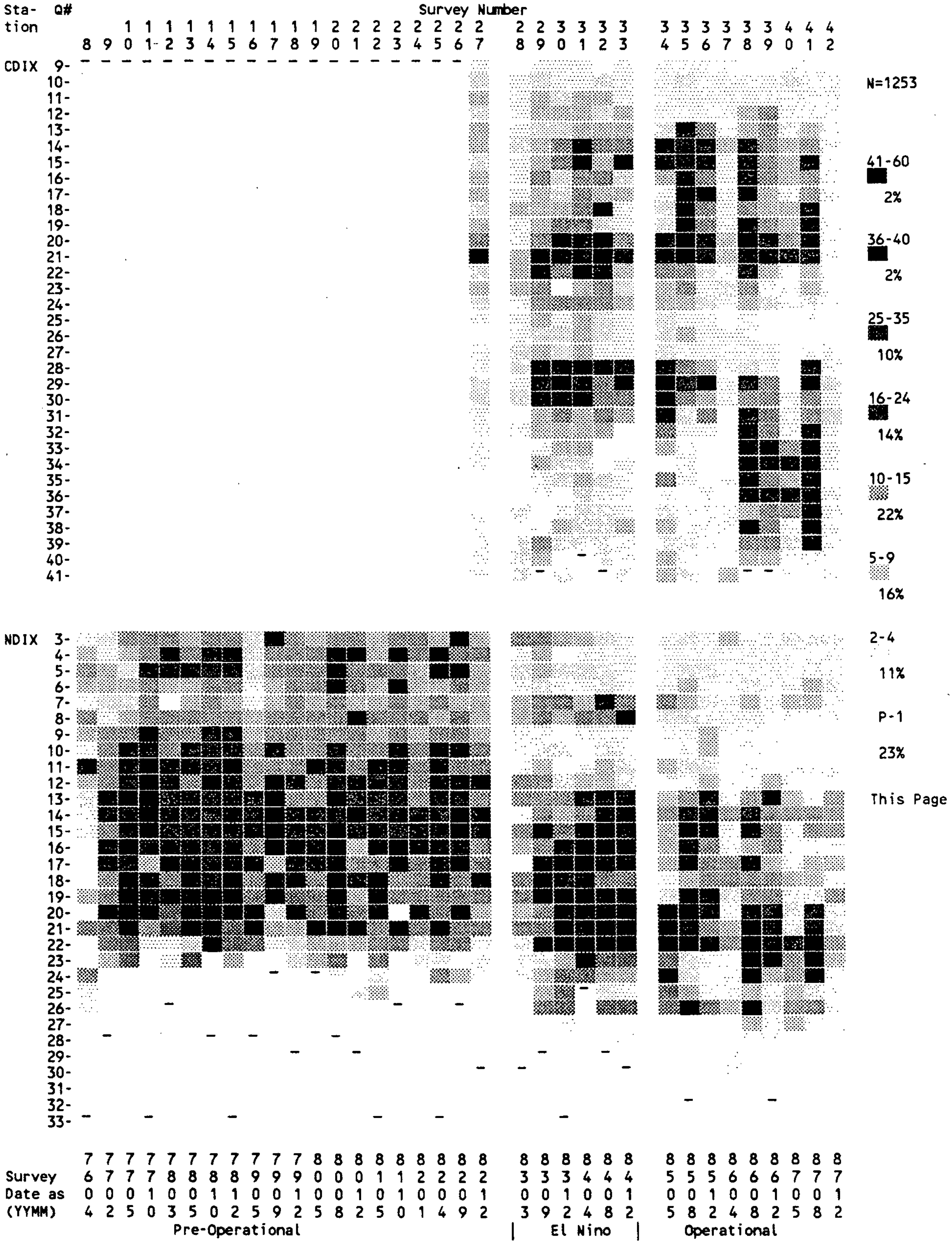
El Niño: 1982-83 winter storm: Reduction in occurrences and covers at SDIX (cobble overlay, and removal of growth) at mid to lower ranges. NDIX and CDIX with reduction in covers and slight reduction in occurrences. LCIX normal.

El Niño: 1983-1984: SDIX with covers quickly returning to normal at lower part of range but somewhat sporadic until end of 1984, in the mid and upper ranges (shifting cobble), but extending downward in the intertidal to the end of the transect. The population center shifted lower than normal in the intertidal than normal throughout 1984. NDIX recovered quickly in both occurrences and covers and the population center shifted lower than normal in the intertidal. CDIX as at NDIX, but unable to compare to normal. LCIX declining in covers throughout range to below normal (but here only winter surveys were conducted) and occurrences possibly declined.

Diablo DCPP Operation: SDIX similar to El Niño (i.e., good covers for lower intertidal), possible thinning of covers for upper parts of range starting in early 1987. NDIX with El Niño conditions continuing, but spring surveys with reduced covers (covers were formerly fairly constant throughout the year). A general trend of declining covers at mid-tidal levels commencing in 1987 resulted in greatly reduced covers throughout range by the year end. CDIX maintaining El Niño conditions, but population center probably shifting to lower tidal levels. Covers generally increased at mid-tidal area. Spring covers were low, declining to very low covers throughout range by end of 1987. LCIX occurrences within normal range but covers were probably below normal.

Taxon or Category: Gigartina papillata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

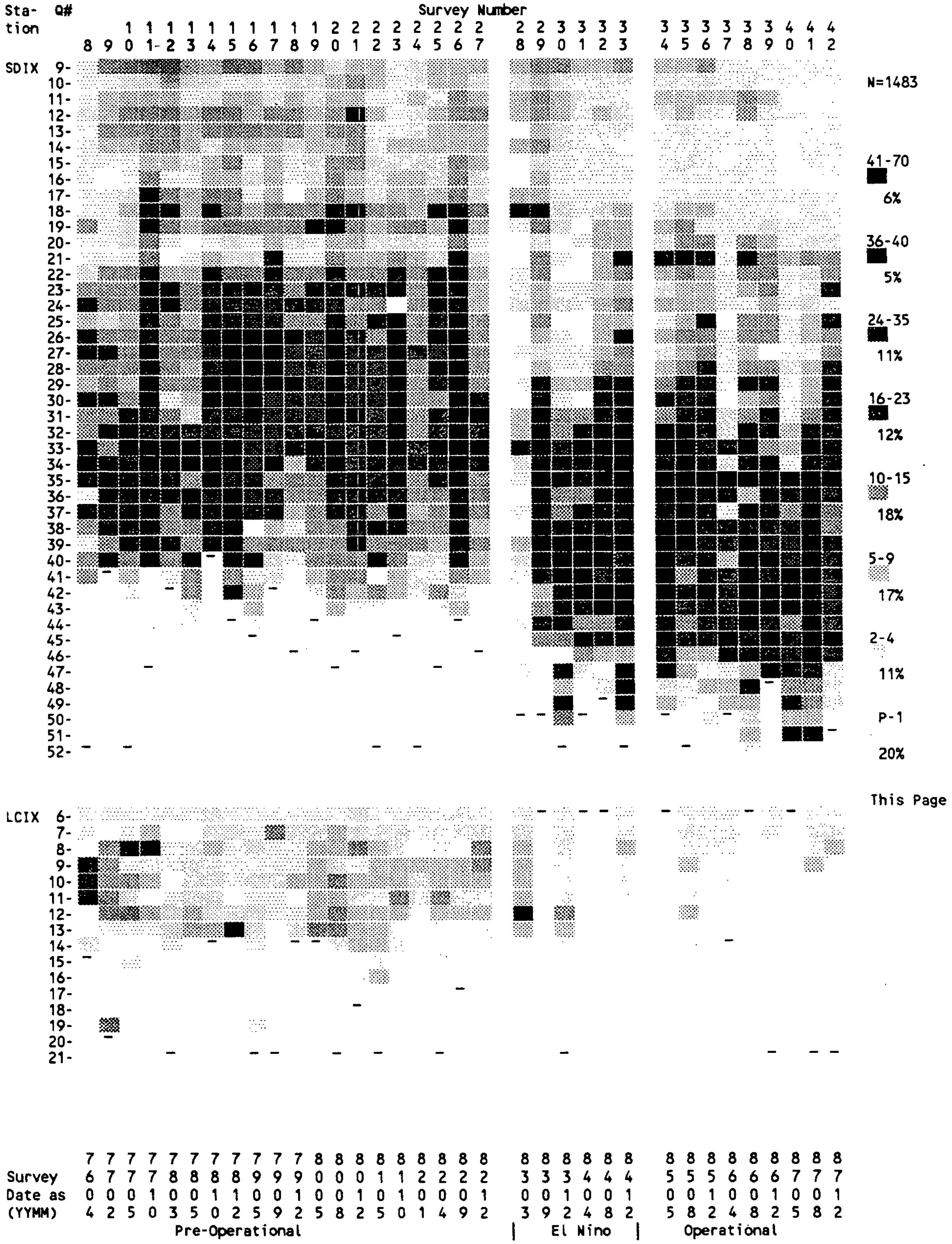


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGPAP CSV 7518 3-29-88 7:31a 04-14-1989 09:46

Taxon or Category: Gigartina papillata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for GIGPAP CSV 7518 3-29-88 7:31a 04-14-1989 09:47

Audit: CLUMRG2P: V.1.2: for SGIGPAP CLU 6581 4-22-89 9:07a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:04:07 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Gigartina papillata: TOTAL Quads with Data = 550

Quad Range USED 5 to 39 for Total of 35 : Range WITH data 1 to 41: : # Dropped 43 : 7.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.583396: Maximum Distance = 2786

```
S27-8212  ----------------------------------I-------------------------------I
S28-8303  -------------I--------------------I                               I
S37-8604  -----------I-I                                                    I-----I
S42-8712  -----------I                                                      I     I
S39-8612  -------------------------------------------I----------------------I     I
S40-8705  -------------------------------------------I                            I-------------------I
S29-8309  -----------------------------------------I--I                           I                   I
S31-8404  -----------------------------------------I  I----I                      I                   I
S30-8312  --------------------------------II          I    I                      I                   I------I
S33-8412  --------------------------------II----------I    I----------------------I                   I      I
S34-8505  ---------------------------------I               I                                          I      I
S36-8512  -------------------------------------------------I                                          I      I------
S32-8408  -----------------------------------------------------------------------I--------------------I      I
S35-8508  -----------------------------------------------------------------------I                           I
S38-8608  --------------------------------------------------------------I------------------------------------I
S41-8708  --------------------------------------------------------------I
```

Station: NDIX: Gigartina papillata: TOTAL Quads with Data = 809

Quad Range USED 3 to 27 for Total of 25 : Range WITH data 2 to 32: : # Dropped 174 : 21.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.604419: Maximum Distance = 2313

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------I
S28-8303  ----------------------------I---I      I----------------------------I
S37-8604  -----------------------I----I   I------I                            I
S42-8712  -----------------------I        I                                   I
S40-8705  --------------------------------I                                   I
S 9-7702  ------------------------------------I                               I
S18-7912  -------------------I------I         I                               I
S24-8201  -------------------I      I---------I-------I                       I---------I
S27-8212  --------------------------I         I       I------I                I         I
S16-7905  ------------------------------------I       I      I                I         I
S13-7805  ------------------------------I-------------I      I--I             I         I
S25-8204  ------------------------------I                    I  I-------I     I         I
S21-8012  ---------------------------------------------------I  I       I     I         I
S22-8105  ------------------------------------------------------I       I     I         I
S29-8309  -----------------------------------I----------I               I-----I         I--------------------I
S30-8312  -----------------------------------I          I-----I         I               I                    I
S32-8408  -----------------------I------------------I   I     I         I               I                    I
S33-8412  -----------------------I                  I---I     I---------I               I                    I
S36-8512  ------------------------------------------I         I                         I                    I
S35-8508  ----------------------------------------------------I                         I                    I
S34-8505  ------------------------------------I------I                                  I                    I------
S41-8708  ------------------------------------I      I----------I                       I                    I
S39-8612  -------------------------------------------I          I-----------------------I                    I
S38-8608  ------------------------------------------------------I                                            I
S10-7705  ---------------------------------------------------I-----I                                         I
S20-8008  ---------------------------------------------------I     I------------------I                      I
S14-7810  ----------------------------------------------I----------I                  I----------------------I
S15-7812  ----------------------------------------------I                             I
S11-7710  ----------------------------------------------------------------------------I
```

Station: SDIX: Gigartina papillata: TOTAL Quads with Data = 1373

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 2 to 52: : # Dropped 564 : 41.1%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.579855: Maximum Distance = 3562

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  -------------------------------------------I
S19-8005  ---------------------------------I-------I I-I
S22-8105  ---------------------------------I       I-I I---------I
S27-8212  -----------------------------------------I   I         I
S10-7705  ---------------------------------I-----------I         I-I
S13-7805  ---------------------------------I                     I I
S18-7912  ------------------------------------------------I------I I------I
S21-8012  ------------------------------------------------I        I      I
S24-8201  --------------------------------------I------------------I      I--------------------I
S28-8303  --------------------------------------I                         I                    I
S25-8204  ----------------------------------------------------------------I                    I------------I
S11-7710  ------------------------------------------------------------I                        I            I
S15-7812  ---------------------------------------------II             I------------------------I            I
S16-7905  --------------------------------------I------II-I           I                                     I
S20-8008  --------------------------------------I       I I-----------I                                     I
S26-8209  ----------------------------------------------I I                                                 I------
S23-8110  ------------------------------------------------I                                                 I
S29-8309  -----------------------------------------------------------------------------I                    I
S30-8312  --------------------------I-------------------------I                        I                    I
S31-8404  --------------------------I                         I-----I                  I                    I
S37-8604  -------------------------------------I--------------I     I                  I--------------------I
S40-8705  -------------------------------------I                    I------I           I
S36-8512  --------------------------I--------I                      I      I           I
S42-8712  --------------------------I        I----------------------I      I           I
S39-8612  -----------------------------------I                             I-----------I
S32-8408  --------------------------------I--------------I                 I
S34-8505  --------------------------------I              I-----------I     I
S33-8412  -------------------------------------------I---I           I-----I
S35-8508  -------------------------------------------I               I
S38-8608  ---------------------------------------I-------------------I
S41-8708  ---------------------------------------I
```

Station: LCIX: Gigartina papillata: TOTAL Quads with Data = 303

Quad Range USED 3 to 16 for Total of 14 : Range WITH data 3 to 19: : # Dropped 50 : 16.5%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.748077: Maximum Distance = 359

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ------------------------------------------------------------------------------I----------I
S20-8008  -------------------------------------------------------------I----------------I          I
S28-8303  -------------------------------------------------------------I                           I
S12-7803  ---------------I--I                                                                      I
S16-7905  ---------------I I------I                                                                I
S36-8512  ---------I--------I     I------I                                                         I
S39-8612  ---------I              I      I                                                         I
S33-8412  -------------I----------I      I----I                                                    I
S42-8712  -------------I                 I    I                                                    I
S35-8508  -------------------------------I    I-I                                                  I---------I
S24-8201  -----------------I-----------I      I I                                                  I         I
S41-8708  -----------------I           I------I I--I                                               I         I
S26-8209  -----------------------------I        I  I----------I                                    I         I
S17-7909  --------------------------------------I  I          I                                    I         I
S13-7805  --------------------------I--------------I          I                                    I         I
S30-8312  --------------------------I                         I------------------------I           I         I------
S21-8012  --------------------------------I---I               I                        I           I         I
S22-8105  --------------------------------I   I-------------I I                        I           I         I
S27-8212  ------------------------------------I             I-I                        I-----------I         I
S23-8110  ----------------------I---------------------------I                          I                     I
S25-8204  ----------------------I                                                      I                     I
S15-7812  -----------------------------------------------------------------------------I                     I
S10-7705  -----------------------------------------------------------I---------------------------------------I
S11-7710  -----------------------------------------------------------I
```

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Hildenbrandia/"Calothrix" Ref. AH, 1976. p 377./n.a.
Phylum Rhodophyta/Blue Green Alga: **Class** Cryptonemiales/n.a.:

Description: Thin crust or speckles, dull to bright red, to black. up to 5 cm diameter. This group probably at times included a mix of fungi, Cyanophytes, and algae.

Distribution: see below.

Diablo Area Specific Information: Common, occurring in about 50% of our quadrats in covers up to 90%.

Habitat: On rocks and cobble, tops, sides, bottoms, upper to lower intertidal. Often under algal mat when mat present.

Observational Errors: Sometimes (perhaps 5% of total observations) mis-identified as *Petrocelis* (especially in mid-lower intertidal). Missed observations difficult to assess, but possibly >5% in sand/gravel and algal mat covered areas. Detection of "*Calothrix*" form influenced by rock color and light conditions.

Field Identification Problems:

General: Depending on coloration, location in the intertidal, and lighting conditions, could be confused with *Petrocelis franciscana*, *Peyssonnellia meridionalis*, or *Bangia* complex, or overlooked entirely. Field identified as *Hildenbrandia* (black or red) and "*Calothrix*".

Station Specific: n.a.

General Comments: "*Calothrix*" form was very difficult to collect (i.e., extremely thin adherent film on rock). Collections usually yielded *Hildenbrandia* or possibly a fungus. Data for this group should be regarded cautiously because of likelihood that several species in varying amounts were involved.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Probably within normal limits at all stations other than CDIX where a large decline occurred.

El Niño: 1983-1984: SDIX (excluding upper sand/gravel areas) probably with some sporadic reduction in occurrences. NDIX within normal limits. CDIX with a "bloom" throughout most of the transect (Winter 1983), but declining rapidly just afterwards. LCIX within normal limits but lower in occurrences at lower tidal levels than surveys just prior to storms.

Diablo DCPP Operation: SDIX returning to within normal limits until Spring 1987 when there were sporadic increases in covers and occurrences in the mid to lower intertidal. NDIX with a slow reduction in occurrences at mid-lower tidal levels, but recovery starting in Winter 1986. CDIX as for NDIX but return started in Winter 1985. LCIX within normal limits and with occurrences extending downward into lower intertidal, similar to pre-El Niño occurrences.

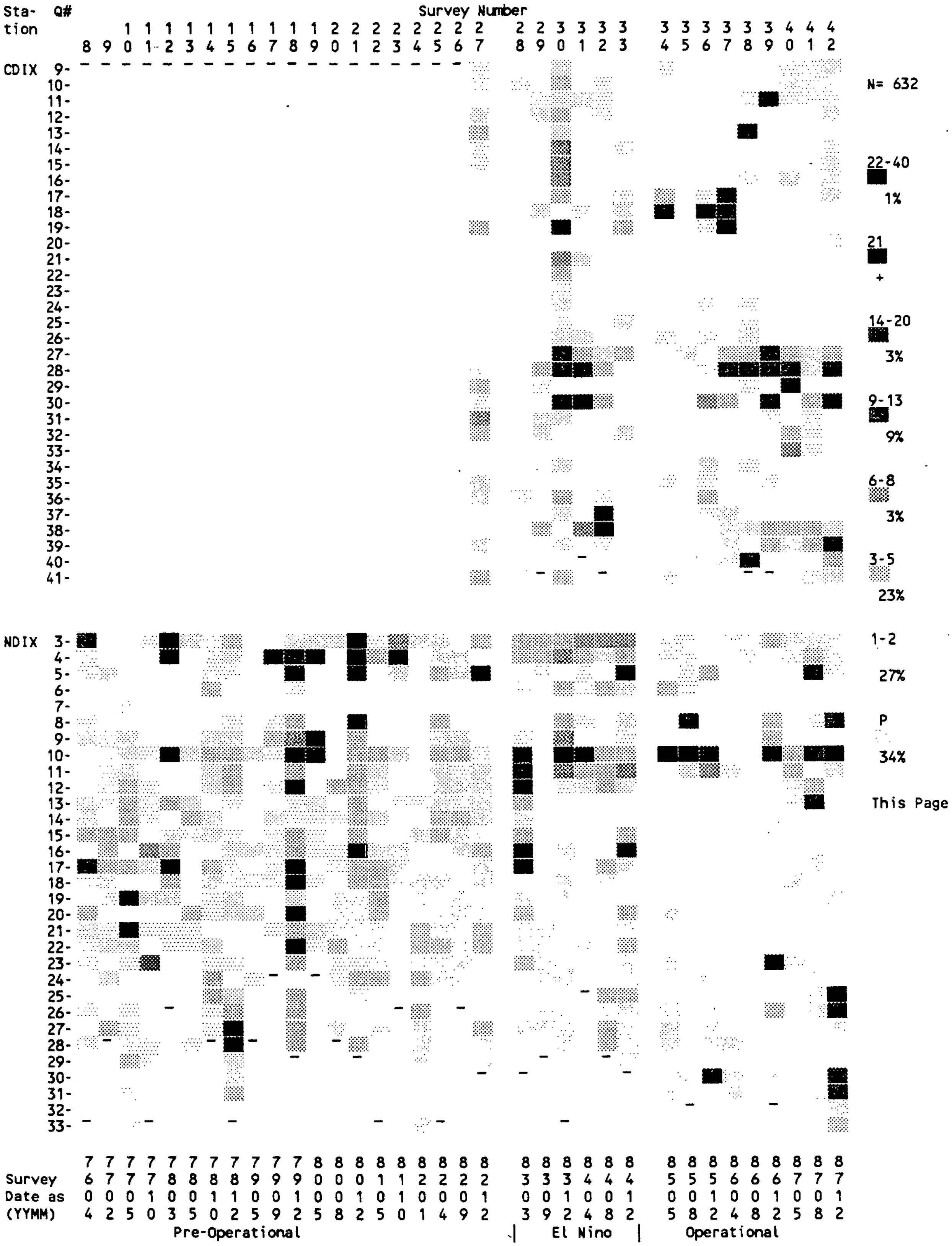
Hildenbrandia occidentalis: Northern British Columbia to Isla San Geronimo, Baja California (and Galapagos Islands).

Hildenbrandia prototypus: Alaska to Oaxaca, Mexico. (nearly world-wide in distribution).

"*Calothrix*": unknown.

Taxa or Category: Hildenbrandia spp. +"Calothrix"

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

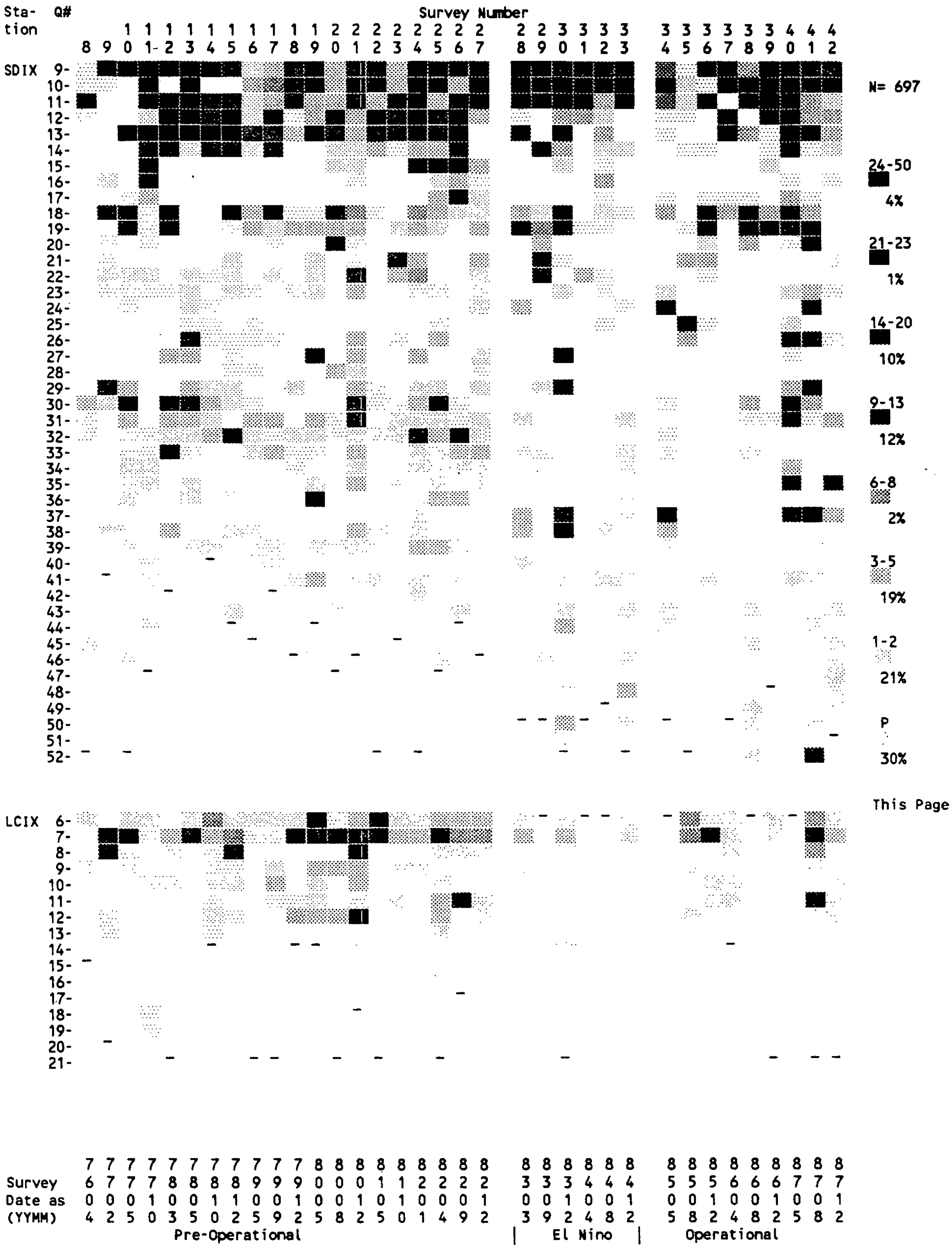


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HILCAL CSV 6630 9-30-88 7:36a 04-14-1989 09:47

Taxa or Category: Hildenbrandia spp. +"Calothrix"

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



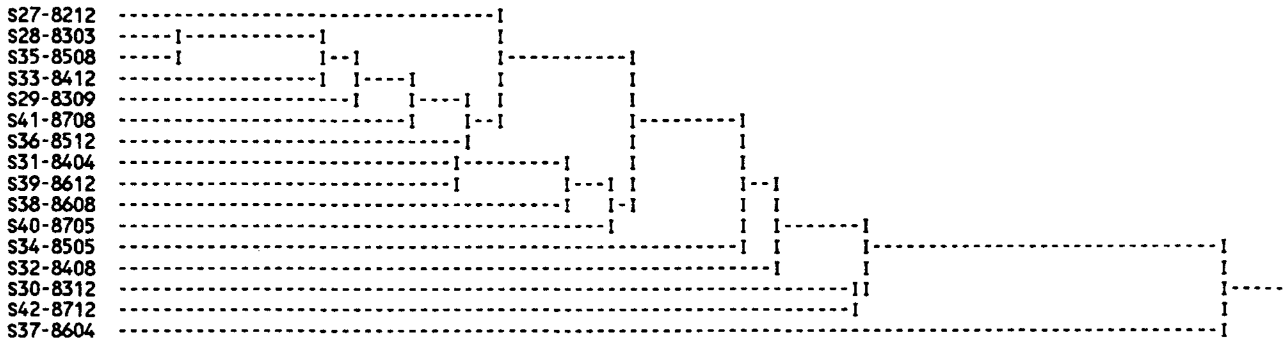
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HILCAL CSV 6630 9-30-88 7:36a 04-14-1989 09:47

Audit: CLUMRG2P: V.1.2: for SHILCAL CLU 7249 4-22-89 9:13a: 04-27-1989/17:32
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:09:39 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

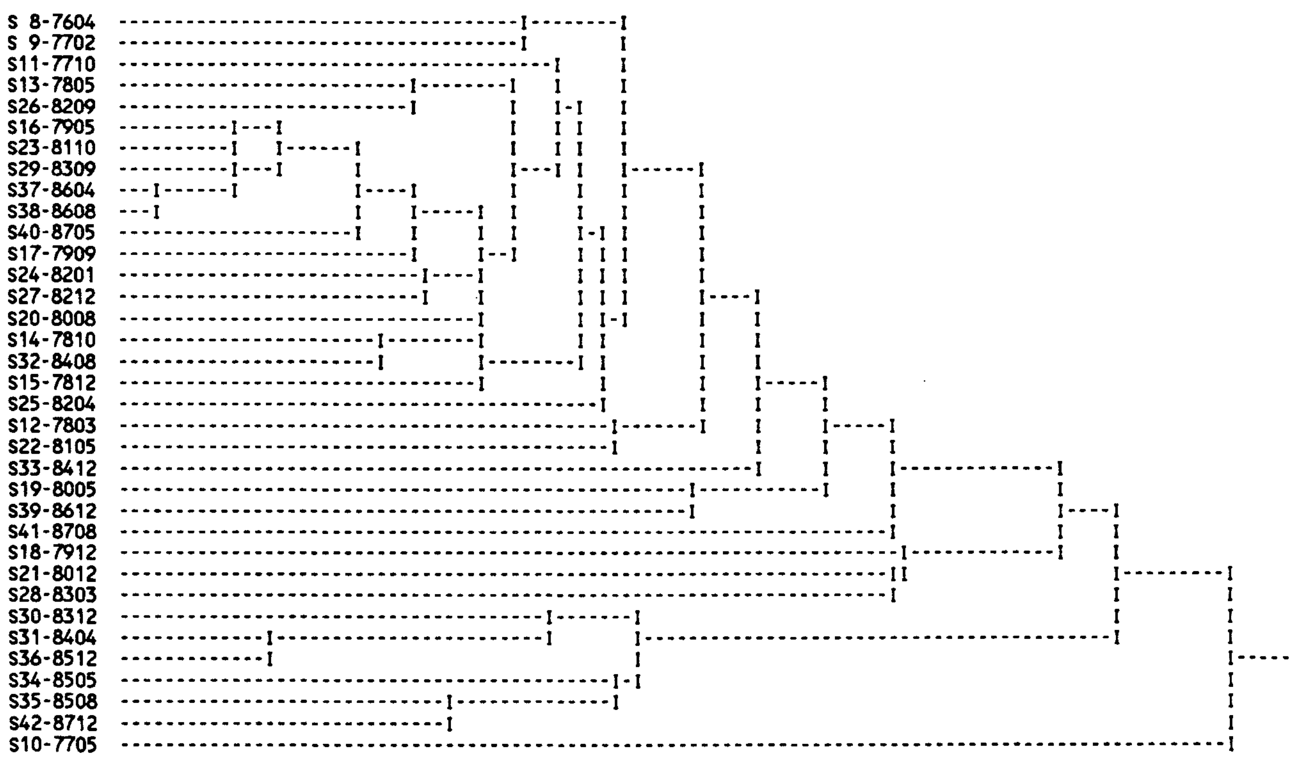
Station: CDIX: Hildenbrandia spp. +"Calothrix": TOTAL Quads with Data = 233

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 78 : 33.5%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.695787: Maximum Distance = 1296



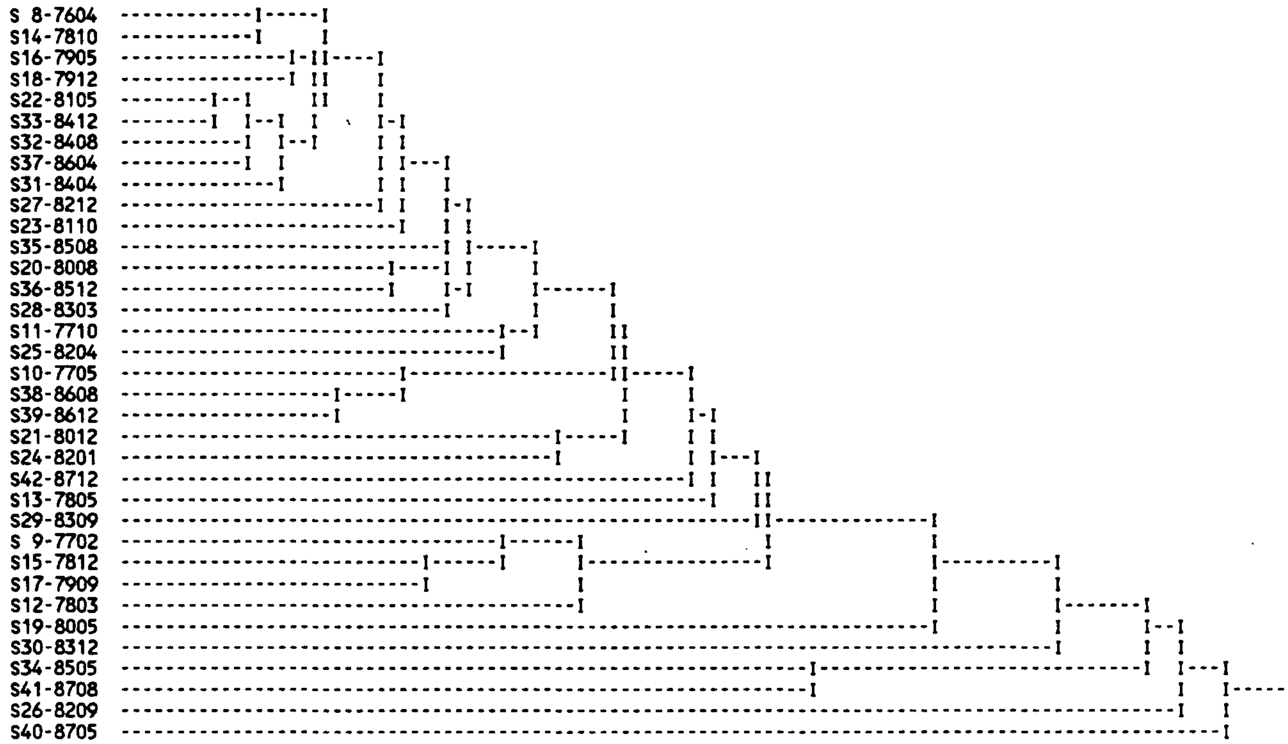
Station: NDIX: Hildenbrandia spp. +"Calothrix": TOTAL Quads with Data = 538

Quad Range USED 6 to 23 for Total of 18 : Range WITH data 1 to 33: : # Dropped 233 : 43.3%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.758790: Maximum Distance = 491



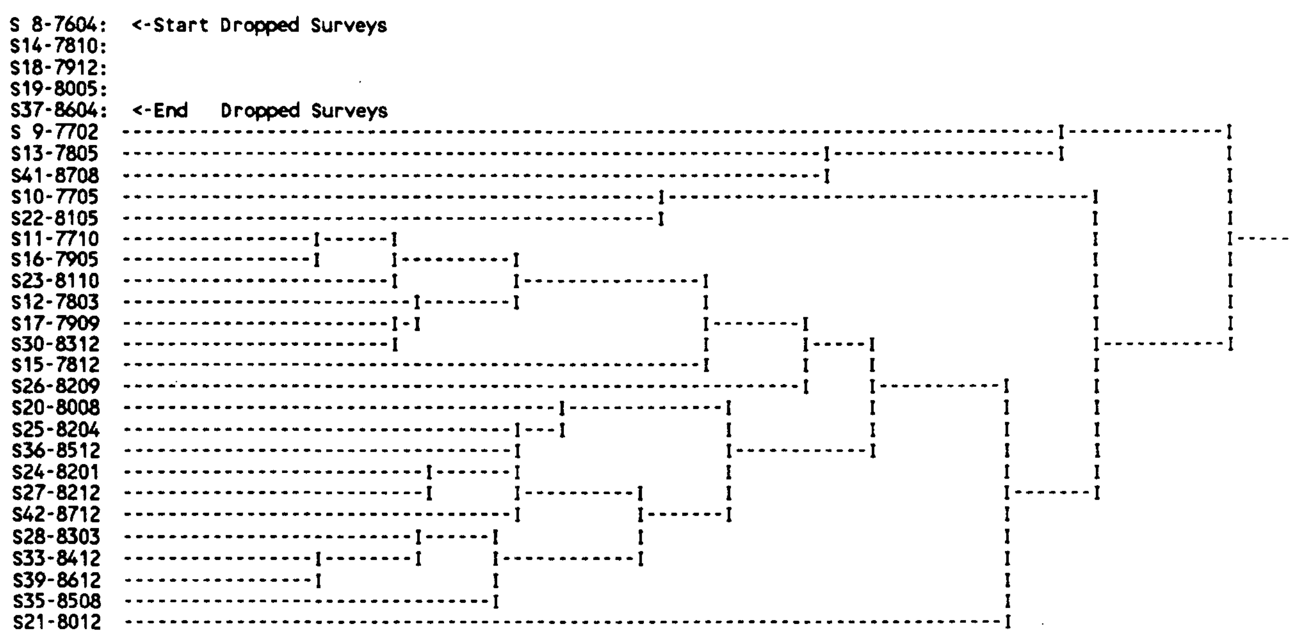
Station: SDIX: Hildenbrandia spp. +"Calothrix": TOTAL Quads with Data = 796

Quad Range USED 15 to 39 for Total of 25 : Range WITH data 1 to 52: : # Dropped 457 : 57.4%
Surveys 35 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.823854: Maximum Distance = 1210



Station: LCIX: Hildenbrandia spp. +"Calothrix": TOTAL Quads with Data = 259

Quad Range USED 4 to 16 for Total of 13 : Range WITH data 1 to 19: : # Dropped 118 : 45.6%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.618454: Maximum Distance = 336



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Iridaea cordata (Iridescent Alga). (Turner, 1809) Ref. AH, 1976. p 529ff.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Broad thick blades from fleshy holdfast, stipe short to moderately long, purple to blackish, some with brown overtones and/or bluish sheen. 5 - 100+ cm long, about 1/3 to 1/2 as broad as tall.

Distribution: Alaska to Northern Baja California, but see below. Abundant lower intertidal to subtidal (7 m). A warm-tolerant species, but note that one variety (*I. c.* var. *cordata* is probably not warm-tolerant).

Diablo Area Specific Information: Moderately rare, occurring in about 10% of our quadrats in covers up to 70%.

Habitat: On rock, tops and sides, lower-mid (in wetter areas) to low intertidal. Sometimes covering large areas, often mixed with other algae, occasionally as pure stands.

Observational Errors: Can sometimes be mis-identified (see below) possibly as much as >5% of the time. Missed observations occur possibly <5% of the time due to small blades, eroded blades, or when small clumps mixed with other *Iridaea* spp. or when coloration is not typical. Questionably separated from other *Iridaea* species for surveys prior to 1978.

Field Identification Problems:

General: Possibly confused with *Iridaea flaccida* when coloration not typical or when occurring as small or severely eroded or deteriorating old blades (infrequently with *I. heterocarpa*).

Station Specific: n.a.

General Comments: Usually in areas that remain wet during low tides and occurrences very inconsistent (possibly confusion with other species of genus).

Impacts to Taxon:

El Niño: 1982-83 winter storm: Not found at SDIX for survey just prior to nor after storms. NDIX and CDIX with 1 and 0 occurrences respectively for survey just prior to, and 2 and 1 just afterwards. LCIX within normal limits.

El Niño: 1983-1984: SDIX towards end of period with well developed population at lower tidal levels (missing for Winter 1984 and perhaps mis-identified as *I. heterocarpa*). NDIX with sporadic increasing occurrences but probably below normal. CDIX somewhat resembling SDIX, but with lower covers, and with reduced covers and occurrences in Winter 1984 . LCIX still occurring as isolated occurrences.

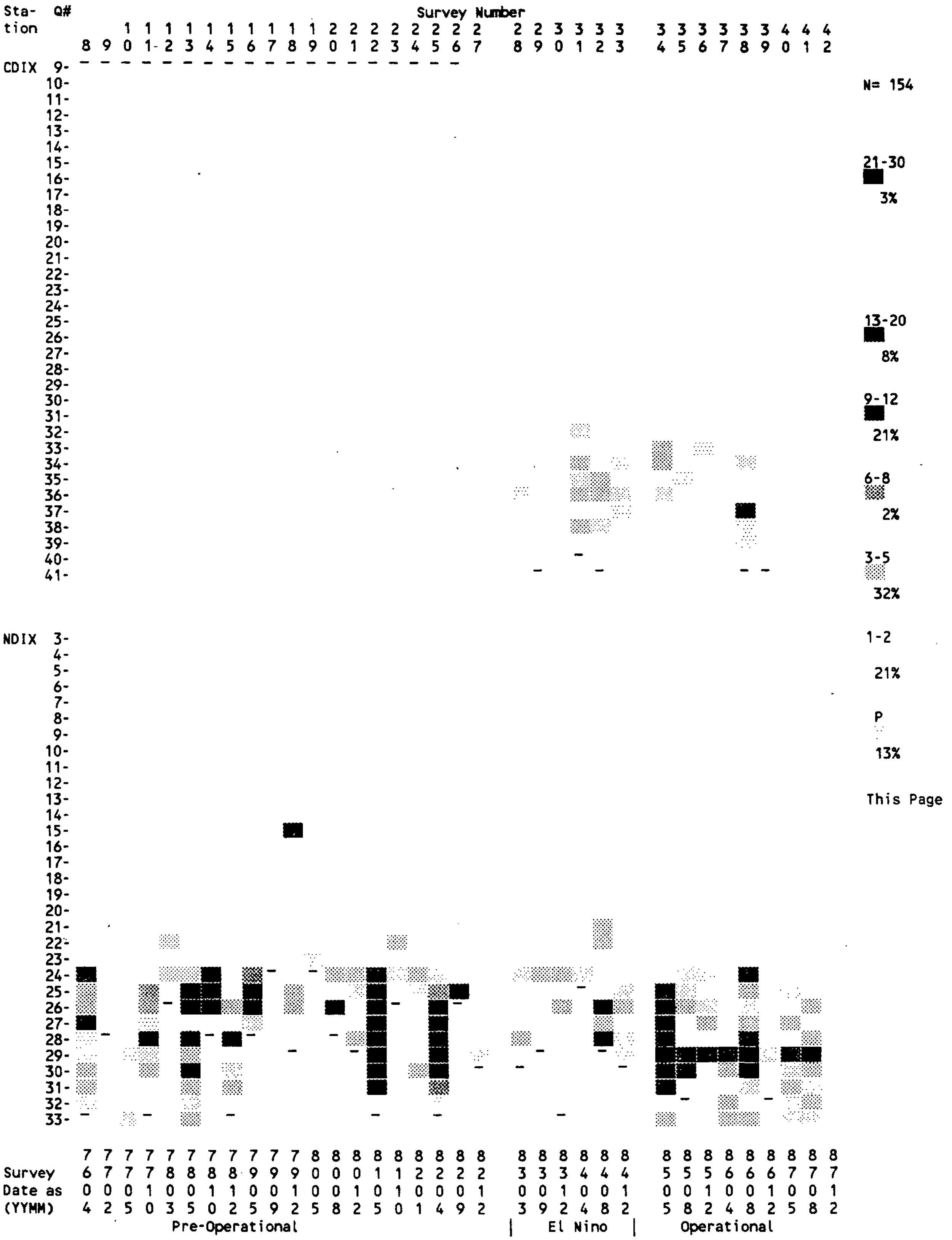
Diablo DCPP Operation: SDIX with population at lowest quadrats persisting at dense covers; then starting in Winter 1986 to lose occurrences at upper part of range but remaining common in lower intertidal; then almost disappearing throughout transect Winter 1987 (perhaps confused with *I. flaccida*). NDIX with covers possibly higher than normal but sporadic occurrences (perhaps confused with *I. flaccida*), covers declining in 1987. CDIX declining in occurrences compared to El Niño, (one burst upwards for Autumn 1986), then disappearing for rest of study period. LCIX probably within normal limits, but lower in occurrences and covers compared to period from 1980 to early 1982.

Iridaea cordata var. *cordata*: Pribilof Island (Alaska) to Ventura Co. (California), occasional south of Monterey Peninsula.

Iridaea cordata var. *splendens*: Queen Charlotte Island (British Columbia) to Northern Baja California.

Taxon or Category: Iridaea cordata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

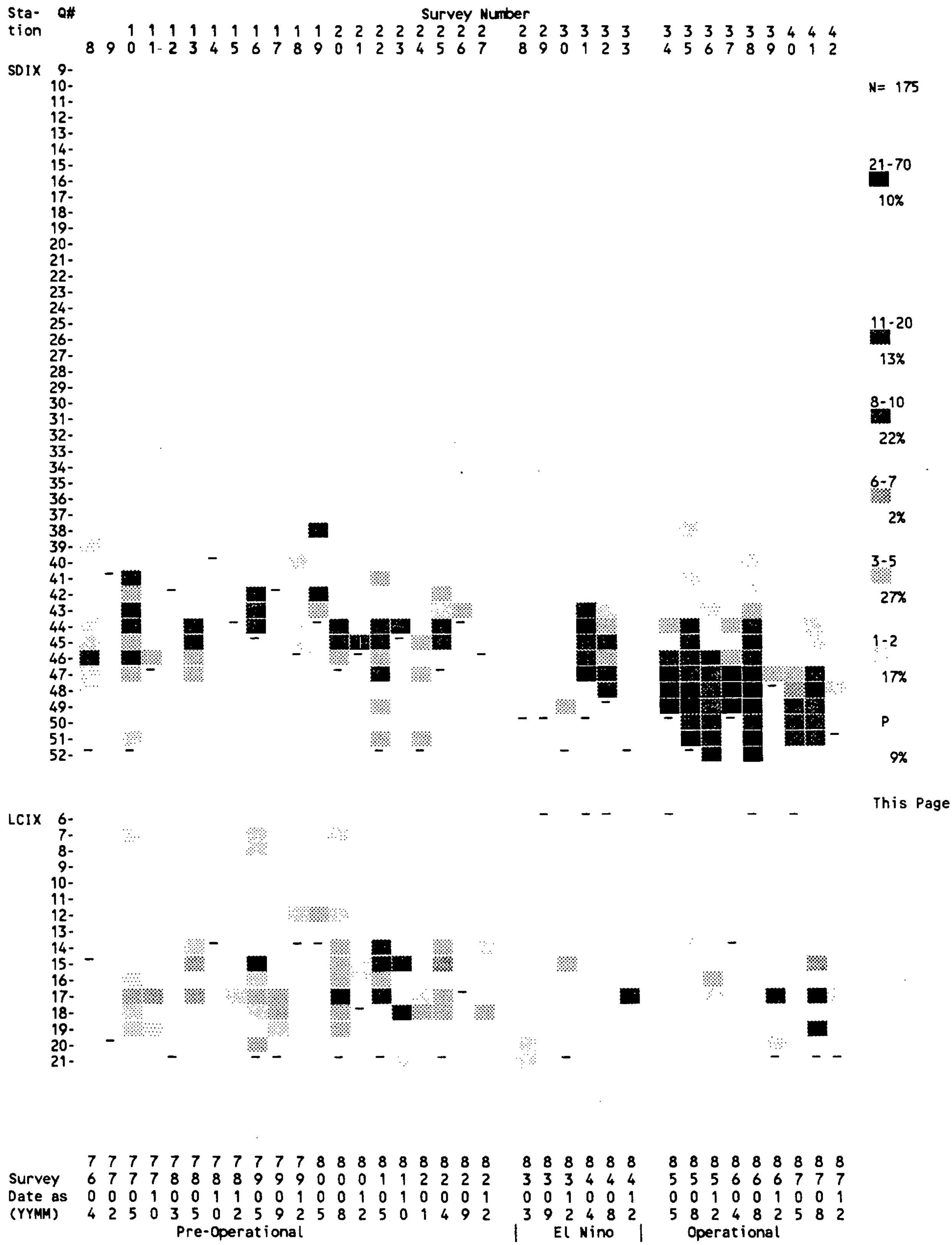


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for IRICOR CSV 5392 3-29-88 7:33a 04-14-1989 10:13

Taxon or Category: Iridaea cordata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for IRICOR CSV 5392 3-29-88 7:33a 04-14-1989 10:13

Audit: CLUMRG2P: V.1.2: for SIRICOR CLU 5829 4-22-89 9:20a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:15:39 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Iridaea cordata: TOTAL Quads with Data = 21

Quad Range USED 33 to 39 for Total of 7 : Range WITH data 32 to 39: : # Dropped 1 : 4.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.951875: Maximum Distance = 142

```
S27-8212  I
S29-8309  I
S30-8312  I
S37-8604  I---I
S39-8612  I   I
S40-8705  I   I
S41-8708  I   I------I
S42-8712  I   I      I
S28-8303  ----I      I-----------------------I
S35-8508  ----I      I                       I
S36-8512  ----I      I                       I-----I
S33-8412  -----------I                       I     I---------------------------------------------------------I
S32-8408  -----------------------------------I     I                                                         I
S31-8404  -------------------------------------I---I                                                         I------
S34-8505  -------------------------------------I                                                             I
S38-8608  ---------------------------------------------------------------------------------------------------I
```

Station: NDIX: Iridaea cordata: TOTAL Quads with Data = 133

Quad Range USED 21 to 27 for Total of 7 : Range WITH data 15 to 33: : # Dropped 73 : 54.9%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.780782: Maximum Distance = 115

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ----------------------------------I-----------I
S22-8105  ----------------------------------I           I--------------------I
S38-8608  ----------------------------------------------I                    I----------------------I
S25-8204  --------------------I----------------------------------------------I                      I--------I
S34-8505  --------------------I                                                                     I        I
S13-7805  -----------------------------------------------------------------------I------------------I        I
S14-7810  ----------------------------------------------I------------------------I                           I
S16-7905  ----------------------------------------------I                                                    I
S 9-7702  I                                                                                                  I
S10-7705  I                                                                                                  I
S27-8212  I----------I                                                                                       I
S37-8604  I          I                                                                                       I
S39-8612  I          I-----------------------I                                                               I
S42-8712  I          I                       I                                                               I------
S28-8303  -----------I                       I------I                                                        I
S21-8012  -----I--I                          I      I                                                        I
S24-8201  -----I  I--------------------------I      I----I                                                   I
S29-8309  --------I                                 I    I                                                   I
S36-8512  -----------------I------------------------I    I                                                   I
S40-8705  -----------------I                             I----------------------------I                      I
S11-7710  -------------I------------I                    I                            I                      I
S18-7912  -------------I            I----------------I   I                            I                      I
S15-7812  I---------------I         I                I   I                            I                      I
S41-8708  I               I---------I                I---I                            I----------------------I
S33-8412  ----------------I                          I                                I
S35-8508  ----------------I                          I                                I
S20-8008  -----------------------I-------------------I                                I
S30-8312  -----------------------I                                                    I
S32-8408  ----------------------------------------------------------------------------I
```

Station: SDIX: Iridaea cordata: TOTAL Quads with Data = 113

Quad Range USED 41 to 45 for Total of 5 : Range WITH data 38 to 52: : # Dropped 75 : 66.4%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.885363: Maximum Distance = 200

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604  II
S18-7912  II---I
S41-8708  -I   I
S11-7710  I    I
S27-8212  I    I
S28-8303  I    I-----I
S29-8309  I    I     I
S30-8312  II   I     I
S33-8412  II   I     I
S39-8612  II---I     I-------I
S40-8705  II         I       I
S42-8712  II         I       I
S36-8512  -I         I       I---------------------------I
S34-8505  ----I------I       I                           I
S37-8604  ----I              I                           I
S21-8012  ---------I---------I                           I--------------------------------------------------I
S24-8201  ---------I                                     I                                                  I
S10-7705  -------------------------------------------I   I                                                  I
S13-7805  ----------I---------------I                I   I                                                  I
S32-8408  ----------I               I-----I          I--I                                                   I
S35-8508  -----------------I--------I     I          I                                                      I------
S38-8608  -----------------I              I----------I                                                      I
S20-8008  ---------------I--------------I I                                                                 I
S25-8204  ---------------I              I-I                                                                 I
S22-8105  ------------------------------I                                                                   I
S31-8404  ----------------------------------------------------------------------------------------------------I
```

Station: LCIX: Iridaea cordata: TOTAL Quads with Data = 63

Quad Range USED 12 to 19 for Total of 8 : Range WITH data 7 to 23: : # Dropped 16 : 25.4%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.772833: Maximum Distance = 119

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  I
S12-7803  I-----I
S28-8303  I     I---I
S35-8508  ------I   I----------------------I
S15-7812  ------I---I                      I
S42-8712  ------I                          I-------I
S10-7705  --------------------I------I     I       I
S11-7710  --------------------I      I-----I       I---I
S17-7909  ------------------I--------I             I   I
S24-8201  ------------------I                      I   I-I
S27-8212  -----------------------------------------I   I I------------I
S36-8512  ---------------------------------------------I I            I-------I
S30-8312  -----------------------------------------------I            I       I
S33-8412  I-----------------------------------------------------------I       I---------------------I
S39-8612  I                                                                   I                     I
S13-7805  ------------------------------------I-------I                       I                     I--------I
S16-7905  ------------------------------------I       I-----------------------I                     I        I
S25-8204  --------------------------------------------I                                             I        I------
S23-8110  ------------------------------------------------------------------------------------------I        I
S20-8008  ------------------------------------------------------------I---------------------------I          I
S22-8105  ------------------------------------------------------------I                           I-----I
S41-8708  ----------------------------------------------------------------------------------------------I
```

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Iridaea flaccida (Iridescent Alga). (Setchell & Gardner, 1937) Ref. AH, 1976. p 533.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Blades from fleshy holdfast, stipe short, green to yellowish-green, with iridescent purples and browns. 5 - 40+ cm long, about 1/3 as broad as tall.

Distribution: Alaska to Northern Baja California. Locally abundant mid to lower intertidal. Occurs only in cold upwelling areas in Baja California. Not a warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 55% of our quadrats in covers up to 90%.

Habitat: On rock, tops and sides, upper-mid to low intertidal. Often covering large areas, intermingled with other algae, occasionally as pure stands.

Observational Errors: Sometimes mis-identified (see below) but probably <2% of the time. Missed observations occur possibly <1% of the time due to small blades, eroded blades, or when small clumps mixed with other *Iridaea* spp. or when coloration is not typical.

Field Identification Problems:

General: When coloration not typical or when occurring as small or severely eroded blades possibly confused with *Iridaea cordata* or infrequently with *I. heterocarpa*.

Station Specific: n.a.

General Comments: Most common overstory algae in study area.

Impacts to Taxon:

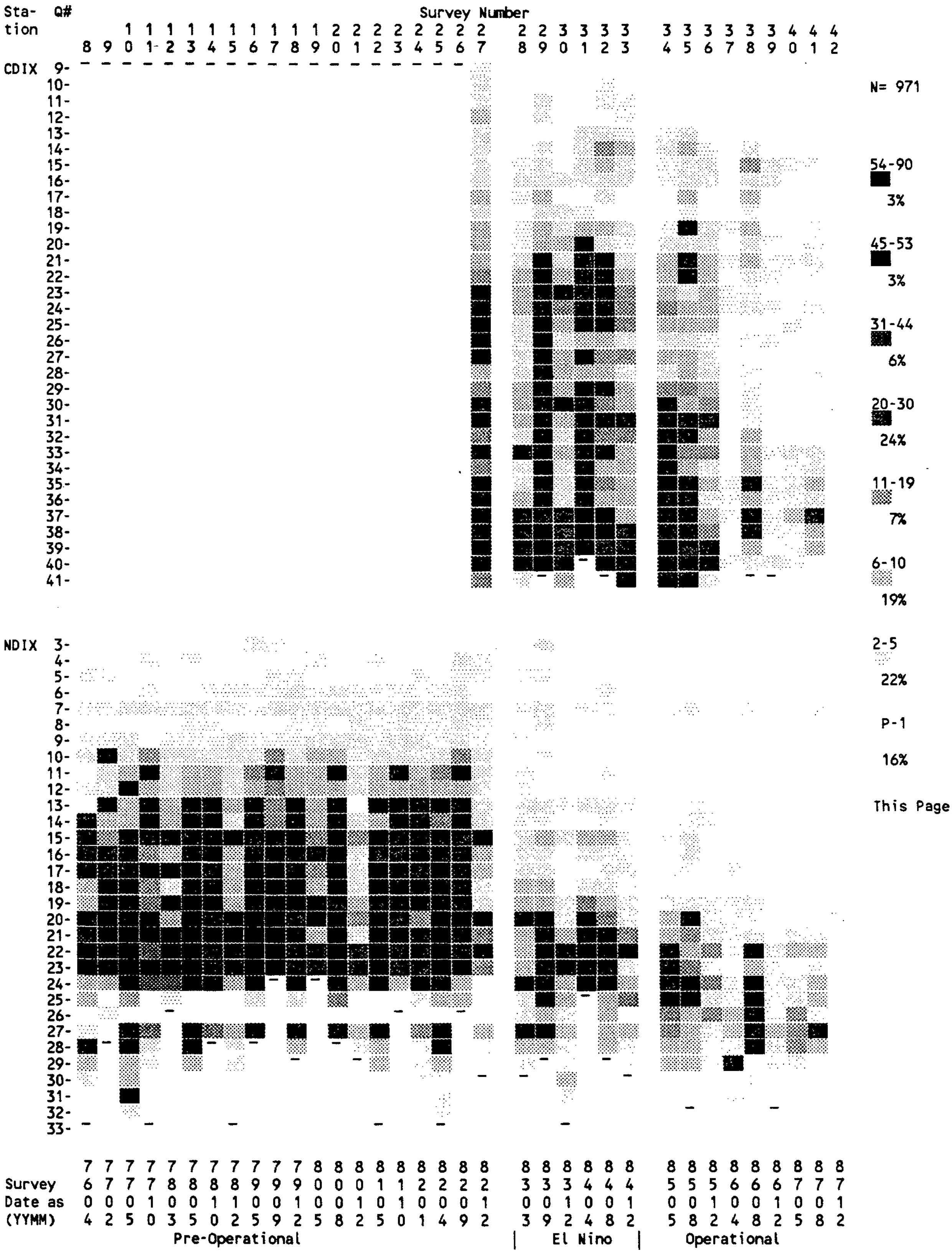
El Niño: 1982-83 winter storm: SDIX reduced to about 1/2 the occurrences of survey just prior and with covers to <10% (due to cobble overlay and storm removal). NDIX and CDIX with occurrences and covers reduced, mainly at upper parts of range in intertidal. LCIX within normal limits except at one quadrat where boulder was removed.

El Niño: 1983-1984: SDIX with covers recovering rapidly (but below normal) then stabilizing. Occurrences at upper parts of range not recovering, sporadically gaining occurrences in lower intertidal, then with large decline in both covers and occurrences Winter 1984. NDIX with covers recovering rapidly (possibly slightly subnormal) then stable, but sporadically losing occurrences at upper part of intertidal. CDIX recovered rapidly in covers but with slight sporadic reduction in occurrences at upper edge of range. LCIX within normal limits but with covers in lower areas sparse (Spring 1978 was the only other survey where such low covers occurred).

Diablo DCPP Operation: SDIX remaining much as El Niño (i.e., population shifted downward in intertidal) with sporadic retreats from upper and lower parts of range, until winter 1986 when covers were very low and possible trend thereafter of continued loss of occurrences at upper part of range. Occurrences and covers much lower than normal by end of 1987. NDIX throughout this period with sporadic retreat from upper parts and possibly lower parts of range, with general sporadic decline in covers. CDIX maintaining El Niño conditions (i.e., probably normal) until Spring 1986, when almost disappeared for one survey, reappeared for the next, then declined in covers with occurrences limited to lower portions of the transect. LCIX normal with well-developed Autumn covers.

Taxon or Category: Iridaea flaccida

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

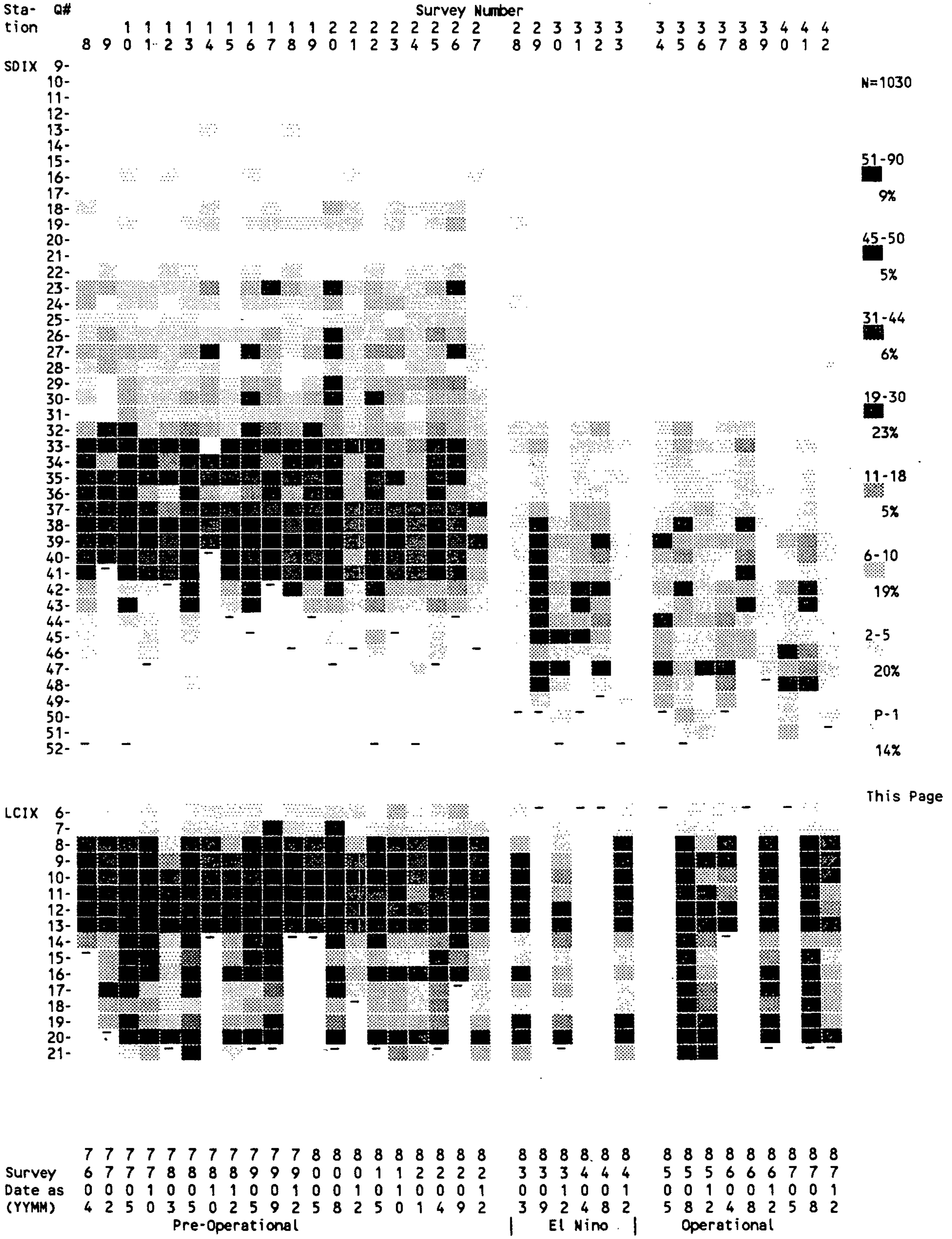


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for IRIFLA CSV 6301 3-29-88 7:33a 04-14-1989 10:13

Taxon or Category: Iridaea flaccida

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for IRIFLA CSV 6301 3-29-88 7:33a 04-14-1989 10:14

Audit: CLUMRG2P: V.1.2: for SIRIFLA CLU 6581 4-22-89 9:24a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:21:34 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Iridaea flaccida: TOTAL Quads with Data = 354

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 5 to 41: : # Dropped 24 : 6.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.665524: Maximum Distance = 3337

```
S27-8212 ------------------------------------------------I--------I
S34-8505 ------------------------------------------------I        I----------I
S35-8508 ---------------------------------------------------------I          I------------------------------I
S29-8309 ----------------------------------------I--------------------I      I                              I
S31-8404 ----------------------------------------I                    I------I                              I
S32-8408 -------------------------------------------------------------I                                     I
S28-8303 -------------------------I---------I                                                               I------
S30-8312 ----------------------I--I         I---------------I                                               I
S36-8512 ----------------------I            I               I                                               I
S33-8412 -----------------------------------I               I                                               I
S37-8604 --I-I                                              I-----------------------------------------------I
S42-8712 --I I-------I                                      I
S39-8612 ----I       I---------I                            I
S40-8705 ------------I         I------------------------I   I
S41-8708 ----------------------I                        I---I
S38-8608 -----------------------------------------------I
```

Station: NDIX: Iridaea flaccida: TOTAL Quads with Data = 622

Quad Range USED 7 to 27 for Total of 21 : Range WITH data 2 to 32: : # Dropped 195 : 31.4%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.734995: Maximum Distance = 2519

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End  Dropped Surveys
S 8-7604 ------------------------------------------------------I
S 9-7702 --------------------------------------I               I
S11-7710 --------------------------I----I      I-------I       I--------I
S14-7810 -----------------I--------I    I--I   I       I       I        I
S18-7912 -----------------I             I  I---I       I-------I        I
S24-8201 -------------------------------I  I           I                I
S15-7812 ----------------------------------I           I                I
S29-8309 ----------------------------------------------I                I
S21-8012 ---------------I---------I                                     I
S27-8212 ---------------I         I---I                                 I-----------------------------------I
S28-8303 -----------------------I-I   I                                 I                                   I
S30-8312 ---------------I-------I     I                                 I                                   I
S33-8412 ---------------I             I------I                          I                                   I
S36-8512 ---------------I-I           I      I                          I                                   I
S40-8705 ---------I-----I I           I      I                          I                                   I
S41-8708 ---------I       I-----------I      I                          I                                   I
S37-8604 --------I-I      I                  I--------------------------I                                   I
S39-8612 --------I I------I                  I                                                              I------
S42-8712 ----------I                         I                                                              I
S32-8408 ----------------------I-I           I                                                              I
S34-8505 ----------------------I I-------I   I                                                              I
S35-8508 ------------------------I       I---I                                                              I
S38-8608 --------------------------------I                                                                  I
S10-7705 ----------------------------------------I------I                                                   I
S22-8105 ----------------------------------------I      I                                                   I
S13-7805 ----------------------------I---I              I---------------------------------------------------I
S16-7905 ----------------------------I   I---------I    I
S25-8204 --------------------------------I         I----I
S20-8008 ------------------------------------------I
```

Station: SDIX: Iridaea flaccida: TOTAL Quads with Data = 642

Quad Range USED 23 to 43 for Total of 21 : Range WITH data 13 to 51: : # Dropped 203 : 31.6%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.775029: Maximum Distance = 2368

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------------I
S11-7710  ------------------------I-------I                  I
S23-8110  ------------------------I       I-----I            I---I
S15-7812  --------------------------------I     I------I     I   I
S18-7912  -----------------------------I--------I      I-----I   I
S19-8005  -----------------------------I               I         I-------I
S16-7905  --------------------------------I------------I         I       I
S22-8105  --------------------------------I                      I       I
S26-8209  -------------------------------------------------------I       I--------------------------------------I
S10-7705  -----------------------------------------I-----I               I                                      I
S13-7805  -----------------------------------------I     I----I          I                                      I
S25-8204  -----------------------------------------------I    I----------I                                      I
S20-8008  ----------------------------------------------------I                                                 I
S21-8012  -------------------I-----I                                                                            I
S27-8212  -------------------I     I---I                                                                        I
S38-8608  -------------------------I   I--------I                                                               I
S24-8201  -----------------------------I        I                                                               I------
S28-8303  ------I--------I                      I                                                               I
S33-8412  ----I-I        I                      I                                                               I
S39-8612  --II           I                      I--------I                                                      I
S42-8712  --I            I-------------I        I        I                                                      I
S30-8312  --------I---I  I             I        I        I                                                      I
S37-8604  ------I-I   II I             I        I        I                                                      I
S40-8705  ------I     II-I             I        I        I                                                      I
S34-8505  ------------II               I--------I        I------------------------------------------------------I
S36-8512  -------------I               I                 I
S31-8404  --------------I-I            I                 I
S41-8708  --------------I I------I     I                 I
S32-8408  ----------------I      I-----I                 I
S35-8508  -----------------------I                       I
S29-8309  -----------------------------------------------I
```

Station: LCIX: Iridaea flaccida: TOTAL Quads with Data = 404

Quad Range USED 8 to 19 for Total of 12 : Range WITH data 4 to 23: : # Dropped 154 : 38.1%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.607550: Maximum Distance = 1101

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  --------------------I------I
S27-8212  --------------------I      I------I
S33-8412  ---------------------------I      I--------I
S24-8201  ------------------------I---------I        I
S42-8712  ------------------------I                  I-I
S28-8303  --------------------------------II         I I
S39-8612  --------------------------------II---------I I---------------------------------------------------------I
S36-8512  ----------------------------------I          I                                                         I
S12-7803  ------------------------I--------------------I                                                         I
S30-8312  ------------------------I                                                                              I
S10-7705  ----------------------------------------I--------------I                                               I
S13-7805  ----------------------------------------I              I----------I                                    I------
S15-7812  -------------------------------------------------------I          I----------I                         I
S23-8110  ------------------------------------------------------------------I          I                         I
S11-7710  -------------------------------------------I----I                            I-----I                   I
S16-7905  -------------------------------------------I    I------------I               I     I                   I
S25-8204  ------------------------------------------------I            I----I          I     I                   I
S22-8105  ------------------------------------------------------I------I    I----------I     I-------------------I
S35-8508  ------------------------------------------------------I           I                I
S17-7909  --------------------------------------------------------I---------I                I
S20-8008  --------------------------------------------------------I                          I
S41-8708  -----------------------------------------------------------------------------------I
```

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Iridaea heterocarpa (Postels & Ruprecht, 1840) Ref. AH, 1976. p 533.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Limp divided blades from fleshy holdfast, reddish-brown, drying to brown or tan. 5 - 20+ cm long, about 1/3 as broad as tall.

Distribution: Alaska to Ventura (California). Common in isolated clumps, mid-intertidal. Not a warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 25% of our quadrats with covers up to 40%.

Habitat: On rock, tops and sides, upper-mid to low intertidal. Sometimes covering large areas, but mostly mixed with other algae.

Observational Errors: Sometimes mis-identified (see below) but probably <5% of the time. Missed observations occur possibly <2% of the time due to small blades, eroded blades, or when small clumps mixed with other *Iridaea* spp. or *Gigartina papillata* or when coloration is not typical.

Field Identification Problems:

General: When coloration not typical or when occurring as small or severely eroded blades possibly confused with *Iridaea cordata* (less frequently with *I. flaccida*). Also some specimens of *Gigartina papillata* and *Rhodoglossum roseum* can resemble this taxon.

Station Specific: n.a.

General Comments: Evaluation of this taxon moderately confused by possible mis-identifications or large seasonal fluctuations for single surveys. Trends are probably valid when using results from several surveys.

Impacts to Taxon:

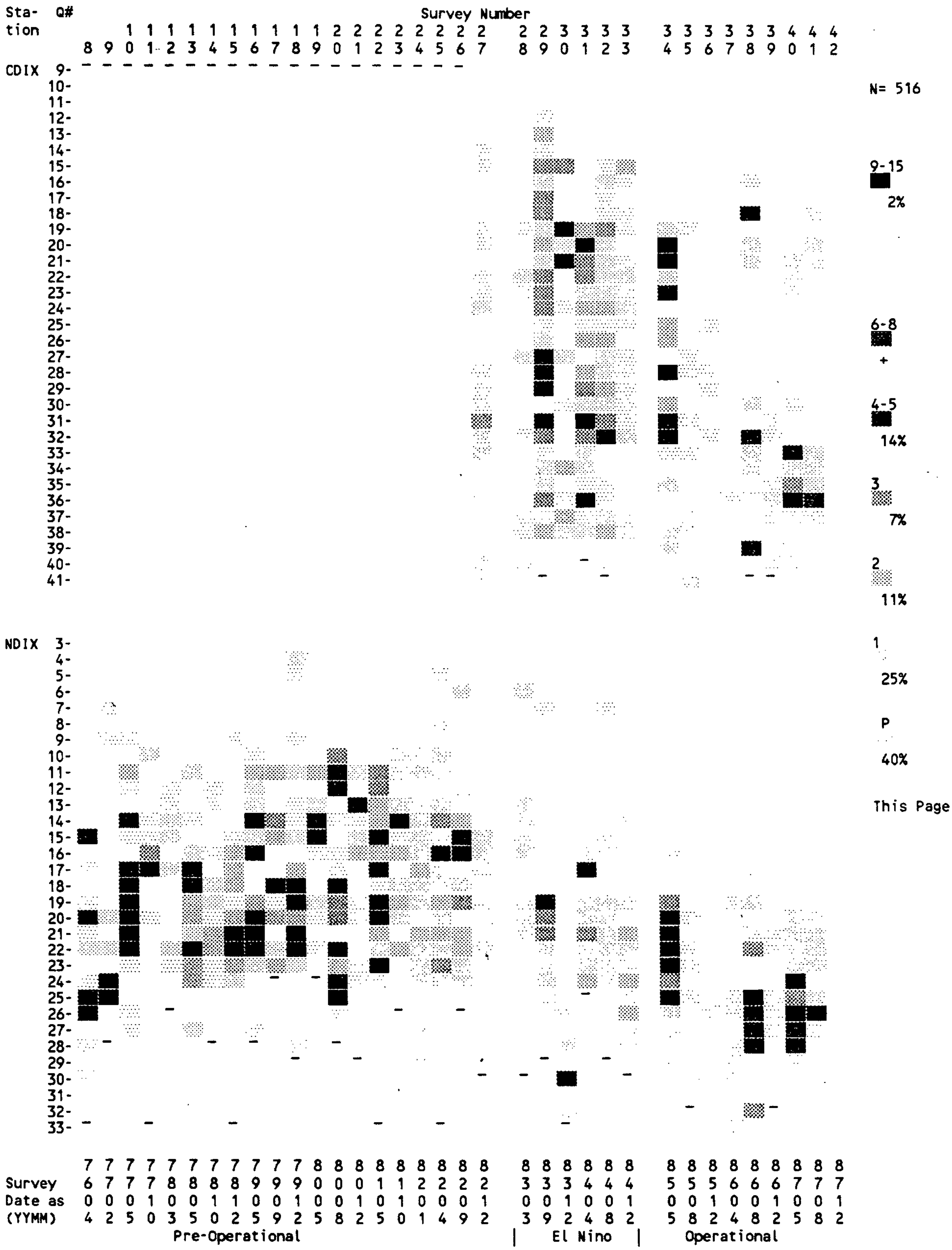
El Niño: 1982-83 winter storm: SDIX population reduced to zero, (due to cobble overlay and storm removal), but was well below normal just prior to storms. NDIX and CDIX with occurrences somewhat reduced (no apparent pattern) but NDIX was below normal just prior to storms. LCIX within normal limits (i.e., not a major component of the flora).

El Niño: 1983-1984: SDIX with covers sporadically recovering, occurrences at upper parts of range not recovering, and sporadically gaining occurrences in lower intertidal. NDIX with covers recovering rapidly (perhaps slightly subnormal) then stable, but sporadically losing occurrences at upper part of intertidal. CDIX recovered rapidly in covers but with sporadic loss of occurrences at all levels. LCIX within normal limits (i.e., scattered occurrences).

Diablo DCPP Operation: All Cove stations with large to moderate declines in occurrences and covers Autumn 1985 to Spring 1986. SDIX recovering occurrences toward upper parts of range but not to previously occurring tidal levels, possibly retreating slightly from lower intertidal. Covers sporadic but within normal limits. NDIX with reductions as noted above and with trend of decline for upper parts of range. Covers and occurrences somewhat sporadic. CDIX with reductions as noted above, then with sporadic covers and occurrences with trend towards loss of occurrences in upper part of range. LCIX normal with scattered occurrences.

Taxon or Category: Iridaea heterocarpa

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

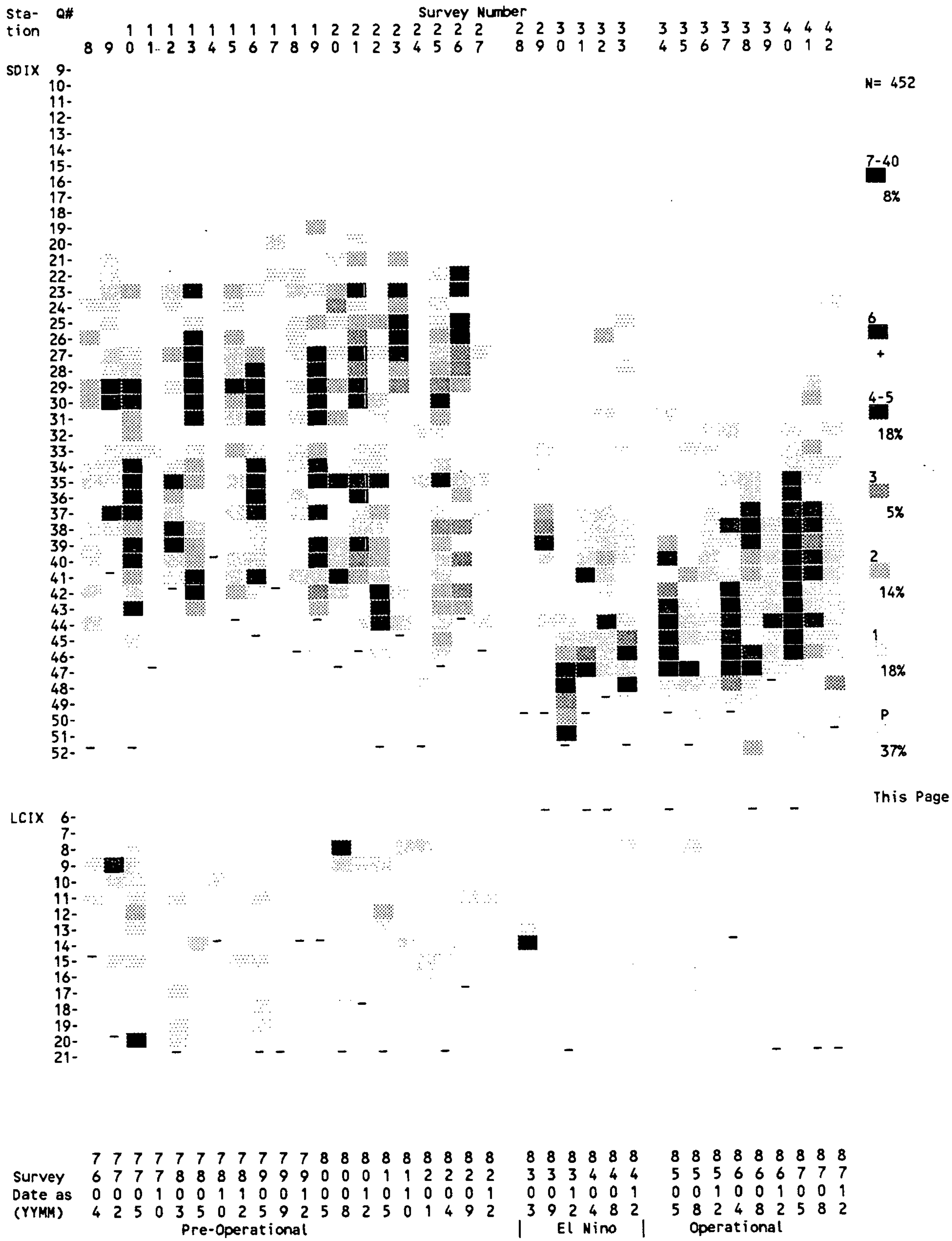


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for IRIHET CSV 5787 3-29-88 7:33a 04-14-1989 10:14

Taxon or Category: Iridaea heterocarpa

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for IRIHET CSV 5787 3-29-88 7:33a 04-14-1989 10:14

Audit: CLUMRG2P: V.1.2: for SIRIHET CLU 6581 4-22-89 9:28a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:25:52 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Iridaea heterocarpa: TOTAL Quads with Data = 185

Quad Range USED 12 to 39 for Total of 28 : Range WITH data 12 to 41: : # Dropped 8 : 4.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.747104: Maximum Distance = 543

```
S27-8212  ------------------------------I
S28-8303  -------------------I          I
S35-8508  ---------------I   I------I   I--------------------I
S36-8512  -----------I--II---I      I   I                    I
S37-8604  -----I-----I  II          I---I                    I
S42-8712  -----I        I           I                        I--I
S39-8612  --------------I           I                        I  I
S33-8412  --------------------------I                        I  I-I
S32-8408  ---------------------------------------------------I  I I-----I
S30-8312  ------------------------------------------------------I I     I
S40-8705  ------------------------------------I-------------------I     I------------------I
S41-8708  ------------------------------------I                         I                  I--------------------I
S38-8608  --------------------------------------------------------------I                  I                    I
S29-8309  --------------------------------------------------------------------I------------I                    I------
S31-8404  --------------------------------------------------------------------I                                 I
S34-8505  ------------------------------------------------------------------------------------------------------I
```

Station: NDIX: Iridaea heterocarpa: TOTAL Quads with Data = 331

Quad Range USED 9 to 27 for Total of 19 : Range WITH data 4 to 33: : # Dropped 88 : 26.6%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.800796: Maximum Distance = 336

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ------------------------------------------------------------------I------I
S38-8608  ------------------------------------------------------------------I      I
S 9-7702  -----------------------------------------------------I                   I
S11-7710  -----------------------------------------------I     I                   I
S14-7810  ------------------I--I                         I     I                   I
S32-8408  ------------------I  I---I                     I     I                   I
S33-8412  ---------------------I   I                     I     I                   I
S27-8212  ------------------I--I   I----------I          I     I----I              I
S28-8303  ------------------I  I   I          I          I     I    I              II
S30-8312  I----I               I---I          I          II    I    I              II
S36-8512  I    I--I            I              I          II    I    I              II
S42-8712  -----I  I--I         I              I--I       II    I    I              II
S37-8604  --------I  I---------I              I  I       II    I    I              II
S39-8612  -----------I                        I  I--I    II----I    I--I           II
S35-8508  -----------I                        I  I  I    II         I  I           II
S24-8201  ------------------------------------I  I  I----II         I  I           II-------I
S41-8708  ---------------------------------------I  I     I         I  I           II       I
S21-8012  ------------------------------------------I     I         I  I-----------II       I
S29-8309  ------------------------------------------------I         I  I            I       I
S13-7805  ---------------------------------------------I------------I  I            I       I---------I
S15-7812  ---------------------------------------------I               I            I       I         I
S25-8204  -------------------------------------------------------------I            I       I         I
S34-8505  --------------------------------------------------------------------------I       I         I-----I
S10-7705  ----------------------------------------------------------------------I-----------I         I     I
S22-8105  ----------------------------------------------------------------------I                     I     I---I
S40-8705  --------------------------------------------------------------------------------------------I     I   I------
S20-8008  --------------------------------------------------------------------------------------------------I   I
S16-7905  ----------------------------------------------------------------------------------------I-------------I
S18-7912  ----------------------------------------------------------------------------------------I
```

Station: SDIX: Iridaea heterocarpa: TOTAL Quads with Data = 397

Quad Range USED 20 to 43 for Total of 24 : Range WITH data 17 to 52: : # Dropped 107 : 27.0%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.909660: Maximum Distance = 1098

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  ----------I
S11-7710  -I-I      I
S28-8303  II II     I
S30-8312  I  III    I
S27-8212  ---III    I
S24-8201  ----II--I I
S33-8412  -----I  I I-I
S35-8508  -----I  I-I I
S32-8408  -------II I I
S36-8512  ----I-III I I--I
S42-8712  ----I II  I I  I
S39-8612  ------I   I I  I---I
S18-7912  ----------I I  I   I
S31-8404  ------------I  I   I-I
S29-8309  ---------------I   I I
S34-8505  -------------------I I---I
S15-7812  ------------------I-II   I
S25-8204  ------------------I II   I--------I
S20-8008  --------------------I    I        I-I
S41-8708  -------------------------I        I I
S23-8110  -------------------------I--------I I----I
S26-8209  -------------------------I          I    I
S22-8105  ----------------------I-------------I    I
S37-8604  ----------------------I                  I-----I
S10-7705  -------------------------I---I           I     I
S19-8005  -------------------------I   I-I         I     I---------I
S16-7905  -----------------------------I I---------I     I         I
S21-8012  -------------------------------I               I         I---------------------------------------I
S38-8608  -----------------------------------------------I         I                                       I------
S13-7805  ---------------------------------------------------------I                                       I
S40-8705  -------------------------------------------------------------------------------------------------I
```

Station: LCIX: Iridaea heterocarpa: TOTAL Quads with Data = 55

Quad Range USED 8 to 17 for Total of 10 : Range WITH data 8 to 20: : # Dropped 11 : 20.0%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.881370: Maximum Distance = 65

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  -------------------------------------------------------------------------------------------------I
S10-7705  ------------------------------I----------------------I                                           I
S22-8105  ------------------------------I                      I                                           I
S11-7710  I                                                    I                                           I
S17-7909  I-------------I                                      I                                           I
S36-8512  I             I---I                                  I                                           I
S42-8712  I             I   I                                  I                                           I
S15-7812  I-------------I   I--I                               I                                           I
S39-8612  I                 I  I                               I                                           I
S12-7803  --------------I---I  I-I                             I-------------------------------------I     I------
S30-8312  I-------------I      I I                             I                                     I     I
S41-8708  I                    I I-I                           I                                     I     I
S33-8412  ---------------------I I I                           I                                     I     I
S16-7905  --------------I--------I II                          I                                     I     I
S27-8212  --------------I         II---I                       I                                     I     I
S21-8012  -------------------------II  I------------I          I                                     I---I I
S35-8508  -------------------------I   I            I          I                                     I   I I
S13-7805  -------------------------I---I            I-----I    I                                     I   I I
S25-8204  -------------------------I                I     I---I                                      I   I--I
S23-8110  ------------------------------------------I     I                                          I   I
S24-8201  ------------------------------------------------I                                          I   I
S28-8303  -------------------------------------------------------------------------------------------I   I
S20-8008  -----------------------------------------------------------------------------------------------I
```

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Laurencia spectabilis/blinksii Ref. AH, 1976. p 728ff.
Phylum Rhodophyta: **Class** Ceramiales:

Description: Crisp dense flabellate blades, in clumps, brown to rose-red. 2 - 20+ cm tall.

Distribution: see below. Frequent, mid to low intertidal. Not a warm-tolerant group.

Diablo Area Specific Information: Fairly rare, occurring in about 10% of our quadrats in covers up to 20%.

Habitat: On rock, tops and sides, mid (LCIX only) to low intertidal. Mostly intermingled with other algae, sometimes as relatively pure stands.

Observational Errors: Rarely mis-identified. Missed observations occur possibly <5% of the time due to small blades, eroded blades, or when small clumps mixed with other turf algae.

Field Identification Problems:

General: Field identified to species.

Station Specific: *Laurencia blinksii* only occurred at LCIX, and sometimes difficult to separate this taxon correctly and consistently from *L. spectabilis* here.

General Comments: n.a.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX reduced to zero, (due to cobble overlay and storm removal). NDIX reduced to 1 occurrence compared to 10 just prior to storms. CDIX with slight reduction in occurrences and some reduction in covers. LCIX some reduction in occurrences and possibly cover.

El Niño: 1983-1984: At SDIX covers low until late 1984 and upper range occurrences lost. NDIX with covers below normal but occurrences within normal limits. CDIX probably normal. LCIX slowly declining in covers, occurrences within normal limits.

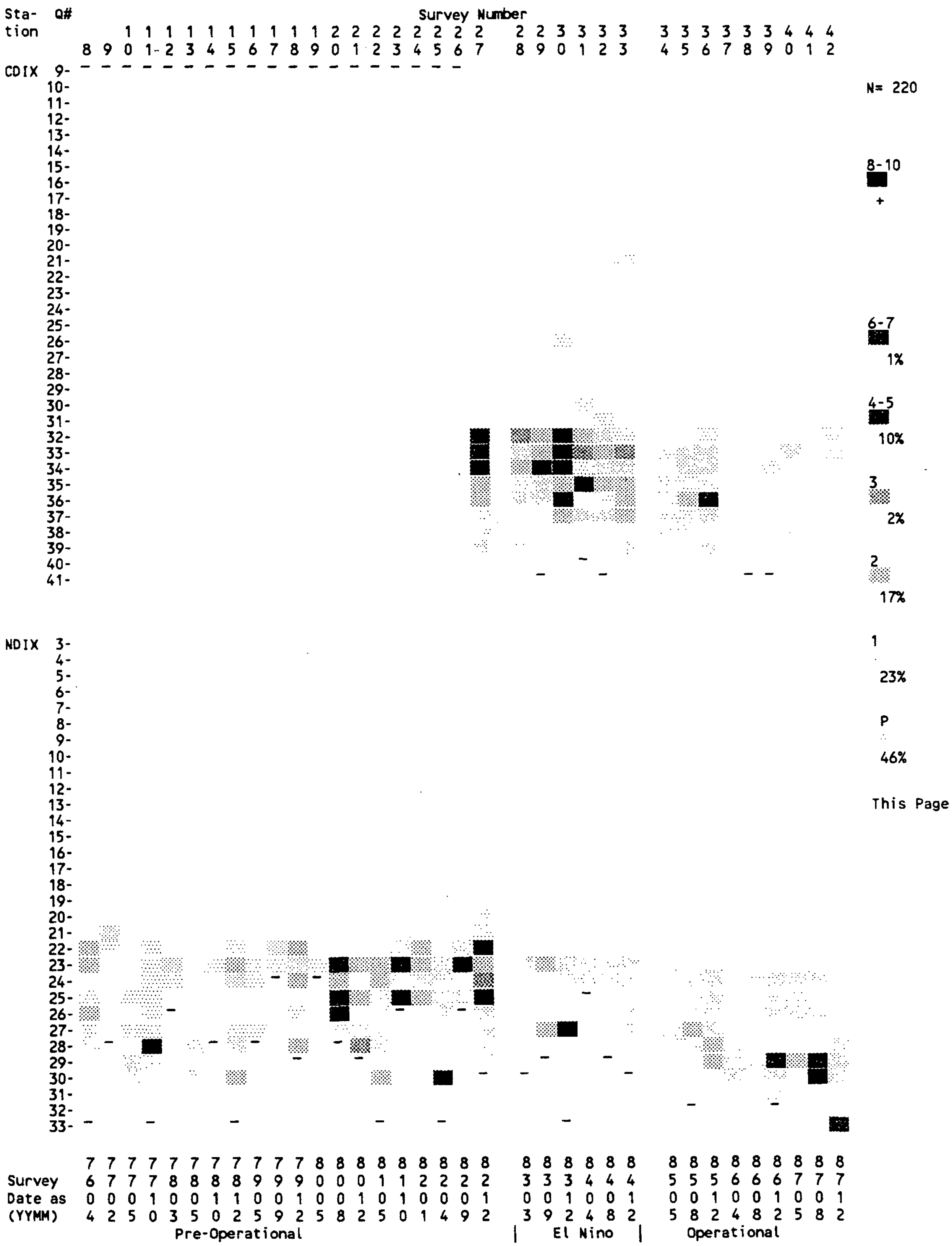
Diablo DCPP Operation: SDIX sporadically maintaining occurrences (but lower in intertidal than normal) and maintaining covers until Winter 1986. NDIX sporadically maintaining occurrences (possibly losing upper parts of range) and with covers low (brief "bloom" in several quadrats) but all within normal limits (i.e., similar to 1978). CDIX as for El Niño (but covers lower) until Spring 1986 when disappeared until Winter 1986. Low occurrences and covers thereafter. LCIX approximately normal but sporadic for occurrences, with covers probably lower than normal.

Laurencia blinksii: Pigeon Point (San Mateo Co., Calif) to San Luis Obispo Co. (Calif.).

Laurencia spectabilis: Alaska to San Diego (California).

Taxa or Category: Laurencia spectabilis +[L. blinksii (LCIX ONLY)]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

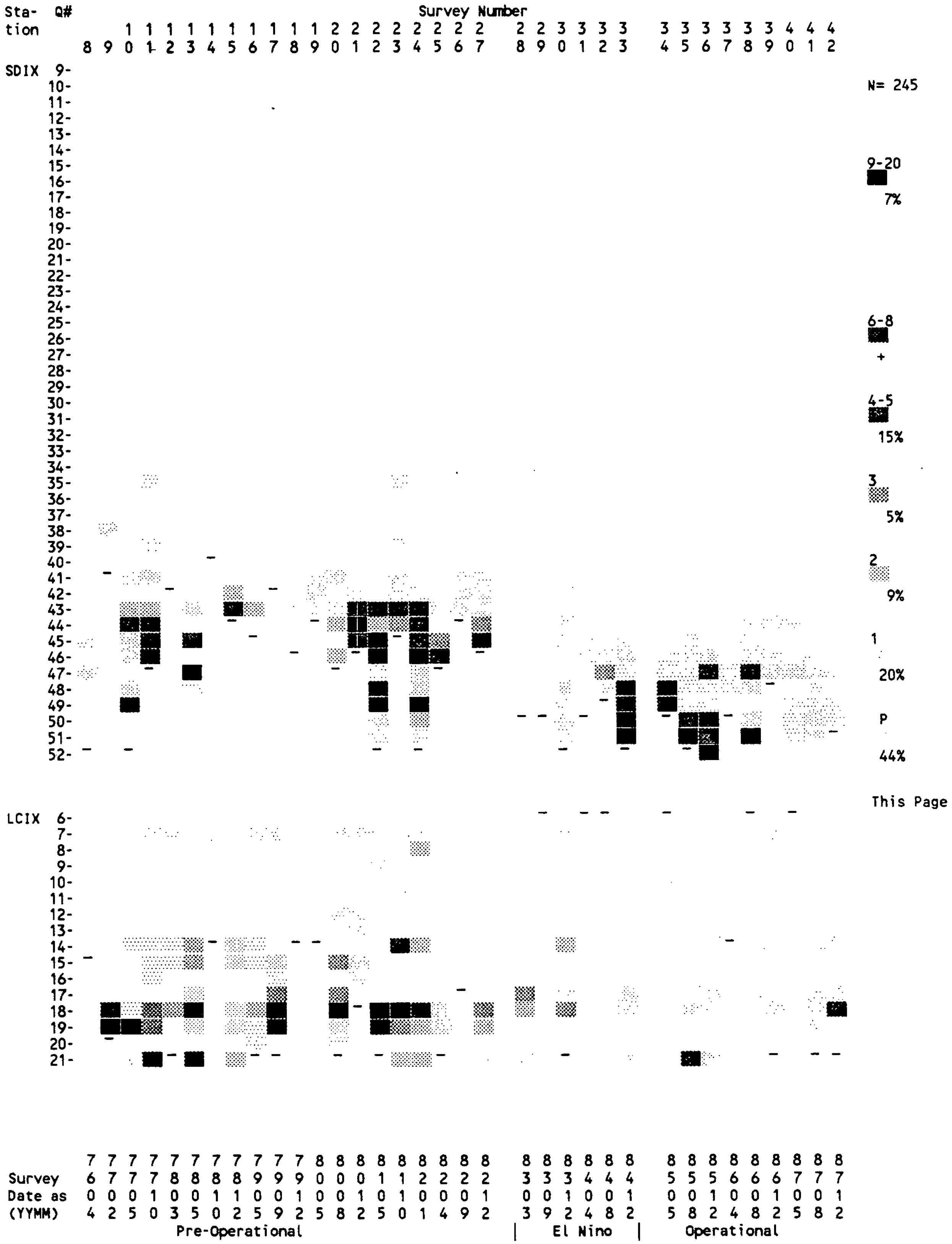


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for LAUSBL CSV 5406 9-30-88 7:37a 04-14-1989 10:45

Taxa or Category: Laurencia spectabilis +[L. blinksii (LCIX ONLY)]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for LAUSBL CSV 5406 9-30-88 7:37a 04-14-1989 10:45

Audit: CLUMRG2P: V.1.2: for SLAUSBL CLU 5829 4-22-89 9:33a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:30:43 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Laurencia spectabilis +[L. blinksii (LCIX ONLY)]: TOTAL Quads with Data = 71
Abrev. taxon name(s): LAURENC SPE Quant. Data

Quad Range USED 32 to 39 for Total of 8 : Range WITH data 21 to 39: : # Dropped 4 : 5.6%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.764922: Maximum Distance = 81

```
S27-8212  -------------------------------------------------I-------------------------------------------------I
S30-8312  -------------------------------------------------I                                                 I
S28-8303  --------------------------------------I                                                            I
S32-8408  ---------------------------I----I     I-----I                                                      I
S35-8508  ---------------------------I    I-----I     I                                                      I
S33-8412  --------------------------------I           I---------------I                                      I
S34-8505  -------------------I-I                      I               I                                      I------
S40-8705  -------------------I I                      I               I                                      I
S37-8604  I                    I----------------------I               I                                      I
S38-8608  I------------I       I                                      II                                     I
S41-8708  I            II      I                                      II                                     I
S39-8612  -------------II------I                                      II-----I                               I
S42-8712  --------------I                                             II     I                               I
S29-8309  ------------------------------------------------------------II     I-------------------------------I
S36-8512  -------------------------------------------------------------I     I
S31-8404  -------------------------------------------------------------------I
```

Station: NDIX: Laurencia spectabilis +[L. blinksii (LCIX ONLY)]: TOTAL Quads with Data = 149
Abrev. taxon name(s): LAURENC SPE Quant. Data

Quad Range USED 21 to 27 for Total of 7 : Range WITH data 20 to 33: : # Dropped 58 : 38.9%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.892029: Maximum Distance = 64

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End   Dropped Surveys
S 8-7604  --------------------------------I
S15-7812  ------------------I------I      II
S18-7912  ------------------I      I------II
S24-8201  -------------------------I       I
S10-7705  ----------------I                I
S13-7805  I---------I     I--I             I
S37-8604  I         II    I  I             I
S14-7810  ----------II----I  I------I      I
S42-8712  -----------I       I      I      I-I
S16-7905  I-----------------II      I      I I
S34-8505  I                 II      I--I   I I
S32-8408  ----------I-I     I       I  I   I I
S38-8608  ----------I I-----I       I  I   I I
S41-8708  ------------I             I  I   I I
S21-8012  -----------------------I--I  I   I I
S28-8303  ---------------------I-I     I---I I
S29-8309  ---------------------I       I     I----------------------------I
S11-7710  ------------------II         I     I                            I
S22-8105  ------------------II---I     I     I                            I
S33-8412  -------------------I   I-I   I     I                            I
S25-8204  -----------------------I II  I     I                            I
S39-8612  I------------------------II--I     I                            I-----------------------------------I
S40-8705  I                         I        I                            I                                   I
S35-8508  ------------------I-------I        I                            I                                   I
S36-8512  ------------------I                I                            I                                   I------
S 9-7702  -----------------------------------I                            I                                   I
S30-8312  ----------------------------------------------------------------I                                   I
S20-8008  ----------------------------------------------------------------------------------------------I-----I
S27-8212  ----------------------------------------------------------------------------------------------I
```

Station: SDIX: Laurencia spectabilis +[L. blinksii (LCIX ONLY)]: TOTAL Quads with Data = 136
Abrev. taxon name(s): LAURENC SPE Quant. Data

Quad Range USED 39 to 45 for Total of 7 : Range WITH data 35 to 52: : # Dropped 93 : 68.4%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.869446: Maximum Distance = 63

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604 I
S31-8404 I---------I
S33-8412 I         I
S35-8508 I         I
S28-8303 I         I-I
S29-8309 I         I I
S32-8408 I         I I
S34-8505 I---------I I
S36-8512 I           I----------I
S37-8604 I           I          I
S41-8708 I           I          I
S18-7912 ------------I          I
S38-8608 ----------I I          I--------I
S39-8612 I         I-I          I        I
S40-8705 I---------I            I        I--------------------I
S42-8712 I                      I        I                    I
S30-8312 -----------------------I        I                    I--------------------------------------------I
S20-8008 --------------------------------I                    I                                            I
S13-7805 ------------------------I----------------------------I                                            I
S25-8204 ------------------------I                                                                         I------
S10-7705 --------------------------I--------------------I                                                  I
S11-7710 --------------------------I                    I------------------I                               I
S27-8212 -----------------------------------------------I                  I-------------------I           I
S21-8012 --------------------------------------------I---------------------I                   I-----------I
S24-8201 --------------------------------------------I                                         I
S22-8105 --------------------------------------------------------------------------------------I
```

Station: LCIX: Laurencia spectabilis +[L. blinksii (LCIX ONLY)]: TOTAL Quads with Data = 110
Abrev. taxon name(s): LAURENC SPE +LAURENC BLI Quant. Data

Quad Range USED 12 to 19 for Total of 8 : Range WITH data 7 to 22: : # Dropped 37 : 33.6%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.879339: Maximum Distance = 150

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702 -----------------------------I----------I
S22-8105 -----------------------------I          II
S17-7909 ----------------I-----------------------II------I
S20-8008 ----------------I                        I      I
S23-8110 -----------------------------------------I      I
S11-7710 ----------------I                               I
S24-8201 ----I------I    I-I                             I
S27-8212 ----I      I----I I                             I
S30-8312 -----------I      I                             I
S12-7803 ----I----I        I                             I-------------------------------------------------I
S16-7905 ----I    II       I---I                         I                                                 I
S39-8612 ---------II-I     I   I                         I                                                 I
S33-8412 ----I--I  I I     I   I                         I                                                 I
S36-8512 ----I  I--I II    I   I                         I                                                 I
S35-8508 -------I    II-I  I   I-I                       I                                                 I
S25-8204 ------------II I--I   I I                       I                                                 I------
S41-8708 -------------I I      I I-----------------------I                                                 I
S15-7812 ---------------I      I I                                                                         I
S28-8303 ----------------------I I                                                                         I
S13-7805 ---------------I--------I                                                                         I
S42-8712 ---------------I                                                                                  I
S10-7705 --------------------------------------------------------------------------------------------------I
```

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Microcladia coulteri Harvey, 1853. Ref. AH, 1976. p 606.
Phylum Rhodophyta: **Class** Ceramiales:

Description: Lacy blades, epiphytic, deep rose drying to black. 1 - 30 + cm tall.

Distribution: Vancouver Island (British Columbia) to Baja California. Abundant epiphyte on large red algae, mid intertidal to subtidal (10 m). A warm-tolerant taxon.

Diablo Area Specific Information: Fairly uncommon, occurring in about 10% of our quadrats in covers up to 40%.

Habitat: Mainly on *Iridaea* spp., *Gigartina* spp., and *Prionitis* spp., lower intertidal.

Observational Errors: Rarely mis-identified. Missed observations occur possibly 5% of the time due to eroded specimens. For earlier surveys was noted only as present (with some relapses in later surveys).

Field Identification Problems:

General: None known, but could possibly include almost any similar appearing epiphyte.

Station Specific: n.a.

General Comments: Most common macroscopic epiphyte in our study area. Normally quite seasonal with most stable population occurring at NDIX. Indirect impacts could include loss of host plants, affecting distributions of the epiphyte.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX reduced to zero, (due to cobble overlay and storm removal of hosts), but low in occurrence for survey just prior. NDIX somewhat reduced in occurrences but remaining covers good. CDIX with only 1 occurrence compared to 6 for prior survey. LCIX within normal limits.

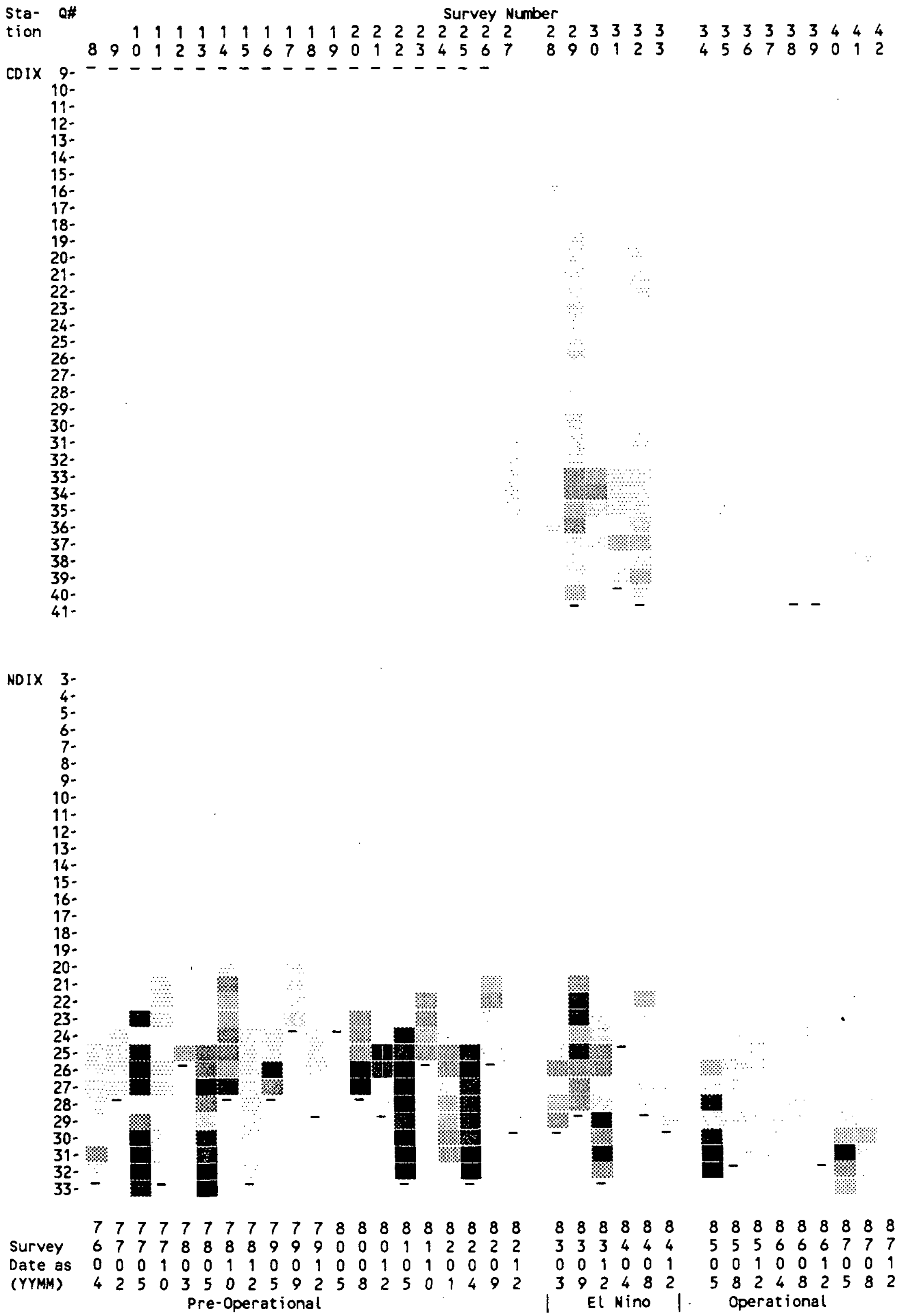
El Niño: 1983-1984: SDIX within normal limits but probably losing occurrences at upper part of range (perhaps host plants unavailable). NDIX within normal limits, but towards end of period, with greatly reduced occurrences. CDIX with a "bloom" of occurrences throughout mid to lower levels, declining rapidly to normal, then with no occurrences at end of period. LCIX with no occurrences until end of period.

Diablo DCPP Operation: SDIX with sporadic "blooms" of cover (usually in Autumn of year), very sporadic in occurrences and never extending as high in the intertidal as previously (possibly host plant loss) but otherwise within normal limits. NDIX sporadic in covers and occurrences, with a probably trend of loss of occurrences at upper parts of range. CDIX with only 2 occurrences for period. LCIX within normal limits (i.e., sporadic occurrences).

NOTE: much if not all of impact to this taxon was probably due to loss of host plants.

Taxon or Category: Microcladia coulteri [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



N= 239

13-40
9%

9-12
9%

6-8
1%

4-5
15%

2-3
9%

1
6%

P
51%

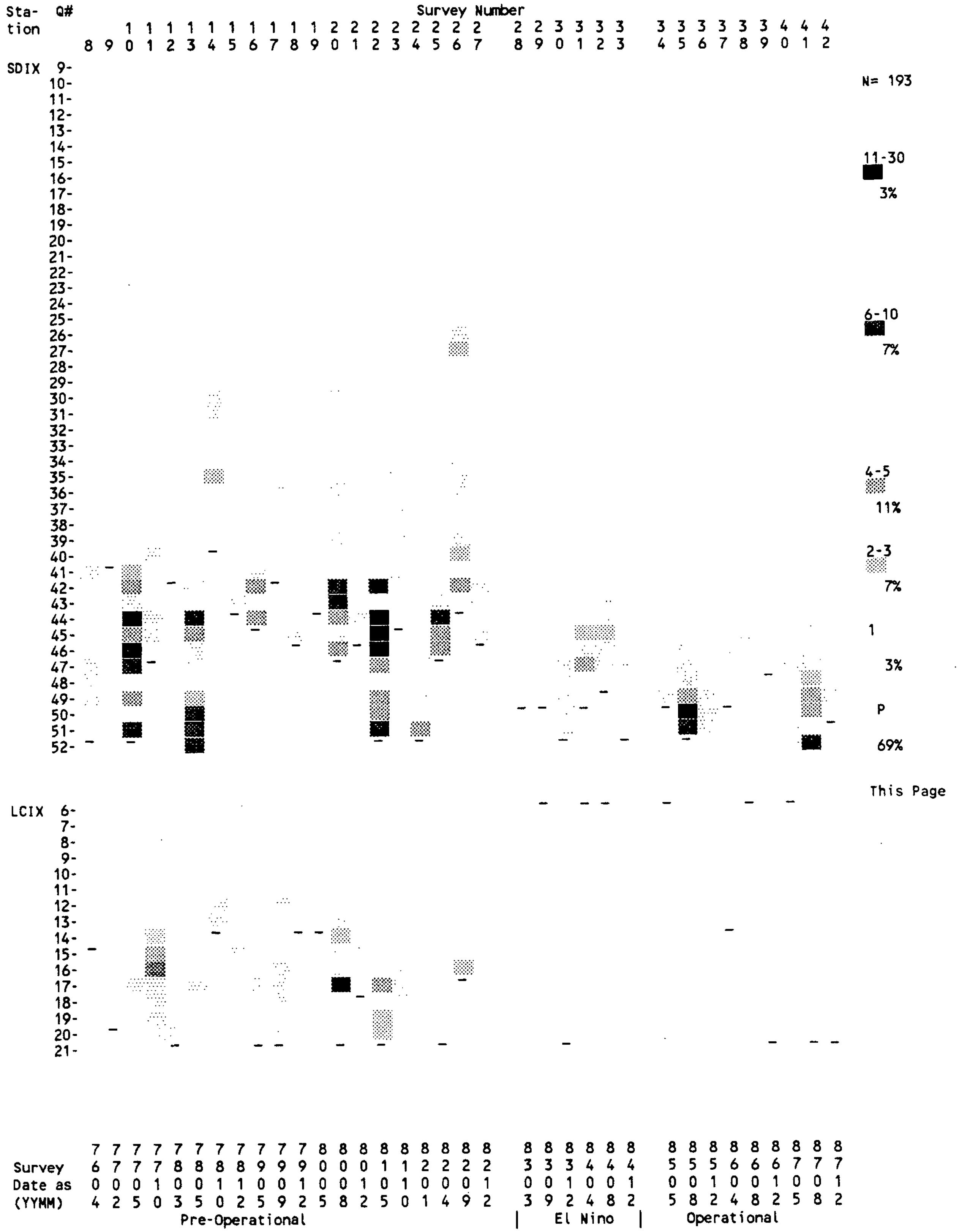
This Page

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for MICCOU CSV 5429 3-29-88 7:35a 04-14-1989 10:45

Taxon or Category: Microcladia coulteri [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for MICCOU CSV 5429 3-29-88 7:35a 04-14-1989 10:45

Audit: CLUMRG2P: V.1.2: for SMICCOU CLU 6163 4-22-89 9:43a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:35:07 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Microcladia coulteri [Mixed P/%]: TOTAL Quads with Data = 53

Quad Range USED 18 to 39 for Total of 22 : Range WITH data 16 to 40: : # Dropped 3 : 5.7%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.939073: Maximum Distance = 249

```
S27-8212  --------------------I
S28-8303  --------I           I
S33-8412  I       I           I
S34-8505  I       I           I
S36-8512  I       I           I---I
S37-8604  I-------II          I   I
S38-8608  I       II          I   I
S39-8612  I       II          I   I
S40-8705  I       II----------I   I---------------------I
S42-8712  I       II              I                     I
S35-8508  --------II              I                     I---------I
S41-8708  ---------I              I                     I         I
S31-8404  ------------------------I                     I         I-----------------------------------------I
S32-8408  ----------------------------------------------I         I                                         I------
S30-8312  --------------------------------------------------------I                                         I
S29-8309  --------------------------------------------------------------------------------------------------I
```

Station: NDIX: Microcladia coulteri [Mixed P/%]: TOTAL Quads with Data = 186

Quad Range USED 18 to 27 for Total of 10 : Range WITH data 17 to 33: : # Dropped 97 : 52.2%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.927680: Maximum Distance = 341

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End  Dropped Surveys
S 8-7604  --I
S 9-7702  I II
S15-7812  I-III
S35-8508  I  II
S18-7912  --IIII
S36-8512  --I II
S27-8212  ----II
S34-8505  ----III
S33-8412  --I  II
S37-8604  I I  II
S39-8612  I I  II
S40-8705  I-I--II-------------I
S41-8708  I I   I             I
S42-8712  I I   I             I
S38-8608  --I   I             I---------I
S11-7710  ----I-I             I         I
S32-8408  ----I               I         I
S24-8201  ------I--------I    I         I-----------------I
S30-8312  ------I        I----I         I                 I
S28-8303  ---------------I              I                 I-----------I
S16-7905  ------------------------------I                 I           I
S14-7810  -------------------------------------I----------I           II
S29-8309  -------------------------------------I                      II
S21-8012  ------------------------------------------------------------II-------------------------------------I
S10-7705  --------------------------------I---------------I            I                                     I
S25-8204  --------------------------------I               I------------I                                     I------
S13-7805  ------------------------------------------------I                                                  I
S20-8008  ------------------------I--------------------------------------------------------------------------I
S22-8105  ------------------------I
```

Station: SDIX: Microcladia coulteri [Mixed P/%]: TOTAL Quads with Data = 128

Quad Range USED 30 to 44 for Total of 15 : Range WITH data 26 to 55: : # Dropped 92 : 71.9%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.962554: Maximum Distance = 305

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  ----I
S18-7912  I   I
S28-8303  I   I
S30-8312  I   II
S33-8412  I   II
S34-8505  I   II
S35-8508  I---II
S36-8512  I    I
S37-8604  I    I
S38-8608  I    II
S39-8612  I    II
S40-8705  I    II
S42-8712  I    II
S24-8201  ----III
S29-8309  ----III---I
S11-7710  ----III   I
S21-8012  I---III   I
S31-8404  I    II   I---------------------------------I
S32-8408  -----II   I                                 I
S27-8212  ----I-I   I                                 I
S41-8708  ----I     I                                 I---------------------------I
S23-8110  ----------I                                 I                           I
S13-7805  ----I-------------------------I             I                           I-------------------------I
S25-8204  ----I                         I-------------I                           I                         I
S16-7905  ------------------------------I                                         I                         I------
S20-8008  ------------------------------------------------------------------------I                         I
S10-7705  ----------------------I---------------------------------------------------------------------------I
S22-8105  ----------------------I
```

Station: LCIX: Microcladia coulteri [Mixed P/%]: TOTAL Quads with Data = 70

Quad Range USED 12 to 19 for Total of 8 : Range WITH data 7 to 24: : # Dropped 32 : 45.7%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.908929: Maximum Distance = 65

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  I
S12-7803  I
S24-8201  I----------I
S27-8212  I          I
S30-8312  I          I-I
S42-8712  I          I I
S10-7705  I          I I
S13-7805  I----------I II
S16-7905  I            II
S28-8303  I            II
S15-7812  -------------II----I
S25-8204  I-------------I    I
S33-8412  I             I    I----I
S36-8512  I-------------I    I    I
S39-8612  I                  I    I--------------I
S35-8508  -------------------I    I              I
S17-7909  --------------------I---I              I---------------------------------------I
S41-8708  --------------------I                  I                                       I------------------I
S23-8110  ---------------------------------------I                                       I                  I------
S11-7710  -------------------------------------------------------------------------------I                  I
S20-8008  --------------------------------------------------------------I-----------------------------------I
S22-8105  --------------------------------------------------------------I
```

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Neoagardhiella baileyi. (now *N. gaudichaudii*) (Kutzing, 1866) Ref. AH, 1976. p 483.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Bushy clumps of crisp branches, red to rose-red. 2 - 40 cm tall.

Distribution: British Columbia to Baja California. Common, extremely variable, intertidal to subtidal (30 m) mostly near sand. A warm-tolerant species.

Diablo Area Specific Information: Uncommon, occurring in about 10% of our quadrats at covers up to 30%.

Habitat: On rocks, occasionally on tops, mostly on sides, low intertidal. Sometimes mixed with other algae, usually in areas with sand/gravel around boulders and cobbles.

Observational Errors: Rarely mis-identified (see below). Missed observations may be moderately common, possibly occurring about <5% possibly due to missing eroded or cryptic (on sides of rock covered by other plants) specimens.

Field Identification Problems:

General: Can be confused with *Pseudogloiophloea confusa* (but in Diablo area, this taxon mainly subtidal).

Station Specific: n.a.

General Comments: Occurs at lower ends of transect so some surveys failed to include area where occurred. Never occurring regularly at LCIX (no sandy areas here) and moderately sparse at CDIX (not much sand).

Impacts to Taxon:

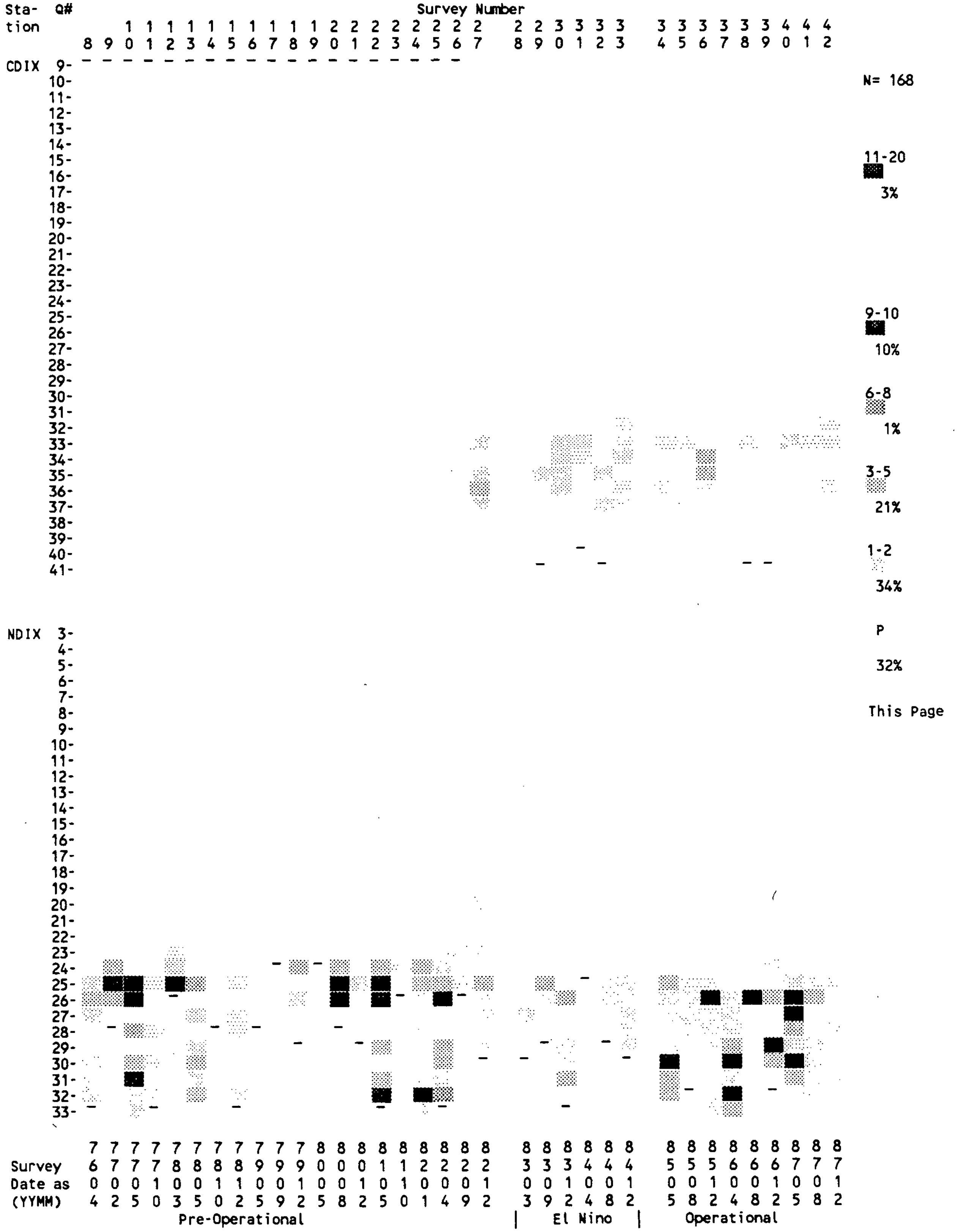
El Niño: 1982-83 winter storm: All stations with zero or 1 (NDIX) occurrence after storms.

El Niño: 1983-1984: SDIX moderately rapid recovery to normal covers except at upper parts of range. NDIX as at SDIX but here with covers possibly subnormal and more sporadic in occurrences. CDIX as for NDIX, but covers perhaps normal. LCIX with no occurrences which was normal.

Diablo DCPP Operation: SDIX with sporadic loss of a few occurrences at upper parts of range, covers occasionally above normal. NDIX with moderately stable occurrences (except Autumn and Winter 1986, when low), covers possibly subnormal towards end of 1987. CDIX with sporadic occurrences, occasionally to 0, but no trend, covers low, nevertheless probably within normal limits. LCIX within normal range, i.e., only one occurrence in Winter 1986.

Taxon or Category: Neoagardhiella baileyi (N. gaudichaudii)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

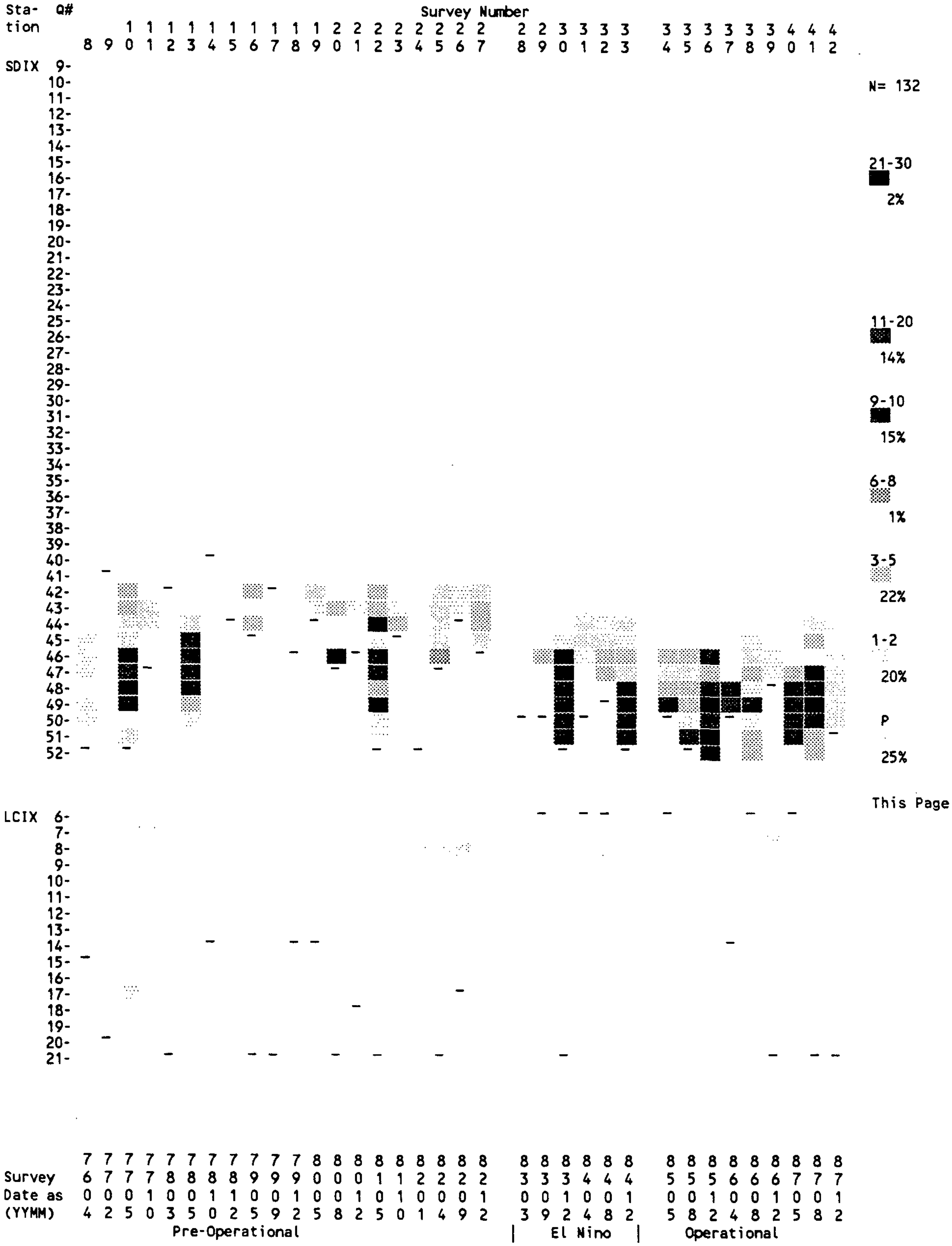


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for NEOBAI CSV 5398 3-29-88 7:35a 04-28-1989 08:15

Taxon or Category: Neoagardhiella baileyi (N. gaudichaudii)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for NEOBAI CSV 5398 3-29-88 7:35a 04-28-1989 08:15

Audit: CLUMRG2P: V.1.2: for SNEOBAI CLU 5829 4-22-89 9:47a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:44:49 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Neoagardhiella baileyi (N. gaudichaudii): TOTAL Quads with Data = 31

Quad Range USED 32 to 37 for Total of 6 : Range WITH data 32 to 37: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 37
COPHENETIC CORRELATION COEFFICIENT = 0.833694: Maximum Distance = 41

```
S27-8212  -------------------------------------------------I----------I
S30-8312  -------------------------------------------------I          I
S28-8303  I                                                           I
S37-8604  I------------I                                              I
S39-8612  I            I---I                                          I
S38-8608  I------------I   I--I                                       I--------------------------------------I
S41-8708  I                I  I---I                                   I                                      I
S35-8508  -----------------I  I   I                                   I                                      I
S34-8505  -------------I------I   I------------I                      I                                      I
S42-8712  -------------I          I            I                      I                                      I
S31-8404  -------------I----------I            I-I                    I                                      I------
S40-8705  -------------I                       I I--------------------I                                      I
S33-8412  -------------------------------------I I                                                           I
S29-8309  ----------------------------I----------I                                                           I
S32-8408  ----------------------------I                                                                      I
S36-8512  ---------------------------------------------------------------------------------------------------I
```

Station: NDIX: Neoagardhiella baileyi (N. gaudichaudii): TOTAL Quads with Data = 137

Quad Range USED 23 to 27 for Total of 5 : Range WITH data 18 to 33: : # Dropped 75 : 54.7%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.877409: Maximum Distance = 111

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End  Dropped Surveys
S 8-7604  --------------I
S30-8312  ----I         I-----I
S39-8612  ----I---------I     I-----------I
S41-8708  ----I               I           I
S36-8512  -----I--------------I           I
S38-8608  -----I                          I
S11-7710  I---I                           I
S42-8712  I   I                           I
S14-7810  I---I-I                         I
S16-7905  I   I I--I                      I---------------I
S15-7812  ----I I  I-I                    I               I
S21-8012  ------I  I I------------I       I               I
S28-8303  ---------I I            I       I               I
S32-8408  ---------I-I            I       I               I
S33-8412  -------I-I              I------II               I
S35-8508  ----I--I                I      II               I
S37-8604  ----I                   I      II               I-------I
S13-7805  --------I               I      II               I       I
S27-8212  -----I  I---------------I      I                I       I
S29-8309  -----I--I                      I                I       I
S34-8505  -----I                         I                I       I
S18-7912  -----------------I-------------I                I       I-------------------------------------------I
S24-8201  -----------------I                              I       I                                           I
S 9-7702  -------------------------------I----------------I       I                                           I
S10-7705  --------------------I----------I                        I                                           I------
S25-8204  --------------------I                                   I                                           I
S40-8705  --------------------------------------------------------I                                           I
S20-8008  --------------------------------------------I-------------------------------------------------------I
S22-8105  --------------------------------------------I
```

Station: SDIX: Neoagardhiella baileyi (N. gaudichaudii): TOTAL Quads with Data = 127

Quad Range USED 42 to 45 for Total of 4 : Range WITH data 42 to 55: : # Dropped 92 : 72.4%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.920351: Maximum Distance = 40

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604  I
S30-8312  I--------I
S38-8608  I        I
S18-7912  I        I
S24-8201  I        II
S28-8303  I        II
S29-8309  I        II
S34-8505  I--------II
S35-8508  I         I
S36-8512  I         I------------I
S37-8604  I         I            I
S39-8612  I         I            I
S40-8705  I         I            I---I
S21-8012  ----------I            I   I
S42-8712  ----------I            I   I
S31-8404  -------------I         I   I----------I
S32-8408  -------------I---------I   I          I
S33-8412  -------------I             I          I--------------------I
S11-7710  ---------------------------I          I                    I
S25-8204  ----------------------------------I---I                    I-----------------------------------I
S41-8708  ----------------------------------I                        I                                   I
S20-8008  -----------------------------------------------------------I                                   I---I
S10-7705  --------------------------------------------------------I--------------I                       I   I
S27-8212  --------------------------------------------------------I              I-----------------------I   I------
S22-8105  -----------------------------------------------------------------------I                           I
S13-7805  ---------------------------------------------------------------------------------------------------I
```

Station: LCIX: Neoagardhiella baileyi (N. gaudichaudii): TOTAL Quads with Data = 7:**** Prob. INSUFFICIENT Data

Quad Range USED 7 to 17 for Total of 11 : Range WITH data 7 to 17: : # Dropped 1 : 14.3%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.952233: Maximum Distance = 12

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  I
S12-7803  I
S13-7805  I
S15-7812  I
S16-7905  I
S17-7909  I
S20-8008  I
S21-8012  I
S23-8110  I--------------------------------------------------------------------------------------------I
S27-8212  I                                                                                            I
S28-8303  I                                                                                            I
S30-8312  I                                                                                            I
S33-8412  I                                                                                            I-I
S35-8508  I                                                                                            I I
S36-8512  I                                                                                            I I
S41-8708  I                                                                                            I I--I
S42-8712  I                                                                                            I I  I
S10-7705  ---------------------------------------------------------------------------------------------I I  I-I
S11-7710  I----------------------------------------------------------------------------------------------I  I I
S39-8612  I                                                                                                I I------
S22-8105  --------------------------------------------------------------------------------------------------I I
S24-8201  I---------------------------------------------------------------------------------------------------I
S25-8204  I
```

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Petrocelis francsicana/Ralfsia spp. Ref. AH, 1976. p 476/167.
Phylum Rhodophyta/Phaeophyta: **Class** Gigartinales/Chordariales:

Description: Crusts, olive-brown to reddish-black to black. About 0.2 - 1 mm thick and up to 1 m diameter. *Ralfsia* occasionally with growth rings visible.

Distribution: see below. Common, upper to mid-intertidal. A warm-tolerant group.

Diablo Area Specific Information: Abundant, occurring in about 80% of our quadrats in covers up to 90%.

Habitat: On rocks and cobbles, tops, sides, occasionally undersides, upper to low intertidal. In open areas as extensive patches or as scattered small patches under algal overstory and mat.

Observational Errors: Difficult to assess mis-identification (see below). Missed observations infrequent occurring about <1% possibly due to mis-identification, missing small patches under dense algal mats or in sand/gravel areas, or because of commonness, forgetting to record occurrence. *Ralfsia* and *Petrocelis* were not separately field identified until mid 1978.

Field Identification Problems:

General: The two taxa were separately identified in the field (after 1978), but the distinguishing field characteristics of *Ralfsia* not always present. Depending on coloration, age, erosion, etc. could be identified as almost any of the non-coralline crusts (*Hildenbrandia*, *Peyssonellia*, or other species of the *Petrocelis*). Note below the species that have been laboratory identified for our intertidal stations.

Errors in cover estimates could be relatively large due to thickness of overlying algal mat and confusion with black bare rock, depending on lighting and wetness of area.

Station Specific: *Ralfsia* observed infrequently at LCIX. Also at LCIX the typically dense algal mat hampers reliable assessment of covers.

General Comments: *Ralfsia* was a relatively minor part of the flora at our stations (in about 10% of our quadrats), but where occurring could form extensive covers.

Impacts to Taxon:

El Niño: 1982-83 winter storm: All stations with slight reductions in covers, with SDIX most affected, losing occurrences (cobble overlay), and LCIX with some reduction of occurrences and covers.

El Niño: 1983-1984: SDIX with rapid but somewhat sporadic recovery of covers (except at mid range where cobble overlay affected covers) and occurrences. Occurrences possibly beginning to extend farther down in the intertidal. NDIX with reduced covers at upper part of range and in several quadrats in mid range where large boulders were introduced. Possible trend of increasing covers at lower part of range. CDIX probably normal, but covers somewhat sporadic and possibly some thinning at upper levels. LCIX probably returned to normal but covers could be in error due to overlying algal mat.

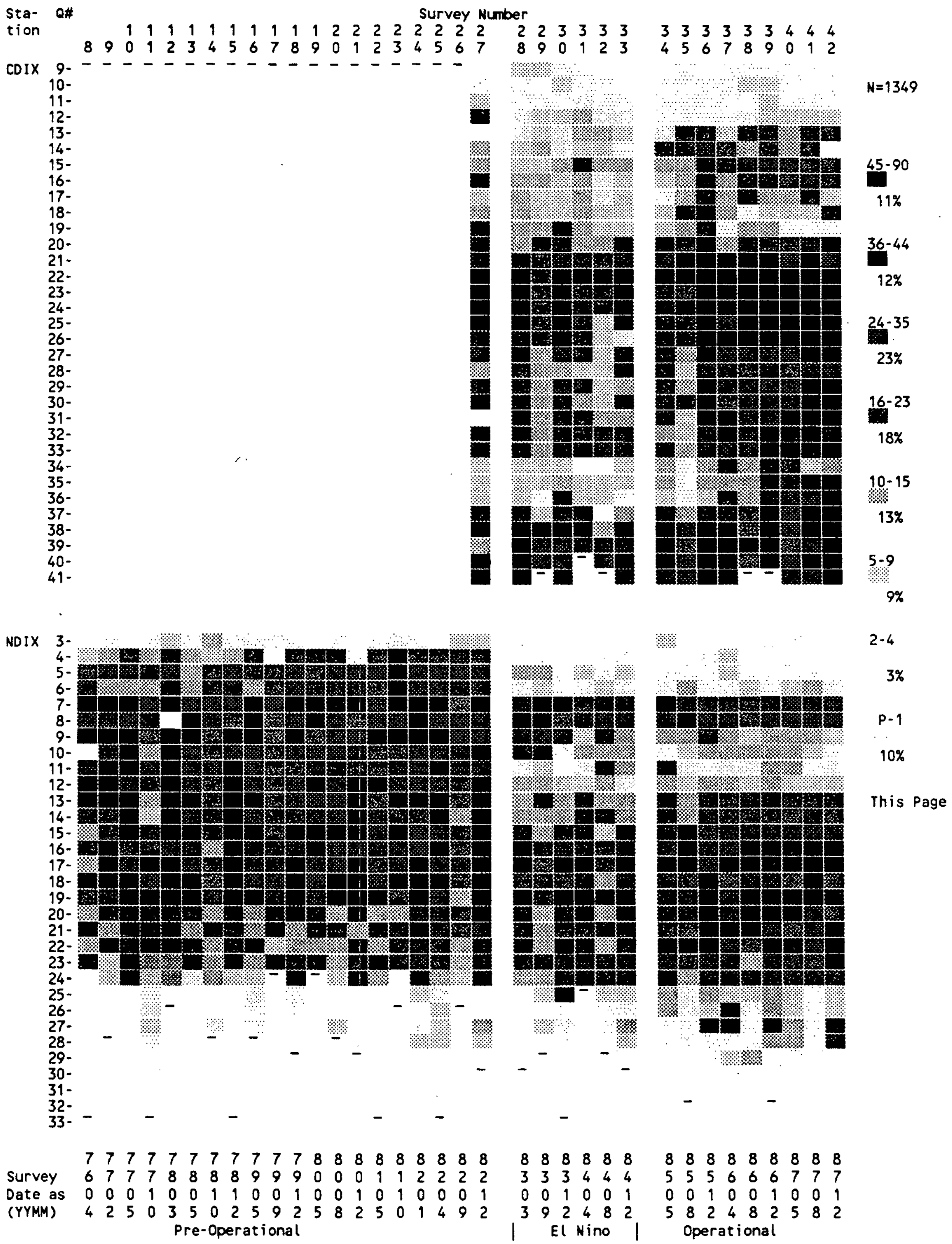
Diablo DCPP Operation: SDIX with upper and mid quadrats still unstable cobble with lower than normal covers. Still occurring sporadically farther down in intertidal than normal. NDIX much as during El Niño, with no indication of increasing covers at upper parts of range or where boulders were introduced. CDIX with trend towards increase of covers at mid-upper part of range and at lower part of range and less sporadic in cover than during El Niño. LCIX within normal limits.

Petrocelis francsicana: Hope Island (British Columbia) to Baja California.

Ralfsia pacifica: Alaska to Sinaloa, Mexico.

Taxa or Category: Petrocelis franciscana +Ralfsia sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

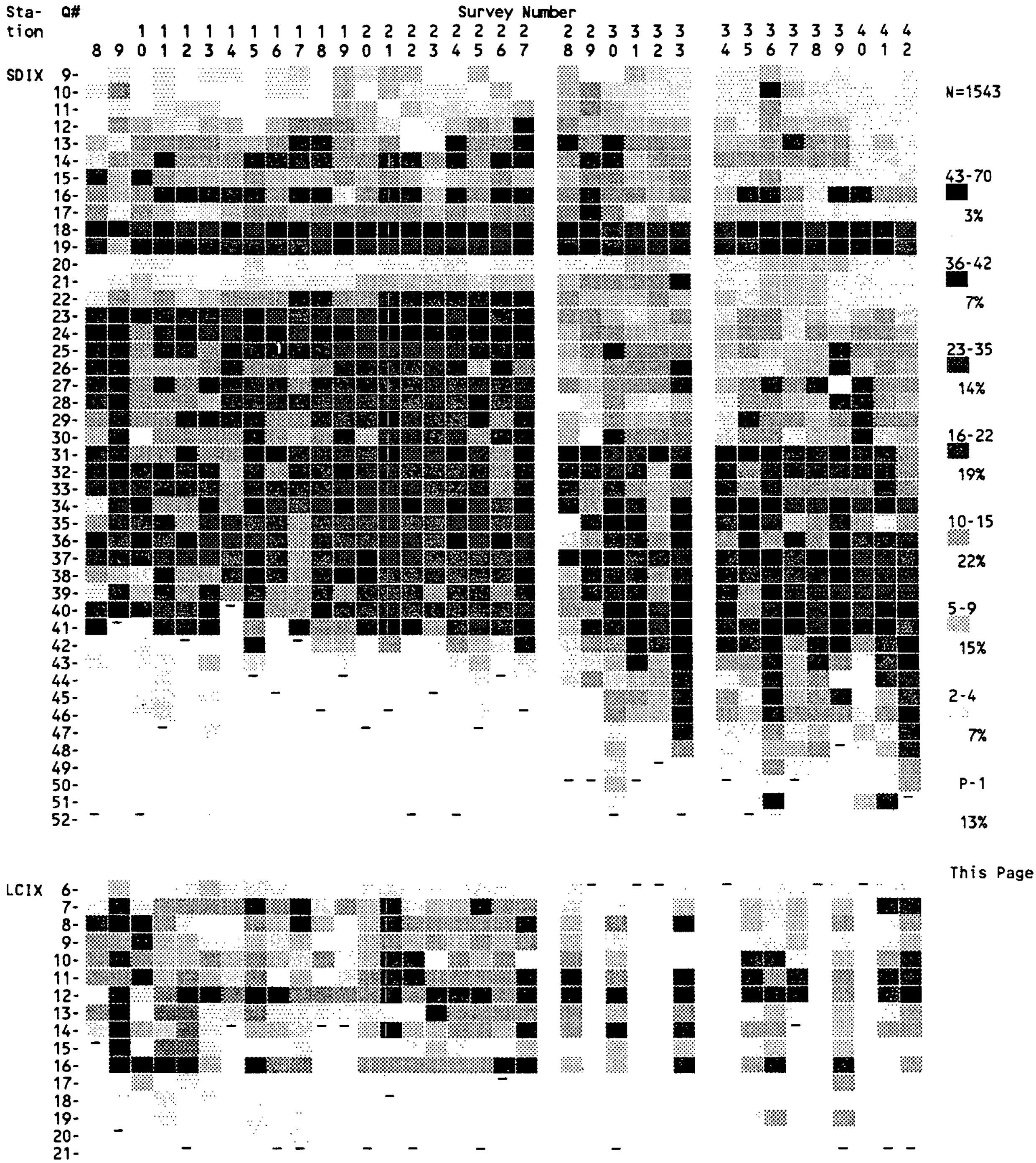


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PETRAL CSV 7627 9-30-88 7:34a 04-14-1989 10:47

Taxa or Category: Petrocelis franciscana +Ralfsia sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Date as (YYMM)

Survey Number	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Date (YYMM)	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212

Pre-Operational

Survey Number	28	29	30	31	32	33
Date (YYMM)	8303	8309	8312	8404	8408	8412

El Nino

Survey Number	34	35	36	37	38	39	40	41	42
Date (YYMM)	8505	8508	8512	8604	8608	8612	8705	8708	8712

Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PETRAL CSV 7627 9-30-88 7:34a 04-14-1989 10:48

Audit: CLUMRG2P: V.1.2: for SPETRAL CLU 6581 4-22-89 9:57a: 04-27-1989/17:33
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:54:34 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Petrocelis franciscana +Ralfsia sp.: TOTAL Quads with Data = 550

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 4 to 41: : # Dropped 67 : 12.2%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.497581: Maximum Distance = 3852

```
S27-8212 -----------------------------------------------I---------I
S30-8312 -----------------------------------------------I         II
S33-8412 ---------------------------------------------------------II-----I
S28-8303 -----------------------------------------------I----------I     I
S37-8604 -----------------------------------------------I                I---------------------------------I
S29-8309 -------------------------------------------I------I             I                                 I
S32-8408 -------------------------------------------I      I-------------I                                 I
S31-8404 --------------------------------------I------I    I                                               I
S34-8505 --------------------------------------I      I----I                                               I------
S35-8508 ---------------------------------------------I                                                    I
S36-8512 -----------------------------------------------------------------I                                I
S38-8608 -------------------------------------------I-----I               I-----------------------I        I
S40-8705 -------------------------------------------I     I-------I       I                       I        I
S39-8612 -------------------------------------------------I       I-------I                       I--------I
S41-8708 ---------------------------------------------------------I                               I
S42-8712 -----------------------------------------------------------------------------------------I
```

Station: NDIX: Petrocelis franciscana +Ralfsia sp.: TOTAL Quads with Data = 848

Quad Range USED 4 to 25 for Total of 22 : Range WITH data 1 to 33: : # Dropped 167 : 19.7%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.603691: Maximum Distance = 2050

```
S17-7909:  <-Start Dropped Surveys
S19-8005:
S31-8404:  <-End   Dropped Surveys
S 8-7604 -----------------------------------------------------------------------------------------I
S 9-7702 --------------------------------------------------------------I                          I
S13-7805 --------------------------------------I-----------I           I--I                       I
S16-7905 --------------------------------------I           I------I    I  I                       I
S20-8008 ---------------------------------------------I----I      I----I  I                       I--------I
S22-8105 ---------------------------------------------I           I       I                       I        I
S23-8110 ------------------------------------------------------I--I       I---I                   I        I
S24-8201 ---------------------------------------------I--------I          I   I                   I        I
S25-8204 ---------------------------------------------I                   I   I                   I        I
S15-7812 -----------------------------------------------I-----I           I   I-------------------I        I
S21-8012 -------------------------------------------I---I     I-----------I   I                            I
S27-8212 -------------------------------------------I         I               I                            I
S18-7912 -----------------------------------------------------I               I                            I
S10-7705 ------------------------------------------------------------I--------I                            I------
S12-7803 ------------------------------------------------------------I                                     I
S11-7710 ------------------------------------------------------I                                           I
S14-7810 -------------------------------------------I------I   I----I                                      I
S32-8408 -------------------------------------------I      I---I    I----------------I                     I
S29-8309 --------------------------------------------------I        I                I                     I
S26-8209 -----------------------------------------------------------I                I                     I
S28-8303 -----------------------------------------------------I                      I                     I
S33-8412 --------------------------------------------I-I      I                      I                     I
S35-8508 --------------------------------------------I I      I----I                 I                     I
S37-8604 ------------------------------------I-I       II     I    I                 I---------------------I
S39-8612 -------------------------I----------I I--I    II     I    I                 I
S40-8705 -------------------------I            I  I----II-----I    I-I               I
S38-8608 --------------------------------------I  I     I          I I               I
S41-8708 -----------------------------------------I     I          I I--------I      I
S42-8712 -----------------------------------------------I          I I        I      I
S30-8312 ----------------------------------------------------------I I        I------I
S36-8512 ------------------------------------------------------------I        I
S34-8505 ---------------------------------------------------------------------I
```

Station: SDIX: Petrocelis franciscana +Ralfsia sp.: TOTAL Quads with Data = 1274

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 3 to 52: : # Dropped 426 : 33.4%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.564911: Maximum Distance = 3384

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------------------------------I
S10-7705  -------------------------------------------------------------------I I
S11-7710  -------------------------------------I--------I                    I I----I
S20-8008  -------------------------------------I        I-----I              I I    I
S13-7805  -----------------------------------------I----I     I              I-I    I
S26-8209  -----------------------------------------I          I              I      I
S15-7812  ----------------------------------I-------I         I              I      I
S18-7912  ----------------------------------I       I---I     I              I      I
S19-8005  --------------------------------I-------I I   I     I--------------I      I
S23-8110  --------------------------------I       I-I   II    I                     I
S22-8105  ----------------------------I-----------I     II    I                     I
S24-8201  ----------------------------I                 II---II                     I--I
S25-8204  ----------------------------------------------II   II                     I  I
S21-8012  --------------------------------------------I--I   II                     I  I
S27-8212  --------------------------------------------I      I                      I  I
S16-7905  ---------------------------------------------------I                      I  I
S28-8303  ------------------------------------------------I----I                    I  I
S32-8408  ------------------------------------------------I    I---------I          I  I
S29-8309  -----------------------------------------------------I         I          I  I
S30-8312  ---------------------------------------------I----I            I          I  I
S31-8404  -------------------------------------I-------I    I            I          I  I--------------------I
S34-8505  -------------------------------------I            I---I        I----------I  I                    I
S37-8604  ------------------------------I---I               I   I        I             I                    I
S41-8708  ------------------------------I   I---I           I   I----I   I             I                    I
S40-8705  ----------------------------------I   I-----------I   I    I   I             I                    I
S38-8608  --------------------------------------I               I    I---I             I                    I------
S42-8712  ------------------------------------------------------I    I                 I                    I
S36-8512  -----------------------------------------------------I-----I                 I                    I
S39-8612  -----------------------------------------------------I                       I                    I
S35-8508  -----------------------------------------------------------------------------I                    I
S33-8412  --------------------------------------------------------------------------------------------------I
```

Station: LCIX: Petrocelis franciscana +Ralfsia sp.: TOTAL Quads with Data = 347

Quad Range USED 6 to 16 for Total of 11 : Range WITH data 1 to 21: : # Dropped 108 ; 31.1%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.672704: Maximum Distance = 586

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 9-7702  --------------------------------------------------------------------------------------------------I
S10-7705  ----------------------------------------------------------------------------------------I         I
S11-7710  --------------------I--I                                                                I         I
S39-8612  --------------------I  I---------I                                                      I         I
S26-8209  -----------------------I         I---------I                                            I         I------
S17-7909  ---------------------------------I         I                                            I         I
S13-7805  ----------------------I-I                  I---I                                        I         I
S16-7905  ----------------------I I--------------I   I   I                                        I         I
S20-8008  ------------------------I              I   I   I                                        I         I
S22-8105  -----------------------I------I        I---I   I                                        I---------I
S35-8508  -----------------------I      I---I    I       I--------I                               I
S24-8201  ------------------------------I   I----I       I        I                               I
S36-8512  ----------------------------------I            I        I                               I
S23-8110  ---------------------------------I--------I    I        I--I                            I
S25-8204  ---------------------------------I        I----I        I  I                            I
S30-8312  ------------------------------------------I             I  I--------------I             I
S28-8303  ------------------------------------I-------------------I  I              I             I
S41-8708  ------------------------------------I                      I              I             I
S12-7803  --------------------------------------------------I--------I              I-------------I
S15-7812  --------------------------------------------------I                       I
S21-8012  -----------------------------------------------------------I-----------I  I
S42-8712  -----------------------------------------------------------I           I--I
S27-8212  -------------------------------------I---------------------------------I
S33-8412  -------------------------------------I
```

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Porphyra spp. C. Agardh, 1824 Ref. AH, 1976. p 294ff.
Phylum Rhodophyta: **Class** Bangiales:

Description: Thin blades, gray-green to brownish-purple to pinkish. To 1 m long, often almost as broad.

Distribution: see below. Common, upper to mid-intertidal, sometimes lower. A warm-tolerant group.

Diablo Area Specific Information: Moderately common, but usually an ephemeral, occurring in about 15% of our quadrats in covers up to 60%.

Habitat: On rocks and cobbles, tops, sides, and epiphytic on a number of algae, upper to lower intertidal. In recently disturbed areas as extensive patches or as scattered small patches mixed with other plants, or as small ruffles to moderately large epiphytic blades.

Observational Errors: Difficult to assess mis-identification (see below). Missed observations not assessed because group is typically an ephemeral, but can occur when plant present as short ruffles.

Field Identification Problems:

General: No general attempt was made to identify this group to species, (see below for species laboratory identified). Could be confused with *Bangia*, *Smithora* , etc.

Station Specific: *Bangia* apparently occurred only at CDIX in quantity and only at upper tidal levels (probably mis-identified here frequently prior to 1985).

General Comments: LCIX only station that had a persistent population of this group prior to El Niño, declining in 1982.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX with "bloom" at lower quadrats. Other Cove stations with scattered occurrences (apparently normal). LCIX slightly higher in occurrences than for surveys just prior to storms.

El Niño: 1983-1984: All Cove stations with moderate covers and occurrences throughout period except in winters when large decreases occurred. NDIX and CDIX respectively with moderate to dense covers. LCIX with disappearance of this group.

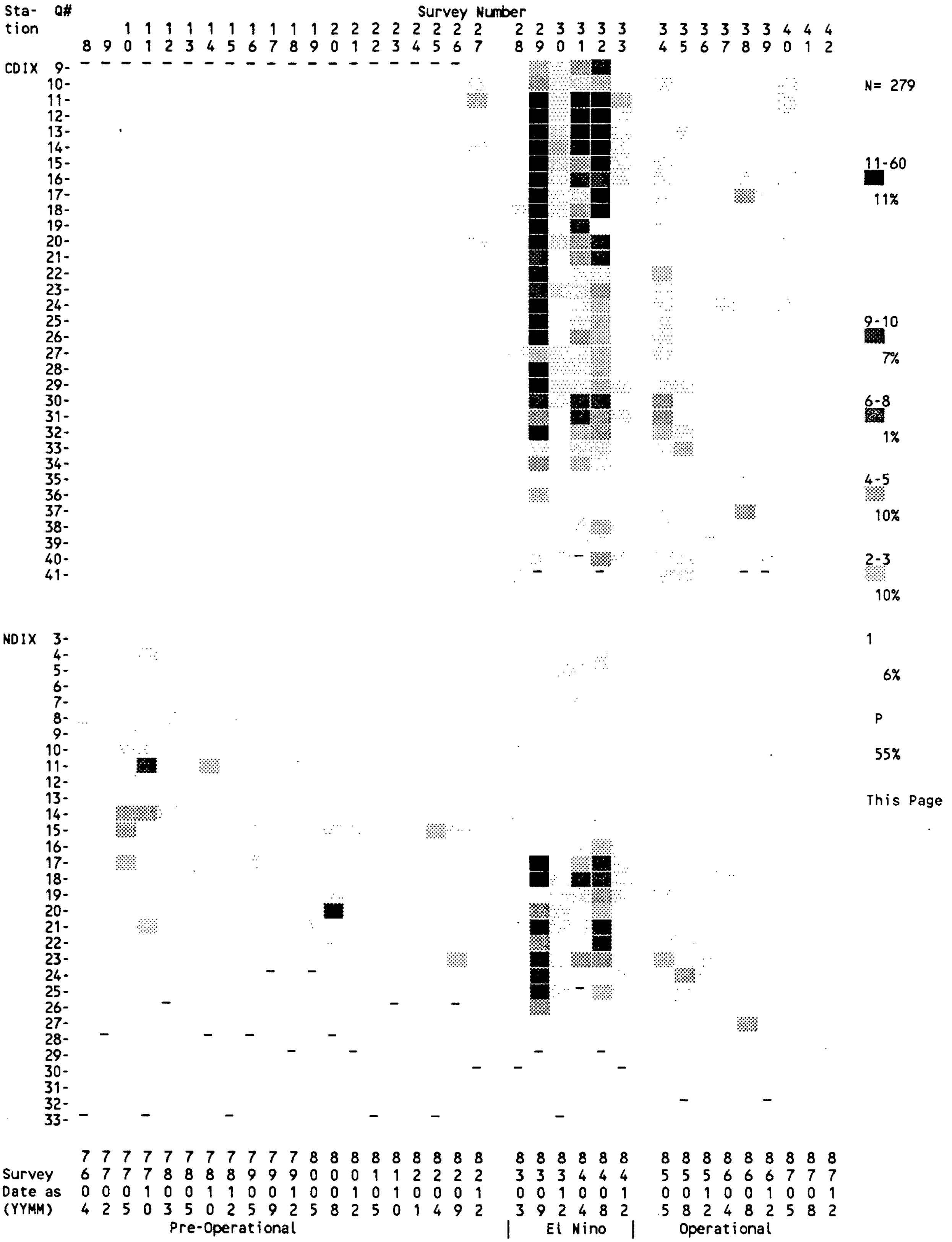
Diablo DCPP Operation: SDIX, NDIX, and probably CDIX with rapid return to normal, then with occurrences possibly below normal. LCIX with only sporadic occurrences, which was moderately unusual, persisting over a 3 year period.

Porphyra perforata: Alaska to Baja California.

Porphyra sp.

Taxon or Category: Porphyra sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

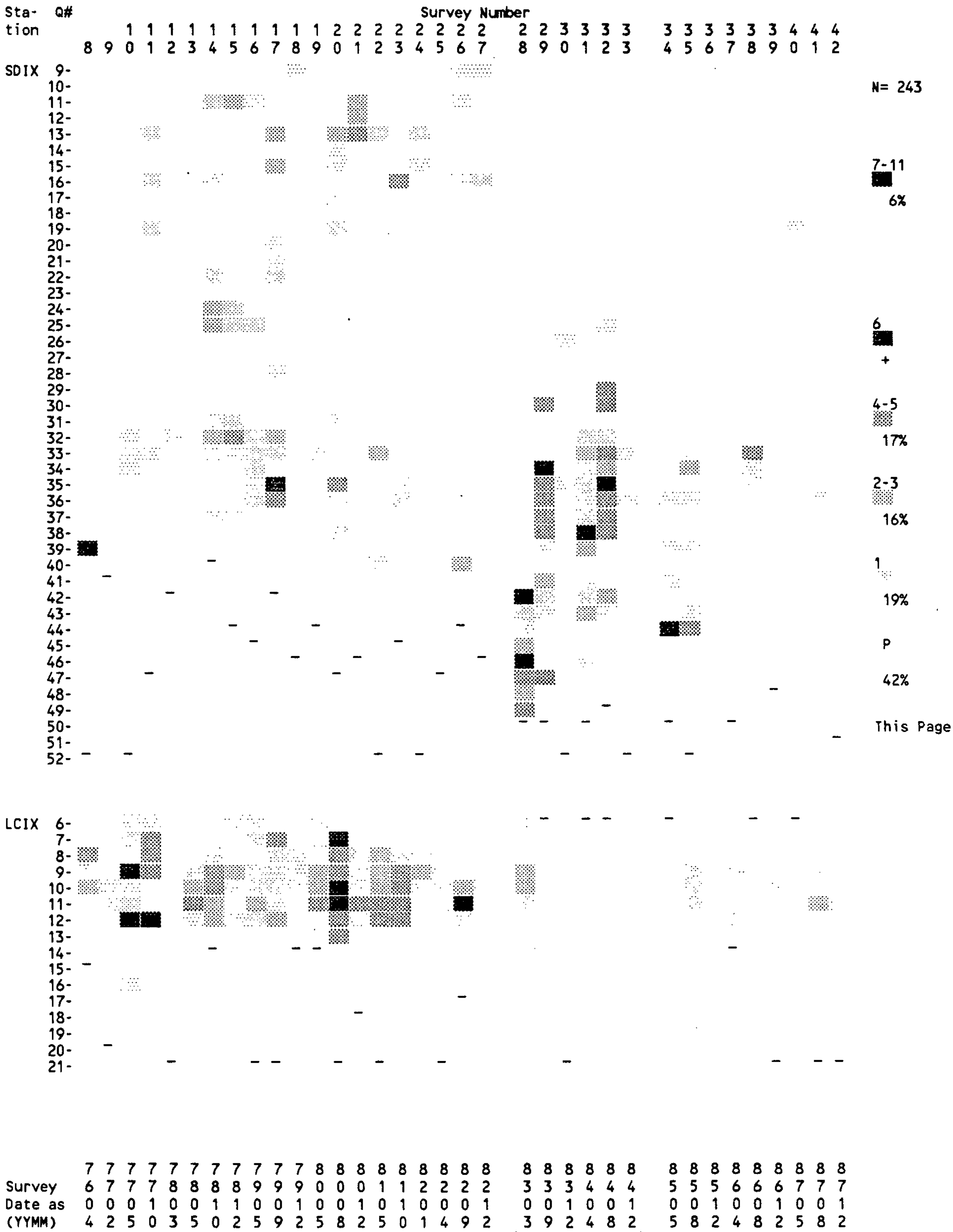


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PORPHY CSV 5403 3-29-88 7:37a 04-14-1989 10:49

Taxon or Category: Porphyra sp.

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PORPHY CSV 5403 3-29-88 7:37a 04-14-1989 10:49

Audit: CLUMRG2P: V.1.2: for SPORPHY CLU 6581 4-22-89 10:07a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:04:10 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Porphyra sp.: TOTAL Quads with Data = 203

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 42 : 20.7%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.952739: Maximum Distance = 3451

```
S27-8212  -II
S40-8705  -II
S28-8303  I I
S41-8708  I I
S36-8512  IIII
S42-8712  IIII
S39-8612  IIII-I
S37-8604  -III I
S35-8508  --II I-I
S33-8412  ---I I I-I
S30-8312  -----I I I---------------------------------I
S38-8608  -------I I                                 I------------------------------I
S34-8505  ---------I                                 I                              I----------------------I
S31-8404  -------------------------------------------I                              I                      I------
S32-8408  ----------------------------------------------------------------------------I                      I
S29-8309  ---------------------------------------------------------------------------------------------------I
```

Station: NDIX: Porphyra sp.: TOTAL Quads with Data = 106

Quad Range USED 5 to 25 for Total of 21 : Range WITH data 4 to 27: : # Dropped 16 : 15.1%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.980569: Maximum Distance = 831

```
S17-7909:  <-Start Dropped Surveys
S19-8005:
S31-8404:  <-End   Dropped Surveys
S 8-7604  I-I
S15-7812  I I
S 9-7702  I I
S41-8708  I-I
S42-8712  I I
S13-7805  I-I
S37-8604  I I
S39-8612  --II
S21-8012  I II
S24-8201  I-II
S27-8212  I III
S23-8110  --III
S38-8608  --III
S40-8705  --III
S12-7803  ---II
S22-8105  ---II-I
S14-7810  --I-I I
S18-7912  --I I I
S16-7905  ----I I
S28-8303  ----I II
S26-8209  ---II II
S36-8512  ---I  III
S25-8204  ------III
S33-8412  ------III------I
S34-8505  -------II      I-----I
S30-8312  --------I      I     I---I
S35-8508  ---------------I     I   I---I
S10-7705  ---------------------I   I   I-----------------------I
S20-8008  -------------------------I   I                       I-------------------------------------------I
S11-7710  -----------------------------I                       I                                           I------
S32-8408  -----------------------------------------------------I                                           I
S29-8309  ---------------------------------------------------------------------------------------------------I
```

Station: SDIX: Porphyra sp.: TOTAL Quads with Data = 136

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 6 to 49: : # Dropped 50 : 36.8%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.947623: Maximum Distance = 508

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------------------I
S10-7705  ---------I                                               I
S13-7805  I        I                                               I
S18-7912  I        I                                               I
S21-8012  I        I                                               I
S25-8204  I----I   I                                               I
S36-8512  I    I   II                                              I
S37-8604  I    I   II                                              I
S39-8612  I    II  II                                              I
S42-8712  I    II  II                                              I
S19-8005  -----II-III                                              I
S24-8201  -----II III-I                                            I
S40-8705  -----II III I                                            I--I
S33-8412  -----II I I I                                            I  I
S41-8708  -----I  I I I--I                                         I  I
S30-8312  --------I I I  I                                         I  I
S34-8505  ----------I I  II                                        I  I
S27-8212  ------------I  II                                        I  I
S22-8105  ------------I  II------I                                 I  I
S35-8508  ---------------II      I-I                               I  I----I
S11-7710  ----------------I      I I--------I                      I  I    I
S26-8209  -----------------------I I        I-I                    I  I    I
S16-7905  -------------------------I        I I----I               I  I    I
S38-8608  ----------------------------------I I    I               I  I    I--------------------------------I
S23-8110  ------------------------------------I    I---------------I  I    I                                I
S15-7812  -----------------------------------------I                  I    I                                I
S20-8008  -----------------------------------------I                  I    I                                I------
S28-8303  ------------------------------------------------------------I    I                                I
S31-8404  -----------------------------------------------------------------I                                I
S29-8309  ----------------------------------------------------------------I---------------------------------I
S32-8408  ----------------------------------------------------------------I
```

Station: LCIX: Porphyra sp.: TOTAL Quads with Data = 111

Quad Range USED 7 to 13 for Total of 7 : Range WITH data 6 to 19: : # Dropped 12 : 10.8%
Surveys 29 : Dropped 0 Surveys if quads sampled < 13
COPHENETIC CORRELATION COEFFICIENT = 0.900790: Maximum Distance = 137

```
S 8-7604  -------------------------------I
S 9-7702  ----II                         I
S39-8612  ----III                        I
S12-7803  I    II                        I
S30-8312  I----II-I                      I
S33-8412  I     I I                      I
S36-8512  I     I II                     I-I
S27-8212  ------I II                     I I
S42-8712  --------II-----I               I I
S15-7812  ------I  I     I               I I
S25-8204  ------I-II     I               I I
S37-8604  ------I II     I               I I
S18-7912  ----I---I      I---------------I I---I
S24-8201  ----I          I                 I   I
S16-7905  ------I-I      I                 I   I
S28-8303  ------I I-I    I                 I   I
S41-8708  --------I I----I                 I   I
S35-8508  ----------I                      I   I-------I
S17-7909  ---------------------------------I   I       I
S13-7805  ------I-----I                        I       I
S19-8005  ------I     I-------------I          I       I--------------------I
S21-8012  ------------I             I-I        I       I                    I
S26-8209  --------------------------I I--------I       I                    I
S22-8105  ----------------------------I                I                    I-------------------------------I
S14-7810  ----------------------------I----------------I                    I                               I
S23-8110  ----------------------------I                                     I                               I------
S10-7705  -------------------------------------------I----------------------I                               I
S11-7710  -------------------------------------------I                                                      I
S20-8008  --------------------------------------------------------------------------------------------------I
```

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Prionitis lanceolata. (Harvey, 1833) Ref. AH, 1976. p 447.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Usually as lancelike blades with bladelets, from discoid holdfast, reddish-brown to rose to almost black. To 0.8 m long.

Distribution: Vancouver Island (British Columbia) to Punta Santa Rosalia (Baja California). Locally abundant, high intertidal to subtidal (30 m). A warm-tolerant species.

Diablo Area Specific Information: Common, and persistent, occurring in about 20% of our quadrats in covers up to 50%.

Habitat: On rocks, tops, and sides, occasionally as gnarled plants in small high intertidal tidepools, upper to low intertidal.

Observational Errors: Mis-identification moderately rare, occurring <2% of time (see below). Missed observations may be about 2% and usually occur when plant was severely eroded or small and in areas of dense algal cover. Quadrat boundary errors occurred.

Field Identification Problems:

General: Occasionally (<2% of time) confused with short-statured or abnormal specimens of *Prionitis linearis* or *P. lyallii*.

Station Specific: n.a.

General Comments: A persistent species at all stations mostly at lower tidal levels.

Impacts to Taxon:

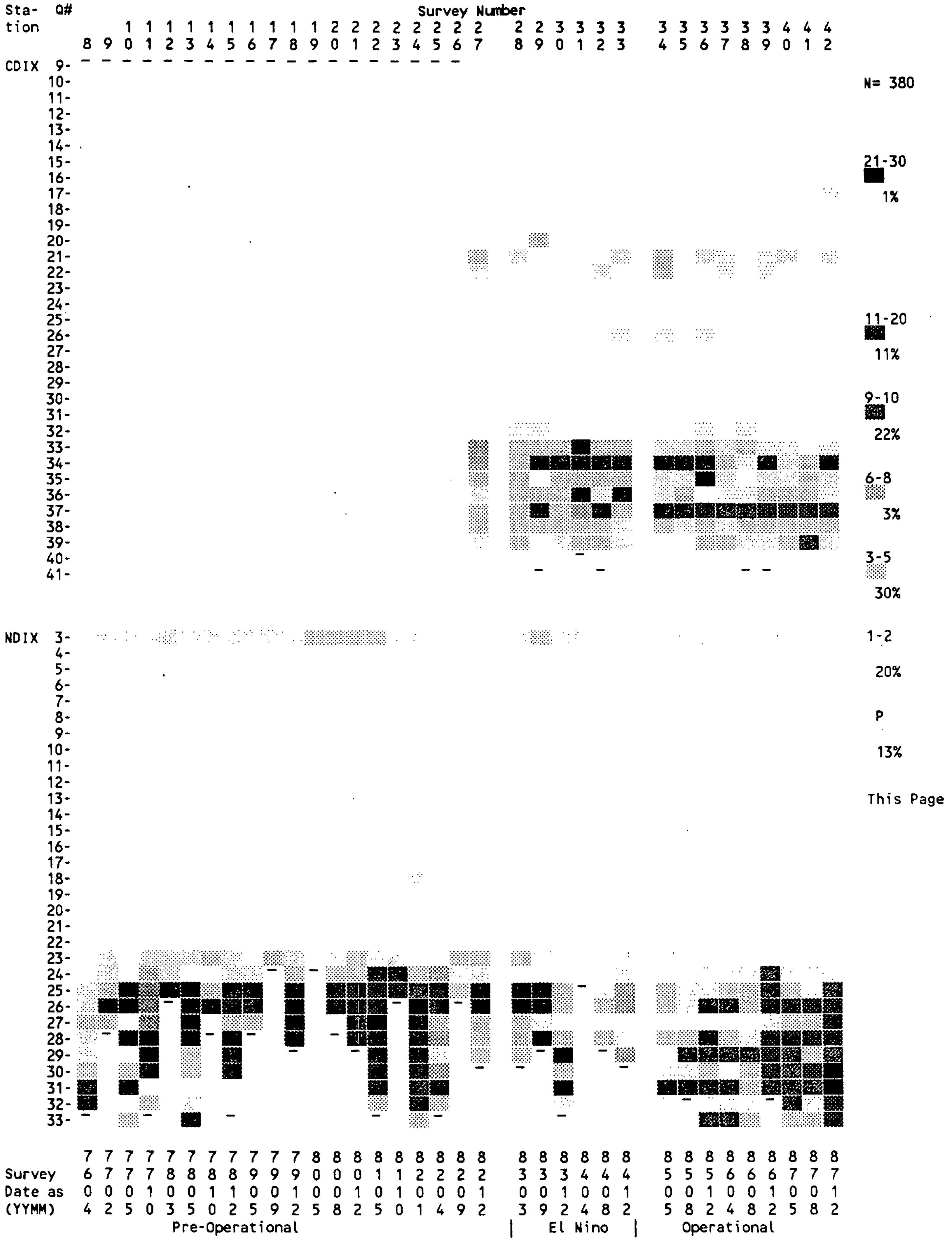
El Niño: 1982-83 winter storm: SDIX with reduction of cover and occurrences (cobble overlay). NDIX and CDIX normal. LCIX lost occurrences at 2 to 3 out of normal 5 quadrats.

El Niño: 1983-1984: All Cove stations with moderate covers and occurrences throughout period except in winters when large decreases occurred. NDIX and CDIX respectively with moderate to dense covers. LCIX with disappearance of this taxon.

Diablo DCPP Operation: SDIX, NDIX, and probably CDIX with rapid return to normal, then possibly with occurrences subnormal. LCIX with only sporadic occurrences which was moderately unusual for a 3 year period.

Taxon or Category: Prionitis lanceolata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

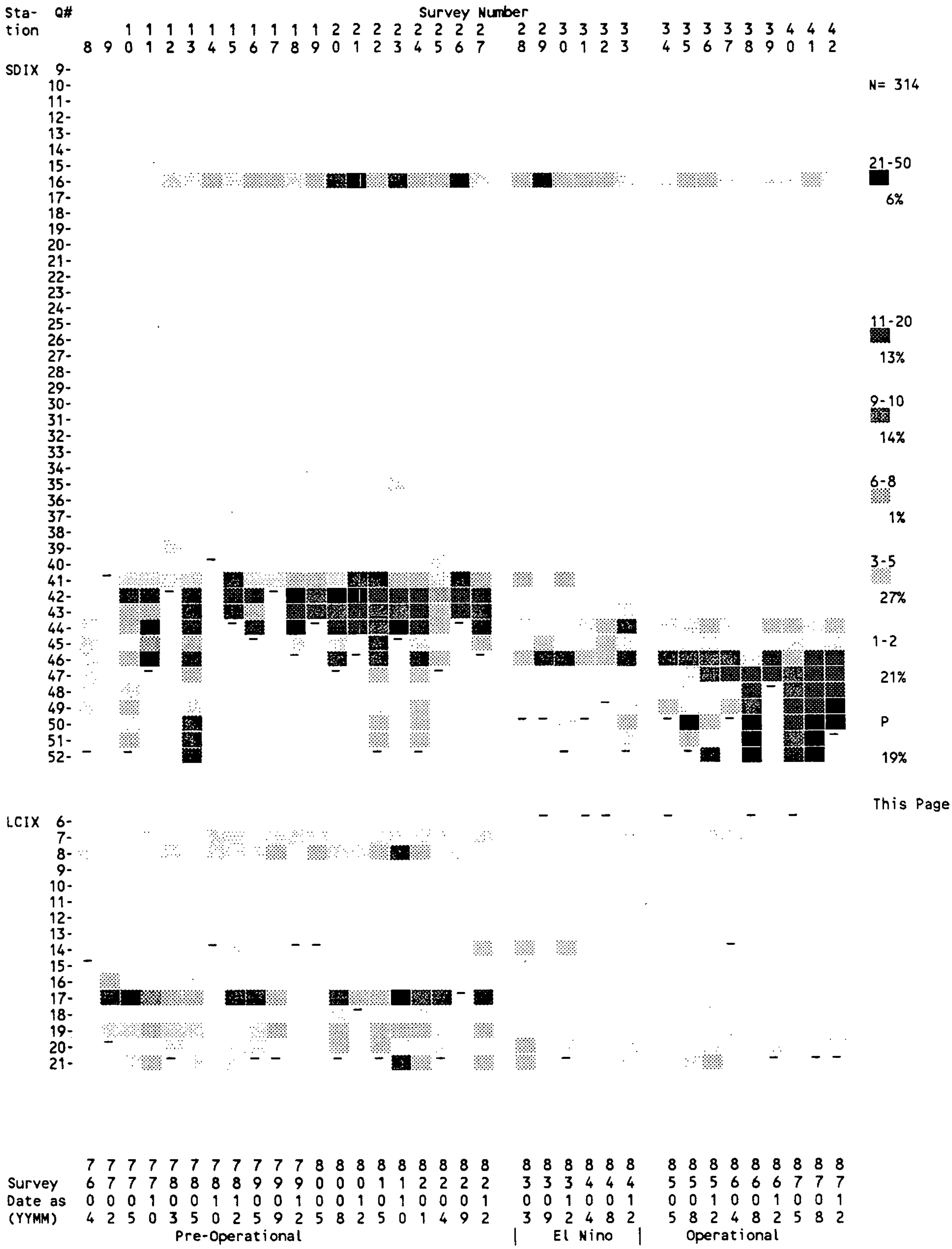


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PRILAN CSV 5531 3-29-88 7:38a 04-14-1989 10:49

Taxon or Category: Prionitis lanceolata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



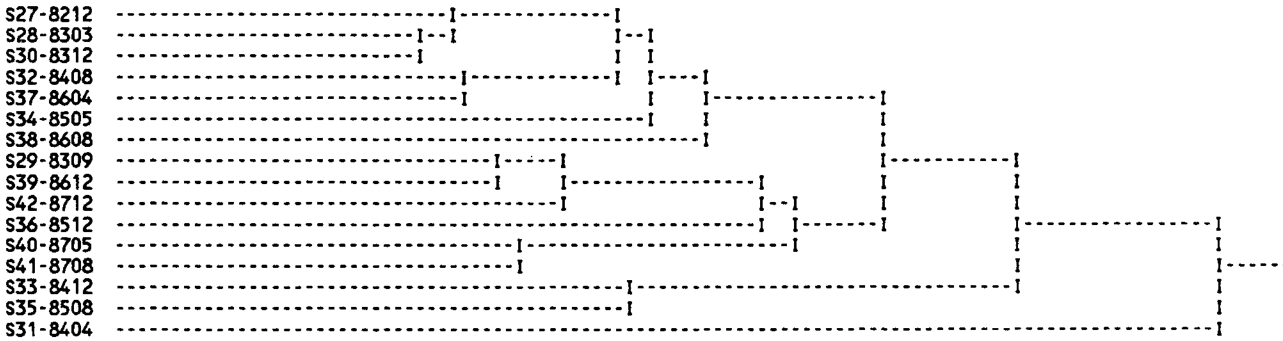
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PRILAN CSV 5531 3-29-88 7:38a 04-14-1989 10:49

Audit: CLUMRG2P: V.1.2: for SPRILAN CLU 5829 4-22-89 10:12a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:09:11 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Prionitis lanceolata: TOTAL Quads with Data = 128

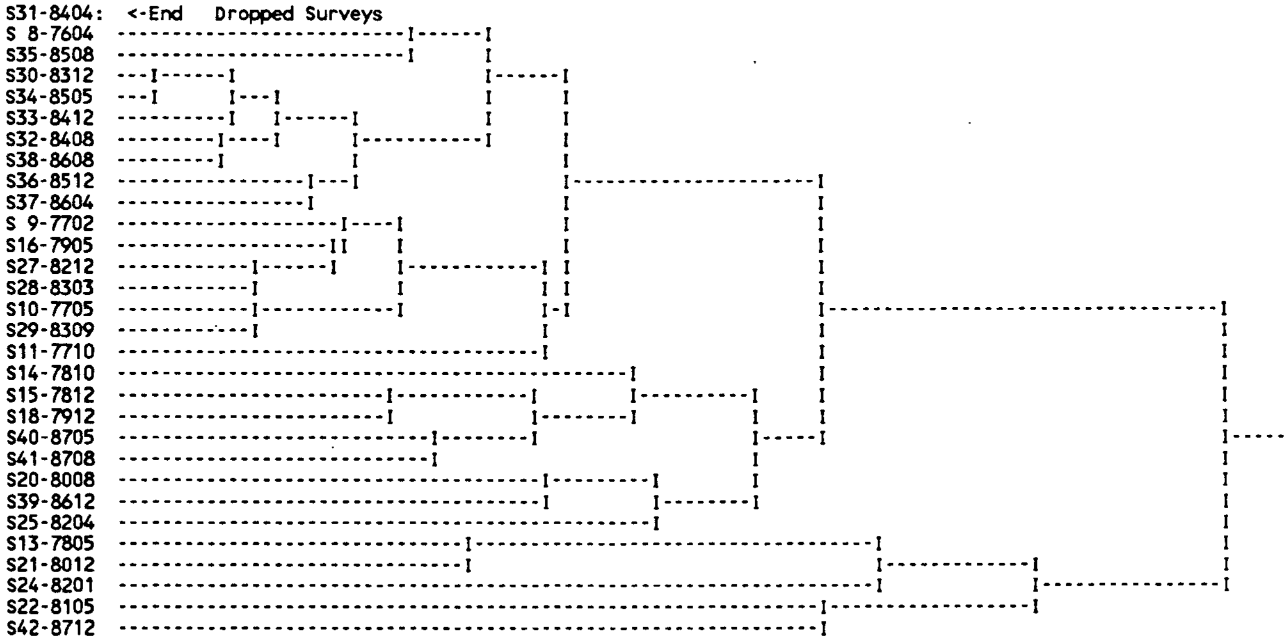
Quad Range USED 21 to 39 for Total of 19 : Range WITH data 17 to 39: : # Dropped 2 : 1.6%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.516174: Maximum Distance = 392



Station: NDIX: Prionitis lanceolata: TOTAL Quads with Data = 253

Quad Range USED 23 to 27 for Total of 5 : Range WITH data 2 to 33: : # Dropped 149 : 58.9%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.718281: Maximum Distance = 112

S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End Dropped Surveys



Station: SDIX: Prionitis lanceolata: TOTAL Quads with Data = 208

Quad Range USED 41 to 45 for Total of 5 : Range WITH data 16 to 55: : # Dropped 146 : 70.2%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.865494: Maximum Distance = 158

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604  -----I
S31-8404  I-I  I-----I
S35-8508  I I-II     I
S34-8505  --I II     I
S37-8604  I-I I      I----I
S41-8708  I I-I      I    I
S38-8608  --I        I    I--I
S29-8309  -----------I    I  I
S28-8303  ------I---------I  I
S30-8312  ------I            I----------I
S32-8408  --------I          I          I
S36-8512  --I-I   I----I     I          I
S39-8612  --I I---I    I     I          I-------------------------------------------------------------------I
S40-8705  I---I        I-----I          I                                                                   I
S42-8712  I            I                I                                                                   I
S33-8412  -------------I                I                                                                   I
S25-8204  ------------------------------I                                                                   I------
S10-7705  -------------------------------------------I-------------I                                        I
S22-8105  -------------------------------------------I             I                                        I
S11-7710  ---------------------------------I                       I                                        I
S13-7805  ------------I----------I         I---------I             I----------------------------------------I
S27-8212  ------------I          I---------I         I-------I     I
S24-8201  -----------------------I                   I       I     I
S20-8008  ----------------------------------I--------I       I-----I
S21-8012  ----------------------------------I                I
S18-7912  ---------------------------------------------------I
```

Station: LCIX: Prionitis lanceolata: TOTAL Quads with Data = 114

Quad Range USED 7 to 19 for Total of 13 : Range WITH data 7 to 24: : # Dropped 43 : 37.7%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.808354: Maximum Distance = 278

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  -------------------------------I
S10-7705  ------I                        I
S16-7905  ------I-----I                  I
S25-8204  ------I     I------I           I--I
S15-7812  ------------I      I--I        I  I
S11-7710  --------------I----I  I        I  I
S12-7803  --------I-----I       I--------I  I---------I
S13-7805  --------I             I           I         I
S20-8008  ---------------I------I           I         I
S24-8201  ---------------I                  I         I------------------------------------------------------I
S17-7909  ---------I------------------------I         I                                                      I
S22-8105  ---------I                                  I                                                      I
S28-8303  ----------I---------I                       I                                                      I
S30-8312  ----------I         I-----------------------I                                                      I
S33-8412  --------I--I        I                                                                              I------
S36-8512  --------I  I--------I                                                                              I
S35-8508  --------I-II                                                                                       I
S39-8612  ----I---I II                                                                                       I
S42-8712  ----I     I                                                                                        I
S41-8708  ----------I                                                                                        I
S23-8110  -------------------------------------------------------------------I-------------------------------I
S27-8212  -------------------------------------------------------------------I
```

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Prionitis lyallii Harvey, 1862 Ref. AH, 1976. p 448.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Usually as firm to soft-slippery lancelike blades, from discoid holdfast, brownish to bright brick-red. To 0.7 m long.

Distribution: Vancouver Island (British Columbia) to Punta Maria (Baja California). Common, on low intertidal rocks covered with coarse sand, to subtidal (35 m). A warm-tolerant species.

Diablo Area Specific Information: Rare prior to El Niño, moderately rare thereafter, occurring in about <1% of our quadrats in covers up to 10%.

Habitat: On rocks, rarely tops, and sides, low intertidal.

Observational Errors: Mis-identification moderately uncommon (see below). Unable to evaluate missed observations, but possible in areas of dense algal cover.

Field Identification Problems:

General: Occasionally confused with specimens of *Prionitis lanceolata*, *Grateloupia doryphora*, and *Schizymenia pacifica*.

Station Specific: n.a.

General Comments: Occurred rarely prior to El Niño only at SDIX: not found at LCIX.

Impacts to Taxon:

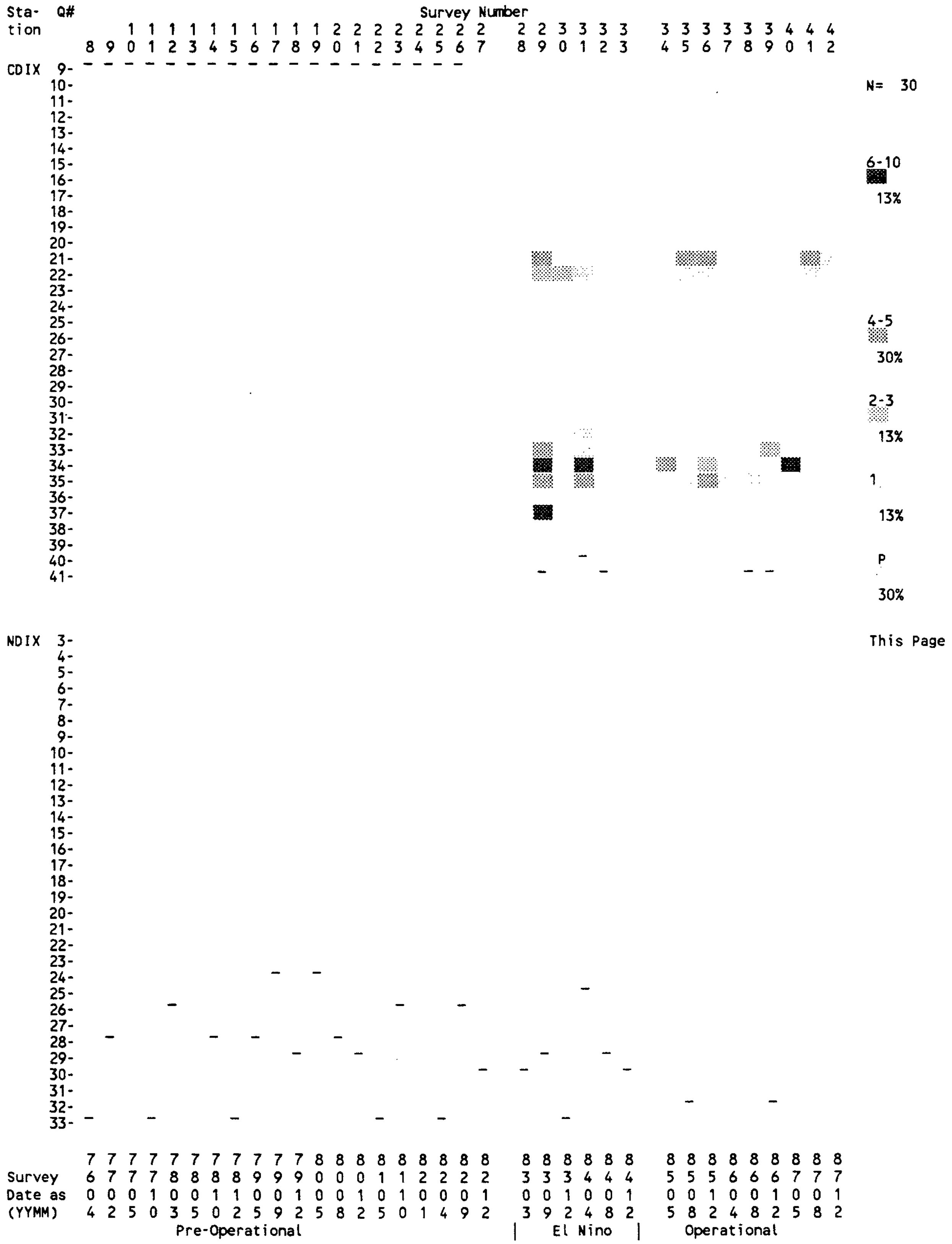
El Niño: 1982-83 winter storm: No occurrences at any station for surveys just prior to storms.

El Niño: 1983-1984: CDIX with sporadic occurrences and moderate covers. NDIX with one occurrence. All other stations with no occurrences.

Diablo DCPP Operation: As for El Niño, but NDIX with 2 occurrences.

Taxon or Category: Prionitis lyallii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

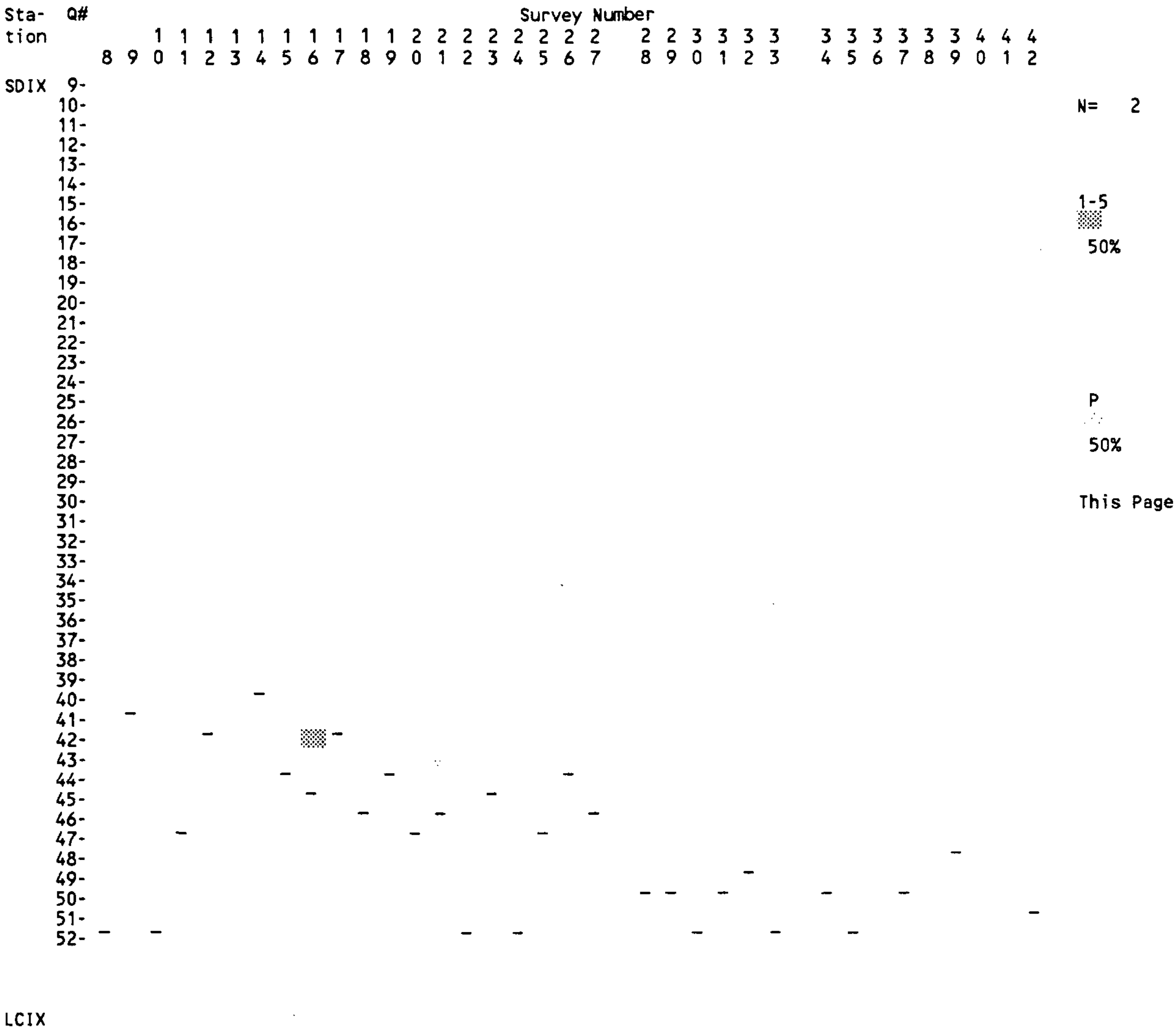


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PRILYA CSV 5531 10-03-88 5:52a 04-17-1989 10:20

Taxon or Category: Prionitis lyallii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Date as (YYMM)	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PRILYA CSV 5531 10-03-88 5:52a 04-17-1989 10:20

Audit: CLUMRG2P: V.1.2: for SPRILYA CLU 6581 4-22-89 10:20a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:13:58 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Prionitis lyallii: TOTAL Quads with Data = 27

Quad Range USED 21 to 37 for Total of 17 : Range WITH data 21 to 37: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 37
COPHENETIC CORRELATION COEFFICIENT = 0.847049: Maximum Distance = 283

```
S27-8212  I
S28-8303  I----I
S32-8408  I    II
S33-8412  I    II---I
S37-8604  -----II   I-I
S42-8712  ------I   I II
S38-8608  ----------I II-----------------------I
S30-8312  ------------II                       I-------------I
S39-8612  -------------I                       I             I
S35-8508  ------------I------------------------I             I-----I
S41-8708  ------------I                                      I     I-----------------------------------------I
S36-8512  ---------------------------------------------------I     I                                         I
S31-8404  -----------------------------------------I---------------I                                         I------
S34-8505  -----------------------I-----------------I                                                         I
S40-8705  -----------------------I                                                                           I
S29-8309  ---------------------------------------------------------------------------------------------------I
```

Station: NDIX: Prionitis lyallii: TOTAL Quads with Data = 3:**** Prob. INSUFFICIENT Data ****

Quad Range USED 26 to 27 for Total of 2 : Range WITH data 26 to 30: : # Dropped 1 : 33.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.997365: Maximum Distance = 3

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  I
S 9-7702  I
S10-7705  I
S11-7710  I
S13-7805  I
S14-7810  I
S15-7812  I
S16-7905  I
S18-7912  I
S20-8008  I
S21-8012  I
S22-8105  I
S24-8201  I
S25-8204  I--------------------------------------------------------------------------------------------------I
S27-8212  I                                                                                                  I
S28-8303  I                                                                                                  I
S29-8309  I                                                                                                  I
S30-8312  I                                                                                                  I
S32-8408  I                                                                                                  I
S33-8412  I                                                                                                  I
S34-8505  I                                                                                                  I------
S35-8508  I                                                                                                  I
S36-8512  I                                                                                                  I
S38-8608  I                                                                                                  I
S39-8612  I                                                                                                  I
S40-8705  I                                                                                                  I
S41-8708  I                                                                                                  I
S42-8712  I                                                                                                  I
S37-8604  ---------------------------------------------------------------------------------------------------I
```

```
Station:  SDIX:   Prionitis lyallii:   TOTAL Quads with Data = 2:**** Prob. INSUFFICIENT Data ****

        Quad Range USED 42 to 43 for Total of 2 :  Range WITH data 42 to 43:  :  # Dropped  0 :    0.0%
        Surveys  31 :  Dropped  4 Surveys if quads sampled < 43
        COPHENETIC CORRELATION COEFFICIENT = 0.996926:                          Maximum Distance = 12

S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604 I
S10-7705 I
S11-7710 I
S13-7805 I
S15-7812 I
S18-7912 I
S19-8005 I
S20-8008 I
S22-8105 I
S23-8110 I
S24-8201 I
S25-8204 I
S26-8209 I
S27-8212 I
S28-8303 I---------------I
S29-8309 I               I
S30-8312 I               I
S31-8404 I               I
S32-8408 I               I
S33-8412 I               I
S34-8505 I               I
S35-8508 I               I----------------------------------------------------------------------------------I
S36-8512 I               I                                                                                  I
S37-8604 I               I                                                                                  I
S38-8608 I               I                                                                                  I
S39-8612 I               I                                                                                  I------
S40-8705 I               I                                                                                  I
S41-8708 I               I                                                                                  I
S42-8712 I               I                                                                                  I
S21-8012 ----------------I                                                                                  I
S16-7905 ---------------------------------------------------------------------------------------------------I


Station:  LCIX:   Prionitis lyallii:   :  No data for this station

                                                NO DATA
                                          NO DATA
                                    NO DATA
                              NO DATA
                        NO DATA
                  NO DATA
            NO DATA
      NO DATA
      NO DATA
            NO DATA
                  NO DATA
                        NO DATA
                              NO DATA
                                    NO DATA
                                          NO DATA
                                                NO DATA
```

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Pseudolithophyllum neofarlowii (Setchell & Mason, 1943) Ref. AH, 1976. p 397.
Phylum Rhodophyta: **Class** Cryptonemiales:

Description: Crust to 0.1 cm thick (sometimes with excrescences), lavender to violet to purplish, to whitish, to 10+ cm diameter.

Distribution: Alaska to Baja California. A warm-tolerant species.

Diablo Area Specific Information: Abundant, occurring in about 70% of our quadrats in cover up to 60%.

Habitat: On rock (bedrock to cobble), tops, sides, and underneath, often at upper tide levels, in crevices, upper to low intertidal. Often under algal mats.

Observational Errors: Probably about <5% confusion with other very similar crustose corallines *(Mesophyllum, Lithophyllum, and Lithothamnium)* and some confusion with eroded basal crusts of erect corallines. Missed observations occur about 3% of the time when small clumps were intermingled with dense algal mats.

Correct identification requires microscopic study.

Field Identification Problems:

General: Confused with similar *Mesophyllum, Lithophyllum, Lithothamnium*, and as noted above, with eroded basal portions of erect corallines.

Station Specific: n.a.

General Comments: Changes between surveys, sometimes difficult to assess because of moderate number of mis-identifications with *Mesophyllum, Lithophyllum, Lithothamnium*. Over longer intervals assessment was adequate.

Impacts to Taxon:

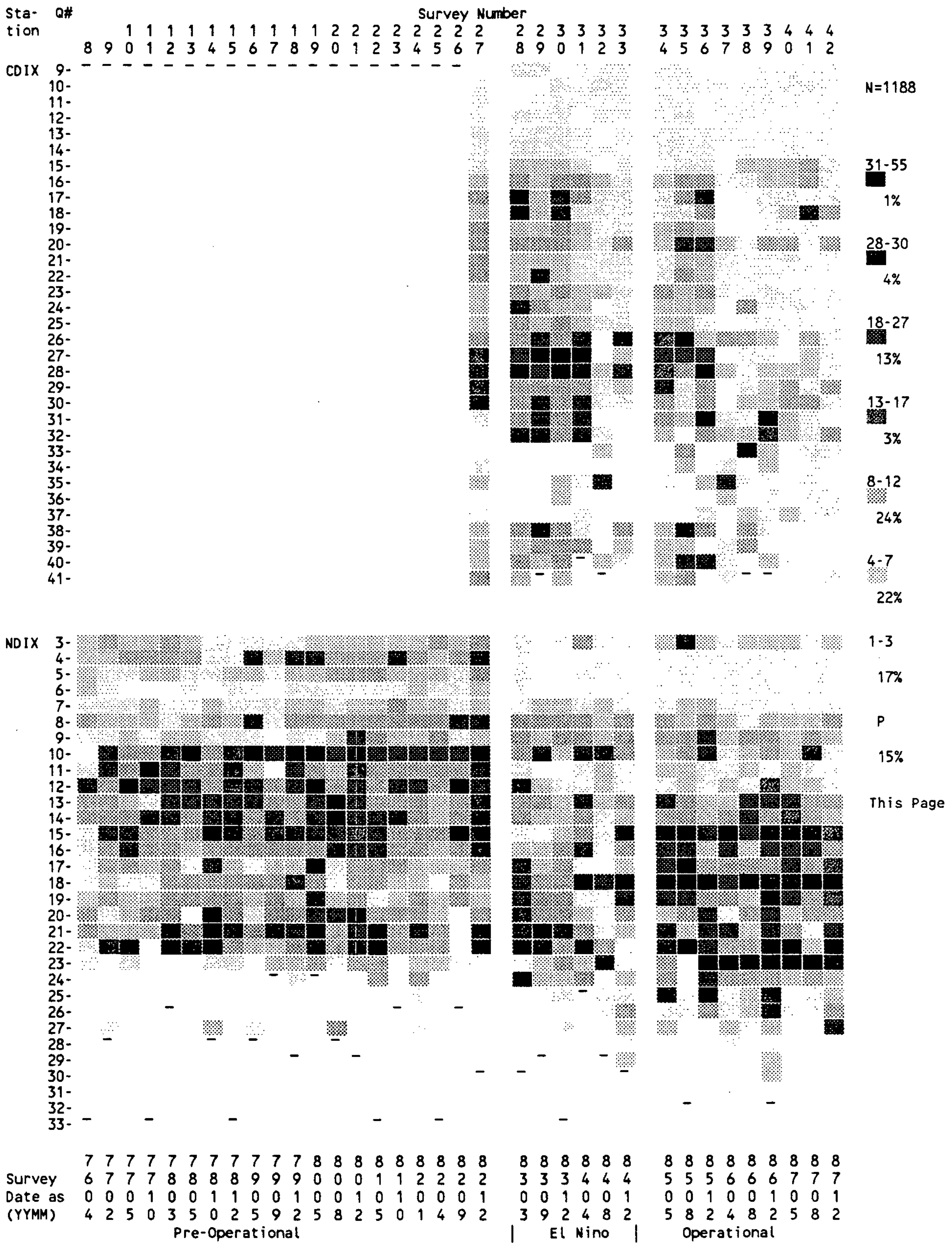
El Niño: 1982-83 winter storm: Somewhat reduced in occurrence at SDIX (cobble overlay, and possibly removal), NDIX with little affect. CDIX and LCIX with some reduction of occurrences.

El Niño: 1983-1984: At SDIX with possible coverage declines in mid tide areas (probably due to shifting of cobble). All other stations probably normal.

Diablo DCPP Operation: SDIX as for El Niño. NDIX possibly with increasing covers except at upper parts of range, and occurrences probably extending downward in the intertidal. CDIX with trend of declining covers at most levels, but less marked at lower tidal levels (or damp areas). LCIX normal.

Taxon or Category: Pseudolithophyllum neofarlowii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

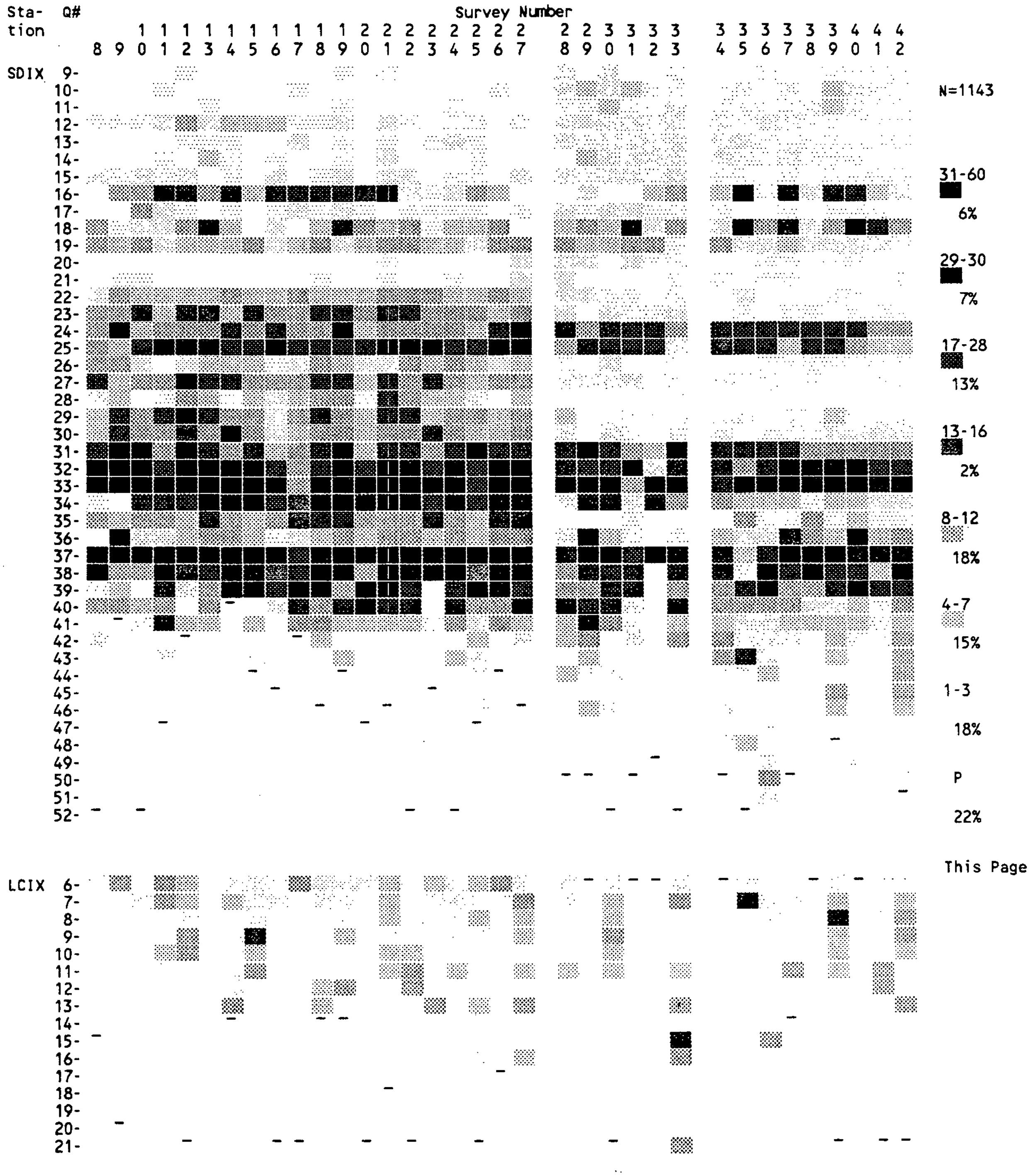


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PSEUDN CSV 6994 3-29-88 7:38a 04-14-1989 10:50

Taxon or Category: Pseudolithophyllum neofarlowii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Date as (YYMM)	7604	7702	7705	7710	7803	7803	7815	7810	7902	7925	7909	8002	8015	8008	8012	8105	8120	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8702	8705	8718

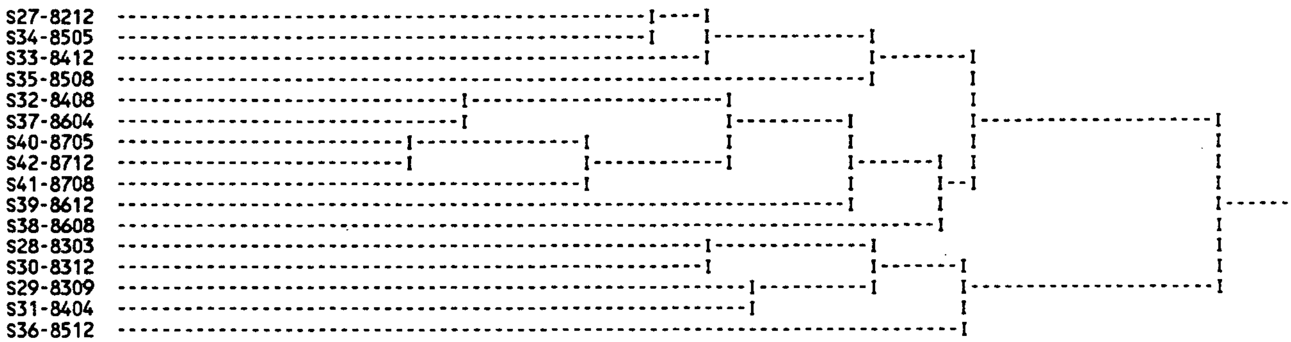
Pre-Operational | El Nino | Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for PSEUDN CSV 6994 3-29-88 7:38a 04-14-1989 10:51

Audit: CLUMRG2P: V.1.2: for SPSEUDN CLU 6915 4-22-89 10:24a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:21:23 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Pseudolithophyllum neofarlowii: TOTAL Quads with Data = 469

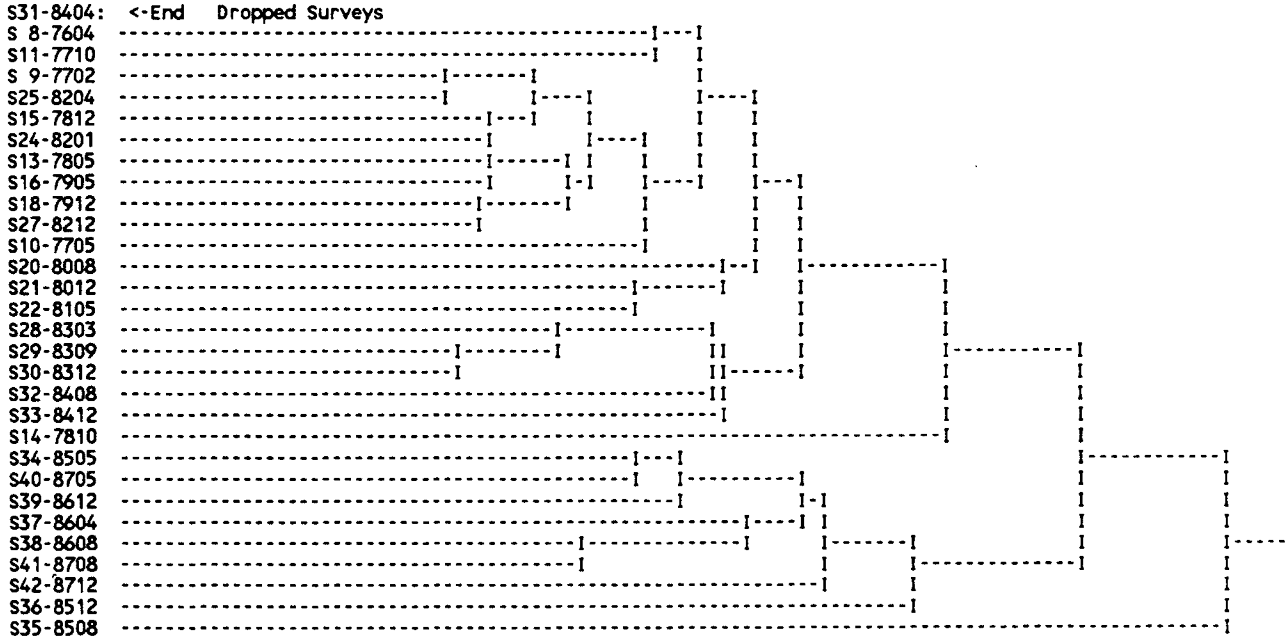
Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 68 : 14.5%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.468265: Maximum Distance = 1668



Station: NDIX: Pseudolithophyllum neofarlowii: TOTAL Quads with Data = 782

Quad Range USED 3 to 27 for Total of 25 : Range WITH data 2 to 31: : # Dropped 146 : 18.7%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.616379: Maximum Distance = 1816

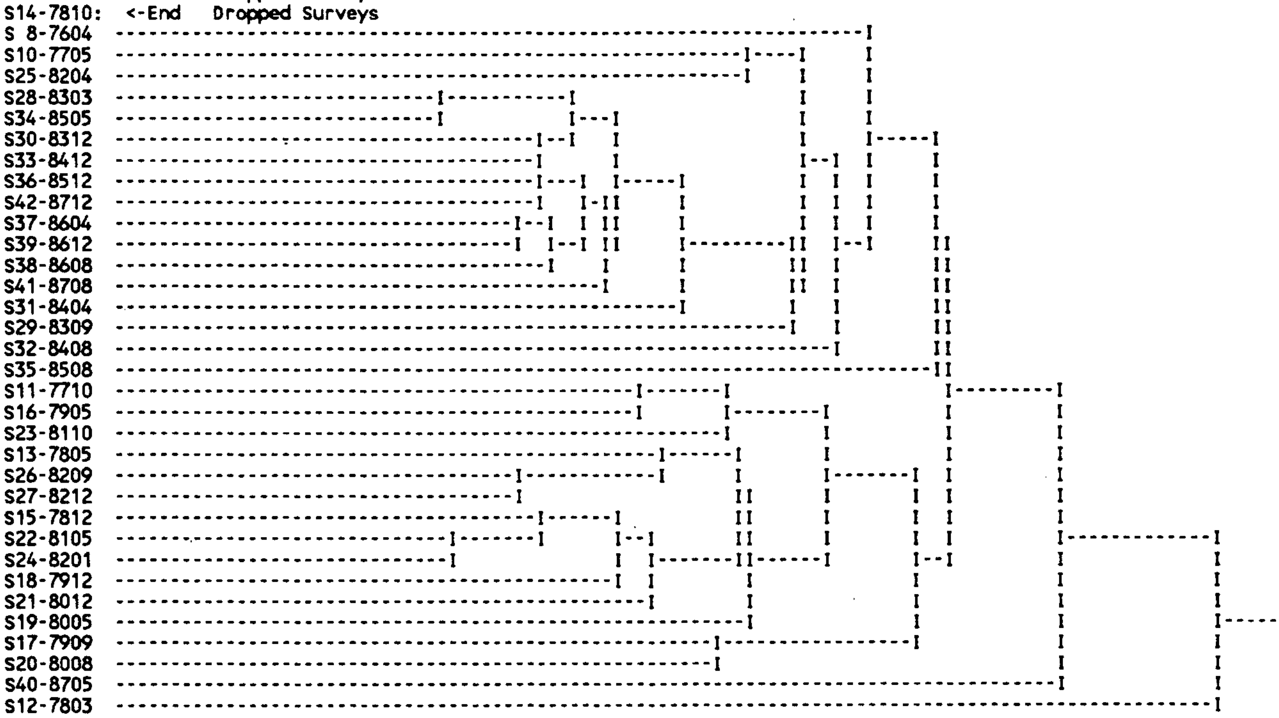
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End Dropped Surveys



Station: SDIX: Pseudolithophyllum neofarlowii: TOTAL Quads with Data = 1039

Quad Range USED 15 to 41 for Total of 27 : Range WITH data 3 to 51: : # Dropped 279 : 26.9%
Surveys 33 : Dropped 2 Surveys if quads sampled < 41
COPHENETIC CORRELATION COEFFICIENT = 0.543290: Maximum Distance = 2118

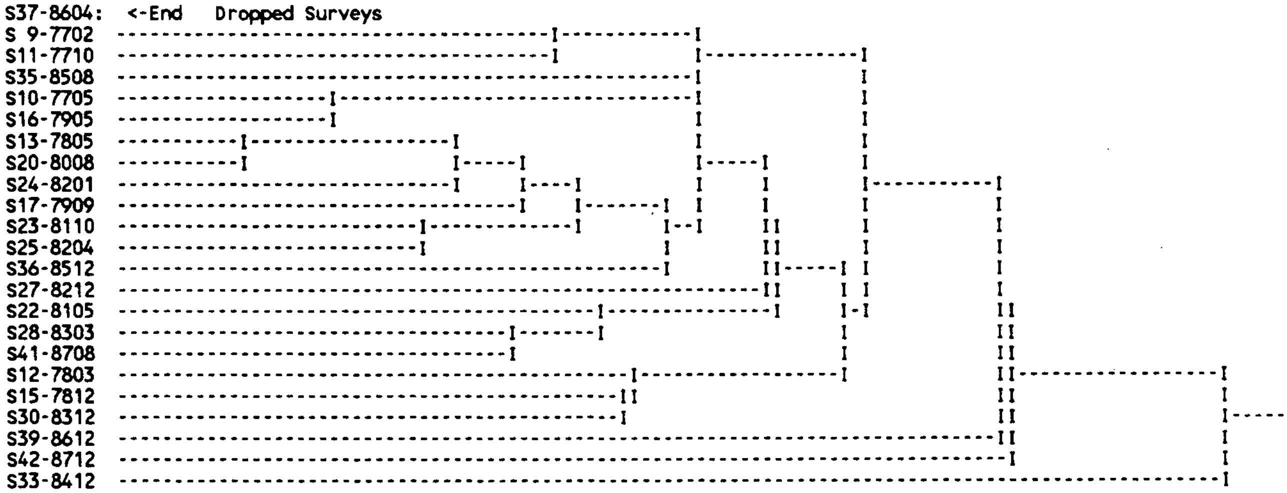
S 9-7702: <-Start Dropped Surveys
S14-7810: <-End Dropped Surveys



Station: LCIX: Pseudolithophyllum neofarlowii: TOTAL Quads with Data = 224

Quad Range USED 4 to 19 for Total of 16 : Range WITH data 2 to 21: : # Dropped 75 : 33.5%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.552236: Maximum Distance = 481

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End Dropped Surveys



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Rhodoglossum affine (Harvey, 1841) Ref. AH, 1976. p 539.
Phylum Rhodophyta: **Class** Gigartinales:

Description: Bushy tufts of foliose blades, greenish-olive to reddish-purple to almost black. 0.5 - 5 cm tall.

Distribution: British Columbia to Isla Cedros (Baja California). Locally abundant, mid-tidal (occasionally low intertidal). Uncommon south of San Luis Obispo Co. (California). A possible warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 20% of our quadrats in covers up to 20%.

Habitat: On rocks, tops, sides, upper-mid to lower intertidal.

Observational Errors: Mis-identified when other similar algal species were present (see below). Missed observations possibly fairly common, occurring about <6% and usually in areas of dense algal cover or when mis-identified. This species may have been field identified as *Gigartina papillata* until early 1977.

Field Identification Problems:

General: Could be confused with *Gigartina papillata, I. heterocarpa, Cryptopleura violacea,* and *Hymenena multiloba* depending on morphologies and coloration.

Station Specific: n.a.

General Comments: Rare at LCIX (outer coast station). Comparisons between adjacent surveys somewhat unreliable because of moderately high mis-identifications or missed observations, but comparisons over longer periods probably permissible.

Impacts to Taxon:

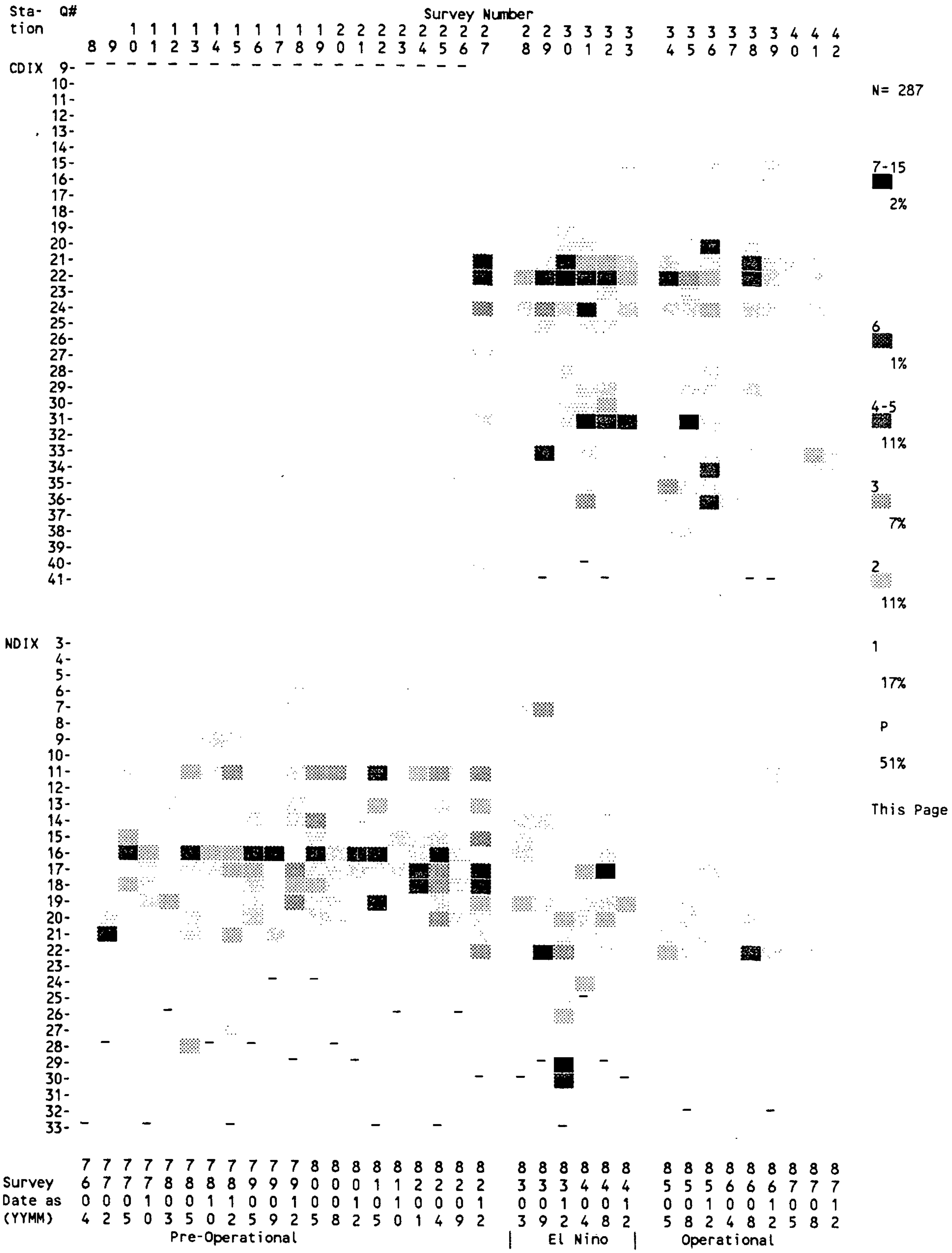
El Niño: 1982-83 winter storm: Reduction in occurrences and covers at SDIX (cobble overlay, and removal of growth) at most tidal levels. NDIX and CDIX with reduction in covers and slight reduction in occurrences. LCIX normal.

El Niño: 1983-1984: At SDIX covers quickly returning to normal at lower part of range but somewhat sporadic until end of 1983 in mid and upper ranges (possibly cobbles shifting), but extending downward in the intertidal to the end of the transect. Population center may have shifted to lower than normal in the intertidal for all of 1984. NDIX with sporadic occurrences and covers. Possibly with a declining trend for upper parts of range. CDIX with sporadic increase in occurrences at lower tidal levels. LCIX normal, i.e., scattered occurrences.

Diablo DCPP Operation: SDIX decreasing in occurrences and covers, loss of occurrences mostly in upper range. NDIX decreasing in occurrences (somewhat sporadic) and covers (rarely >1%), loss of occurrences mostly in upper range. CDIX maintaining El Niño conditions until Winter 1986, then declining in covers and possibly trend of declining occurrences at upper parts of range. LCIX within normal limits.

Taxon or Category: Rhodoglossum affine

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

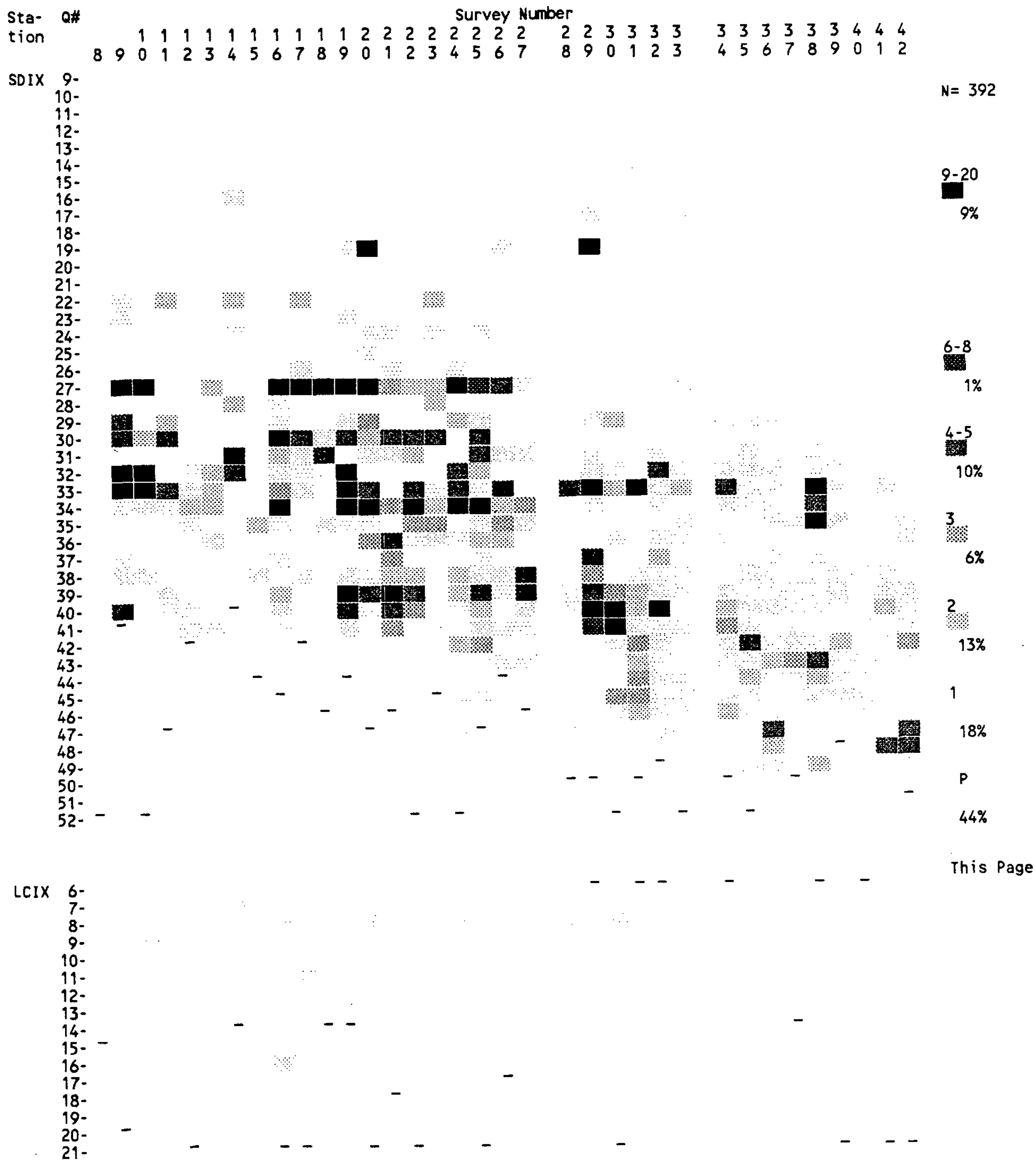


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for RHOAFF CSV 5773 3-29-88 7:39a 04-14-1989 10:51

Taxon or Category: Rhodoglossum affine

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Date as (YYMM)																																		
7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for RHOAFF CSV 5773 3-29-88 7:39a 04-14-1989 10:51

Audit: CLUMRG2P: V.1.2: for SRHOAFF CLU 6163 4-22-89 10:30a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:27:22 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Rhodoglossum affine: TOTAL Quads with Data = 101

Quad Range USED 16 to 39 for Total of 24 : Range WITH data 7 to 40: : # Dropped 7 : 6.9%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.605883: Maximum Distance = 284

```
S27-8212 ---------------------------------I--------I
S38-8608 ---------------------------------I        I------------I
S30-8312 ------------------------------------------I            I------------I
S34-8505 -------------------------------------------------------I            I---I
S29-8309 --------------------------------------------------------------------I   I
S28-8303 ----------------I----I                                                  I-----------I
S39-8612 ----------------I    I---I                                              I           I
S41-8708 ---------------------I   I----------------------------------------------I           I
S37-8604 --------------I----------I                                                          I--------------I
S40-8705 -----------I--I                                                                     I              I
S42-8712 -----------I                                                                        I              I
S31-8404 --------------------------------------------------------------------I               I              I------
S32-8408 -----------------------------------I------------I                   I---------------I              I
S33-8412 -----------------------------------I            I-------------------I                              I
S35-8508 ------------------------------------------------I                                                  I
S36-8512 ---------------------------------------------------------------------------------------------------I
```

Station: NDIX: Rhodoglossum affine: TOTAL Quads with Data = 187

Quad Range USED 11 to 25 for Total of 15 : Range WITH data 6 to 33: : # Dropped 48 : 25.7%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.859628: Maximum Distance = 238

```
S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End   Dropped Surveys
S 8-7604 I--------I
S37-8604 I        I--I
S40-8705 I----I   I  I
S41-8708 I    I---I  II
S42-8712 -----I      II-I
S36-8512 ------------II I--I
S34-8505 -------------I I  I
S12-7803 --------------II  II
S33-8412 ----------I---I   II
S35-8508 ----------I       II-I
S39-8612 ------------------II I
S11-7710 -----------------I-I I-I
S14-7810 -------------I---I   I I
S26-8209 -------------I       I I------I
S23-8110 ---------------------I I      I---I
S28-8303 -----------------------I      I   I
S15-7812 -----------------I------------I   I----I
S20-8008 -----------------I                I    I
S30-8312 -------------------I--------------I    I-I
S38-8608 -------------------I                   I II
S18-7912 ---------------------------------------I II
S 9-7702 -----------------------------------------II------------------I
S10-7705 ----------------------I                   I                  I
S13-7805 -----------------I--I I-------------------I                  I
S21-8012 -----------------I  I-I                                      I----I
S16-7905 --------------------I                                        I    I
S22-8105 -------------------------------------------------------------I    I
S24-8201 ------------------------------------I----------I             I    I--------------------------------I
S27-8212 ------------------------------------I          I-------------I    I                                I
S25-8204 -----------------------------------------------I                  I                                I------
S29-8309 ------------------------------------------------------------------I                                I
S32-8408 ---------------------------------------------------------------------------------------------------I
```

Station: SDIX: Rhodoglossum affine: TOTAL Quads with Data = 365

Quad Range USED 22 to 44 for Total of 23 : Range WITH data 16 to 50: : # Dropped 114 : 31.2%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.735203: Maximum Distance = 433

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209: <-End   Dropped Surveys
S 8-7604 -------------I--------I
S40-8705 -------------I        I-I
S13-7805 -----------------I----I I
S33-8412 -----------------I      I----I
S36-8512 ---------------I-I      I    I
S39-8612 ---------------I I---I  I    I
S41-8708 -----------------I   I--I    I------I
S37-8604 --------------------II       I      I
S42-8712 --------------------I        I      I-----------I
S35-8508 -----------------------------I      I           I
S28-8303 -------------------------------I----I           I---I
S34-8505 -------------------------------I                I   I
S11-7710 ------------------------------------------I-----I   I--------------I
S23-8110 ------------------------------------------I         I              I--I
S27-8212 ----------------------------------------------------I              I  I-------------I
S18-7912 -------------------------------------------------------------------I  I             I
S30-8312 ----------------------------------------------------------I-----------I             I---I
S32-8408 ----------------------------------------------------------I                         I   I-------I
S38-8608 ------------------------------------------------------------------------------------I   I       I
S10-7705 --------------------------------------------------------I-------------------------------I       I--I
S24-8201 --------------------------------------------------------I                                       I  I
S29-8309 ------------------------------------------------------------------------I-----------------------I  I
S31-8404 ------------------------------------------------------------------------I                          I------
S16-7905 ---------------------------------------------------------------------------------I--------I        I
S21-8012 -----------------------------------------------------------------I---------------I        I        I
S22-8105 -------------------------------------------------------I---------I                        I--------I
S25-8204 -------------------------------------------------------I                                  I
S20-8008 ------------------------------------------------------------------------------------------I
```

Station: LCIX: Rhodoglossum affine: TOTAL Quads with Data = 27

Quad Range USED 7 to 16 for Total of 10 : Range WITH data 6 to 16: : # Dropped 4 : 14.8%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.802317: Maximum Distance = 23

```
S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604: <-End   Dropped Surveys
S 9-7702 I
S11-7710 I
S12-7803 I
S13-7805 I
S15-7812 I------------------------------------------I
S21-8012 I                                          I
S23-8110 I                                          I-I
S26-8209 I                                          I I
S35-8508 I                                          I I--------------I
S17-7909 -------------------------------------------I I              I
S25-8204 ---------------------------------------------I              I
S20-8008 I------------------------------------------I                I---------------I
S30-8312 I                                          I                I               I
S22-8105 I                                          I-----I          I               I
S27-8212 I                                          I     I          I               I
S28-8303 I------------------------------------------I     I----------I               I----------I
S36-8512 I                                                I                          I          I
S39-8612 I                                                I                          I          I
S42-8712 -------------------------------------------------I                          I          I-----------I
S16-7905 -------------------------------------------I---------I                      I          I           I
S24-8201 -------------------------------------------I         I----------------------I          I           I------
S33-8412 -----------------------------------------------------I                                 I           I
S41-8708 ---------------------------------------------------------------------------------------I           I
S10-7705 ---------------------------------------------------------------------------------------------------I
```

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Phyllospadix scouleri (Surf-grass). (Hook) Ref. Munz, p 1323.
Phylum Tracheophyta: **Class** Angiospermae:

Description: Long grass-green blades arising from rhizomal structures. 0.2 - 3.5 m long.

Distribution: British Columbia to Santa Monica (California). On surf-beaten rocky shores. A warm-tolerant species.

Diablo Area Specific Information: Uncommon, occurring in about 10% of our quadrats in covers up to 100%.

Habitat: On rocks, tops, sides, lower intertidal.

Observational Errors: Possibility of mis-identification (see below). Missed observations fairly rare, occurring about <1% and usually when only rhizomes (roots) present under areas of dense algal cover. Quadrat boundary errors possible.

Field Identification Problems:

General: We rarely observed flowering spadices, so *Phyllospadix torreyi* could be present in the study area.

Station Specific: n.a.

General Comments: Uncommon at LCIX (outer coast station).

Impacts to Taxon:

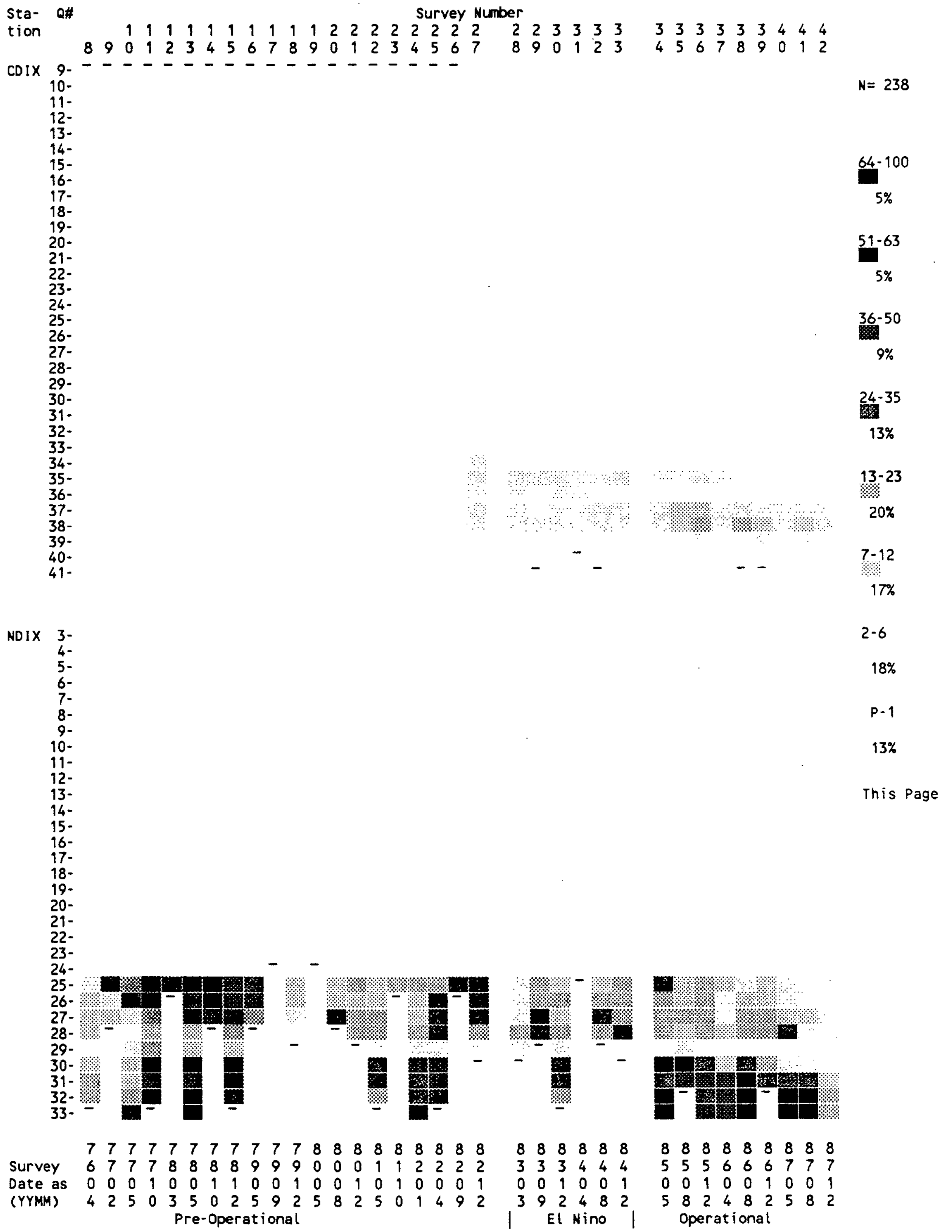
El Niño: 1982-83 winter storm: Removed at SDIX (cobble overlay, and removal of growth). NDIX with reduced covers. CDIX possibly with some reduction in covers. LCIX removed.

El Niño: 1983-1984: SDIX with only 1 occurrence, also disappearing in adjacent areas. NDIX possibly with slightly lower covers than normal. CDIX losing one occurrence toward end of period. Absent at LCIX.

Diablo DCPP Operation: Absent at SDIX. NDIX decreasing in covers only in upper range, with possibly reduced covers throughout range during Winter 1987. CDIX stable until Autumn 1986, when another occurrence lost. LCIX still absent.

Taxa or Category: Phyllospadix scouleri +P. sp. (ALL prob. P. scouleri)

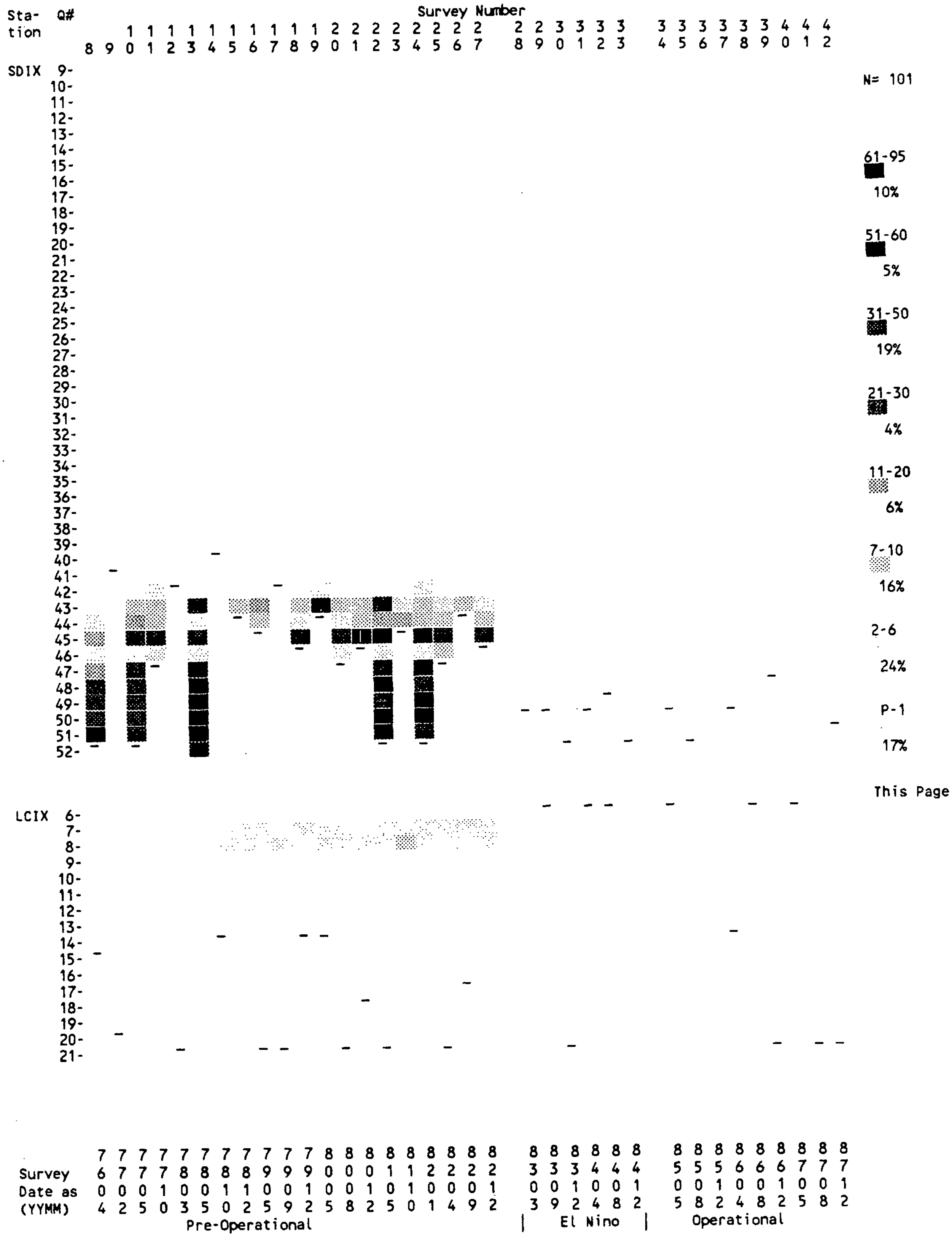
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxa or Category: Phyllospadix scouleri +P. sp. (ALL prob. P. scouleri)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PHYSPP CSV 5348 3-29-88 7:37a 04-14-1989 10:48

Audit: CLUMRG2P: V.1.2: for SPHYSPP CLU 5829 4-22-89 10:02a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/09:59:33 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Phyllospadix scouleri +P. sp. (ALL prob. P. scouleri): TOTAL Quads with Data = 50
Abrev. taxon name(s): PHYLLOSP SP +PHYLLOSP SCO Quant. Data

Quad Range USED 35 to 39 for Total of 5 : Range WITH data 34 to 39: : # Dropped 1 : 2.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.722736: Maximum Distance = 59

```
S27-8212 ----------------I------I
S28-8303 ----------------I      I------------------I
S30-8312 -----------------------I                  I-----I
S29-8309 ------------------------I-------------I   I     I
S31-8404 ------------------------I             I---I     I
S32-8408 -------I-----------I                  I         I---------I
S37-8604 -------I           I------------------I         I         I
S40-8705 -------I-----------I                            I         I
S42-8712 -------I                                        I         I----------------------------------------I
S33-8412 I-----------------------------------------------I         I                                        I
S34-8505 I                                                         I                                        I------
S39-8612 I---------------------------------------------------------I                                        I
S41-8708 I                                                                                                  I
S35-8508 -----------------------------------------------------------I---------------------------------------I
S36-8512 ------------------------------------------------I----------I
S38-8608 ------------------------------------------------I
```

Station: NDIX: Phyllospadix scouleri +P. sp. (ALL prob. P. scouleri): TOTAL Quads with Data = 188
Abrev. taxon name(s): PHYLLOSP SP +PHYLLOSP SCO Quant. Data

Quad Range USED 25 to 28 for Total of 4 : Range WITH data 10 to 33: : # Dropped 90 : 47.9%
Surveys 25 : Dropped 10 Surveys if quads sampled < 28
COPHENETIC CORRELATION COEFFICIENT = 0.803664: Maximum Distance = 242

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S16-7905:
S17-7909:
S19-8005:
S20-8008:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 --------------I---I
S41-8708 --------------I   I-I
S42-8712 ------------------I II
S37-8604 --------------------II----------------------I
S18-7912 ---------------------I                      I
S21-8012 -----------I                                I
S22-8105 I-----I    I-----I                          I
S39-8612 I     I----I     I--I                       I
S38-8608 ------I          I  I-------I               I
S35-8508 -----------------I  I       I               I--------I
S32-8408 --------------------I       I---I           I        I
S24-8201 --------------I------I      I   I           I        I
S36-8512 --------------I      I---I  I   I------I    I        I
S34-8505 ---------------------I   I--I   I      I    I        I
S30-8312 -------------------------I      I      I    I        I---------------------------------------------I
S28-8303 -----------------I--------------I      I----I        I                                             I
S40-8705 -----------------I                     I             I                                             I
S25-8204 ---------------------I---------I       I             I                                             I
S33-8412 ---------------------I         I-------I             I                                             I------
S29-8309 -------------------------------I                     I                                             I
S10-7705 -------------------------------------------------I---I                                             I
S27-8212 -------------------------------------------------I                                                 I
S11-7710 ---------------------------I--------I                                                              I
S15-7812 ---------------------------I        I--------------------------------------------------------------I
S13-7805 ------------------------------------I
```

Station: SDIX: Phyllospadix scouleri +P. sp. (ALL prob. P. scouleri): TOTAL Quads with Data = 80
Abrev. taxon name(s): PHYLLOSP SCO Quant. Data

Quad Range USED 43 to 45 for Total of 3 : Range WITH data 42 to 55: : # Dropped 49 : 61.3%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.882945: Maximum Distance = 158

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604  --------------------------------I
S28-8303  I                               I
S29-8309  I                               I
S30-8312  I                               I
S31-8404  I                               I-------------------------------------------------------------------I
S32-8408  I                               I                                                                   I
S33-8412  I                               I                                                                   I
S34-8505  I                               I                                                                   I
S35-8508  I-------------------------------I                                                                   I
S36-8512  I                                                                                                   I
S37-8604  I                                                                                                   I
S38-8608  I                                                                                                   I
S39-8612  I                                                                                                   I
S40-8705  I                                                                                                   I------
S41-8708  I                                                                                                   I
S42-8712  I                                                                                                   I
S10-7705  --------------------------I                                                                         I
S11-7710  ---I--------------I       I---I                                                                     I
S20-8008  ---I              I-------I   I                                                                     I
S25-8204  -------I----------I           I--------I                                                            I
S27-8212  -------I                      I        I                                                            I
S21-8012  I-----------------------------I        I------------------------I                                   I
S24-8201  I                                      I                        I-----------------------------------I
S18-7912  ---------------------------------------I                        I
S13-7805  --------------------------------------------------------I-------I
S22-8105  --------------------------------------------------------I
```

Station: LCIX: Phyllospadix scouleri +P. sp. (ALL prob. P. scouleri): TOTAL Quads with Data = 25
Abrev. taxon name(s): PHYLLOSP SCO Quant. Data

Quad Range USED 7 to 8 for Total of 2 : Range WITH data 7 to 24: : # Dropped 1 : 4.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 8
COPHENETIC CORRELATION COEFFICIENT = 0.885710: Maximum Distance = 13

```
S 8-7604  I
S 9-7702  I
S10-7705  I
S11-7710  I
S12-7803  I
S13-7805  I
S28-8303  I
S30-8312  I--------------I
S33-8412  I              I
S35-8508  I              I
S36-8512  I              I
S37-8604  I              I-----I
S39-8612  I              I     I
S41-8708  I              I     I-------I
S42-8712  I              I     I       I
S14-7810  ---------------I     I       I---------------------------I
S15-7812  I--------------------I       I                           I
S16-7905  I                            I                           I-------------------------------------------I
S21-8012  -----------------------------I                           I                                           I
S18-7912  ---------------I-----------------------------------I     I                                           I
S25-8204  ---------------I                                   I-----I                                           I
S20-8008  -------------------------------I-------------------I                                                 I------
S26-8209  -------------------------------I                                                                     I
S17-7909  ---------------I-----I                                                                               I
S19-8005  I--------------I     I------------------------I                                                      I
S22-8105  I                    I                        I-------------------I                                  I
S24-8201  ---------------------I                        I                   I----------------------------------I
S27-8212  ----------------------------------------------I                   I
S23-8110  ------------------------------------------------------------------I
```

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Anthopleura elegantissima (Aggregating Anemone). (Brandt, 1835). Ref. MAH 1980, p 58.
Phylum Cnidaria: **Class** Anthozoa:

Description: Column with tubercles, white to pale green. Disk pale greenish to brilliant green. Tentacles numerous, short, 5 or more rows, brilliant green to pink, blue or lavender at tips. Diameter 2 - 10+ cm (25 cm, MAH), about 2x as high as diam. (when extended). Mostly with material (shell fragments, pebbles, and other debris) adhering to column. When contracted can resemble small mounds of such material. Usually distinguishable from *A. xanthogrammica* by material adhering to column and softer body when contracted.

Distribution: Alaska to Baja California, mid intertidal to subtidal. Abundant on rock faces or boulders or on wharf pilings, singly or as dense aggregations; characteristic of semiprotected rocky shores (in bays and outer coast). (from MAH). A warm-water tolerant species.

Diablo Area Specific Information: Very common, occurring in approximately 40% of our quadrats in numbers to 100 per m^2.

Habitat: On rocks sometimes in sand covered areas, mid to low tide levels. Occur in relatively open areas, on tops, sides, and undersides. Small single individuals can occur under dense algal cover usually in small depressions. Aggregating groups occasionally occur.

Observational Errors: When dense algal mat present, small individuals can be missed. If sand deposits are present, underlying organisms cannot be observed. Under-rock specimens can be missed because of tidal (water level) conditions. Quadrat boundary errors apply for individuals occurring on undersides of rock or near edges of quadrat.

Field Identification Problems:

General: Confusion with *A. xanthogrammica* does occur but probably less than 2% of the time. Questionable specimens were usually tested for body firmness. Prior to Oct 1977 identifications were questionable, especially at NDIX and LCIX.

Station Specific: LCIX had quadrats containing specimens of both *Anthopleura* species of similar size. Adhering material was frequently absent on *A. elegantissima* and these individuals were difficult to assess.

General Comments: MAH (1980) indicates that this taxon survives in areas of thermal (up to +10°C) outfalls but with a reduced reproductive ability.

Impacts to Taxon:

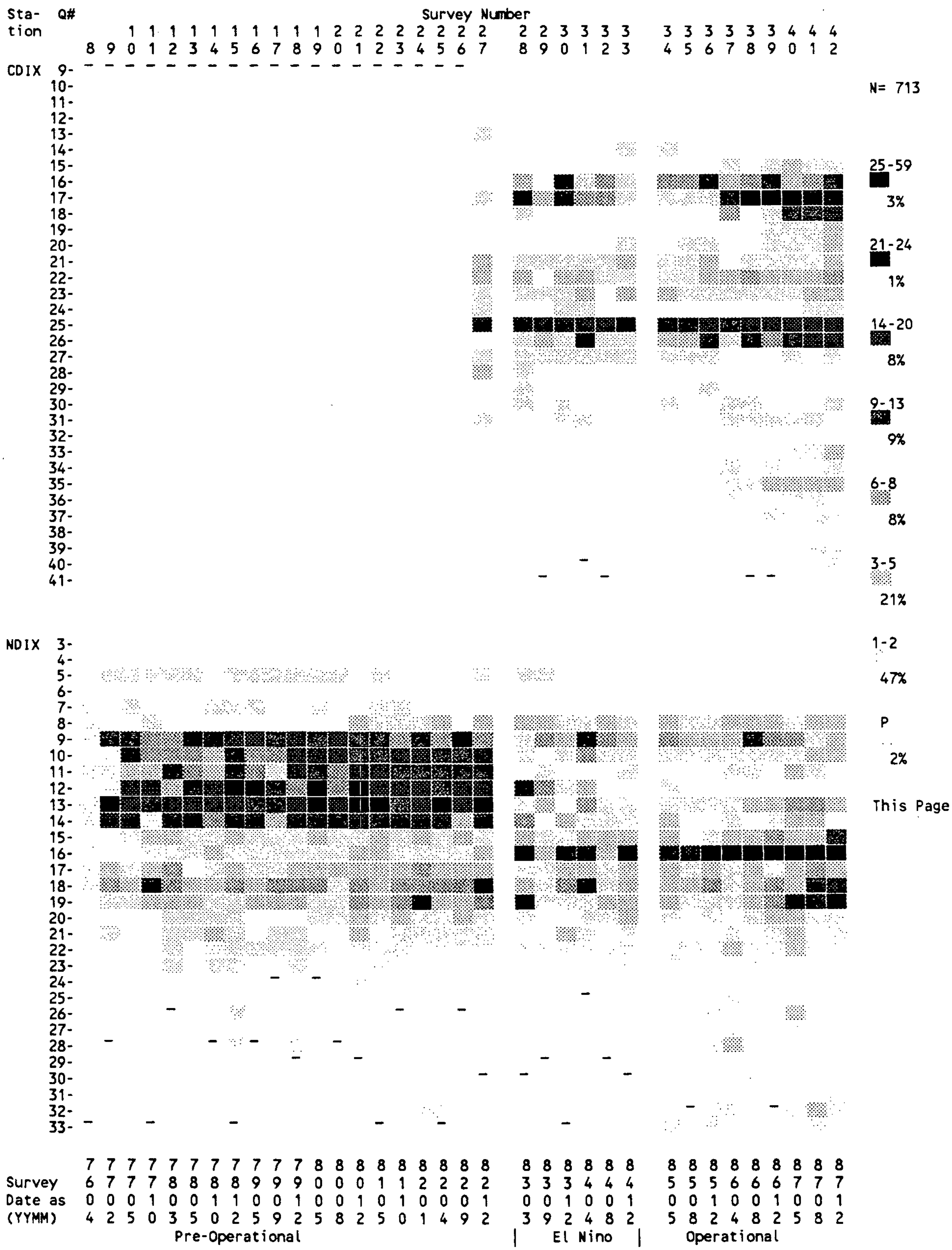
El Niño: 1982-83 winter storm: SDIX and NDIX with some reduction in occurrences probably related to substrate shifts and removal. CDIX about normal. LCIX with reduction in occurrences (one boulder removed by storms).

El Niño: 1983-1984: SDIX with slow decline in numbers and occurrences (because of cobble overlay and instability?). All stations except SDIX were probably normal in distribution (but reduced in numbers) by the end of 1984.

Diablo DCPP Operation: SDIX with reduced numbers, but slowly expanding occurrences, still not up to pre-El Niño conditions. NDIX and LCIX probably stable but again not up to pre-El Niño numbers. CDIX with slowly increasing occurrences, possibly related to available space (i.e. reduction in space competition by other organisms).

Taxon or Category: Anthopleura elegantissima [Mixed #/%?]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

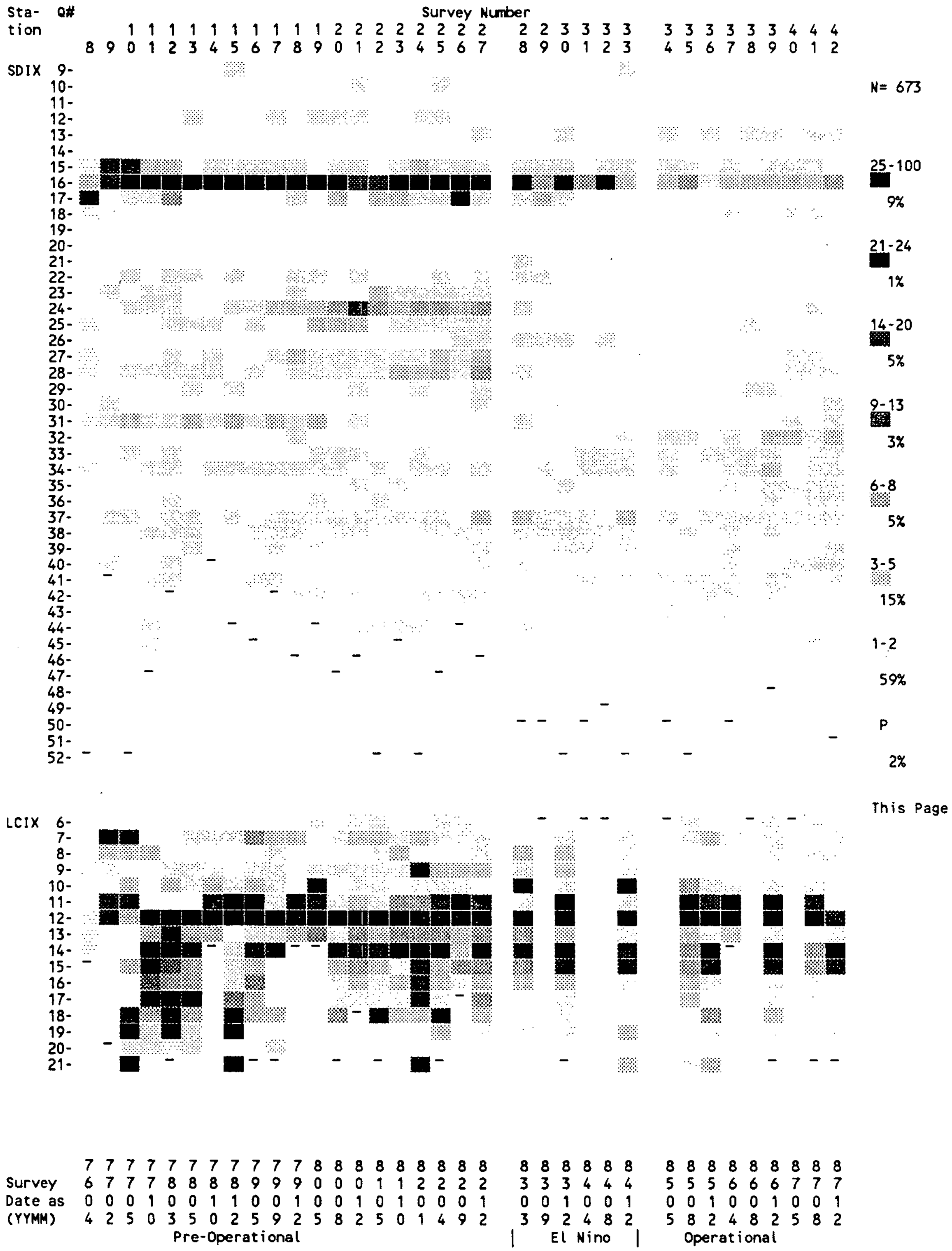


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ANTHOE CSV 5656 3-29-88 7:48a 04-15-1989 06:19

Taxon or Category: Anthopleura elegantissima [Mixed #/%?]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



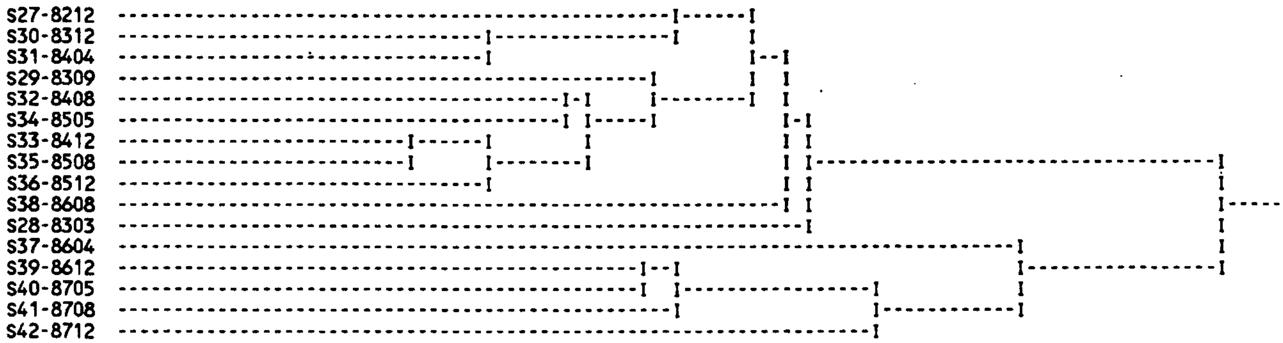
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ANTHOE CSV 5656 3-29-88 7:48a 04-15-1989 06:20

Audit: CLUMRG2P: V.1.2: for SANTHOEB CLU 6915 4-22-89 11:44a: 04-27-1989/17:11
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/11:41:09 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Anthopleura elegantissima [Mixed #/%?]: TOTAL Quads with Data = 189

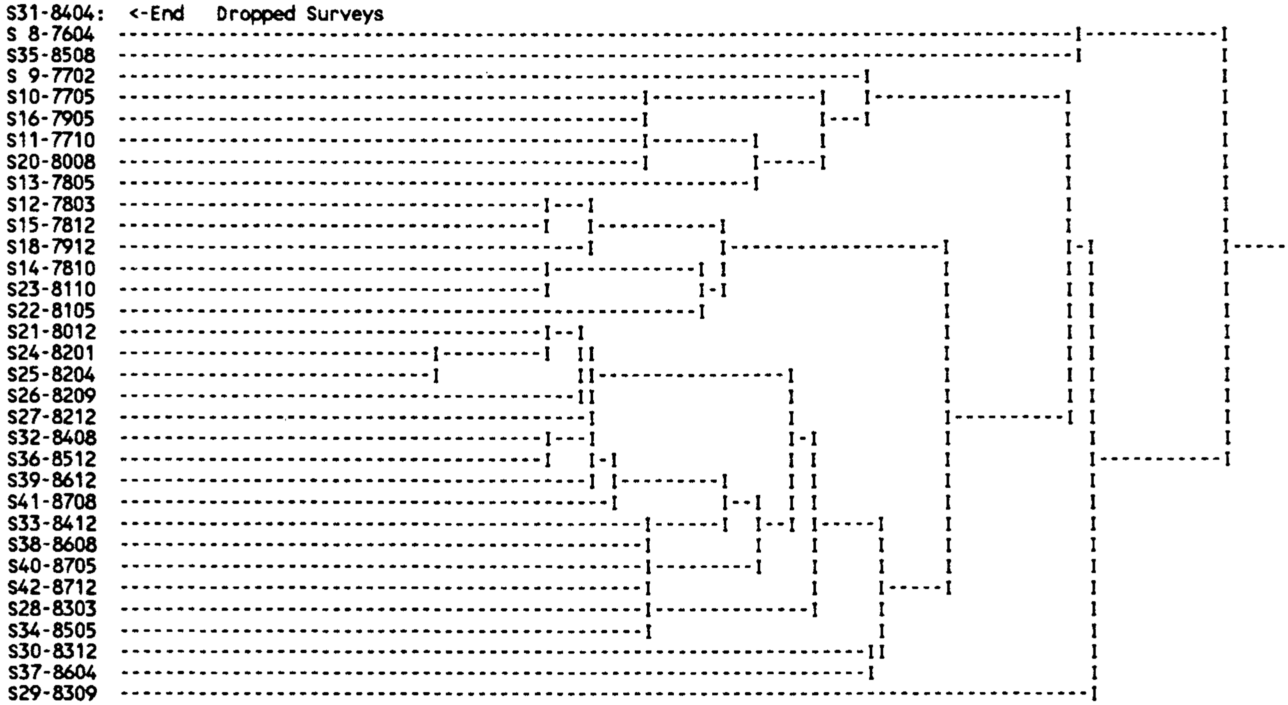
Quad Range USED 15 to 39 for Total of 25 : Range WITH data 13 to 40: : # Dropped 4 : 2.1%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.723190: Maximum Distance = 15



Station: NDIX: Anthopleura elegantissima [Mixed #/%?]: TOTAL Quads with Data = 524

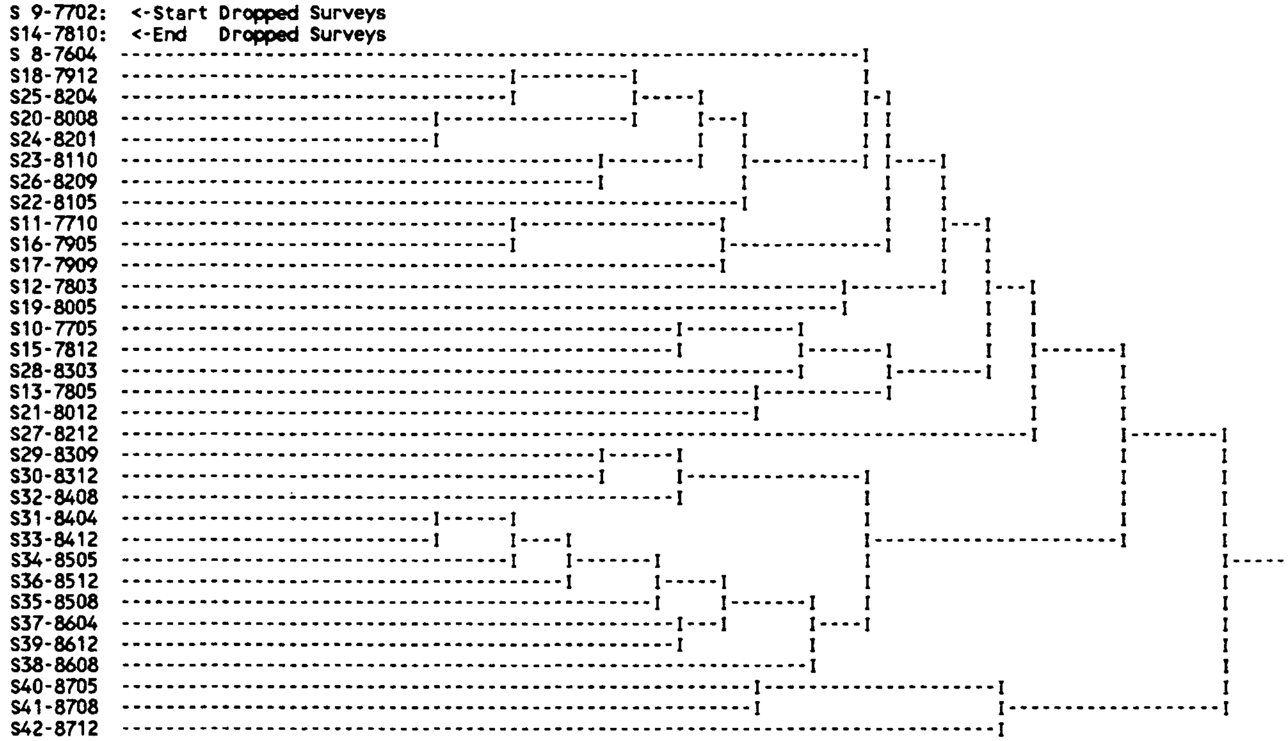
Quad Range USED 5 to 25 for Total of 21 : Range WITH data 5 to 33: : # Dropped 84 : 16.0%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.611352: Maximum Distance = 10

S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End Dropped Surveys



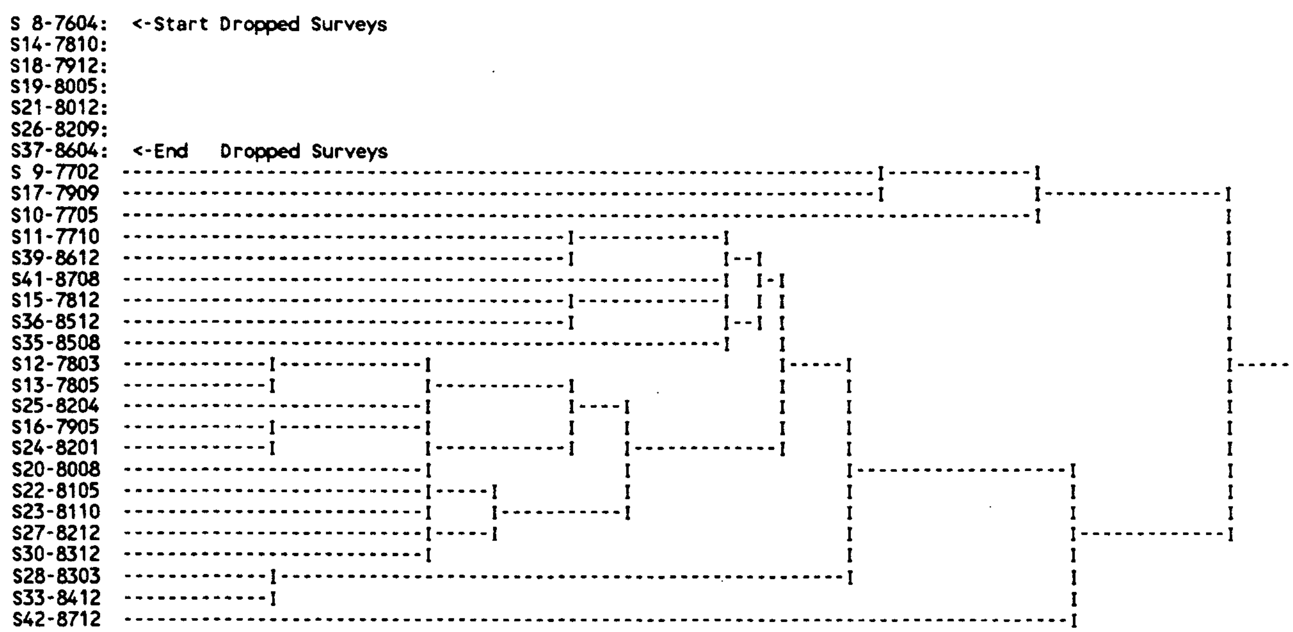
Station: SDIX: Anthopleura elegantissima [Mixed #/%?]: TOTAL Quads with Data = 395

Quad Range USED 15 to 41 for Total of 27 : Range WITH data 8 to 45: : # Dropped 61 : 15.4%
Surveys 33 : Dropped 2 Surveys if quads sampled < 41
COPHENETIC CORRELATION COEFFICIENT = 0.542747: Maximum Distance = 14



Station: LCIX: Anthopleura elegantissima [Mixed #/%?]: TOTAL Quads with Data = 289

Quad Range USED 8 to 19 for Total of 12 : Range WITH data 3 to 21: : # Dropped 92 : 31.8%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.687884: Maximum Distance = 7



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Corynactis californica (Strawberry Anemone). Carlgren, 1936. Ref. MAH 1980, p 64.
Phylum Cnidaria: **Class** Anthozoa:

Description: Column smooth, trumpet-shaped or flaring to tentacular crown, red to pink but also purple, brown, orange to white. Disk cream to white. Tentacles numerous, club-tipped, arranged in radial rows, color as disk. Diameter 0.5 - 1 + cm (tentacles to 2.5 cm, MAH), about as high as diam. (when extended).

Distribution: Sonoma Co. to San Diego (California), low intertidal to subtidal (30 m). Abundant on shaded rocks and ledges; also on concrete wharf pilings and plastic foam floats (Monterey Harbor) and on offshore oil towers (southern California). (from MAH). Warm-water tolerant.

Diablo Area Specific Information: Sparse data set, occurring in about 2% of our quadrats. Within the Cove never abundant within a quadrat, but at LCIX could cover moderate areas (to ~50 cm^2).

Habitat: On rocks, lower intertidal levels. Occurs in cryptic areas, on tops, sides, and undersides. Small single individuals and aggregates can occur under dense algal cover usually in depressions.

Observational Errors: When dense algal mat present individuals can be missed. Missed observation probably over 10% for this species. Not consistently quantified (i.e., has been called as present, percent cover, and estimated numbers).

Field Identification Problems:

General: When retracted and not accessible to feel, can be confused with *Balanophyllia elegans* (Orange Cup Coral) because club-shaped tentacles cannot be seen and the cup of *B. elegans* cannot be felt.

Station Specific: n.a.

General Comments: Probably an ephemeral species within the Cove although common here subtidally, never occurring at CDIX. Outer coast station (LCIX) only station with established population.

Impacts to Taxon:

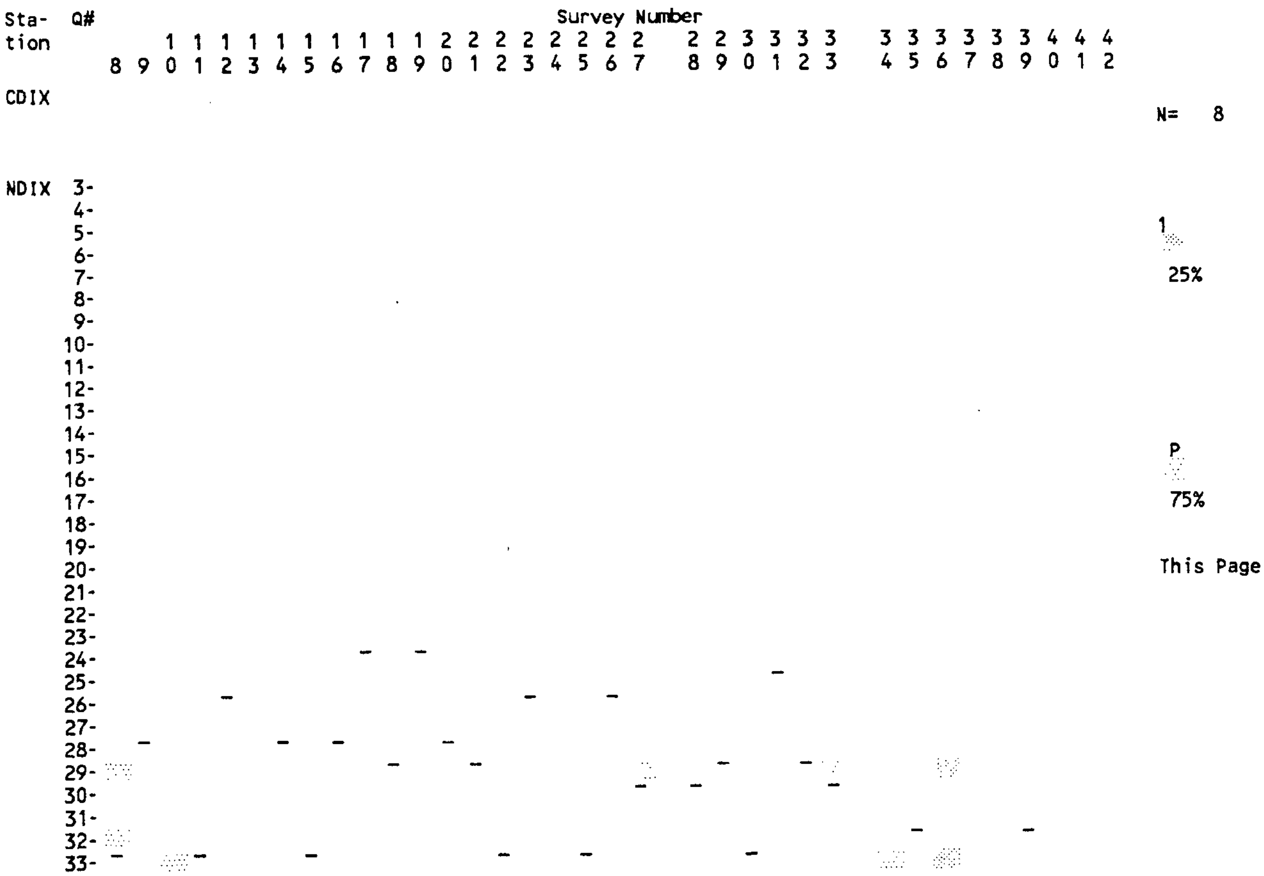
El Niño: 1982-83 winter storm: LCIX with reduction in occurrences compared to immediately preceding survey.

El Niño: 1983-1984: LCIX with sporadic occurrences.

Diablo DCPP Operation: LCIX population may be declining.

Taxon or Category: Corynactis californica [Mixed P/#/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



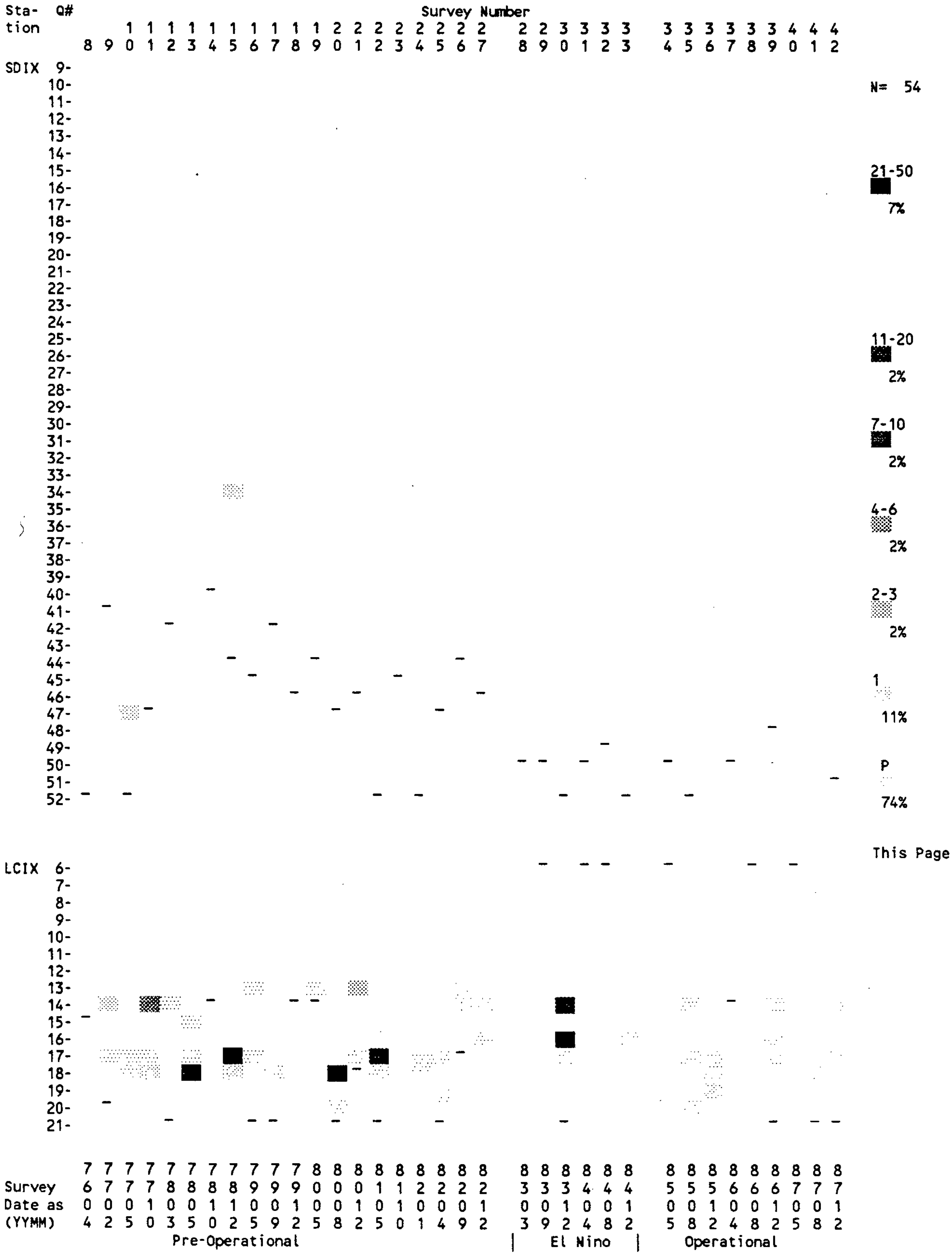
Survey Number	Survey Date as (YYMM)	Period
8	7604	Pre-Operational
9	7702	Pre-Operational
10	7705	Pre-Operational
11	7710	Pre-Operational
12	7803	Pre-Operational
13	7805	Pre-Operational
14	7810	Pre-Operational
15	7812	Pre-Operational
16	7905	Pre-Operational
17	7909	Pre-Operational
18	7912	Pre-Operational
19	8005	Pre-Operational
20	8008	Pre-Operational
21	8012	Pre-Operational
22	8105	Pre-Operational
23	8110	Pre-Operational
24	8201	Pre-Operational
25	8204	Pre-Operational
26	8209	Pre-Operational
27	8212	Pre-Operational
28	8303	El Nino
29	8309	El Nino
30	8312	El Nino
31	8404	El Nino
32	8408	El Nino
33	8412	El Nino
34	8505	Operational
35	8508	Operational
36	8512	Operational
37	8604	Operational
38	8608	Operational
39	8612	Operational
40	8705	Operational
41	8708	Operational
42	8712	Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CORCAL CSV 5201 3-29-88 7:51a 04-15-1989 06:24

Taxon or Category: Corynactis californica [Mixed P/#/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CORCAL CSV 5201 3-29-88 7:51a 04-15-1989 06:25

```
Audit: CLUMRG2P: V.1.2: for SCORCALB CLU     6581   4-28-89   7:28a:   04-28-1989/07:40
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:38:18 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
       METHOD:  GROUP AVERAGE:  ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL:  >> BINARY << Data Used


Station:  CDIX:   Corynactis californica [Mixed P/#/%]:   :  No data for this station


                                                NO DATA
                                          NO DATA
                                    NO DATA
                              NO DATA
                        NO DATA
                  NO DATA
            NO DATA
      NO DATA
      NO DATA
            NO DATA
                  NO DATA
                        NO DATA
                              NO DATA
                                    NO DATA
                                          NO DATA
                                                NO DATA


Station:  NDIX:   Corynactis californica [Mixed P/#/%]:   TOTAL Quads with Data = 8:**** Prob. INSUFFICIENT Data ***

        Quad Range USED 29 to 33 for Total of 5 :  Range WITH data 29 to 33:  :  # Dropped  4 :   50.0%
        Surveys  10 :  Dropped  25 Surveys if quads sampled < 33
        COPHENETIC CORRELATION COEFFICIENT = 0.602752:                           Maximum Distance = 5

S 8-7604:  <-Start Dropped Surveys
S 9-7702:
S11-7710:
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S18-7912:
S19-8005:
S20-8008:
S21-8012:
S22-8105:
S23-8110:
S25-8204:
S26-8209:
S27-8212:
S28-8303:
S29-8309:
S30-8312:
S31-8404:
S32-8408:
S33-8412:
S35-8508:
S39-8612:  <-End   Dropped Surveys
S10-7705  ---------------------------------------------------------------I--------------------I
S34-8505  ---------------------------------------------------------------I                    I
S13-7805  ---------------------------------------------------------------I                    I---------------I
S24-8201  ---------------------------------------------------------------I                    I               I
S37-8604  ---------------------------------------------------------------I                    I               I
S38-8608  ---------------------------------------------------------------I--------------------I               I------
S40-8705  ---------------------------------------------------------------I                                    I
S41-8708  ---------------------------------------------------------------I                                    I
S42-8712  ---------------------------------------------------------------I                                    I
S36-8512  ----------------------------------------------------------------------------------------------------I
```

```
Station:  SDIX:   Corynactis californica [Mixed P/#/%]:   TOTAL Quads with Data = 2:**** Prob. INSUFFICIENT Data ***

        Quad Range USED 34 to 47 for Total of 14 :  Range WITH data 34 to 47:  :  # Dropped  1 :   50.0%
        Surveys  20 :  Dropped  15 Surveys if quads sampled < 47
        COPHENETIC CORRELATION COEFFICIENT = 0.202782:                      Maximum Distance = 14

S 9-7702:  <-Start Dropped Surveys
S11-7710:
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S18-7912:
S19-8005:
S20-8008:
S21-8012:
S23-8110:
S25-8204:
S26-8209:
Driver Prg. CSVtoDEK:  <-End  Dropped Surveys
S 8-7604   --------------------------------------------------------------------------------------------------I
S13-7805   --------------------------------------------------------------------------------------------------I
S22-8105   --------------------------------------------------------------------------------------------------I
S24-8201   --------------------------------------------------------------------------------------------------I
S28-8303   --------------------------------------------------------------------------------------------------I
S29-8309   --------------------------------------------------------------------------------------------------I
S30-8312   --------------------------------------------------------------------------------------------------I
S31-8404   --------------------------------------------------------------------------------------------------I
S32-8408   --------------------------------------------------------------------------------------------------I
S33-8412   --------------------------------------------------------------------------------------------------I-------I
S34-8505   --------------------------------------------------------------------------------------------------I       I
S35-8508   --------------------------------------------------------------------------------------------------I       I
S36-8512   --------------------------------------------------------------------------------------------------I       I
S37-8604   --------------------------------------------------------------------------------------------------I       I
S38-8608   --------------------------------------------------------------------------------------------------I       I------
S39-8612   --------------------------------------------------------------------------------------------------I       I
S40-8705   --------------------------------------------------------------------------------------------------I       I
S41-8708   --------------------------------------------------------------------------------------------------I       I
S42-8712   --------------------------------------------------------------------------------------------------I       I
S10-7705   ----------------------------------------------------------------------------------------------------------I


Station:  LCIX:   Corynactis californica [Mixed P/#/%]:   TOTAL Quads with Data = 56

        Quad Range USED 13 to 19 for Total of 7 :  Range WITH data 7 to 24:  :  # Dropped  15 :   26.8%
        Surveys  22 :  Dropped  7 Surveys if quads sampled < 19
        COPHENETIC CORRELATION COEFFICIENT = 0.616664:                      Maximum Distance = 3

S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End  Dropped Surveys
S 9-7702   I
S35-8508   I-------------------------------------I
S42-8712   I                                     I---------------------I
S11-7710   --------------------------------------I                     I--------------------I
S27-8212   --------------------------------------I---------------------I                    I
S30-8312   I-------------------------------------I                                          I------------------------I
S39-8612   I                                                                                I                        I
S12-7803   --------------------------------------I------------------I                       I                        I
S23-8110   --------------------------------------I                  I-----------------------I                        I
S33-8412   ---------------------------------------------------------I                                                I
S10-7705   I                                                                                                         I
S15-7812   I-------------------------------------I                                                                   I
S22-8105   I                                     I------I                                                            I------
S24-8201   I                                     I      I                                                            I
S13-7805   --------------------------------------I      I-----------I                                                I
S17-7909   I                                            I           I                                                I
S20-8008   I--------------------------------------------I           I-------------------------------------I          I
S41-8708   I                                                        I                                     II         I
S36-8512   ---------------------------------------------------------I                                     II         I
S25-8204   --------------------------------------I--------------------------------------------------------II---------I
S28-8303   --------------------------------------I                                                         I
S16-7905   ------------------------------------------------------------------------------------------------I
```

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Eurystomella bilabiata (Moss Animal). (Hinks, 1884). Ref. MAH 1980, p 98.
Phylum Ectoprocta: **Class** Gymnolaemata:

Description: Flat, single-layered encrusting colonies to 5+ cm in diameter, rose-red to red-orange to brown, smooth and shiny.

Distribution: Alaska to Tenacatita Bay (Mexico). Common at lower intertidal levels on rocky shores in Central California; subtidally to 64 m. On stones and mollusk shells. (from MAH). Possibly a warm-tolerant species.

Diablo Area Specific Information: Sparse data set, occurring in only about 4% of our quadrats with covers of up to about 5% of a quadrat.

Habitat: On rocks and cobble, lower intertidal levels. Occurs in cryptic areas, on tops, sides, and undersides.

Observational Errors: When dense algal mat present individuals can be missed, missed calls probably about 10% of total. Not consistently identified during early surveys. Colonies <1 cm in diameter were frequently missed.

Field Identification Problems:

General: Only two species of encrusting ectoprocts (bryozoans) are normally field-identified in our study, this one and *Rhynchozoon*. Coloration and texture are the main field identification characteristics for this taxon, i.e., a pink to rusty brown coloration and smooth surface. Colonies not matching criteria for this taxon or for *Rhynchozoon* are called "encrusting bryozoans".

Station Specific: LCIX's normally dense algal mat precludes consistent observation of this taxon.

General Comments: n.a.

Impacts to Taxon:

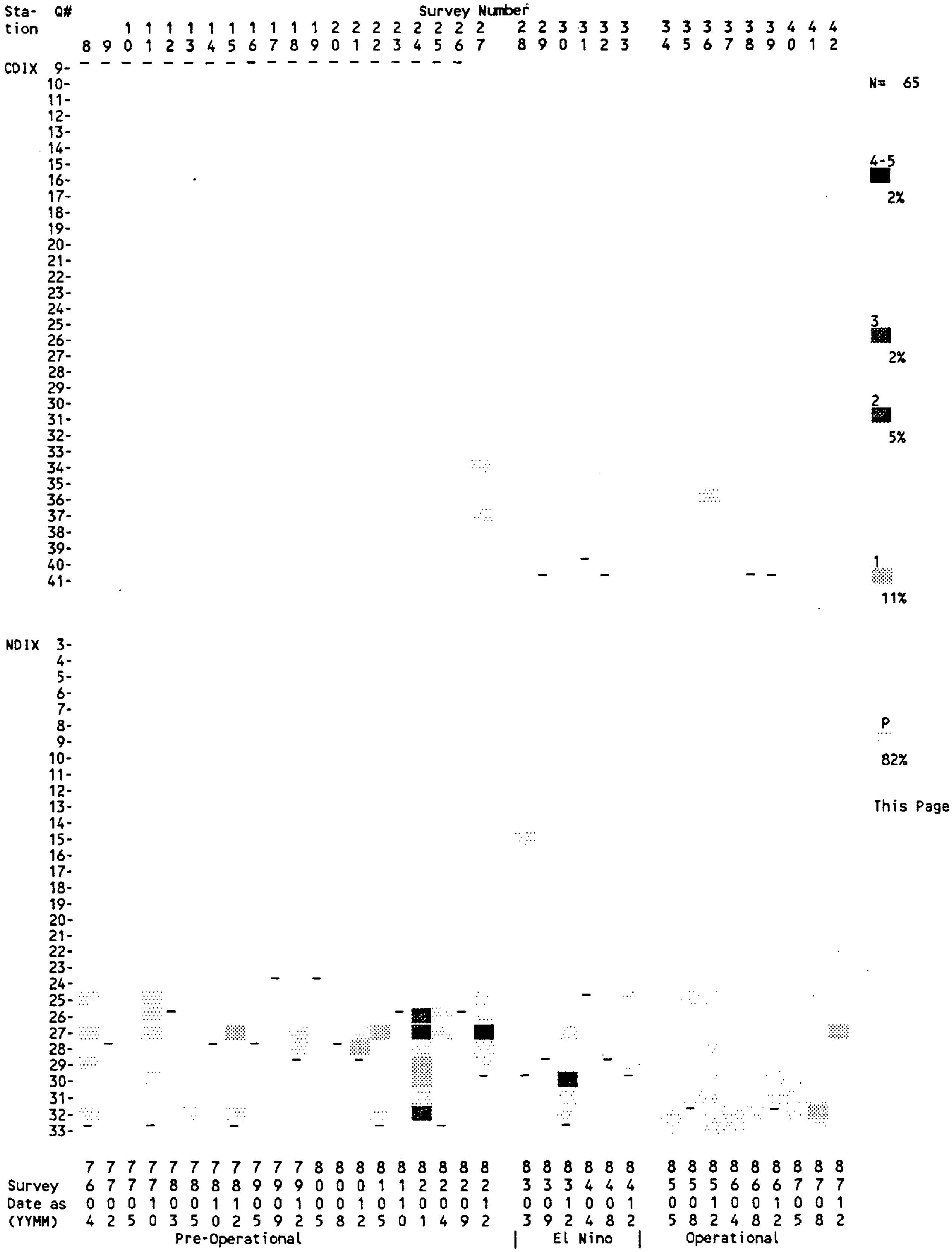
El Niño: 1982-83 winter storm: SDIX all but disappeared, probably due to the cobble overlay from a nearby collapsed cliff. NDIX with no occurrences. LCIX with no occurrences prior to or after storm.

El Niño: 1983-1984: SDIX and NDIX with sporadic, scattered occurrences. At CDIX and LCIX no assessment possible because of rarity of taxon.

Diablo DCPP Operation: SDIX below normal in occurrences, but again possibly due to cobble overlay. NDIX may have recovered from El Niño, but our last survey (Dec 1987) with occurrence in only 1 quadrat. At LCIX response is not estimatable because of low occurrence and high probability of missed observations.

Taxon or Category: Eurystomella bilabiata [Mixed P/%/no-call]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

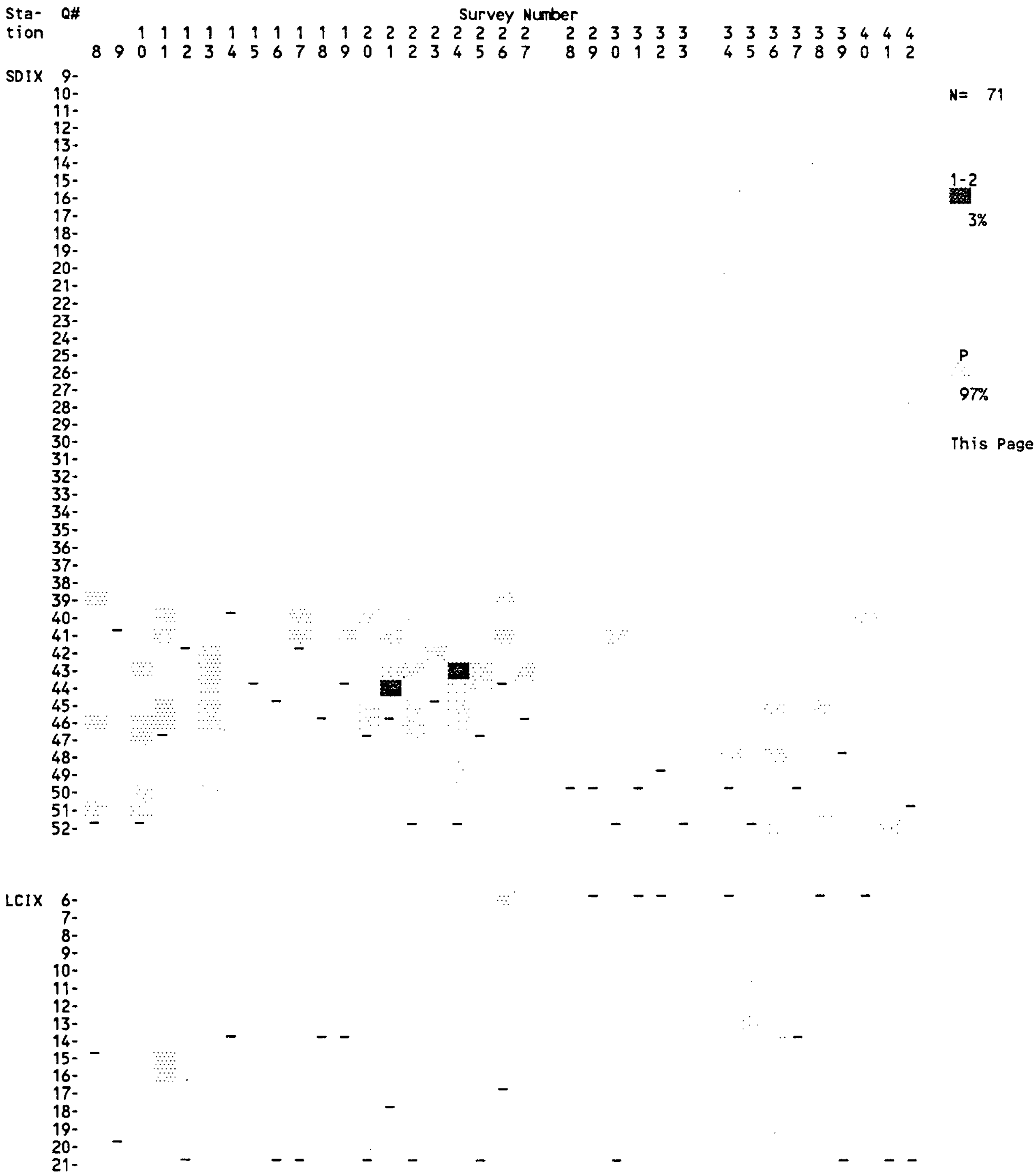


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for EURBIL CSV 5314 3-29-88 7:53a 04-15-1989 06:25

Taxon or Category: Eurystomella bilabiata [Mixed P/%/no-call]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Date as (YYMM)	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for EURBIL CSV 5314 3-29-88 7:53a 04-15-1989 06:26

Audit: CLUMRG2P: V.1.2: for SEURBILB CLU 7249 4-22-89 7:06a: 04-28-1989/07:40
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:45:54 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Eurystomella bilabiata [Mixed P/%/no-call]: TOTAL Quads with Data = 3:**** Prob. INSUFFICIENT Da

Quad Range USED 34 to 37 for Total of 4 : Range WITH data 34 to 37: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 37
COPHENETIC CORRELATION COEFFICIENT = 0.945890: Maximum Distance = 3

```
S27-8212 ---------------------------------------------------------------------------------------------------I
S28-8303 --------------------------------I                                                                  I
S29-8309 --------------------------------I                                                                  I
S30-8312 --------------------------------I                                                                  I
S31-8404 --------------------------------I                                                                  I
S32-8408 --------------------------------I                                                                  I------
S33-8412 --------------------------------I                                                                  I
S34-8505 --------------------------------I-------------------------------I                                  I
S35-8508 --------------------------------I                               I                                  I
S37-8604 --------------------------------I                               I                                  I
S38-8608 --------------------------------I                               I                                  I
S39-8612 --------------------------------I                               I----------------------------------I
S40-8705 --------------------------------I                               I
S41-8708 --------------------------------I                               I
S42-8712 --------------------------------I                               I
S36-8512 ----------------------------------------------------------------I
```

Station: NDIX: Eurystomella bilabiata [Mixed P/%/no-call]: TOTAL Quads with Data = 62

Quad Range USED 15 to 32 for Total of 18 : Range WITH data 15 to 33: : # Dropped 21 : 33.9%
Surveys 16 : Dropped 19 Surveys if quads sampled < 32
COPHENETIC CORRELATION COEFFICIENT = 0.509256: Maximum Distance = 15

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S16-7905:
S17-7909:
S18-7912:
S19-8005:
S20-8008:
S21-8012:
S23-8110:
S26-8209:
S27-8212:
S28-8303:
S29-8309:
S31-8404:
S32-8408:
S33-8412:
S35-8508:
S39-8612:  <-End   Dropped Surveys
S 8-7604 ------------------------------------------------------------------------------------I
S10-7705 ----------------------------------------------------------------------I             I
S13-7805 ---------------------------------------------------------------I      II            I
S34-8505 ---------------------------------------------------------------I------II            I-I
S37-8604 ---------------------------------------------------------------I       I---I        I I
S38-8608 ---------------------------------------------------------------I       I   I---I    I I
S41-8708 -----------------------------------------------------------------------I   I   I    I I
S15-7812 ----------------------------------------------------------------------I----I   I----I I----I
S22-8105 ----------------------------------------------------------------------I        I      I    I
S25-8204 ----------------------------------------------------------------------I--------I      I    I
S42-8712 ----------------------------------------------------------------------I               I    I-----I
S30-8312 ----------------------------------------------------------------------I---------I     I    I     I
S40-8705 ----------------------------------------------------------------------I         I-----I    I     I------
S36-8512 --------------------------------------------------------------------------------I          I     I
S11-7710 -------------------------------------------------------------------------------------------I     I
S24-8201 -------------------------------------------------------------------------------------------------I
```

Station: SDIX: Eurystomella bilabiata [Mixed P/%/no-call]: TOTAL Quads with Data = 58

Quad Range USED 39 to 46 for Total of 8 : Range WITH data 39 to 52: : # Dropped 29 : 50.0%
Surveys 23 : Dropped 12 Surveys if quads sampled < 46
COPHENETIC CORRELATION COEFFICIENT = 0.830745: Maximum Distance = 4

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S18-7912:
S19-8005:
S21-8012:
S23-8110:
S26-8209:
S27-8212: <-End  Dropped Surveys
S 8-7604 ----------------------------------------------------------------I
S28-8303 I                                                               I
S29-8309 I                                                               I
S31-8404 I                                                               I
S32-8408 I                                                               I
S33-8412 I                                                               I
S34-8505 I---------------------------I                                   I--I
S35-8508 I                           I                                   I  I
S37-8604 I                           I                                   I  I
S39-8612 I                           I-I                                 I  I
S41-8708 I                           I I                                 I  I
S42-8712 I                           I I---I                             I  I------------------------------I
S30-8312 ----------------------------I I   I                             I  I                              I
S36-8512 I-----------------------------I   I-----------------------------I  I                              I
S38-8608 I                                 I                                I                              I-I
S40-8705 ----------------------------------I                                I                              I I
S25-8204 -------------------------------------------------------------------I                              I I
S11-7710 ----------------------------I---------------------------------------------------------------------I I------
S20-8008 ----------------------------I                                                                       I
S10-7705 ----------------------------I----------------------------I                                          I
S22-8105 ----------------------------I                            I------------------------------------------I
S13-7805 ----------------------------I----------------------------I
S24-8201 ----------------------------I
```

Station: LCIX: Eurystomella bilabiata [Mixed P/%/no-call]: TOTAL Quads with Data = 16

Quad Range USED 15 to 19 for Total of 5 : Range WITH data 6 to 24: : # Dropped 9 : 56.3%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.867451: Maximum Distance = 3

```
S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End  Dropped Surveys
S 9-7702 --------------------------------------I
S10-7705 --------------------------------------I
S12-7803 --------------------------------------I
S13-7805 --------------------------------------I
S15-7812 --------------------------------------I
S16-7905 --------------------------------------I
S17-7909 --------------------------------------I
S20-8008 --------------------------------------I--------------------------------------I
S22-8105 --------------------------------------I                                      I
S23-8110 --------------------------------------I                                      I
S24-8201 --------------------------------------I                                      I
S25-8204 --------------------------------------I                                      I----------------------I
S27-8212 --------------------------------------I                                      I                      I
S28-8303 --------------------------------------I                                      I                      I
S30-8312 --------------------------------------I                                      I                      I
S35-8508 --------------------------------------I                                      I                      I------
S33-8412 --------------------------------------I--------------------------------------I                      I
S36-8512 --------------------------------------I                                                             I
S11-7710 -----------------------------------------------------------------------------I-----------I          I
S39-8612 --------------------------------------I--------------------------------------I           I----------I
S42-8712 --------------------------------------I                                                  I
S41-8708 -----------------------------------------------------------------------------------------I
```

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Phragmatapoma californica (Sand Reef Worm). (Fewkes, 1889). Ref. MAH 1980, p 468.
Phylum Annelida: **Class** Polychaeta:

Description: Tubes of cemented sand forming masses up to several meters in extent. Tubes regularly arranged in honeycomb pattern, each with flared rim. Tubes rarely solitary. Animal to 5 cm long. (from MAH, 1980).

Distribution: Central California to Ensenada (Baja California). Locally abundant on rocky shores at mid intertidal and rarely lower, subtidal to 75 m. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 30% of our quadrats. Solitary tubes common (but see below).

Habitat: On rocks and rarely cobbles, mid-upper to low tide levels. Occurs as extensive mats in mid-upper intertidal only at LCIX (open coast station) and at our other stations as individuals or small colonies, on tops, sides, and sometimes undersides. Covers of up to about 70% (at LCIX) of a quadrat have been observed. Solitary tubes tend to occur in small crevices or depressions.

Observational Errors: When dense algal mat present solitary tubes are easily missed, may have occurred about 10% of the time in our Cove stations.

Field Identification Problems:

General: Observation of the animal inhabiting the tube rarely occurred and often the tubes are somewhat eroded, we cannot be sure that what we call is really *Phragmatapoma californica*. Another very similar tubeworm, *Sabellaria cementarium*, occurs in our study area. We made no extensive collections of these solitary individuals for laboratory identification so this taxon could be a mix of the two. We did not break open the tubes to observe the animal, which would have destroyed them.

Station Specific: n.a.

General Comments: n.a.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX with reduced occurrences, probably due to the cobble overlay from nearby collapsed cliff. All other stations with a probable small reduction in occurrences.

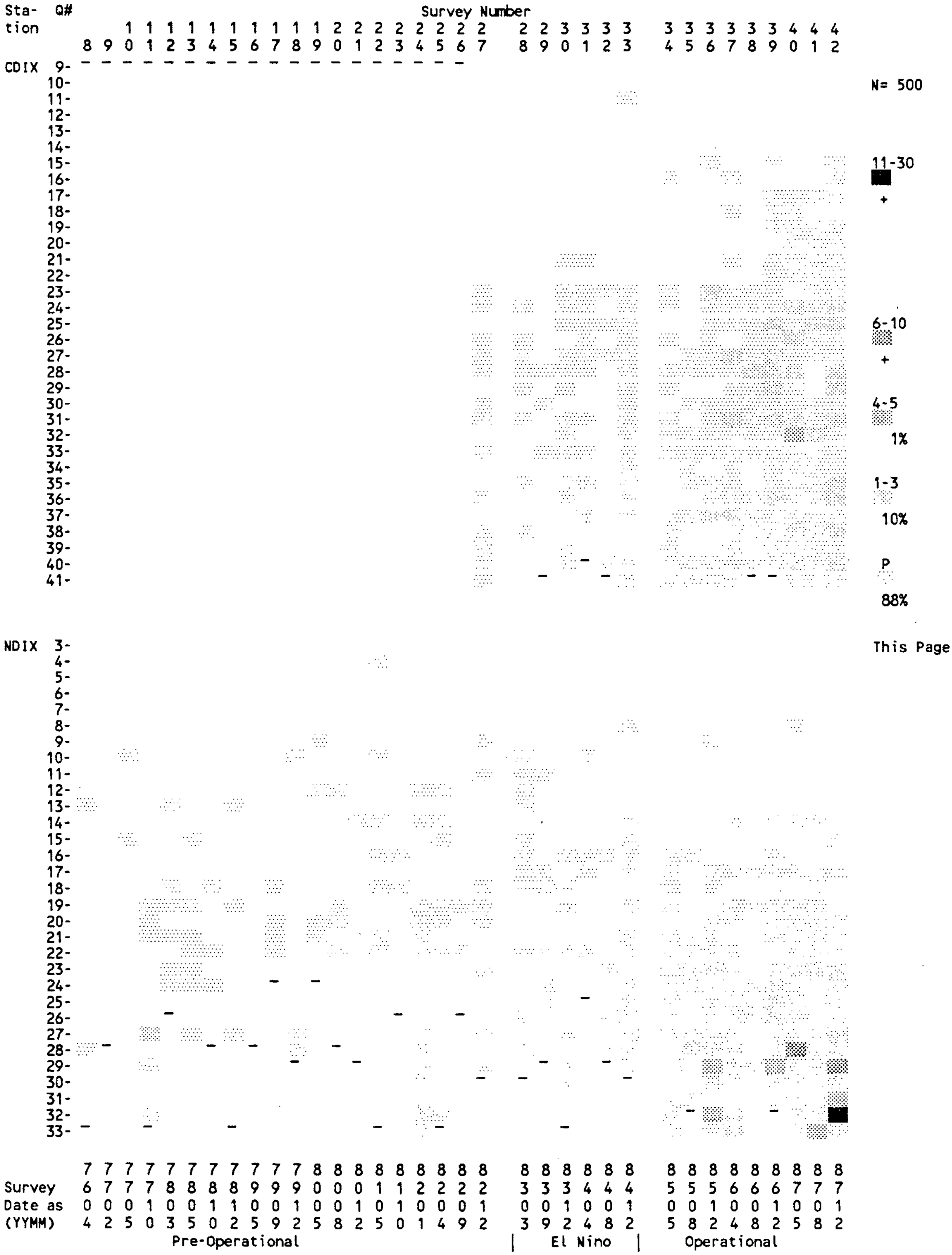
El Niño: 1983-1984: SDIX and NDIX with sporadic increase in occurrences to approximately normal. At CDIX there were two surveys with reduced number of occurrences (possibly missed observations). At LCIX, solitary tubes appeared to extend their range downward into quadrats where the taxon had not been observed since 1978.

Diablo DCPP Operation: SDIX with expanded range of occurrences into higher and lower tidal levels than normal, possibly due to increased visibility as the algal mat thinned. NDIX similar to SDIX but here extension was mainly downward. CDIX also similar to SDIX, but there was insufficient data to determine normal background conditions for that station. LCIX approximately normal, but lower in cover than peaks occurring in 1978-1980.

Sabellaria cementarium: Alaska to southern California.

Taxon or Category: Phragmatopoma/Sabellaria sp. [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PHRAGM CSV 5617 3-31-88 10:17a 04-15-1989 06:34

Taxon or Category: Phragmatopoma/Sabellaria sp. [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

Sta-tion / Q# — Survey Number 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

SDIX 9- 10- 11- 12- 13- 14- 15- 16- 17- 18- 19- 20- 21- 22- 23- 24- 25- 26- 27- 28- 29- 30- 31- 32- 33- 34- 35- 36- 37- 38- 39- 40- 41- 42- 43- 44- 45- 46- 47- 48- 49- 50- 51- 52-

LCIX 6- 7- 8- 9- 10- 11- 12- 13- 14- 15- 16- 17- 18- 19- 20- 21-

N= 471

Range	%
31-70	13%
27-30	5%
19-26	5%
13-18	2%
7-12	4%
4-6	4%
1-3	10%
P	57%

This Page

Survey Date as (YYMM)	7604	7702	7705	7710	7803	7805	7810	7902	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8402	8404	8408	8412	8505	8508	8602	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PHRAGM CSV 5617 3-31-88 10:17a 04-15-1989 06:34

Audit: CLUMRG2P: V.1.2: for SPHRAGMB CLU 6581 4-23-89 7:14a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:11:57 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Phragmatopoma/Sabellaria sp. [Mixed P/%]: TOTAL Quads with Data = 243

Quad Range USED 15 to 40 for Total of 26 : Range WITH data 11 to 41: : # Dropped 21 : 8.6%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.539517: Maximum Distance = 14

```
S31-8404:  <-Start Dropped Surveys
S27-8212  -------------------------------------------------I
S33-8412  ----------------------I---I                      I-----I
S36-8512  ----------------------I   I----------------------I     I-----I
S38-8608  --------------------------I                            I     I
S30-8312  --------------------------------------------I----------I     I--------------I
S37-8604  --------------------------------------------I                I              I
S34-8505  -------------------------------------------------------------I              I-----------------------I
S39-8612  ----------------------I---I                                                 I                       I
S40-8705  ----------------------I   I-----I                                           I                       I
S42-8712  --------------------------I     I-------------------------------------------I                       I------
S41-8708  --------------------------------I                                                                   I
S28-8303  --------------------------------------------------------------------------I                         I
S29-8309  --------------------------------------------I--------------I              I-------------------------I
S35-8508  --------------------------------------------I              I--------------I
S32-8408  -----------------------------------------------------------I
```

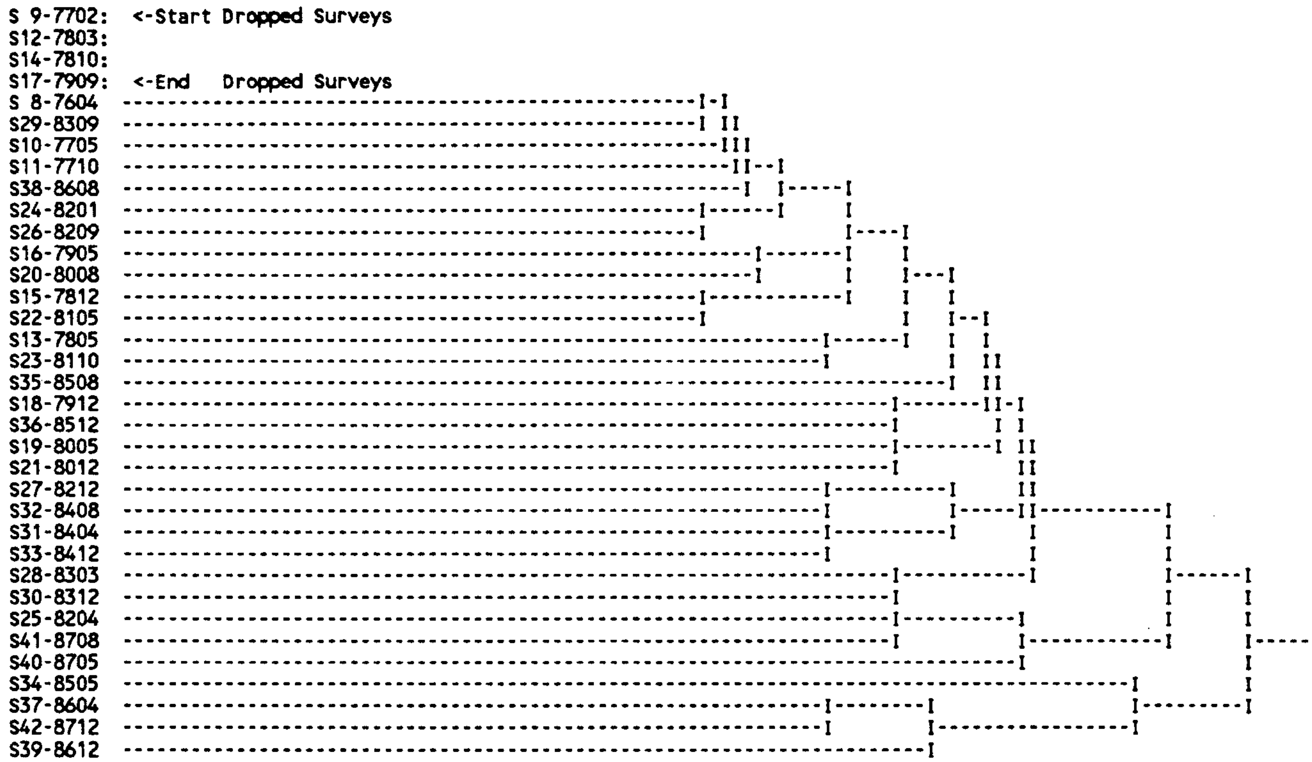
Station: NDIX: Phragmatopoma/Sabellaria sp. [Mixed P/%]: TOTAL Quads with Data = 257

Quad Range USED 7 to 27 for Total of 21 : Range WITH data 4 to 33: : # Dropped 81 : 31.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.681761: Maximum Distance = 12

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ----------------I--I
S 9-7702  -------I-------I  I---------I
S16-7905  -------I          I         I-----------I
S21-8012  -------------------I         I           I
S10-7705  -------------------------I---I           I----I
S18-7912  -------------------------I               I    I
S11-7710  ---------------------------------I-------I    I-----------I
S15-7812  ---------------------------------I            I           I
S32-8408  ----------------------------------------------I           I-I
S13-7805  -----------------------------------------I-------I        I I
S35-8508  -----------------------------------------I       I--------I I---I
S30-8312  -------------------------------------------------I          I   I
S14-7810  ---------------------------------I-------------------I      I   I
S29-8309  ---------------------------------I                   I------I   I-I
S38-8608  -----------------------------------------------------I          I I
S20-8008  -------------------------I-------I                              I I-----I
S25-8204  -------------------------I       I------------------------------I I     I
S24-8201  ---------------------------------I                                I     I-----------------I
S22-8105  ------------------------------------------------------------------I     I                 I
S27-8212  ------------------------------------------------------------------------I                 I----------I
S33-8412  --------------------------------------------------------I                                 I          I
S34-8505  -------------------------------------------I            I                                 I          I
S37-8604  -------------------------I                 I-I          I---------------------------------I          I
S40-8705  -------------------------I-------I         I I          I                                            I------
S41-8708  -------------------------I       I---------I I----------I                                            I
S39-8612  ---------------------------------I           I                                                       I
S36-8512  ---------------------------------I-----------I                                                       I
S42-8712  ---------------------------------I                                                                   I
S28-8303  -----------------------------------------------------------------------------------------------------I
```

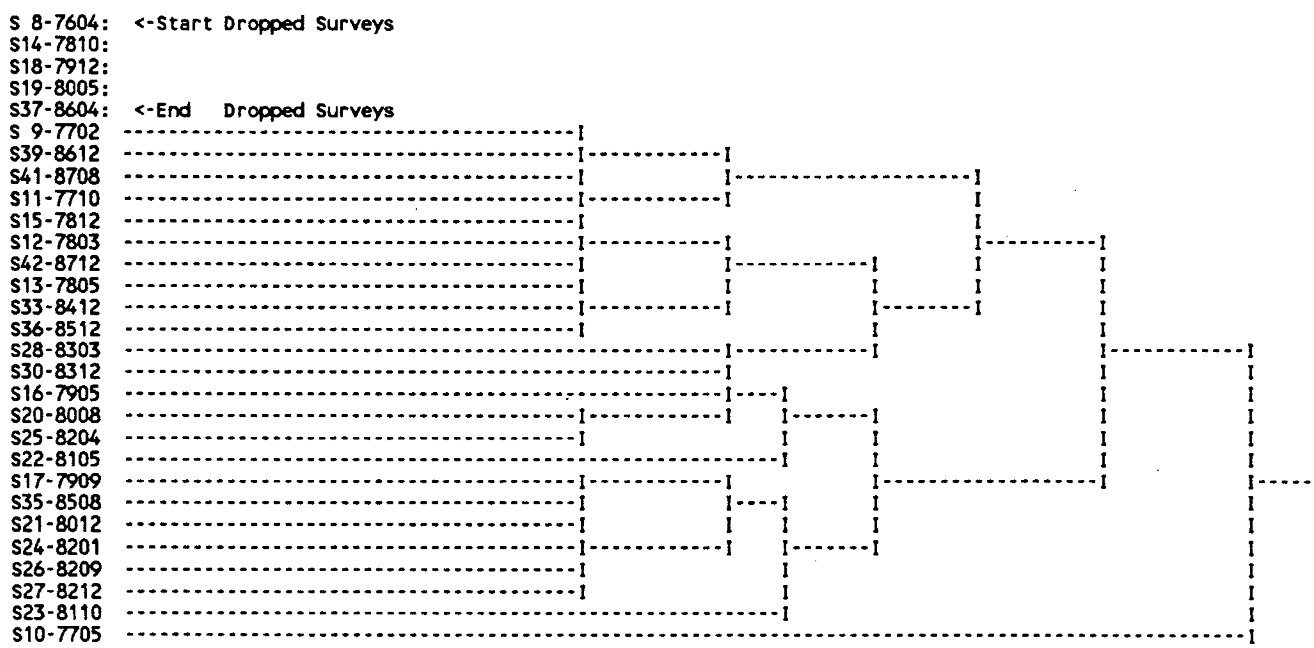
Station: SDIX: Phragmatopoma/Sabellaria sp. [Mixed P/%]: TOTAL Quads with Data = 212

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 14 to 52: : # Dropped 64 : 30.2%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.661145: Maximum Distance = 17



Station: LCIX: Phragmatopoma/Sabellaria sp. [Mixed P/%]: TOTAL Quads with Data = 276

Quad Range USED 6 to 16 for Total of 11 : Range WITH data 3 to 24: : # Dropped 83 : 30.1%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.662337: Maximum Distance = 7



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Pista elongata (Basket Worm). Moore, 1909. Ref. MAH 1980, p 470.
Phylum Annelida: **Class** Polychaeta:

Description: Tubes of parchment-like material terminating in a reticulate spongelike fiber network (basket). Animal to 20 cm long. (from MAH).

Distribution: British Columbia to at least San Diego (California), Panama and Japan. Under rocks and in crevices, mid intertidal and below on rocky shores. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Generally uncommon, occurring in about 4% of our quadrats, but for several surveys at SDIX (1976 and 1981-82), formed large beds of up to 60% of certain quadrats. Tube almost always with a much reduced basket, probably due to wave erosion.

Habitat: Rarely on rocks, most often in sandy areas among boulders and cobbles, lower tide levels.

Observational Errors: When dense algal mat present solitary tubes are easily missed, and this may have occurred about 5% of the time.

Field Identification Problems:

General: Animals inhabiting the tube never observed in the field and we may be confusing this taxon with some other tube building polychaete.

Station Specific: n.a.

General Comments: n.a.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX greatly reduced compared to surveys just prior to storms, probably due to removal by waves. NDIX sporadic prior to this, none were observed for the March 1983 survey. At LCIX tubes present, as was true for prior surveys.

El Niño: 1983-1984: SDIX with sporadic recover of occurrences. NDIX with no occurrences for this period, but here normally quite sporadic. At CDIX and LCIX tubes were occasionally present, as was true for prior surveys.

Diablo DCPP Operation: Because of the sporadic occurrence of this taxon in our transects, it is difficult to assess response to power plant operation. At CDIX just prior to and during El Niño, it occurred in about 1 quadrat for each survey. It appeared in 4 quadrats in December 1987. LCIX still with occasional tubes present.

Taxon or Category: Pista elongata [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

```
Sta-  Q#                                  Survey Number
tion            1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2   2 2 3 3 3 3   3 3 3 3 3 3 4 4 4
            8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7   8 9 0 1 2 3   4 5 6 7 8 9 0 1 2
CDIX  9-                                                                               N=  35
     10- ... 41-                                                                       P
                                                                                       100%
                                                                                       This Page

NDIX  3- ... 33-

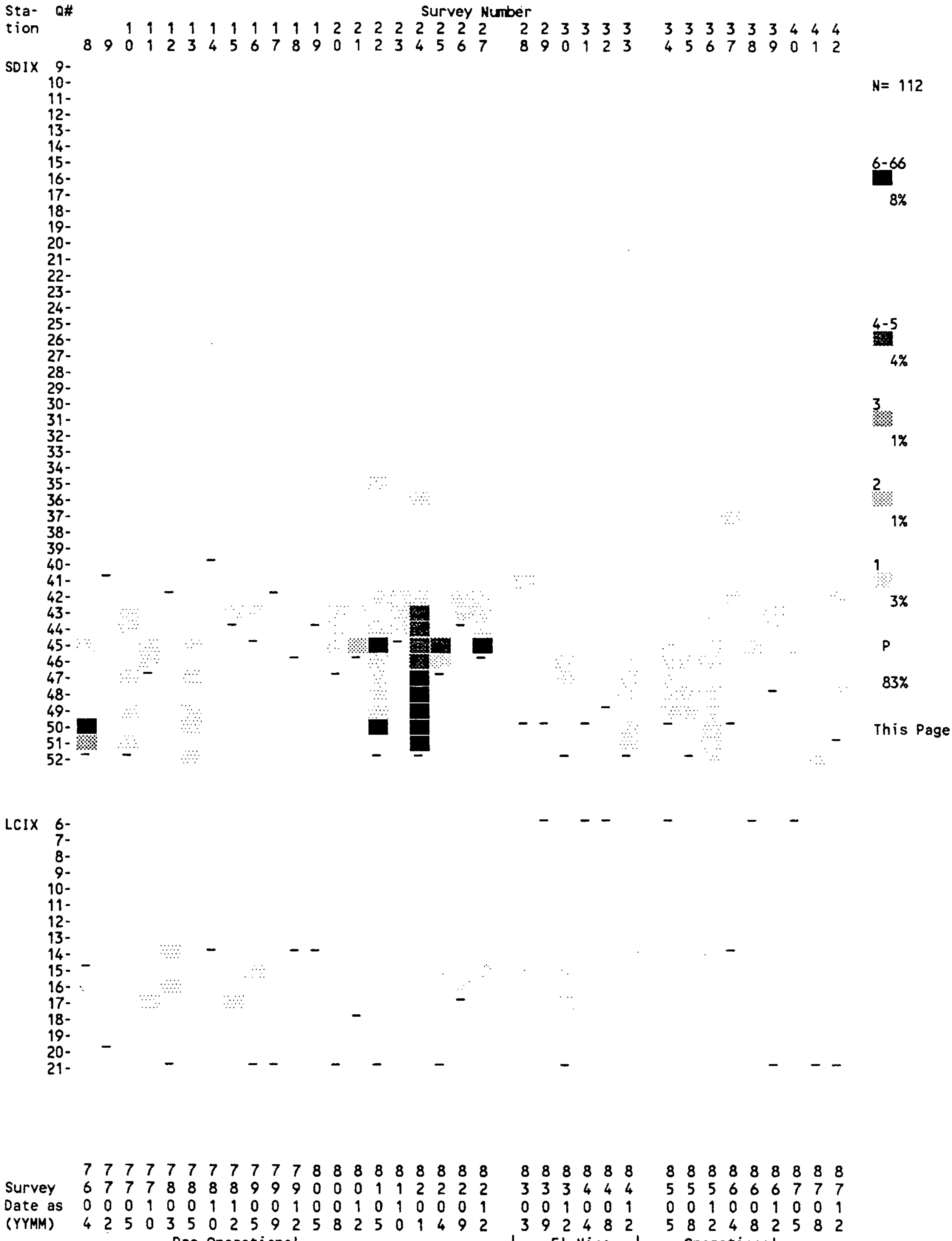
             7 7 7 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8   8 8 8 8 8 8   8 8 8 8 8 8 8 8 8
Survey       6 7 7 7 8 8 8 8 9 9 9 0 0 0 1 1 2 2 2 2   3 3 3 4 4 4   5 5 5 6 6 6 7 7 7
Date as      0 0 0 1 0 0 1 1 0 0 1 0 0 1 0 1 0 0 0 1   0 0 1 0 0 1   0 0 1 0 0 1 0 0 1
(YYMM)       4 2 5 0 3 5 0 2 5 9 2 5 8 2 5 0 1 4 9 2   3 9 2 4 8 2   5 8 2 4 8 2 5 8 2
                       Pre-Operational               |   El Nino   |   Operational
```

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PISTAS CSV 5379 3-29-88 8:08a 04-15-1989 06:35

Taxon or Category: Pista elongata [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PISTAS CSV 5379 3-29-88 8:08a 04-15-1989 06:35

```
Audit: CLUMRG2P: V.1.2: for SPISTASB CLU     5328   4-23-89   7:27a:   04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:23:04 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
       METHOD:  GROUP AVERAGE:  ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL:  >> BINARY << Data Used


Station:  CDIX:   Pista elongata [Mixed P/%]:   TOTAL Quads with Data = 22

        Quad Range USED 22 to 37 for Total of 16 :  Range WITH data 22 to 37:  :  # Dropped  0 :    0.0%
        Surveys  16 :  Dropped  0 Surveys if quads sampled < 37
        COPHENETIC CORRELATION COEFFICIENT = 0.552469:                          Maximum Distance = 12

S27-8212 ---------------------------------------------------------------------------------I
S28-8303 -------------------------------------------------------------------------I       II
S31-8404 -------------------------------------------------------------------------I       II
S32-8408 -------------------------------------------------------------------------I-------II
S34-8505 -------------------------------------------------------------------------I        II
S35-8508 -------------------------------------------------------------------------I        II
S38-8608 -------------------------------------------------------------------------I        II---------------I
S29-8309 ----------------------------------------------------------------------------------II               I
S33-8412 -----------------------------------------------------------------------------------I               I
S41-8708 -----------------------------------------------------------------------------------I               I
S37-8604 -------------------------------------------------------------------------------------------------------I------
S30-8312 -------------------------------------------------------------------------I-------I                     I
S40-8705 -------------------------------------------------------------------------I       I----I               I
S39-8612 ---------------------------------------------------------------------------------I    I----I          I
S36-8512 --------------------------------------------------------------------------------------I    I-------I
S42-8712 -------------------------------------------------------------------------------------------I


Station:  NDIX:   Pista elongata [Mixed P/%]:   TOTAL Quads with Data = 13:**** Prob. INSUFFICIENT Data ****

        Quad Range USED 25 to 28 for Total of 4 :  Range WITH data 25 to 33:  :  # Dropped  6 :   46.2%
        Surveys  25 :  Dropped  10 Surveys if quads sampled < 28
        COPHENETIC CORRELATION COEFFICIENT = 0.904669:                          Maximum Distance = 2

S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S16-7905:
S17-7909:
S19-8005:
S20-8008:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  I-----------------------------------------------------------I
S24-8201  I                                                           I
S10-7705  I                                                           I
S11-7710  I                                                           I
S13-7805  I                                                           I
S15-7812  I                                                           I----I
S18-7912  I                                                           I    I
S21-8012  I                                                           I    I
S22-8105  I                                                           I    I
S27-8212  I                                                           I    I
S28-8303  I                                                           I    I
S29-8309  I-----------------------------------------------------------I    I
S30-8312  I                                                                I
S32-8408  I                                                                I-----------------------------------I
S34-8505  I                                                                I                                   I
S37-8604  I                                                                I                                   I
S38-8608  I                                                                I                                   I
S39-8612  I                                                                I                                   I
S40-8705  I                                                                I                                   I------
S41-8708  I                                                                I                                   I
S42-8712  I                                                                I                                   I
S33-8412  I----------------------------------------------------------------I                                   I
S36-8512  I                                                                                                    I
S25-8204  ------------------------------------------------------------I----------------------------------------I
S35-8508  ------------------------------------------------------------I
```

Station: SDIX: Pista elongata [Mixed P/%]: TOTAL Quads with Data = 95

Quad Range USED 42 to 46 for Total of 5 : Range WITH data 35 to 55: : # Dropped 54 : 56.8%
Surveys 23 : Dropped 12 Surveys if quads sampled < 46
COPHENETIC CORRELATION COEFFICIENT = 0.655685: Maximum Distance = 3

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S18-7912:
S19-8005:
S21-8012:
S23-8110:
S26-8209:
S27-8212: <-End   Dropped Surveys
S 8-7604  I----------------------------I
S13-7805  I                            I-----------I
S11-7710  I                            I           I
S25-8204  I----------------------------I           I--------------I
S34-8505  I                                        I              I
S42-8712  -----------------------------------------I              I
S28-8303  I                                                       I---------I
S29-8309  I                                                       I         I
S31-8404  I----------------------------I                          I         I
S32-8408  I                            I----I                     I         I-I
S41-8708  I                            I    I---------------------I         I I
S35-8508  -----------------------------I    I                               I I---------------I
S37-8604  ----------------------------------I                               I I               I
S33-8412  ------------------------------------------------------------------I I               I
S30-8312  -----------------------------I--------------------------------------I               I---------------I
S36-8512  -----------------------------I                                                      I               I
S10-7705  I----------------------------I                                                      I               I
S39-8612  I                            I--------------I                                       I               I------
S20-8008  I----------------------------I              I---------------------------------------I               I
S40-8705  I                                           I                                                       I
S38-8608  --------------------------------------------I                                                       I
S22-8105  -----------------------------I----------------------------------------------------------------------I
S24-8201  -----------------------------I
```

Station: LCIX: Pista elongata [Mixed P/%]: TOTAL Quads with Data = 18

Quad Range USED 14 to 19 for Total of 6 : Range WITH data 13 to 19: : # Dropped 2 : 11.1%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.729589: Maximum Distance = 3

```
S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End   Dropped Surveys
S 9-7702  --------------------------------I
S10-7705  --------------------------------I
S13-7805  --------------------------------I
S17-7909  --------------------------------I
S20-8008  --------------------------------I---------------------------------I
S22-8105  --------------------------------I                                 I
S23-8110  --------------------------------I                                 I
S24-8201  --------------------------------I                                 I----I
S35-8508  --------------------------------I                                 I    I
S39-8612  --------------------------------I                                 I    I---------------I
S11-7710  --------------------------------I---------------------------------I    I               I
S15-7812  --------------------------------I                                      I               I
S41-8708  -----------------------------------------------------------------------I               I
S16-7905  --------------------------------I                                                      I------------I
S27-8212  --------------------------------I---------------------------------I                    I            I
S28-8303  --------------------------------I                                 I-----I              I            I
S33-8412  --------------------------------I                                 I     I----I         I            I------
S25-8204  ------------------------------------------------------------------I     I    I---------I            I
S30-8312  ------------------------------------------------------------------------I    I                      I
S42-8712  -----------------------------------------------------------------------------I                      I
S12-7803  ------------------------------------------------------------------I---------------------------------I
S36-8512  ------------------------------------------------------------------I
```

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Acmaea mitra (White-Cap Limpet). Rathke, 1833. Ref. MAH 1980, p 240.
Phylum Mollusca: **Class** Gastropoda:

Description: Conical, white. Diameter 0.3 - 2+ cm (3.5 cm, MAH), about as high as diam., apex almost central. Can be encrusted with coralline algae.

Distribution: Pribilof and Aleutian Islands (Alaska) to Isla San Martin (Baja California), low intertidal to shallow subtidal. Common on coralline algae-covered rocks in protected sites near areas of "heavy" surf. (from MAH). Possibly a warm-tolerant species (in southern California, found below the thermocline).

Diablo Area Specific Information: Moderately rare, occurring in only 5% of our quadrats in numbers up to 5 per m^2.

Habitat: On rocks, mid to low tide levels. Occurs in relatively open areas, also under dense algal cover.

Observational Errors: When dense algal mat present can be missed, with missed observations approximately 10% of total.

Field Identification Problems: None known.

General: n.a.

Station Specific: n.a.

General Comments: Frequency of occurrence lower at all stations prior to El Niño.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Disappeared at SDIX (because of cobble overlay introduced by nearby cliff collapse?). NDIX with only one occurrence, probably caused by relatively large changes in existing substrate (large boulders removed and new ones introduced by storms) or removal of organisms by the storms. CDIX with about 1/2 occurrences of pre-storm survey. LCIX from 2 occurrences just prior to storms and none after.

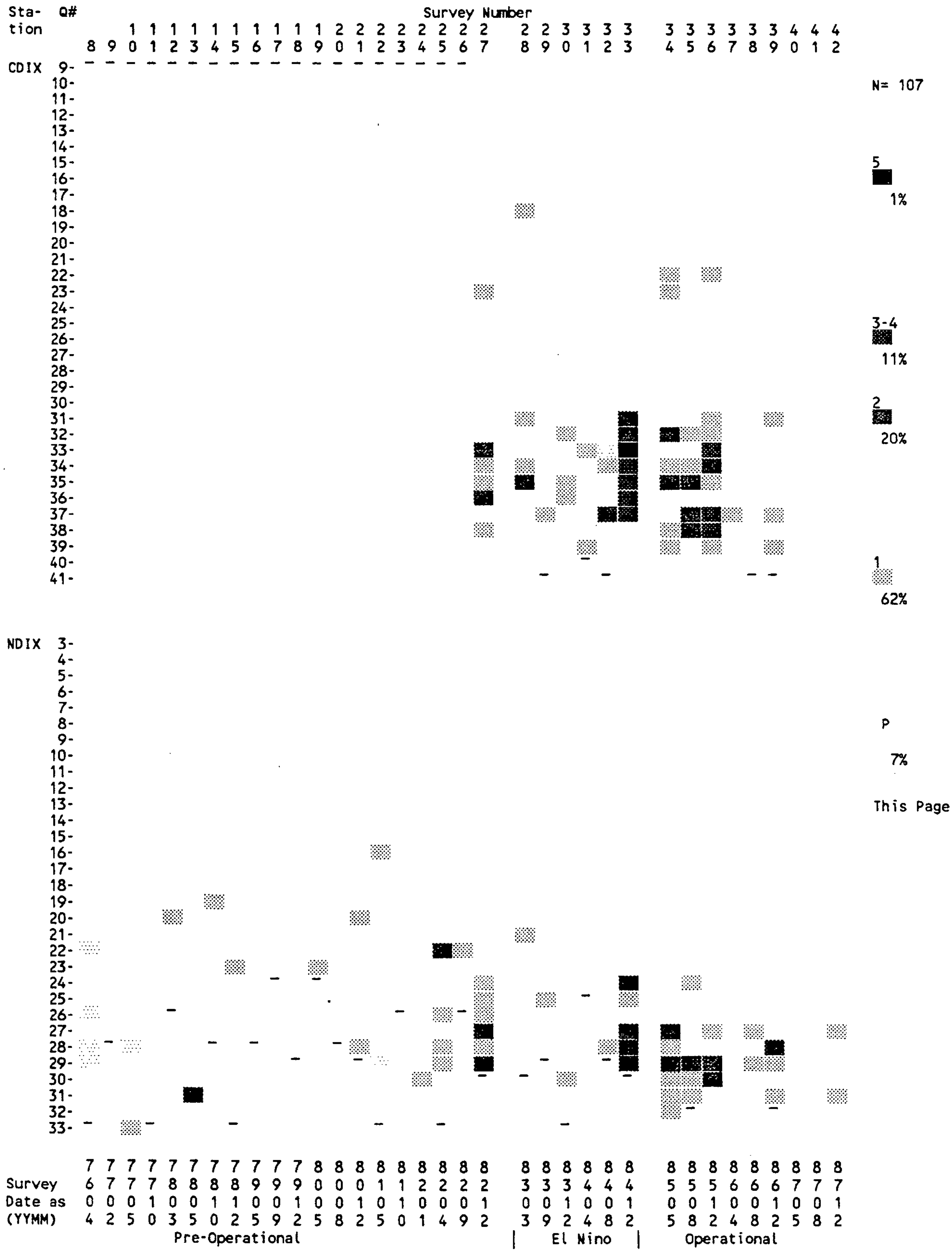
El Niño: 1983-1984: At SDIX with no occurrences, possibly due to cobble overlay still too unstable to allow colonization by this taxon. NDIX with sporadic occurrences, but towards end of period with occurrences and numbers close to survey immediately prior to 1982-83 storm (which was higher than normal for this transect). CDIX much as NDIX but numbers and occurrences higher compared to survey just prior to El Niño survey. LCIX only regained this taxon in late 1984.

All stations except SDIX, had relatively high numbers and occurrences of this taxon by the end of 1984 with NDIX (and CDIX?) possibly being higher than normal.

Diablo DCPP Operation: SDIX with sporadic gains in occurrence, but now occurring only at lower tidal levels than normal (possibly due to cobble instability in middle parts of the transect). NDIX slowly declining in numbers and occurrences, disappearing for 2 surveys, then re-appearing. CDIX declining then disappearing entirely (mid-1987). LCIX with possibly higher than normal numbers and occurrences, but this may be the result of slightly reduced algal cover (i.e., enhanced visibility).

Taxon or Category: Acmaea mitra [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

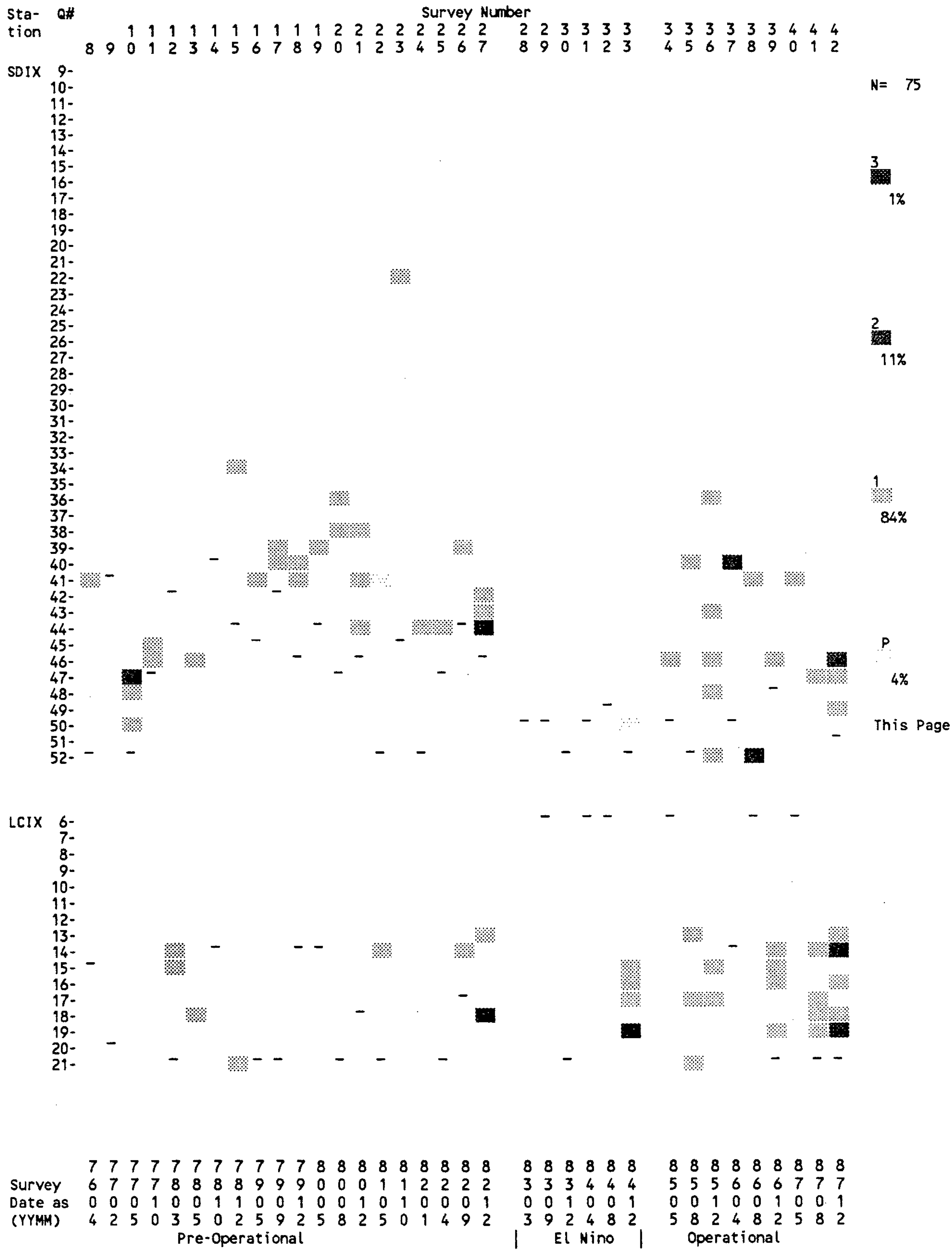


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ACMMIT CSV 5245 3-29-88 7:48a 04-15-1989 06:19

Taxon or Category: Acmaea mitra [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ACMMIT CSV 5245 3-29-88 7:48a 04-15-1989 06:19

Audit: CLUMRG2P: V.1.2: for SACMMITB CLU 6163 4-22-89 11:38a: 04-27-1989/17:11
Driver Prg: CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/11:25:26 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Acmaea mitra [Mixed P/#]: TOTAL Quads with Data = 51

Quad Range USED 20 to 39 for Total of 20 : Range WITH data 18 to 39: : # Dropped 1 : 2.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.619906: Maximum Distance = 16

```
S27-8212 ----------------------------------------------------------------------------------------I
S30-8312 ----------------------------------------------------------------------------------I     I--I
S33-8412 ----------------------------------------------------------------------------------I-----I  I
S35-8508 ----------------------------------------------------------------------------------I        I
S28-8303 --------------------------------------------------------------------------------I          I---------I
S29-8309 --------------------------------------------------------I-----I                 I          I         I
S37-8604 --------------------------------------------------------I     I---------I       I          I         I
S38-8608 --------------------------------------------------------I     I         I       I----------I         I
S40-8705 --------------------------------------------------------I-----I         I-I     I                    I
S41-8708 --------------------------------------------------------I               I I     I                    I------
S42-8712 --------------------------------------------------------I               I II    I                    I
S31-8404 ------------------------------------------------------------------------I II----I                    I
S32-8408 --------------------------------------------------------------------------II                         I
S39-8612 ---------------------------------------------------------------------------I                         I
S34-8505 ----------------------------------------------------------------------------------I------------------I
S36-8512 ----------------------------------------------------------------------------------I
```

Station: NDIX: Acmaea mitra [Mixed P/#]: TOTAL Quads with Data = 56

Quad Range USED 20 to 27 for Total of 8 : Range WITH data 16 to 33: : # Dropped 36 : 64.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.905262: Maximum Distance = 3

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 I--------------------------------------------------------------------I
S25-8204 I                                                                    I
S 9-7702 I                                                                    I
S10-7705 I                                                                    I
S11-7710 I                                                                    I
S13-7805 I                                                                    I
S14-7810 I                                                                    I
S16-7905 I                                                                    I
S18-7912 I                                                                    I
S20-8008 I----------------------------I                                       I
S22-8105 I                            I                                       I
S24-8201 I                            I                                       I--------------------------------I
S30-8312 I                            I                                       I                                I
S32-8408 I                            I-I                                     I                                I
S37-8604 I                            I I                                     I                                I
S39-8612 I                            I I                                     I                                I
S40-8705 I                            I II                                    I                                I
S41-8708 I                            I II                                    I                                I
S15-7812 -----------------------------I III                                   I                                I
S21-8012 -------------------------------III-I                                 I                                I------
S28-8303 --------------------------------II I                                 I                                I
S29-8309 ---------------------------------I I---I                             I                                I
S34-8505 I                                  I   I                             I                                I
S36-8512 I----------------------------------I   I-----------------------------I                                I
S38-8608 I                                      I                                                              I
S42-8712 I                                      I                                                              I
S35-8508 ---------------------------------------I                                                              I
S27-8212 -----------------------------I------------------------------------------------------------------------I
S33-8412 -----------------------------I
```

Station: SDIX: Acmaea mitra [Mixed P/#]: TOTAL Quads with Data = 44

Quad Range USED 26 to 44 for Total of 19 : Range WITH data 22 to 52: : # Dropped 23 : 52.3%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.677378: Maximum Distance = 15

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604  -----------------------------------------------------------------------------I
S16-7905  -----------------------------------------------------------------------------I
S22-8105  -----------------------------------------------------------------------------I------I
S38-8608  -----------------------------------------------------------------------------I      I
S40-8705  -----------------------------------------------------------------------------I      I
S10-7705  -----------------------------------------------------------------------------I      I
S11-7710  -----------------------------------------------------------------------------I      II
S13-7805  -----------------------------------------------------------------------------I      II
S23-8110  -----------------------------------------------------------------------------I      II
S28-8303  -----------------------------------------------------------------------------I      II
S29-8309  -----------------------------------------------------------------------------I      II
S30-8312  -----------------------------------------------------------------------------I------II
S31-8404  -----------------------------------------------------------------------------I       I-I
S32-8408  -----------------------------------------------------------------------------I       I I
S33-8412  -----------------------------------------------------------------------------I       I I
S34-8505  -----------------------------------------------------------------------------I       I I
S39-8612  -----------------------------------------------------------------------------I       I I------I
S41-8708  -----------------------------------------------------------------------------I       I I      I
S42-8712  -----------------------------------------------------------------------------I       I I      I
S24-8201  -----------------------------------------------------------------------------I-------I I      I
S25-8204  -----------------------------------------------------------------------------I         I      I--I
S18-7912  ------------------------------------------------------------------------------------I--I      I  I
S35-8508  -----------------------------------------------------------------------------I------I         I  I
S37-8604  -----------------------------------------------------------------------------I                I  I--I
S20-8008  -------------------------------------------------------------------------------------------I--I  I  I
S36-8512  -------------------------------------------------------------------------------------------I     I  I------
S21-8012  -------------------------------------------------------------------------------------------------I  I
S27-8212  ----------------------------------------------------------------------------------------------------I
```

Station: LCIX: Acmaea mitra [Mixed P/#]: TOTAL Quads with Data = 32

Quad Range USED 13 to 19 for Total of 7 : Range WITH data 4 to 21: : # Dropped 4 : 12.5%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.857653: Maximum Distance = 4

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  I
S10-7705  I
S11-7710  I
S15-7812  I
S16-7905  I
S17-7909  I----------------------I
S20-8008  I                      I
S23-8110  I                      I
S25-8204  I                      I--------------I
S28-8303  I                      I              I
S30-8312  I                      I              I------------I
S13-7805  I----------------------I              I            I
S24-8201  I                                     I            I-------------------------I
S12-7803  -----------------------I--------------I            I                         I
S22-8105  -----------------------I                           I                         I----------------------I
S27-8212  ----------------------------------------------I----I                         I                      I
S35-8508  ----------------------------------------------I                              I                      I
S33-8412  ----------------------------------------------I------------------------------I                      I------
S36-8512  ----------------------------------------------I                                                     I
S39-8612  -----------------------------------------------------------------------I----------I                 I
S42-8712  -----------------------------------------------------------------------I          I-----------------I
S41-8708  ----------------------------------------------------------------------------------I
```

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Collisella digitalis (Ribbed Limpet). (Rathke, 1833). Ref. MAH 1980, p 244.
Phylum Mollusca: **Class** Gastropoda:

Description: Moderately elevated, beige to brownish-black to black. Diameter 0.3 - 2+ (3, MAH) cm, about 1/3+ as high as diam., apex near edge to overhanging. Can be severely eroded.

Distribution: Aleutian Islands (Alaska) to southern Baja California, upper intertidal and splash zones (co-occurring with *C. scabra*). Common on vertical rock faces. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in over 30% of our quadrats in concentrations up to 600 per m^2.

Habitat: On rocks, splash zone to mid tide levels. Occurs on vertical faces and tops of rocks (usually bedrock or larger boulders) and on other animals (*Pollicipes*).

Observational Errors: Eroded specimens may be confused with *C. scabra* (see below). Otherwise missed observations were probably limited to areas with dense *Endocladia* cover.

Field Identification Problems:

General: Older, eroded specimens may be confused with eroded *C. scabra*. This confusion probably occurs for <5% of the observations.

Station Specific: n.a.

General Comments: none.

Impacts to Taxon:

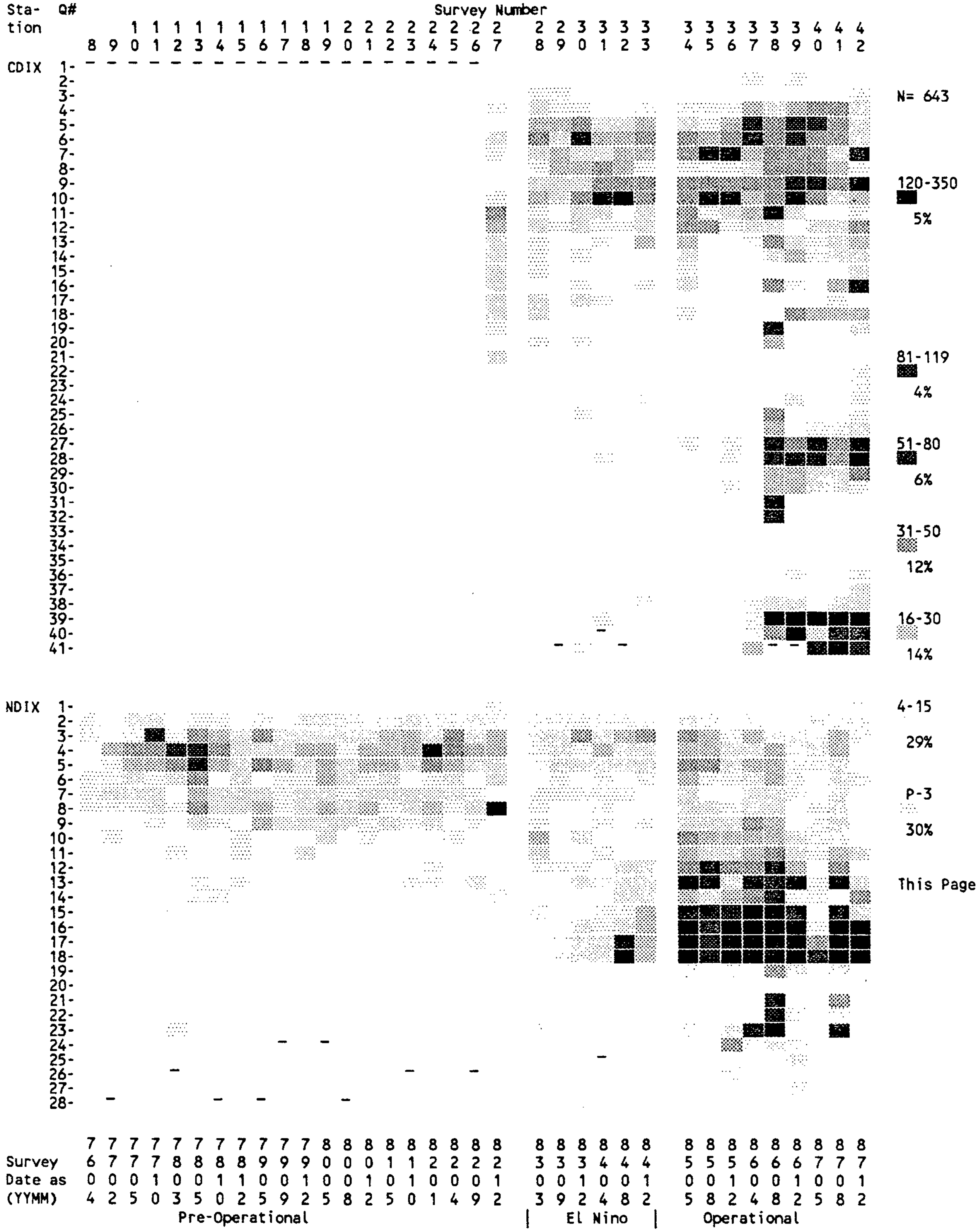
El Niño: 1982-83 winter storm: SDIX with slight decrease in occurrences. NDIX and possibly CDIX with slight increase in occurrences. LCIX with no apparent change.

El Niño: 1983-1984: SDIX sporadically extended its range somewhat into the mid to lower intertidal but lost occurrences in the upper intertidal (sand/gravel area). NDIX with well defined increases of numbers and occurrences in the former mid intertidal (several large [>1.5 m)] high relief boulders were introduced by storms), with decreased occurrences in upper-mid intertidal. CDIX difficult to access, but occurrences in the mid intertidal may be somewhat reduced. LCIX remained normal.

Diablo DCPP Operation: SDIX at end of 1987 with greatly reduced occurrences in the upper to mid intertidal. NDIX and CDIX continued expansion of occurrences and numbers downward in the intertidal but towards end of 1987 possibly retreating a bit. NDIX losing occurrences in the upper-mid intertidal by end of 1987. LCIX remained normal.

Taxon or Category: Collisella digitalis [Mixed P/#]

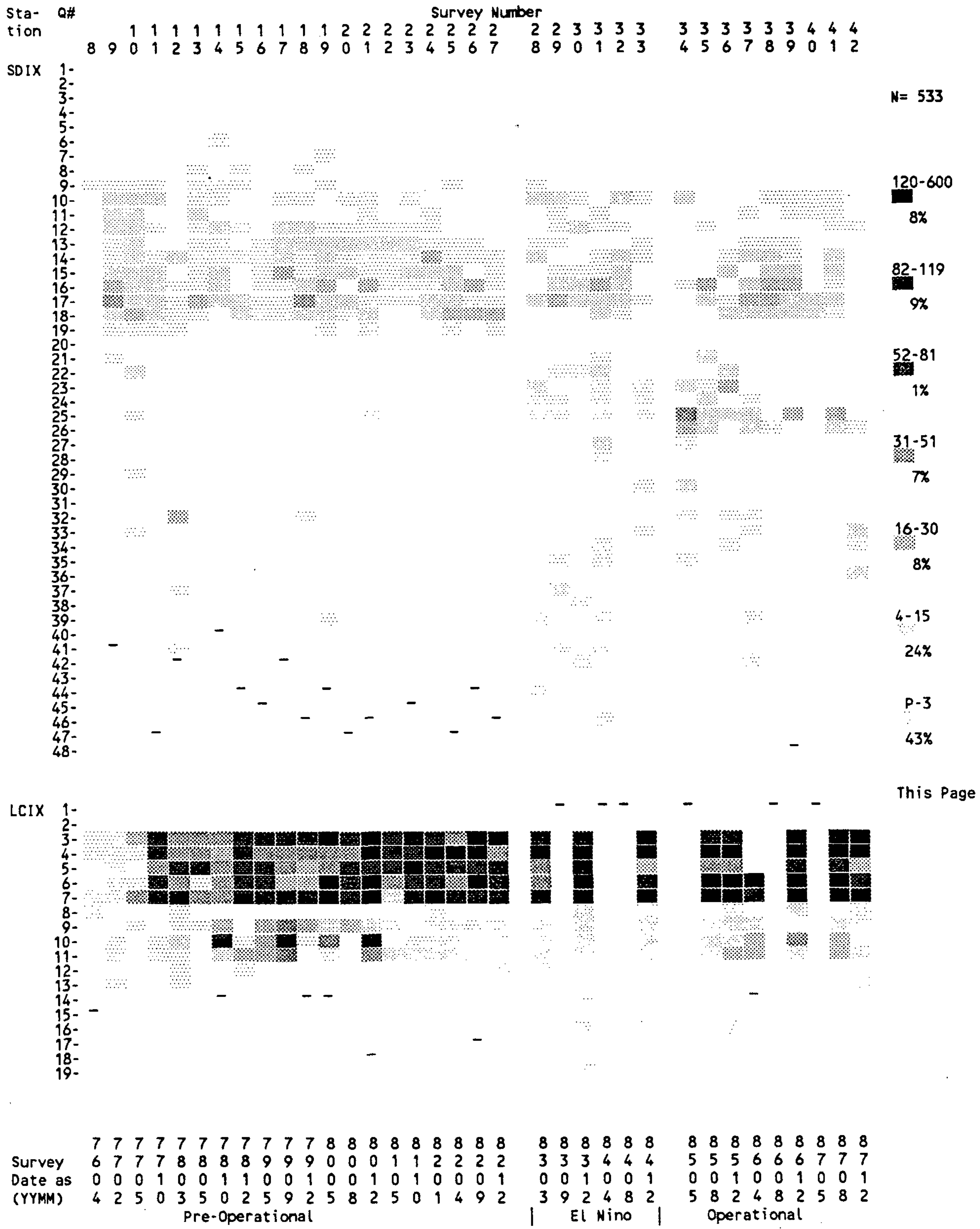
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxon or Category: Collisella digitalis [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: CLUMRG2P: V.1.2: for SCOLDIGB CLU 7249 4-23-89 4:57a: 04-27-1989/17:11
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/04:53:03 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Collisella digitalis [Mixed P/#]: TOTAL Quads with Data = 256

Quad Range USED 4 to 39 for Total of 36 : Range WITH data 2 to 41: : # Dropped 16 : 6.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.614323: Maximum Distance = 19

```
S27-8212 ----------------------------------------------------------------------------------------I
S28-8303 ---------------------------------------------------I----------I                         I
S34-8505 ---------------------------------------------------I          I-----I                   I----------I
S30-8312 --------------------------------------------------------------I     I                   I          I
S29-8309 ------------------------------------I-I                             I                   I          I
S32-8408 ------------------------------------I I------------I                I-------------------I          I
S35-8508 --------------------------------------I            I-----I          I                              I
S36-8512 ---------------------------------------------------I     I-I        I                              I------
S33-8412 ----------------------------------------------I----------I I--------I                              I
S37-8604 ----------------------------------------------I            I                                       I
S31-8404 -----------------------------------------------------------I                                       I
S38-8608 ------------------------------------------------------------------------------I---I                I
S39-8612 ----------------------------------------------------------------I-------------I   I                I
S40-8705 ----------------------------------------------I-----------------I                 I----------------I
S41-8708 ----------------------------------------------I                                   I
S42-8712 ----------------------------------------------------------------------------------I
```

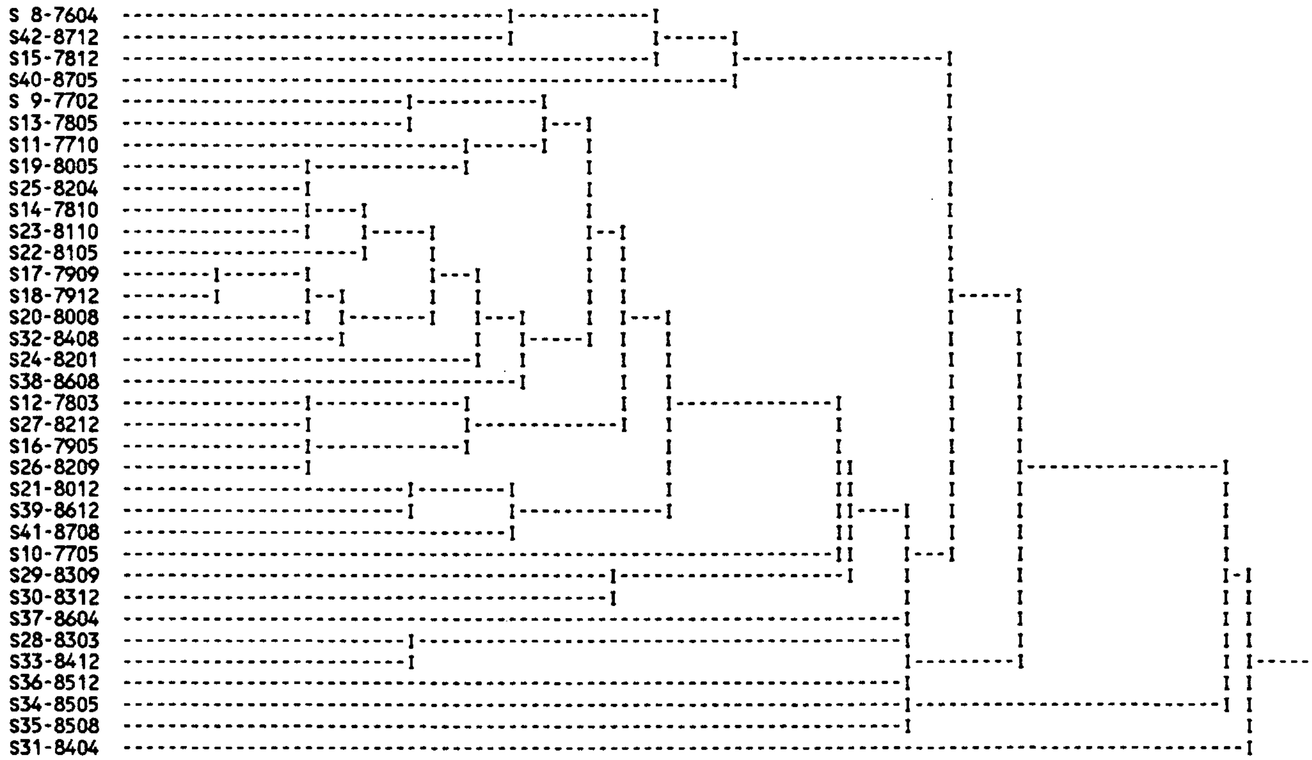
Station: NDIX: Collisella digitalis [Mixed P/#]: TOTAL Quads with Data = 387

Quad Range USED 3 to 23 for Total of 21 : Range WITH data 1 to 27: : # Dropped 37 : 9.6%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.797884: Maximum Distance = 11

```
S 8-7604 --------------------------------------------I
S 9-7702 -----------------I-------------I            I
S25-8204 -----------------I             I-------I    I
S15-7812 -------------------------------I       I    I--I
S10-7705 -----------------I                     I    I  I
S11-7710 --------I        I-I                   I    I  I
S17-7909 --------I--------I I                   I    I  I
S20-8008 --------I          II                  I----I  I
S22-8105 --------I          II--------I         I       I
S18-7912 -------------------II        I         I       I
S19-8005 --------I-----------I        I-I       I       I------------------I
S21-8012 --------I                    I I       I       I                  I
S14-7810 -----------------I----I      I I       I       I                  I
S16-7905 -----------------I    I------I I-------I       I                  I
S23-8110 --------I-------------I        I               I                  I
S26-8209 --------I                      I               I                  I--------------------------------I
S13-7805 --------------------------I----I               I                  I                                I
S24-8201 --------------------------I                    I                  I                                I
S12-7803 -----------------------------------I-----------I                  I                                I
S27-8212 -----------------------------------I                              I                                I
S28-8303 ------------------------------------------------------------------I                                I------
S29-8309 -------------------------------------------------I----I                                            I
S30-8312 -----------------------------------I-------------I    I-------------------I                        I
S32-8408 -----------------------------------I                  I                   I---I                    I
S33-8412 ------------------------------------------------------I                   I   I                    I
S42-8712 --------------------------------------------------------------------------I   I                    I
S31-8404 ------------------------------------------------------I-------I               I--------------------I
S40-8705 ------------------------------------------------------I       I               I
S34-8505 -----------------I----I                                       I               I
S36-8512 -----------------I    I------I                                I---------------I
S37-8604 ----------------------I      I------------I                   I
S35-8508 -----------------------------I            I--------I          I
S38-8608 -----------------I------------------------I        I----------I
S41-8708 -----------------I                                 I
S39-8612 ---------------------------------------------------I
```

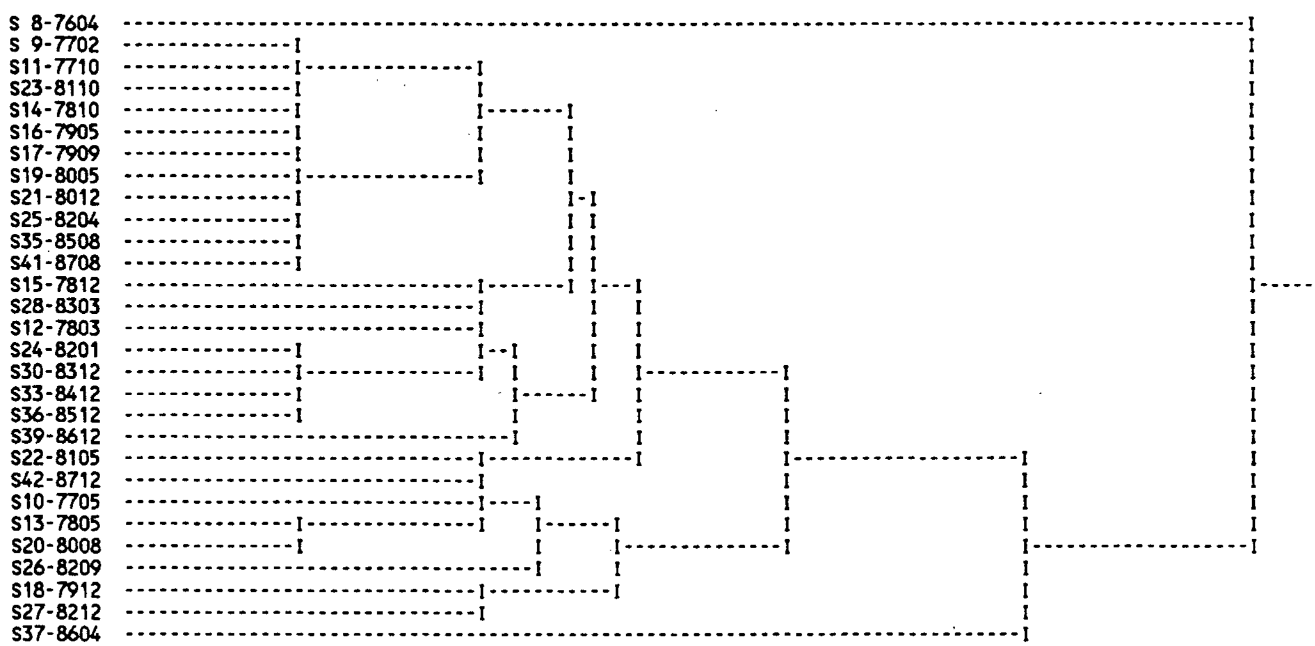
Station: SDIX: Collisella digitalis [Mixed P/#]: TOTAL Quads with Data = 305

Quad Range USED 9 to 30 for Total of 22 : Range WITH data 6 to 46: : # Dropped 35 : 11.5%
Surveys 35 : Dropped 0 Surveys if quads sampled < 30
COPHENETIC CORRELATION COEFFICIENT = 0.737470: Maximum Distance = 11



Station: LCIX: Collisella digitalis [Mixed P/#]: TOTAL Quads with Data = 228

Quad Range USED 3 to 12 for Total of 10 : Range WITH data 3 to 19: : # Dropped 9 : 3.9%
Surveys 29 : Dropped 0 Surveys if quads sampled < 12
COPHENETIC CORRELATION COEFFICIENT = 0.801826: Maximum Distance = 6



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Collisella limatula (File Limpet). (Carpenter, 1864). Ref. MAH 1980. p 243.
Phylum Mollusca: **Class** Gastropoda:

Description: Low shell, orangish yellow, buff, or greenish brown, sometimes with darker spots or mosaic of white angular spots. Diameter 0.5 - 2+ (4.5, MAH) cm, about 1/3 as high as diam., apex about 1/3 from edge. Strong prickly radial ribs, margin with sawtooth notching. (from MAH).

Distribution: Newport (Oregon) to southern Baja California. Abundant on semiprotected rocks, mid to low intertidal. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common to abundant, occurring in about 50% of our quadrats at concentrations to 25 per m^2.

Habitat: Tops, sides, and undersides of rocks and cobbles, upper to lower intertidal. Often moderately common on undersides of cobbles. Usually in relatively clear areas, but can occur under the algal mat.

Observational Errors: Can be missed if present on undersides of cobbles and the under-cobble habitat was not sampled for that quadrat. Possibly up to 10% missed observations for this taxon. Occurred in areas at NDIX and SDIX that are frequently buried by sand and gravel.

This organism may move up or down within the intertidal depending on whether tides occur in daytime or nighttime (MAH, 1980).

Field Identification Problems:

General: Older, eroded specimens in locations not easily observed may be confused with *Notoacmea scutum*.

Station Specific: n.a.

General Comments: MAH (1980) indicates that temperature affects growth and reproduction rates, however wording is such that it could be construed as a seasonal effect.

Impacts to Taxon:

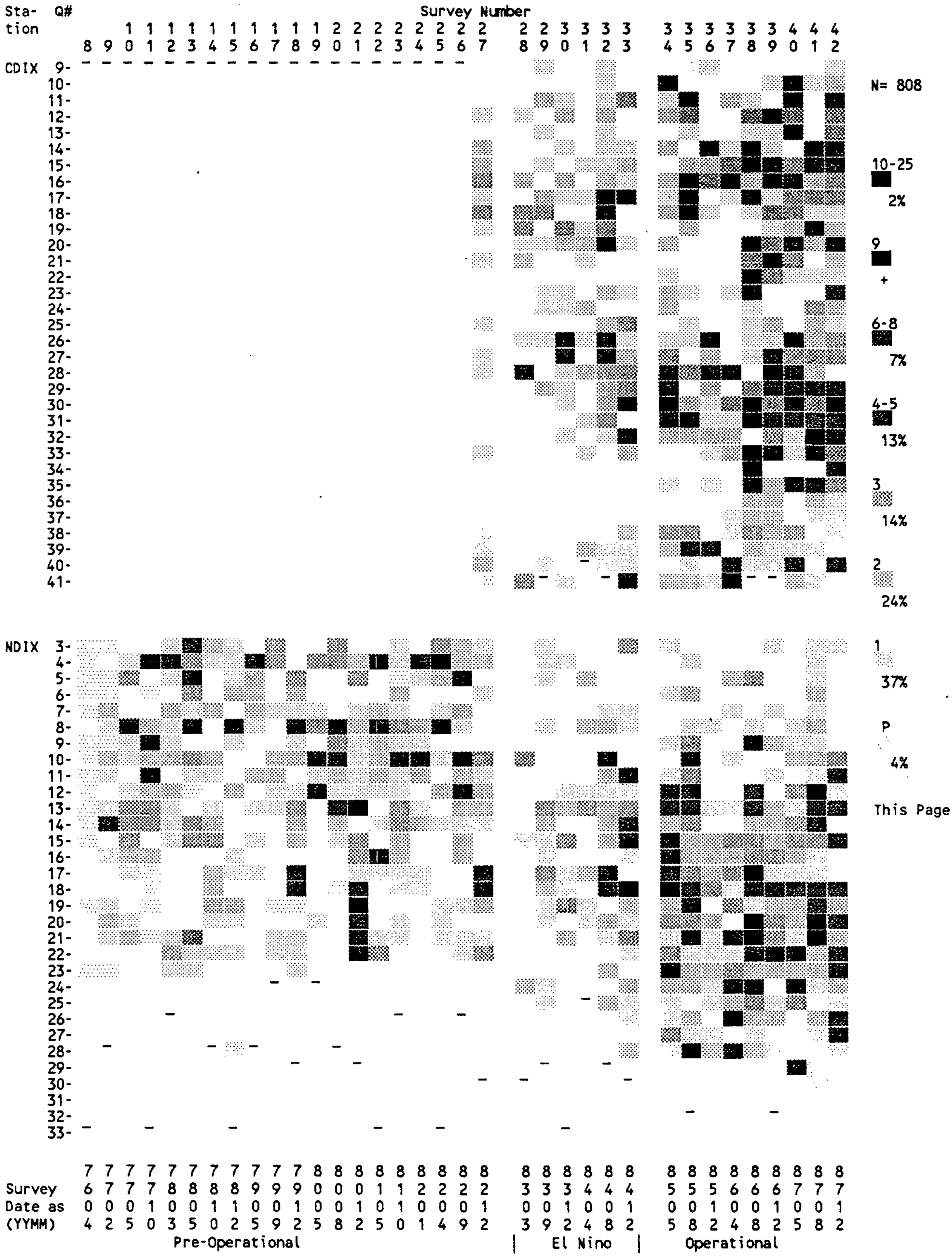
El Niño: 1982-83 winter storm: Occurrences at SDIX and NDIX greatly reduced, probably due to removal by wave-induced cobble smashing or burial. CDIX may have had a slight reduction in number of occurrences. LCIX with a possible reduction in occurrences in the upper intertidal.

El Niño: 1983-1984: SDIX and NDIX rapidly but sporadically returned to normal (or above) in occurrences and numbers, with probable extension downward in the intertidal (sand/gravel areas in upper intertidal with relatively few occurrences in late 1984). CDIX as SDIX and NDIX, but here cannot assess whether normal (only 1 survey prior to El Niño). LCIX perhaps with a reduction in occurrences and numbers, but missed observations are likely here due to dense algal mat.

Diablo DCPP Operation: All Cove stations (SDIX, NDIX, and CDIX) were probably above normal in occurrences and numbers (some sporadic declines) and were maintaining an extension into lower intertidal areas (possibly from fewer missed observations due to thinning algal cover?). All of these stations were possibly losing occurrences in the upper intertidal regions at the end of 1987. LCIX possibly normal (i.e., never very common here).

Taxon or Category: Collisella limatula [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

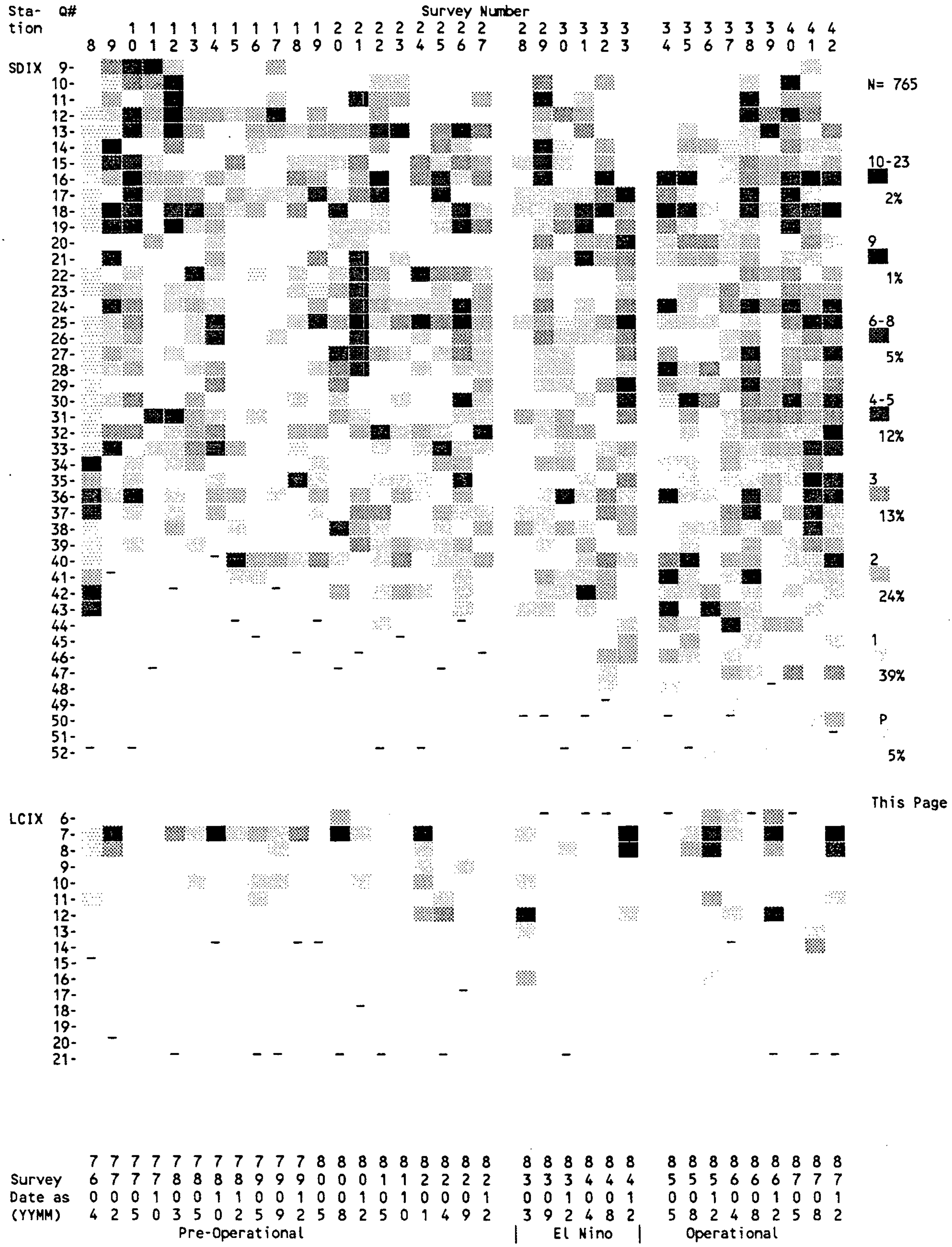


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COLLIM CSV 5989 3-29-88 7:50a 04-15-1989 06:22

Taxon or Category: Collisella limatula [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COLLIM CSV 5989 3-29-88 7:50a 04-15-1989 06:23

Audit: CLUMRG2P: V.1.2: for SCOLLIMB CLU 6581 4-23-89 5:10a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/04:59:28 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Collisella limatula [Mixed P/#]: TOTAL Quads with Data = 337

Quad Range USED 6 to 39 for Total of 34 : Range WITH data 1 to 41: : # Dropped 29 : 8.6%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.406523: Maximum Distance = 18

```
S27-8212 -------------------------------------------------------------------------I------------------I
S28-8303 -------------------------------------------------------------I-----------I                  I---------I
S31-8404 -------------------------------------------------------------I                              I         I
S29-8309 --------------------------------------------------------------------------------------------I         I
S30-8312 --------------------------------------------------------I-I                                           I
S33-8412 --------------------------------------------------------I I---------I                                 I------
S34-8505 ----------------------------------------------------------I         I---------I                       I
S32-8408 --------------------------------------------------I-----------------I         I----I                  I
S35-8508 --------------------------------------------------I                           I    I----I             I
S37-8604 ------------------------------------------------------------------------------I    I    I             I
S36-8512 -----------------------------------------------------------------------------------I    I-------------I
S38-8608 ---------------------------------------I------------------I                             I
S42-8712 ---------------------------------------I                  I-------I                     I
S39-8612 ---------------------------------I------------------------I       I---------------------I
S40-8705 ---------------------------------I                                I
S41-8708 ------------------------------------------------------------------I
```

Station: NDIX: Collisella limatula [Mixed P/#]: TOTAL Quads with Data = 499

Quad Range USED 4 to 25 for Total of 22 : Range WITH data 2 to 30: : # Dropped 72 : 14.4%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.509781: Maximum Distance = 13

```
S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End   Dropped Surveys
S 8-7604 ------------------------------------------------I
S12-7803 -------------------------------I------I         I---I
S13-7805 -------------------------------I      I---------I   I-------I
S26-8209 --------------------------------------I             I       I-I
S18-7912 ----------------------------------------------------I       I I-----I
S25-8204 ------------------------------------------------------------I I     I
S 9-7702 --------------------------------------------------------------I     I
S10-7705 -------------------------------I------I                             I------I
S23-8110 -------------------------------I      I--------------I              I      I
S21-8012 --------------------------------------I              I-----I        I      I
S22-8105 -----------------------------------------------------I     I--------I      I
S11-7710 -------------------------------I---------------------I     I               I------I
S27-8212 -------------------------------I                     I-----I               I      I
S20-8008 -------------------------------I---------------------I                     I      I
S24-8201 -------------------------------I                                           I      I----I
S14-7810 --------------------------------------------------------------I-------I    I      I    I
S30-8312 --------------------------------------------------------------I       I----I      I    I
S16-7905 ----------------------------------------------------------------------I           I    I
S15-7812 ----------------------------------------------------------------------------------I    I--------------I
S29-8309 -----------------------------------------------------------------------I               I              I
S32-8408 -----------------------------------------------------I-----I           I               I              I
S42-8712 -----------------------------------------------------I     II          I               I              I
S33-8412 -----------------------------------------------I---I       II          I---------------I              I
S39-8612 -----------------------------------------------I   I-------II          I                              I
S34-8505 -------------------------------I---------I         I        I          I                              I------
S38-8608 ---------------I---------------I         I---------I        I----------I                              I
S40-8705 ---------------I                         I                  I                                         I
S35-8508 ---------------I-------------------------I                  I                                         I
S41-8708 ---------------I                                            I                                         I
S36-8512 -----------------------------------------------I------------I                                         I
S37-8604 -----------------------------------------------I                                                      I
S28-8303 ------------------------------------------------------------------------------------------------------I
```

Station: SDIX: Collisella limatula [Mixed P/#]: TOTAL Quads with Data = 711

Quad Range USED 9 to 43 for Total of 35 : Range WITH data 4 to 52: : # Dropped 102 : 14.3%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.467563: Maximum Distance = 18

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909: <-End  Dropped Surveys
S 8-7604 ------------------------------------I-I
S29-8309 ---------------------I--------------I I-------------I
S38-8608 ---------------------I                I             I---I
S40-8705 --------------------------------------I             I   I
S26-8209 -----------------------------------------I----------I   I--------I
S42-8712 -----------------------------------------I              I        I--------I
S35-8508 --------------------------------------------------------I        I        I
S37-8604 -----------------------------------------------I-----------------I        I
S41-8708 -----------------------------------------------I                          I-------I
S20-8008 ----------------------------------------------------I-----I               I       I
S27-8212 ----------------------------------------------------I     I------I        I       I
S33-8412 ----------------------------------------------------------I      I--------I       I
S21-8012 -----------------------------------------------------------------I                I---------I
S10-7705 -----------------------------------------------I------------------I               I         I
S13-7805 -----------------------------------------------I                  I------I        I         I
S22-8105 ------------------------------------I-----------------------------I      I        I         I
S25-8204 ------------------------------------I                                    I--------I         I----I
S18-7912 ----------------------------------------------------------I-------I      I                  I    I
S19-8005 ----------------------------------------------------------I       II     I                  I    I
S24-8201 ------------------------------------------------------------------II-----I                  I    I
S39-8612 -------------------------------------------------------------------I                        I    I
S23-8110 ----------------------------------------------------------I---------------------------------I    I------
S31-8404 ----------------------------------------------------------I                                      I
S11-7710 ---------------------------------------------------------------I                                 I
S15-7812 -----------------------------------------------I-------I       I--------------------------I      I
S16-7905 -----------------------------------------------I       I-------I                          I      I
S28-8303 -------------------------------------------------------I                                  I------I
S30-8312 ---------------------------------------------------------------I---------I                I
S32-8408 ---------------------------------------------------------------I         I----------------I
S34-8505 ----------------------------------------------------------I--------------I
S36-8512 ----------------------------------------------------------I
```

Station: LCIX: Collisella limatula [Mixed P/#]: TOTAL Quads with Data = 87

Quad Range USED 3 to 13 for Total of 11 : Range WITH data 3 to 19: : # Dropped 4 : 4.6%
Surveys 29 : Dropped 0 Surveys if quads sampled < 13
COPHENETIC CORRELATION COEFFICIENT = 0.570220: Maximum Distance = 6

```
S 8-7604 -------------------------------I--------I
S42-8712 -------------------------------I        I-------------I
S36-8512 ----------------------------------------I             I------------------I
S30-8312 -------------------------------I--------I             I                  I
S35-8508 -------------------------------I        I-------------I                  I
S33-8412 ----------------------------------------I                                I
S 9-7702 -------------------------------I-----------I                             I
S14-7810 ----------------I--------------I           I-----------------I           I
S18-7912 ----------------I                          I                 I           I-----I
S17-7909 -------------------------------------------I                 I-I         I     I
S12-7803 -------------------------------I--------I                    I I         I     I
S15-7812 -------------------------------I        I--------------------I I         I     I
S13-7805 ----------------I-----------------------I                      I         I     I
S21-8012 ----------------I                                              I         I     I
S10-7705 -------------------------------I-----I                         I---------I     I
S11-7710 ----------------I--------------I     I-----I                   I               II
S23-8110 ----------------I                    I     I                   I               II
S26-8209 -------------------------------------I     I-----------I       I               II
S19-8005 ----------------I--------------I           I           I       I               II
S22-8105 ----------------I              I-----------I           I-------I               II-I
S27-8212 -------------------------------I                       I                       II I
S41-8708 -------------------------------------------------------I                       II I
S16-7905 -------------------------------------------------------------------------------II I--------------I
S20-8008 ------------------------------------------------I----------------I              I I              I
S37-8604 ------------------------------------------------I                I--------------I I              I------
S39-8612 -----------------------------------------------------------------I                I              I
S25-8204 ----------------------------------------------------------------------------------I              I
S24-8201 -----------------------------------------------------------------I-------------------------------I
S28-8303 -----------------------------------------------------------------I
```

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Collisella pelta (Shield Limpet). (Rathke, 1833). Ref. MAH 1980, p 244.
Phylum Mollusca: **Class** Gastropoda:

Description: Moderate to highly elevated, brown to green to mostly black,. Color patterns checkered white, or with rays or bands of white. Variable shell sculpturing, smooth to moderately ribbed. Diameter 0.2 - 3+ cm (4 cm, MAH), about 1/2+ as high as diam., apex near center.

Distribution: Aleutian Islands (Alaska) to Bahia del Rosario (Baja California). Mid to low intertidal zones, common on rocky reefs. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 30% of our quadrats.

Habitat: On rocks, upper-mid to low tide levels. Occurs on tops and sides of rocks and cobbles, common under *Pelvetia*.

Observational Errors: Shell morphology and coloration of this organism is highly variable, and some of our "unid. acmaeids" were probably this taxon. Other missed observations were probably limited to areas with dense algal cover quadrats (possibly as high 5%). Small forms (< ~0.2 cm) of this taxon (or possibly *Collisella digitalis*) were usually called as "unid. acmaeids, juvenile".

Field Identification Problems:

General: Possibly confused with atypical *Notoacmea persona*, *N. insessa* and occasionally *N. scutum*.

Station Specific: n.a.

General Comments: none.

Impacts to Taxon:

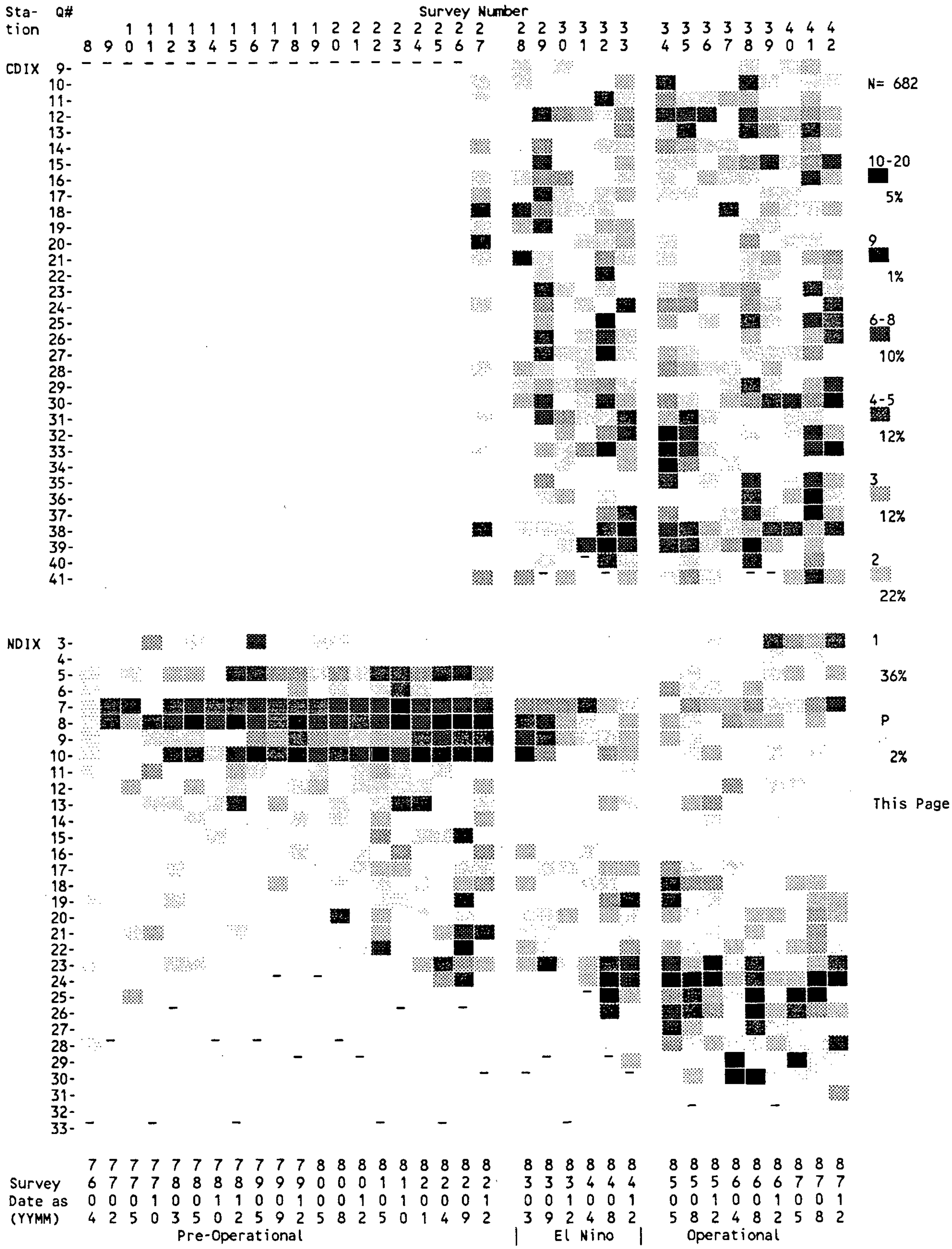
El Niño: 1982-83 winter storm: SDIX with large reduction in occurrences (cobble overlay). NDIX with slight mid-intertidal reduction ("disrupted" by large boulders introduced by storms covered 4 quadrats that had contained this taxon). CDIX with a small reduction in occurrences. LCIX with no immediate change.

El Niño: 1983-1984: SDIX with sporadic increases in occurrences and numbers and extending into lower intertidal. NDIX with slight decrease in numbers in upper intertidal, increases in numbers in lower intertidal, and not re-establishing in "disrupted" quadrats in mid intertidal (overlain by boulders during winter storms above). CDIX with sporadic increase in occurrences and numbers and extending range into lower intertidal. LCIX possibly with reduced occurrences, but only for winter 1983 survey.

Diablo DCPP Operation: SDIX maintained later El Niño state with sporadic decreases, and by the end of 1987 was more common than normal with the population center possibly shifting downward in the intertidal. NDIX decreased in numbers in the upper intertidal, but increased in numbers and range in the lower intertidal, "disrupted" area in the mid-tide area not re-colonized. CDIX with little change from later El Niño conditions, insufficient data to determine normality. LCIX recovered from El Niño and probably became more abundant in numbers and occurrences than normal, with some indication that both declined by the end of 1987.

Taxon or Category: Collisella pelta [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

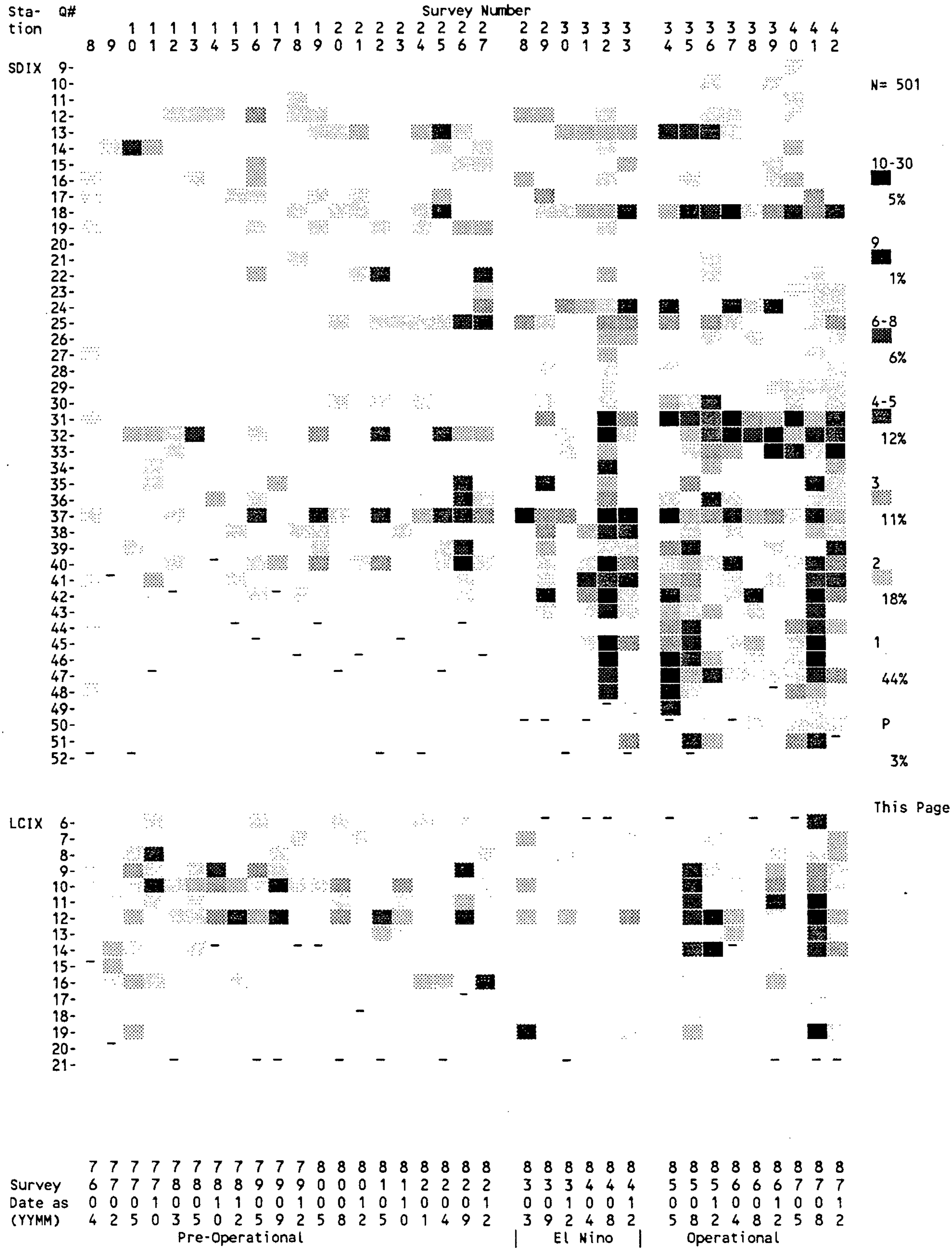


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COLPEL CSV 5619 3-29-88 7:50a 04-15-1989 06:23

Taxon or Category: Collisella pelta [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

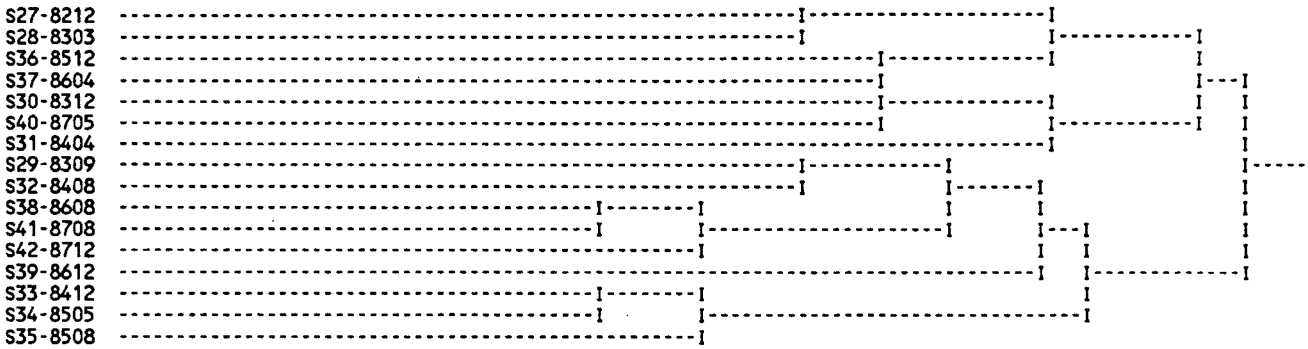


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: CLUMRG2P: V.1.2: for SCOLPELB CLU 6581 4-23-89 5:16a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:12:02 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Collisella pelta [Mixed P/#]: TOTAL Quads with Data = 309

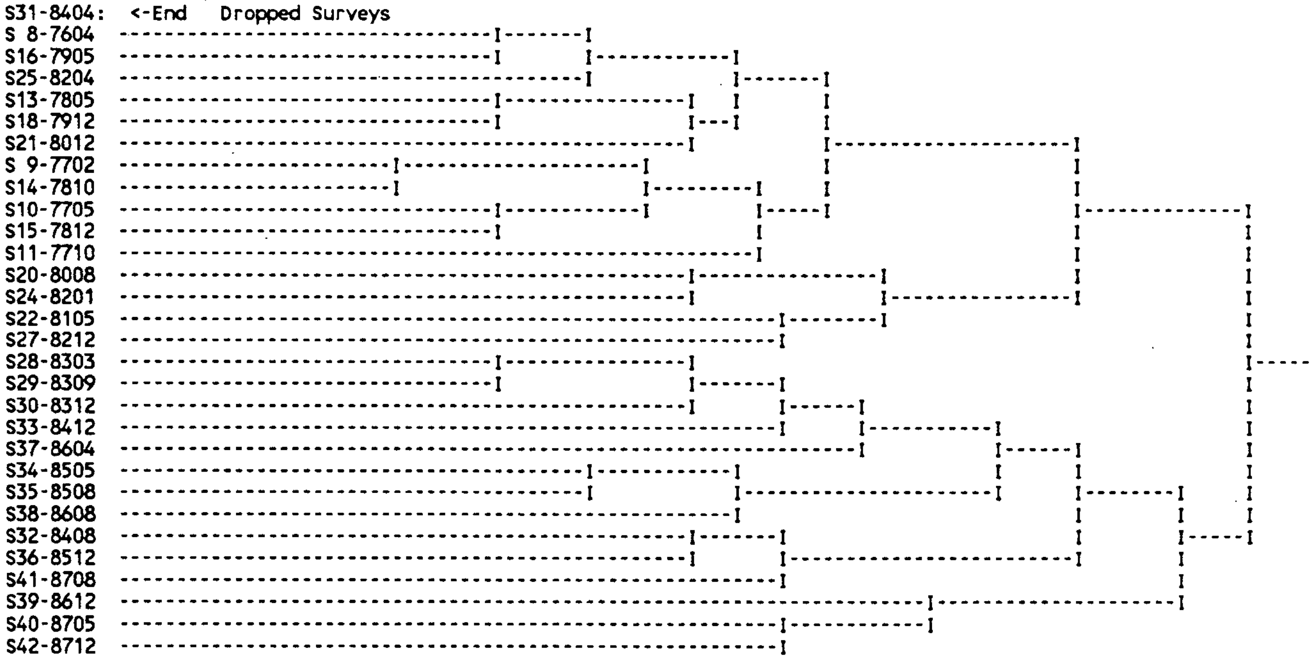
Quad Range USED 9 to 39 for Total of 31 : Range WITH data 4 to 41: : # Dropped 24 : 7.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.349941: Maximum Distance = 16



Station: NDIX: Collisella pelta [Mixed P/#]: TOTAL Quads with Data = 382

Quad Range USED 3 to 27 for Total of 25 : Range WITH data 2 to 33: : # Dropped 82 : 21.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.486849: Maximum Distance = 12

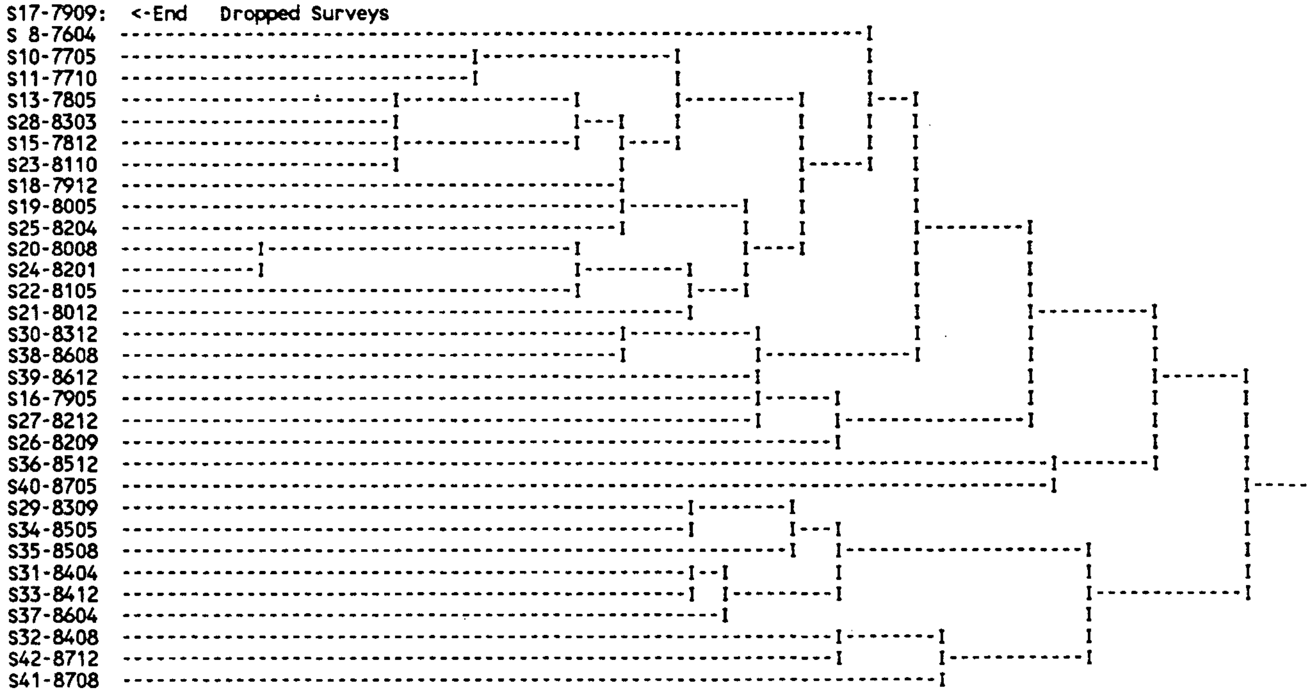
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End Dropped Surveys



Station: SDIX: Collisella pelta [Mixed P/#]: TOTAL Quads with Data = 372

Quad Range USED 12 to 43 for Total of 32 : Range WITH data 9 to 51: : # Dropped 65 : 17.5%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.561653: Maximum Distance = 16

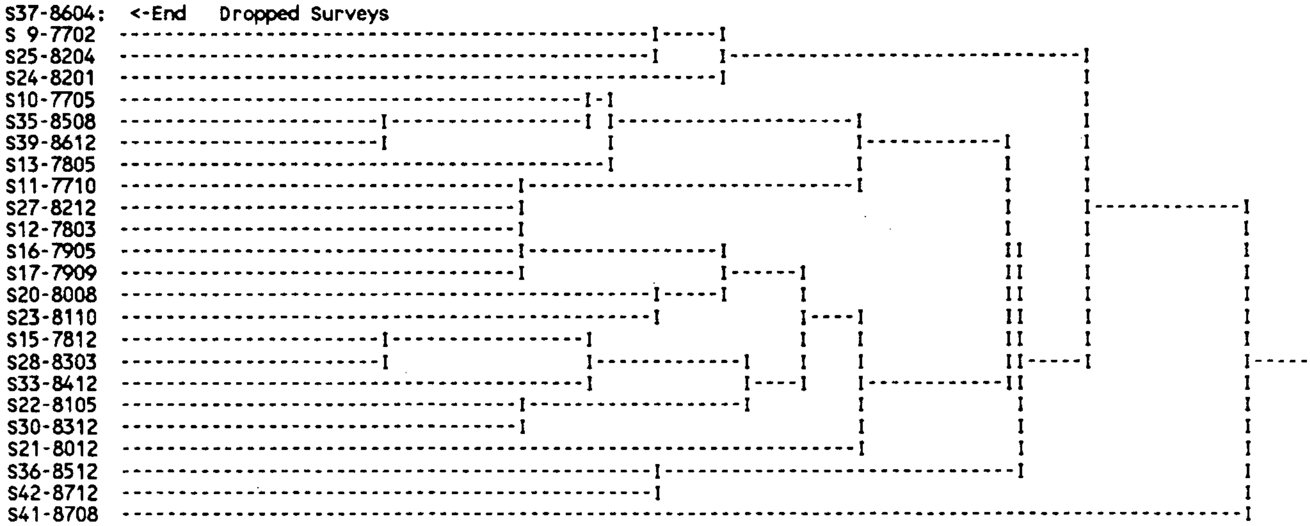
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909: <-End Dropped Surveys



Station: LCIX: Collisella pelta [Mixed P/#]: TOTAL Quads with Data = 138

Quad Range USED 4 to 17 for Total of 14 : Range WITH data 3 to 22: : # Dropped 28 : 20.3%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.509367: Maximum Distance = 8

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604: <-End Dropped Surveys



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Collisella scabra (Rough Limpet). (Gould, 1846). Ref. MAH 1980, p 242.
Phylum Mollusca: **Class** Gastropoda:

Description: Moderately elevated, mottled beige to greenish (white to grey where eroded). Heavily ribbed, with scalloped margin. Diameter 0.3 - 2+ cm (3 cm, MAH), about 1/3+ as high as diam., apex about 1/3 towards edge. Can be severely eroded.

Distribution: Cape Arago (Oregon) to southern Baja California, upper intertidal to splash zone. Common on horizontal or gently sloping rocks. A warm-tolerant species.

Diablo Area Specific Information: Abundant, in over 60% of our quadrats in concentrations to 400 per m^2.

Habitat: On rocks, upper to low tide levels. Occurs on rocks and cobbles in barren areas or small clear areas under algal mat.

Observational Errors: Large eroded specimens were fairly easily confused with *C. digitalis* (see below). Missed observations otherwise estimated to be < 3% and probably limited to areas with dense algal mat.

Field Identification Problems:

General: Older, eroded specimens may be confused with eroded *C. digitalis*. This confusion probably occurred for about 3% of the observations.

Station Specific: At LCIX in the upper quadrats, we probably were inconsistent when distinguishing between *C. scabra* and *C. digitalis* where these taxa co-occurred in large numbers.

General Comments: none.

Impacts to Taxon:

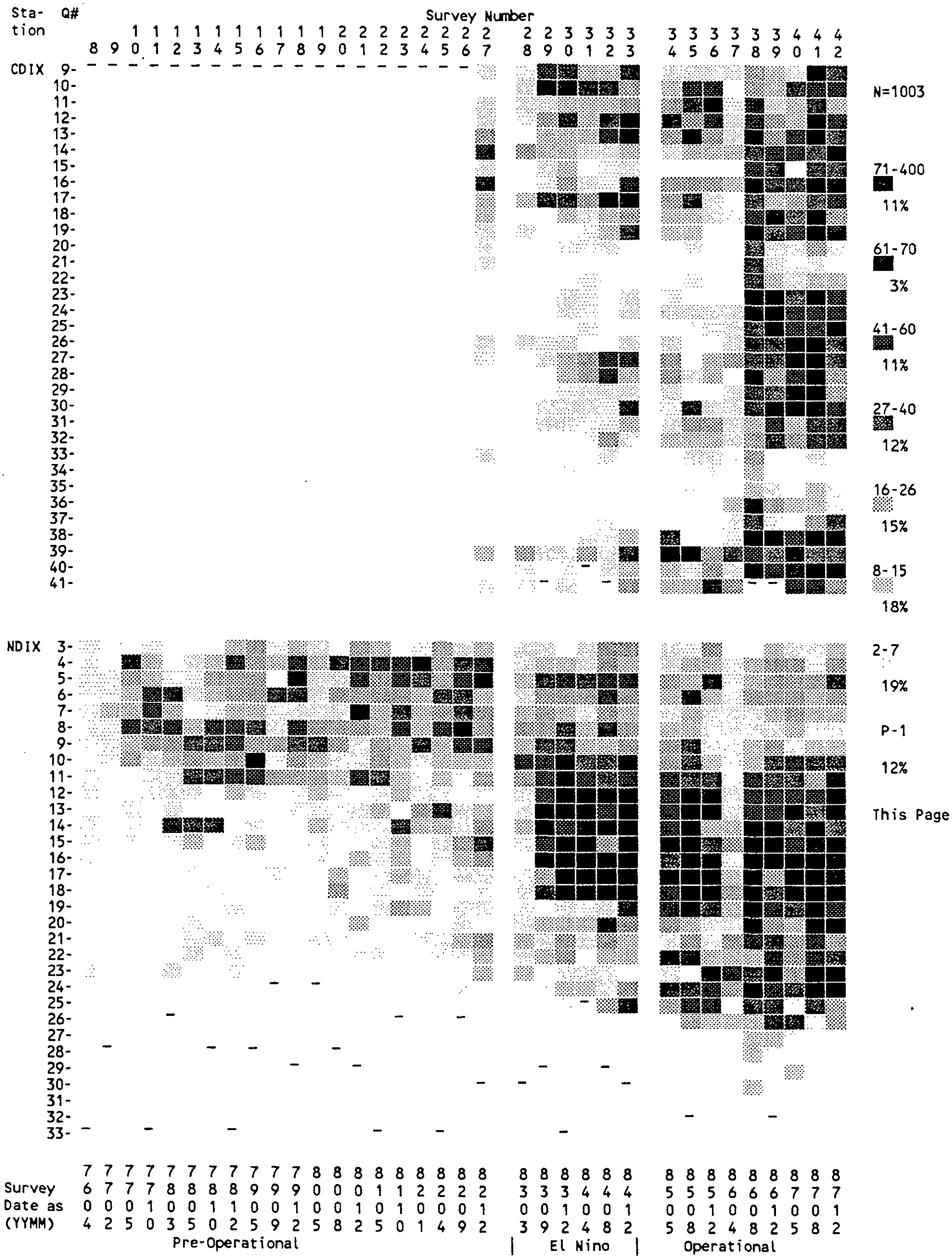
El Niño: 1982-83 winter storm: SDIX with relatively large reductions in mid to lower intertidal (cobble overlay from nearby collapsed cliff). NDIX, CDIX, and possibly LCIX with small to moderate reductions.

El Niño: 1983-1984: SDIX, NDIX, and possibly CDIX population concentrations all increased and extended downward in the intertidal. LCIX remaining approximately normal.
NOTE: At NDIX there may have been a trend of range extension downward in the intertidal for several surveys prior to El Niño.

Diablo DCPP Operation: SDIX remaining about the same as later El Niño, possibly with a slight thinning in numbers of individuals in upper intertidal quadrats. NDIX as SDIX with range extending even farther downward into the intertidal zone. CDIX as NDIX with the numbers of individuals increasing but only after May 1986. Concentrations at LCIX at or above normal.

Taxon or Category: Collisella scabra [Mixed P/#]

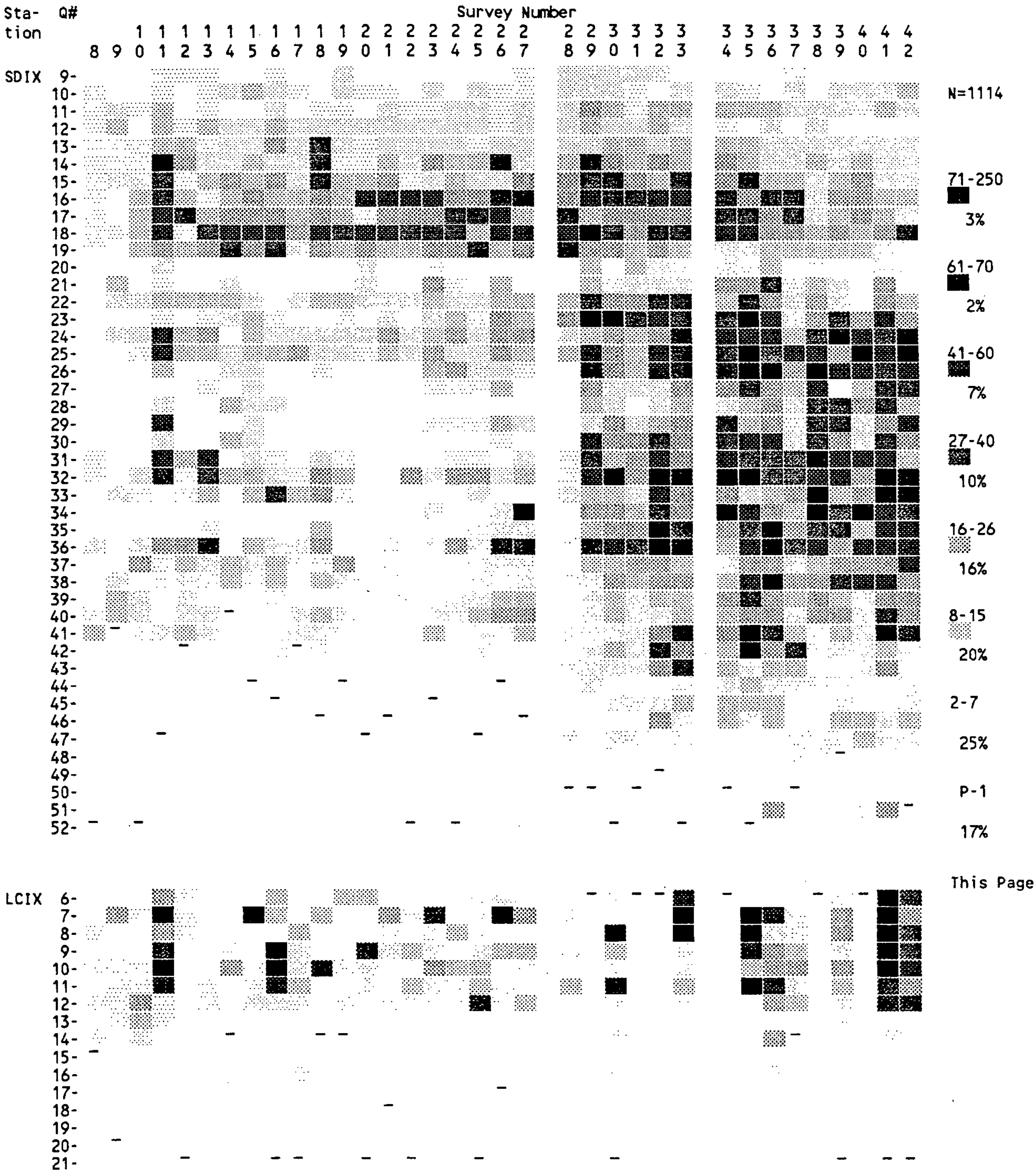
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for COLSCA CSV 6842 3-29-88 7:51a 04-15-1989 06:24

Taxon or Category: Collisella scabra [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Number	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Survey Date as (YYMM)	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

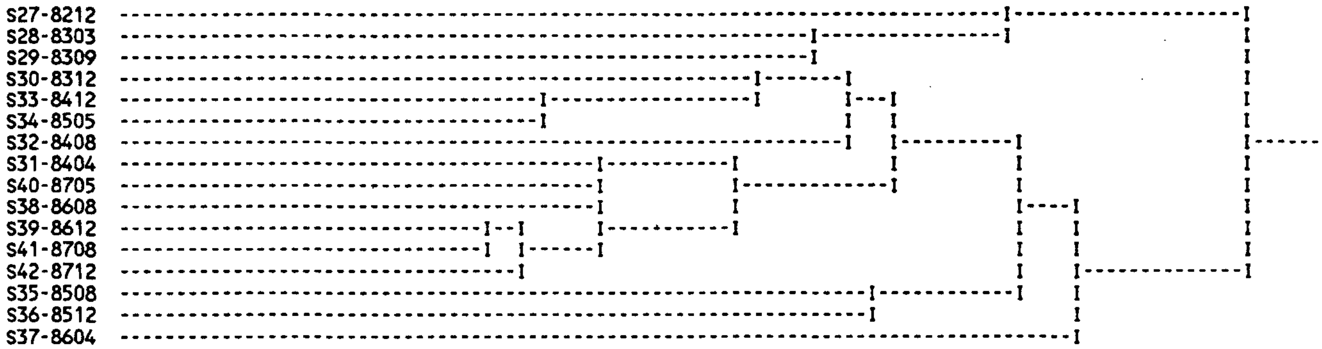
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COLSCA CSV 6842 3-29-88 7:51a 04-15-1989 06:24

Audit: CLUMRG2P: V.1.2: for SCOLSCAB CLU 6581 4-23-89 5:31a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:28:16 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Collisella scabra [Mixed P/#]: TOTAL Quads with Data = 455

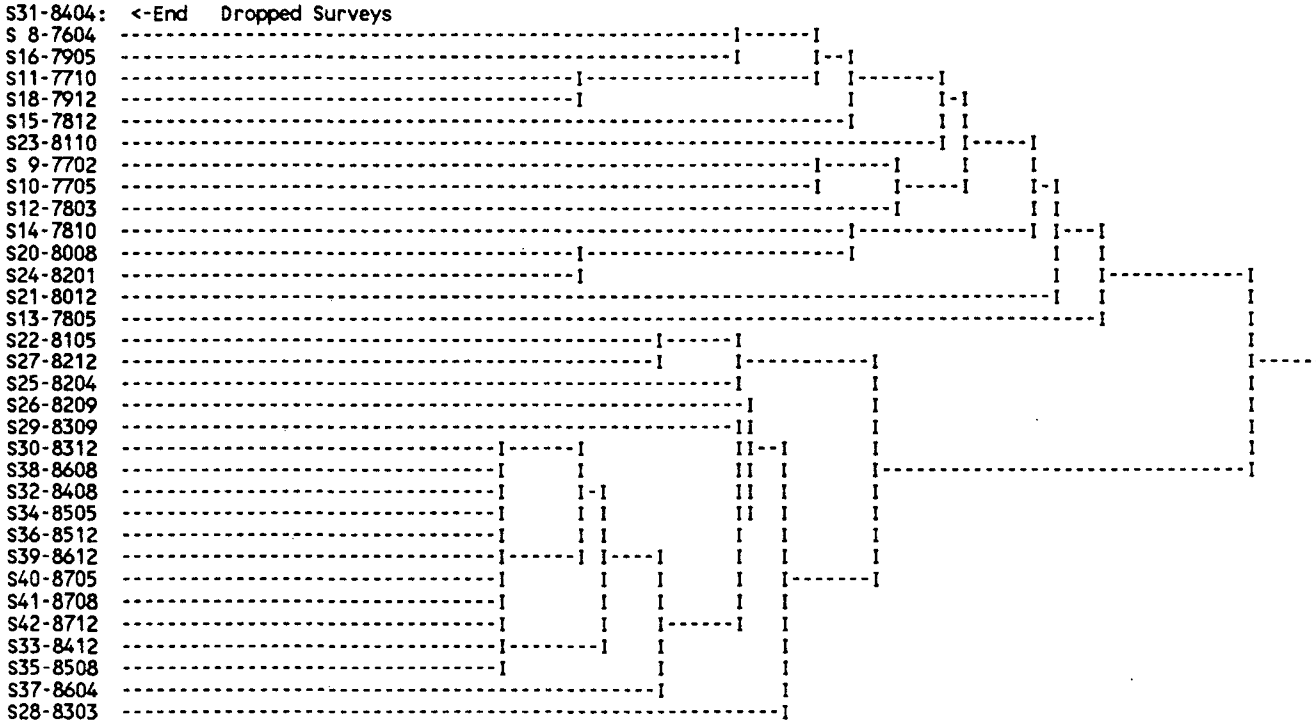
Quad Range USED 4 to 39 for Total of 36 : Range WITH data 2 to 41: : # Dropped 32 : 7.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.619725: Maximum Distance = 21



Station: NDIX: Collisella scabra [Mixed P/#]: TOTAL Quads with Data = 643

Quad Range USED 3 to 25 for Total of 23 : Range WITH data 2 to 30: : # Dropped 85 : 13.2%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.759831: Maximum Distance = 15

S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End Dropped Surveys



Station: SDIX: Collisella scabra [Mixed P/#]: TOTAL Quads with Data = 966

Quad Range USED 10 to 43 for Total of 34 : Range WITH data 5 to 51: : # Dropped 143 : 14.8%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.753063: Maximum Distance = 20

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  --------------------------------------------------------------------------------I
S10-7705  ----------------------------------------------------------------I----I          I
S22-8105  ----------------------------------------------------------------I    I-------I  I--------I
S21-8012  ---------------------------------------------------------------------I       I  I        I
S13-7805  -------------------------------------------------I------I                    I--I        I
S19-8005  -------------------------------------------------I      I--------I           I           I----------I
S28-8303  --------------------------------------------------------I        I-I         I           I          I
S16-7905  -----------------------------------------------------------------I I---------I           I          I
S18-7912  -------------------------------------------------------------------I                     I          I
S20-8008  -----------------------------------------------------------------------------------------I          I
S11-7710  ----------------------------------------------------------------I----------------I                  I
S15-7812  ----------------------------------------------------------------I                I                  I
S25-8204  ------------------------------------------------------I----I                     I                  I
S27-8212  ------------------------------------------------------I    I--------I            I                  I------
S26-8209  -----------------------------------------------------------I        I            I---I              I
S29-8309  ----------------------------------I                                 I            I   I              I
S33-8412  ----------------------------------I----I                            I            I   I              I
S34-8505  ----------------------------------I    II                           I            I   I              I
S30-8312  ---------------------------------------II--I                        I            I   I              I
S31-8404  ----------------------------------------I  I-I                      I------------I   I              I
S32-8408  ----------------------------------I----I   I I                      I                I              I
S36-8512  ----------------------------------I    I---I I                      I                I--------------I
S38-8608  ---------------------------------------I     I-------I              I                I
S35-8508  ----------------------------------I----I     I       I              I                I
S41-8708  ----------------------------------I    I-I   I       I              I                I
S37-8604  ---------------------------------------I I---I       I--------------I                I
S42-8712  -----------------------------------------I           I                               I
S39-8612  -----------------------------------------------------I                               I
S40-8705  -----------------------------------------------------I                               I
S23-8110  -----------------------------------------------------------I-------------------------I
S24-8201  -----------------------------------------------------------I
```

Station: LCIX: Collisella scabra [Mixed P/#]: TOTAL Quads with Data = 195

Quad Range USED 4 to 14 for Total of 11 : Range WITH data 3 to 19: : # Dropped 38 : 19.5%
Surveys 25 : Dropped 4 Surveys if quads sampled < 14
COPHENETIC CORRELATION COEFFICIENT = 0.537113: Maximum Distance = 6

```
S14-7810:  <-Start Dropped Surveys
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 8-7604  -------------------------------------------------------------------------------I-------I
S12-7803  -----------------------------------------------------I-------------------------I       I
S21-8012  -----------------------------------------------------I                                 I
S 9-7702  -----------------I-----------------------------------------I                           I
S15-7812  -----------------I                                         I                           I
S13-7805  -----------------------------------I----------------------II--------------I            I
S24-8201  -----------------------------------I                      II              I            I------------I
S17-7909  -----------------I-----------------I                      II              I            I            I
S23-8110  -----------------I                 I--------I             I               I            I            I
S35-8508  -----------------I-----------------I        I-------------I               I            I            I
S36-8512  -----------------I                          I                             I            I            I
S22-8105  -----------------I--------------------------I                             I            I            I
S28-8303  -----------------I                                                        I------------I            I
S11-7710  -----------------I--------------------------I                             I                         I
S25-8204  -----------------I                          I------I                      I                         I
S39-8612  --------------------------------------------I      I-----------I          I                         I------
S30-8312  -----------------I                                 I           I          I                         I
S33-8412  I                I---------------------------------I           I          I                         I
S41-8708  I----------------I                                             I----I     I                         I
S42-8712  I                                                              I    I     I                         I
S16-7905  -----------------------------------I-----------------I         I    I-----I                         I
S20-8008  -----------------------------------I                 I---------I    I                               I
S27-8212  -----------------------------------------------------I              I                               I
S26-8209  --------------------------------------------------------------------I                               I
S10-7705  ----------------------------------------------------------------------------------------------------I
```

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Cyanoplax spp. (Chiton). Ref. MAH 1980, p 417ff.
Phylum Mollusca: **Class** Polyplacophora:

C. hartwegii is the most common species in study area and its description and distribution follows:

Description: Low lying, ovate, olive-green to olive-brown (mainly green). Length 1 - 3.5+ cm (5 cm, MAH). Valves rounded, sculpture finely-spaced granulations. Girdle darker than valves with dense granular scales. (from MAH).

Distribution: Monterey Bay (California) to Punta Abreojos (Baja California), upper mid intertidal especially under *Pelvetia fastigiata* and in high tidepools. Common on rocks protected from strong surf. (from MAH). A warm-tolerant group.

Diablo Area Specific Information: Moderately common to locally abundant (15+ per m^2), occurring in about 10% of our quadrats.

Habitat: On rocks, mid-upper to low tide levels. Occurs on rocks (tops and sides) and on under-cobble surfaces. Occasionally in small clear areas under algal mat.

Observational Errors: Small chitons (<-0.5 cm) that may belong to this group were identified as "unid. chiton, juveniles". Other missed observations are probably limited to areas of dense algal cover. In our early surveys (from beginning of our study to May 78), we did not routinely field identify this taxon.

Field Identification Problems:

General: It is probable that this group is a mixture of *C. hartwegii* and *C. dentiens* (see below).

Station Specific: none.

General Comments: Identification to species not attempted because we have not done extensive collections with dissections and microscopic examination of this group. Distinguishing in the field such subjective characteristics as "smoother", "smaller", and "more elongate" was impossible with our sampling techniques.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Essentially removed from the biota at all stations possibly due to storm waves. "...they cling to rocks less firmly than other chiton species...." MAH (1980).

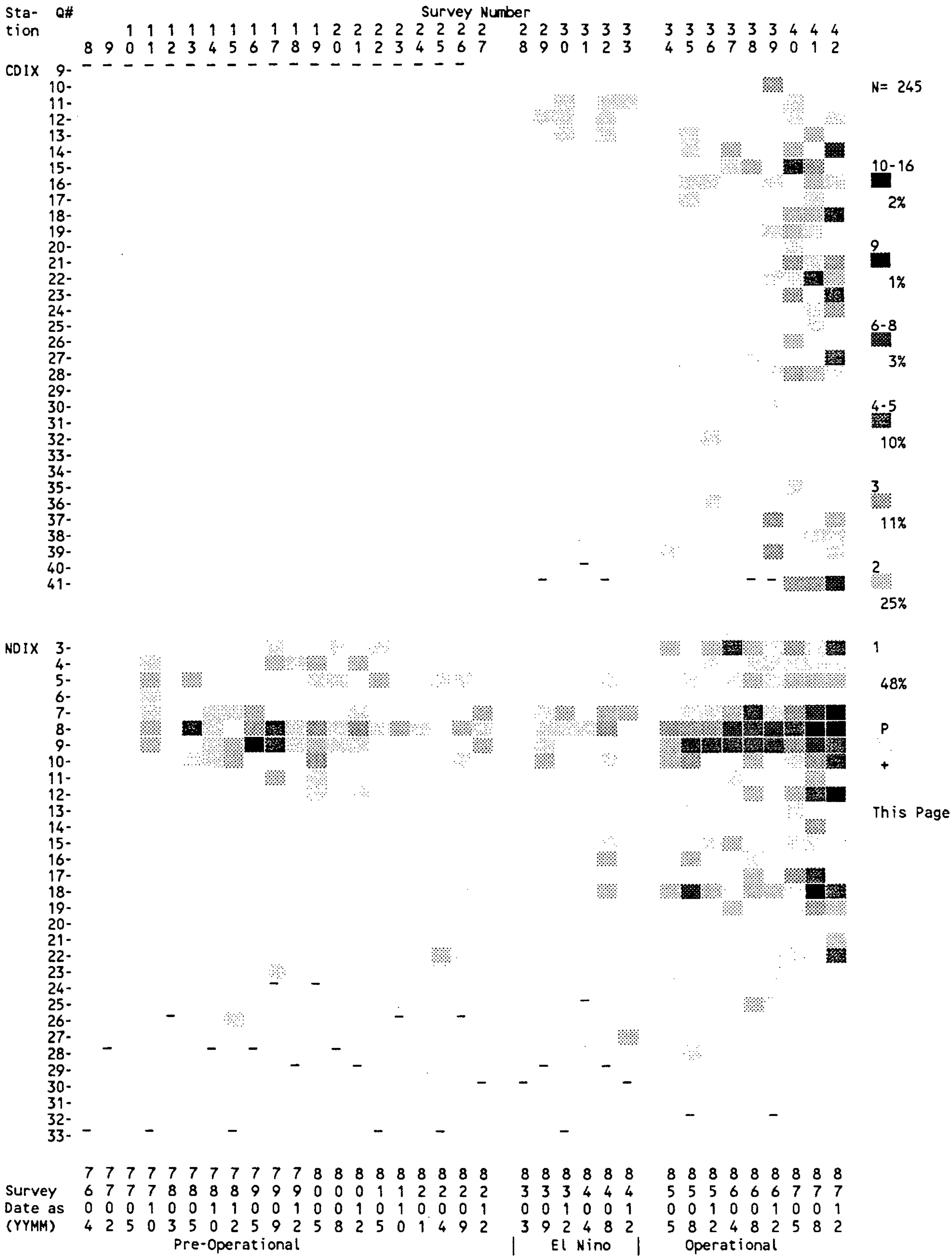
El Niño: 1983-1984: At our Cove stations (SDIX, NDIX, and CDIX?), recovered to normal with indications that they may have started expanding their range downward in the intertidal. Always sparse at LCIX.

Diablo DCPP Operation: SDIX and CDIX populations sporadically (possible missed observations due to algal mat) increased in numbers and distribution downward in the intertidal. By end of 1987 there seemed to be a trend towards a downward shift of the population into the lower intertidal with a decrease in numbers at SDIX. NDIX increased in numbers and occurrences and extended into lower intertidal areas, with possible reduction in occurrences at the mid tidal levels at the end of 1987 but not losing occurrences in the upper intertidal.

Cyanoplax dentiens: Auke Bay (Alaska) to La Jolla (California). Color highly variable, usually dark olive-green. Distinguished from *C. hartwegii* by being smaller, smoother, and more elongate. (from MAH).

Taxon or Category: Cyanoplax spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

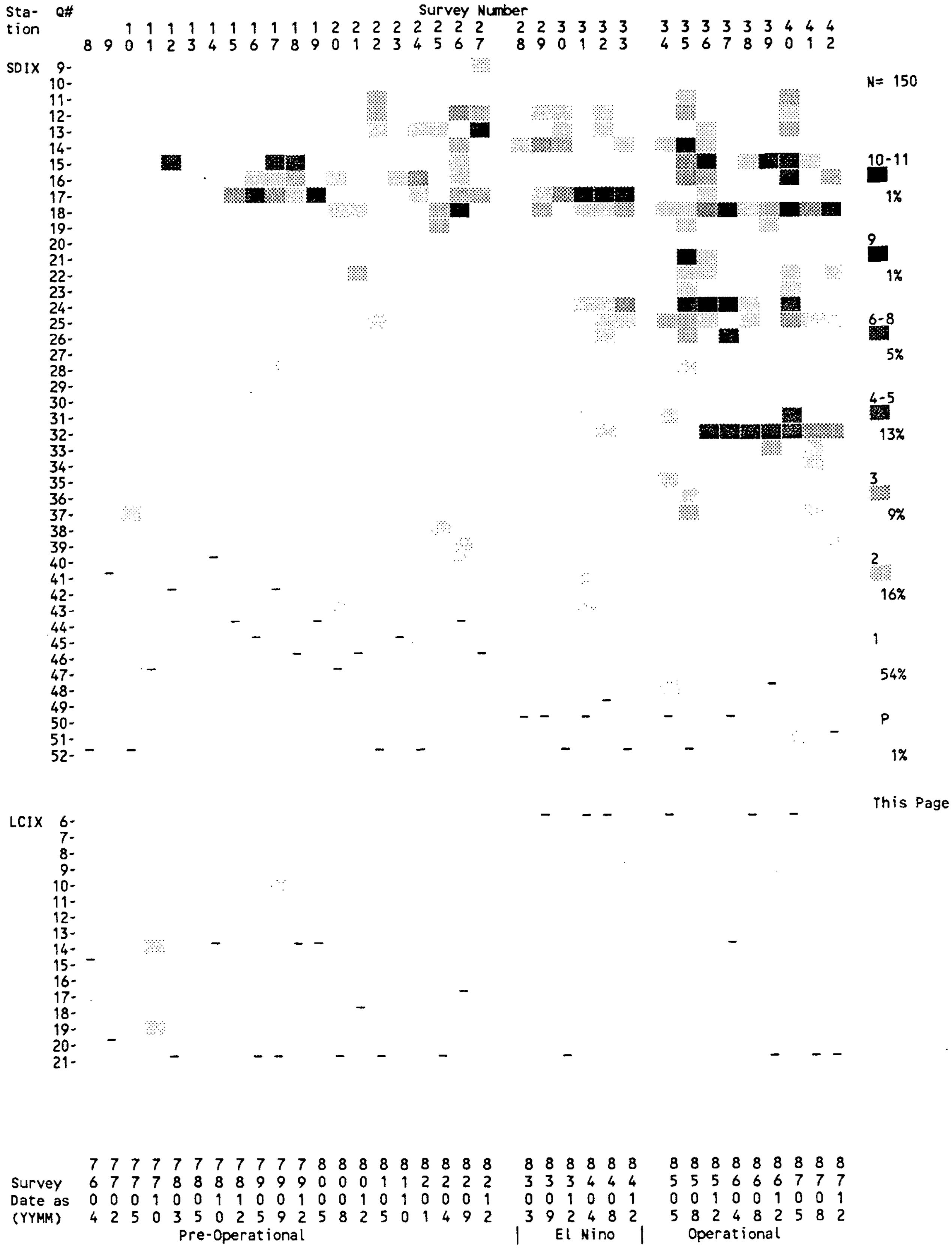


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CYANOP CSV 5351 3-29-88 7:52a 04-15-1989 06:25

Taxon or Category: Cyanoplax spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CYANOP CSV 5351 3-29-88 7:52a 04-15-1989 06:25

Audit: CLUMRG2P: V.1.2: for SCYANOPB CLU 6915 4-23-89 5:44a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:40:04 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Cyanoplax spp. [Mixed P/#]: TOTAL Quads with Data = 78

Quad Range USED 7 to 39 for Total of 33 : Range WITH data 4 to 41: : # Dropped 5 : 6.4%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.813209: Maximum Distance = 19

```
S27-8212  -----------------------------------I-I
S28-8303  ------------------------------I----I I--I
S31-8404  ------------------------------I      I  I---I
S33-8412  -------------------------------------I  I   I----I
S34-8505  ----------------------------------------I   I    I
S37-8604  ----------------------------------------I---I    I-----I
S38-8608  ----------------------------------------I        I     I
S29-8309  ----------------------------------------I--------I     I-I
S30-8312  ------------------------------I---------I              I I
S32-8408  ------------------------------I                        I I---------------------I
S36-8512  -------------------------------------------------------I I                     I------------------I
S35-8508  ---------------------------------------------------------I                     I                  I------
S39-8612  -------------------------------------------------------------------------------I                  I
S40-8705  ----------------------------------------------------------------------------------------------I---I
S41-8708  --------------------------------------------------------------------------------------I-------I
S42-8712  --------------------------------------------------------------------------------------I
```

Station: NDIX: Cyanoplax spp. [Mixed P/#]: TOTAL Quads with Data = 178

Quad Range USED 3 to 23 for Total of 21 : Range WITH data 2 to 28: : # Dropped 9 : 5.1%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.814914: Maximum Distance = 11

```
S 8-7604  I
S 9-7702  I
S10-7705  I-------I
S12-7803  I       I
S28-8303  I       I--I
S23-8110  I       I  I
S24-8201  I-------I  I-------------I
S31-8404  I          I             I
S33-8412  -----------I             I--------I
S14-7810  I-------I                I        I
S29-8309  I       I-----I          I        I
S15-7812  --------I     I----------I        I-I
S16-7905  I-------I     I                   I I
S27-8212  I       I-----I                   I I
S30-8312  --------I                         I I
S11-7710  --------------------------I-------I I-----I
S18-7912  -----------------I--------I         I     I
S21-8012  -----------------I                  I     I
S13-7805  -----------------I-------------I    I     I----------I
S26-8209  -----------------I             I----I     I          I
S20-8008  --------I----------------------I          I          I---I
S22-8105  --------I                                 I          I   I
S25-8204  ------------------------------------------I          I   I
S19-8005  -----------------------------------------------------I   I--------I
S17-7909  -----------------------------------I--------I            I        I
S34-8505  -----------------------------------I        I-----I      I        I
S39-8612  --------------------------------------------I     I------I        I--------------------------------I
S36-8512  -----------------------------------I--------------I               I                                I
S37-8604  -----------------------------------I                              I                                I
S32-8408  -----------------------------------I--------I                     I                                I------
S35-8508  -----------------------------------I        I---------------------I                                I
S38-8608  --------------------------------------------I                                                      I
S40-8705  --------------------------I-------------I                                                          I
S41-8708  --------------------------I             I----------------------------------------------------------I
S42-8712  ----------------------------------------I
```

Station: SDIX: Cyanoplax spp. [Mixed P/#]: TOTAL Quads with Data = 144

Quad Range USED 12 to 41 for Total of 30 : Range WITH data 9 to 51: : # Dropped 10 : 6.9%
Surveys 33 : Dropped 2 Surveys if quads sampled < 41
COPHENETIC CORRELATION COEFFICIENT = 0.823263: Maximum Distance = 18

```
S 9-7702:  <-Start Dropped Surveys
S14-7810:  <-End   Dropped Surveys
S 8-7604 ---------------------I
S11-7710 ---------------------I-----I
S13-7805 ---------------------I     II
S10-7705 ---------------------------III
S12-7803 ----------------------------II---I
S28-8303 -----------------------------I   I-I
S20-8008 ---------------------------I-----I I-I
S23-8110 ---------------------------I       I I
S21-8012 -----------------------------------I I
S15-7812 ---------------------I-----I         I------I
S19-8005 ---------------------I     I---I     I      I
S16-7905 ---------------------------I   I--I  I      I
S24-8201 -------------------------------I  I--I      I---I
S17-7909 ---------------------------I------I         I   I
S18-7912 ---------------------------I                I   I
S22-8105 -----------------------------------I--------I   I--I
S27-8212 ---------------------------I-------I            I  I
S30-8312 ---------------------------I                    I  I
S29-8309 --------------------------------------I--I      I  I----I
S33-8412 --------------------------------------I  I------I  I    I
S31-8404 -----------------------------------------I         I    I--I
S25-8204 ---------------------------------------------------I    I  I
S34-8505 --------------------------------------------------------I  I-----I
S32-8408 -----------------------------------------------I---------I I     I
S37-8604 --------------------------------------I--------I         III     I
S38-8608 --------------------------------------I                  III     I----------I
S42-8712 ---------------------------------------------------------II      I          I
S39-8612 --------------------------------------------I-------------I      I          I-----------------------I
S41-8708 --------------------------------------------I                    I          I                       I
S26-8209 -----------------------------------------------------------------I          I                       I------
S36-8512 -------------------------------------------------------I--------------------I                       I
S40-8705 -------------------------------------------------------I                                            I
S35-8508 ----------------------------------------------------------------------------------------------------I
```

Station: LCIX: Cyanoplax spp. [Mixed P/#]: TOTAL Quads with Data = 16

Quad Range USED 4 to 13 for Total of 10 : Range WITH data 3 to 19: : # Dropped 4 : 25.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 13
COPHENETIC CORRELATION COEFFICIENT = 0.755480: Maximum Distance = 8

```
S 8-7604 ---------------------------------------------------------------------------I
S 9-7702 ---------------------------------------------------------------------------I
S11-7710 ---------------------------------------------------------------------------I
S12-7803 ---------------------------------------------------------------------------I
S13-7805 ---------------------------------------------------------------------------I
S14-7810 ---------------------------------------------------------------------------I
S15-7812 ---------------------------------------------------------------------------I
S16-7905 ---------------------------------------------------------------------------I
S18-7912 ---------------------------------------------------------------------------I
S21-8012 ---------------------------------------------------------------------------I------------I
S23-8110 ---------------------------------------------------------------------------I            I
S24-8201 ---------------------------------------------------------------------------I            I
S26-8209 ---------------------------------------------------------------------------I            I
S27-8212 ---------------------------------------------------------------------------I            I
S28-8303 ---------------------------------------------------------------------------I            I
S30-8312 ---------------------------------------------------------------------------I            I--I
S36-8512 ---------------------------------------------------------------------------I            I  I
S37-8604 ---------------------------------------------------------------------------I            I  I
S42-8712 ---------------------------------------------------------------------------I            I  I
S10-7705 ---------------------------------------------------------------------------I            I  I
S19-8005 ---------------------------------------------------------------------------I            I  I---I
S20-8008 ---------------------------------------------------------------------------I------------I  I   I
S22-8105 ---------------------------------------------------------------------------I               I   I
S25-8204 ---------------------------------------------------------------------------I               I   I---I
S35-8508 ---------------------------------------------------------------------------I               I   I   I
S41-8708 -------------------------------------------------------------------------------------------I   I   I-----
S33-8412 ----------------------------------------------------------------------------------------I------I   I
S39-8612 ----------------------------------------------------------------------------------------I          I
S17-7909 ---------------------------------------------------------------------------------------------------I
```

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Fissurella volcano (Keyhole Limpet). Reeve, 1849. Ref. MAH 1980, p 238.
Phylum Mollusca: **Class** Gastropoda:

Description: Oval, moderately elevated, apical opening narrow just anterior to center, pinkish to reddish with reddish-brown to black rays. Length 0.3 - 3+ cm (3.5 cm MAH), about 1/3+ as high as length.

Distribution: Crescent City (California) to Bahia Magdalena (Baja California), mid intertidal. Locally abundant on sides and undersurfaces of large boulders. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 15% of our quadrats and locally abundant (up to 40 per m^2).

Habitat: On rock (bedrock and boulders), mid to low tide levels. Occurs on bare and algal covered rock tops, sides, and occasionally underneath.

Observational Errors: Can be missed if under moderate to dense algal growth, especially small (<0.5 cm) specimens. Possibly as much as 10% missed observations.

Field Identification Problems:

General: Rarely confused, but smaller specimens, (<0.5 cm) of *Diodora* spp. could possibly be called *F. volcano*.

Station Specific: n.a.

General Comments: Large, field-identifiable specimens of *Diodora* rarely occurred in our intertidal transects and undisturbed specimens usually have the mantle extended over their shell, which *F. volcano* is not capable of doing.

Impacts to Taxon:

El Niño: 1982-83 winter storm: NDIX and SDIX, with moderate to severe (respectively) reduction in occurrence, probably due to substrate movement and introduction. CDIX probably little change. LCIX indeterminate; this taxon was moderately common there only up to 1978.

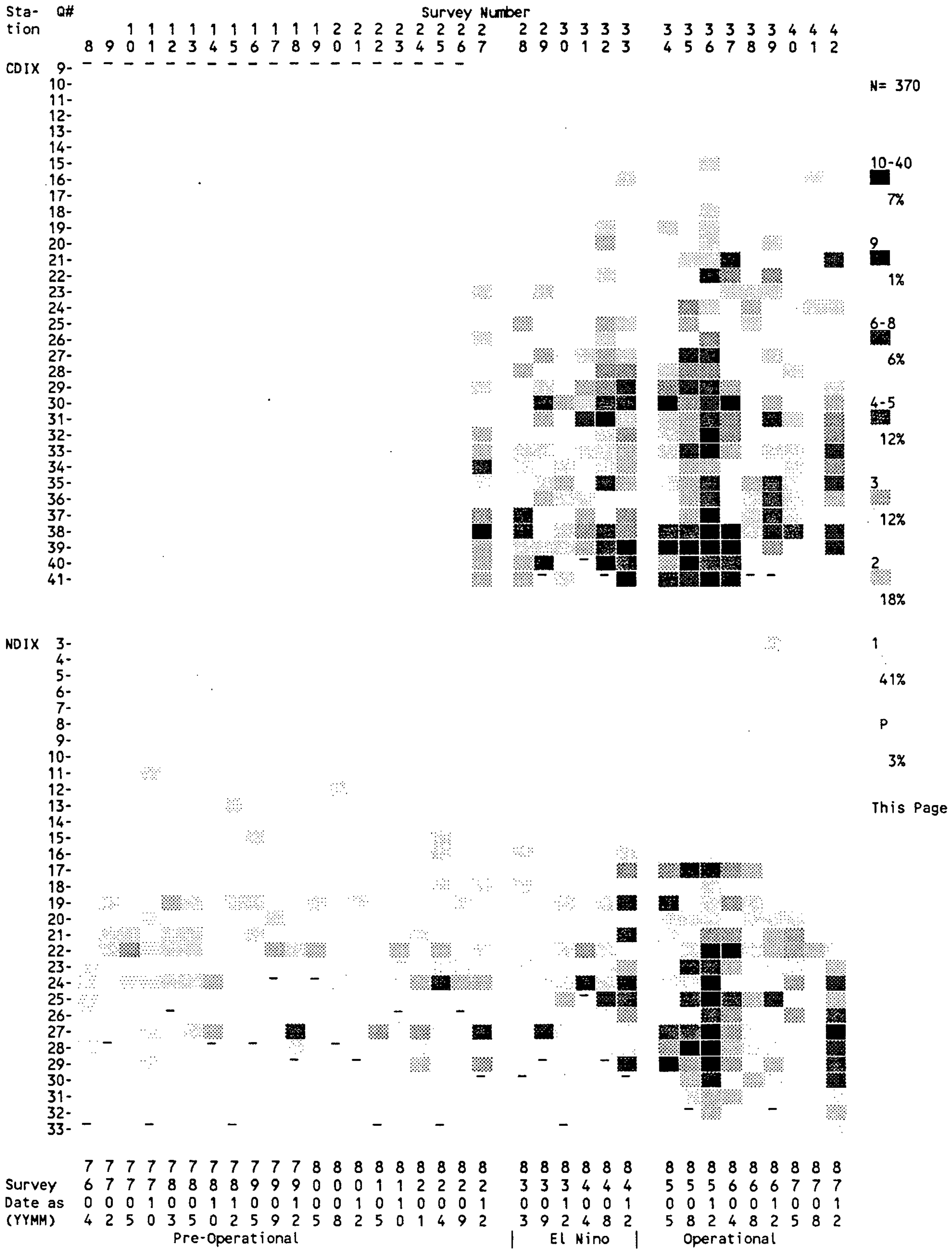
El Niño: 1983-1984: All Cove stations sporadically recovered quickly and increased over pre-El Niño abundances (CDIX?). SDIX's population started to shift downward in the intertidal (possibly due to introduced cobble overlay in the mid intertidal). LCIX began to develop a population similar to that occurring in 1978.

Diablo DCPP Operation: All Cove stations' populations were sporadic. Small (<0.5 cm) individuals would appear commonly in some surveys, then the whole population virtually disappeared in a 3 month period (Aug 1987 at NDIX and CDIX), followed 4 months later by a resurgence to high numbers and distribution. If a trend existed, it was towards a shift downward in the intertidal with increased numbers over pre-operational conditions (again CDIX?). LCIX peaked in numbers and occurrences in Dec. 1985, then declined, but still above normal for both (somewhat similar to 1978 conditions).

Possible explanations for post-1984 changes: 1) predation by *Ocenebra* spp.; 2) high recruitment; 3) extensive movement (i.e., out of our transects); and 4) many missed observations for some surveys.

Taxon or Category: Fissurella volcano

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

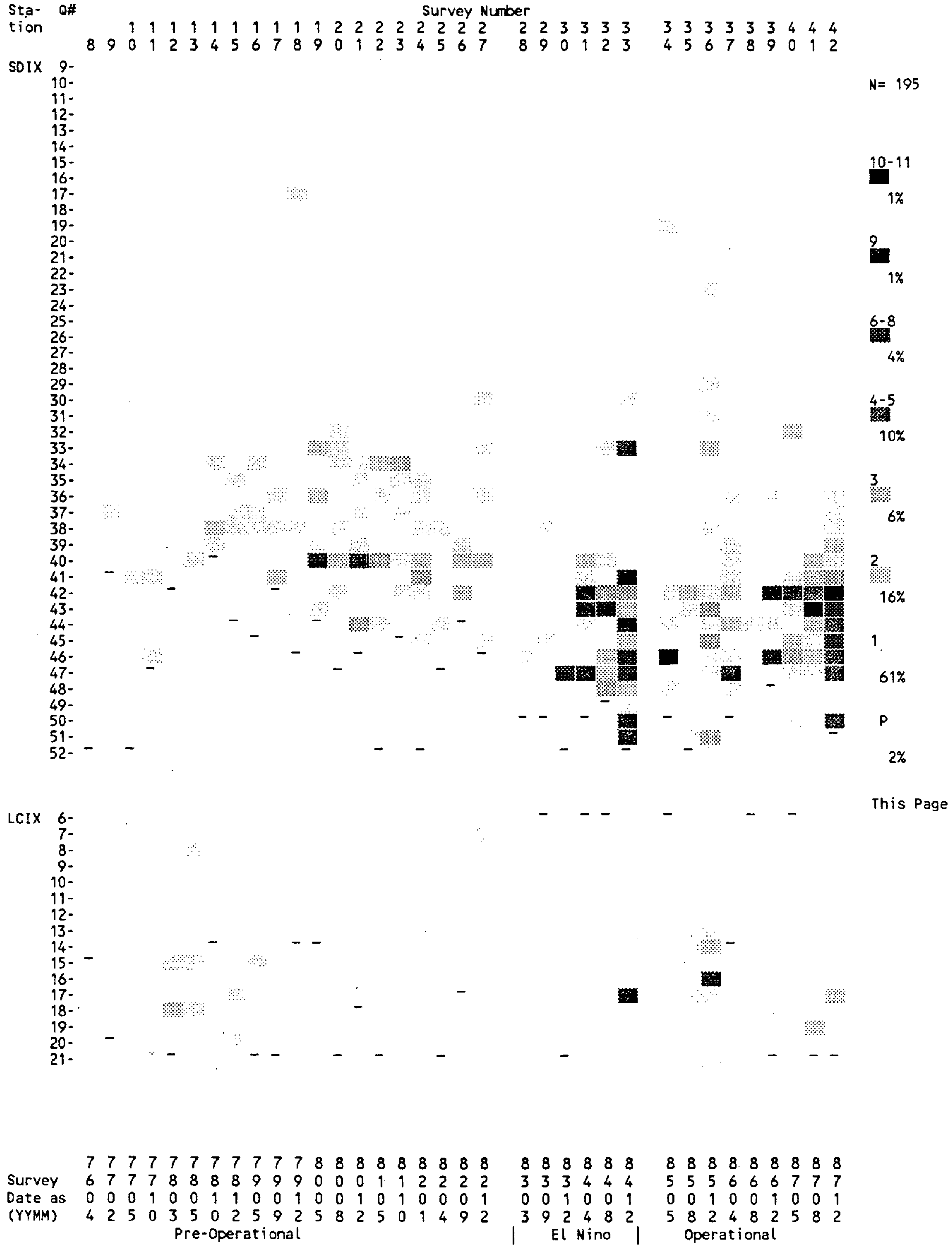


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for FISVOL CSV 5363 3-29-88 7:53a 04-15-1989 06:26

Taxon or Category: Fissurella volcano

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for FISVOL CSV 5363 3-29-88 7:53a 04-15-1989 06:26

Audit: CLUMRG2P: V.1.2: for SFISVOLB CLU 6163 4-23-89 5:53a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:50:44 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Fissurella volcano: TOTAL Quads with Data = 186

Quad Range USED 19 to 39 for Total of 21 : Range WITH data 15 to 41: : # Dropped 21 : 11.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.392972: Maximum Distance = 10

```
S27-8212  --------------------------------------------------------------------------I
S28-8303  ------------------------------------------------I-------------I           I----I
S40-8705  ------------------------------------------------I             I-----------I    I--------------------I
S30-8312  --------------------------------------------------------------I                I                    I
S38-8608  ----------------------------------------------------------I--------------------I                    I
S41-8708  ----------------------------------------------------------I                                         I
S29-8309  --------------------------------------I---------I                                                   I------
S31-8404  --------------------------------------I         I-------------------------I                         I
S39-8612  ------------------------------------------------I                         I---------I               I
S34-8505  ----------------------------------------------------------I---------------I         I               I
S37-8604  ----------------------------------------------------------I                         I---------------I
S32-8408  ------------------------------------------------I--------------------I              I
S36-8512  ------------------------------------------------I                    I--------------I
S33-8412  -----------------------------I-----------------------I               I
S35-8508  -----------------------------I                       I---------------I
S42-8712  -----------------------------------------------------I
```

Station: NDIX: Fissurella volcano: TOTAL Quads with Data = 184

Quad Range USED 15 to 27 for Total of 13 : Range WITH data 3 to 33: : # Dropped 56 : 30.4%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.597692: Maximum Distance = 6

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End   Dropped Surveys
S 8-7604  -------------------------------I
S32-8408  -------------------------------I---------------------------------I
S42-8712  -------------------------------I                                 I---------------I
S39-8612  -----------------------------------------------I-----------------I               I
S40-8705  -----------------------------------------------I                                 I-------------------I
S33-8412  -----------------------------------------------I------I                          I                   I
S37-8604  -----------------------------------------------I      I--------------------------I                   I
S36-8512  ------------------------------------------------------I                                              I
S 9-7702  -------------------------------I                                                                     I
S10-7705  -------------------------------I--------------------I                                                I
S13-7805  -------------------------------I                    I-----I                                          I
S15-7812  I------------------------------I                    I     I                                          I
S21-8012  I                              I--------------------I     I                                          I
S16-7905  -------------------------------I                          I--------------------I                     I------
S11-7710  -------------------------------I----------I               I                    I                     I
S27-8212  -------------------------------I          I               I                    I                     I
S14-7810  ----------------I------I                  I---------------I                    I                     I
S20-8008  ----------------I      I--I               I                                    I                     I
S24-8201  -----------------------I  I-------------I I                                    I                     I
S29-8309  --------------------------I             I-I                                    I------------------I  I
S18-7912  ----------------I------I                I                                      I                  I  I
S22-8105  ----------------I      I----------------I                                      I                  I  I
S41-8708  -----------------------I                                                       I                  I  I
S30-8312  -----------------------------------------------I------I                        I                  I--I
S38-8608  -----------------------------------------------I      I-------------------I    I                  I
S35-8508  ------------------------------------------------------I                   I----I                  I
S34-8505  --------------------------------------------------------------------------I                       I
S25-8204  ---------------------------------------------------------------I----------------------------------I
S28-8303  ---------------------------------------------------------------I
```

Station: SDIX: Fissurella volcano: TOTAL Quads with Data = 157

Quad Range USED 30 to 44 for Total of 15 : Range WITH data 17 to 52: : # Dropped 63 : 40.1%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.675746: Maximum Distance = 6

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209: <-End   Dropped Surveys
S 8-7604  I
S28-8303  I-------------I
S30-8312  I             I------I
S10-7705  I-------------I      I-----I
S11-7710  I                    I     I
S13-7805  ---------------------I     I-----------I
S18-7912  I-------------I            I           I
S29-8309  I             I------------I           I---------------I
S25-8204  --------------I                        I               I
S34-8505  --------------I-------I                I               I--------------I
S38-8608  --------------I       I----------------I               I              I
S39-8612  ----------------------I                                I              I-------I
S16-7905  -------------------------------------------------------I              I       I
S22-8105  --------------------------------------------------------------I-------I       I
S27-8212  --------------------------------------------------------------I               I
S31-8404  I---------------------------------------------I                               I---------------I
S41-8708  I                                             I                               I               I
S32-8408  -------------------------------I--------------I---------I                     I               I
S35-8508  -------------------------------I              I         I---------------I     I               I---I
S40-8705  ----------------------------------------------I         I               I-----I               I   I
S33-8412  --------------------------------------------------------I               I                     I   I-I
S36-8512  ------------------------------------------------------------------------I                     I   I I
S20-8008  ----------------------------------------------------------------------------------------------I   I I
S24-8201  ----------------------------------------------------------------------I---------------------------I I------
S37-8604  ----------------------------------------------I-----------------------I                             I
S42-8712  ----------------------------------------------I                                                     I
S21-8012  ----------------------------------------------I-----------------------------------------------------I
S23-8110  ----------------------------------------------I
```

Station: LCIX: Fissurella volcano: TOTAL Quads with Data = 38

Quad Range USED 13 to 19 for Total of 7 : Range WITH data 7 to 21: : # Dropped 6 : 15.8%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.843808: Maximum Distance = 4

```
S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End   Dropped Surveys
S 9-7702  I
S10-7705  I
S11-7710  I
S17-7909  I
S20-8008  I--------------------I
S22-8105  I                    I
S23-8110  I                    I
S24-8201  I                    I-I
S25-8204  I                    I I
S28-8303  I                    I I-I
S15-7812  ---------------------I I I-------------I
S27-8212  -----------------------I I             I
S30-8312  -------------------------I             I---------------------------I
S12-7803  I--------------------I                 I                           I
S13-7805  I                    I-----------------I                           I------------------------I
S16-7905  ---------------------I                                             I                        I
S39-8612  -------------------------------------------------------------------I                        I-------I
S33-8412  ---------------------------------------------I---------------------I                        I       I
S42-8712  ---------------------------------------------I                     I------------------------I       I------
S36-8512  ---------------------------------------------I---------------------I                                I
S41-8708  ---------------------------------------------I                                                      I
S35-8508  ----------------------------------------------------------------------------------------------------I
```

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Haliotis cracherodii (Black Abalone). Leach, 1814. Ref. MAH 1980, p. 236.
Phylum Mollusca: **Class** Gastropoda:

Description: Flat, oval, dark blue-black, dark green to nearly black. Diameter 1 - 14+ cm (20 cm, MAH), about 1/8+ as high as length.

Distribution: Coos Bay (Oregon) to Cabo San Lucas (Baja California). Common under large rocks and in crevices, upper intertidal to subtidal (6 m). (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 20% of our quadrats, locally abundant (up to 45 per m^2).

Habitat: On rocks, upper-mid to low tide levels. Larger specimens occur under boulders and in crevices, while smaller ones can nestle in depressions on algal covered rock tops and sides.

Observational Errors: Smaller specimens can be missed if present under moderate to dense algal growth. Specimens under rocks and in deep crevices can be missed depending on the amount of sand fill and also the tidal water height at the time of observation. Occasionally identification was by "feel".

Quadrat boundary errors occur. Missed observations probably less than 5%.

Field Identification Problems:

General: Rarely but possibly confused (when identified by feel) with almost any *Haliotis* spp.

Station Specific: n.a.

General Comments: Boundary errors occur most commonly at Station LCIX and to a lesser extent at CDIX. Missed observations occur most often in boulder fields that can have sand/gravel deposits around their bases (i.e., NDIX and SDIX).

Impacts to Taxon:

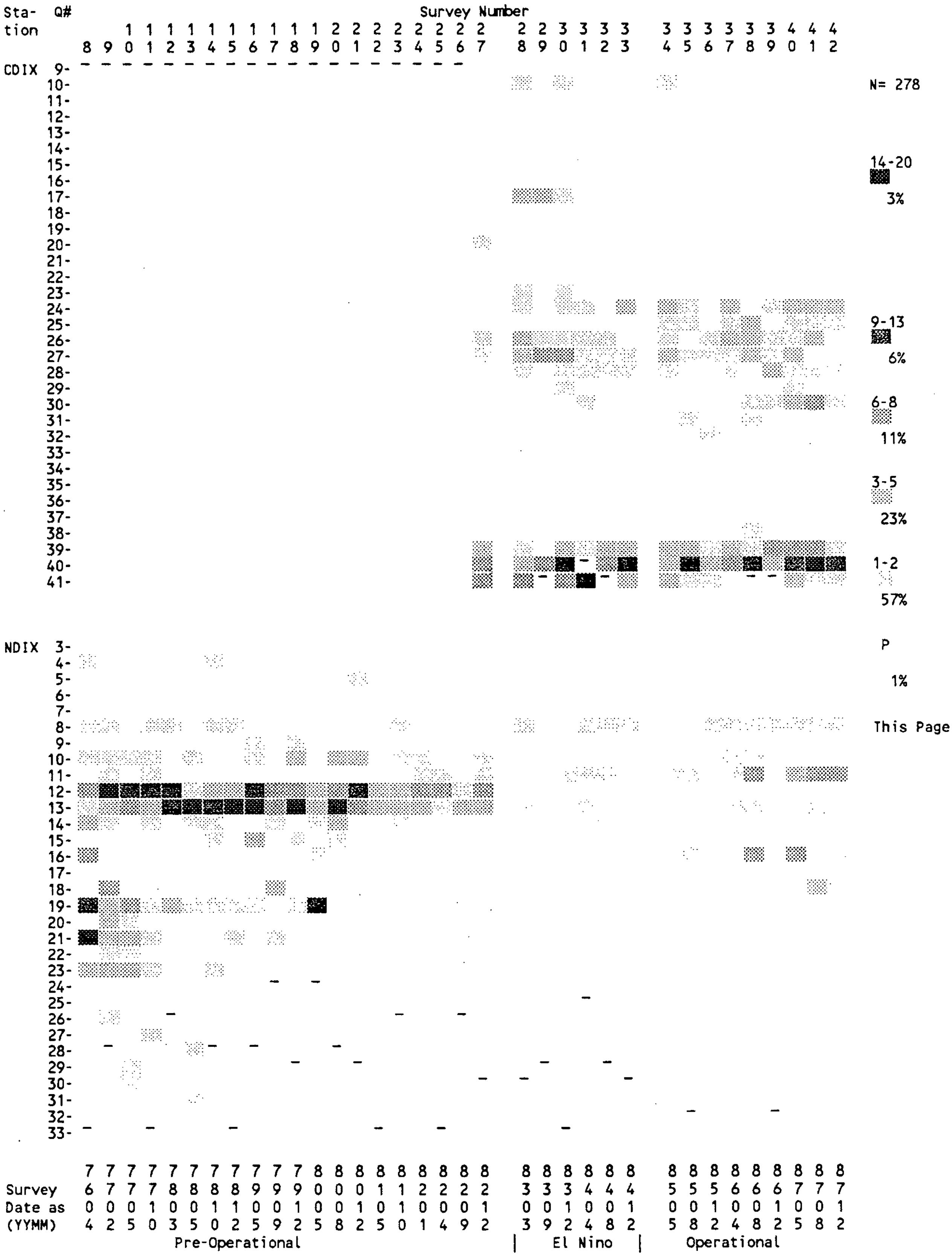
El Niño: 1982-83 winter storm: SDIX total disappearance due to large boulder group that moved off the transect. NDIX similar, but single individuals remained in two quadrats. CDIX and LCIX no apparent change.

El Niño: 1983-1984: At SDIX and NDIX, difficult to assess because there were major shifts in existing habitat due to storms, but little recruitment occurred. CDIX slowly lost some occurrences in the upper intertidal but numbers remained fairly constant. LCIX possibly with a slight increase in numbers in the middle tide zone, but suitable habitat lost at two quadrats due to rock and boulder removal by storm action.

Diablo DCPP Operation: SDIX, without a major change in its physical characteristics, will probably not return to normal, because the boulder jumble at quadrats 29 to 34 was removed by the 1982-83 winter storms. NDIX still has some suitable habitats for abalone and limited expansion of the population occurred throughout the operational period, but did not reach pre-operational levels in abundances or distribution. Prior to El Niño, the low intertidal population at this station was decreasing. CDIX remained relatively constant, with possible extension of the population into the lower intertidal. LCIX remained as for the El Niño period with possible slight decline in numbers from normal conditions.

Taxon or Category: Haliotis cracherodii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

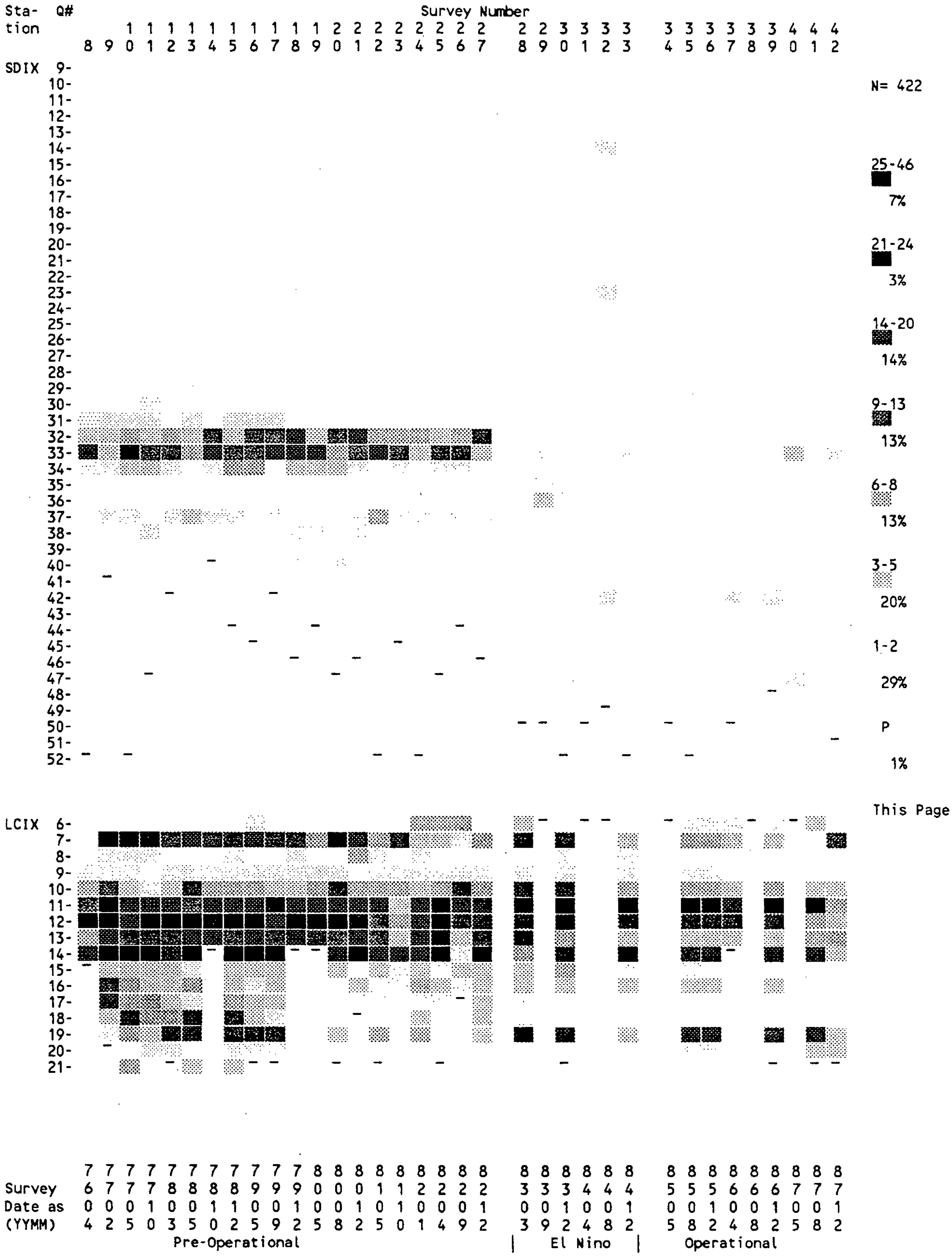


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HALCRA CSV 5321 3-29-88 7:53a 04-15-1989 06:27

Taxon or Category: Haliotis cracherodii

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



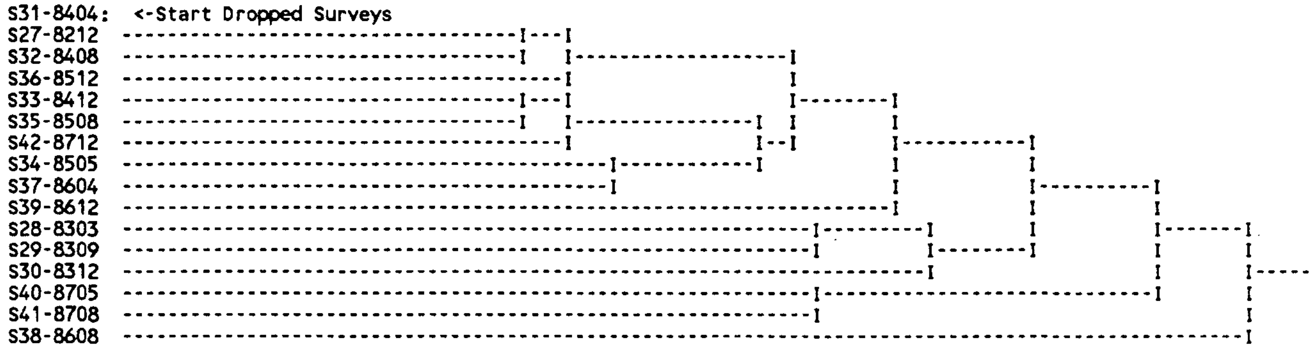
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HALCRA CSV 5321 3-29-88 7:53a 04-15-1989 06:27

Audit: CLUMRG2P: V.1.2: for SHALCRA CLU 7249 4-23-89 5:58a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:55:19 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

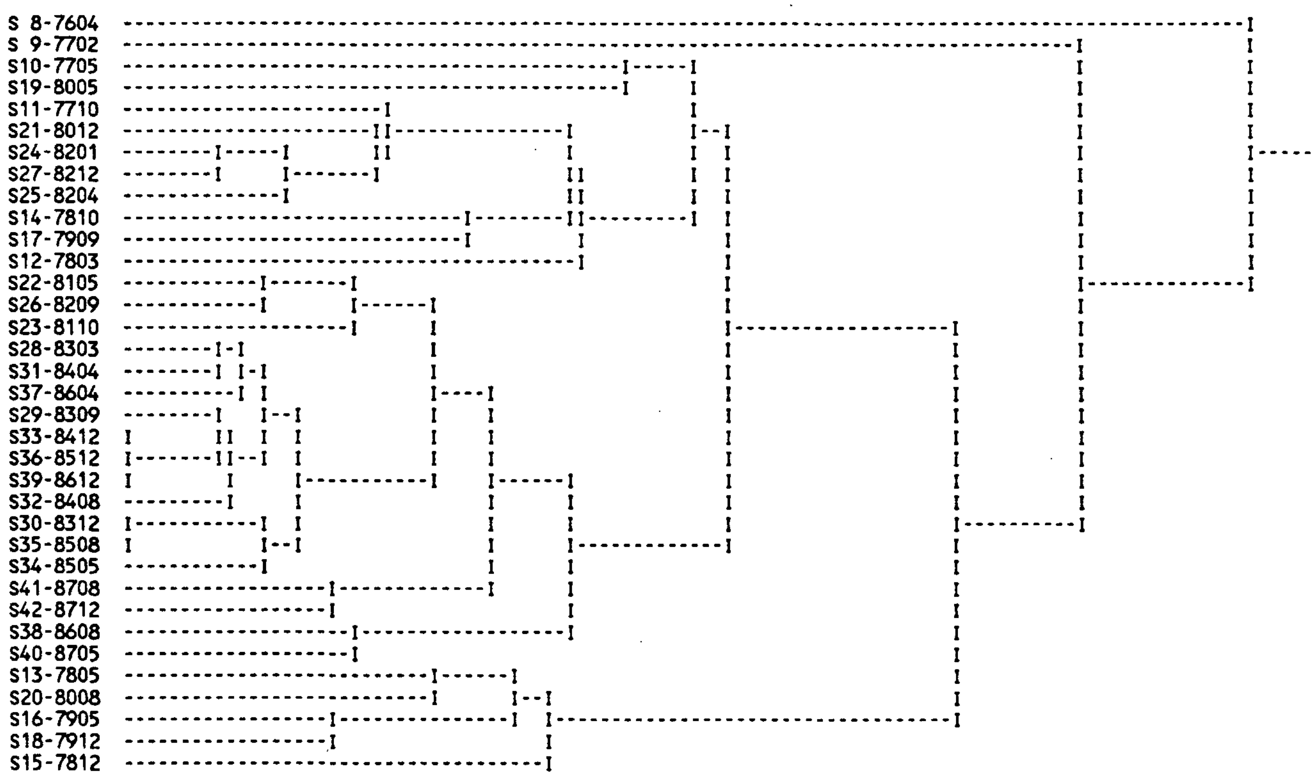
Station: CDIX: Haliotis cracherodii: TOTAL Quads with Data = 120

Quad Range USED 10 to 40 for Total of 31 : Range WITH data 8 to 41: : # Dropped 20 : 16.7%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.459824: Maximum Distance = 345



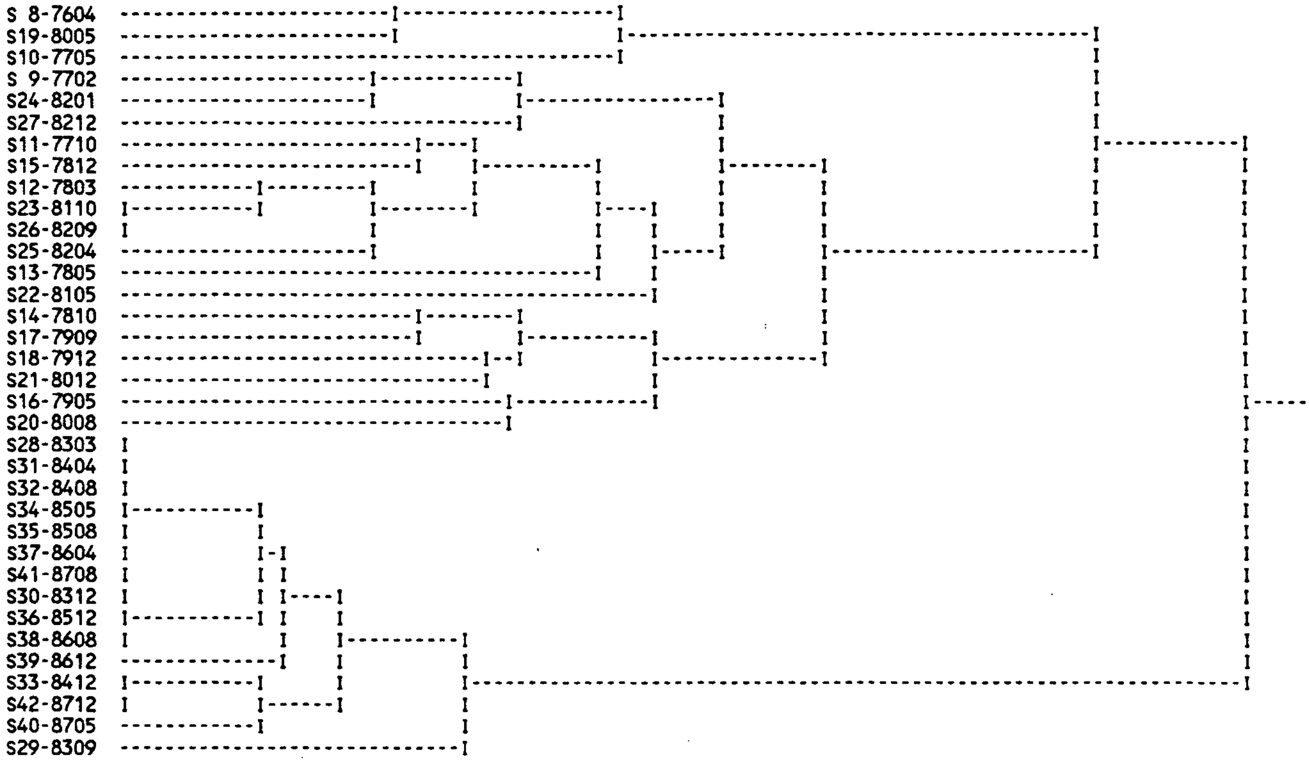
Station: NDIX: Haliotis cracherodii: TOTAL Quads with Data = 160

Quad Range USED 8 to 23 for Total of 16 : Range WITH data 4 to 31: : # Dropped 9 : 5.6%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.793131: Maximum Distance = 341



Station: SDIX: Haliotis cracherodii: TOTAL Quads with Data = 99

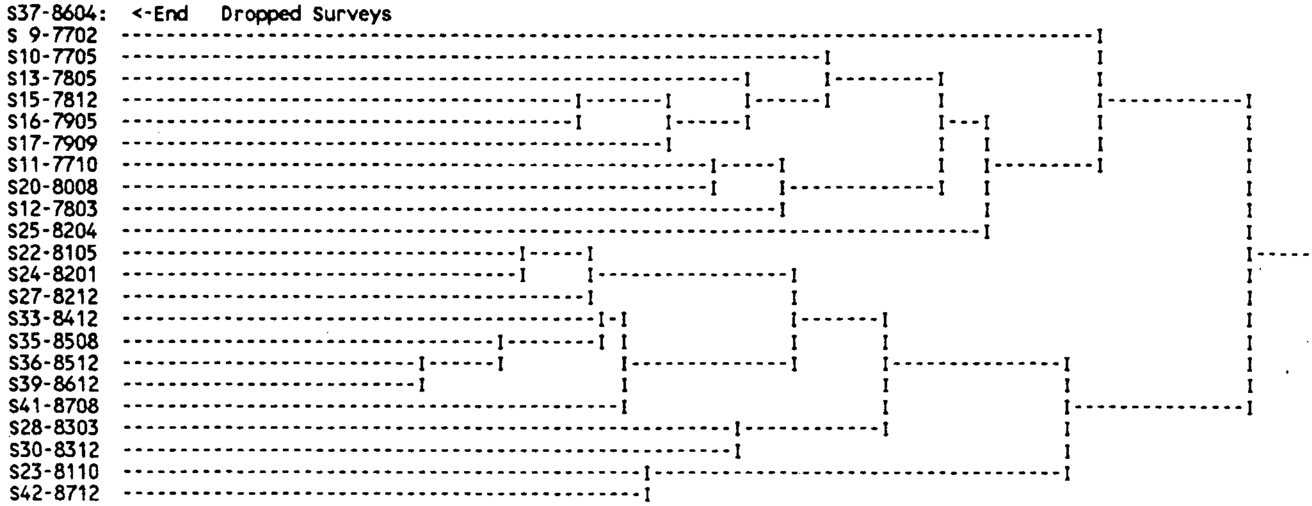
Quad Range USED 31 to 39 for Total of 9 : Range WITH data 14 to 47: : # Dropped 8 : 8.1%
Surveys 35 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.744003: Maximum Distance = 134



Station: LCIX: Haliotis cracherodii: TOTAL Quads with Data = 324

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 4 to 21: : # Dropped 69 : 21.3%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.521999: Maximum Distance = 461

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End Dropped Surveys



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Littorina planaxis (Eroded Periwinkle). Philippi, 1847. Ref. MAH 1980, p. 257.
Phylum Mollusca: **Class** Gastropoda:

Description: Color grey-brown to blackish, sometimes with white spots, columella wide, light in color. Length 0.1 - 1.8+ cm, length about 1.2+ diam. (from MAH). Collumella with conspicuous smooth flattened area.

Distribution: Charleston (Oregon) to Bahia Magdalena (Baja California). Abundant on rocks, upper intertidal and splash zone. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately common occurring in about 20% of our quadrats, locally abundant (1000's per m^2).

Habitat: On rocks and rarely algae, splash zone (in crevices and small depressions) to upper tide levels.

Observational Errors: Smaller specimens can be missed. SDIX and NDIX frequently have sand and gravel covering most of the upper intertidal. Under these conditions the apparent distribution and numbers of this taxon decreases.

Field Identification Problems:

General: Can be easily confused with *L. scutulata*. Such mis-identification has probably occurred <5% of the time. Small *Littorina* spp. that are out of their habitat range (i.e., in mid to low intertidal) could possibly be identified as *Lacuna*.

Station Specific: LCIX's upper quadrats have had relatively high confusion among the Littorines.

General Comments: Field discrimination between *L. planaxis* and *L. scutulata* is completely reliable only when the organism is removed from the rock and the aperture area observed. Our sampling methods preclude such detailed observation for each specimen. In areas where both species occur, a small subsample of specimens were usually removed to check for species.

Impacts to Taxon:

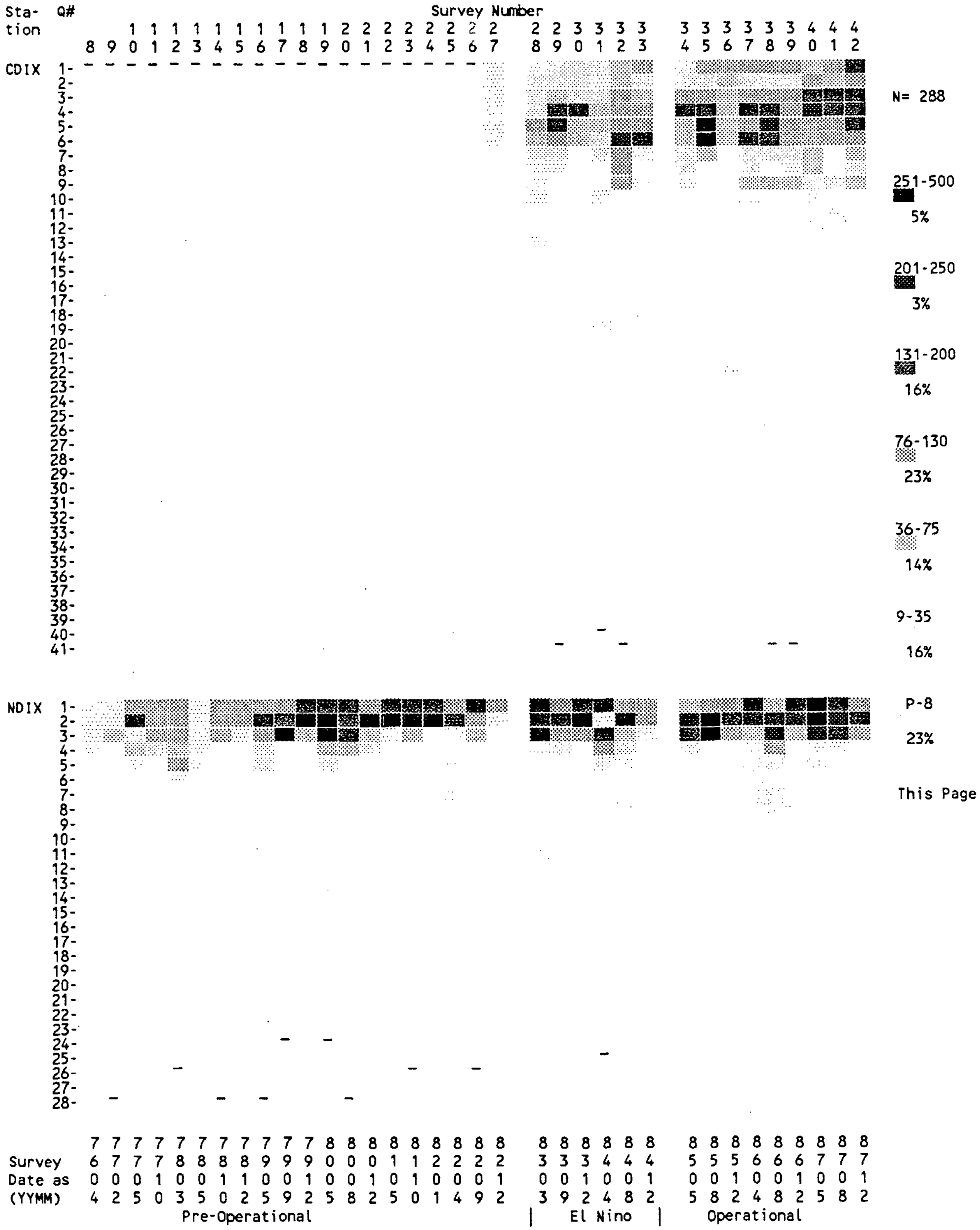
El Niño: 1982-83 winter storm: No easily defined impact at any station.

El Niño: 1983-1984: SDIX and NDIX probably normal (see Observational Errors above concerning sand/gravel cover). CDIX possibly increasing in abundance and range, but with only one pre-operational survey to establish normality. LCIX appeared normal.

Diablo DCPP Operation: SDIX, CDIX, and LCIX little change from El Niño conditions. NDIX possibly having a tendency to extend range into mid tidal area.

Taxon or Category: Littorina planaxis [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

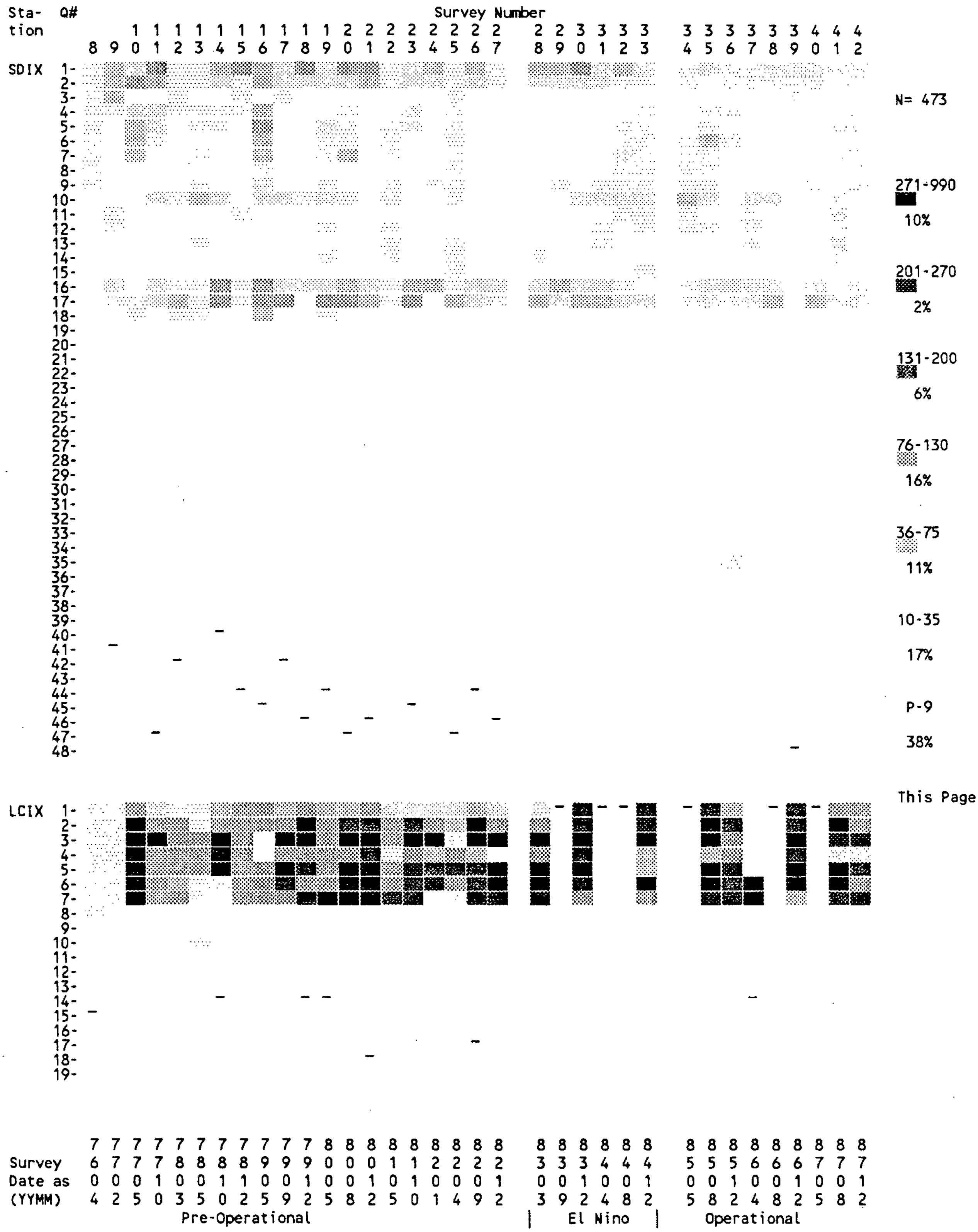


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for LITTPL CSV 5736 3-29-88 7:56a 04-15-1989 09:56

Taxon or Category: Littorina planaxis [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for LITTPL CSV 5736 3-29-88 7:56a 04-15-1989 09:56

Audit: CLUMRG2P: V.1.2: for SLITTPLB CLU 7249 4-23-89 6:12a: 05-16-1989/06:19
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:09:29 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Littorina planaxis [Mixed P/#]: TOTAL Quads with Data = 138

Quad Range USED 1 to 11 for Total of 11 : Range WITH data 1 to 26: : # Dropped 7 : 5.1%
Surveys 16 : Dropped 0 Surveys if quads sampled < 11
COPHENETIC CORRELATION COEFFICIENT = 0.552741: Maximum Distance = 9

```
S27-8212 -------------------------------------------------------------------I
S30-8312 -------------------------------------------------------------------I-----------I
S36-8512 -------------------------------------------------------------------I           I-------I
S35-8508 -------------------------------------------------------------------------------I       I---------I
S31-8404 ---------------------------------------------------------------------------------------I         I-I
S41-8708 -------------------------------------------------------------------------------------------------I I
S28-8303 -------------------------------------------------------------------I                               I
S37-8604 -------------------------------------------------------------------I-----------I                   I
S40-8705 -------------------------------------------------------------------I           I----I              I------
S32-8408 -------------------------------------------------------------------I           I    I              I
S34-8505 -------------------------------------------------------------------I-----------I    II             I
S39-8612 -------------------------------------------------------------------I                II             I
S42-8712 -------------------------------------------------------------------I                II-------------I
S29-8309 ------------------------------------------------------------------------------------II
S33-8412 -------------------------------------------------------------------I-----------------I
S38-8608 -------------------------------------------------------------------I
```

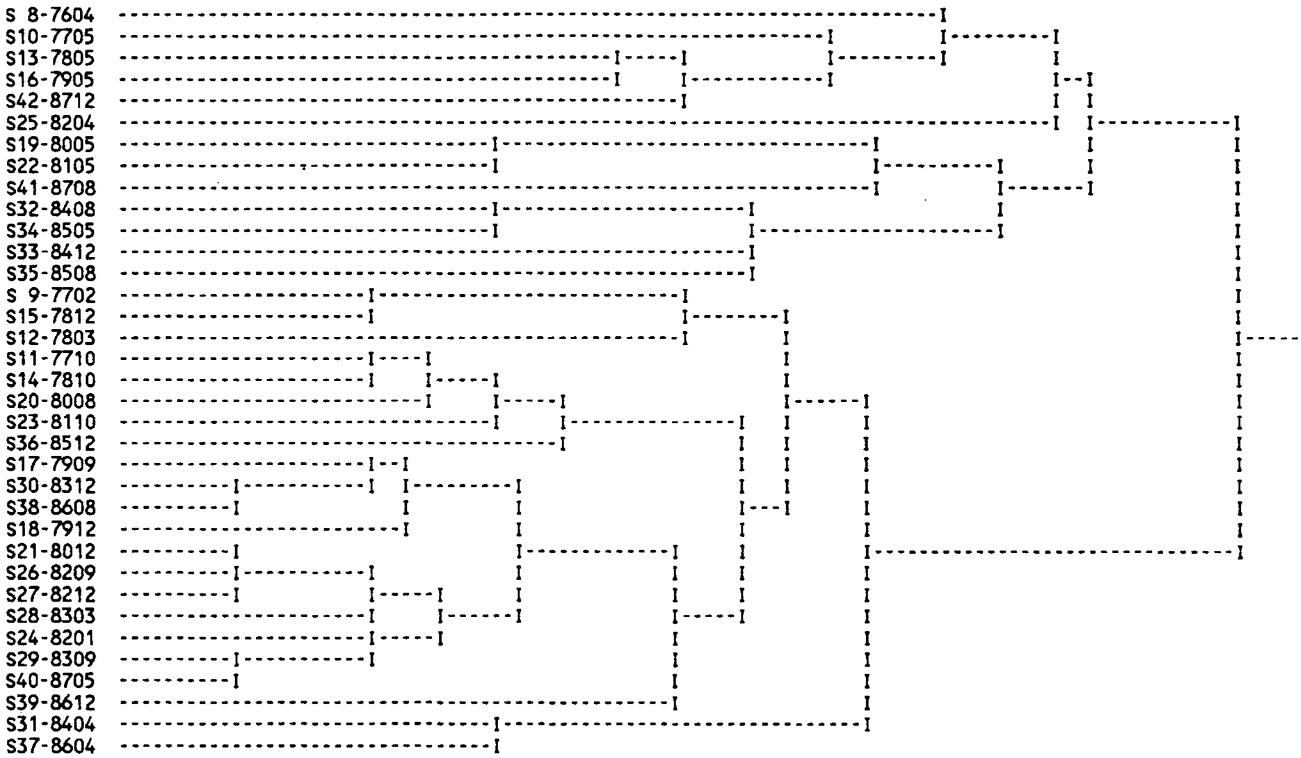
Station: NDIX: Littorina planaxis [Mixed P/#]: TOTAL Quads with Data = 150

Quad Range USED 1 to 10 for Total of 10 : Range WITH data 1 to 16: : # Dropped 3 : 2.0%
Surveys 35 : Dropped 0 Surveys if quads sampled < 10
COPHENETIC CORRELATION COEFFICIENT = 0.795094: Maximum Distance = 8

```
S 8-7604 -------------------------------------I
S11-7710 -------------------------------------I
S20-8008 -------------------------------------I-----------I
S21-8012 -------------------------------------I           I
S28-8303 -------------------------------------I           I
S29-8309 -------------------------------------I           I
S 9-7702 -------------------------------------I           I----I
S14-7810 -------------------------------------I           I    I
S15-7812 -------------------------------------I           I    I
S17-7909 -------------------------------------I           I    I
S18-7912 -------------------------------------I           I    I
S22-8105 -------------------------------------I-----------I    I
S23-8110 -------------------------------------I                I
S26-8209 -------------------------------------I                I--I
S30-8312 -------------------------------------I                I  I
S33-8412 -------------------------------------I                I  I
S35-8508 -------------------------------------I                I  I
S36-8512 -------------------------------------I                I  I----------I
S24-8201 -------------------------------------I----------------I  I          I
S27-8212 -------------------------------------I                I  I          I
S39-8612 ------------------------------------------------------I  I          I
S41-8708 -------------------------------------------------I-------I          I
S42-8712 -------------------------------------------------I                  I
S10-7705 -------------------------------------I                              I
S13-7805 -------------------------------------I                              I-------------------------------I
S16-7905 -------------------------------------I-----------I                  I                               I
S19-8005 -------------------------------------I           I                  I                               I
S31-8404 -------------------------------------I           I----------I       I                               I
S34-8505 -------------------------------------I           I          I       I                               I
S12-7803 -------------------------------------------------I          I------II                               I------
S32-8408 -------------------------------------------------I------I   I      II                               I
S38-8608 -------------------------------------------------I      I---I      II                               I
S40-8705 --------------------------------------------------------I          I                                I
S25-8204 -------------------------------------------------------------------I                                I
S37-8604 ----------------------------------------------------------------------------------------------------I
```

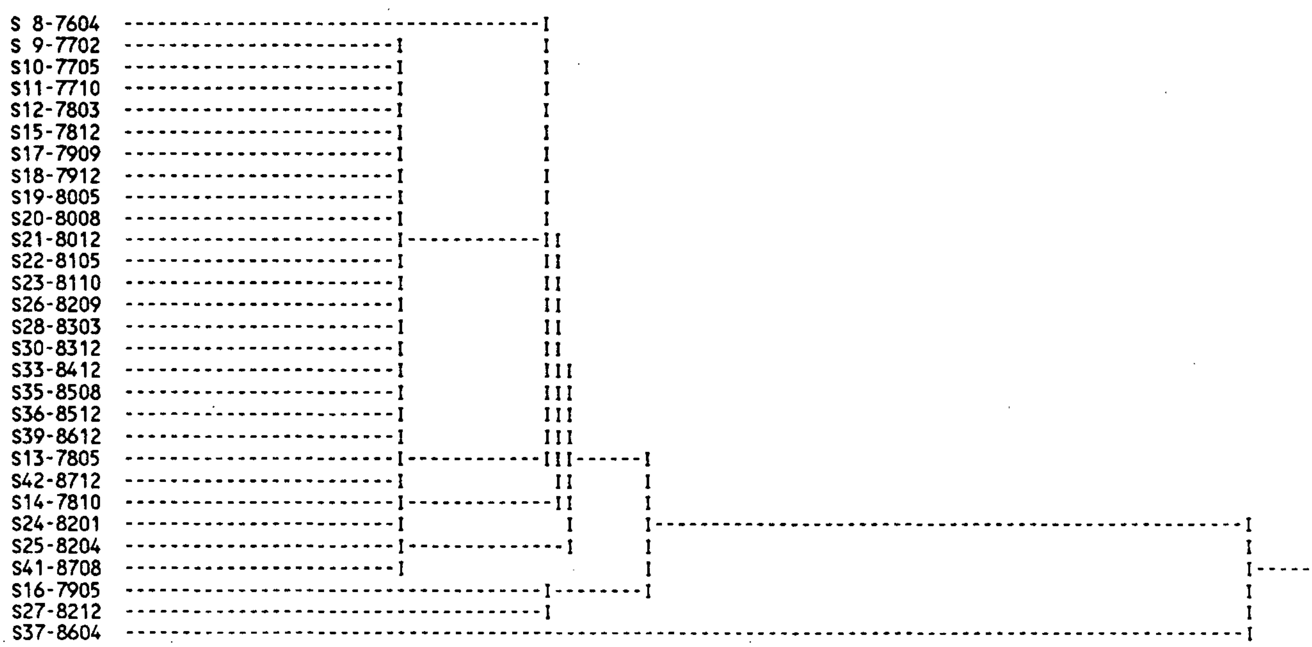
Station: SDIX: Littorina planaxis [Mixed P/#]: TOTAL Quads with Data = 274

Quad Range USED 1 to 18 for Total of 18 : Range WITH data 1 to 35: : # Dropped 1 : 0.4%
Surveys 35 : Dropped 0 Surveys if quads sampled < 18
COPHENETIC CORRELATION COEFFICIENT = 0.707173: Maximum Distance = 9



Station: LCIX: Littorina planaxis [Mixed P/#]: TOTAL Quads with Data = 199

Quad Range USED 1 to 11 for Total of 11 : Range WITH data 1 to 11: : # Dropped 0 : 0.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 11
COPHENETIC CORRELATION COEFFICIENT = 0.948822: Maximum Distance = 8



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Littorina scutulata (Checkered Periwinkle). Gould, 1849. Ref. MAH 1980, p. 259.
Phylum Mollusca: **Class** Gastropoda:

Description: Color grey-brown to black, often with checkered dots. Length 0.2 - 1.1 + cm (1.3 cm, MAH), about 0.7 times as wide as length. (from MAH). Narrow columella lacking flattened area.

Distribution: Kodiak Island (Alaska) to Bahia de Tortuga (Baja California). Rocky shores, abundant in high and upper middle intertidal. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 35% of our quadrats and locally abundant (to about 300 per m^2).

Habitat: On rocks and rarely algae, upper to mid tide levels (extending to mid-lower intertidal during operational phase).

Observational Errors: Smaller specimens can be missed. (see also comments for *L. planaxis*).

Field Identification Problems:

General: Can be easily confused with *L. planaxis*. Upper intertidal quadrats are probably the worst offenders for such confusion. Such mis-identification has probably occurred <5% of the time. Small *Littorina* spp. that are out of their habitat (i.e. in mid to low intertidal) could possibly be identified as *Lacuna*.

Station Specific: LCIX's upper quadrats have had relatively high confusion among the Littorines.

General Comments: see comments for *L. planaxis*.

Impacts to Taxon:

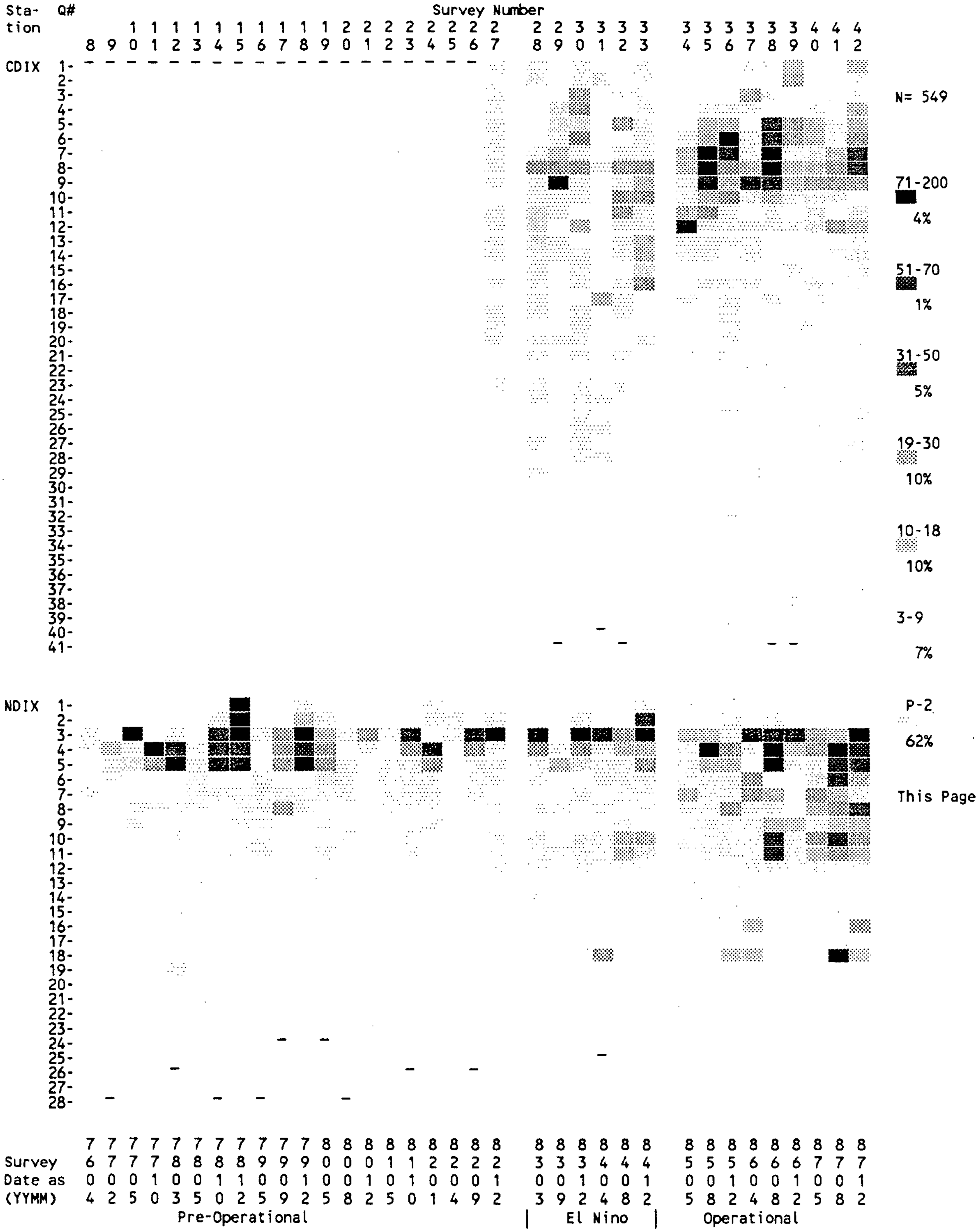
El Niño: 1982-83 winter storm: No clear-cut impact at any station.

El Niño: 1983-1984: All Cove stations' populations sporadically extended their distribution downward in the intertidal (CDIX?). LCIX apparently losing part of its lower range, perhaps an artifact of missed observations due to presence of dense algal mat.

Diablo DCPP Operation: SDIX probably returning to normal, but slight trend towards retaining some of its downward range extension from El Niño responses. NDIX retaining its downward extension (some sporadic retreats), with a possible increase in numbers. CDIX much as El Niño conditions with sporadic fluctuation in numbers and occurrences. LCIX as pre-operational.

Taxon or Category: Littorina scutulata [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

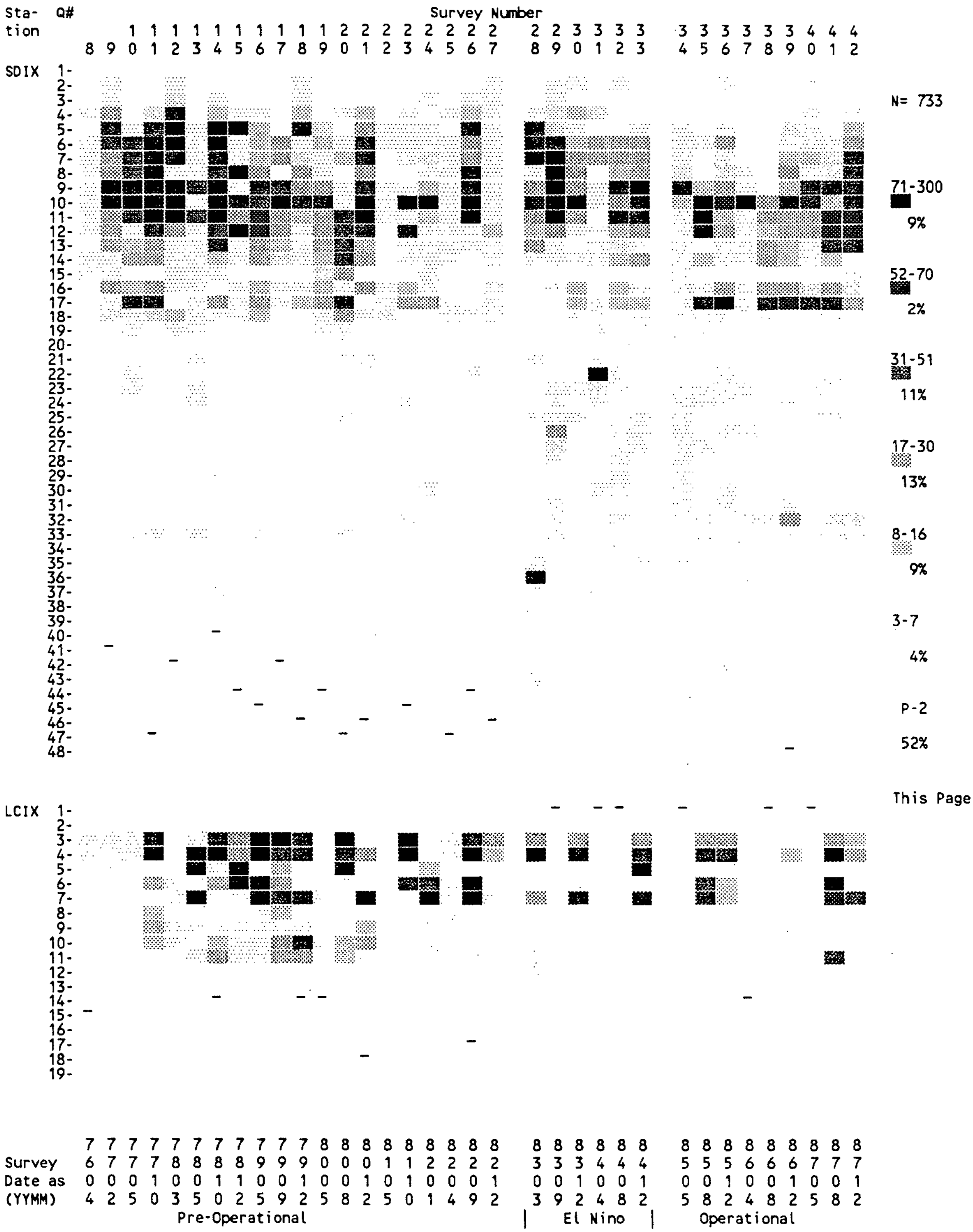


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for LITTSC CSV 6382 3-29-88 7:57a 04-15-1989 09:56

Taxon or Category: Littorina scutulata [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for LITTSC CSV 6382 3-29-88 7:57a 04-15-1989 09:56

```
Audit: CLUMRG2P: V.1.2: for SLITTSCB CLU     7249   4-23-89   6:17a:   04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:13:39 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
       METHOD:  GROUP AVERAGE:  ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL:  >> BINARY << Data Used
```

Station: CDIX: Littorina scutulata [Mixed P/#]: TOTAL Quads with Data = 246

```
        Quad Range USED 1 to 28 for Total of 28 :  Range WITH data 1 to 40:  :  # Dropped  8 :    3.3%
        Surveys  16 :  Dropped  0 Surveys if quads sampled < 28
        COPHENETIC CORRELATION COEFFICIENT = 0.526953:                         Maximum Distance = 18

S27-8212  --------------------------------I--------I
S33-8412  --------------------------------I        I------------------I
S42-8712  -----------------------------------------I                  I--I
S30-8312  ------------------------------------------------------------I  I------I
S28-8303  ---------------------------------------------------------------I      I
S29-8309  ---------------------I-------------I                                  I
S35-8508  ---------------------I             I----------I                       II
S34-8505  -----------------------------------I          I--------I              II
S37-8604  --------------------------------I-------------I        I              II
S41-8708  --------------------------------I                      I--------------II
S32-8408  --------------------------------------------I----I     I               I---------------------------I
S36-8512  --------------------------------------------I    I-----I               I                           I
S38-8608  --------------------------------I----------------I                     I                           I------
S40-8705  --------------------------------I                                      I                           I
S39-8612  -----------------------------------------------------------------------I                           I
S31-8404  ---------------------------------------------------------------------------------------------------I
```

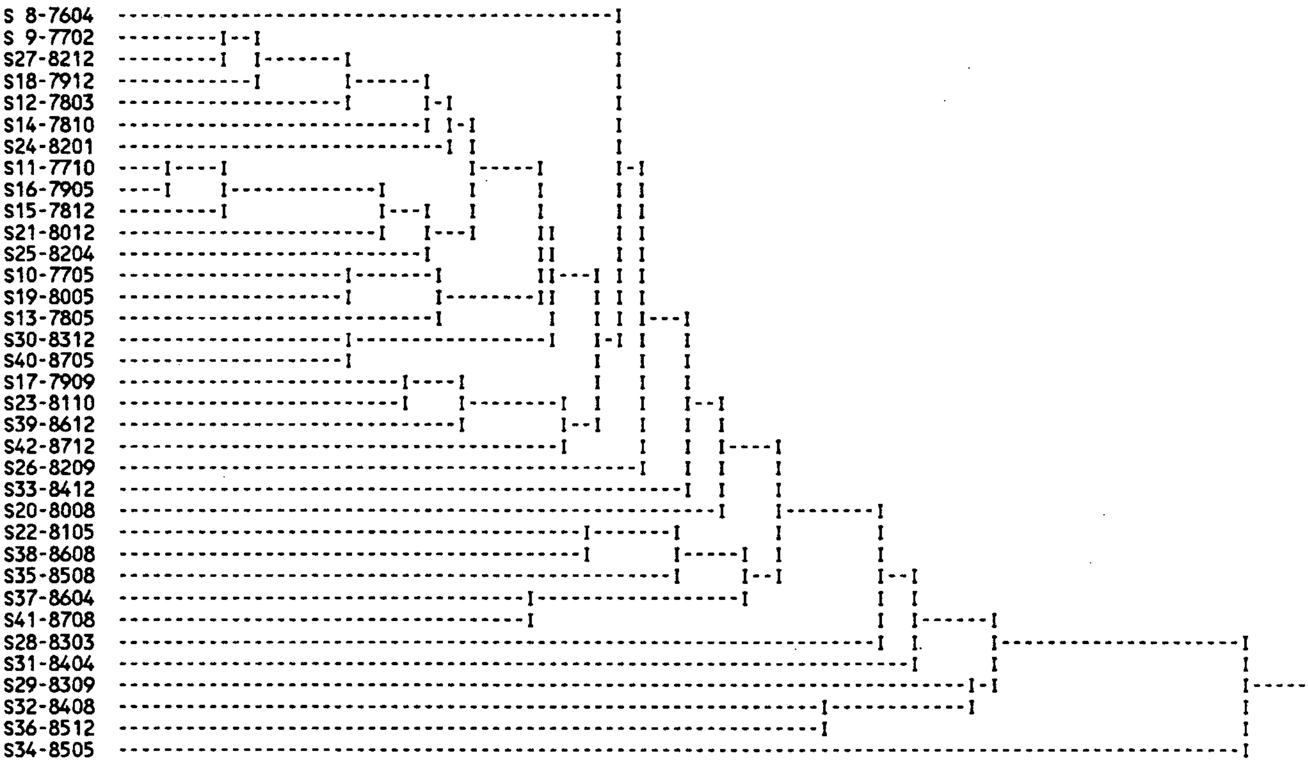
Station: NDIX: Littorina scutulata [Mixed P/#]: TOTAL Quads with Data = 303

```
        Quad Range USED 2 to 18 for Total of 17 :  Range WITH data 1 to 22:  :  # Dropped  9 :    3.0%
        Surveys  35 :  Dropped  0 Surveys if quads sampled < 18
        COPHENETIC CORRELATION COEFFICIENT = 0.633414:                         Maximum Distance = 9

S 8-7604  ----------I-----------------I
S21-8012  ----------I                 I----------------------I
S25-8204  ----------------------------I                      I
S 9-7702  ----------------------I----------I                 I
S11-7710  ----------------------I          I-----------I     I------------I
S13-7805  ---------------------------------I           I---I I            I
S20-8008  ---------------------------------I-----------I   I I            I
S22-8105  ----------------------I----------I               I I            I
S26-8209  ----------------------I                          I-I            I
S10-7705  ---------------------------------I------------I  I              I
S12-7803  ---------------------------------I            I  I              I--------I
S14-7810  ----------I-----I                             I--I              I        I
S18-7912  ----------I     I-------------I               I                 I        I
S17-7909  ----------------I             I--------I      I                 I        I-------------------------I
S15-7812  ------------------------------I        I------I                 I        I                         I
S24-8201  ---------------------------------------I                        I        I                         I
S19-8005  ----------------------------------------------------------------I        I                         I
S29-8309  -------------------------------------------------------------------------I                         I
S16-7905  ---------------------------------I-------------I                                                   I
S23-8110  ---------------------------------I             I----------------------I                            I------
S27-8212  ----------------------I----------I             I                      I                            I
S33-8412  ----------------------I          I-------------I                      I---I                        I
S40-8705  ---------------------------------I                                    I   I                        I
S39-8612  ----------------------------------------------------------------------I   I                        I
S28-8303  ---------------------------------I---------------------I                  I                        I
S31-8404  ---------------------------------I                     I                  I------------------------I
S34-8505  ----------------------I----------I                     I--------I         I
S36-8512  ----------------------I          I--I                  I        I         I
S35-8508  ----------I----------------------I  I------------------I        I         I
S41-8708  ----------I                         I                           I---------I
S37-8604  ----------I-------------------------I                           I
S42-8712  ----------I                                                     I
S30-8312  ---------------------------------I-----------------I            I
S32-8408  ---------------------------------I                 I------------I
S38-8608  ---------------------------------------------------I
```

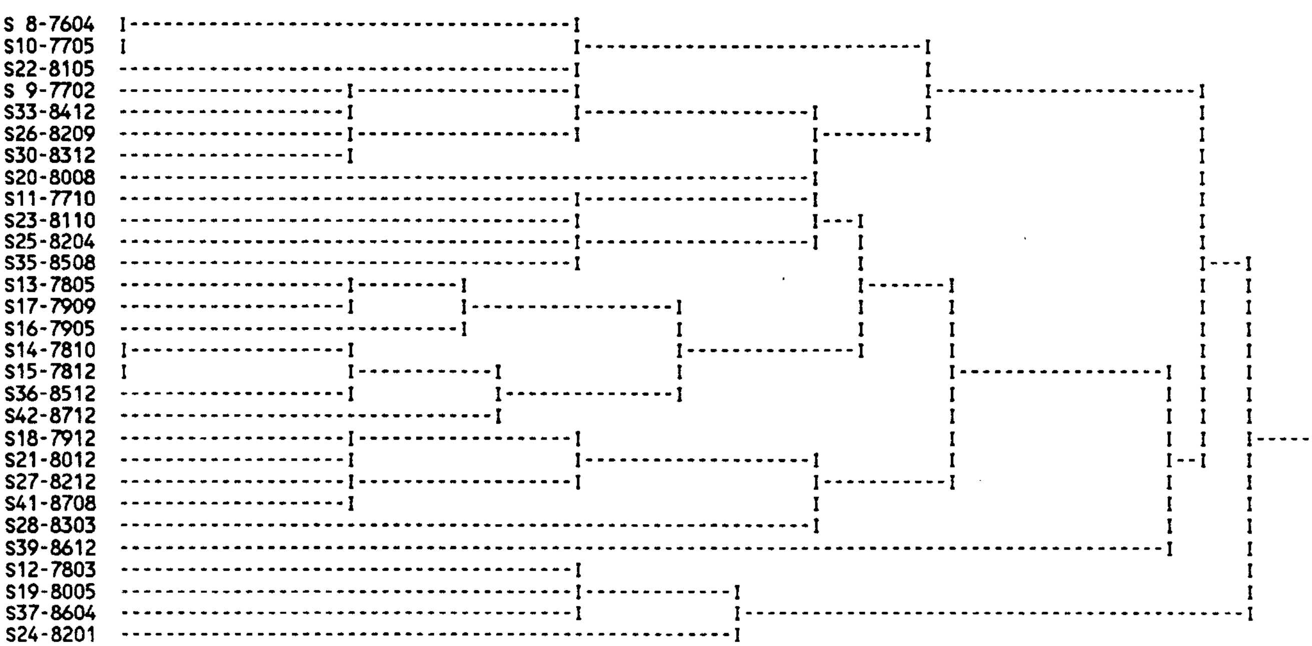
Station: SDIX: Littorina scutulata [Mixed P/#]: TOTAL Quads with Data = 576

Quad Range USED 2 to 39 for Total of 38 : Range WITH data 2 to 49: : # Dropped 9 : 1.6%
Surveys 35 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.738772: Maximum Distance = 19



Station: LCIX: Littorina scutulata [Mixed P/#]: TOTAL Quads with Data = 158

Quad Range USED 3 to 12 for Total of 10 : Range WITH data 3 to 12: : # Dropped 0 : 0.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 12
COPHENETIC CORRELATION COEFFICIENT = 0.512964: Maximum Distance = 5



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Mopalia spp. (Chiton) Ref: MAH 1980, p. 420ff.
Phylum Mollusca: **Class** Polyplacophora:

Description: Girdle bristled, valves often covered with algal growth. Length 1 - 6+ cm.

Distribution: see below. Mixed warm-tolerant intolerant group.

Diablo Area Specific Information: Sparse data set, occurring in about 5% of our quadrats.

Habitat: On rocks, mid to low tide levels. Occurs on algal covered rocks.

Observational Errors: Small chitons (<1 cm) that may be this group have been identified as "unid. chiton, juveniles". Missed observations are probably moderately common (>10%) and occur in areas with dense algal cover. Some members of this group can be densely overgrown with algae and blend in so well that they are easily missed. In our early surveys (from beginning of our study to Mar. 78), we did not routinely field identify this taxon.

Field Identification Problems:

General: Possibly rarely confused with *Placaphorella* (rare in our intertidal areas) if only posterior part of animal visible.

Station Specific: none.

General Comments: *Mopalia muscosa* is the most common *Mopalia* in our study area but uncertainty exists because we have not performed extensive collections and dissections of this group.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Removed from SDIX and NDIX, i.e., algal mat severely pruned, or overlain with cobble, so missed observations very unlikely. CDIX possibly with some decrease. LCIX never common.

El Niño: 1983-1984: SDIX and NDIX with sporadic occurrences. CDIX possibly with a declining population. LCIX possibly with a slight increase in occurrences above normal.

Diablo DCPP Operation: SDIX probably normal (but missed observations probably fewer than before, because of thinned algal mat). NDIX and CDIX with increase in numbers and occurrences, but decreasing towards end of 1987. LCIX returning to normal, i.e., very few organisms.

M. acuta: Monterey Bay to Rancho Socorro (northern Baja California).

M. ciliata: Aleutian Islands (Alaska) to Baja California.

M. hindsii: Auke Bay (Alaska) to Ventura Co. (California).

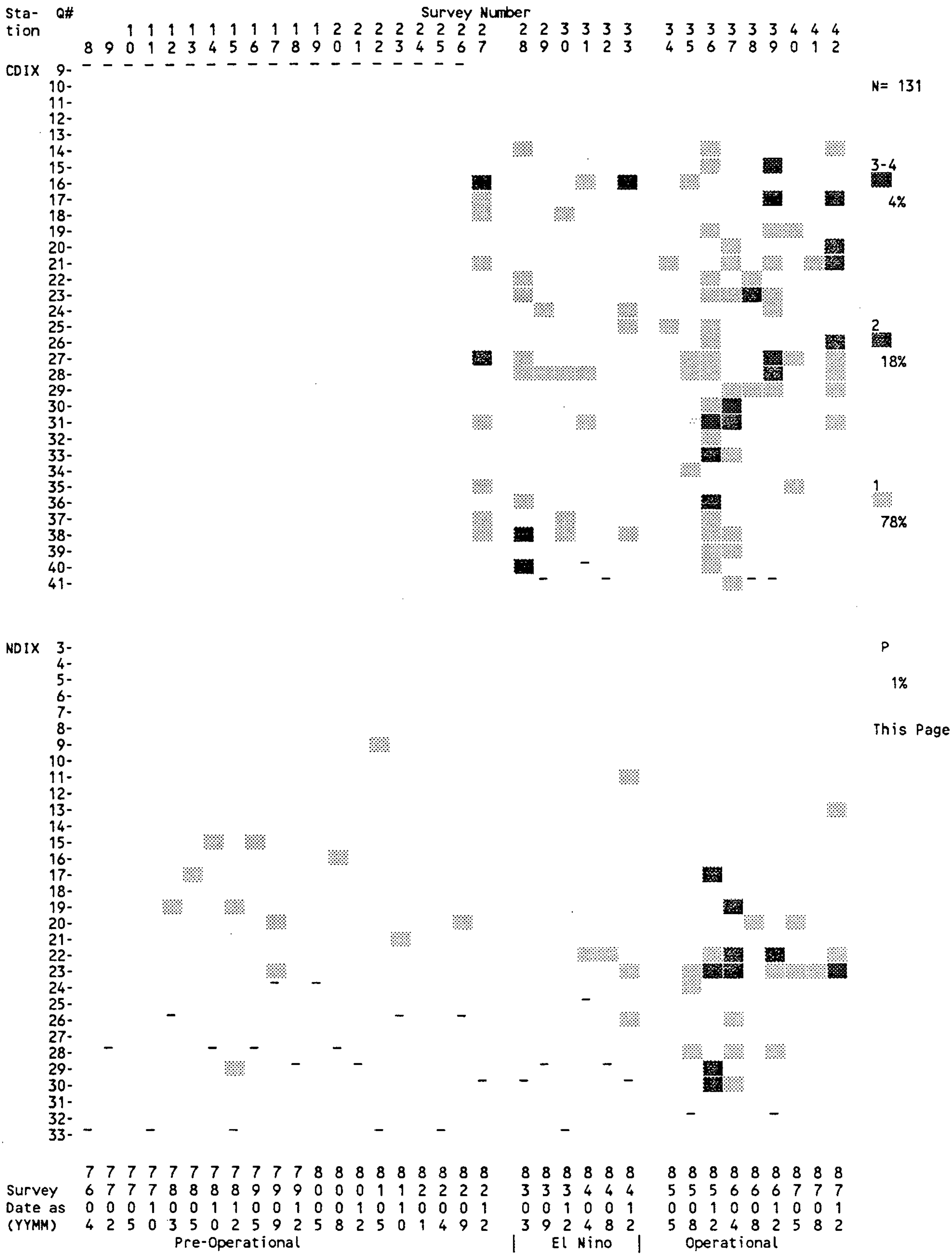
M. lowei: Bodega Bay to La Jolla (California).

M. lignosa: Prince William Sound (Alaska) to Pt. Conception (California).

M. muscosa: Queen Charlotte Islands (British Columbia) to Isla Cedros (Baja California).

Taxon or Category: Mopalia spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

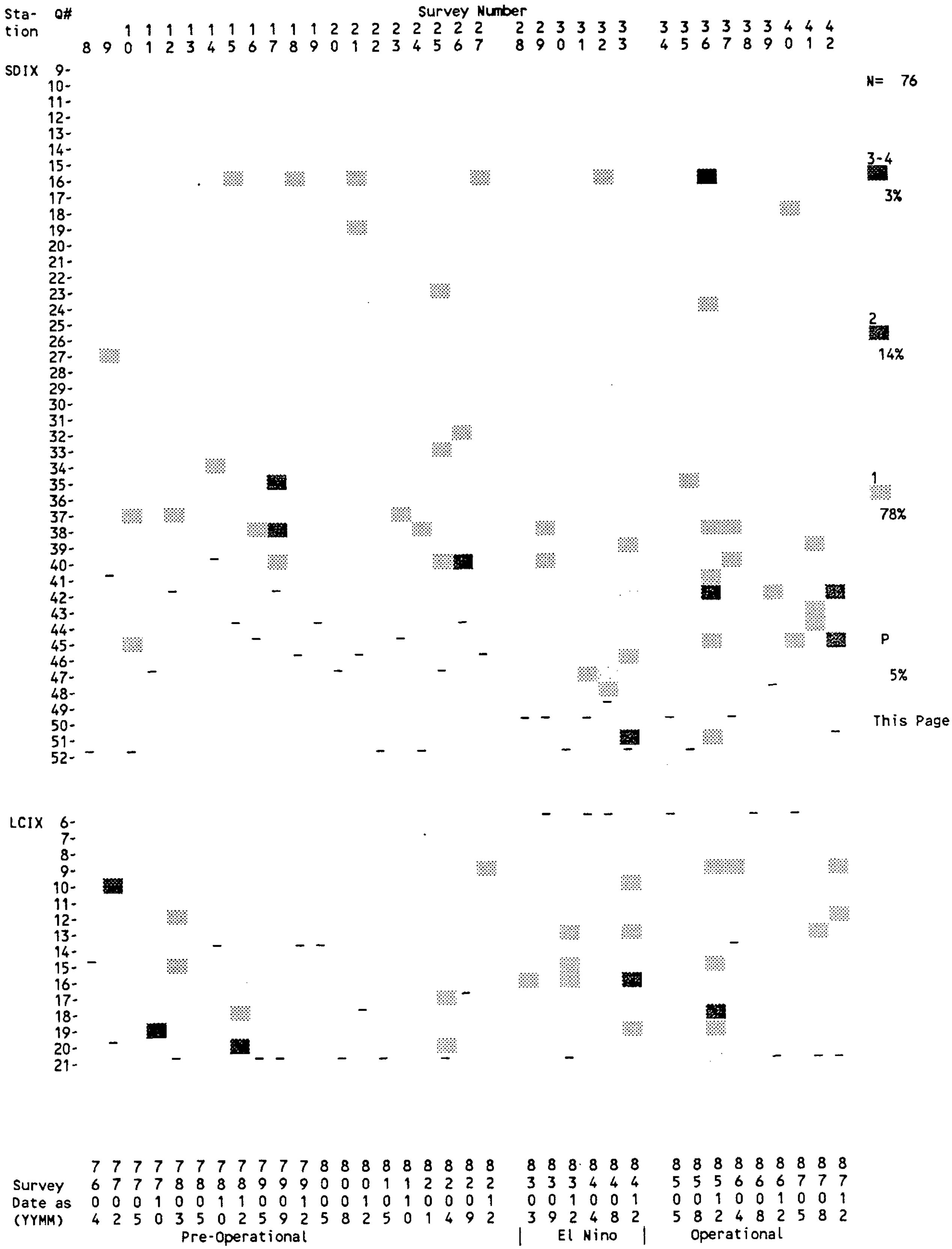


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for MOPALI CSV 5250 3-29-88 7:59a 04-15-1989 06:29

Taxon or Category: Mopalia spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for MOPALI CSV 5250 3-29-88 7:59a 04-15-1989 06:29

Audit: CLUMRG2P: V.1.2: for SMOPALIB CLU 6581 4-23-89 6:22a: 04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:19:16 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Mopalia spp. [Mixed P/#]: TOTAL Quads with Data = 90

Quad Range USED 14 to 39 for Total of 26 : Range WITH data 14 to 41: : # Dropped 3 : 3.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.736712: Maximum Distance = 16

```
S27-8212 ------------------------------------------------------------I
S28-8303 --------------------------------------------------I         I
S29-8309 -------------------I                              I         I-I
S32-8408 -----I--I          I-------I                      I         I I
S41-8708 -----I  I----------I       I--I                   I         I I
S34-8505 --------I                  I  II                  I---------I I
S33-8412 ---------------------------I  II--I               I           I
S38-8608 ------------------------------II  I-I             I           I-----I
S40-8705 -------------------------------I  I I             I           I     I
S31-8404 -------------I--------------------I I-------------I           I     I
S35-8508 -------------I                      I                         I     I-----------------------------------I
S30-8312 ------------------------------------I                         I     I                                   I
S39-8612 ----------------------------------------------------I---------I     I                                   I------
S42-8712 ----------------------------------------------------I               I                                   I
S37-8604 --------------------------------------------------------------------I                                   I
S36-8512 --------------------------------------------------------------------------------------------------------I
```

Station: NDIX: Mopalia spp. [Mixed P/#]: TOTAL Quads with Data = 41

Quad Range USED 15 to 27 for Total of 13 : Range WITH data 9 to 30: : # Dropped 16 : 39.0%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.794653: Maximum Distance = 8

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 -----------------------------------------------------I
S 9-7702 -----------------------------------------------------I
S10-7705 -----------------------------------------------------I
S11-7710 -----------------------------------------------------I
S18-7912 -----------------------------------------------------I
S21-8012 -----------------------------------------------------I
S22-8105 -----------------------------------------------------I------------I
S24-8201 -----------------------------------------------------I            I
S25-8204 -----------------------------------------------------I            I
S27-8212 -----------------------------------------------------I            I
S28-8303 -----------------------------------------------------I            II
S29-8309 -----------------------------------------------------I            II
S30-8312 -----------------------------------------------------I            III
S34-8505 -----------------------------------------------------I            III
S13-7805 ------------------------------------------------------------------IIII
S14-7810 -----------------------------------------------------I-------------III
S16-7905 -----------------------------------------------------I              II-------I
S15-7812 --------------------------------------------------------------------II       I-I
S20-8008 ---------------------------------------------------------------------I       I I
S38-8608 ------------------------------------------------------------------I----------I I---I
S40-8705 ------------------------------------------------------------------I            I   I
S33-8412 ------------------------------------------------------------------I------I     I   I
S41-8708 ------------------------------------------------------------------I      I-----I   I---------------------I
S35-8508 -------------------------------------------------------------------------I         I                     I
S32-8408 ------------------------------------------------------------------I---I            I                     I
S39-8612 -----------------------------------------------------I------------I   I------------I                     I-----
S42-8712 -----------------------------------------------------I                I                                  I
S36-8512 ----------------------------------------------------------------------I                                  I
S37-8604 ---------------------------------------------------------------------------------------------------------I
```

Station: SDIX: Mopalia spp. [Mixed P/#]: TOTAL Quads with Data = 49

Quad Range USED 16 to 43 for Total of 28 : Range WITH data 16 to 51: : # Dropped 17 : 34.7%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.692661: Maximum Distance = 18

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604 -----------------------------------------------------------------------I
S11-7710 -----------------------------------------------------------------------I
S13-7805 -----------------------------------------------------------------------I
S19-8005 -----------------------------------------------------------------------I
S20-8008 -----------------------------------------------------------------------I
S22-8105 -----------------------------------------------------------------------I
S28-8303 -----------------------------------------------------------------------I
S30-8312 -----------------------------------------------------------------------I----I
S31-8404 -----------------------------------------------------------------------I    I
S34-8505 -----------------------------------------------------------------------I    II
S38-8608 -----------------------------------------------------------------------I    II
S10-7705 -----------------------------------------------------------------------I----III
S23-8110 -----------------------------------------------------------------------I     III
S35-8508 -----------------------------------------------------------------------------III
S40-8705 ------------------------------------------------------------------------------II-I
S15-7812 -----------------------------------------------------------------------I       I I
S18-7912 -----------------------------------------------------------------------I----I  I I
S27-8212 -----------------------------------------------------------------------I    I--I II
S32-8408 -----------------------------------------------------------------------I    I    II
S21-8012 ----------------------------------------------------------------------------I    II
S33-8412 ----------------------------------------------------------------------------I----II--I
S39-8612 -----------------------------------------------------------------------I----I     I  I
S42-8712 -----------------------------------------------------------------------I          I  I
S16-7905 -----------------------------------------------------------------------I----I     I  II
S24-8201 -----------------------------------------------------------------------I    I-----I  II
S29-8309 -----------------------------------------------------------------------I----I        II----I
S37-8604 -----------------------------------------------------------------------I             II    I
S26-8209 -------------------------------------------------------------------------------------II    I-------I
S41-8708 --------------------------------------------------------------------------------------I    I       I------
S25-8204 -------------------------------------------------------------------------------------------I       I
S36-8512 ---------------------------------------------------------------------------------------------------I
```

Station: LCIX: Mopalia spp. [Mixed P/#]: TOTAL Quads with Data = 27

Quad Range USED 9 to 19 for Total of 11 : Range WITH data 9 to 21: : # Dropped 4 : 14.8%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.817834: Maximum Distance = 6

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702 ------------------------------------------------I
S10-7705 --------------------------------I               I
S13-7805 --------------------------------I               II
S16-7905 --------------------------------I               II
S17-7909 --------------------------------I               II
S20-8008 --------------------------------I---------------II
S22-8105 --------------------------------I                 I-I
S23-8110 --------------------------------I                 I I
S24-8201 --------------------------------I                 I II
S35-8508 --------------------------------I                 I II
S11-7710 --------------------------------------------------I III
S15-7812 ----------------------------------------------------IIII
S25-8204 -----------------------------------------------------III-------I
S28-8303 ------------------------------------------------------II       I-I
S41-8708 -------------------------------------------------------I       I I
S12-7803 ------------------------------------------------I--------------I I---------------------------I
S39-8612 ------------------------------------------------I                I                           I
S27-8212 ------------------------------------------------I----------------I                           I------I
S42-8712 ------------------------------------------------I                                            I      I
S30-8312 ---------------------------------------------------------------------------------I-----------I      I------
S33-8412 ---------------------------------------------------------------------------------I
S36-8512 ----------------------------------------------------------------------------------------------------I
```

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Mytilus californianus (California Mussel). Conrad, 1837. Ref. MAH 1980, p 360.
Phylum Mollusca: **Class** Bivalvia:

Description: Shell inflated, pointed at attachment end, broadening, blue-black in color. Sculpture of radial ribs and irregular growth lines. Length 0.2 - 13+ cm. (from MAH).

Distribution: Aleutian Islands (Alaska) to southern Baja California. Upper-mid intertidal on exposed coasts, forming extensive beds; subtidal to 24 m depth. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately sparse data set, occurring in about 10% of our quadrats, never forming large mats at any of our stations.

Habitat: On rocks, upper-mid to low tide levels, juveniles often nestling in algal mat.

Observational Errors: Small individuals (<0.5 cm) often occur among algal mats (mainly *Endocladia*), and these are easy to miss. Missed observations were probably moderately common (5%) and occurred in areas with dense algal cover. For earlier surveys this taxon was usually quantified as percent cover.

Field Identification Problems:

General: Small individuals (<0.3 cm) possibly rarely confused with other mytillids.

Station Specific: none.

General Comments: Most of the adult *Mytilus* in our station areas were of small to moderate sizes (~4 cm), often without well-developed ribbing. Smaller *Mytilus* in general do not have easily observable radial ridges, which is the major field distinguishable feature of *M. californianus*. For this reason we called *Mytilus* sp.

Impacts to Taxon:

El Niño: 1982-83 winter storm: SDIX and NDIX, no change, i.e., established populations lacking. CDIX and LCIX no detectable change.

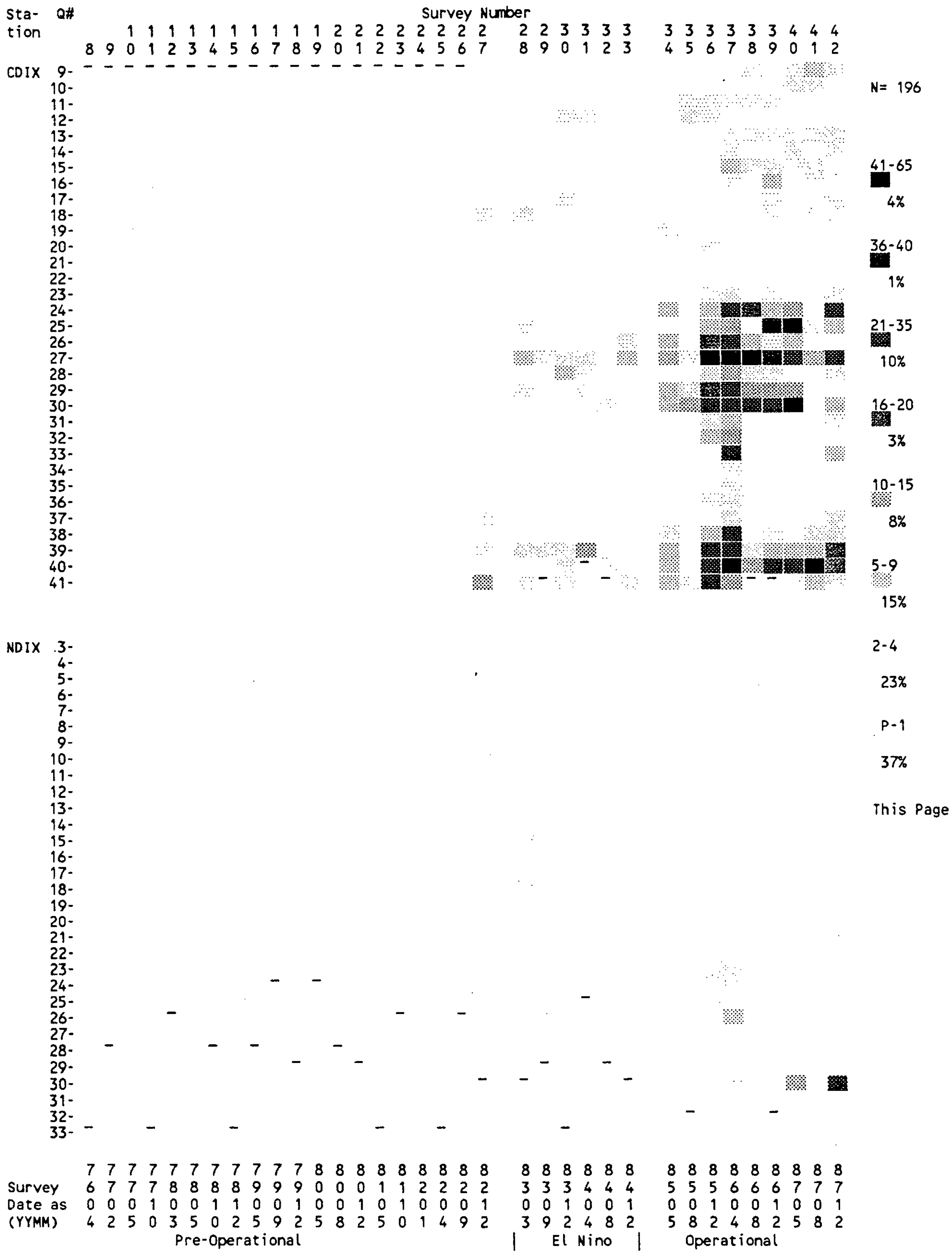
El Niño: 1983-1984: CDIX possibly with slight expansion into lower intertidal. All other stations with no change.

Diablo DCPP Operation: SDIX with sporadic scattered occurrences, but with no population establishing itself. NDIX trending towards developing a population in the mid to lower intertidal. CDIX with well developed population of smaller individuals throughout most of the quadrats of the mid to lower intertidal, however sporadic in the lower reaches. LCIX possibly with declining numbers, but maintaining its normal 3 quadrat range.

Mytilus edulis: Arctic Ocean to Isla Cedros (Baja California); and many other parts of world. Low intertidal; subtidal to 40 m depth. Bays and sheltered areas. Shell more inflated than *M. californianus*, Lacking radial ribs. Length to 10 cm. (from MAH).

Taxon or Category: Mytilus sp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

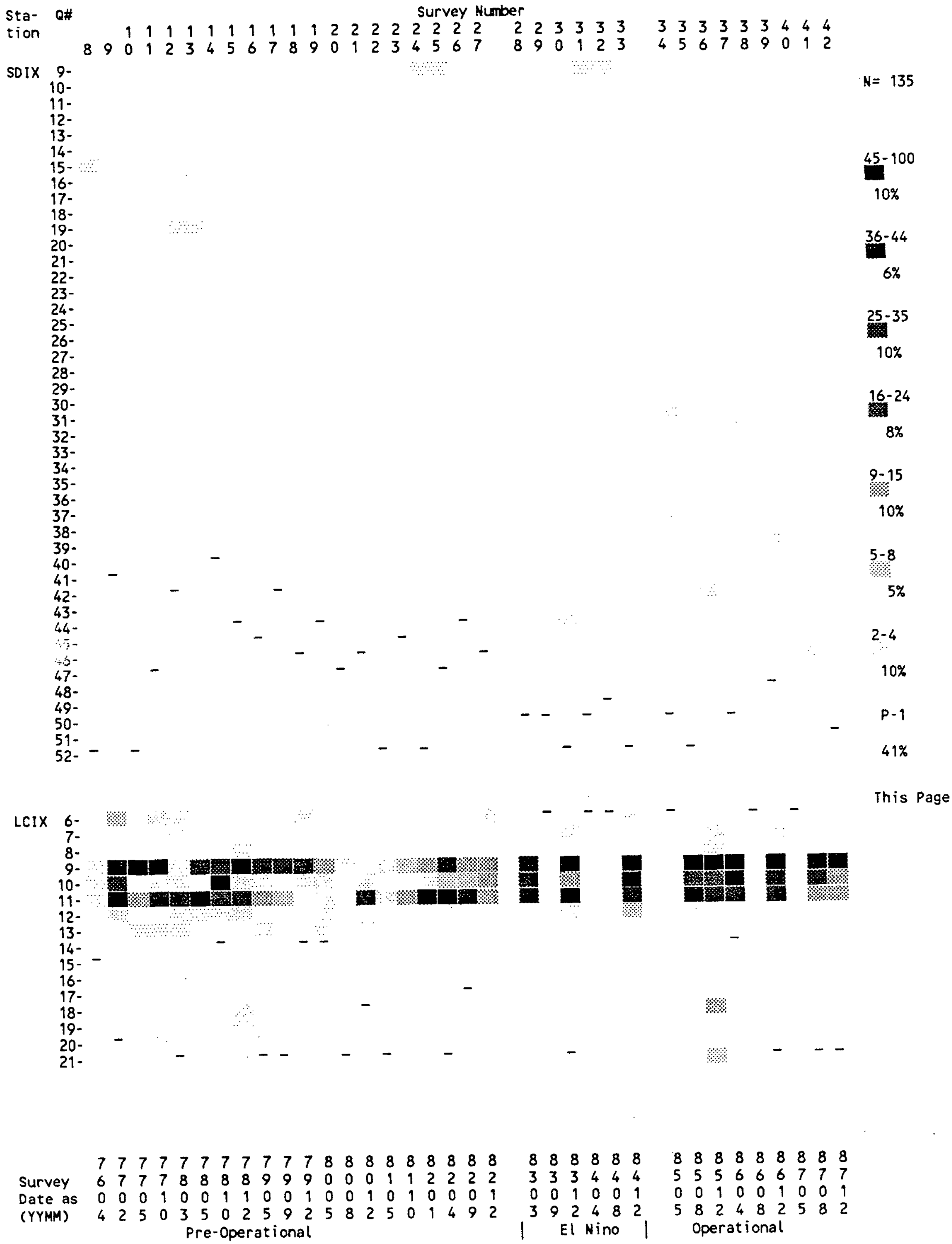


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for MYTILU CSV 5220 3-29-88 7:59a 04-15-1989 06:29

Taxon or Category: Mytilus sp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for MYTILU CSV 5220 3-29-88 7:59a 04-15-1989 06:29

Audit: CLUMRG2P: V.1.2: for SMYTILUB CLU 6581 4-23-89 6:34a: 04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:24:45 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Mytilus sp. [Mixed P/#]: TOTAL Quads with Data = 165

Quad Range USED 9 to 40 for Total of 32 : Range WITH data 6 to 41: : # Dropped 21 : 12.7%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.603754: Maximum Distance = 17

```
S31-8404: <-Start Dropped Surveys
S27-8212 ---------------------------------I
S28-8303 ---------------------------------I-----I
S29-8309 ----------------------I----------I     I----I
S33-8412 ----------------------I                I    I-I
S32-8408 ---------------------------------------I    I I---------------------------I
S35-8508 --------------------------------------------I I                           I
S30-8312 ----------------------------------------------I                           I-------------------------I
S34-8505 -----------------------------------------------------I---------I          I                         I
S38-8608 ---------------------------------------I-------------I         I------I   I                         I
S40-8705 ---------------------------------------I                       I      I---I                         I------
S39-8612 ---------------------------------------------------------------I      I                             I
S41-8708 ----------------------------------------------------------------------I                             I
S36-8512 ---------------------------------------------------------------------I----------------I             I
S37-8604 ---------------------------------------------------------------------I                I-------------I
S42-8712 --------------------------------------------------------------------------------------I
```

Station: NDIX: Mytilus sp. [Mixed P/#]: TOTAL Quads with Data = 35

Quad Range USED 3 to 27 for Total of 25 : Range WITH data 3 to 30: : # Dropped 8 : 22.9%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.907035: Maximum Distance = 18

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End  Dropped Surveys
S 8-7604 -------------------------------------------------------I
S 9-7702 -------------------------------------------------------I
S10-7705 -------------------------------------------------------I
S11-7710 -------------------------------------------------------I
S13-7805 -------------------------------------------------------I
S14-7810 -------------------------------------------------------I
S15-7812 -------------------------------------------------------I
S16-7905 -------------------------------------------------------I
S18-7912 -------------------------------------------------------I-----I
S20-8008 -------------------------------------------------------I     I
S21-8012 -------------------------------------------------------I     I
S22-8105 -------------------------------------------------------I     I
S24-8201 -------------------------------------------------------I     I
S25-8204 -------------------------------------------------------I     II
S29-8309 -------------------------------------------------------I     II
S30-8312 -------------------------------------------------------I     II
S32-8408 -------------------------------------------------------I     II
S35-8508 -------------------------------------------------------I     II--I
S27-8212 -------------------------------------------------------------II  I
S33-8412 -------------------------------------------------------------II  I
S34-8505 --------------------------------------------------------------I  I-------I
S38-8608 --------------------------------------------------------------I  I       I
S28-8303 -------------------------------------------------------------I---I       I
S41-8708 -------------------------------------------------------------I   I       I---------------I
S39-8612 -------------------------------------------------------------I---I       I               I
S40-8705 -------------------------------------------------------------I           I               I----------I
S36-8512 -------------------------------------------------------------------------I               I          I------
S37-8604 -----------------------------------------------------------------------------------------I          I
S42-8712 ----------------------------------------------------------------------------------------------------I
```

Station: SDIX: Mytilus sp. [Mixed P/#]: TOTAL Quads with Data = 18

Quad Range USED 9 to 43 for Total of 35 : Range WITH data 9 to 52: : # Dropped 5 : 27.8%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.463324: Maximum Distance = 28

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  --------------------------------------------------------------------------------------------I
S10-7705  ----------------------------------------------------------------------------------------I   I
S11-7710  ----------------------------------------------------------------------------------------I   I
S15-7812  ----------------------------------------------------------------------------------------I   I
S16-7905  ----------------------------------------------------------------------------------------I   I
S18-7912  ----------------------------------------------------------------------------------------I   I
S19-8005  ----------------------------------------------------------------------------------------I   I
S20-8008  ----------------------------------------------------------------------------------------I   I
S21-8012  ----------------------------------------------------------------------------------------I   I
S22-8105  ----------------------------------------------------------------------------------------I   I
S23-8110  ----------------------------------------------------------------------------------------I   I
S26-8209  ----------------------------------------------------------------------------------------I---I
S27-8212  ----------------------------------------------------------------------------------------I   II
S28-8303  ----------------------------------------------------------------------------------------I   II
S29-8309  ----------------------------------------------------------------------------------------I   II
S30-8312  ----------------------------------------------------------------------------------------I   II
S33-8412  ----------------------------------------------------------------------------------------I   II
S35-8508  ----------------------------------------------------------------------------------------I   II
S38-8608  ----------------------------------------------------------------------------------------I   II
S40-8705  ----------------------------------------------------------------------------------------I   II
S41-8708  ----------------------------------------------------------------------------------------I   II--I
S42-8712  ----------------------------------------------------------------------------------------I   II  I
S13-7805  --------------------------------------------------------------------------------------------II  I
S24-8201  ----------------------------------------------------------------------------------------I   II  I
S25-8204  ----------------------------------------------------------------------------------------I---II  I---I
S31-8404  ----------------------------------------------------------------------------------------I    I  I   I
S32-8408  ----------------------------------------------------------------------------------------I    I  I   I
S36-8512  ---------------------------------------------------------------------------------------------I  I   I------
S39-8612  ---------------------------------------------------------------------------------------------I  I   I
S34-8505  ------------------------------------------------------------------------------------------------I   I
S37-8604  ----------------------------------------------------------------------------------------------------I
```

Station: LCIX: Mytilus sp. [Mixed P/#]: TOTAL Quads with Data = 120

Quad Range USED 6 to 13 for Total of 8 : Range WITH data 4 to 22: : # Dropped 12 : 10.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 13
COPHENETIC CORRELATION COEFFICIENT = 0.633482: Maximum Distance = 4

```
S 8-7604  I
S24-8201  I
S26-8209  I--------------------------I
S28-8303  I                          I
S37-8604  I                          I-----------I
S42-8712  I                          I           I
S14-7810  I                          I           I
S25-8204  I--------------------------I           I---------------I
S35-8508  I                                      I               I
S13-7805  ---------------------------I           I               I
S17-7909  I                          I-----------I               I
S22-8105  I--------------------------I                           I------I
S23-8110  I                                                      I      I
S 9-7702  I--------------------------I                           I      I
S33-8412  I                          I-------------I             I      I--I
S27-8212  I--------------------------I             I-------------I      I  I
S41-8708  I                                        I                    I  I
S18-7912  -----------------------------------------I                    I  I----------I
S15-7812  --------------------------------------------------------------I  I          I
S30-8312  ---------------------------I-------------I                       I          I
S39-8612  ---------------------------I             I-----------------------I          I
S36-8512  -----------------------------------------I                                  I-----------------------I
S10-7705  ---------------------------I-------------I                                  I                       I
S16-7905  ---------------------------I             I----I                             I                       I
S11-7710  -----------------------------------------I    I-I                           I                       I------
S19-8005  ----------------------------------------------I I------------------I        I                       I
S21-8012  ------------------------------------------------I                  I--------I                       I
S20-8008  -------------------------------------------------------------------I                                I
S12-7803  ----------------------------------------------------------------------------------------------------I
```

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Notoacmea scutum (Plate Limpet). (Rathke, 1833). Ref. MAH 1980, p. 247.
Phylum Mollusca: **Class** Gastropoda:

Description: Low to moderately elevated, color variable, mainly brownish to greenish black with white spots. Diameter 0.4 - 3+ (6.3 MAH) cm, about 1/4- as high as diam., apex near central. (from MAH).

Distribution: Southern Bering Sea to Point Conception (California). Common on rocks, mid intertidal, in protected areas. (from MAH). Not a warm-tolerant species.

Diablo Area Specific Information: Quite common, occurring in about 50% of our quadrats.

Habitat: On rocks, mid-upper to low tide levels. Occurs on rocks and cobbles.

Observational Errors: Morphology of this organism is variable, and we have confused it with *N. fenestrata* and *Collisella limatula*. Other missed observations are probably limited to areas with dense algal cover quadrats. In our early surveys (from beginning of our study to Feb. 77), we did not field identify this taxon.

Field Identification Problems:

General: Atypical specimens have been confused with *Notoacmea fenestrata* and occasionally with larger atypical *Collisella limatula*.

Station Specific: CDIX has a moderately large number of *Notoacmea fenestrata* in the mid to upper intertidal that we identified as *N. scutum* up until survey 37 (April 84).

General Comments: MAH (1980) indicates that this species can move up to 1 meter during a tidal cycle, i.e., could move in and out of quadrats fairly rapidly.

Impacts to Taxon:

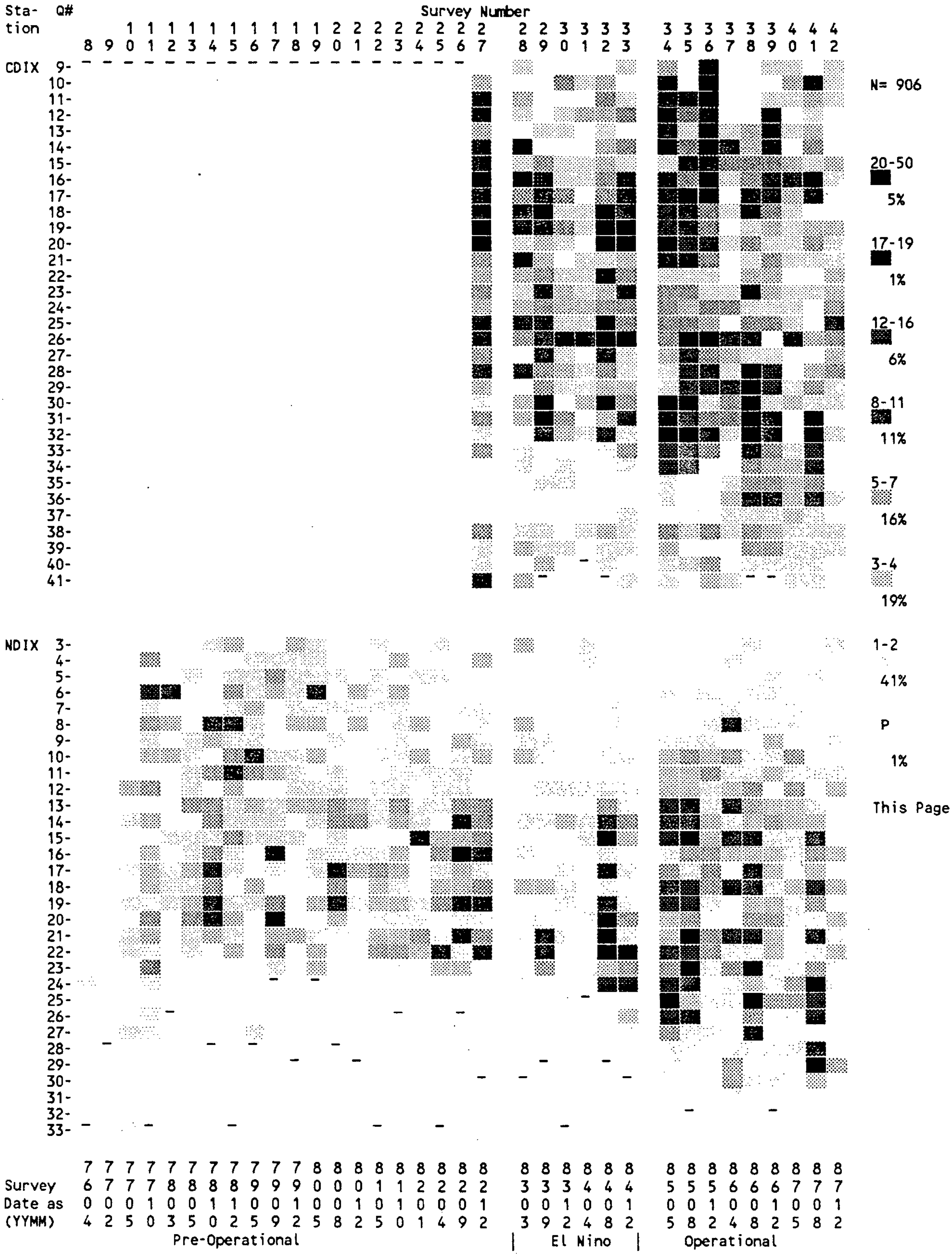
El Niño: 1982-83 winter storm: SDIX numbers declined because quadrats in the mid to lower intertidal were overlain with new cobble. NDIX with reduction in numbers and about 1/2 the normal occurrences probably due to wave action and introduced boulders. CDIX with possibly a minor reduction of the population (Note: *N. fenestrata* was being identified as this taxon). LCIX with almost total removal of this taxon.

El Niño: 1983-1984: SDIX and NDIX with sporadic increases in numbers and occurrences to normal or above normal conditions. CDIX much as our single pre-El Niño survey. LCIX not present until end of 1984 with four occurrences.

Diablo DCPP Operation: All Cove stations sporadic, but possibly a trend of increased numbers and extension farther down in the intertidal than normal (CDIX?), some of this may be due to fewer missed observations due to thinner algal mat cover. LCIX slowly returned to pre-El Niño conditions.

Taxon or Category: Notoacmea scutum [Mixed P/#]

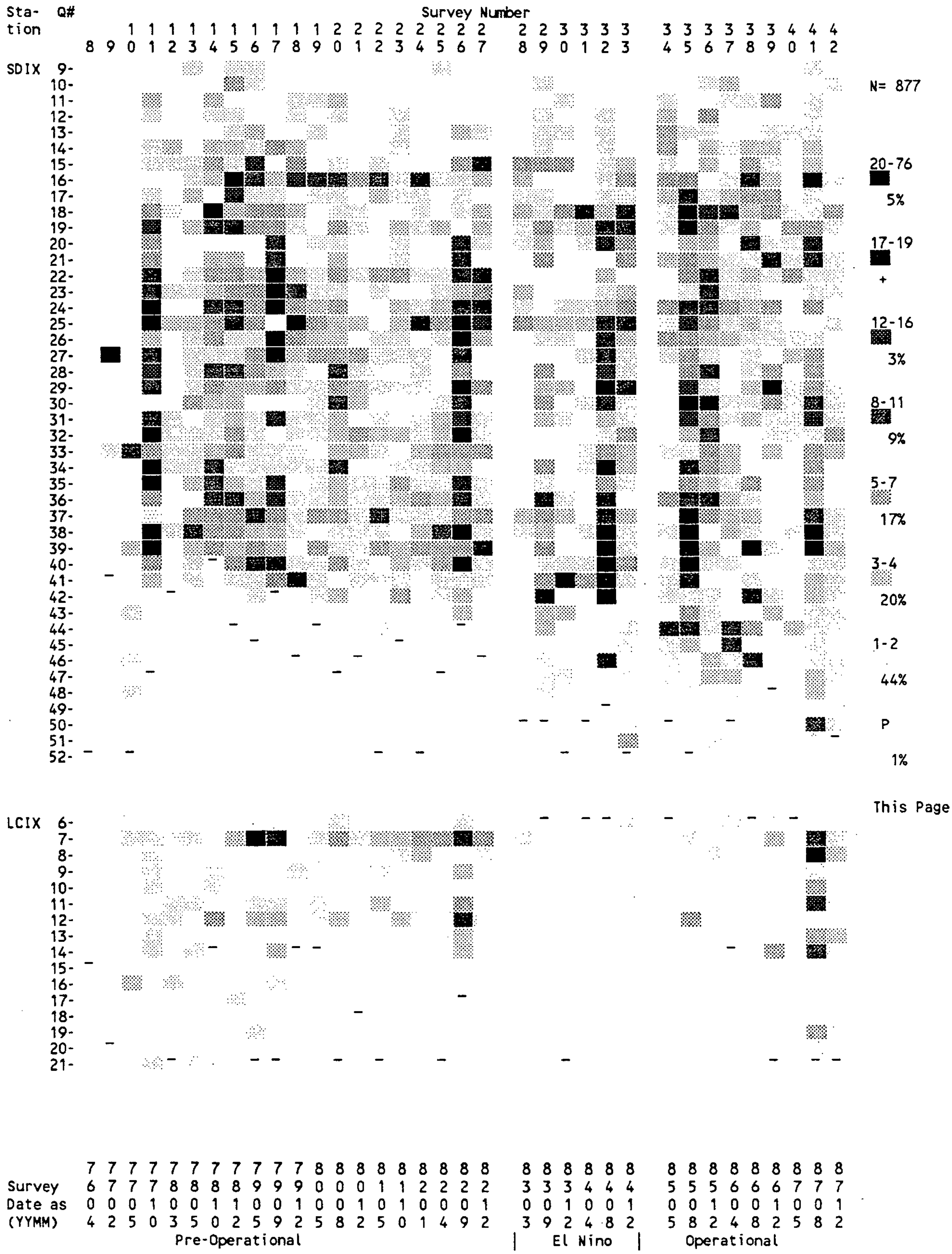
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for NOTSCU CSV 6138 3-29-88 8:00a 04-15-1989 06:30

Taxon or Category: Notoacmea scutum [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for NOTSCU CSV 6138 3-29-88 8:00a 04-15-1989 06:30

Audit: CLUMRG2P: V.1.2: for SNOTSCUB CLU 6581 4-23-89 6:40a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:37:12 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Notoacmea scutum [Mixed P/#]: TOTAL Quads with Data = 434

Quad Range USED 10 to 39 for Total of 30 : Range WITH data 4 to 41: : # Dropped 51 : 11.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.620203: Maximum Distance = 15

```
S27-8212 --------------------I-----I
S32-8408 --------------------I     I-------------------I
S36-8512 --------------------------I                   I--------I
S33-8412 ---------------------------------I------------I        I
S35-8508 ---------------------------------I                     I--------I
S34-8505 ---------------------------------------I--I            I        I
S39-8612 ---------------------------------------I  I------------I        I---------I
S38-8608 ------------------------------------------I                     I         I------------I
S28-8303 ----------------------------------------------------------------I         I            I
S29-8309 ------------------------------------------------------------I-------------I            I-----I
S30-8312 ------------------------------------------------------------I                          I     I
S40-8705 -------------------------------------------------------------------------I-------------I     I--------I
S41-8708 -------------------------------------------------------------------------I                   I        I
S31-8404 ------------------------------------------------------------------I--------------------------I        I------
S42-8712 ------------------------------------------------------------------I                                   I
S37-8604 ------------------------------------------------------------------------------------------------------I
```

Station: NDIX: Notoacmea scutum [Mixed P/#]: TOTAL Quads with Data = 498

Quad Range USED 3 to 25 for Total of 23 : Range WITH data 3 to 33: : # Dropped 74 : 14.9%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.611434: Maximum Distance = 13

```
S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End   Dropped Surveys
S 8-7604 -------I-----------------------------------------------I
S 9-7702 -------I                                               I------I
S10-7705 -----------------------I-------------------------------I      I---I
S30-8312 -----------------------I                                      I   I-----------------------------------I
S12-7803 --------------------------------------------------------------I   I                                   I
S21-8012 ------------------------------------------------------------------I                                   I
S11-7710 -----------------------I---------------I                                                              I
S23-8110 -----------------------I               I-------------I                                                I
S27-8212 -------------------------------I-------I             I                                                I
S32-8408 -------------------------------I                     I                                                I
S26-8209 -----------------------I--I                          I-----I                                          I
S34-8505 I----------------------I  I----I                     I     I                                          I
S35-8508 I                         I    I                     I     I                                          I
S36-8512 --------------------------I    I---------------------I     I--------I                                 I
S38-8608 -------------------------------I                           I        I                                 I------
S39-8612 -------------------------------I                           I        I                                 I
S33-8412 ---------------------------------------------------I-------I        I                                 I
S37-8604 ---------------------------------------I-----------I                I---------------I                 I
S40-8705 ---------------------------------------I                            I               I                 I
S13-7805 -------------------------------I---------------I                    I               I                 I
S20-8008 -------------------------------I               I-----------I        I               I                 I
S14-7810 -----------------------------------------------I           I------I I               I                 I
S25-8204 ---------------------------------------I-------------------I      I-I               I----------I      I
S41-8708 ---------------------------------------I                          I                 I          I      I
S15-7812 -----------------------------------------------I------------------I                 I          I      I
S22-8105 -----------------------------------------------I                                    I          I      I
S28-8303 -----------------------------------------------I                                    I          I------I
S29-8309 -----------------------------------------------I------------------------------------I          I
S42-8712 -----------------------------------------------I                                               I
S16-7905 -------------------------------------------------------I----------I                            I
S18-7912 -------------------------------------------------------I          I----------------------------I
S24-8201 ------------------------------------------------------------------I
```

Station: SDIX: Notoacmea scutum [Mixed P/#]: TOTAL Quads with Data = 783

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 5 to 51: : # Dropped 173 : 22.1%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.721597: Maximum Distance = 18

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End  Dropped Surveys
S 8-7604  ----------------I-------------------------------------------------------------I
S10-7705  ----------------I                                                             I---------------------I
S28-8303  --------------------------------------------------------------I---------------I                     I
S31-8404  --------------------------------------------------------I-----I                                     I
S34-8505  --------------------------------------------------------I                                           I
S11-7710  ----------------I--I                                                                                I
S15-7812  ----------------I  I---I                                                                            I
S33-8412  -------------------I   I                                                                            I
S16-7905  ----------I-----I      I---I                                                                        I
S32-8408  ----------I     I---I  I   I                                                                        I
S20-8008  ----------------I   I--I   I                                                                        I
S26-8209  ----------I         I      I--------I                                                               I
S35-8508  ----------I---------I      I        I                                                               I
S41-8708  ----------I                I        I--------I                                                      I
S36-8512  ---------------------------I        I        I-----I                                                I------
S38-8608  ------------------------------------I        I     I                                                I
S18-7912  ---------------------------------I-----------I     I----I                                           I
S27-8212  ---------------------------------I                 I    I                                           I
S13-7805  ---------------------------------------I----------II    I                                           I
S22-8105  ---------------------------------------I          II    II                                          I
S21-8012  ---------------------------------I----------------I     II                                          I
S24-8201  ---------------------------------I                      II----------I                               I
S19-8005  ---------------------------I----------------------------II          I                               I
S23-8110  ---------------------------I                             I          I------I                        I
S25-8204  ---------------------------------------I-----------------I          I      I                        I
S37-8604  ---------------------------------------I                            I      I-------I                I
S42-8712  --------------------------------------------------------------------I      I       I                I
S29-8309  --------------------------------------------------------------I------------I       I----------------I
S30-8312  --------------------------------------------------------------I                    I
S39-8612  --------------------------------------------------------------------------I--------I
S40-8705  --------------------------------------------------------------------------I
```

Station: LCIX: Notoacmea scutum [Mixed P/#]: TOTAL Quads with Data = 112

Quad Range USED 3 to 16 for Total of 14 : Range WITH data 3 to 21: : # Dropped 17 : 15.2%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.621970: Maximum Distance = 8

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604:  <-End  Dropped Surveys
S 9-7702  -----------------------I------------I
S30-8312  -----------------------I            I---I
S28-8303  ------------------------------------I   I-------------I
S36-8512  ----------------------------------------I             I-I
S10-7705  ------------------------------------I-----------------I I---I
S35-8508  ------------------------------------I                   I   I
S15-7812  ------------------------------------I-------------------I   I----------I
S21-8012  ------------------------------------I                       I          I
S23-8110  ------------------------------------I-----------------I     I          I
S24-8201  ------------------------------------I                 I-----I          I--I
S25-8204  ------------------------------------------------------I                I  I
S13-7805  ------------------------------------------------I-----------I          I  I-----I
S16-7905  ------------------------------------------------I           I----------I  I     I
S22-8105  ------------------------------------------------------------I             I     I
S20-8008  --------------------------------------------------------------------------I     I--------------------I
S12-7803  ------------------------------------I-----I                                     I                    I
S17-7909  ------------------------------------I     I-----------------I                   I                    I
S39-8612  ------------------------------------------I                 I-------------------I                    I------
S27-8212  ------------------------------------------------------------I                                        I
S11-7710  ------------------------------------------------------------------------------------I-------I        I
S41-8708  ------------------------------------------------I-----------------------------------I       I--------I
S42-8712  ------------------------------------------------I                                           I
S26-8209  ------------------------------------------------------------------------I-------------------I
S33-8412  ------------------------------------------------------------------------I
```

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Nuttalina californica (Chiton). (Reeve, 1847). Ref. MAH, 1980, p. 419.
Phylum Mollusca: **Class** Polyplacophora:

Description: Elongate, moderately elevated; valves beaked, granular or corrugated, eroded in older specimens; dark brown, olive-brown or blackish when not eroded. Girdle wide with short brownish spinelets, dull, often with alternating dark and light bands. Length 1 - 4+ (5, MAH) cm.

Distribution: Puget Sound (Washington) to San Diego (California), high to mid intertidal. Very common on rocks (often in crevices or depressions), hidden under coralline algae or wedged between mussels and barnacles. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 10% of our quadrats.

Habitat: On rocks, mid-upper to mid-lower tide levels, usually in depressions or crevices, less commonly in open areas. Infrequent in coralline algae areas.

Observational Errors: Small chitons (<1 cm) that may be this group have been identified as "unid. chiton, juveniles". Other missed observations are probably limited to areas with dense algal cover quadrats and may occur about 10% of the time. In our early surveys (from beginning of our study to May 78), we did not routinely field identify this taxon.

Field Identification Problems:

General: none.

Station Specific: none.

General Comments: *Nuttalina californica* is the most common *Nuttalina* in our study area but since we have not performed extensive collections and lab identifications of this group, some of our field identifications may be *N. fluxa*, which has been reported from the Diablo area but has been laboratory identified by us only at LCIX.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Rare at SDIX and NDIX prior to storms, but at NDIX probably moved into area on two large boulders introduced by storms. CDIX and LCIX not affected.

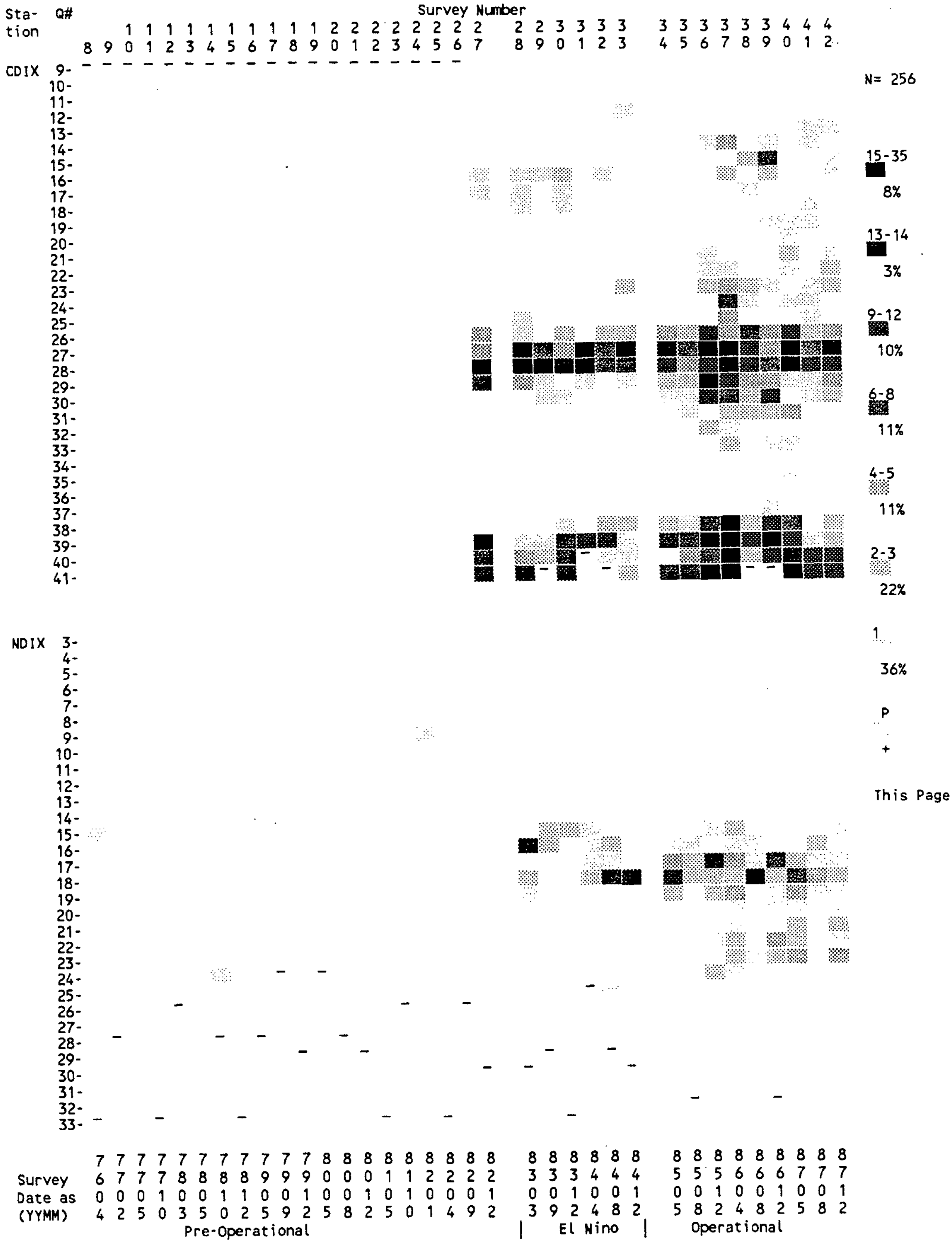
El Niño: 1983-1984: SDIX with no apparent change. NDIX with increased numbers and occurrences, but sporadic. CDIX remaining about the same, but possibly with loss of occurrences in the upper parts of its range. LCIX about normal.

Diablo DCPP Operation: SDIX with possible sporadic increase in numbers and occurrences. NDIX with sporadic but well-developed population (species very rare in pre-El Niño surveys). CDIX possibly extending its range into mid intertidal where it had not occurred before. LCIX possibly with declining numbers and occurrences by end of 1987.

N. fluxa: Monterey Bay or Point Conception (depending on reference) to central Baja California.

Taxon or Category: Nuttallina spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

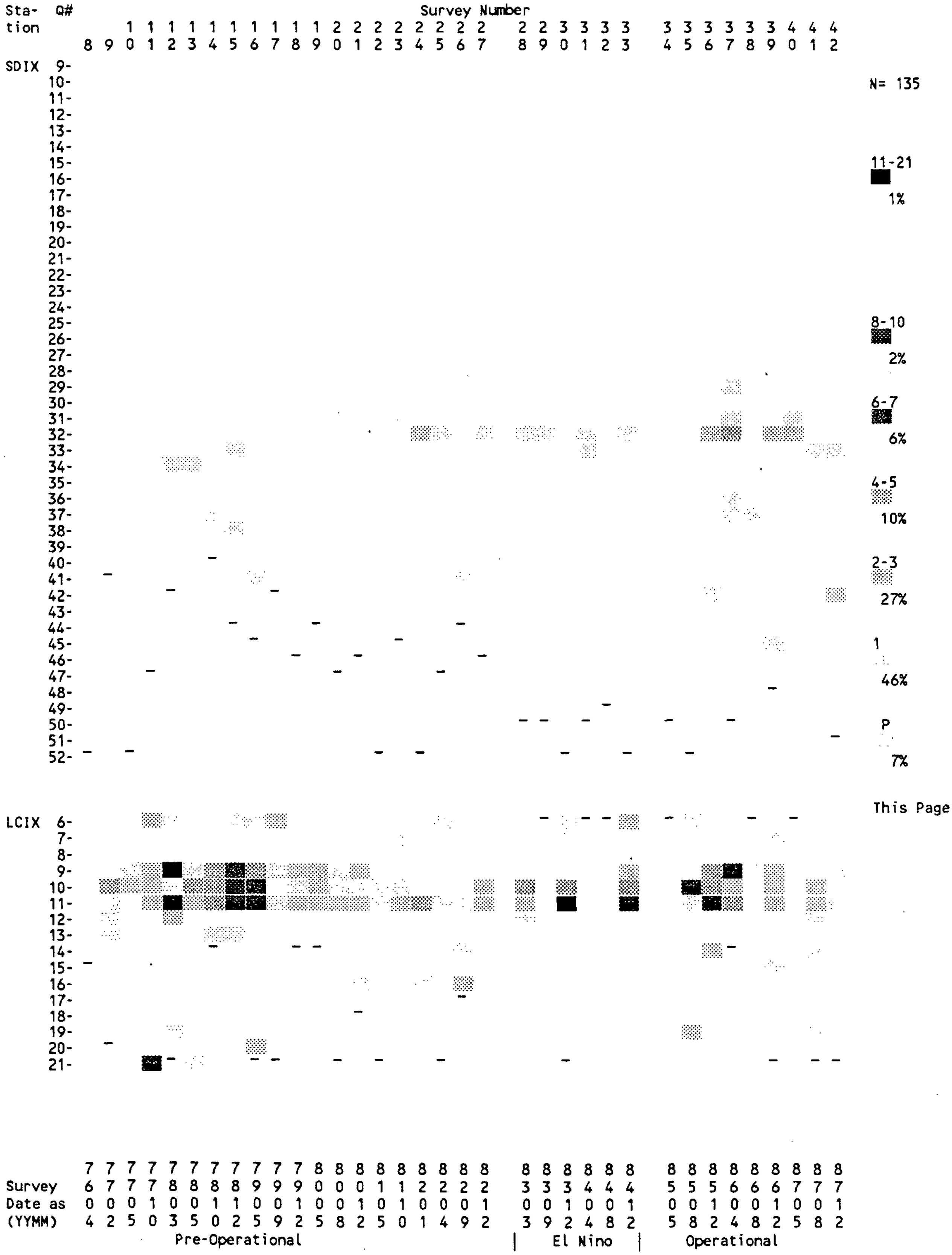


' _ ' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for NUTTAL CSV 5233 3-29-88 8:02a 04-15-1989 06:31

Taxon or Category: Nuttallina spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for NUTTAL CSV 5233 3-29-88 8:02a 04-15-1989 06:31

Audit: CLUMRG2P: V.1.2: for SNUTTALB CLU 6581 4-23-89 6:47a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:44:50 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Nuttallina spp. [Mixed P/#]: TOTAL Quads with Data = 184

Quad Range USED 13 to 40 for Total of 28 : Range WITH data 12 to 41: : # Dropped 16 : 8.7%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.560616: Maximum Distance = 16

```
S31-8404:  <-Start Dropped Surveys
S27-8212 ----------------------------------------------I-------------I
S28-8303 ----------------------------------------------I             II
S29-8309 ------------------------------------------------------------II----I
S30-8312 ------------------------------------------------------I------I    I-----------I
S32-8408 ------------------------------------------------------I           I           I
S33-8412 ------------------------------------------------------I-----------I           I-----I
S34-8505 ----------------------------------------------I-------I                       I     I
S35-8508 ----------------------------------------------I                               I     I----------I
S38-8608 ------------------------------------------------------------------------------I     I          I
S36-8512 ------------------------------------------------------------------I-----------------I          II
S42-8712 ------------------------------------------------------------------I                            II
S37-8604 --------------------------------------------------------------------------------I---------------II--------I
S39-8612 --------------------------------------------------------------------------------I               I         I------
S41-8708 ------------------------------------------------------------------------------------------------I         I
S40-8705 ----------------------------------------------------------------------------------------------------------I
```

Station: NDIX: Nuttallina spp. [Mixed P/#]: TOTAL Quads with Data = 72

Quad Range USED 14 to 27 for Total of 14 : Range WITH data 9 to 27: : # Dropped 5 : 6.9%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.898122: Maximum Distance = 9

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 ----------------------I-----------I
S30-8312 ----------------------I           I
S 9-7702 ----------------------I           I
S10-7705 ----------------------I           I
S11-7710 ----------------------I           II
S13-7805 ----------------------I           II
S15-7812 ----------------------I           II
S16-7905 ----------------------I           II
S18-7912 ----------------------I-----------II
S20-8008 ----------------------I            II
S21-8012 ----------------------I            II
S22-8105 ----------------------I            II
S24-8201 ----------------------I            II--------I
S25-8204 ----------------------I            II        I
S27-8212 ----------------------I            II        I---------------------I
S14-7810 -----------------------------------II        I                     I
S33-8412 ------------------------------------I        I                     I
S29-8309 ----------------------------------------------I                     I-------------------------------------I
S28-8303 ----------------------------------I-------------I                  I                                     I
S34-8505 ----------------------I-----------I             I                  I                                     I
S41-8708 ----------------------I                         I------------------I                                     I
S32-8408 ----------------------------------I----I        I                                                        I------
S35-8508 ----------------------------------I    I--------I                                                        I
S38-8608 ---------------------------------------I                                                                 I
S36-8512 -----------------------------------------------------------------------------------I                      I
S37-8604 ---------------------------------------------------------I                         I----------------------I
S39-8612 ----------------------------------I----I                 I-------------------------I
S40-8705 ----------------------------------I    I-----------------I
S42-8712 ---------------------------------------I
```

Station: SDIX: Nuttallina spp. [Mixed P/#]: TOTAL Quads with Data = 31

Quad Range USED 30 to 43 for Total of 14 : Range WITH data 29 to 45: : # Dropped 4 : 12.9%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.788966: Maximum Distance = 9

```
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909: <-End   Dropped Surveys
S 8-7604 -----------------------------------------------------------I
S10-7705 -----------------------------------------------------------I
S11-7710 -----------------------------------------------------------I
S18-7912 -----------------------------------------------------------I
S19-8005 -----------------------------------------------------------I
S20-8008 -----------------------------------------------------------I
S21-8012 -----------------------------------------------------------I-----------I
S22-8105 -----------------------------------------------------------I           I
S23-8110 -----------------------------------------------------------I           I
S30-8312 -----------------------------------------------------------I           I
S32-8408 -----------------------------------------------------------I           I-I
S34-8505 -----------------------------------------------------------I           I I
S35-8508 -----------------------------------------------------------I           I I
S13-7805 -----------------------------------------------------------------------I I--I
S16-7905 -----------------------------------------------------------I-----------I I  I
S26-8209 -----------------------------------------------------------I             I  I
S38-8608 -------------------------------------------------------------------------I  I
S24-8201 -----------------------------------------------------------I                I
S25-8204 -----------------------------------------------------------I                I-------I
S27-8212 -----------------------------------------------------------I                I       I
S28-8303 -----------------------------------------------------------I-----------I    I       I
S29-8309 -----------------------------------------------------------I           I    I       I
S33-8412 -----------------------------------------------------------I           II   I       I---------------I
S39-8612 -----------------------------------------------------------I           II---I       I               I
S31-8404 -----------------------------------------------------------------------II           I               I
S36-8512 ------------------------------------------------------------------------I           I               I------
S15-7812 -----------------------------------------------------------------------I----I       I               I
S41-8708 -----------------------------------------------------------------------I    I-------I               I
S42-8712 ----------------------------------------------------------------------------I                       I
S37-8604 -----------------------------------------------------------------------I----------------------------I
S40-8705 -----------------------------------------------------------------------I
```

Station: LCIX: Nuttallina spp. [Mixed P/#]: TOTAL Quads with Data = 106

Quad Range USED 6 to 17 for Total of 12 : Range WITH data 3 to 21: : # Dropped 28 : 26.4%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.546338: Maximum Distance = 6

```
S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604: <-End   Dropped Surveys
S 9-7702 -------------------------------------------------------------------------I---------------------------I
S41-8708 -------------------------------------------------------------------------I                           I
S10-7705 ------------------------------------------------------I-----I                                        I
S13-7805 ------------------------------------I-----------------I     I-----------I                            I
S20-8008 ------------------------------------I                       I           I                            I
S21-8012 ------------------------------------------------------------I           I                            I
S11-7710 ------------------------------------I                                   I--------I                   I
S16-7905 ------------------------------------I-----------------I                 I        I                   I
S33-8412 ------------------------------------I                 I----I            I        II                  I
S12-7803 ------------------------------------------------------I    I------------I        II                  I
S15-7812 -----------------------------------------------------------I                     II                  I------
S17-7909 ------------------------------------------------------I--------------------------II-------I          I
S25-8204 ------------------------------------------------------I                           I       I          I
S22-8105 ------------------------------------I-----------------I                           I       I          I
S27-8212 ------------------------------------I                 I--------------I            I       I          I
S23-8110 ------------------------------------------------------I              I------------I       I------I   I
S28-8303 ------------------------------------------------------I---------I    I                    I      I   I
S35-8508 ------------------------------------------------------I         I----I                    I      I   I
S30-8312 ----------------------------------------------------------------I                         I      I--II
S36-8512 ------------------------------------------------------I-----------------------------------I      I  II
S42-8712 ------------------------------------------------------I                                          I  II
S39-8612 -------------------------------------------------------------------------------------------------I  I
S24-8201 ----------------------------------------------------------------------------------------------------I
```

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Ocenebra circumtexta (Circled Rock Snail). Stearns, 1871. Ref. MAH, 1980, p. 277.
Phylum Mollusca: **Class** Gastropoda:

Description: Moderately inflated shell, aperture about 2/3 of length. Color white to light grey to creamish, with two bands of brown spots per whorl. Length 0.4 - 2.5+ cm.

Distribution: Trinidad (Humboldt Co., Calif.) to Scammon Lagoon (Baja California), mid to lower intertidal in areas of heavy surf. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 25% of our quadrats.

Habitat: On rocks, tops, sides, and undersides, mid-upper to lower tide levels.

Observational Errors: Small individuals (<0.6 cm) that may be this group were field identified as *Ocenebra* sp. Other missed observations were probably limited to areas with dense algal cover. No estimate of number of missed observations is available as this species is quite motile. In our early surveys (from beginning of our study to late 1977), we field identified this species as *Ocenebra* sp.

Field Identification Problems:

General: Small individuals (<1 cm) may be confused with *O. interfossa*, which typically has a somewhat longer and narrower anterior end.

Station Specific: none.

General Comments: Sporadic in occurrence, but always present in at least several quadrats except at LCIX where never very common.

Impacts to Taxon:

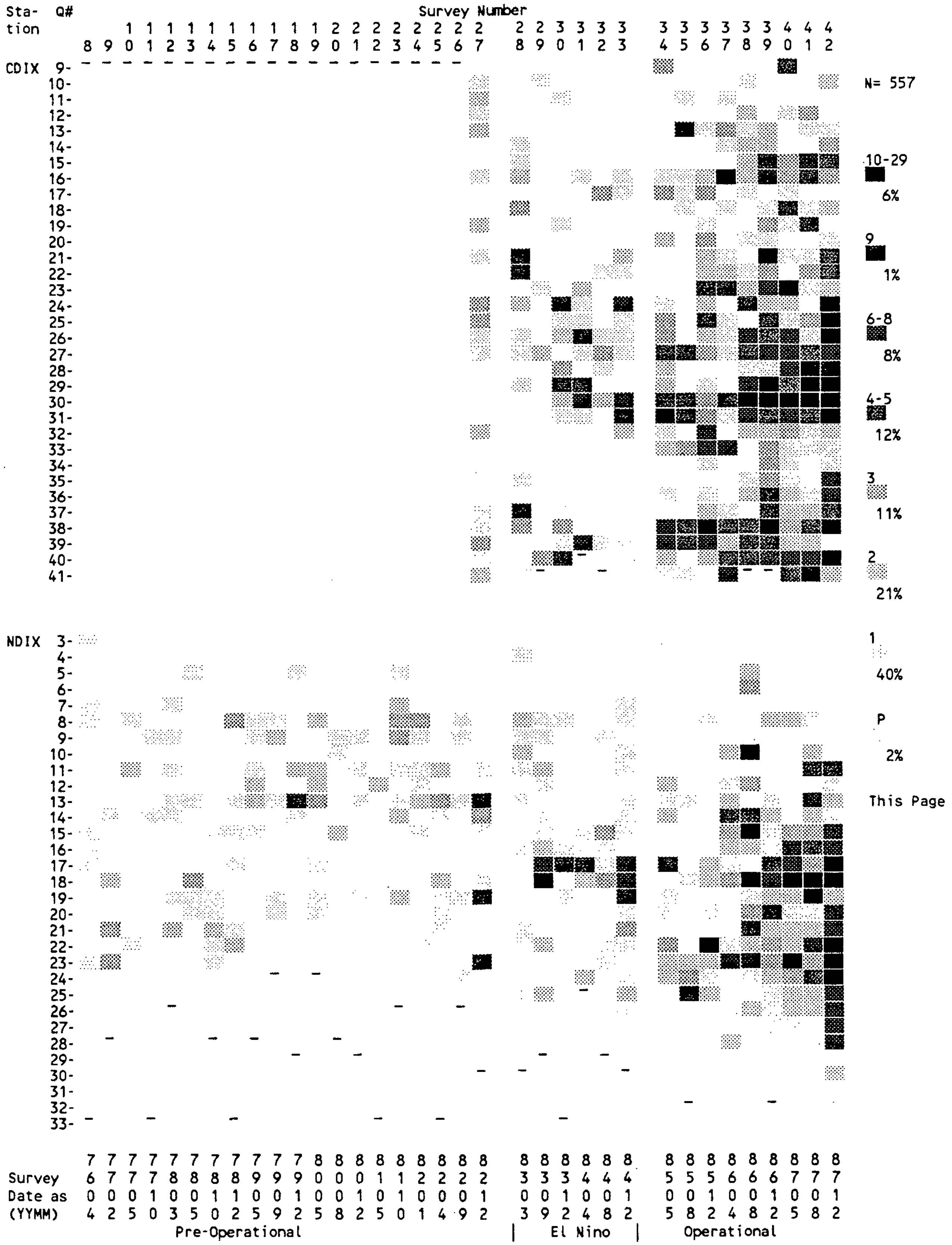
El Niño: 1982-83 winter storm: SDIX possibly with reduced numbers and occurrences. NDIX and CDIX no apparent change. LCIX indeterminate.

El Niño: 1983-1984: SDIX with possible reduction in numbers compared to normal. NDIX possibly with increased numbers and occurrences, but sporadic. CDIX sporadic and difficult to assess. LCIX about normal.

Diablo DCPP Operation: All Cove stations with increases in numbers and occurrences and extending farther down in the intertidal compared to pre-operational period (CDIX?). Occurrences at SDIX somewhat sporadic. LCIX as for pre-operational, i.e., spotty.

Taxa or Category: Ocenebra circumtexta +Ocenebra sp. (early surveys) [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

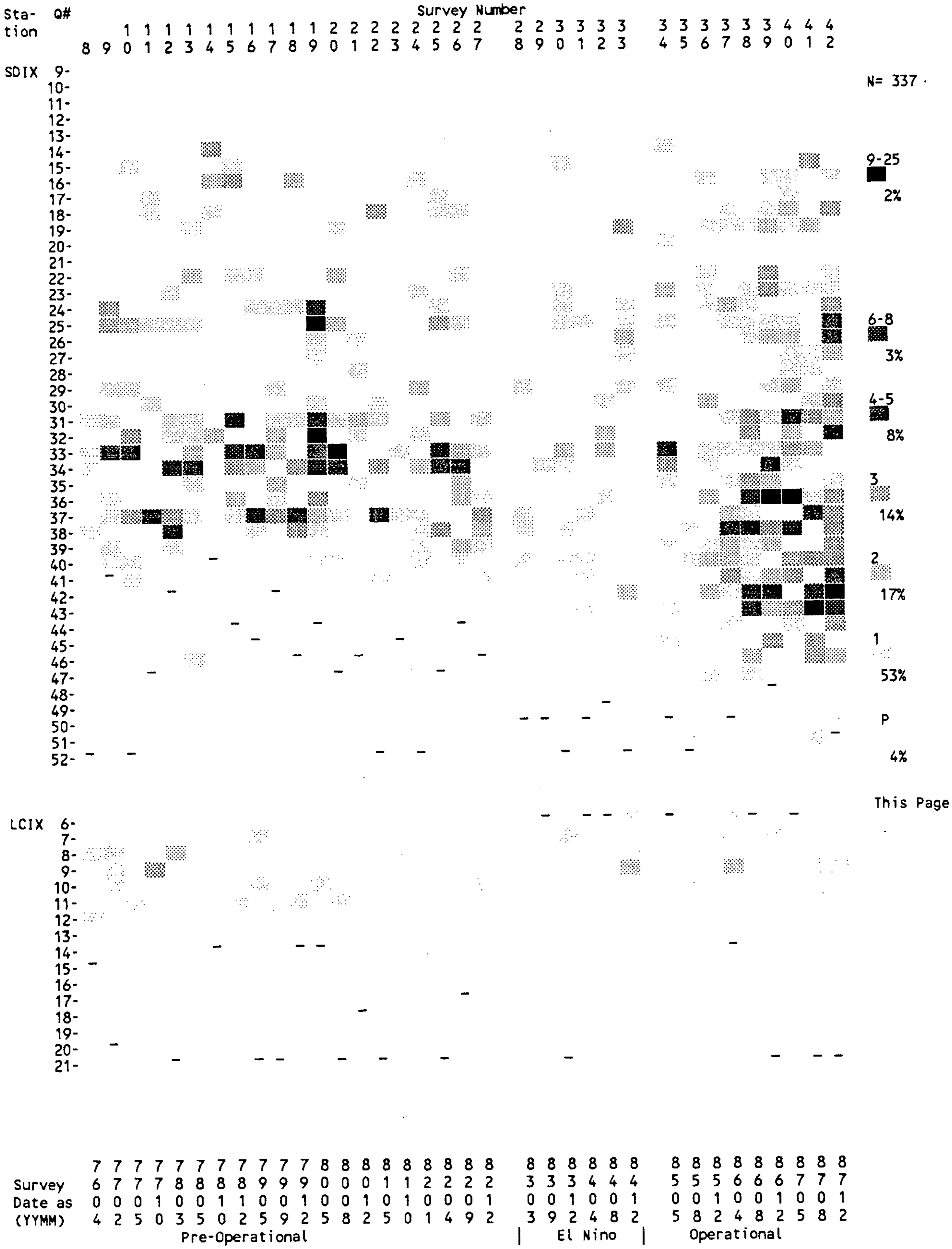


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for OCECSP CSV 5548 9-30-88 7:17a 04-15-1989 06:31

Taxa or Category: Ocenebra circumtexta +Ocenebra sp. (early surveys) [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for OCECSP CSV 5548 9-30-88 7:17a 04-15-1989 06:32

Audit: CLUMRG2P: V.1.2: for SOCENCIB CLU 6581 4-23-89 6:53a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:49:46 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Ocenebra circumtexta [Mixed P/#]: TOTAL Quads with Data = 277

Quad Range USED 10 to 40 for Total of 31 : Range WITH data 7 to 41: : # Dropped 21 : 7.6%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.434212: Maximum Distance = 16

```
S31-8404: <-Start Dropped Surveys
S27-8212 ----------------------------------------------------------------------------------I
S30-8312 -----------------------------------------------------I--------I                   II
S34-8505 -----------------------------------------------------I        I--------------I    II
S32-8408 -----------------------------------------------I--------------I              I----II
S33-8412 -----------------------------------------------I                             I     I--I
S35-8508 -----------------------------------------------------I-----------------------I     I  I
S37-8604 -----------------------------------------------------I                             I  I----------I
S29-8309 -----------------------------------------------------------------------------------I  I          I
S28-8303 --------------------------------------------------------------------------------------I          I
S36-8512 --------------------------------------------I---I                                                I------
S39-8612 -----------------I--------------------------I   I---------------I                                I
S42-8712 -----------------I                              I               I                                I
S40-8705 -----------------------------------------I------I               I--------------------------------I
S41-8708 -----------------------------------------I                      I
S38-8608 ----------------------------------------------------------------I
```

Station: NDIX: Ocenebra circumtexta [Mixed P/#]: TOTAL Quads with Data = 272

Quad Range USED 5 to 25 for Total of 21 : Range WITH data 4 to 32: : # Dropped 36 : 13.2%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.580098: Maximum Distance = 11

```
S17-7909: <-Start Dropped Surveys
S19-8005:
S31-8404: <-End  Dropped Surveys
S 8-7604 -----------------I--------I
S10-7705 -----------------I        I--I
S11-7710 --------------------------I  I-----I
S22-8105 -----------------------------I     I--------------I
S20-8008 -----------------------------------I              I-------I
S26-8209 --------------------------------------------I-----I       I-------I
S30-8312 --------------------------------------------I             I       I
S15-7812 ------------------------------------------------I---------I       I
S16-7905 --------I---------------------------------------I                 I
S24-8201 --------I                                                         I----------I
S 9-7702 --------------------------------------------I---I                 I          I
S27-8212 --------------------------------------------I   I--------I        I          I
S13-7805 -----------------------------------I------------I        I        I          I
S25-8204 -----------------------------------I                     I--------I          I
S12-7803 --------------------------I-----------------I            I                   I----I
S21-8012 --------------------------I                 I------------I                   I    I
S18-7912 -----------------------------------I--------I                                I    I
S23-8110 -----------------------------------I                                         I    I
S14-7810 --------------------------------------------------------------I--------I     I    I----------------I
S34-8505 --------------------------------------------------------------I        I-----I    I                I
S35-8508 --------------------------------------------I--------------------------I          I                I
S36-8512 --------------------------------------------I                                     I                I
S28-8303 ----------------------------------------------------------------------------------I                I------
S29-8309 ---------------------------------------------------------I--------------------------I              I
S32-8408 --------------------------------------------I------------I                          I              I
S37-8604 --------------------------------------------I                                       I              I
S33-8412 --------------------------I------------I                                            I--------------I
S41-8708 --------------------------I            I----------------------------------I         I
S39-8612 -----------------I-----------------I   I                                  I         I
S40-8705 -----------------I                 I---I                                  I---------I
S42-8712 -----------------------------------I                                      I
S38-8608 --------------------------------------------------------------------------I
```

Station: SDIX: Ocenebra circumtexta [Mixed P/#]: TOTAL Quads with Data = 292

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 14 to 51: : # Dropped 42 : 14.4%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.720758: Maximum Distance = 16

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  -----I-----I
S10-7705  -----I     I-------I
S29-8309  -----------I       I-------I
S23-8110  -------------------I       I---I
S28-8303  -----------------I---------I   I-------I
S35-8508  -----------------I             I       I--I
S31-8404  -------------------------------I       I  I
S32-8408  ---------------------------------------I  I----I
S16-7905  ------------------------------I-----I     I    I
S18-7912  ------------------------------I     I-----I    I-----I
S27-8212  ------------------------------------I          I     I
S11-7710  ------------------------------------I----------I     I---I
S22-8105  ------------------------------------I                I   I
S21-8012  -----------------------------------------------------I   II
S13-7805  ------------------------I--------------------I           II
S20-8008  ------------------------I                    I-----------II-----I
S15-7812  ---------------------------------------------I            I     I
S25-8204  ------------------------------------------I---------------I     I---I
S30-8312  ------------------------------------------I                     I   I--I
S24-8201  ----------------------------------------------------------------I   I  I
S26-8209  ------------------------------------------------------I-------------I  I-I
S34-8505  ------------------------------------------------------I                I I----------I
S33-8412  -----------------------------------------------------------------------I I          I--------------I
S19-8005  -------------------------------------------------------------------------I          I              I
S36-8512  -------------------------------------------------------------------------I----------I              I
S41-8708  -------------------------------------------------------------------------I                         I------
S37-8604  ------------------------------------------I-----------------------I                                I
S38-8608  ------------------------------------------I                       I---------I                      I
S42-8712  ------------------------------------------------------------------I         I----------------------I
S39-8612  ------------------------------------------------------------I---------------I
S40-8705  ------------------------------------------------------------I
```

Station: LCIX: Ocenebra circumtexta [Mixed P/#]: TOTAL Quads with Data = 27

Quad Range USED 3 to 11 for Total of 9 : Range WITH data 3 to 11: : # Dropped 0 : 0.0%
Surveys 29 : Dropped 0 Surveys if quads sampled < 11
COPHENETIC CORRELATION COEFFICIENT = 0.839638: Maximum Distance = 4

```
S 8-7604  ----------------------I
S12-7803  ----------------------I
S13-7805  ----------------------I
S17-7909  ----------------------I
S21-8012  ----------------------I
S22-8105  ----------------------I---------------------I
S24-8201  ----------------------I                     I
S25-8204  ----------------------I                     I
S26-8209  ----------------------I                     I
S28-8303  ----------------------I                     I-----I
S30-8312  ----------------------I                     I     I
S36-8512  ----------------------I                     I     I
S10-7705  ----------------------I                     I     I-I
S15-7812  ----------------------I---------------------I     I I
S18-7912  ----------------------I                           I I
S20-8008  ----------------------I                           I I-----I
S19-8005  ----------------------I---------------------------I I     I
S35-8508  ----------------------I                             I     I
S23-8110  ----------------------------------------------------I     I------I
S39-8612  ----------------------------------------------------I     I      I
S11-7710  ----------------------I---------------------I             I      I----------------------------I
S42-8712  ----------------------I                     I-------------I      I                            I
S41-8708  --------------------------------------------I                    I                            I
S14-7810  --------------------------------------------I--------------------I                            I----I
S27-8212  --------------------------------------------I                                                 I    I
S 9-7702  -------------------------------------------------------------------I---------------------I    I    I------
S33-8412  -------------------------------------------------------------------I                     I----I    I
S37-8604  -----------------------------------------------------------------------------------------I         I
S16-7905  ---------------------------------------------------------------------------------------------------I
```

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Serpulorbis squamigerus (Scaled Worm Snail). (Carpenter, 1857). Ref. MAH, 1980, p. 261.
Phylum Mollusca: **Class** Gastropoda:

Description: Tubular shell, twisted or loosely coiled, wrinkled, with longitudinal ribs, earlier portions of tube cement to substrate, last part usually erect. Color grey to pinkish-grey. Length 5 - 8+ cm (12.5, MAH), diameter about 1/10th length. (mostly from MAH).

Distribution: Monterey Bay (California) to Baja California, Common, on upper surfaces of protected rocks, intertidal to depths of 20+ m. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Not common, occurring in about 5% of our quadrats, sometimes as many as 50 per m^2, but never as mats.

Habitat: On rocks, tops, sides, and crevices, mid-lower to low tide levels.

Observational Errors: Missed observations could occur in areas with dense algal mats, estimated at >10%. In our early surveys (from beginning of our study to late 1980, and some relapses in our later surveys), we did not count individuals of this taxa but noted them as present.

Field Identification Problems:

General: Small individuals (<1-2 cm) are probably not identified.

Station Specific: none.

General Comments: For our Cove stations, probably always present in pre-operational period, but often missed due to typically dense algal mats and general cryptic nature of this species.

Impacts to Taxon:

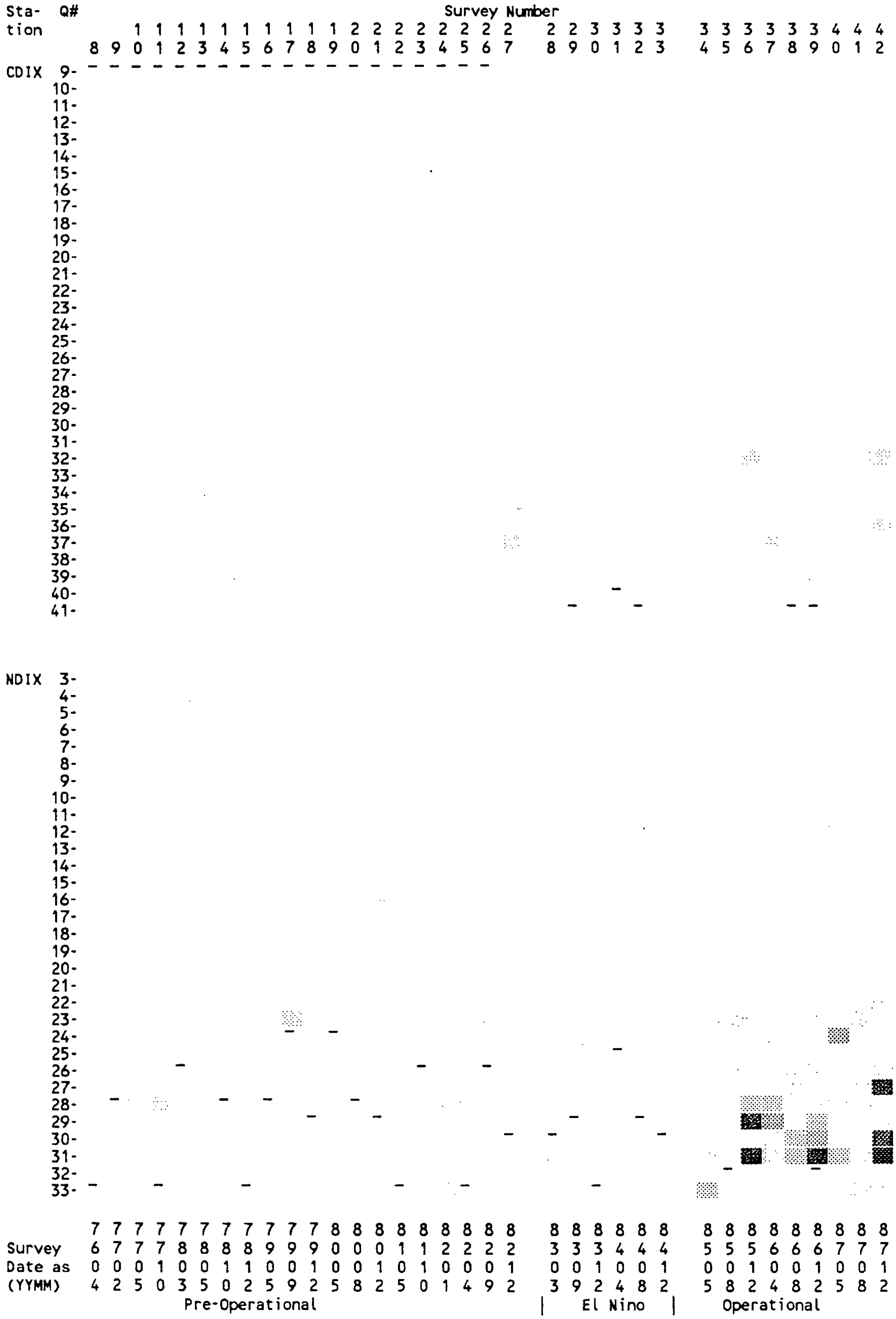
El Niño: 1982-83 winter storm: All Cove stations with no observed individuals (even though algal mat was thin). LCIX lost several occurrences of this species due to a boulder removed by wave action.

El Niño: 1983-1984: All Cove stations remained almost barren of this species. LCIX returned approximately to normal.

Diablo DCPP Operation: SDIX and NDIX developed good populations, probably somewhat masked by missed observations. CDIX as of end of 1987 had several specimens in 2 quadrats. LCIX as pre-operational with possibly higher numbers.

Taxon or Category: Serpulorbis squamigerus [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



N= 52

6-7 2%

4-5 10%

3 6%

2 13%

1 56%

P 13%

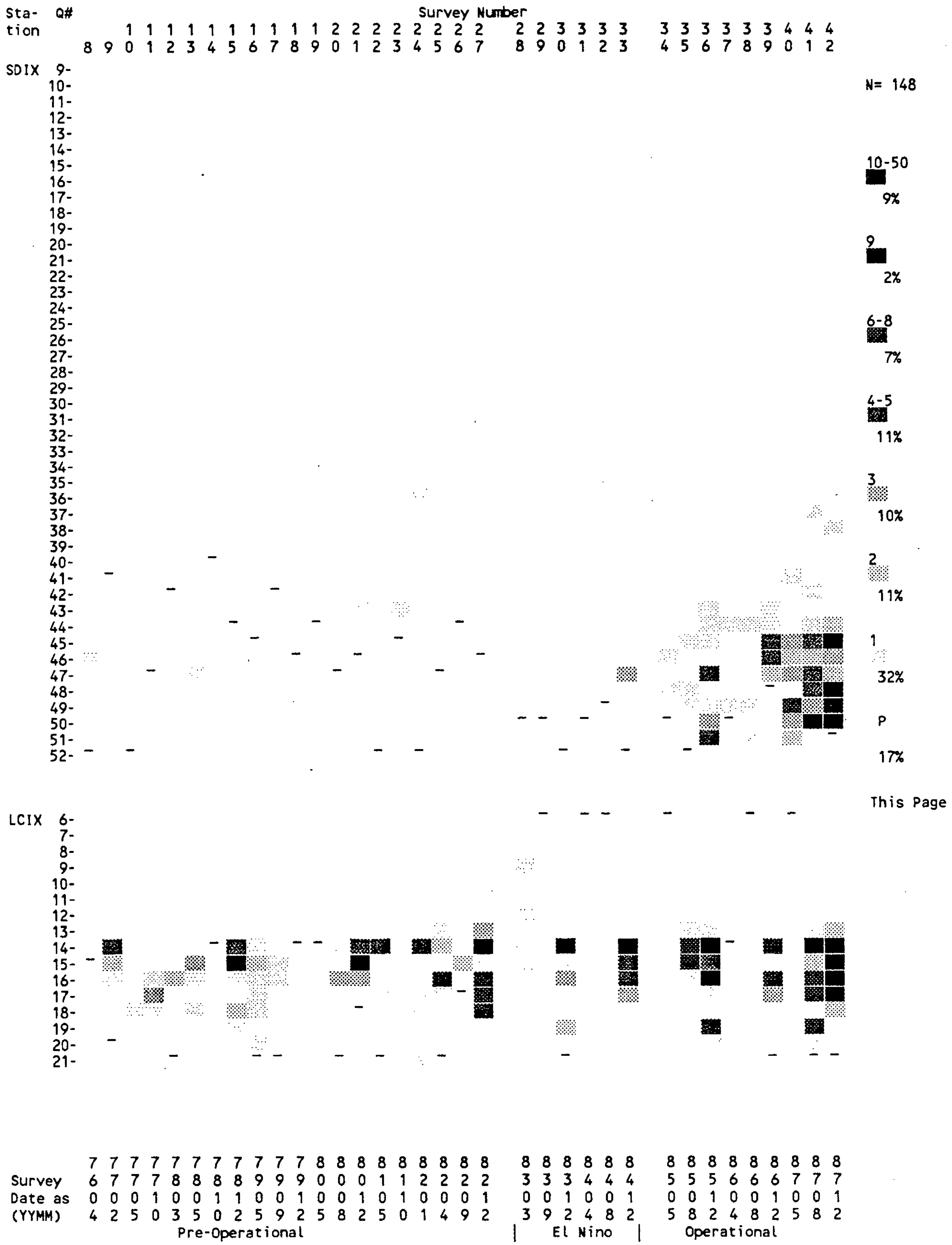
This Page

'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for SERSQU CSV 5263 3-29-88 8:12a 04-15-1989 06:36

Taxon or Category: Serpulorbis squamigerus [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for SERSQU CSV 5263 3-29-88 8:12a 04-15-1989 06:36

Audit: CLUMRG2P: V.1.2: for SSERSQUB CLU 5829 4-23-89 7:37a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:34:20 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Serpulorbis squamigerus [Mixed P/#]: TOTAL Quads with Data = 5:**** Prob. INSUFFICIENT Data ****

Quad Range USED 32 to 37 for Total of 6 : Range WITH data 32 to 37: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 37
COPHENETIC CORRELATION COEFFICIENT = 0.750671: Maximum Distance = 5

```
S27-8212 ----------------------------------------I---------------I
S37-8604 ----------------------------------------I               I
S28-8303 ----------------------------------------I               I
S29-8309 ----------------------------------------I               I----------I
S30-8312 ----------------------------------------I               I          I
S31-8404 ----------------------------------------I               I          I
S32-8408 ----------------------------------------I               I          I
S33-8412 ----------------------------------------I---------------I          I
S34-8505 ----------------------------------------I                          I------
S35-8508 ----------------------------------------I                          I
S38-8608 ----------------------------------------I                          I
S39-8612 ----------------------------------------I                          I
S40-8705 ----------------------------------------I                          I
S41-8708 ----------------------------------------I                          I
S36-8512 --------------------------------------------------------I----------I
S42-8712 --------------------------------------------------------I
```

Station: NDIX: Serpulorbis squamigerus [Mixed P/#]: TOTAL Quads with Data = 47

Quad Range USED 23 to 27 for Total of 5 : Range WITH data 16 to 33: : # Dropped 33 : 70.2%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.881103: Maximum Distance = 3

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End   Dropped Surveys
S 8-7604 --------------------I
S 9-7702 --------------------I
S10-7705 --------------------I
S11-7710 --------------------I
S13-7805 --------------------I
S14-7810 --------------------I
S15-7812 --------------------I
S16-7905 --------------------I
S18-7912 --------------------I
S20-8008 --------------------I--------------------I
S21-8012 --------------------I                    I
S22-8105 --------------------I                    I
S24-8201 --------------------I                    I
S25-8204 --------------------I                    I
S28-8303 --------------------I                    I--I
S29-8309 --------------------I                    I  I
S30-8312 --------------------I                    I  I
S32-8408 --------------------I                    I  I-----------------I
S34-8505 --------------------I                    I  I                 I
S27-8212 --------------------I--------------------I  I                 I
S33-8412 --------------------I                       I                 I
S37-8604 --------------------I-----------------------I                 I----------I
S40-8705 --------------------I                                         I          I
S35-8508 --------------------I--------------------I                    I          I
S36-8512 --------------------I                    I----------I         I          I------
S39-8612 -----------------------------------------I          I---------I          I
S41-8708 ----------------------------------------------------I                    I
S38-8608 --------------------I----------------------------------------------------I
S42-8712 --------------------I
```

```
Station:  SDIX:   Serpulorbis squamigerus [Mixed P/#]:   TOTAL Quads with Data = 53

        Quad Range USED 37 to 45 for Total of 9 :  Range WITH data 36 to 51:  :  # Dropped  34 :   64.2%
        Surveys  26 :  Dropped  9 Surveys if quads sampled < 45
        COPHENETIC CORRELATION COEFFICIENT = 0.924892:                        Maximum Distance = 6

S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604  ---------------------------------I
S10-7705  ---------------------------------I
S11-7710  ---------------------------------I
S13-7805  ---------------------------------I
S18-7912  ---------------------------------I
S20-8008  ---------------------------------I
S22-8105  ---------------------------------I
S24-8201  ---------------------------------I
S25-8204  ---------------------------------I-----------------I
S27-8212  ---------------------------------I                 I
S28-8303  ---------------------------------I                 I
S29-8309  ---------------------------------I                 I
S30-8312  ---------------------------------I                 II
S31-8404  ---------------------------------I                 II
S32-8408  ---------------------------------I                 II
S33-8412  ---------------------------------I                 II---------I
S34-8505  ---------------------------------I                 II         I
S21-8012  ---------------------------------------------------II         I--------------------I
S37-8604  ---------------------------------I-----------------I          I                    I
S38-8608  ---------------------------------I                            I                    I
S35-8508  ---------------------------------------------------I----------I                    I----------------I
S40-8705  ---------------------------------------------------I                               I                I
S36-8512  ---------------------------------I-----------------------------------I             I                I------
S39-8612  ---------------------------------I                                   I-------------I                I
S42-8712  ---------------------------------------------------------------------I                              I
S41-8708  ----------------------------------------------------------------------------------------------------I


Station:  LCIX:   Serpulorbis squamigerus [Mixed P/#]:   TOTAL Quads with Data = 96

        Quad Range USED 13 to 19 for Total of 7 :  Range WITH data 9 to 24:  :  # Dropped  13 :   13.5%
        Surveys  22 :  Dropped  7 Surveys if quads sampled < 19
        COPHENETIC CORRELATION COEFFICIENT = 0.548119:                        Maximum Distance = 4

S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  --------------------------I------------I
S17-7909  --------------------------I            I------------I
S12-7803  --------------------------I------------I            I-------------------------I
S20-8008  --------------------------I                         I                         I
S13-7805  ----------------------------------------------------I                         I---------------------I
S10-7705  I-----------------------------------------------------------------I           I                     I
S23-8110  I                                                                 I-----I     I                     I
S11-7710  --------------------------I---------------------------------------I     I-----I                     I
S24-8201  --------------------------I                                             I                           I
S22-8105  ------------------------------------------------------------------------I                           I------
S15-7812  --------------------------I---------------------I                                                   I
S28-8303  I-------------------------I                     I                                                   I
S30-8312  I                                               I-------------------------I                         I
S33-8412  I-------------------------I                     I                         I                         I
S39-8612  I                         I---------------------I                         I                         I
S36-8512  I-------------------------I                                               I-------------------------I
S41-8708  I                                                                         I
S16-7905  --------------------------I---------------------I                         I
S27-8212  I-------------------------I                     I-------------------------I
S42-8712  I                                               I
S25-8204  --------------------------I---------------------I
S35-8508  --------------------------I
```

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Tegula brunnea (Brown Turban Snail). (Philippi, 1848). Ref. MAH, 1980, p. 252.
Phylum Mollusca: **Class** Gastropoda:

Description: Rounded-conical, smooth, aperture about 1/3+ of length. Color orange or bright brown. Foot with dark brown or black sides, white-cream below. Length 0.6 - 3+ cm, diam. about same as length. (from MAH).

Distribution: Cape Arago (Oregon) to Santa Barbara Island (Channel Islands, California), abundant lower intertidal to subtidal on rocky shores, and upper blades and stipes of kelps offshore. (from MAH). Not a warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 20% of our quadrats in concentrations up to 80 per m^2. Often overgrown by fleshy algal crust, *Peyssonellia meridionalis*.

Habitat: On rocks, tops, sides, and undersides, sometimes in small depressions (LCIX), mid to lower tide levels.

Observational Errors: Small individuals (<0.5 cm) that may be this group are field identified as *Tegula* sp. juveniles, if distinctive color not readily observed. Other missed observations are probably limited to areas with dense algal (or surf-grass) cover quadrats and no estimate of number missed is available as this is quite a fairly motile species.

In earlier surveys (prior to 1978) this taxon was not routinely counted, but noted as present (with occasional relapses in following surveys).

Field Identification Problems:

General: Smaller individuals (<0.5 cm) may be confused with almost any of the *Tegula* spp. occurring in the area.

Station Specific: none.

General Comments: none.

Impacts to Taxon:

El Niño: 1982-83 winter storm: All Cove stations possibly with reduced occurrence in mid intertidal and some reduction in numbers. LCIX with reduced occurrence in outer parts of transect and some reduction in numbers.

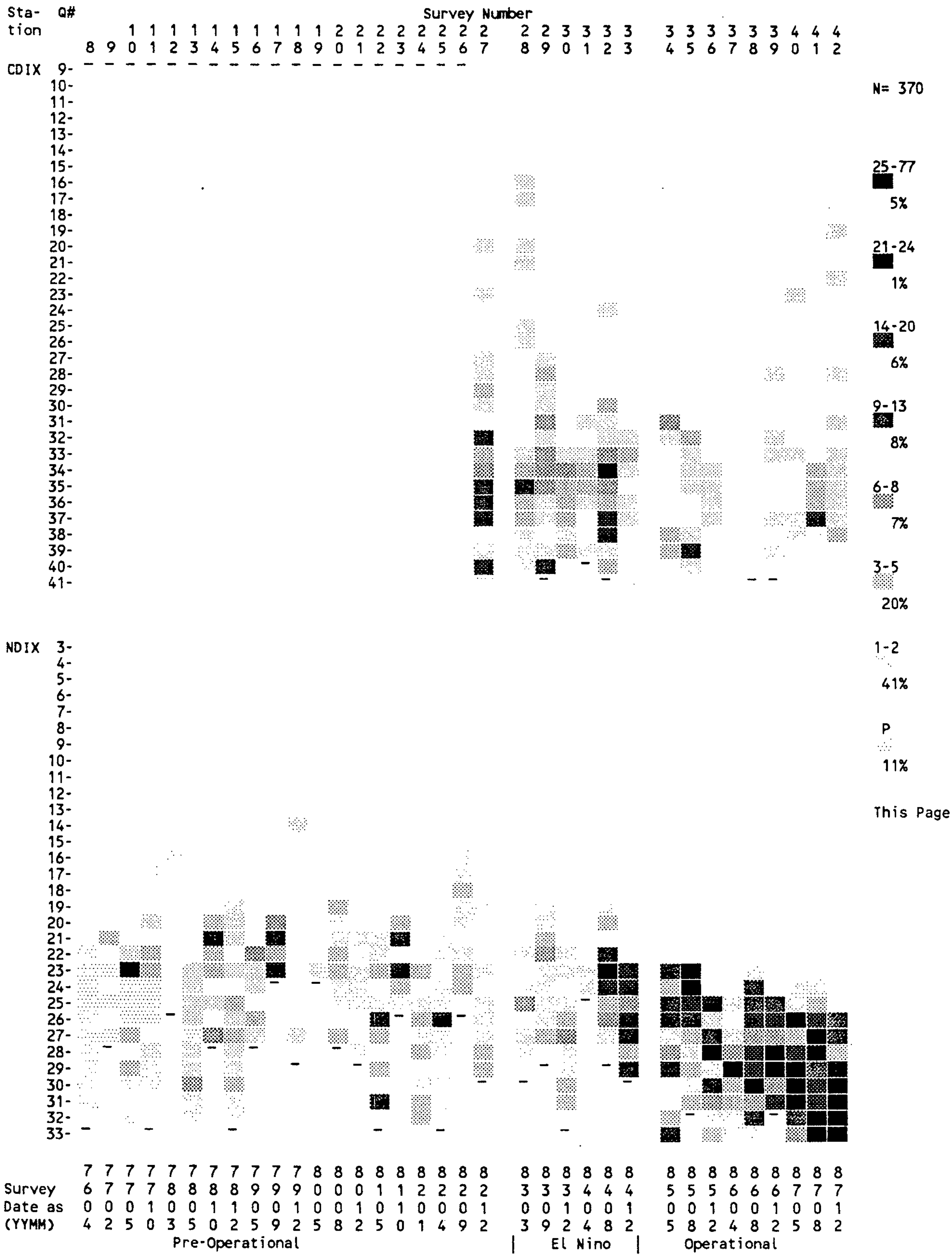
El Niño: 1983-1984: SDIX with possible slow and sporadic recovery, with a shift downward in the intertidal, (where occurring, more numerous?). NDIX with sporadic recovery to above normal numbers, but losing occurrences in the mid intertidal. CDIX with sporadic reduction in range in the mid intertidal, but high quadrats at end of transect were less affected. LCIX losing mid-tide occurrences with possible decline in numbers in remaining quadrats.

Diablo DCPP Operation: SDIX maintained its late El Niño extension into the lower intertidal, but sporadic declines in numbers and mid intertidal occurrences. NDIX with moderately stable populations with numbers greater than normal, and losing 1 quadrat at its upper range in the intertidal. CDIX very sporadic, declining in numbers and occurrences until end of 1986, then increasing in occurrences but with low numbers. LCIX recovering to pre-operational conditions.

Shift downward in range at SDIX and loss of upper range at NDIX could possibly be result of thinning algal mat in these areas, i.e., less protection for this species from environmental factors.

Taxon or Category: Tegula brunnea [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

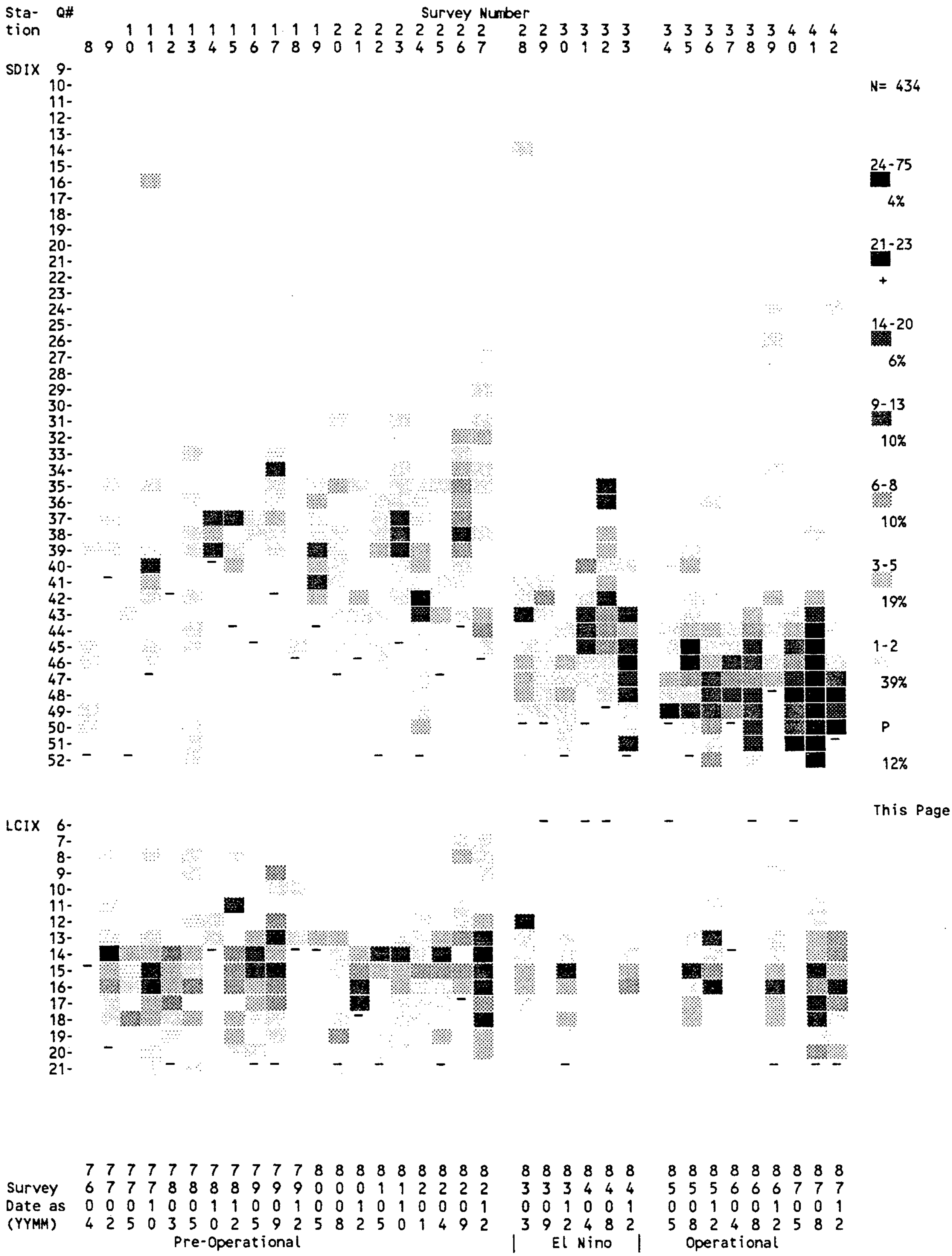


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for TEGBRU CSV 5568 3-29-88 8:13a 04-15-1989 06:37

Taxon or Category: Tegula brunnea [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for TEGBRU CSV 5568 3-29-88 8:13a 04-15-1989 06:37

Audit: CLUMRG2P: V.1.2: for STEGBRUB CLU 5829 4-23-89 8:03a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/08:00:27 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Tegula brunnea [Mixed P/#]: TOTAL Quads with Data = 111

Quad Range USED 20 to 39 for Total of 20 : Range WITH data 16 to 41: : # Dropped 10 : 9.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.558415: Maximum Distance = 9

```
S27-8212 -------------------------------------------------I-----------------------------------------------------------------------------------------------------I
S29-8309 -------------------------------------------------I                                                                                                     I
S28-8303 ----------------------------------------------------------------------------------------------------------------------------------------I              I
S30-8312 -------------------------------------------------I-------I                                                                              I              I------
S31-8404 -------------------------------------------------I       I--------------I                                                               I              I
S35-8508 ---------------------------------------------------------I              I--------------I                                                I              I
S33-8412 -------------------------------------------------I----------------------I              I                                                I--------------I
S36-8512 I------------------------------------------------I                                     I-----I                                          I
S41-8708 I                                                                                      I     I--------------I                           I
S42-8712 ---------------------------------------------------------------------------------------I     I              I                           I
S32-8408 ---------------------------------------------------------------------------------------------I              I---------------------------I
S34-8505 ----------------------------------------------------------------I-----------I                               I
S37-8604 I---------------------------------------------------------------I           I----I                          I
S38-8608 I                                                                           I    I--------------------------I
S40-8705 ----------------------------------------------------------------------------I    I
S39-8612 ---------------------------------------------------------------------------------I
```

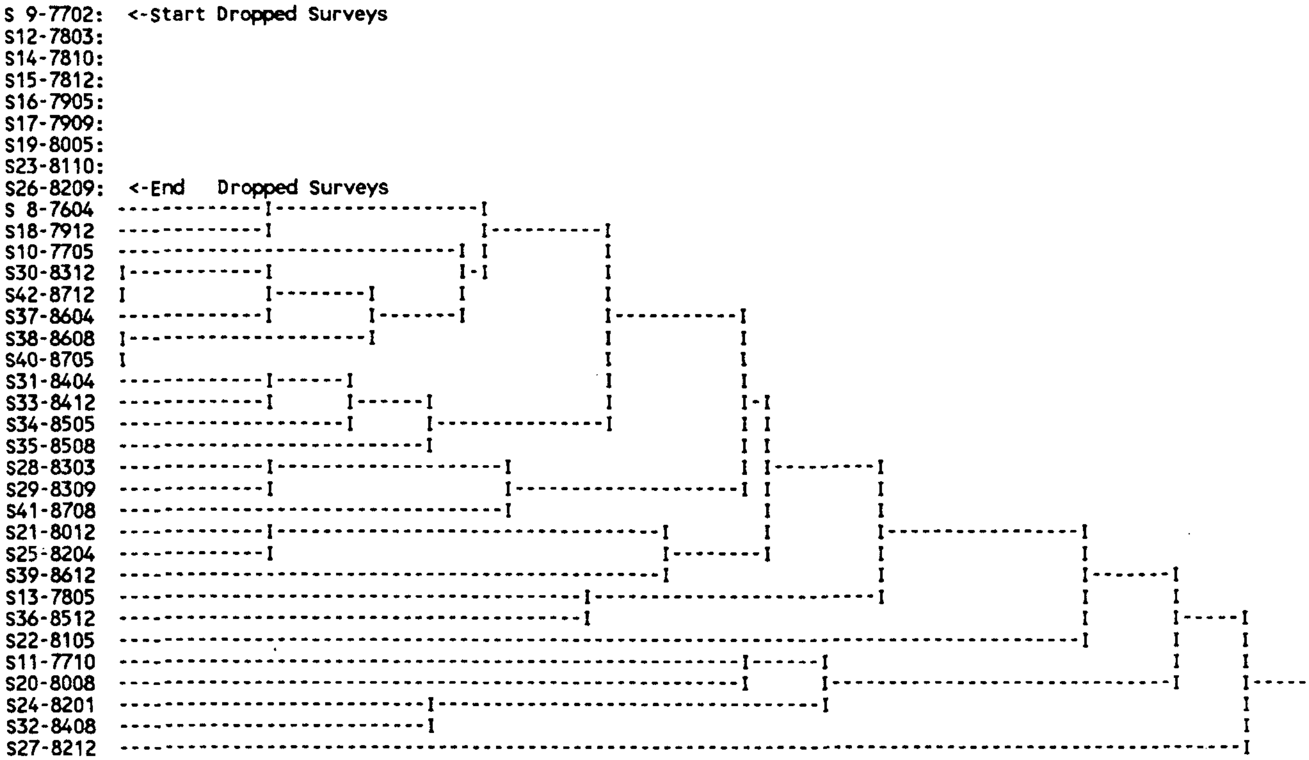
Station: NDIX: Tegula brunnea [Mixed P/#]: TOTAL Quads with Data = 259

Quad Range USED 17 to 27 for Total of 11 : Range WITH data 14 to 33: : # Dropped 115 : 44.4%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.643398: Maximum Distance = 5

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End  Dropped Surveys
S 8-7604 I------------------------------I
S10-7705 I                              I-------------I
S13-7805 I                              I             I
S35-8508 I------------------------------I             I-I
S38-8608 I                                            I I---------------I
S33-8412 ---------------------------------------------I I               I-----------I
S34-8505 -----------------------------------------------I               I           I
S16-7905 ---------------------------------------------------------------I           I-----------------I
S22-8105 -------------------------------I-------------------------------I           I                 I
S30-8312 -------------------------------I                               I-----------I                 I
S24-8201 -------------------------------I-------------------------------I                             I-------I
S27-8212 -------------------------------I                                                             I       I
S18-7912 -------------------------------I---------------I                                             I       I
S37-8604 -------------------------------I               I----------I                                  I       I
S42-8712 -----------------------------------------------I          I----------------------------------I       I------------------------------I
S36-8512 I------------------------------I                          I                                          I                              I
S39-8612 I                              I--------------------------I                                          I                              I
S40-8705 I------------------------------I                                                                     I                              I
S41-8708 I                                                                                                    I                              I------------------I
S25-8204 ---------------------------------------------------------------I-------------------------------------I                              I                  I
S28-8303 ---------------------------------------------------------------I                                                                    I                  I
S 9-7702 ---------------------------------------------------------------I--------------------------------I                                   I                  I------
S14-7810 ---------------------------------------------------------------I                                I-----------------------------------I                  I
S21-8012 ------------------------------------------------------------------------------------------------I                                                      I
S11-7710 -------------------------------------------------------------------------------------------------------------------------------------------------I     I
S15-7812 --------------------------------------------------------------------------------------I                                                          I-----I
S20-8008 -------------------------------I---------------I                                      I----------------------------------------------------------I
S29-8309 -------------------------------I               I--------------------------------------I
S32-8408 -----------------------------------------------I
```

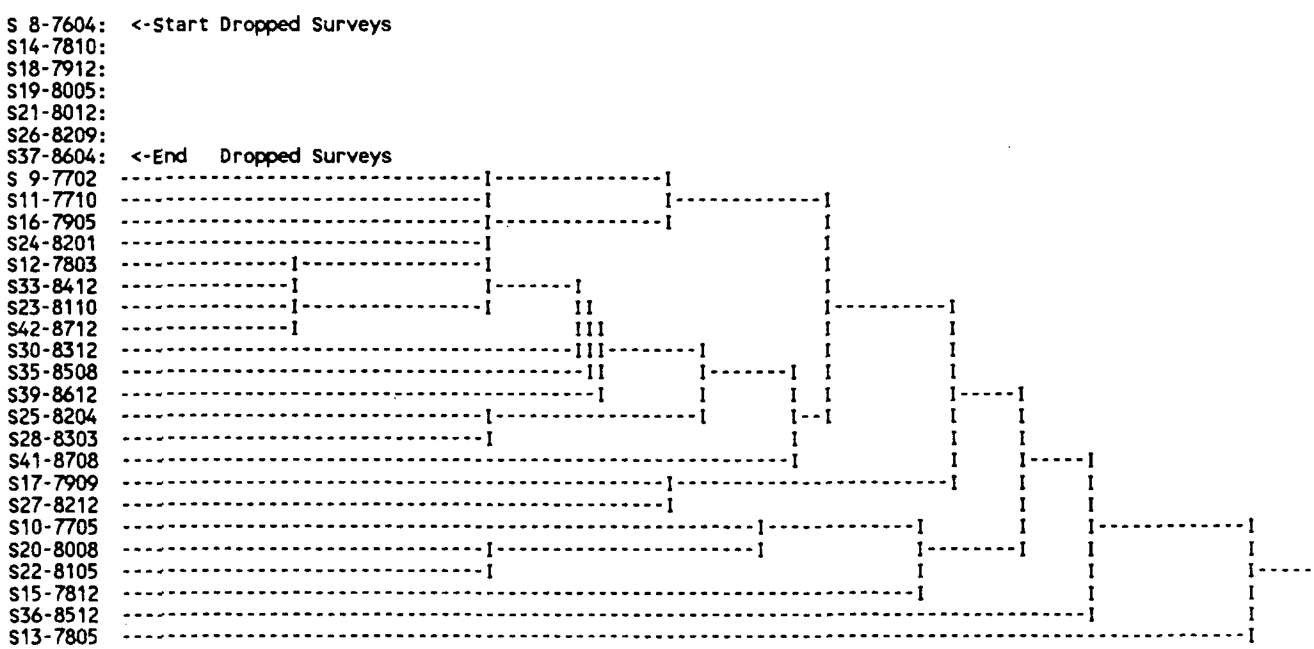
Station: SDIX: Tegula brunnea [Mixed P/#]: TOTAL Quads with Data = 258

Quad Range USED 31 to 45 for Total of 15 : Range WITH data 14 to 55: : # Dropped 141 : 54.7%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.684940: Maximum Distance = 7



Station: LCIX: Tegula brunnea [Mixed P/#]: TOTAL Quads with Data = 180

Quad Range USED 8 to 19 for Total of 12 : Range WITH data 4 to 22: : # Dropped 33 : 18.3%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.591152: Maximum Distance = 6



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Tegula funebralis (Black Turban Snail). (A. Adams, 1855). Ref. MAH, 1980, p. 253.
Phylum Mollusca: **Class** Gastropoda:

Description: Rounded-conical, weak spiral striations, aperture about 1/3+ of length. Color dark purple to black. Foot black on sides. Length 0.6 - 3+ cm, diam. about same as length. (from MAH).

Distribution: Vancouver Island (British Columbia) to central Baja California, common to abundant mid intertidal in protected coastal areas. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Abundant, occurring in about 75% of our quadrats in numbers up to 700+ per m^2.

Habitat: On rocks, tops, sides, and undersides, cobbles, sand/gravel areas, and algae, often in dense aggregates, upper to low tide levels.

Observational Errors: Small individuals (<0.5 cm) that may be this group were field identified as *Tegula* sp. juveniles, to avoid possible confusion. Other missed observations are probably limited to areas with dense algal cover quadrats and no estimate of number missed is available as this is a fairly motile species. Occasionally (<0.5% of the observations) we might have neglected to call this taxon.

Field Identification Problems:

General: Smaller individuals (<0.5 cm) may be confused with almost any of the *Tegula* spp. occurring in the area.

Station Specific: none.

General Comments: In earlier surveys (prior to 1977) this taxon was not routinely counted, but noted as present (with occasional relapses in following surveys).

Impacts to Taxon:

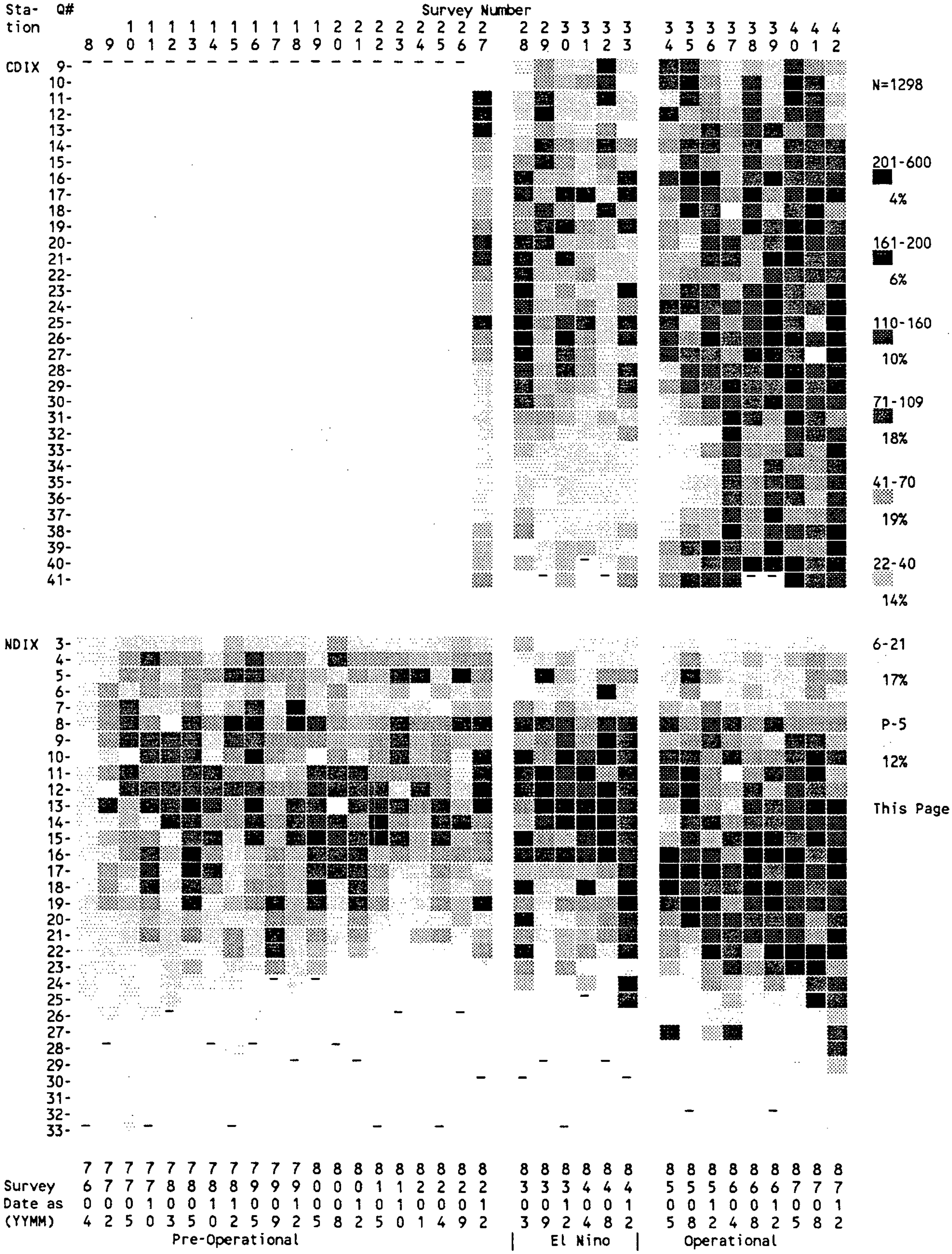
El Niño: 1982-83 winter storm: SDIX with increased numbers and occurrences in the lower intertidal, probably washed in by the storms. All other stations no discernable change.

El Niño: 1983-1984: SDIX and NDIX probably with higher numbers, with SDIX populations extending farther down into the lower intertidal than normal, and NDIX's numbers increasing in the low intertidal. CDIX with insufficient pre-El Niño data to assess, but occurrence and numbers similar to pre-El Niño survey. LCIX never with large numbers of this taxon, but apparently remained normal.

Diablo DCPP Operation: SDIX maintained its El Niño extension into the lower intertidal, with the center of the population shifting downwards. NDIX much as El Niño for numbers and extension of occurrences into the lower intertidal, and as for SDIX, the center of the population shifting downwards. CDIX with slowly increasing numbers, also with a shift of population densities towards lower intertidal levels. LCIX possibly losing some occurrences at the lower tidal levels towards the end of 1987.

Taxon or Category: Tegula funebralis [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

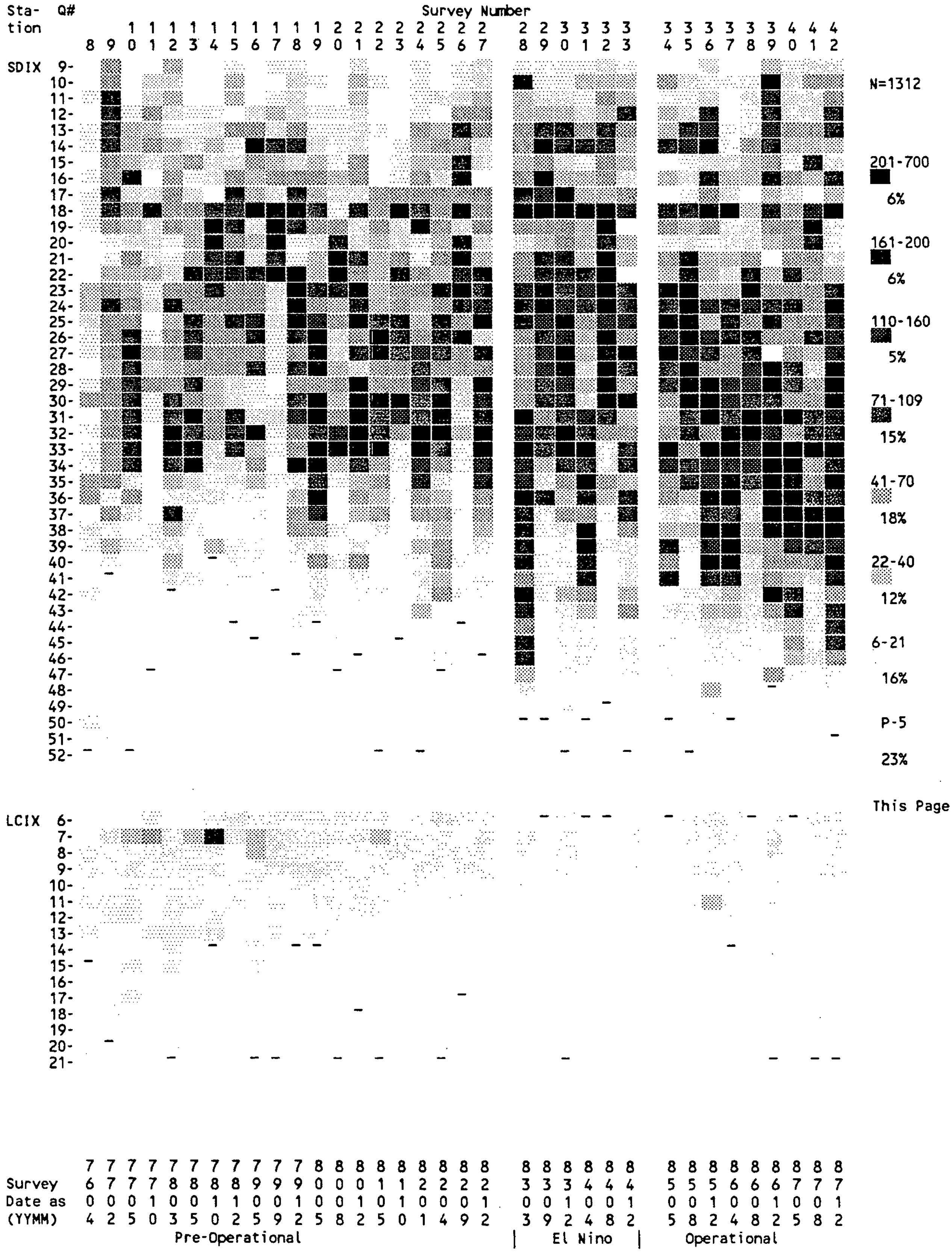


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for TEGFUN CSV 7812 3-29-88 8:13a 04-15-1989 06:38

Taxon or Category: Tegula funebralis [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for TEGFUN CSV 7812 3-29-88 8:13a 04-15-1989 06:38

Audit: CLUMRG2P: V.1.2: for STEGFUNB CLU 6581 4-23-89 8:08a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/08:04:24 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Tegula funebralis [Mixed P/#]: TOTAL Quads with Data = 550

Quad Range USED 3 to 39 for Total of 37 : Range WITH data 3 to 41: : # Dropped 25 : 4.5%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.331032: Maximum Distance = 25

```
S27-8212  -------------------------------------------------------------------------------------------I-----I
S28-8303  -------------------------------------------------------------------------------------------I     I
S29-8309  ------------------------------------------------------------------------------------------I      I
S30-8312  -------------------------------------------------------------------------------I          I      I
S32-8408  -------------------------------------------------------------------------------I---I      II     I
S40-8705  -------------------------------------------------------------------------------I   II     II     I
S31-8404  -----------------------------------------------------------------------------------II-I   II     I-I
S39-8612  ------------------------------------------------------------------------------------I I---III    I I
S38-8608  -----------------------------------------------------------------------------------I--I    II    I I
S42-8712  -----------------------------------------------------------------------------------I       II    I I
S33-8412  -------------------------------------------------------------------------------------------II--I I I------
S35-8508  ---------------------------------------------------------------------------------------I---II  I I I
S36-8512  ---------------------------------------------------------------------------------------I    I  I-I I
S41-8708  --------------------------------------------------------------------------------------------I  I   I
S37-8604  -----------------------------------------------------------------------------------------------I   I
S34-8505  ---------------------------------------------------------------------------------------------------I
```

Station: NDIX: Tegula funebralis [Mixed P/#]: TOTAL Quads with Data = 805

Quad Range USED 3 to 25 for Total of 23 : Range WITH data 2 to 33: : # Dropped 120 : 14.9%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.753015: Maximum Distance = 11

```
S17-7909:  <-Start Dropped Surveys
S19-8005:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------------------------------------------------------------I
S 9-7702  ------------------------------------------------------------I--I                                   I
S16-7905  ----------------------------------------------------I-------I  I----------I                        I
S22-8105  ----------------------------------------------------I          I          I                        I
S25-8204  ---------------------------------------------------------------I          I                        I
S20-8008  ---------------------------------------------------------------------I    I                        I
S24-8201  ---------------------------------------------------------------------I----I                        I
S32-8408  ---------------------------------------------------------------------I    I                        I
S10-7705  ------------------------------------------------------------I             I                        I
S18-7912  ----------------------------------------------------I       I             I                        I
S21-8012  ----------------------------------------------------I       II            I                        I
S27-8212  ----------------------------------------------------I       II            I                        I
S33-8412  ----------------------------------------------------I       II            I-----I                  I
S34-8505  ----------------------------------------------------I-------II            I     I                  I
S38-8608  ----------------------------------------------------I        II           I     I                  I------
S39-8612  ----------------------------------------------------I        II           I     I                  I
S40-8705  ----------------------------------------------------I        II           I     I                  I
S41-8708  ----------------------------------------------------I        II-I         I     I                  I
S12-7803  -------------------------------------------------------------II I         I     I                  I
S13-7805  ----------------------------------------------------I         I I         I     I                  I
S15-7812  ----------------------------------------------------I---------I I----I    I     II                 I
S30-8312  ----------------------------------------------------I           I    I    I     II                 I
S35-8508  ----------------------------------------------------I           I    I----I     II                 I
S37-8604  ----------------------------------------------------------------I    I          II                 I
S36-8512  ------------------------------------------------------------I--------I          II                 I
S42-8712  ------------------------------------------------------------I                   II---------------I I
S11-7710  ------------------------------------------------------------I----I              II               I I
S26-8209  ------------------------------------------------------------I    I------I       II               I I
S14-7810  -----------------------------------------------------------------I      I-------II               I-I
S29-8309  ------------------------------------------------------------------------I        I               I
S28-8303  ---------------------------------------------------------------------------------I               I
S23-8110  -------------------------------------------------------------------------------------------------I
```

Station: SDIX: Tegula funebralis [Mixed P/#]: TOTAL Quads with Data = 1160

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 3 to 52: : # Dropped 378 : 32.6%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.860735: Maximum Distance = 17

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  -------------------------------------------------------------------------------------------I
S10-7705  ----------------------------------I-------------I                                          I
S32-8408  ----------------------------------I             I----------I                               I
S15-7812  ---------------------------------------I--------I          I                               I
S16-7905  ---------------------------------------I                   I                               I
S18-7912  ---------------------------------------------I--I          I                               I
S35-8508  ---------------------------------------------I  I          I                               I
S19-8005  ----------------------------------I             I          I                               I
S24-8201  ----------------------------------I             I          I                               I
S28-8303  ----------------------------------I             I          I                               I
S30-8312  ----------------------------------I             II         I                               I
S31-8404  ----------------------------------I----I        II         II                              I-------I
S36-8512  ----------------------------------I    I        II         II                              I       I
S37-8604  ----------------------------------I    I----I   II         II                              I       I
S40-8705  ----------------------------------I    I    I   II         II                              I       I
S42-8712  ----------------------------------I    I    I   III        II                              I       I
S38-8608  ----------------------------------I----I    I---III        II                              I       I
S41-8708  ----------------------------------I         I    II        II                              I       I
S21-8012  ---------------------------------------I--I I    II---I    II--------I                     I       I
S25-8204  ---------------------------------------I  I-I    II   I    II        I                     I       I
S29-8309  ------------------------------------------I      II   I----II        I                     I       I------
S33-8412  -------------------------------------------------II   I     I        I                     I       I
S39-8612  --------------------------------------------------I   I     I        I                     I       I
S34-8505  ------------------------------------------------------I     I        I---------------------I       I
S13-7805  ---------------------------------------------------I--I     I        I                             I
S27-8212  ---------------------------------------------------I  I-----I        I                             I
S22-8105  ------------------------------------------------------I              I                             I
S20-8008  ---------------------------------------------------I--I              I                             I
S23-8110  ---------------------------------------------------I  I--------------I                             I
S26-8209  ------------------------------------------------------I                                            I
S11-7710  ---------------------------------------------------------------------------------------------------I
```

Station: LCIX: Tegula funebralis [Mixed P/#]: TOTAL Quads with Data = 236

Quad Range USED 3 to 14 for Total of 12 : Range WITH data 3 to 20: : # Dropped 39 : 16.5%
Surveys 25 : Dropped 4 Surveys if quads sampled < 14
COPHENETIC CORRELATION COEFFICIENT = 0.469578: Maximum Distance = 4

```
S14-7810:  <-Start Dropped Surveys
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 8-7604  --------------------------------------------I
S13-7805  --------------------------------------------I-----------------------------I
S28-8303  --------------------------------------------I                             I--------------------I
S23-8110  --------------------------------------------------------------------------I                    I---I
S16-7905  --------------------------------------------I--------------------------------------------------I   I
S25-8204  --------------------------------------------I                                                      I
S 9-7702  ----------------------I--------------------------------I                                           I
S10-7705  ----------------------I                                I------------------I                        I
S12-7803  -------------------------------------------------------I                  I--------I               I
S39-8612  --------------------------------------------------------------------------I        I               I------
S11-7710  ----------------------I----------I                                                 I               I
S27-8212  ----------------------I          I---I                                             I-------I       I
S30-8312  ---------------------------------I   I------------I                                I       I       I
S42-8712  -------------------------------------I            I---------------------I          I       I       I
S21-8012  ----------------------I---------------------------I                     I          I       I       I
S24-8201  ----------------------I                                                 I----------I       I       I
S17-7909  ----------------------I----------I                                      I                  I-------I
S22-8105  ----------------------I          I---I                                  I                  I
S26-8209  ---------------------------------I   I----------------------------------I                  I
S36-8512  -------------------------------------I                                                     I
S15-7812  --------------------------------------------I                                              I
S33-8412  --------------------------------------------I---------------------------------I            I
S35-8508  --------------------------------------------I                                 I------------I
S41-8708  --------------------------------------------I                                 I
S20-8008  ------------------------------------------------------------------------------I
```

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Balanus spp.

Balanus glandula (Barnacle). Darwin, 1854. Ref. MAH, 1980, p. 520.
Phylum Arthropoda: **Class** Crustacea:

Description: White to gray, variable shape and texture, similar to *B. crenatus*, usually distinguishable by the dark area on each scutum. Diameter 0.3 - 1 + cm (2.2 cm, MAH), diam. about same or greater than height. (from MAH).

Distribution: Aleutian Islands (Alaska) to Bahia de San Quintin (Baja California), abundant, high to mid intertidal on rocks, pier pilings, and hard-shelled animals along outer coastal areas. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 10% of our quadrats in numbers up to 300+ per m^2.

Habitat: On rocks, tops and sides. Upper to low tide levels.

Observational Errors: Small individuals (<0.3 cm) that may be this group are field identified as "unid. balanomorphs, juvenile" to avoid possible confusion with *Chthamalus* spp. Missed observations occur moderately frequently in areas of dense algal cover, upper intertidal areas occasionally covered with sand and gravel (SDIX and NDIX) and when mixed with large numbers of *Chthamalus* spp.

Indications are that we did not consistently identify this group during some of our surveys, and we estimate that missed calls were about 10% of the total. In addition we have not been consistent in attempting to count individuals, so numbers should not be compared between surveys.

Field Identification Problems:

General: Smaller individuals (<0.6 cm) may be confused with almost any of the whitish low-lying barnacles occurring in the area, and red-marked *Balanus* spp., may occasionally confused with small *Tetraclita*.

Station Specific: At LCIX in the upper intertidal, the only station where this genus is common, we may sometimes miss it, because there it is mixed in with large *Chthamalus* spp.

General Comments: Red-marked specimens of this genus, are rarely found at our intertidal stations. Never a common part of the biota at Cove stations, with last moderate occurrences in 1978-79.

Impacts to Taxon:

El Niño: 1982-83 winter storm: At Cove stations almost non-existent just prior to and after storms. At LCIX no apparent change.

El Niño: 1983-1984: At all Cove stations, sporadic and scattered occurrences. LCIX probably normal although somewhat confused by probable missed observations.

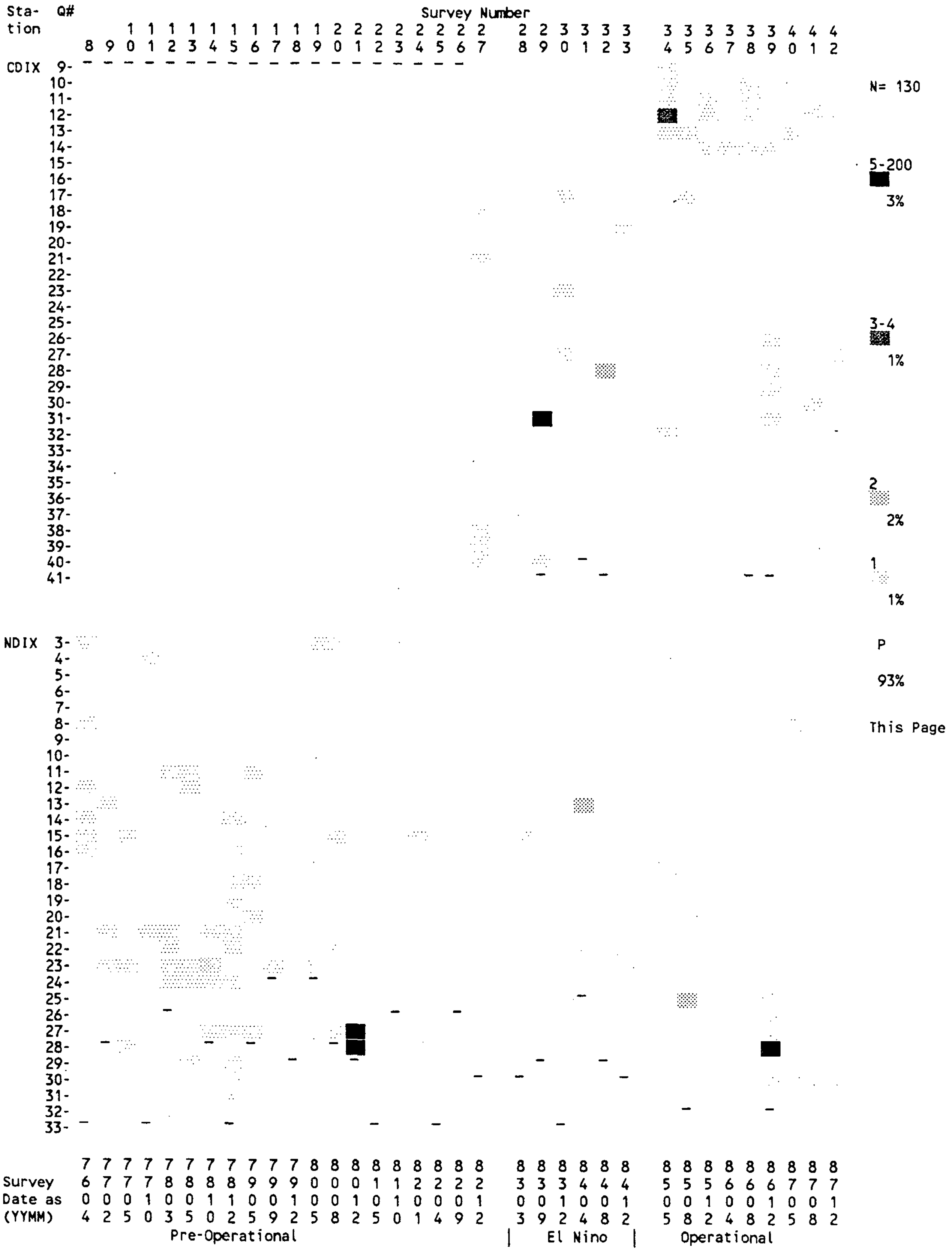
Diablo DCPP Operation: All Cove stations, still with sporadic occurrences. LCIX no apparent change.

Balanus crenatus: Uncommon on rocks, low intertidal zone, Alaska south to Santa Barbara (California). (from MAH).

Red-marked *Balanus*'es that may occur in low intertidal of this area: *B. trigonus*, *B. pacificus*, *B. amphitrite*.

Taxon or Category: Balanus sp. [Mixed P/#/%]

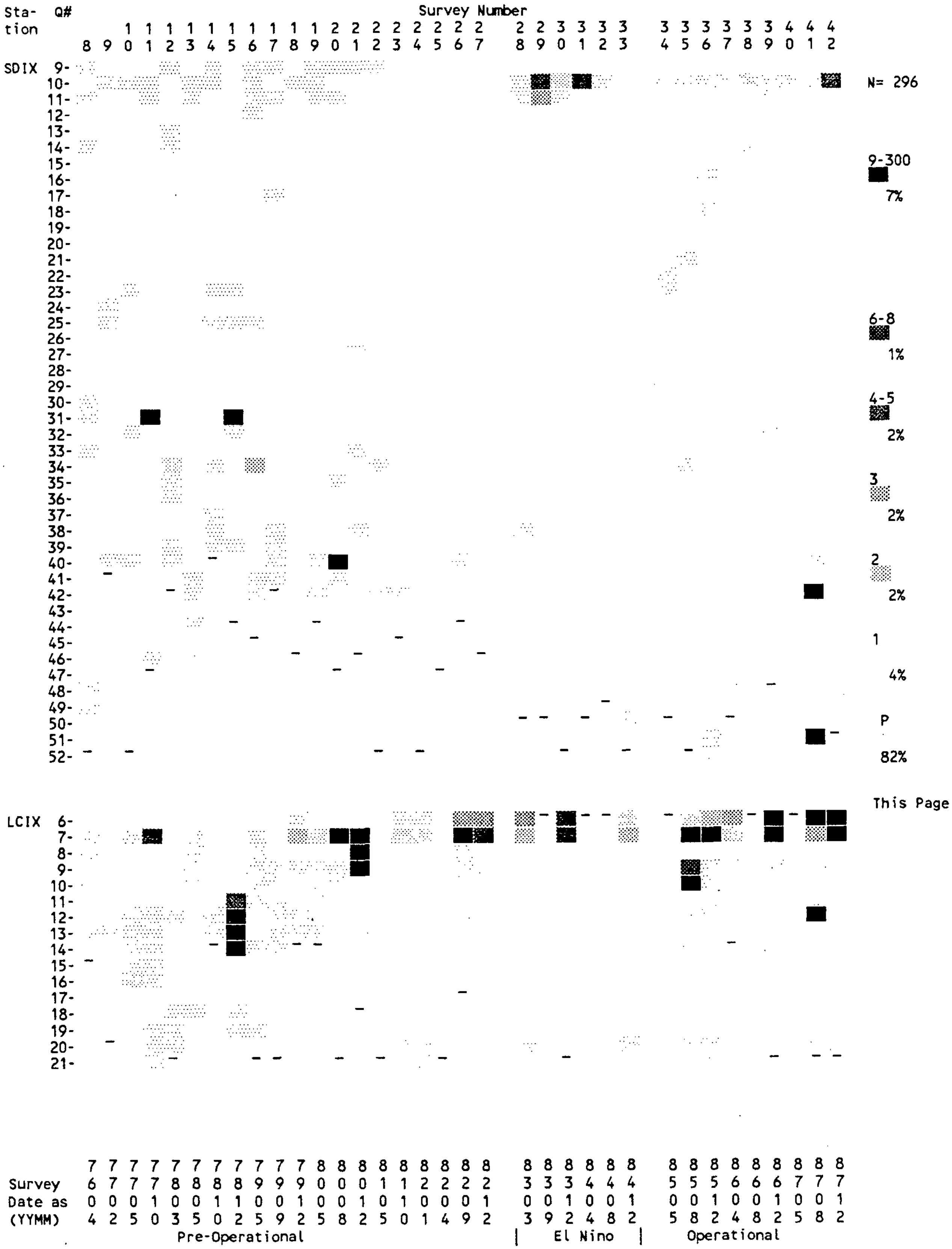
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxon or Category: Balanus sp. [Mixed P/#/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for BALANA CSV 5450 3-31-88 10:16a 04-15-1989 06:20

Audit: CLUMRG2P: V.1.2: for SBALANAB CLU 6581 4-23-89 4:45a: 04-27-1989/17:11
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/04:41:10 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Balanus sp. [Mixed P/#/%]: TOTAL Quads with Data = 51

Quad Range USED 4 to 39 for Total of 36 : Range WITH data 4 to 40: : # Dropped 2 : 3.9%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.598486: Maximum Distance = 21

```
S27-8212 ------------------------------------------------------------------------------I
S28-8303 ---------------------------------------------------I----I                     I
S31-8404 ---------------------------------------------------I    I-I                   I
S29-8309 --------------------------------------------------------I II                  I
S33-8412 ----------------------------------------------------------II----I             I-I
S37-8604 ----------------------------------------------------------II    I----I        I I
S40-8705 -----------------------------------------------------------I    I    I-I      I I
S42-8712 ----------------------------------------------------------------I    I I---I  I I
S30-8312 ---------------------------------------------------------------------I I   I--I I-------I
S32-8408 -----------------------------------------------------------------------I   I    I       I
S35-8508 ---------------------------------------------------------------------------I    I       I
S36-8512 ------------------------------------------------------------------I------I      I       I---------I
S38-8608 ------------------------------------------------------------------I      I------I       I         I
S41-8708 -------------------------------------------------------------------------I              I         I------
S39-8612 ----------------------------------------------------------------------------------------I         I
S34-8505 --------------------------------------------------------------------------------------------------I
```

Station: NDIX: Balanus sp. [Mixed P/#/%]: TOTAL Quads with Data = 90

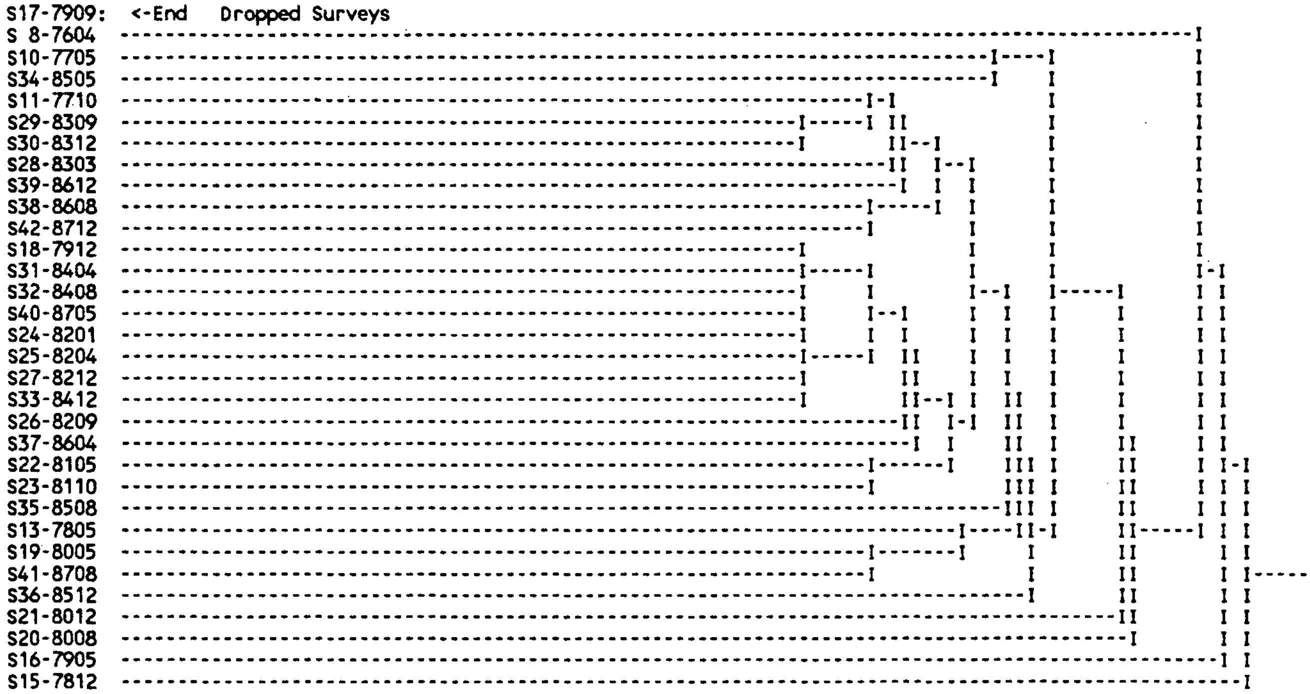
Quad Range USED 4 to 27 for Total of 24 : Range WITH data 3 to 31: : # Dropped 30 : 33.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.805389: Maximum Distance = 13

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End  Dropped Surveys
S 8-7604 -----------------------------------------------------------------------------------I
S 9-7702 ------------------------------------------------------I-I                          I
S14-7810 -------------------------------------------I----------I I---------I                I
S21-8012 -------------------------------------------I            I         I                I
S37-8604 --------------------------------------------------------I         I                I
S10-7705 -------------------------------------------I---I                  I                I
S24-8201 -------------------------------------I-----I   I                  I                I
S28-8303 -------------------------------------I         I                  I                I
S18-7912 -------------------------------------I         I                  I                I
S22-8105 -------------------------------------I         I                  I                I
S29-8309 -------------------------------------I         I-----I            I                I
S30-8312 -------------------------------------I-----I   I     I            I--I             I
S36-8512 -------------------------------------I     I   I     I            I  I             I--------------I
S38-8608 -------------------------------------I     II  I     I            I  I             I              I
S41-8708 -------------------------------------I     II  I     I-I          I  I             I              I
S42-8712 -------------------------------------I     II--I     I I          I  I             I              I
S32-8408 -------------------------------------------II        I I          I  I             I              I
S40-8705 --------------------------------------------I        I I-----I    I  I--I          I              I
S33-8412 -----------------------------------------------------I I     I    I  I  I          I              I
S11-7710 ---------------------------------------------------I---I     I-I  I  I  I          I              I
S25-8204 ---------------------------------------------------I   I     I I  I  I  I          I              I------
S34-8505 -------------------------------------------------------I     I I--I  I  I-I        I              I
S20-8008 -------------------------------------------------------------I I     I  I I        I              I
S35-8508 ---------------------------------------------------------------I     I  I I        I              I
S27-8212 ----------------------------------------------------------I----------I  I I--------I              I
S39-8612 ----------------------------------------------------------I             I I                       I
S13-7805 ------------------------------------------------------------------------I I                       I
S16-7905 --------------------------------------------------------------------------I                       I
S15-7812 --------------------------------------------------------------------------------------------------I
```

Station: SDIX: Balanus sp. [Mixed P/#/%]: TOTAL Quads with Data = 129

Quad Range USED 10 to 43 for Total of 34 : Range WITH data 9 to 52: : # Dropped 56 : 43.4%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.724950: Maximum Distance = 18

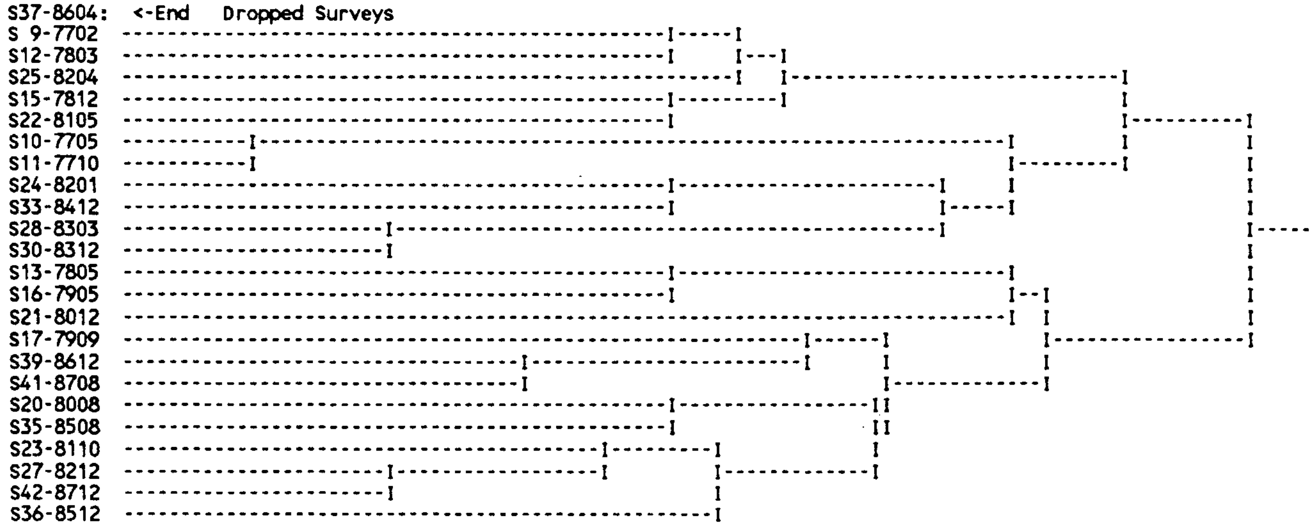
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909: <-End Dropped Surveys



Station: LCIX: Balanus sp. [Mixed P/#/%]: TOTAL Quads with Data = 199

Quad Range USED 3 to 17 for Total of 15 : Range WITH data 3 to 23: : # Dropped 59 : 29.6%
Surveys 23 : Dropped 6 Surveys if quads sampled < 17
COPHENETIC CORRELATION COEFFICIENT = 0.506556: Maximum Distance = 8

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S26-8209:
S37-8604: <-End Dropped Surveys



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Chthamalus spp.

Chtamalus fissus (Barnacle). Darwin, 1854. Ref. MAH, 1980, p. 515.
Phylum Arthropoda: **Class** Crustacea:

Description: White to gray. Diameter 0.2 - 0.8+ cm, diam. about same or greater than height.

Distribution: San Francisco (California) to Baja California, common, high to upper-mid intertidal on rocks, pier pilings, and hard-shelled animals. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Very common, occurring in about 60% of our quadrats in covers to 30%.

Habitat: On rocks, tops and sides as aggregates or scattered individuals. Upper to low tide levels.

Observational Errors: Small individuals (<0.2 cm) that may be this group are field identified as "unid. balanomorphs, juvenile" to avoid possible confusion with *Balanus* spp. Missed observations occur moderately frequently in areas of dense algal cover, and in upper intertidal areas occasionally covered with sand and gravel (SDIX and NDIX).

We were not consistent in estimating covers for this group for earlier surveys (prior to 1978), so these earlier survey numbers should not be compared with later surveys.

Field Identification Problems:

General: Smaller individuals (<0.2 cm) may be confused with almost any of the whitish low-lying barnacles occurring in the area (i.e., *Balanus* spp.). *C. fissus* and *C. dalli* can only be separated when dissected and microscopically examined.

Station Specific: none.

General Comments: Scattered individuals commonly occur in the mid to lower intertidal (see **Observational Errors** above), and when dense algal mat is present these can easily be missed during any single survey.

Impacts to Taxon:

El Niño: 1982-83 winter storm: No apparent impact with the possible exception of CDIX, where it possibly disappeared from about 4 quadrats in the lower intertidal and cover declined in several of the upper-mid intertidal quadrats.

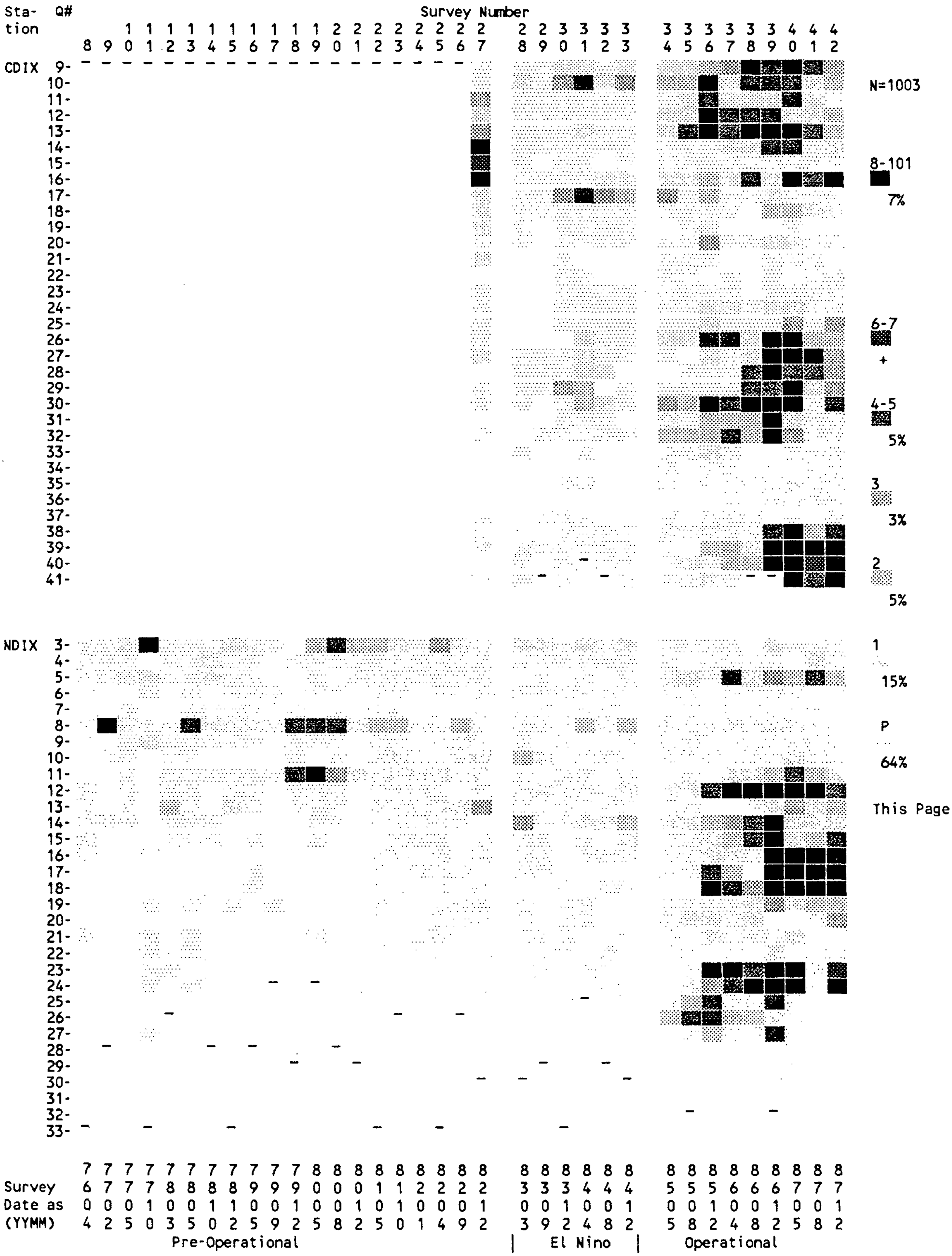
El Niño: 1983-1984: At SDIX possible increase in occurrences probably because of the availability of substrate for settlement due to introduced cobble from cliff collapse. Other stations appearing much as prior surveys.

Diablo DCPP Operation: All Cove stations with increasing numbers and number of occurrences with center of population shifting downward in the intertidal, with possible trend toward declining numbers at these lower quadrats toward the end of 1987. LCIX with no apparent change.

Chtamalus dalli: As *C. fissus*, but range Alaska to San Diego (California). (from MAH).

Taxon or Category: Chthamalus sp. [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

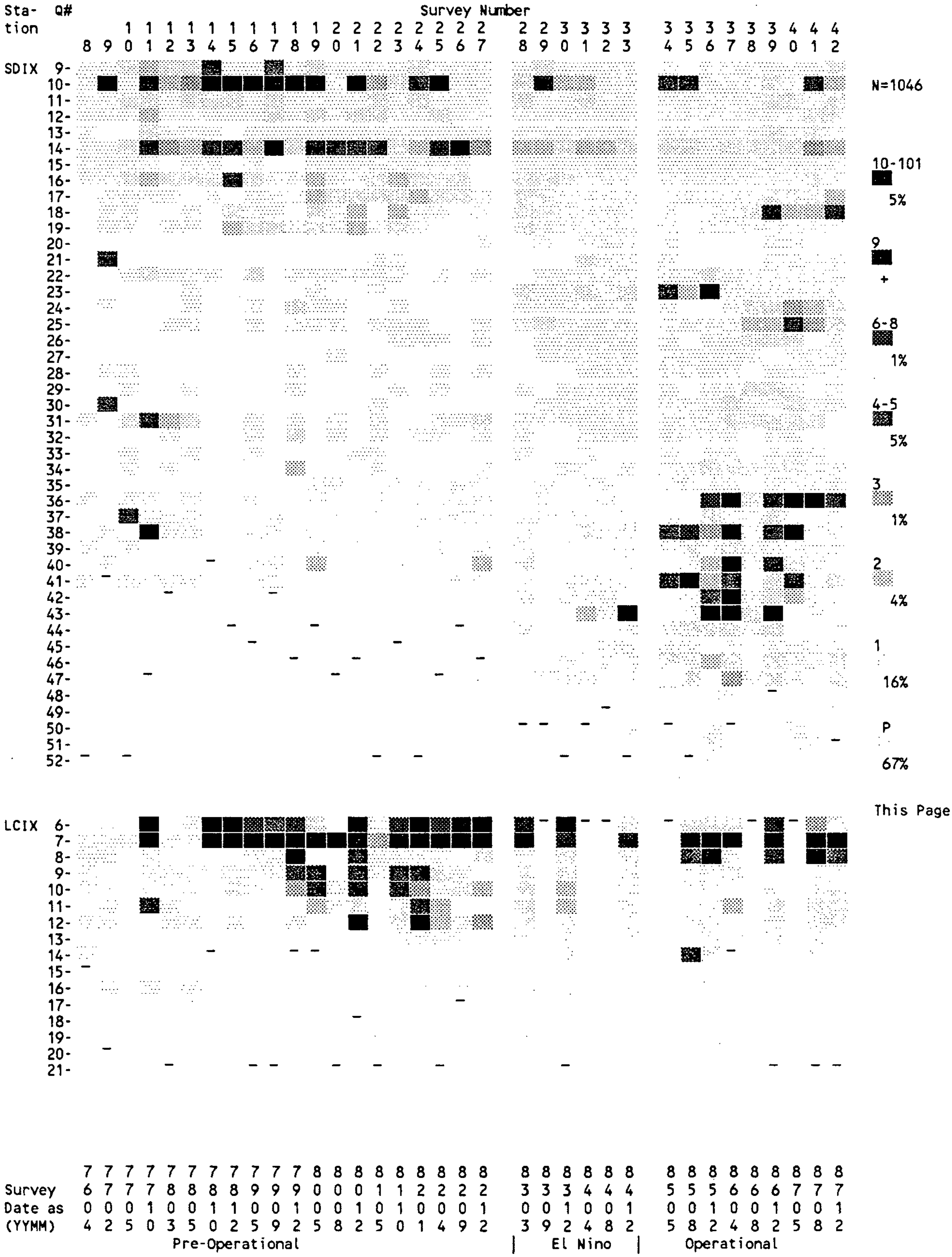


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CHTHAM CSV 6968 3-31-88 10:17a 04-15-1989 06:21

Taxon or Category: Chthamalus sp. [Mixed P/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CHTHAM CSV 6968 3-31-88 10:17a 04-15-1989 06:21

Audit: CLUMRG2P: V.1.2: for SCHTHAMB CLU 6581 4-23-89 4:51a: 04-27-1989/17:11
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/04:47:38 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Chthamalus sp. [Mixed P/%]: TOTAL Quads with Data = 506

Quad Range USED 5 to 39 for Total of 35 : Range WITH data 1 to 41: : # Dropped 40 : 7.9%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.647601: Maximum Distance = 22

```
S27-8212  ------------------------------------------------------I---------------------I
S33-8412  ------------------------------------------------------I                     I----I
S32-8408  ----------------------------------------------------------------------------I    I
S30-8312  -----------------------------------------------------------------------I         I
S31-8404  ----------------------------------------------------------I----I       I-I       I
S36-8512  ------------------------------------------------------I---I    I       I I       I------------------I
S40-8705  ------------------------------------------------------I        I-------I I       I                  I
S34-8505  -----------------------------------------------------------I   I         I       I                  I
S37-8604  ---------------------------------------------I----------I  I---I         I--I    I                  I
S42-8712  ---------------------------------------------I          I--I             I  I    I                  I------
S39-8612  -------------------------------------------------I------I                I  I----I                  I
S41-8708  -------------------------------------------------I                       I  I                       I
S38-8608  -------------------------------------------------------------------------I  I                       I
S35-8508  ----------------------------------------------------------------------------I                       I
S28-8303  -------------------------------------------------------------------------------------I--------------I
S29-8309  -------------------------------------------------------------------------------------I
```

Station: NDIX: Chthamalus sp. [Mixed P/%]: TOTAL Quads with Data = 588

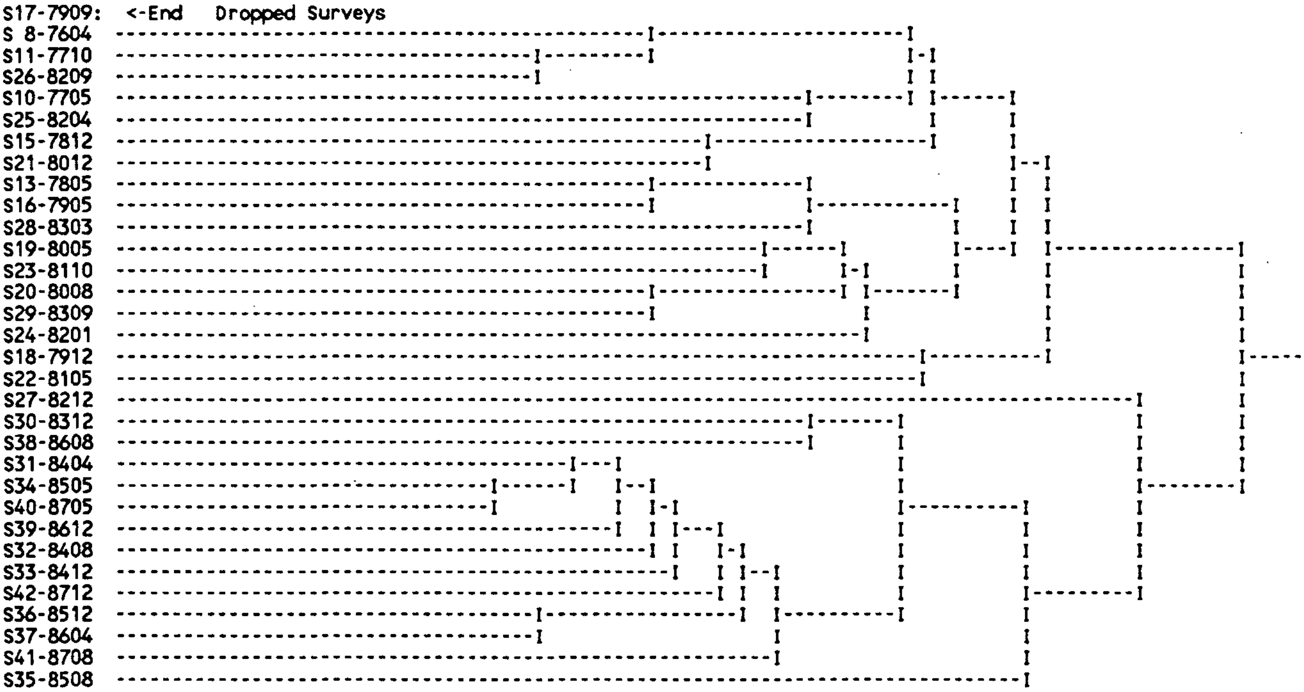
Quad Range USED 3 to 25 for Total of 23 : Range WITH data 2 to 31: : # Dropped 87 : 14.8%
Surveys 32 : Dropped 3 Surveys if quads sampled < 25
COPHENETIC CORRELATION COEFFICIENT = 0.675453: Maximum Distance = 13

```
S17-7909:  <-Start Dropped Surveys
S19-8005:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ----------------------------------------------I--------------------I
S24-8201  ----------------------------------------------I                    I
S 9-7702  -------------------------------I----------I                        I
S21-8012  -------------------------------I          I-------------------I    I--------------------------I
S14-7810  ------------------------------------------I                   I    I                          I
S10-7705  -----------------------I-------I                              I    I                          I
S20-8008  -----------------------I       I------------I                 I----I                          I
S18-7912  -------------------------------I            I-I               I                               I
S12-7803  --------------------------------------------I I----I          I                               I
S23-8110  ----------------------------------------------I    I----------I                               I
S15-7812  ---------------------------------------I-----------I                                          I
S16-7905  ---------------------------------------I                                                      I
S13-7805  ------------------------------------------------------I----------I                            I
S30-8312  ------------------------------------------------------I          I                            I
S22-8105  --------------I---I                                              I                            I-----I
S25-8204  --------------I   I------------I                                 I                            I     I
S42-8712  ------------------I            I-------I                         I                            I     I
S27-8212  -------------------------------I       I                         I                            I     I
S34-8505  -------------------------------I---I   I------I                  I----I                       I     I
S35-8508  -------------------------------I   I-I I      I                  I    I                       I     I
S41-8708  -----------------------------------I I-I      I                  I    I                       I     I
S37-8604  -----------------------I-------I     I        I-I                I    I                       I     I
S39-8612  -----------------------I       I-----I        I I                I    I                       I     I------
S40-8705  -------------------------------I              I I--------I       I    I-----I                 I     I
S33-8412  -------------------------------I--------------I I        I       I    I     I                 I     I
S38-8608  -------------------------------I                I        I-------I    I     I                 I     I
S28-8303  ------------------------------------------------I        I            I     I-----------------I     I
S36-8512  ---------------------------------------------------------I            I     I                       I
S29-8309  ------------------------------------------------------I---------------I     I                       I
S32-8408  ------------------------------------------------------I                     I                       I
S26-8209  ----------------------------------------------------------------------------I                       I
S11-7710  ----------------------------------------------------------------------------------------------------I
```

Station: SDIX: Chthamalus sp. [Mixed P/%]: TOTAL Quads with Data = 981

Quad Range USED 4 to 43 for Total of 40 : Range WITH data 2 to 52: : # Dropped 133 : 13.6%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.591124: Maximum Distance = 21

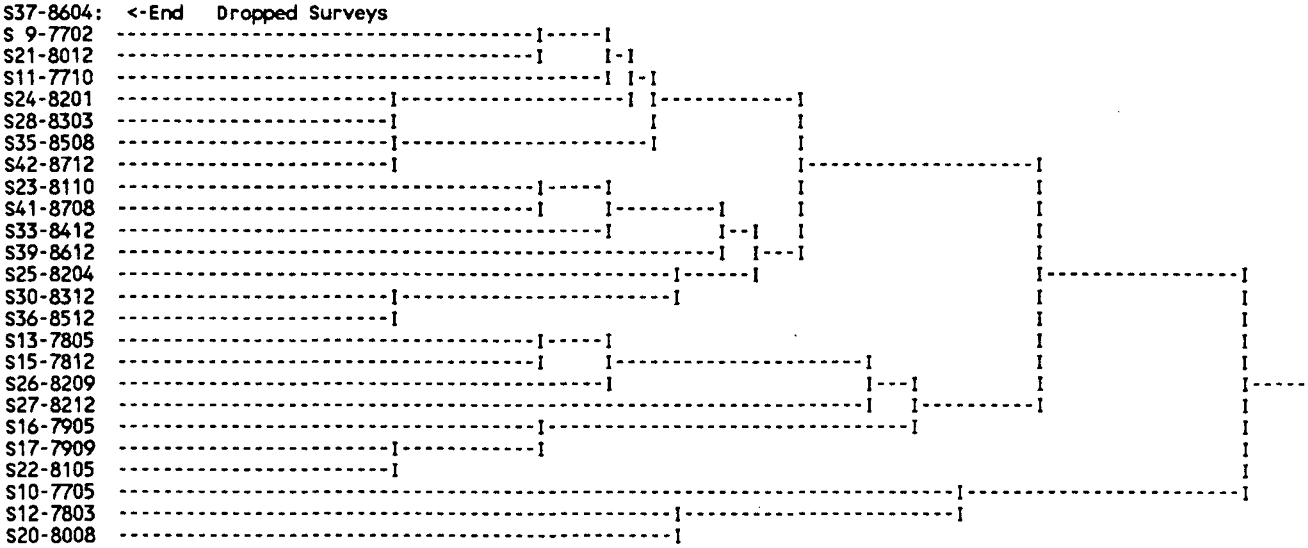
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909: <-End Dropped Surveys



Station: LCIX: Chthamalus sp. [Mixed P/%]: TOTAL Quads with Data = 263

Quad Range USED 3 to 16 for Total of 14 : Range WITH data 3 to 21: : # Dropped 42 : 16.0%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.627919: Maximum Distance = 8

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604: <-End Dropped Surveys



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Hemigrapsus spp.

Hemigrapsus nudus (Purple Shore Crab). (Dana, 1851). Ref. MAH, 1980, p. 621.
Phylum Arthropoda: **Class** Crustacea:

Description: Purple, sometimes greenish yellow or reddish brown, chelae (claws) with red or purplish spots. Width 2 - 6+ (5.6, MAH) cm.

Distribution: Yakobi Island (Alaska) to Bahia de Tortuga (Baja California), common in some areas, mid - low intertidal on rocky shores under stones and among seaweeds. Uncommon in southern California and southward. (from MAH). A possible warm-tolerant species.

Diablo Area Specific Information: Moderately rare, occurring in only 7% of our quadrats in numbers up to 7 per m^2.

Habitat: Usually in crevices and under boulders, but occasionally wandering around on sand and gravel. Upper to low tide levels.

Observational Errors: Small individuals (<1+ cm) that may be this group are field identified as "unid. grapsoids, juvenile" to avoid possible confusion with *Pachygrapsus crassipes*. Missed observations cannot be estimated as this is a highly motile group. Occasionally noted as present rather than counted.

Field Identification Problems:

General: Cryptic individuals that have only their anterior visible may be mis-identified as *Pachygrapsus* (the most common shore crab in the Diablo area). *H. oregonensis* occurs rarely in the Diablo area, but we have never distinguished it in the field (although if crab is fully visible it is easily done).

Station Specific: none.

General Comments:. Moderately spotty in occurrence from survey to survey, but usually present at our Cove stations, rarely occurring at LCIX.

Impacts to Taxon:

El Niño: 1982-83 winter storm: Sporadic nature of occurrences made it difficult to assess the immediate impact of the storm and related damage, but possibly all but eliminated at NDIX and SDIX.

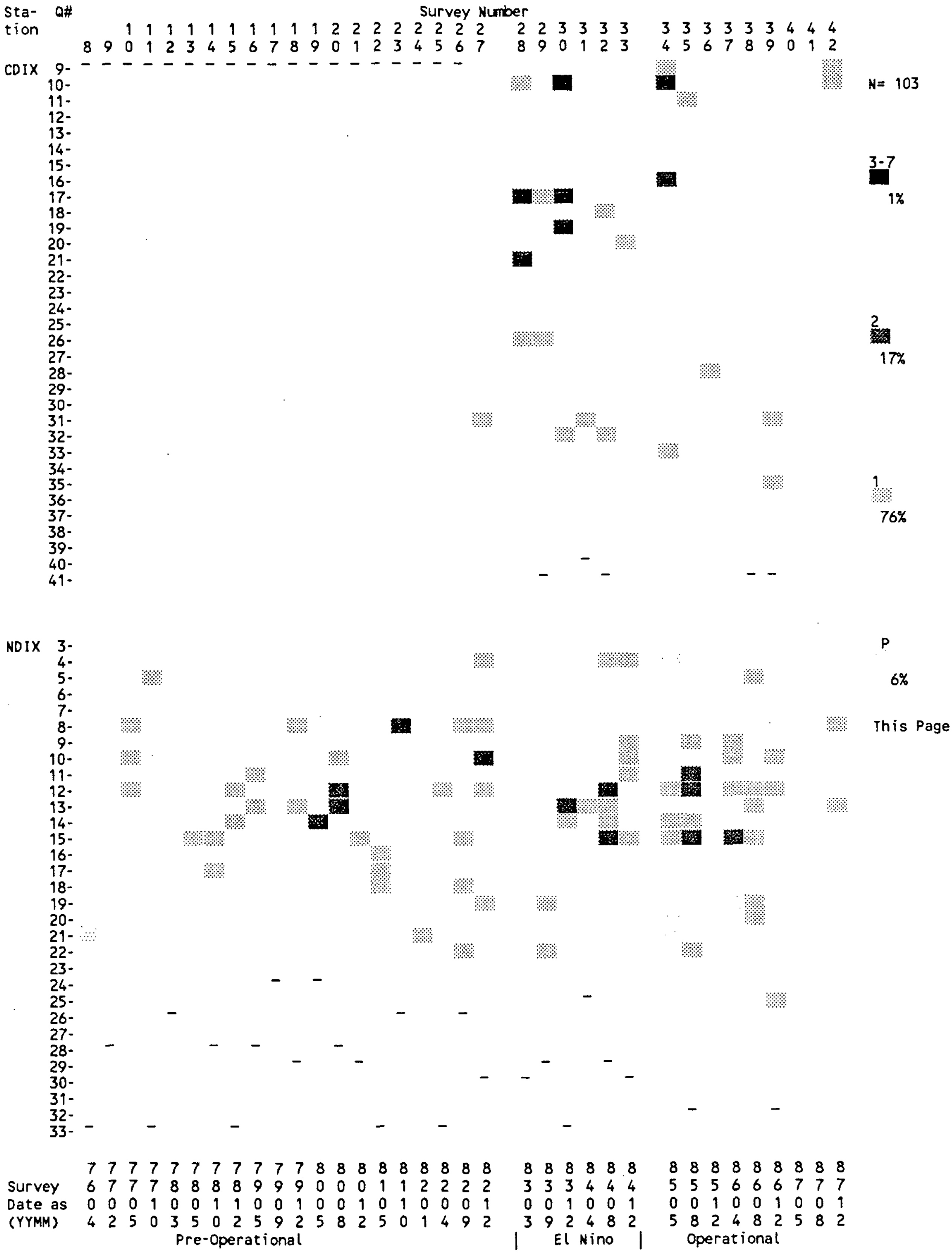
El Niño: 1983-1984: Probably normal at all stations, (CDIX however with only 1 prior survey).

Diablo DCPP Operation: SDIX and NDIX with declining occurrences in the upper to mid intertidal for 1987 (which also occurred in 1980-1981). CDIX with declining occurrences, (but our first survey there in 1982 had only 1 occurrence of this taxon). LCIX normal (i.e., still with sporadic occurrences).

Hemigrapsus oregonensis: Typically a bay or estuary species. Range Resurrection Bay (Alaska) to Bahia de Todos Santos (Baja California). (from MAH). A warm-tolerant species.

Taxon or Category: Hemigrapsus spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

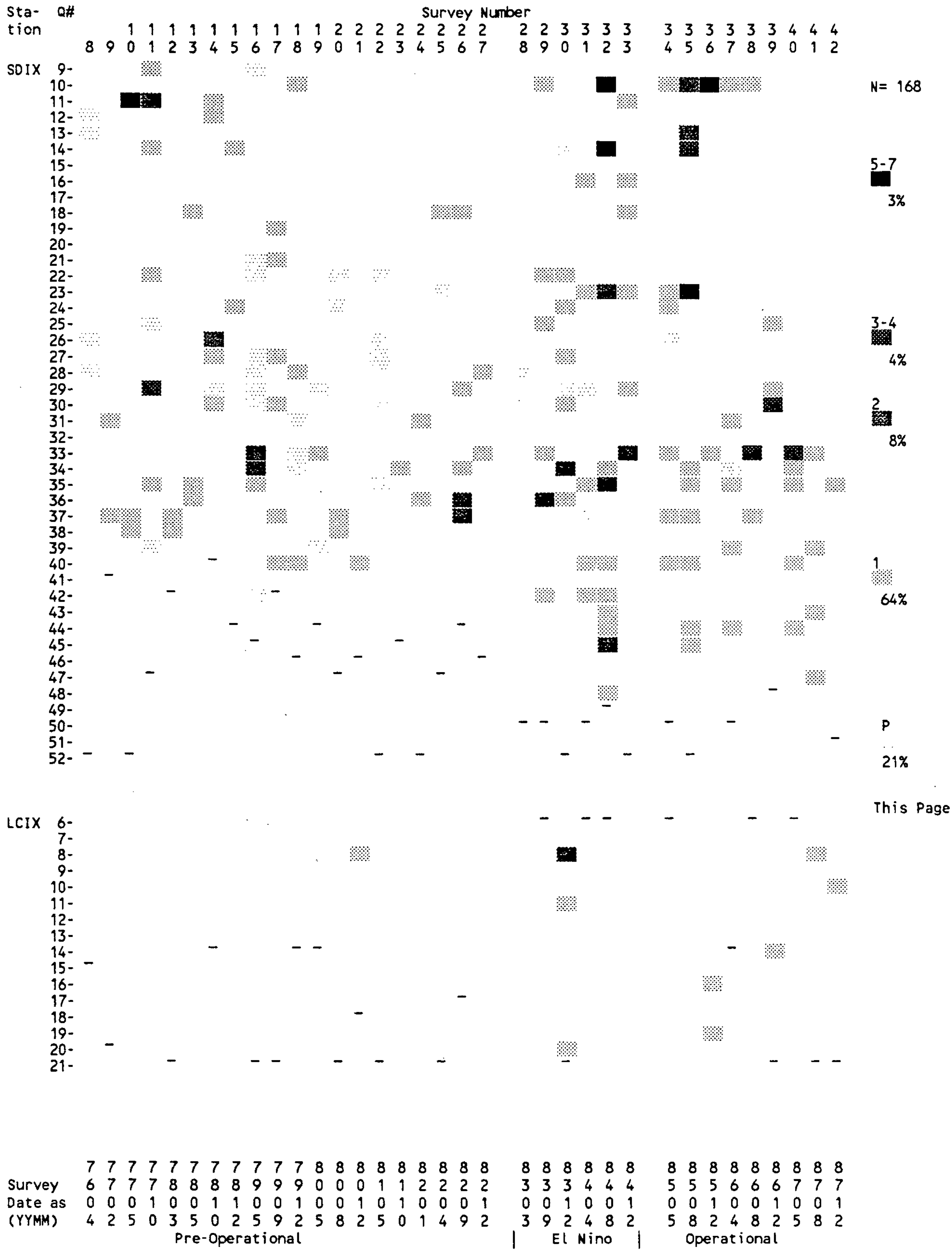


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HEMIGR CSV 5400 3-29-88 7:53a 04-15-1989 06:27

Taxon or Category: Hemigrapsus spp. [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for HEMIGR CSV 5400 3-29-88 7:53a 04-15-1989 06:27

Audit: CLUMRG2P: V.1.2: for SHEMIGRB CLU 6915 4-23-89 6:06a: 04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/05:59:57 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Hemigrapsus spp. [Mixed P/#]: TOTAL Quads with Data = 30

Quad Range USED 7 to 35 for Total of 29 : Range WITH data 5 to 35: : # Dropped 1 : 3.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 35
COPHENETIC CORRELATION COEFFICIENT = 0.486183: Maximum Distance = 17

```
S27-8212  -------------------------------------------------------------------------I-----I
S31-8404  -------------------------------------------------------------------------I     I-I
S37-8604  -------------------------------------------------------------------------I     I I
S38-8608  -------------------------------------------------------------------------I-----I I-----I
S40-8705  -------------------------------------------------------------------------I       I     I
S41-8708  -------------------------------------------------------------------------I       I     II
S33-8412  ---------------------------------------------------------------------------------I     III
S32-8408  ---------------------------------------------------------------------------------------III--I
S35-8508  ----------------------------------------------------------------------------------------II  I----I
S36-8512  -----------------------------------------------------------------------------------------I  I    I---I
S39-8612  --------------------------------------------------------------------------------------------I    I   I
S34-8505  -------------------------------------------------------------------------------------I-----------I   I------
S42-8712  -------------------------------------------------------------------------------------I               I
S28-8303  -------------------------------------------------------------------------------------------I--------II
S29-8309  -------------------------------------------------------------------------------------------I        II
S30-8312  ----------------------------------------------------------------------------------------------------I
```

Station: NDIX: Hemigrapsus spp. [Mixed P/#]: TOTAL Quads with Data = 78

Quad Range USED 4 to 23 for Total of 20 : Range WITH data 4 to 25: : # Dropped 1 : 1.3%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.779756: Maximum Distance = 9

```
S 8-7604  ---------------------------------I-----------I
S24-8201  ---------------------------------I           I
S 9-7702  ---------------------------------I           I--I
S12-7803  ---------------------------------I           I  I
S17-7909  ---------------------------------I-----------I  I
S36-8512  ---------------------------------I              II
S40-8705  ---------------------------------I              II
S41-8708  ---------------------------------I              II---I
S11-7710  ------------------------------------------------II   I
S25-8204  -------------------------------------------------I   I---I
S13-7805  ---------------------------------I-----------I       I   I
S21-8012  ---------------------------------I           I-------I   I--I
S14-7810  ---------------------------------------------I           I  I
S15-7812  ---------------------------------------------I---I       I  I
S19-8005  ---------------------------------I-----------I   I-------I  I------I
S28-8303  ---------------------------------I               I          I      I
S30-8312  -------------------------------------------------I          I      I
S16-7905  ---------------------------------------------I--------I     I      I
S31-8404  ---------------------------------------------I        I-----I      I---------I
S18-7912  ---------------------------------I-----------I        I            I         I
S42-8712  ---------------------------------I           I--------I            I         I---I
S23-8110  ---------------------------------------------I                     I         I   I
S29-8309  -------------------------------------------------------------------I         I   I
S22-8105  -----------------------------------------------------------------------------I   I-----I
S10-7705  ---------------------------------------------I----I                              I     I
S39-8612  ---------------------------------------------I    I----------------I             I     I
S20-8008  --------------------------------------------------I                I-------I     I     I----------I
S27-8212  -------------------------------------------------------------------I       I-----I     I           I
S37-8604  ---------------------------------------------------------------------------I           I           I--I
S26-8209  ---------------------------------------------------------------------------------------I           I  I
S32-8408  -------------------------------------------------------------------I---------------------------I   I  I------
S34-8505  -------------------------------------------------------------------I                           I---I  I
S38-8608  -----------------------------------------------------------------------------------------------I      I
S33-8412  ------------------------------------------------------------------------------------------I-----------I
S35-8508  ------------------------------------------------------------------------------------------I
```

Station: SDIX: Hemigrapsus spp. [Mixed P/#]: TOTAL Quads with Data = 162

Quad Range USED 3 to 41 for Total of 39 : Range WITH data 3 to 48: : # Dropped 22 : 13.6%
Surveys 33 : Dropped 2 Surveys if quads sampled < 41
COPHENETIC CORRELATION COEFFICIENT = 0.649119: Maximum Distance = 18

```
S 9-7702: <-Start Dropped Surveys
S14-7810: <-End   Dropped Surveys
S 8-7604 ----------------------------------------------------------------------------I------I
S22-8105 ----------------------------------------------------------------------------I      I
S10-7705 -----------------------------------------------------------I--------I              I
S20-8008 -----------------------------------------------------------I        I----------I   I
S12-7803 --------------------------------------------------------------------I          I   I
S13-7805 ------------------------------------------------------I----I                   I   I
S42-8712 ------------------------------------------------------I    I-I                 I   I--I
S24-8201 -----------------------------------------------------------I I                 I   I  I
S21-8012 ------------------------------------------------------I--I   I                 I   I  I
S23-8110 ------------------------------------------------------I  I---I-I               I   I  I
S27-8212 ------------------------------------------------I--------I   I I               I   I  I
S28-8303 ------------------------------------------------I            I II              I   I  I
S25-8204 -------------------------------------------------------------I II              I---I  I
S15-7812 ---------------------------------------------------------------II----I         I      I
S19-8005 ------------------------------------------------I----------I    I    I         I      I
S41-8708 ------------------------------------------------I          I----I    I---I     I      II
S36-8512 ------------------------------------------------I----------I         I   I     I      II
S38-8608 ------------------------------------------------I                    I   II    I      II
S39-8612 ---------------------------------------------------------------------I   II    I      II
S29-8309 -------------------------------------------------------------------------II---II      II
S18-7912 -----------------------------------------------------------------I----I   I   II      II-I
S40-8705 -----------------------------------------------------------------I    I---I   II      II I
S37-8604 ----------------------------------------------------------------------I       I       II I
S26-8209 ------------------------------------------------------------------------------I       II I
S33-8412 --------------------------------------------------------------------------------------II I---------I
S31-8404 ----------------------------------------------------------------------------I----I     I I         I
S32-8408 ------------------------------------------------------I---------------------I    I-----I I         I
S35-8508 ------------------------------------------------------I                          I       I         I------
S34-8505 ---------------------------------------------------------------------------------I       I         I
S17-7909 -----------------------------------------------------------------------------------------I         I
S11-7710 --------------------------------------------------------------------------------------------------II
S16-7905 ---------------------------------------------------------------------------------------I----------I
S30-8312 ---------------------------------------------------------------------------------------I
```

Station: LCIX: Hemigrapsus spp. [Mixed P/#]: TOTAL Quads with Data = 10:**** Prob. INSUFFICIENT Data ****

Quad Range USED 3 to 20 for Total of 18 : Range WITH data 3 to 20: : # Dropped 1 : 10.0%
Surveys 21 : Dropped 8 Surveys if quads sampled < 20
COPHENETIC CORRELATION COEFFICIENT = 0.656840: Maximum Distance = 13

```
S 8-7604: <-Start Dropped Surveys
S 9-7702:
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End   Dropped Surveys
S10-7705 ---------------------------------------------------------------------------I
S12-7803 ---------------------------------------------------------------------------I
S13-7805 ---------------------------------------------------------------------------I
S15-7812 ---------------------------------------------------------------------------I
S16-7905 ---------------------------------------------------------------------------I
S17-7909 ---------------------------------------------------------------------------I
S20-8008 ---------------------------------------------------------------------------I
S22-8105 ---------------------------------------------------------------------------I------I
S23-8110 ---------------------------------------------------------------------------I      I
S24-8201 ---------------------------------------------------------------------------I      I
S25-8204 ---------------------------------------------------------------------------I      I
S27-8212 ---------------------------------------------------------------------------I      II
S28-8303 ---------------------------------------------------------------------------I      II
S33-8412 ---------------------------------------------------------------------------I      II
S35-8508 ---------------------------------------------------------------------------I      III
S11-7710 ----------------------------------------------------------------------------------III
S39-8612 -----------------------------------------------------------------------------------II-------I
S41-8708 -----------------------------------------------------------------------------------II       I------I
S42-8712 ------------------------------------------------------------------------------------I       I      I------
S36-8512 --------------------------------------------------------------------------------------------I      I
S30-8312 ---------------------------------------------------------------------------------------------------I
```

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Pachygrapsus crassipes (Striped Shore Crab). (Randall, 1839). Ref. MAH, 1980, p. 619.
Phylum Arthropoda: **Class** Crustacea:

Description: Red, purple, to sometimes greenish with upper surface striped with lighter color. Width 2 - 4+ (4.8, MAH) cm.

Distribution: Charleston (Oregon) to Isla de Santa Margarita (Baja California), abundant in crevices, tidepools, and mussel beds, upper to mid intertidal on rocky shores, sometimes on pilings in harbors and on hard muddy shores of bays and estuaries. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately common, occurring in about 15% of our quadrats in numbers of up to 7 per m^2.

Habitat: Usually in crevices and under boulders, but often wandering around on sand and gravel. Upper to mid-low tide levels.

Observational Errors: Small individuals (<1+ cm) that may be this group are field identified as "unid. grapsoids, juvenile" to avoid possible confusion with *Hemigrapsus* spp. Missed observations cannot be estimated as this is a highly motile group. Occasionally noted as present rather than counted.

Field Identification Problems:

General: Cryptic individuals that have only their posterior visible may be mis-identified as *Hemigrapsus* spp.

Station Specific: none.

General Comments:. Moderately spotty in occurrence during pre-El Niño surveys except at LCIX, where it was moderately common from survey to survey.

Impacts to Taxon:

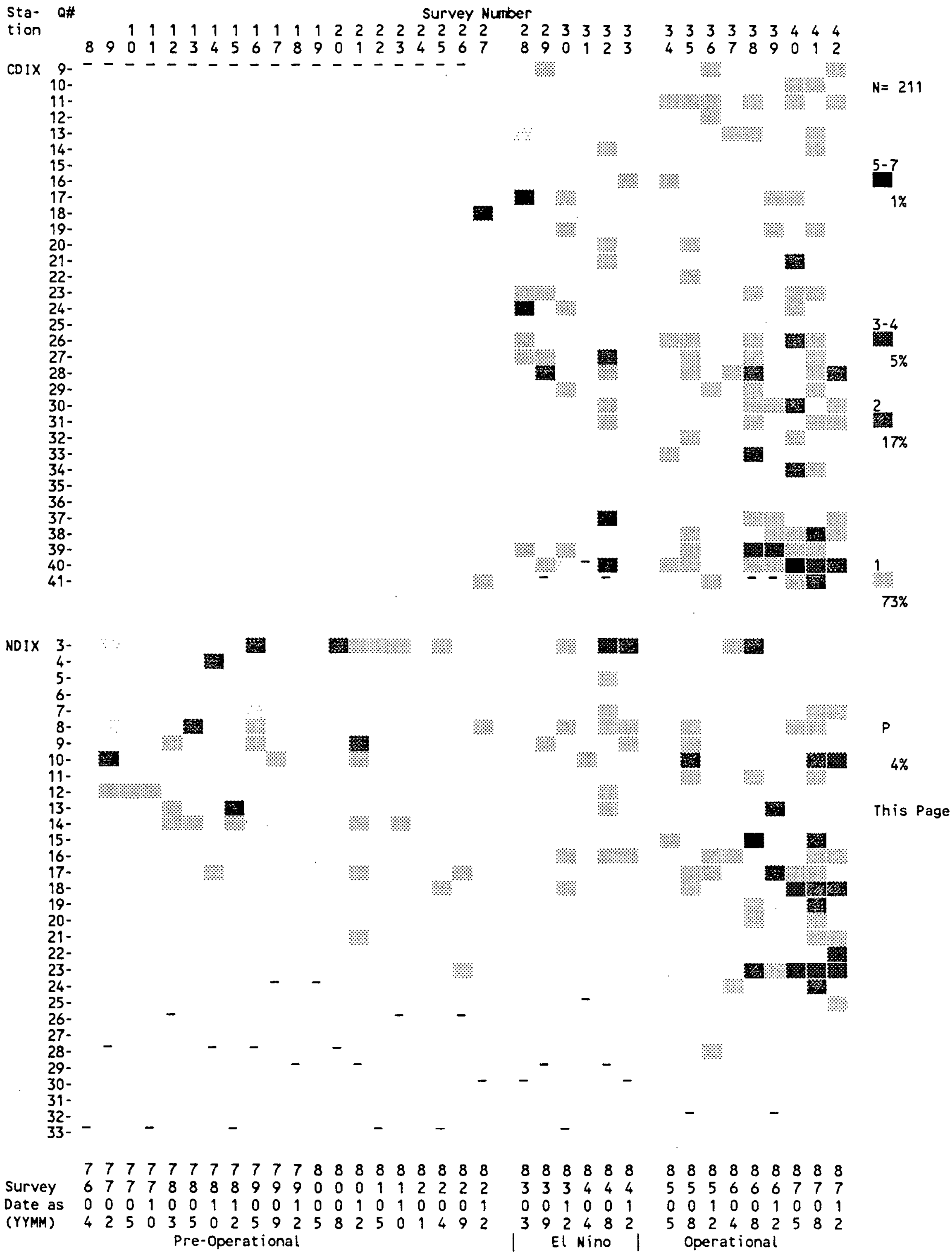
El Niño: 1982-83 winter storm: Sporadic nature of occurrences makes it difficult to assess the immediate impact of the storm and related damage, but possibly all but eliminated at NDIX, SDIX, and LCIX, with CDIX retaining moderate occurrences.

El Niño: 1983-1984: Probably a trend towards increased number of occurrences at Cove stations, (CDIX however with only 1 prior survey). LCIX by end of 1984 somewhat recovered, but probably still with reduced number of occurrences.

Diablo DCPP Operation: NDIX and possibly CDIX greater than normal numbers and number of occurrences. SDIX probably retaining its El Niño gains. SDIX and NDIX possibly with declining occurrences in the upper to mid intertidal for 1987. LCIX normal (i.e., still moderately common but somewhat sporadic).

Taxon or Category: Pachygrapsus crassipes [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

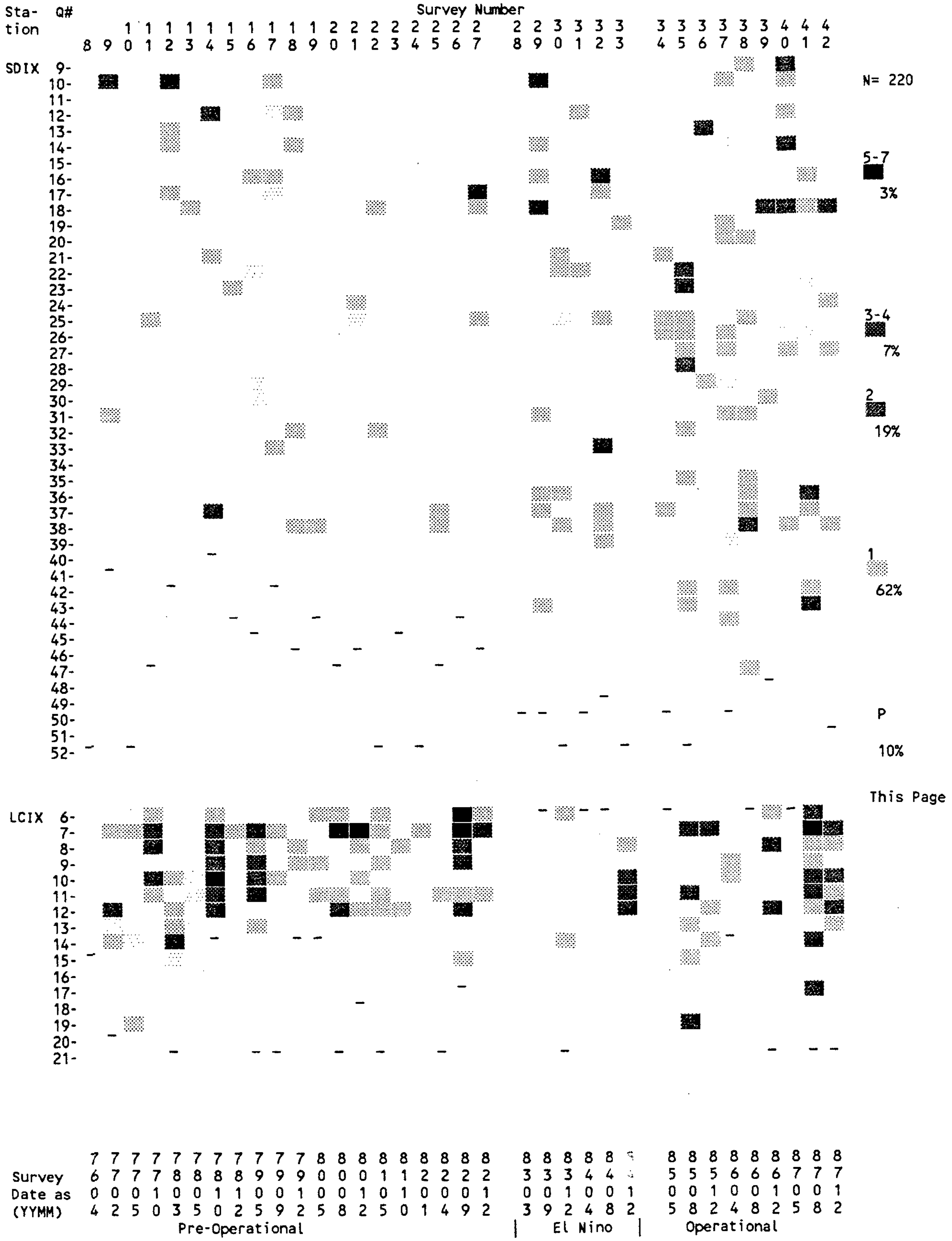


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PACCRA CSV 5342 3-29-88 8:05a 04-15-1989 06:32

Taxon or Category: Pachygrapsus crassipes [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed
Audit: ALSTAPLT: V.2.4a for PACCRA CSV 5342 3-29-88 8:05a 04-15-1989 06:32

Audit: CLUMRG2P: V.1.2: for SPACCRAB CLU 7249 4-23-89 6:58a: 04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/06:54:36 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Pachygrapsus crassipes [Mixed P/#]: TOTAL Quads with Data = 143

Quad Range USED 1 to 40 for Total of 40 : Range WITH data 1 to 41: : # Dropped 4 : 2.8%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.434807: Maximum Distance = 20

```
S31-8404: <-Start Dropped Surveys
S27-8212 ---------------------------------------I--I
S33-8412 ---------------------------------------I  I-------------------I
S37-8604 ------------------------------------------I                   I----I
S34-8505 --------------------------------------------------------------I    I------I
S29-8309 -------------------------------------------------------------------I      I------I
S28-8303 --------------------------------------------------------------------------I      I-----I
S30-8312 -----------------------------------------------------------------I---------------I     I--I
S39-8612 -----------------------------------------------------------------I                     I  I
S36-8512 ---------------------------------------------------------------------------I-----------I  I------I
S42-8712 ---------------------------------------------------------------------------I              I      I---I
S32-8408 ------------------------------------------------------------------------------------------I      I    I
S35-8508 --------------------------------------------------------------------------------------------I----I    I------
S38-8608 ----------------------------------------------------------------------I---------------------I         I
S41-8708 ----------------------------------------------------------------------I                               I
S40-8705 ------------------------------------------------------------------------------------------------------I
```

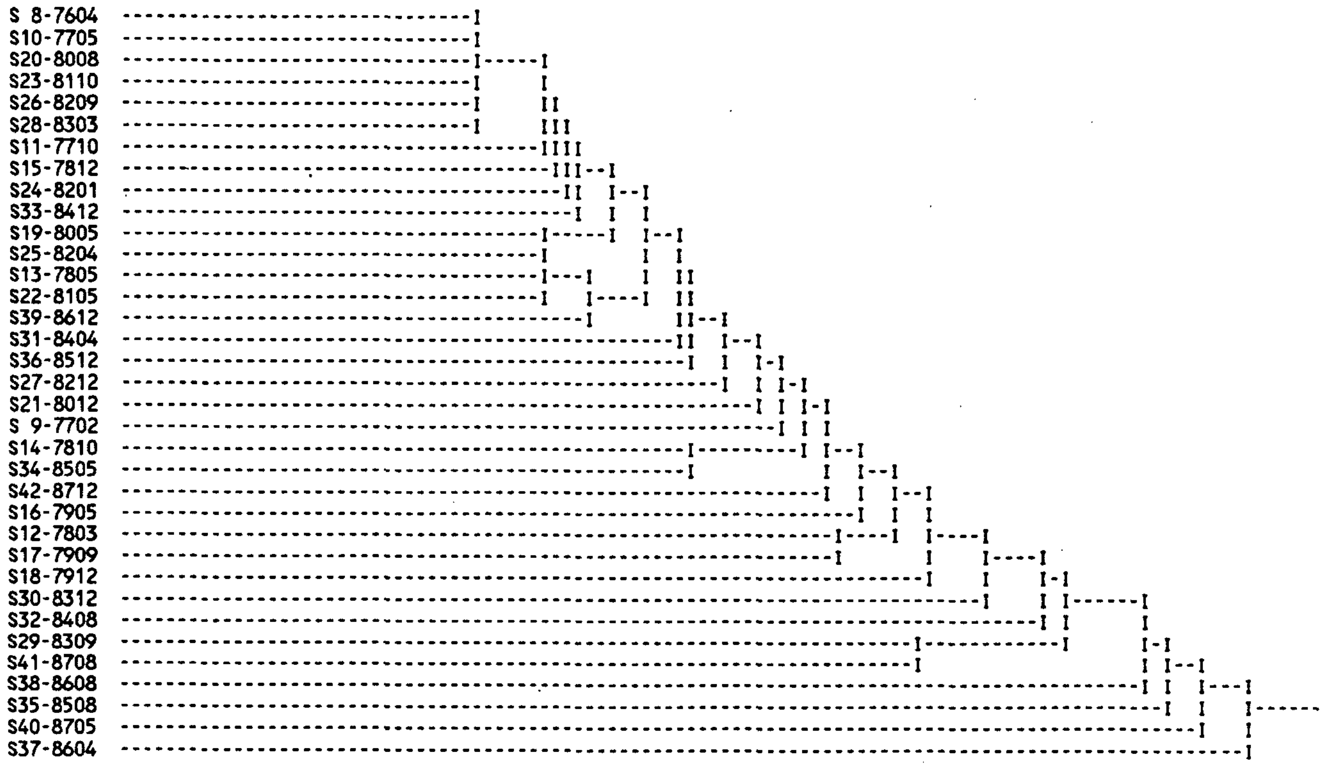
Station: NDIX: Pachygrapsus crassipes [Mixed P/#]: TOTAL Quads with Data = 106

Quad Range USED 1 to 24 for Total of 24 : Range WITH data 1 to 28: : # Dropped 4 : 3.8%
Surveys 33 : Dropped 2 Surveys if quads sampled < 24
COPHENETIC CORRELATION COEFFICIENT = 0.820022: Maximum Distance = 12

```
S17-7909: <-Start Dropped Surveys
S19-8005: <-End   Dropped Surveys
S 8-7604 --------I
S18-7912 --------I-------I
S24-8201 --------I       I-I
S10-7705 ----------------I I-I
S29-8309 ------------------I II
S31-8404 --------------------II----I
S34-8505 ---------------------I    I
S20-8008 --------I-------I         I--I
S22-8105 --------I       I--I      I  I
S23-8110 ----------------I  I------I  I-----I
S25-8204 -------------------I         I     I
S11-7710 ----------------I----I       I     I
S28-8303 ----------------I    I-------I     I----I
S27-8212 ---------------------I             I    I
S12-7803 ----------------I------------I     I    I
S15-7812 ----------------I            I-----I    I-------I
S13-7805 -----------------------------I          I       I
S14-7810 -------------------------I---I          I       I
S36-8512 -------------------------I   I------I   I       I
S26-8209 ----------------I------------I      I---I       I---I
S39-8612 ----------------I                   I           I   I
S40-8705 ------------------------------------I           I   I
S 9-7702 ------------------------------------------I     I   I-----------I
S16-7905 -------------------------I--------I       I-----I   I           I
S33-8412 -------------------------I        I-------I         I           I---I
S30-8312 ----------------------------------I                 I           I   I
S37-8604 ----------------------------------------------------I           I   I-I
S35-8508 ----------------------------------------------------------------I   I I----------I
S21-8012 --------------------------------------------------------------------I I          I-----------------I
S38-8608 ----------------------------------------------------------------------I                            I------
S32-8408 ---------------------------------------------------------------------------------I                 I
S41-8708 -----------------------------------------------------------------------------I---------------------I
S42-8712 -----------------------------------------------------------------------------I
```

Station: SDIX: Pachygrapsus crassipes [Mixed P/#]: TOTAL Quads with Data = 124

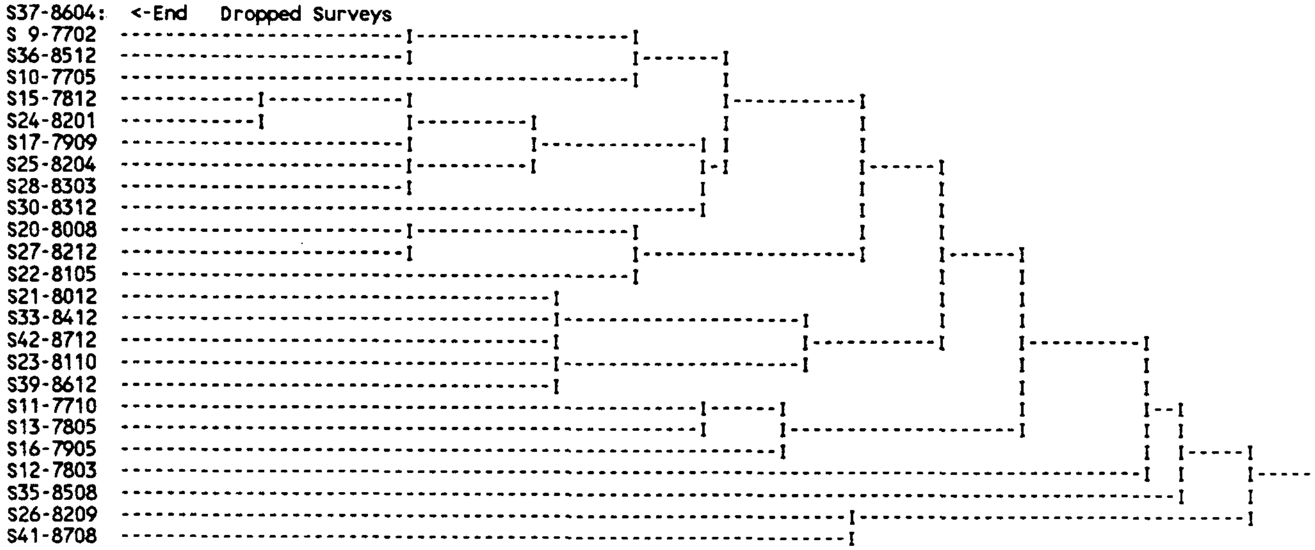
Quad Range USED 2 to 39 for Total of 38 : Range WITH data 1 to 47: : # Dropped 9 : 7.3%
Surveys 35 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.832963: Maximum Distance = 16



Station: LCIX: Pachygrapsus crassipes [Mixed P/#]: TOTAL Quads with Data = 117

Quad Range USED 4 to 16 for Total of 13 : Range WITH data 2 to 19: : # Dropped 23 : 19.7%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.578856: Maximum Distance = 8

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604: <-End Dropped Surveys



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Petrolisthes spp.

Petrolisthes cinctipes. (Flat Porcelain Crab). (Randall, 1839). Ref. MAH, 1980, p. 588.
Phylum Arthropoda: **Class** Crustacea:

Description: Greenish to reddish brown. Width 1 - 3- cm.

Distribution: Queen Charlotte Islands (British Columbia) to Point Conception (Santa Barbara Co., California) and northern Channel Islands. Common under stones and in beds of mussels, mid to low intertidal on exposed rocky coast. (from MAH). Certain members of this group are warm-tolerant.

Diablo Area Specific Information: Common (see below under **Observational Errors**) but moderately rare due to our sampling technique, occurring in only 5% of our quadrats in numbers of up to 50+ per m^2.

Habitat: Usually under loose cobble in sand/gravel areas, also in crevices and under boulders, occasionally wandering around. Mid to low tide levels.

Observational Errors: Main habitat in Diablo area is under cobble, which we did not routinely sample. Occasional observations were made of this under cobble habitat, and many specimens often occurred in such exposed areas. Missed observations cannot be estimated because of our sampling method. Usually noted as present, common, or abundant, rather than counted.

Field Identification Problems:

General: *P. cinctipes* is the only *Petrolisthes* that we have laboratory identified, but there are four other species that can occur in the area. Possibly mis-called as *Pachycheles*, occasionally because of similarity of names and habitat.

Station Specific: none.

General Comments:. Moderately spotty in occurrence from survey to survey, mainly due to our methods of observation. Rare at LCIX and moderately rare at CDIX, stations which have little cobble. El Niño storms, increased available habitat for this taxon at SDIX (introduced cobble).

Impacts to Taxon:

El Niño: 1982-83 winter storm: Sporadic nature of occurrences makes it difficult to assess the immediate impact of the storm and related damage, but possibly removed at NDIX and SDIX.

El Niño: 1983-1984: Probably recovering slightly at SDIX but fewer occurrences than normal. NDIX with about normal occurrences by end of period.

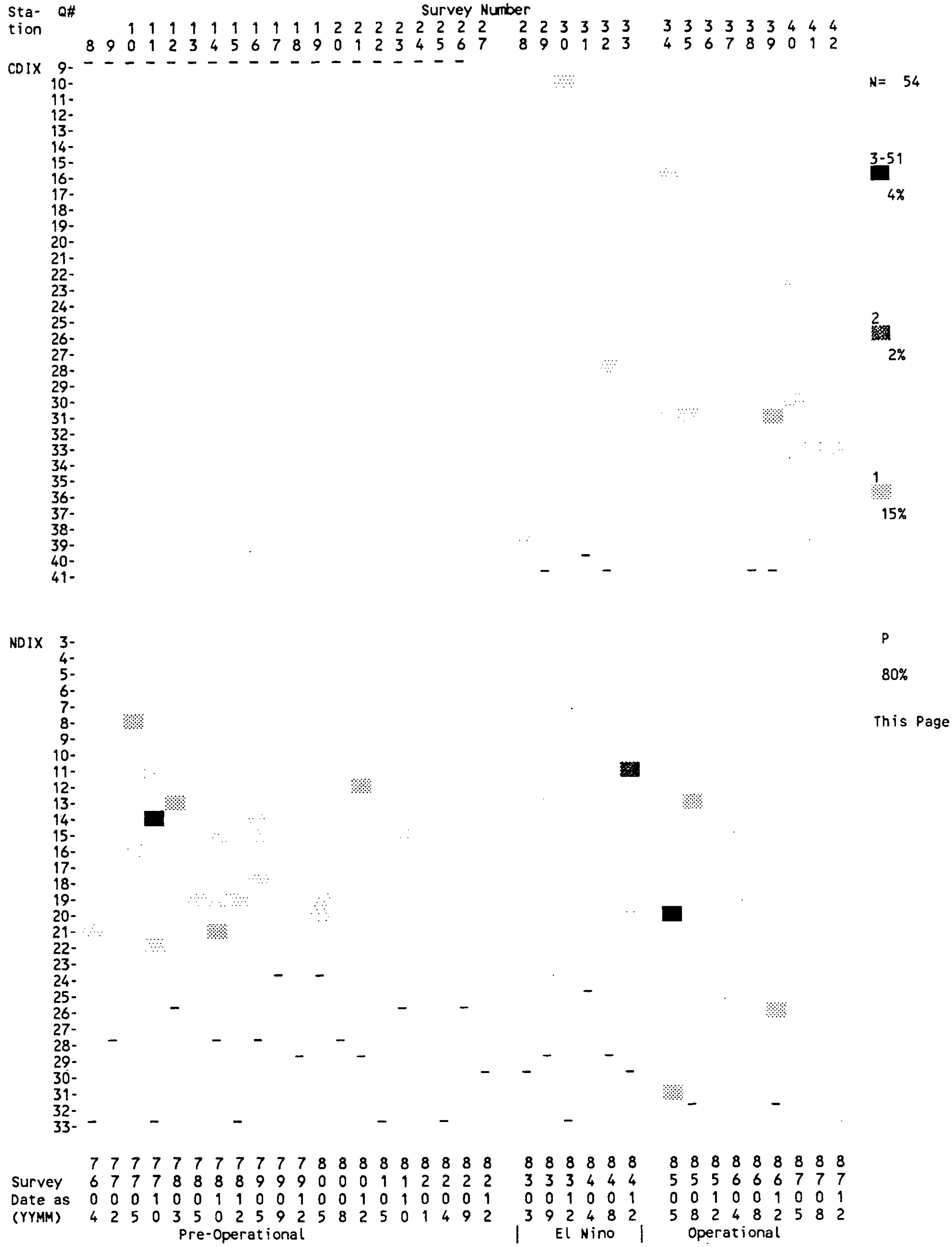
Diablo DCPP Operation: SDIX returned to approximately normal number of occurrences, possibly with a downward trend towards end of 1987. All other stations probably at normal levels.

None of the following species has been laboratory identified from our intertidal transects, but could occur in the area.

P. rathbunae: Monterey Bay to Laguna Beach (California), low intertidal on rocky shores.
P. eriomerus: Chicagof Island (Alaska) to La Jolla (California), low intertidal on protected rocky shores (north of San Luis Obispo Co.).
P. manimaculis: Bodega Harbor (California) to Punta Eugenia (Baja California), low intertidal on rocky shores.
P. cabrilloi: Morro Bay (California) to Bahia Magdalena (Baja California), mid intertidal on rocky shores.

Taxon or Category: Petrolisthes spp. [Mixed P/# includes Under]

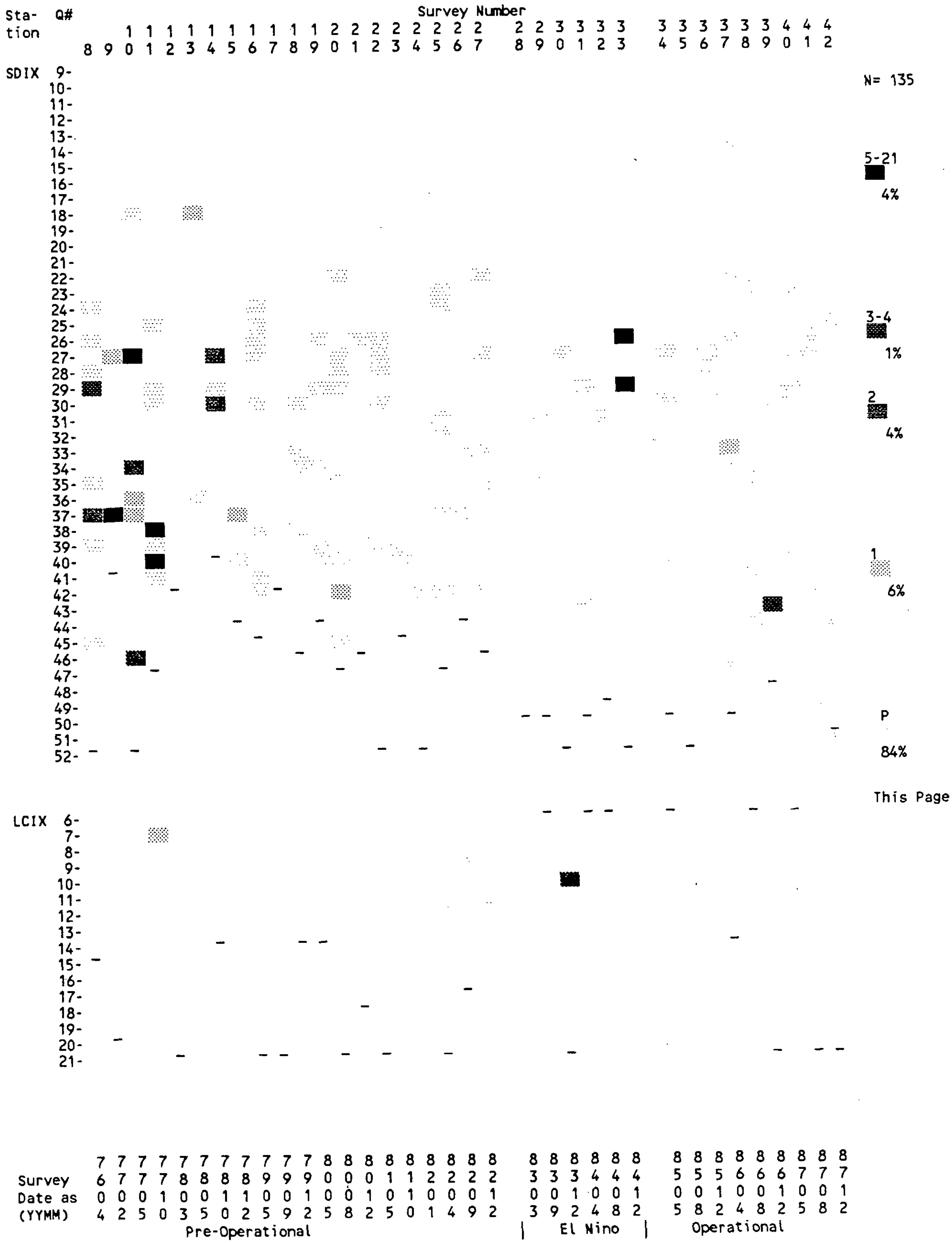
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



' _ ' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxon or Category: Petrolisthes spp. [Mixed P/# includes Under]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PETROS CSV 5438 3-29-88 8:06a 04-15-1989 06:33

Audit: CLUMRG2P: V.1.2: for SPETROSB CLU 6581 4-23-89 7:10a: 04-27-1989/17:12
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:07:14 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Petrolisthes spp. [Mixed P/# includes Under]: TOTAL Quads with Data = 12:**** Prob. INSUFFICIENT

Quad Range USED 10 to 39 for Total of 30 : Range WITH data 10 to 39: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.233768: Maximum Distance = 25

```
S27-8212  -----------------------------------------------------------------------------------------I
S29-8309  -----------------------------------------------------------------------------------------I
S31-8404  -----------------------------------------------------------------------------------------I
S33-8412  -----------------------------------------------------------------------------------------I---I
S36-8512  -----------------------------------------------------------------------------------------I   I
S37-8604  -----------------------------------------------------------------------------------------I   II
S38-8608  -----------------------------------------------------------------------------------------I   II
S28-8303  ---------------------------------------------------------------------------------------------II-I
S30-8312  ----------------------------------------------------------------------------------------------I II
S32-8408  ----------------------------------------------------------------------------------------------I II
S34-8505  ---------------------------------------------------------------------------------------------I--II--I
S35-8508  -----------------------------------------------------------------------------------------I---I   I  I
S39-8612  -----------------------------------------------------------------------------------------I       I  I------
S41-8708  ---------------------------------------------------------------------------------------------I---I  I
S42-8712  ---------------------------------------------------------------------------------------------I      I
S40-8705  ----------------------------------------------------------------------------------------------------I
```

Station: NDIX: Petrolisthes spp. [Mixed P/# includes Under]: TOTAL Quads with Data = 42

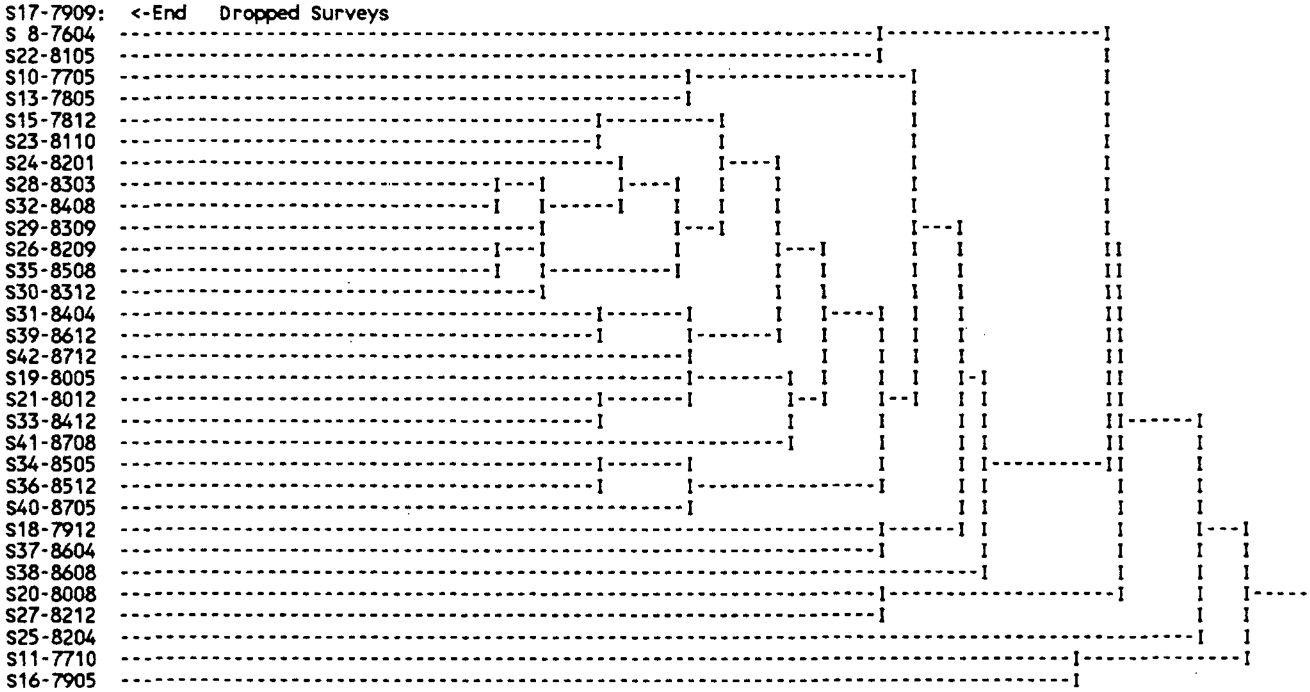
Quad Range USED 8 to 23 for Total of 16 : Range WITH data 8 to 33: : # Dropped 4 : 9.5%
Surveys 35 : Dropped 0 Surveys if quads sampled < 23
COPHENETIC CORRELATION COEFFICIENT = 0.780047: Maximum Distance = 8

```
S 8-7604  -----------------------------------------------------I
S25-8204  -----------------------------------------------------I------------I
S40-8705  -----------------------------------------------------I            I
S 9-7702  -----------------------------------------------------I            I
S17-7909  -----------------------------------------------------I            I-I
S18-7912  -----------------------------------------------------I            I I
S20-8008  -----------------------------------------------------I            I I
S22-8105  -----------------------------------------------------I            I I
S26-8209  -----------------------------------------------------I------------I I
S27-8212  -----------------------------------------------------I              I
S28-8303  -----------------------------------------------------I              I-I
S30-8312  -----------------------------------------------------I              I I
S31-8404  -----------------------------------------------------I              I I
S36-8512  -----------------------------------------------------I              I I
S41-8708  -----------------------------------------------------I              I I
S12-7803  -----------------------------------------------------I              I I-----I
S29-8309  -----------------------------------------------------I--------------I I     I
S35-8508  -----------------------------------------------------I                I     I
S21-8012  ----------------------------------------------------------------------I     I
S24-8201  -----------------------------------------------------I                I     I-----I
S38-8608  -----------------------------------------------------I----------------I     I     I
S39-8612  -----------------------------------------------------I                      I     I
S13-7805  -----------------------------------------------------I------------I         I     I----I
S15-7812  -----------------------------------------------------I            I---------I     I    I
S19-8005  ------------------------------------------------------------------I               I    I--I
S34-8505  ----------------------------------------------------------------------------------I    I  I
S10-7705  -------------------------------------------------------------------------------I-------I  I-I
S42-8712  -------------------------------------------------------------------------------I          I I
S11-7710  ------------------------------------------------------------------I------------------I    I I-----I
S32-8408  ------------------------------------------------------------------I                  I----I I     I
S23-8110  -------------------------------------------------------------------------------------I      I     I-I
S14-7810  ------------------------------------------------------------------I-------------------------I     I I
S37-8604  ------------------------------------------------------------------I                               I I------
S16-7905  --------------------------------------------------------------------------------------------------I I
S33-8412  ----------------------------------------------------------------------------------------------------I
```

Station: SDIX: Petrolisthes spp. [Mixed P/# includes Under]: TOTAL Quads with Data = 127

Quad Range USED 18 to 43 for Total of 26 : Range WITH data 14 to 50: : # Dropped 16 : 12.6%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.653863: Maximum Distance = 12

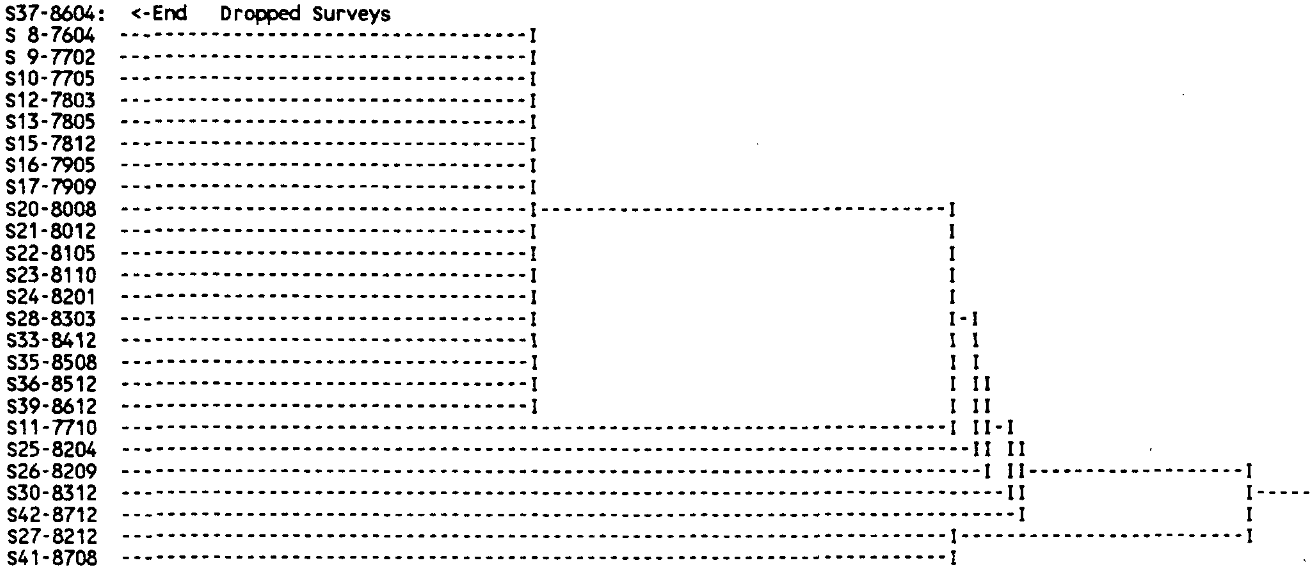
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909: <-End Dropped Surveys



Station: LCIX: Petrolisthes spp. [Mixed P/# includes Under]: TOTAL Quads with Data = 8:**** Prob. INSUFFICIENT

Quad Range USED 7 to 14 for Total of 8 : Range WITH data 7 to 14: : # Dropped 0 : 0.0%
Surveys 25 : Dropped 4 Surveys if quads sampled < 14
COPHENETIC CORRELATION COEFFICIENT = 0.873369: Maximum Distance = 3

S14-7810: <-Start Dropped Surveys
S18-7912:
S19-8005:
S37-8604: <-End Dropped Surveys



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Pollicipes polymerus (Leaf Barnacle). Sowerby, 1833. Ref. MAH, 1980, p. 514.
Phylum Arthropoda: **Class** Crustacea:

Description: White to gray plates, gray to black peduncle. Length 0.3 - 6+ cm (8 cm, MAH).

Distribution: British Columbia to at least Punta Abreojos (Baja California), common usually in clusters, and also mixed with *Mytilus californianus*, mid intertidal on wave-swept rocky shores. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately uncommon, occurring in about 5% of our quadrats in numbers up to 50+ per m^2.

Habitat: On rocks, tops and sides, occasionally associated with *Mytilus* spp. and algae. On open areas or in small crevices. Upper (LCIX only) to mid tide levels.

Observational Errors: Small individuals (<0.2 cm) that may be this group are field identified as "unid. lepedomorphs, juvenile" to avoid possible confusion with ephemeral *Lepas* spp. Missed observations may occur in areas of dense algal cover and maybe as high as 8% of our observations. Occasionally we call this taxon as present rather than numbers.

Field Identification Problems:

General: none.

Station Specific: none.

General Comments: Locally, usually called goose-neck barnacle. Rare at SDIX and NDIX, and prior to 1985 at CDIX also. LCIX (open coast station) was the only station, prior to 1985, that had well established population of this taxon.

Impacts to Taxon:

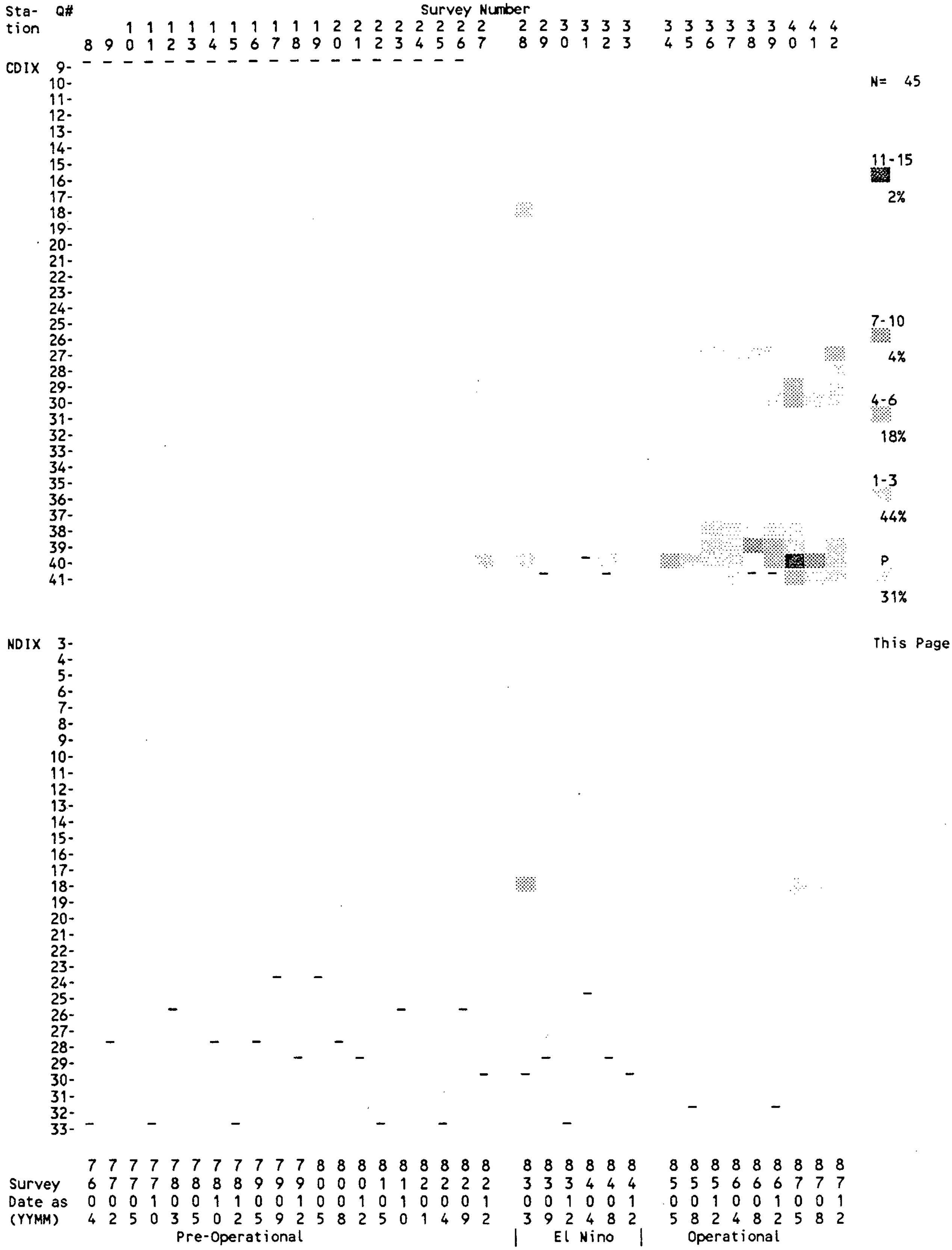
El Niño: 1982-83 winter storm: At NDIX, introduced on a new boulder. SDIX and CDIX with no or two occurrences respectively before storms. LCIX reduction in numbers and number of occurrences.

El Niño: 1983-1984: At all Cove stations, essentially normal (i.e., almost no occurrences). LCIX returned to normal with exception of one quadrat.

Diablo DCPP Operation: By late 1985, CDIX with increasing number of occurrences (from 2 quadrats to 5+ quadrats). NDIX with a brief appearance of young in mid-1987. LCIX possibly losing numbers and occurrences from late 1986 onward.

Taxon or Category: Pollicipes polymerus [Mixed P/#/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

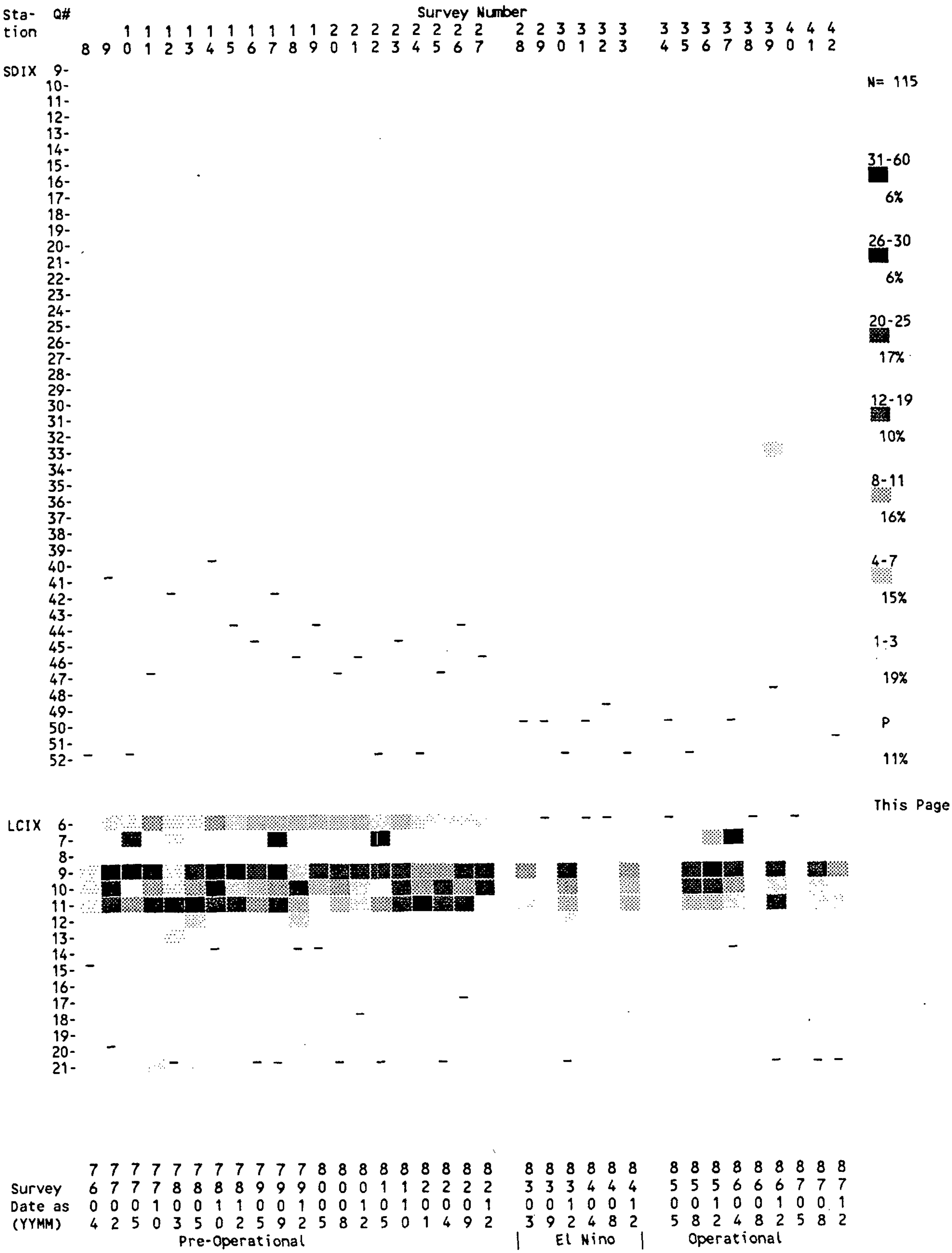


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for POLPOL CSV 5200 3-29-88 8:09a 04-15-1989 06:35

Taxon or Category: Pollicipes polymerus [Mixed P/#/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for POLPOL CSV 5200 3-29-88 8:09a 04-15-1989 06:35

Audit: CLUMRG2P: V.1.2: for SPOLPOLB CLU 7249 4-23-89 7:31a: 04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:28:26 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Pollicipes polymerus [Mixed P/#/%]: TOTAL Quads with Data = 40

Quad Range USED 26 to 40 for Total of 15 : Range WITH data 18 to 41: : # Dropped 5 : 12.5%
Surveys 15 : Dropped 1 Surveys if quads sampled < 40
COPHENETIC CORRELATION COEFFICIENT = 0.599574: Maximum Distance = 12

```
S31-8404: <-Start Dropped Surveys
S27-8212  --------------------------------------------------------------------------I
S28-8303  ------------------------------------------------------------------I       I-I
S32-8408  ------------------------------------------------------------------I-------I I
S34-8505  ------------------------------------------------------------------I         I--I
S35-8508  ------------------------------------------------------------------I         I  I
S29-8309  ------------------------------------------------------------------I         I  I--------------------I
S30-8312  ------------------------------------------------------------------I---------I  I                    I
S33-8412  ------------------------------------------------------------------I            I                    I
S41-8708  -------------------------------------------------------------------------------I                    I
S36-8512  ------------------------------------------------------------------I-------I                         I------
S37-8604  ------------------------------------------------------------------I       I-----I                   I
S39-8612  --------------------------------------------------------------------------I     I--------I          I
S40-8705  --------------------------------------------------------------------------------I        I----I     I
S38-8608  -----------------------------------------------------------------------------------------I    I-----I
S42-8712  ----------------------------------------------------------------------------------------------I
```

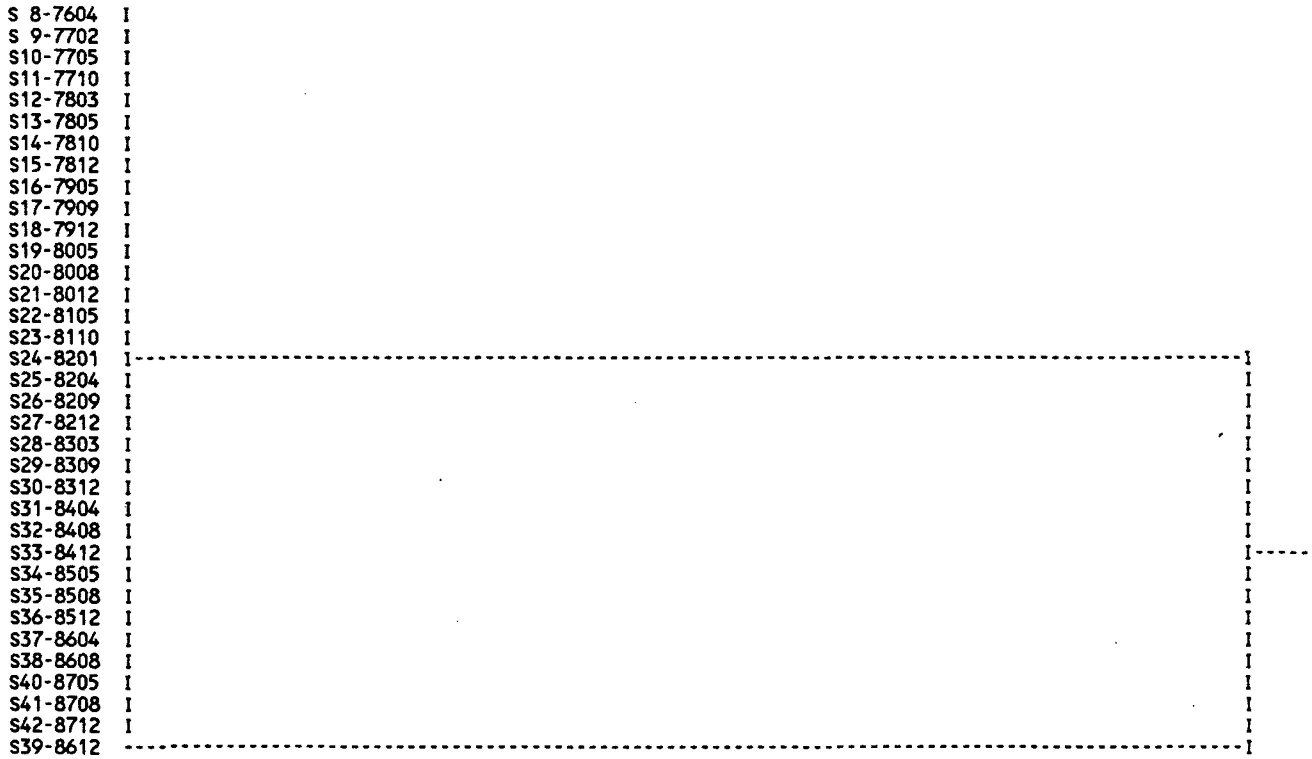
Station: NDIX: Pollicipes polymerus [Mixed P/#/%]: TOTAL Quads with Data = 5:**** Prob. INSUFFICIENT Data ****

Quad Range USED 18 to 19 for Total of 2 : Range WITH data 18 to 19: : # Dropped 0 : 0.0%
Surveys 35 : Dropped 0 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.990834: Maximum Distance = 2

```
S 8-7604  I
S 9-7702  I
S10-7705  I
S11-7710  I
S12-7803  I
S13-7805  I
S14-7810  I
S15-7812  I
S16-7905  I
S17-7909  I
S18-7912  I
S19-8005  I
S20-8008  I
S21-8012  I
S22-8105  I
S23-8110  I--------------------------------------------------I
S24-8201  I                                                 I
S25-8204  I                                                 I
S26-8209  I                                                 I
S27-8212  I                                                 I
S29-8309  I                                                 I
S30-8312  I                                                 I
S31-8404  I                                                 I
S32-8408  I                                                 I-------------------------------------------------I
S33-8412  I                                                 I                                                 I
S34-8505  I                                                 I                                                 I
S35-8508  I                                                 I                                                 I
S36-8512  I                                                 I                                                 I
S37-8604  I                                                 I                                                 I------
S38-8608  I                                                 I                                                 I
S39-8612  I                                                 I                                                 I
S42-8712  I                                                 I                                                 I
S28-8303  ---------------------------------------------------I                                                 I
S40-8705  I---------------------------------------------------------------------------------------------------I
S41-8708  I
```

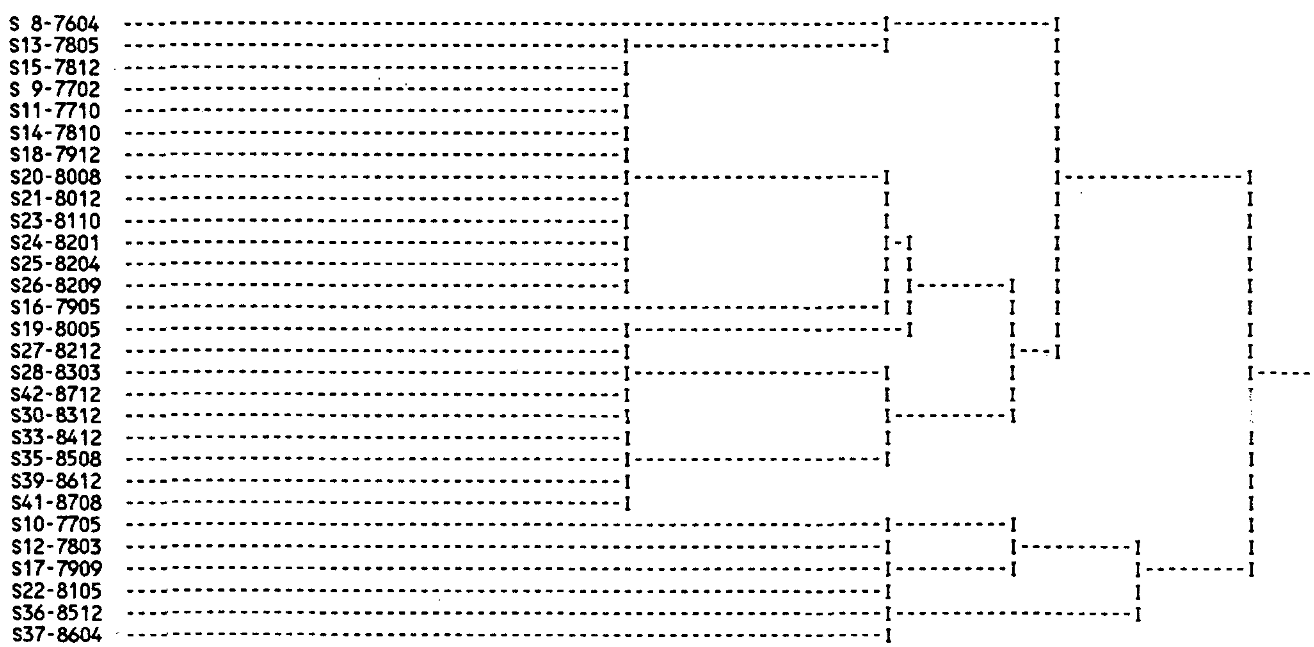
Station: SDIX: Pollicipes polymerus [Mixed P/#/%]: TOTAL Quads with Data = 1:**** Prob. INSUFFICIENT Data ****

Quad Range USED 33 to 33 for Total of 1 : Range WITH data 33 to 33: : # Dropped 0 : 0.0%
Surveys 35 : Dropped 0 Surveys if quads sampled < 33
COPHENETIC CORRELATION COEFFICIENT = 0.998222: Maximum Distance = 1



Station: LCIX: Pollicipes polymerus [Mixed P/#/%]: TOTAL Quads with Data = 143

Quad Range USED 4 to 11 for Total of 8 : Range WITH data 3 to 22: : # Dropped 13 : 9.1%
Surveys 29 : Dropped 0 Surveys if quads sampled < 11
COPHENETIC CORRELATION COEFFICIENT = 0.708060: Maximum Distance = 4



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Tetraclita rubescens (Barnacle). Darwin, 1854. Ref. MAH, 1980, p. 517.
(=*T. squamosa* var. *rubescens*) **Phylum** Arthropoda: **Class** Crustacea:

Description: White when young to reddish as adult, variable orifice size. Diameter 0.2 - 2+ cm (3+ cm, MAH), diam. about same or greater than height. (from MAH).

Distribution: San Francisco Bay (California) to Cabo San Lucas (Baja California), common, mid to low intertidal on rocks exposed to strong surf, occasionally subtidal on hard-shelled animals. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Common, occurring in about 30% of our quadrats in numbers up to 1000's per m^2.

Habitat: On rocks, tops, sides, and undersides (often as large aggregates). Upper (at LCIX), to low tide levels.

Observational Errors: Small individuals (<0.3 cm) that may be this group were field identified as "unid. balanomorphs, juvenile" to avoid possible confusion with *Balanus* (or *Semibalanus*, *Megabalanus*) spp. In areas of dense algal mat or when on undersides of rocks (in cramped observational conditions) could be missed.

Missed observations occurred sometimes in areas of dense algal cover about 4% of the time. We probably did not consistently identify this group during some of our early surveys (prior to late 1979), and we have not been consistent in estimating numbers of individuals versus percent covers, so "numbers" should not be compared from earlier surveys (prior to 1980).

Data prior to 1980 was somewhat spotty as to quality and missed observations.

Field Identification Problems:

General: Small individuals (<0.4 cm) may be confused with almost any of the reddish marked or white moderately pointed barnacles occurring in the area.

Station Specific: none.

General Comments: none.

Impacts to Taxon:

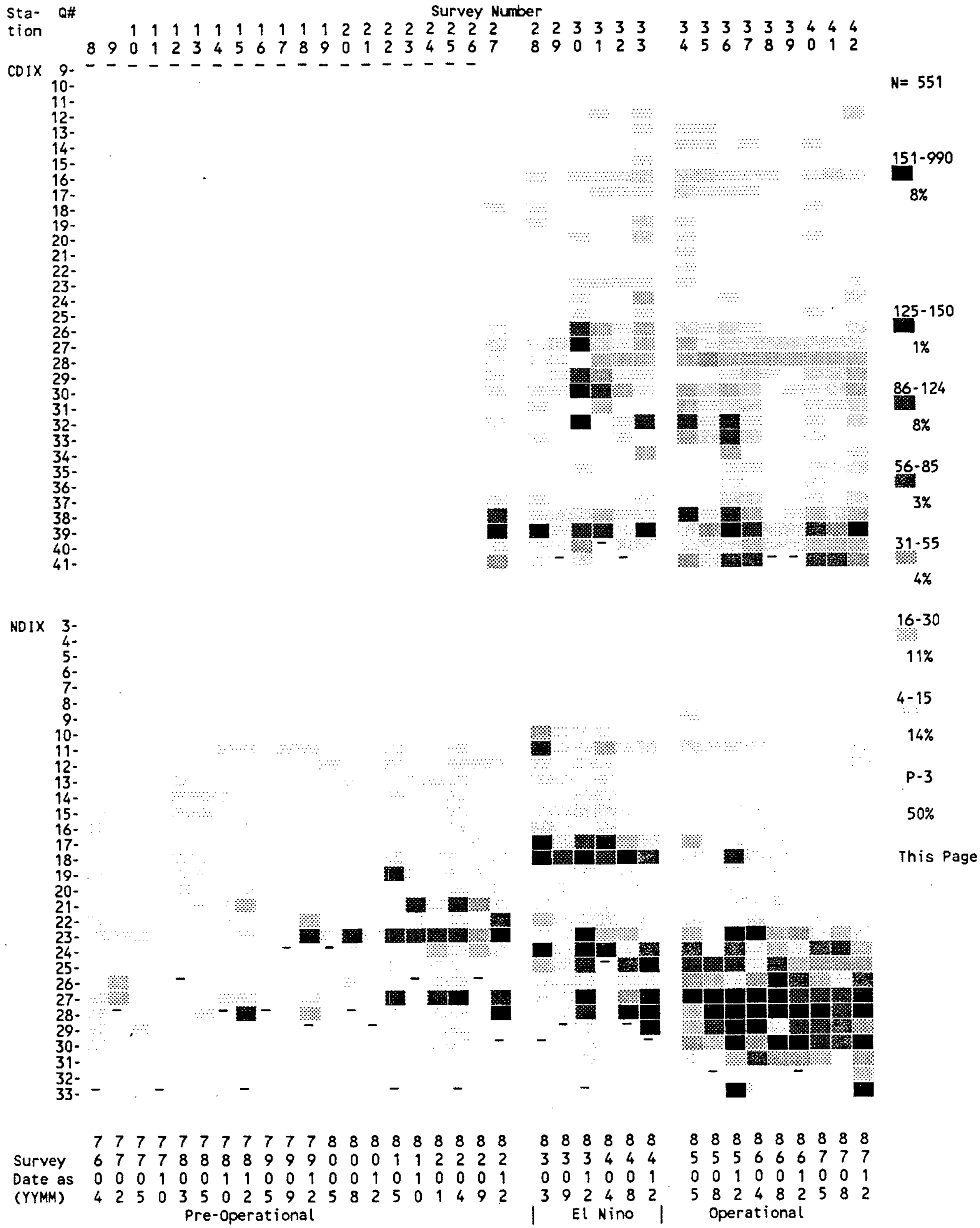
El Niño: 1982-83 winter storm: SDIX with small reduction in numbers and occurrences, due mainly to the overlay by cobble from nearby cliff collapse. NDIX with increase in number and occurrences, probably due to introduction of several large boulders colonized by this taxon. CDIX and LCIX with no apparent change.

El Niño: 1983-1984: At SDIX, recovered by end of 1984 and extending lower in the intertidal. NDIX retained much of increase in occurrences from El Niño but losing somewhat in the mid intertidal. CDIX increasing in number of occurrences, increasing in numbers, then decreasing after 1983. LCIX probably normal although possibly decreasing in numbers at end of 1984 in the mid intertidal.

Diablo DCPP Operation: SDIX retained gains into lower intertidal made during El Niño. NDIX with reduction in occurrences (mainly in the mid intertidal), but with greater than normal concentrations, and extending lower in the intertidal. CDIX with a sharp decline in occurrences in mid-1986, but by end of 1987 comparable to end of El Niño with a possible extension into lower tide levels. LCIX with distribution about normal, with possible increase in numbers.

Taxon or Category: Tetraclita squamosa var. rubescens [Mixed P/#/%]

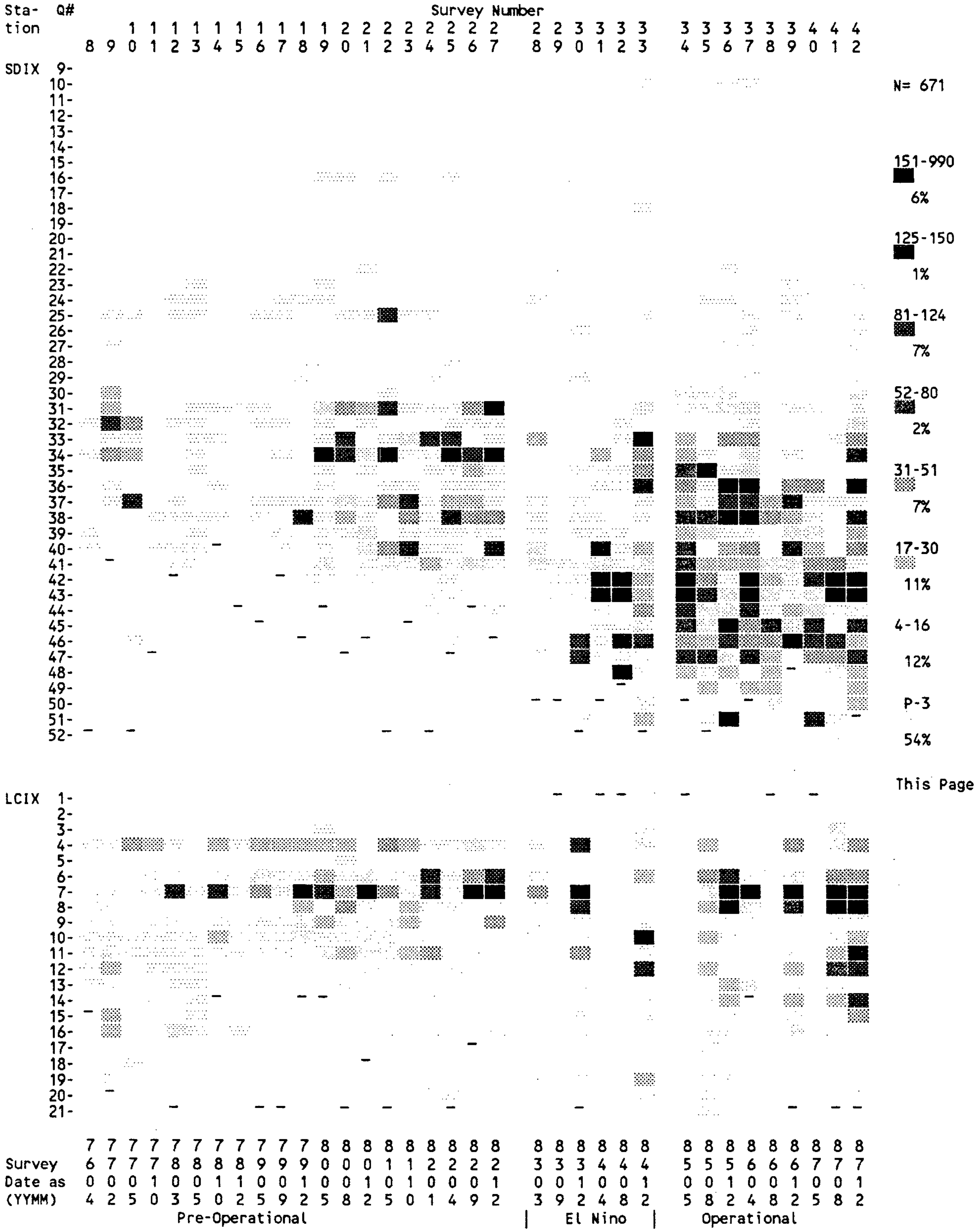
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxon or Category: Tetraclita squamosa var. rubescens [Mixed P/#/%]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

```
Audit: CLUMRG2P: V.1.2: for STETSQUB CLU     5829   4-23-89   8:13a:   04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/08:10:52 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
       METHOD:  GROUP AVERAGE:  ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL:  >> BINARY << Data Used
```

```
Station:  CDIX:   Tetraclita squamosa var. rubescens [Mixed P/#/%]:   TOTAL Quads with Data = 225

        Quad Range USED 16 to 40 for Total of 25 :  Range WITH data 12 to 41:  :  # Dropped  34 :    15.1%
        Surveys  15 :  Dropped  1 Surveys if quads sampled < 40
        COPHENETIC CORRELATION COEFFICIENT = 0.435704:                         Maximum Distance = 12

S31-8404:  <-Start Dropped Surveys
S27-8212  ------------------------------------------------------------------------I
S29-8309  ---------------------------------I-------------------I                  I--------I
S39-8612  ---------------------------------I                   II                 I        I
S38-8608  -----------------------------------------------------II-----------------I        I-----------------I
S41-8708  ------------------------------------------------------I                          I                 II
S28-8303  ---------------------------------------------------------------------------------I                 II
S40-8705  ---------------------------------------------------------------------------------------------------II------
S30-8312  --------------------------------------------------------------------------I--------------------I    I
S33-8412  --------------------------------------------------------------------------I                    I    I
S32-8408  -------------------------------------------------I--------------------I                        I----I
S35-8508  -------------------------------------------------I                    I--------------I         I
S34-8505  ----------------------------------------------------------------------I              I---------I
S36-8512  -------------------------------------------------I------------I                      I
S37-8604  -------------------------------------------------I            I----------------------I
S42-8712  --------------------------------------------------------------I
```

```
Station:  NDIX:   Tetraclita squamosa var. rubescens [Mixed P/#/%]:   TOTAL Quads with Data = 326

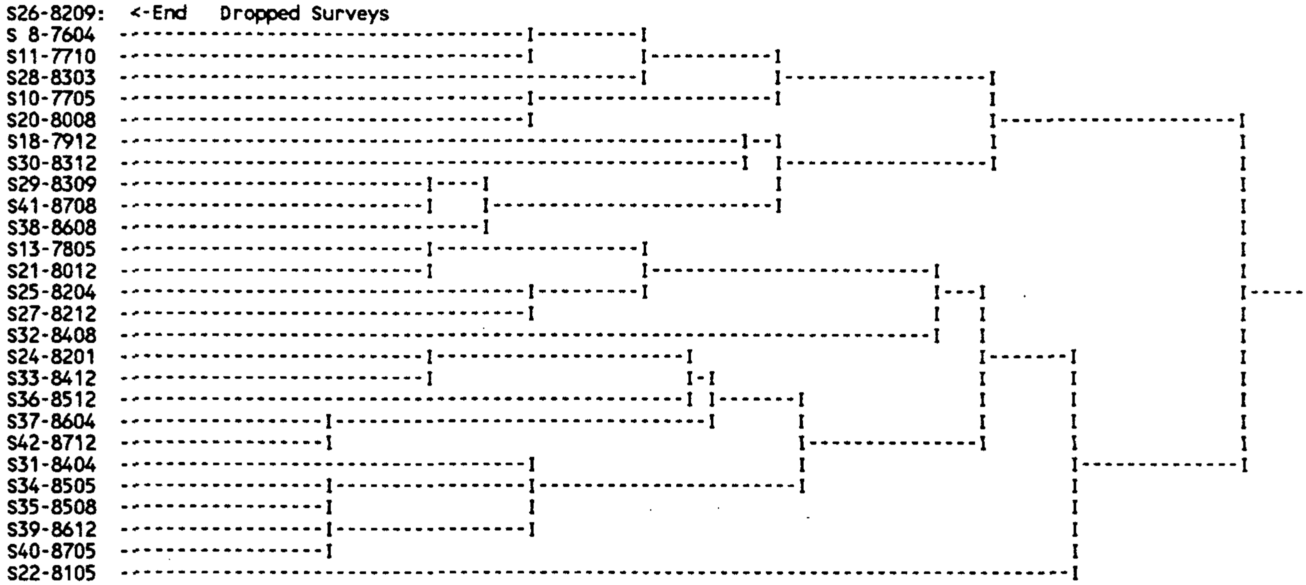
        Quad Range USED 10 to 27 for Total of 18 :  Range WITH data 9 to 33:  :  # Dropped  104 :    31.9%
        Surveys  29 :  Dropped  6 Surveys if quads sampled < 27
        COPHENETIC CORRELATION COEFFICIENT = 0.621679:                         Maximum Distance = 9

S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End  Dropped Surveys
S 8-7604  --------------------------------------------------------------I
S 9-7702  ----------------------I---------------I                       I
S20-8008  ----------------------I               I-----------------I     I---------------I
S10-7705  I---------I                           I                 I     I               I
S21-8012  I         I---------------------------I                 I     I               I
S11-7710  I---------I                                             I-----I               I
S16-7905  I                                                       I                     I-I
S14-7810  ---------------------------------I---------------I      I                     I I
S18-7912  ---------------------------------I               I------I                     I I-------------------I
S15-7812  -------------------------------------------------I                            I I                   I
S27-8212  ------------------------------------------------------------------------------I I                   I
S13-7805  --------------------------------------------------------------------------------I                   I
S22-8105  -------------------------------------------------------I--------I                                   I
S35-8508  -------------------------------------------------------I        I                                   I
S24-8201  ------------------------------------------I                     I                                   I------
S32-8408  ----------I----------------I              I                     I                                   I
S36-8512  ----------I                I---I          I                     I----------------I                  I
S33-8412  ----------I----------------I   I          I                     I                I                  I
S34-8505  ----------I                    I----------I--------------I      I                I                  I
S38-8608  ----------I----I               I          I              I      I                I                  I
S39-8612  ----------I    I---------------I          I              I------I                I                  I
S41-8708  ---------------I                          I              I                       I------------------I
S40-8705  ------------------------------------------I              I                       I
S42-8712  ---------------------------------------------------------I                       I
S25-8204  --------------------------------------------I----------I                         I
S37-8604  --------------------------------------------I          I--I                      I
S28-8303  ---------------------------------I---------------------I  I----------------------I
S29-8309  ---------------------------------I                        I
S30-8312  ----------------------------------------------------------I
```

Station: SDIX: Tetraclita squamosa var. rubescens [Mixed P/#/%]: TOTAL Quads with Data = 414

Quad Range USED 25 to 45 for Total of 21 : Range WITH data 10 to 52: : # Dropped 149 : 36.0%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.547312: Maximum Distance = 11

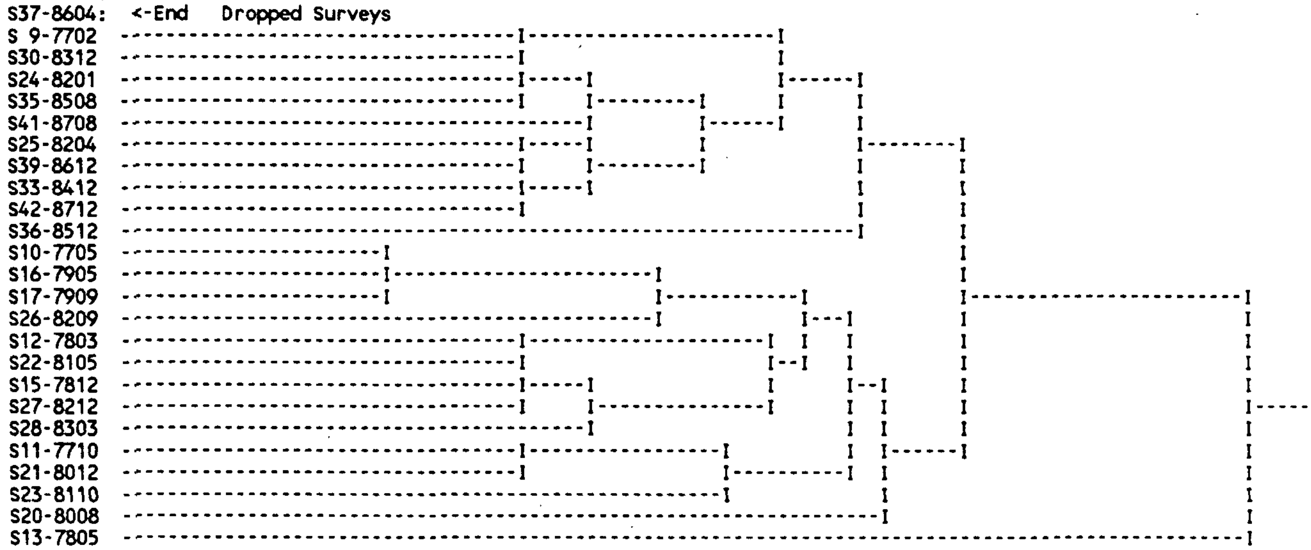
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209: <-End Dropped Surveys



Station: LCIX: Tetraclita squamosa var. rubescens [Mixed P/#/%]: TOTAL Quads with Data = 258

Quad Range USED 4 to 16 for Total of 13 : Range WITH data 3 to 22: : # Dropped 52 : 20.2%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.571702: Maximum Distance = 8

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604: <-End Dropped Surveys



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Pagurus spp. (Unid. pagurids) (Hermit Crab). Ref. MAH, 1980, p. 584ff.
Phylum Arthropoda: **Class** Crustacea:

Description: Inhabiting empty gastropod shells, such shells from 0.1 -4+ cm in diameter. Crab up to 1.9 cm carapace length.

Distribution: See below for distributions of species laboratory identified from our intertidal stations. Common, upper to low intertidal in sand/gravel areas, and in algal mats. (modified from MAH). A warm-tolerant group.

Diablo Area Specific Information: Common, occurring in about 50% of our quadrats in numbers up to 250+ per m^2.

Habitat: In sand/gravel areas out in open or under cobble, and in algal mats, sometimes out on rocks

Observational Errors: MANY. When no water in quadrat, individuals tend to withdraw into shells (often *Tegula funebralis* shells) so observers may be faced with too many *Tegula* shells to study in detail, and in this case, pagurids if found were usually noted as present. Small individuals (occupied shell <0.5 cm) in algal mat quadrats are usually just noted as present and if not common, these can be easily missed. Numbers were estimated, or taxon noted as abundant, common, etc. only when we could easily observe quantitatively without picking up every shell in the quadrat.

Missed observations occurred but number cannot be estimated. A difficult group to quantify. The safest approach involved viewing the data as presence/absence information.

Field Identification Problems:

General: Establishing presence often time-consuming.

Station Specific: none.

General Comments: SDIX and NDIX upper intertidal distribution somewhat confused by the sand/gravel patches that came and went.

Impacts to Taxon:

El Niño: 1982-83 winter storm: All Cove stations with a probable reduction in occurrences in the upper intertidal. LCIX with total removal throughout the transect.

El Niño: 1983-1984: At Cove stations distribution probably normal, with possibly a decline in occurrences in the upper intertidal for NDIX and CDIX. LCIX not recovered.

Diablo DCPP Operation: SDIX approximately normal (possible reduction in numbers at lower tide levels). CDIX and NDIX with a reduction in occurrences in mid-1986, with NDIX probably normal by the end of 1987 and CDIX with increasing occurrences then with a reduced number of occurrences compared to the El Niño period by end of 1987. LCIX with sporadic changes in occurrences, and possibly lower by the end of 1987.

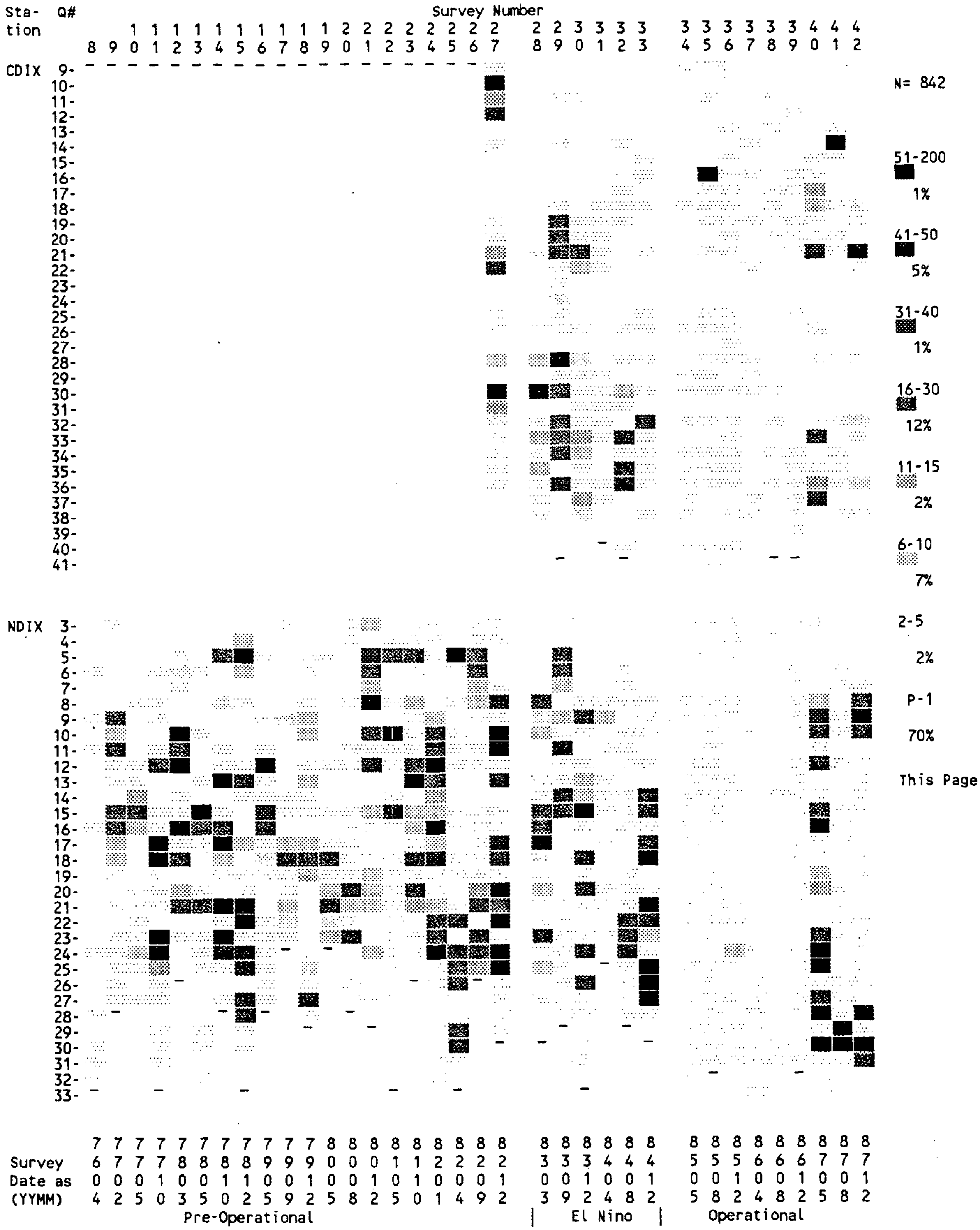
P. granosimanus: Unalaska (Aleutian Is.) to Bahia de Todos Santos (Baja California).

P. hirsutiusculus: Pribilof Islands (Alaska) to San Diego (California); Bering Strait to northern Japan.

P. samuelis: Vancouver Island (British Columbia) to Punta Eugenia (Baja California). Most common of central California intertidal hermit crabs (from MAH).

Taxon or Category: Unid. pagurids [Mixed P/#]

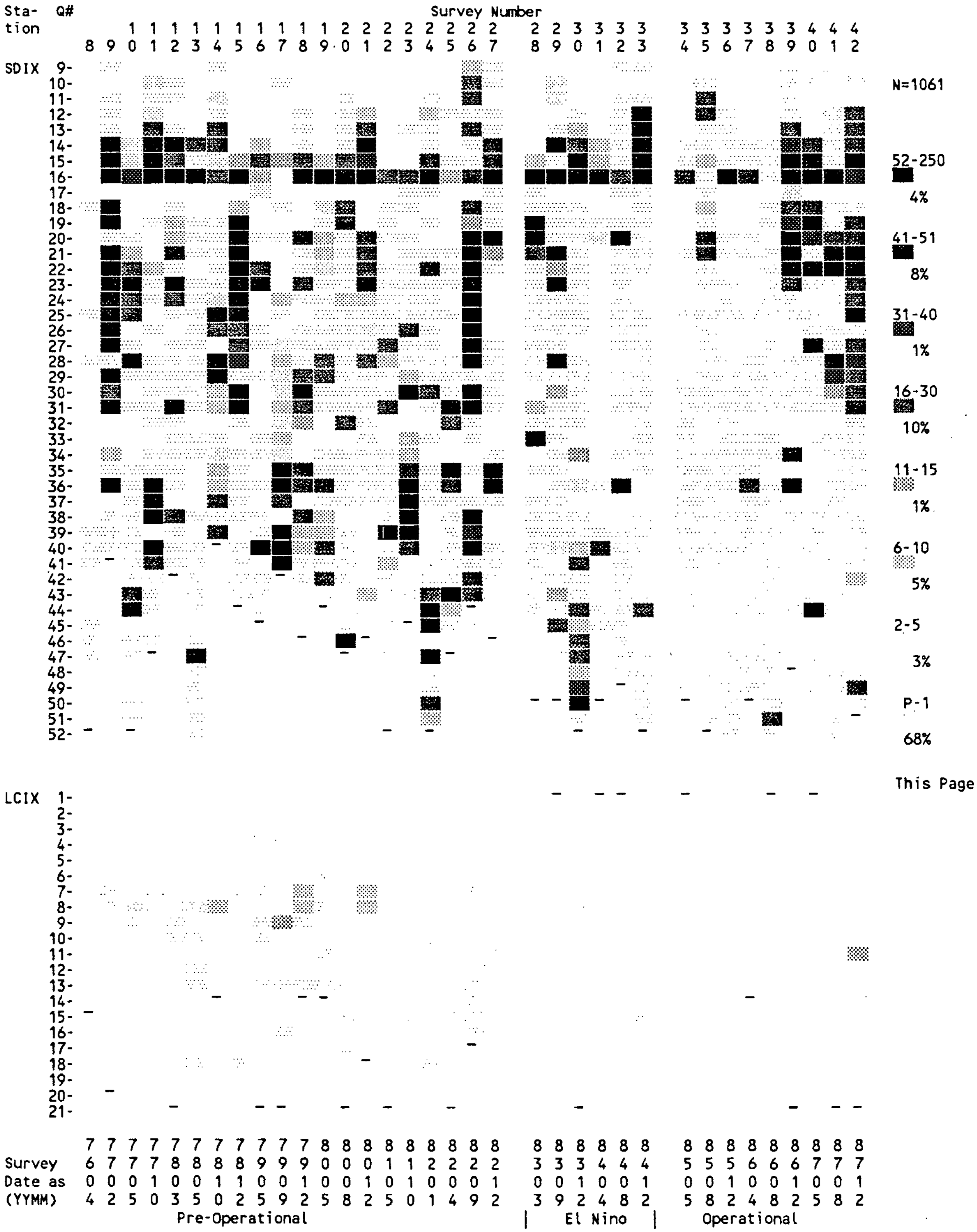
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxon or Category: Unid. pagurids [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

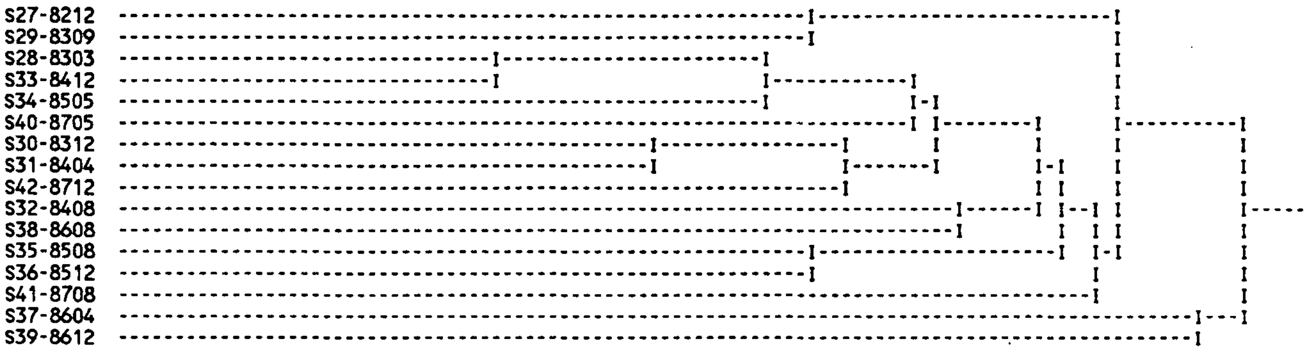


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: CLUMRG2P: V.1.2: for SUPAGURB CLU 6581 4-23-89 8:19a: 04-27-1989/17:15
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/08:16:36 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Unid. pagurids [Mixed P/#]: TOTAL Quads with Data = 231

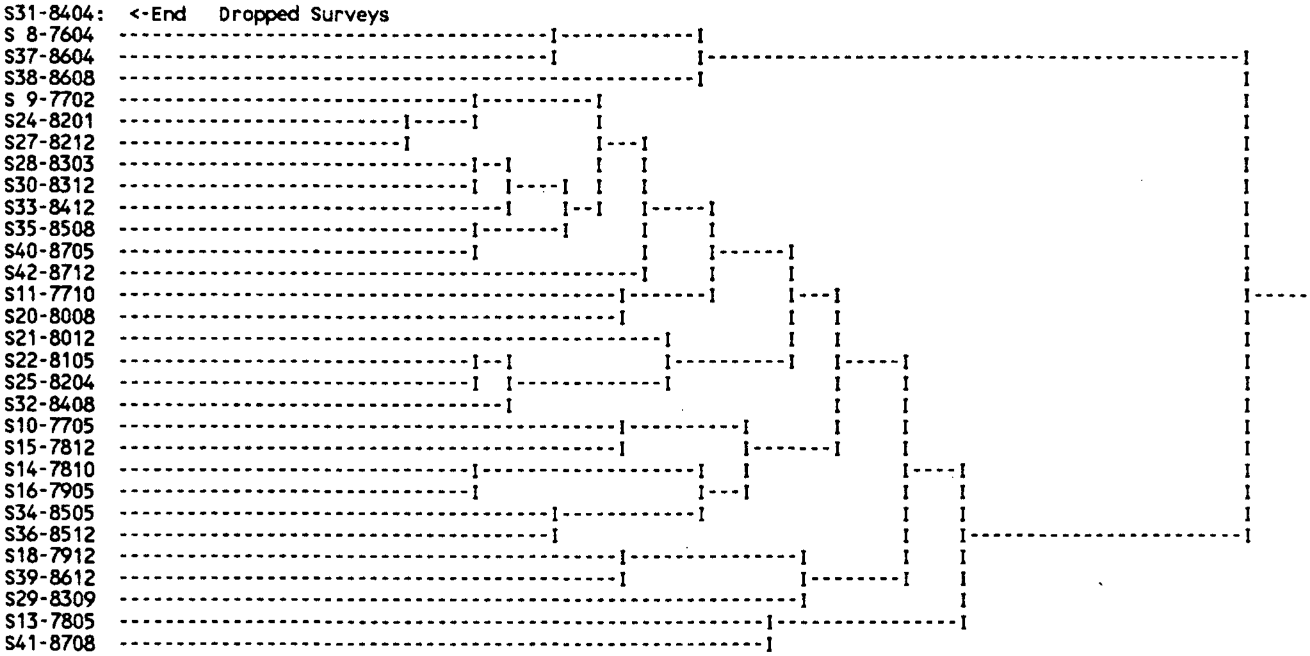
Quad Range USED 8 to 39 for Total of 32 : Range WITH data 7 to 41: : # Dropped 6 : 2.6%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.325689: Maximum Distance = 15



Station: NDIX: Unid. pagurids [Mixed P/#]: TOTAL Quads with Data = 617

Quad Range USED 3 to 27 for Total of 25 : Range WITH data 3 to 33: : # Dropped 162 : 26.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.614021: Maximum Distance = 16

S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End Dropped Surveys



Station: SDIX: Unid. pagurids [Mixed P/#]: TOTAL Quads with Data = 1005

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 4 to 52: : # Dropped 352 : 35.0%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.779436: Maximum Distance = 19

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S17-7909:  <-End   Dropped Surveys
S 8-7604  -----------------------------------------------I---------------------------------------------------I
S31-8404  -----------------------------------------------I                                                   I
S10-7705  --------------------------I-------I                                                                I
S25-8204  --------------------------I       I---------I                                                      I
S18-7912  ----------------------------------I         I-I                                                    I
S11-7710  --------------------------------------------I I                                                    I
S13-7805  ------------------------------------I--I      I                                                    I
S32-8408  ------------------------------------I  I-I    I                                                    I
S39-8612  ---------------------------------------I I    I--I                                                 I
S15-7812  ----------I                              I    I  I                                                 I
S19-8005  ----------I----I                         I    I  I                                                 I
S20-8008  ----------I    I----I                    I    I  I                                                 I
S29-8309  ----------I----I    I                    I    I  I                                                 I
S42-8712  ----------I         I--I                 I----I  I                                                 I------
S22-8105  --------------------I  I----I            I       I                                                 I
S35-8508  --------------------I  I    I--I         I       I-I                                               I
S30-8312  -----------------------I    I  I         I       I I                                               I
S41-8708  ----------------------------I  I---I     I       I I                                               I
S26-8209  ----------I---------------I    I   I     I       I I                                               I
S28-8303  ----------I               I----I   I-----I       I II                                              I
S40-8705  --------------------------I        I             I II                                              I
S38-8608  -----------------------------------I             I II                                              I
S27-8212  -------------------------------------------------I II---I                                          I
S23-8110  ------------------------------------------I--------II   I                                          I
S33-8412  ------------------------------------------I         I   I                                          I
S21-8012  -------------------------------I--------------------I   I-----------I                              I
S24-8201  -------------------------------I                        I           I                              I
S34-8505  --------------------I---------------I                   I           I------------------------------I
S37-8604  --------------------I               I-------------------I           I
S36-8512  ------------------------------------I                               I
S16-7905  --------------------------------------------------------------------I
```

Station: LCIX: Unid. pagurids [Mixed P/#]: TOTAL Quads with Data = 81

Quad Range USED 7 to 16 for Total of 10 : Range WITH data 7 to 18: : # Dropped 15 : 18.5%
Surveys 24 : Dropped 5 Surveys if quads sampled < 16
COPHENETIC CORRELATION COEFFICIENT = 0.611778: Maximum Distance = 5

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S37-8604:  <-End   Dropped Surveys
S 9-7702  I-----------------I
S11-7710  I                 I------I
S15-7812  ------------------I      I--I
S21-8012  -------------------------I  I---------------I
S24-8201  I---------------------------I               I------I
S30-8312  I                                           I      I
S39-8612  --------------------------------------------I      I----I
S20-8008  ------------------I----------------------I         I    I
S33-8412  ------------------I                      I---------I    I
S22-8105  ------------------I---------I            I              I------------------------I
S28-8303  ------------------I         I------------I              I                        I
S36-8512  ----------------------------I                           I                        I-I
S10-7705  ------------------I-------------------------------------I                        I I
S12-7803  ------------------I                                                              I I
S13-7805  ---------------------------------------------------------------------------------I I---------I
S16-7905  I---------------------------------------------------------I                        I         I
S35-8508  I                                                         I------------I           I         I
S17-7909  ----------------------------------------------------------I            I-----------I         I------I
S41-8708  -----------------------------------------------------------------------I                     I      I
S23-8110  ------------------I-----------------------------I                                            I      I------
S25-8204  ------------------I                             I--------------------------------------------I      I
S26-8209  ------------------------------------------------I                                                   I
S27-8212  ----------------------------------------------------------I-----------------------------------------I
S42-8712  ----------------------------------------------------------I
```

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Patiria miniata (Bat Star). (Brandt, 1835). Ref. MAH 1980, p 120.
Phylum Echinodermata: **Class** Asteroidea:

Description: Color extremely variable, commonly red or deep orange, plain or mottled. Disk large, arms (usually 5) short and triangular. Radius 5 - 10 cm.

Distribution: Sitka (Alaska) to Isla de Revillagigedo (Mexico), low intertidal (subtidal to 290 m). Among rocks overgrown with surfgrass, large algae, sponges or bryozoans. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately uncommon, occurring in about 6% of our quadrats.

Habitat: On rocks, in sand/gravel areas, and in nooks and crevices under boulders, upper-mid to low tide levels.

Observational Errors: When dense algal mat present or organism is under boulders, can be missed. During early surveys (prior to 1977) group was not always counted, but noted as present.

Field Identification Problems: None known.

General: n.a.

Station Specific: n.a.

General Comments: Moderate numbers of this taxon only at SDIX and NDIX. Occurrences and numbers at both stations fairly sporadic, with NDIX probably the more stable. Occurrences in the upper-mid intertidal were probably ephemerals (i.e., wave-introduced individuals).

Impacts to Taxon:

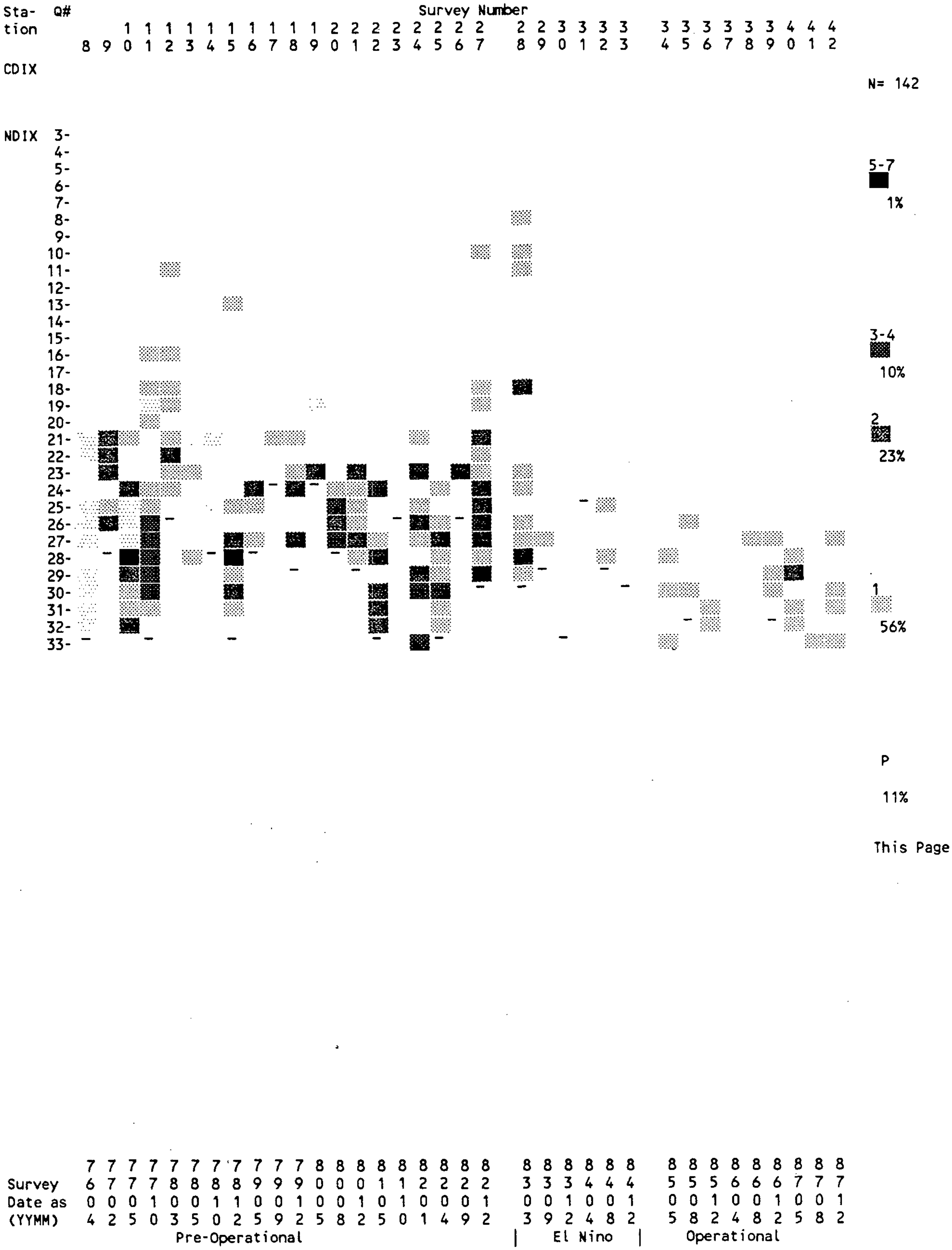
El Niño: 1982-83 winter storm: At SDIX and NDIX little or no change in numbers but with a wider distribution into the upper intertidal (wave-introduced individuals?).

El Niño: Disappeared at SDIX, possibly due to cobble fill of area, reducing taxon's preferred habitat. NDIX with sharp decline in occurrences, and scattered only at lower tide levels. LCIX, last observed individual was in early 1982.

Diablo DCPP Operation: SDIX and NDIX low in numbers and occurrences, but not outside the ranges of pre-El Niño conditions. NDIX with no occurrences in the mid tidal range where this taxon was previously moderately common. CDIX, no specimens ever found. LCIX still with no individuals (last occurrence was 1982).

Taxon or Category: Patiria miniata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

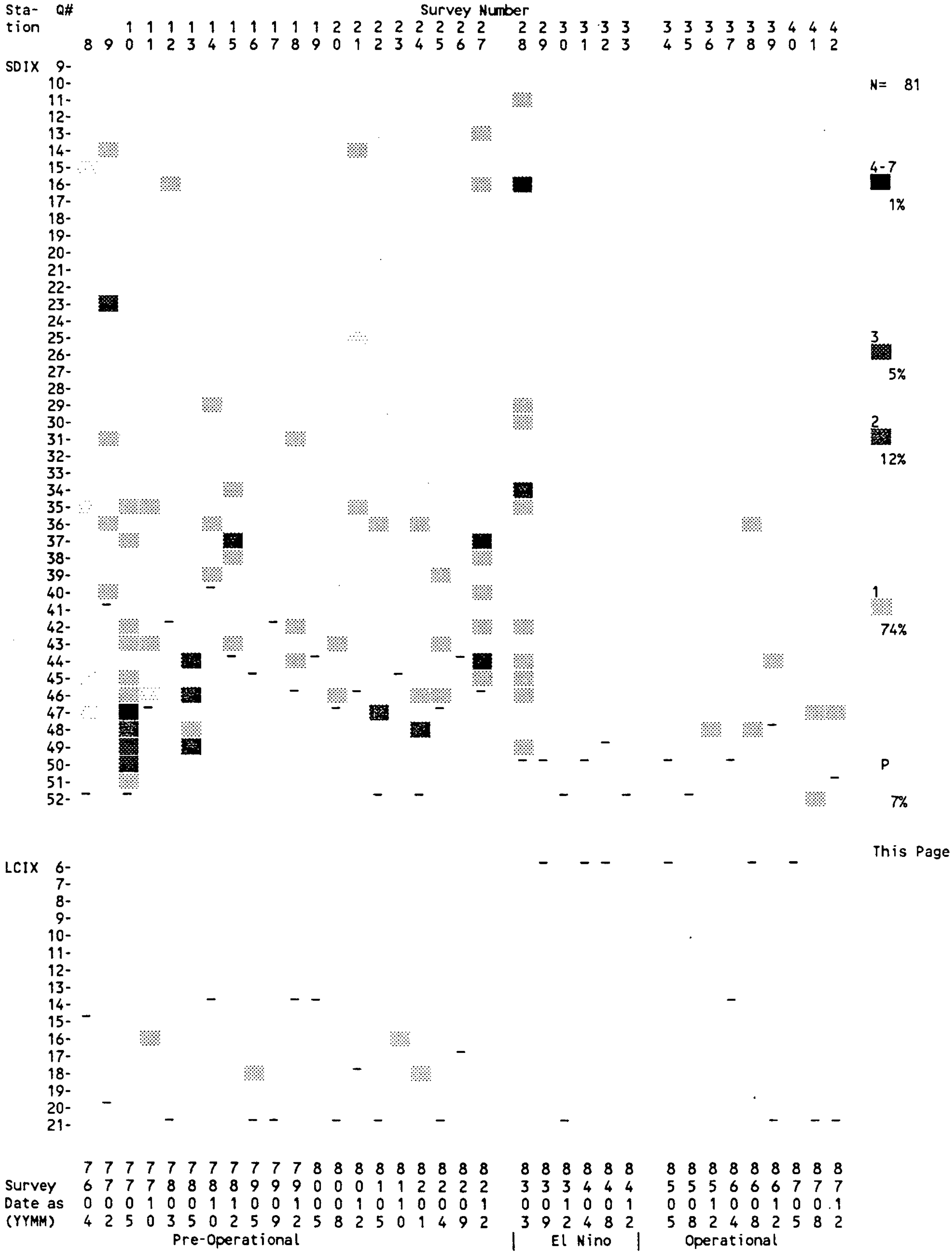


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PATMIN CSV 5288 3-29-88 8:05a 04-15-1989 06:32

Taxon or Category: Patiria miniata

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PATMIN CSV 5288 3-29-88 8:05a 04-15-1989 06:33

Audit: CLUMRG2P: V.1.2: for SPATMINB CLU 5829 4-23-89 7:05a: 04-27-1989/17:11
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:06:13 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Patiria miniata: : No data for this station

```
                                   NO DATA
                              NO DATA
                         NO DATA
                    NO DATA
               NO DATA
          NO DATA
     NO DATA
NO DATA
NO DATA
     NO DATA
          NO DATA
               NO DATA
                    NO DATA
                         NO DATA
                              NO DATA
                                   NO DATA
```

Station: NDIX: Patiria miniata: TOTAL Quads with Data = 142

Quad Range USED 10 to 28 for Total of 19 : Range WITH data 8 to 33: : # Dropped 66 : 46.5%
Surveys 25 : Dropped 10 Surveys if quads sampled < 28
COPHENETIC CORRELATION COEFFICIENT = 0.811208: Maximum Distance = 12

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S16-7905:
S17-7909:
S19-8005:
S20-8008:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  --------------------------------------------------I----------------------I
S24-8201  --------------------------------------------------I                      I
S10-7705  --------------------------------------------------I---I                  I
S21-8012  --------------------------------------------------I   I---------I        I
S22-8105  -----------------------------------------I------------I         I---I    I
S25-8204  -----------------------------------------I                      I   I    I-------------------------I
S18-7912  ----------------------------------------------------------------I   I    I                         I
S13-7805  -----------------------------------------I--I                       I    I                         I
S34-8505  ---------------------------------I-------I  I-----I                 I    I                         I
S40-8705  ---------------------------------I          I     I                 I    I                         I
S32-8408  --------------------------------------------I     I                 I----I                         I
S29-8309  ---------------------------------I                I                 I                              I
S38-8608  ---------------------------------I-------I        I-----------I     I                              I
S39-8612  ---------------------------------I       I        I           I     I                              I------
S42-8712  ---------------------------------I       I---I    I           I     I                              I
S30-8312  ---------------------------------I       I   I    I           I     I                              I
S33-8412  ---------------------------------I       I   I    I           I-----I                              I
S36-8512  ---------------------------------I-------I   I----I           I                                    I
S37-8604  ---------------------------------I           I                I                                    I
S41-8708  ---------------------------------I           I                I                                    I
S35-8508  ---------------------------------------------I                I                                    I
S15-7812  --------------------------------------------------------------I                                    I
S11-7710  ----------------------------------------------------------------------------------------I----------I
S27-8212  ---------------------------------------------------------------------------I------------I
S28-8303  ---------------------------------------------------------------------------I
```

Station: SDIX: Patiria miniata: TOTAL Quads with Data = 80

Quad Range USED 15 to 45 for Total of 31 : Range WITH data 6 to 55: : # Dropped 44 : 55.0%
Surveys 26 : Dropped 9 Surveys if quads sampled < 45
COPHENETIC CORRELATION COEFFICIENT = 0.836180: Maximum Distance = 22

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S19-8005:
S23-8110:
S26-8209:  <-End   Dropped Surveys
S 8-7604  -------------------------------------------------------------------------------I
S11-7710  --------------------------------------------------------------------I--I       I
S20-8008  --------------------------------------------------------------------I  I-I     I
S25-8204  -----------------------------------------------------------------------I I     I
S13-7805  ----------------------------------------------------------------I---I    I     I
S39-8612  ----------------------------------------------------------------I   I    I     I
S29-8309  ----------------------------------------------------------------I   I    I     I
S30-8312  ----------------------------------------------------------------I   I    I     II
S31-8404  ----------------------------------------------------------------I   I    I-I   II
S32-8408  ----------------------------------------------------------------I   II   I I   II
S33-8412  ----------------------------------------------------------------I   II   I I   II
S34-8505  ----------------------------------------------------------------I   II   I I   II
S35-8508  ----------------------------------------------------------------I   II   I I   II
S36-8512  ----------------------------------------------------------------I   II   I I   II
S37-8604  ----------------------------------------------------------------I---II---I I---II------I
S40-8705  ----------------------------------------------------------------I    I     I    I      I
S41-8708  ----------------------------------------------------------------I    I     I    I      I
S42-8712  ----------------------------------------------------------------I    I     I    I      I
S22-8105  ----------------------------------------------------------------I    I     I    I      I-----------I
S24-8201  ----------------------------------------------------------------I----I     I    I      I           I
S38-8608  ----------------------------------------------------------------I          I    I      I           I
S21-8012  ---------------------------------------------------------------------------I    I      I           I------
S18-7912  --------------------------------------------------------------------------------I      I           I
S10-7705  ---------------------------------------------------------------------------------------I           I
S27-8212  ------------------------------------------------------------------------------------------------I--I
S28-8303  ------------------------------------------------------------------------------------------------I
```

Station: LCIX: Patiria miniata: TOTAL Quads with Data = 4:**** Prob. INSUFFICIENT Data ****

Quad Range USED 16 to 18 for Total of 3 : Range WITH data 16 to 18: : # Dropped 0 : 0.0%
Surveys 22 : Dropped 7 Surveys if quads sampled < 18
COPHENETIC CORRELATION COEFFICIENT = 0.922090: Maximum Distance = 2

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702  ------------------------------------------------I
S10-7705  ------------------------------------------------I
S12-7803  ------------------------------------------------I
S13-7805  ------------------------------------------------I
S15-7812  ------------------------------------------------I
S17-7909  ------------------------------------------------I
S20-8008  ------------------------------------------------I
S22-8105  ------------------------------------------------I
S25-8204  ------------------------------------------------I----------------------------------------------I
S27-8212  ------------------------------------------------I                                              I
S28-8303  ------------------------------------------------I                                              I
S30-8312  ------------------------------------------------I                                              I
S33-8412  ------------------------------------------------I                                              I
S35-8508  ------------------------------------------------I                                              I----I
S36-8512  ------------------------------------------------I                                              I    I
S39-8612  ------------------------------------------------I                                              I    I
S41-8708  ------------------------------------------------I                                              I    I------
S42-8712  ------------------------------------------------I                                              I    I
S11-7710  ------------------------------------------------I----------------------------------------------I    I
S23-8110  ------------------------------------------------I                                                   I
S16-7905  ------------------------------------------------I---------------------------------------------------I
S24-8201  ------------------------------------------------I
```

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Pisaster ochraceus (Ochre Starfish). (Brandt, 1835). Ref. MAH 1980, p 125.
Phylum Echinodermata: **Class** Asteroidea:

Description: Color variable, yellow or pale orange to dark brown or purple, plain or with reticulate pattern of white spines. Disk moderately small, arms (usually 5) stout and tapering. Radius 4 - 20+ cm.

Distribution: Prince William Sound (Alaska) to Point Sal (Santa Barbara Co., California), common, mid to low intertidal (subtidal to 88 m), on wave-swept rocky shores. Juveniles in crevices and under rocks. A subspecies, *P. ochraceus segnis* Fisher, extends at least to Ensenada (Baja California). (from MAH). Possibly a warm-tolerant species.

Diablo Area Specific Information: Moderately uncommon, occurring in about 6% of our quadrats.

Habitat: On rocks, occasionally in nooks and crevices under algal mat, and under boulders and ledges, upper-mid to low tide levels.

Observational Errors: When dense algal mat present or organism is under boulders, could be missed. During early surveys (prior to 1977), group was not always counted, but noted as present. Quadrat boundary errors apply to this taxon, especially at LCIX where it occurred far back under bedrock ledges. Also the taxon can occur nestled in small depressions or crevices under the algal mat at LCIX, so here missed observations may occur here about 5% of the time.

Field Identification Problems: Smaller asteroids (< ~3 cm diam.) that were not readily identifiable as this taxon, are identified as "unid. asteroid, juvenile" to avoid possible confusion with other *Pisaster* spp., *Henricia* sp., and possibly *Leptasterias* spp.

General: n.a.

Station Specific: n.a.

General Comments: LCIX was the only station supporting a stable population of this taxon; occurrences at Cove stations were sporadic and never numerous.

Impacts to Taxon:

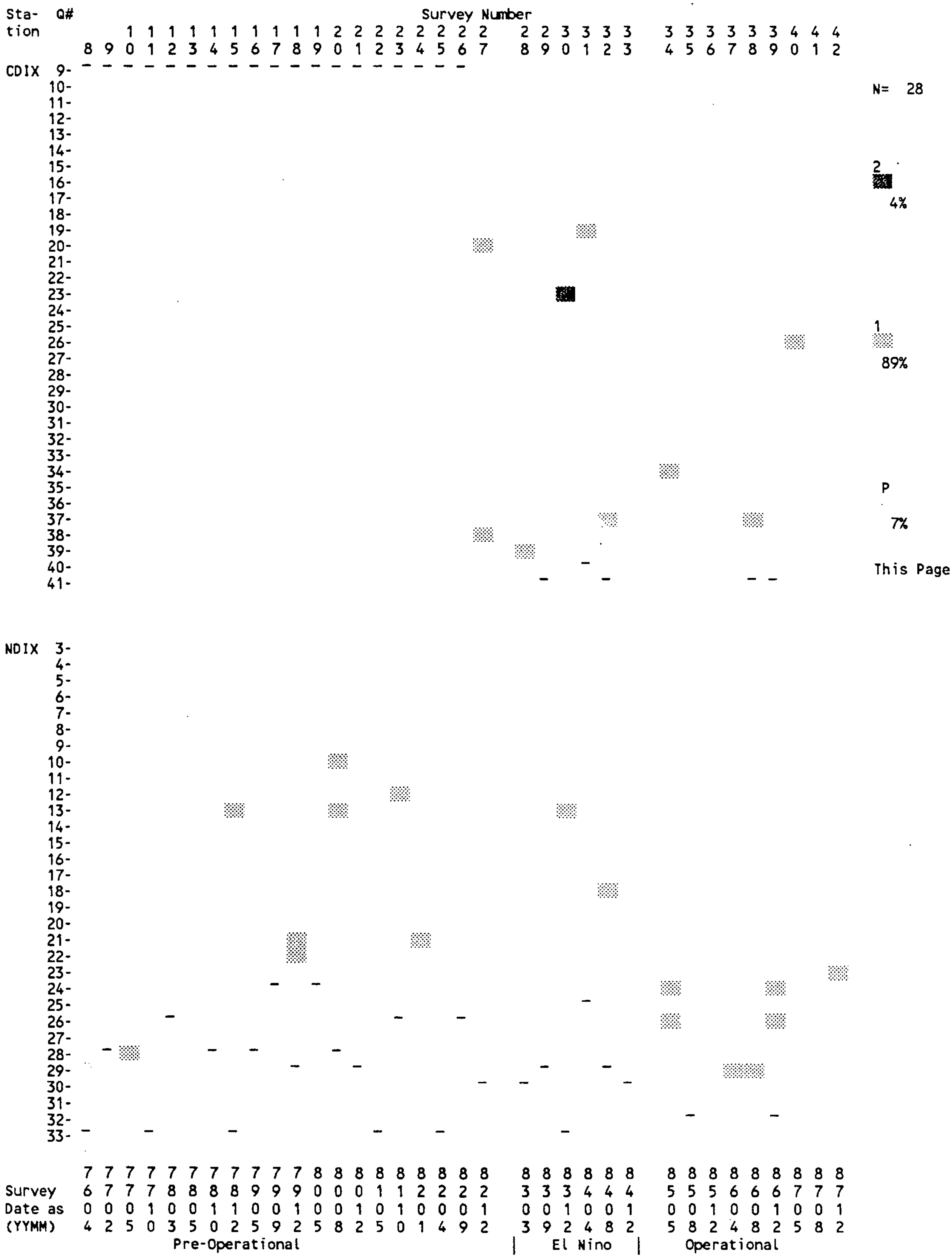
El Niño: 1982-83 winter storm: No discernable change at any station.

El Niño: Possibly a reduction at LCIX during middle of El Niño (winter 1983), but by end of the period was essentially normal. Cove stations, still with sporadic occurrences.

Diablo DCPP Operation: Cove stations too soon to evaluate because taxon still occurring sporadically. LCIX with moderate increase in occurrences for winters of 1985 and 1986 (possibly an artifact, i.e., algal mat usually reduced in winter surveys, so that cryptic individuals more easily observed). LCIX may have had a trend towards an upward shift in the intertidal of the population by the end of 1987.

Taxon or Category: Pisaster ochraceus

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

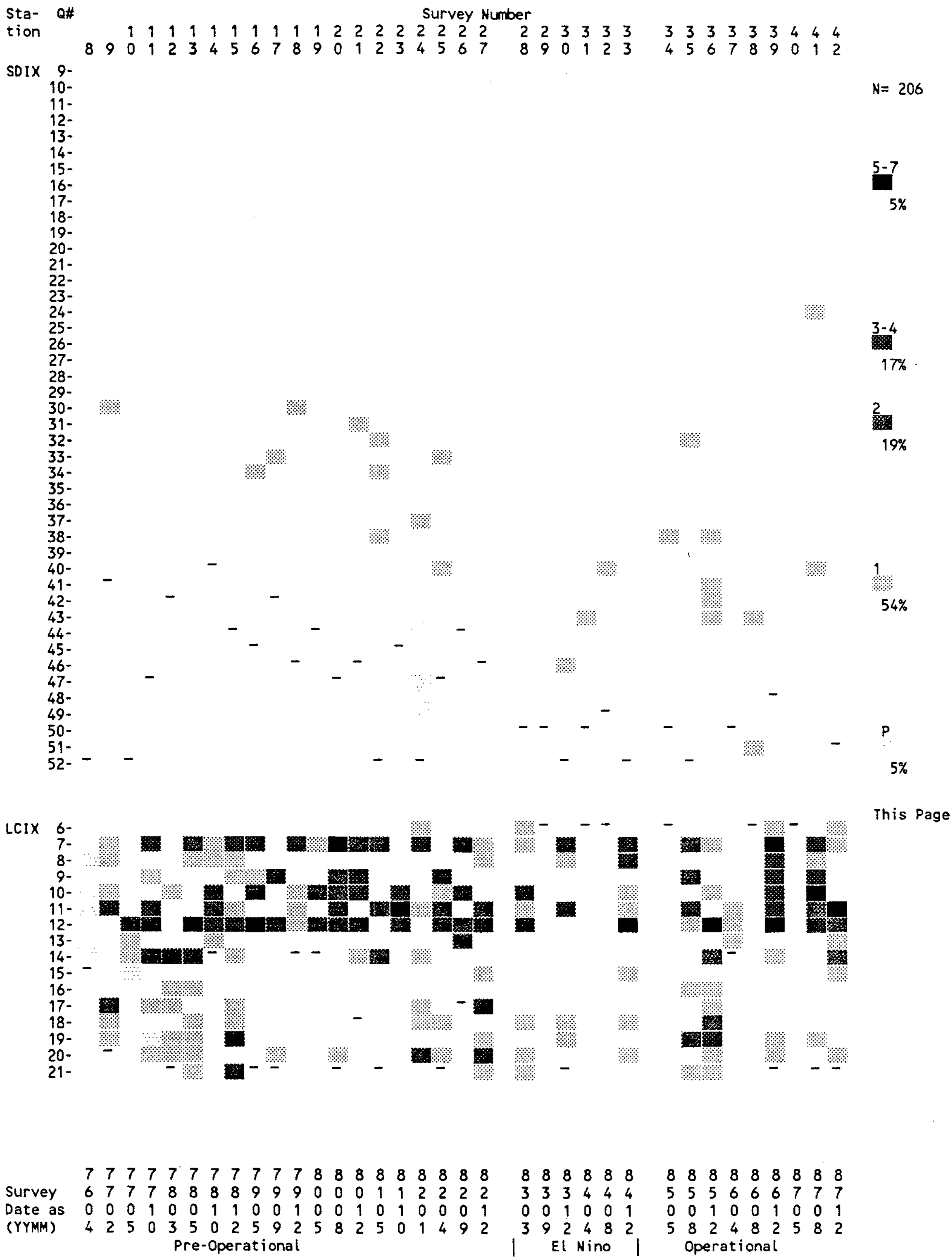


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PISOCH CSV 5233 3-29-88 8:07a 04-15-1989 06:34

Taxon or Category: Pisaster ochraceus

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for PISOCH CSV 5233 3-29-88 8:07a 04-15-1989 06:34

Audit: CLUMRG2P: V.1.2: for SPISOCHB CLU 6163 4-23-89 7:19a: 04-27-1989/17:13
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:17:29 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used

Station: CDIX: Pisaster ochraceus: TOTAL Quads with Data = 9:**** Prob. INSUFFICIENT Data ****

Quad Range USED 19 to 39 for Total of 21 : Range WITH data 19 to 39: : # Dropped 0 : 0.0%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.340586: Maximum Distance = 15

```
S27-8212  ----------------------------------------------------------------------------------------------------I
S28-8303  -------------------------------------------------------------------------------------------I        I
S29-8309  ------------------------------------------------------------------------------------I      I        I
S33-8412  ------------------------------------------------------------------------------------I      I        I
S35-8508  ------------------------------------------------------------------------------------I      I        I
S36-8512  ------------------------------------------------------------------------------------I------II       I------
S37-8604  ------------------------------------------------------------------------------------I      II       I
S39-8612  ------------------------------------------------------------------------------------I      II       I
S41-8708  ------------------------------------------------------------------------------------I      III      I
S42-8712  ------------------------------------------------------------------------------------I      III      I
S30-8312  -------------------------------------------------------------------------------------------III      I
S31-8404  --------------------------------------------------------------------------------------------II------I
S32-8408  ------------------------------------------------------------------------------------I-------II
S38-8608  ------------------------------------------------------------------------------------I        I
S34-8505  ---------------------------------------------------------------------------------------------I
S40-8705  ---------------------------------------------------------------------------------------------I
```

Station: NDIX: Pisaster ochraceus: TOTAL Quads with Data = 19

Quad Range USED 10 to 27 for Total of 18 : Range WITH data 10 to 29: : # Dropped 5 : 26.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.726499: Maximum Distance = 11

```
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End   Dropped Surveys
S 8-7604  -------------------------------------------------------------------------------I
S 9-7702  -------------------------------------------------------------------------------I
S10-7705  -------------------------------------------------------------------------------I
S11-7710  -------------------------------------------------------------------------------I
S13-7805  -------------------------------------------------------------------------------I
S14-7810  -------------------------------------------------------------------------------I
S16-7905  -------------------------------------------------------------------------------I
S21-8012  -------------------------------------------------------------------------------I
S22-8105  -------------------------------------------------------------------------------I
S25-8204  -------------------------------------------------------------------------------I--------I
S27-8212  -------------------------------------------------------------------------------I        I
S29-8309  -------------------------------------------------------------------------------I        I
S33-8412  -------------------------------------------------------------------------------I        I
S35-8508  -------------------------------------------------------------------------------I        I
S36-8512  -------------------------------------------------------------------------------I        II
S37-8604  -------------------------------------------------------------------------------I        II
S38-8608  -------------------------------------------------------------------------------I        II
S40-8705  -------------------------------------------------------------------------------I        II
S41-8708  -------------------------------------------------------------------------------I        II----I
S15-7812  -------------------------------------------------------------------------------I--------II    I
S30-8312  -------------------------------------------------------------------------------I         I    I
S28-8303  -----------------------------------------------------------------------------------------I    I---I
S32-8408  -----------------------------------------------------------------------------------------I    I   I
S42-8712  -----------------------------------------------------------------------------------------I    I   I-I
S18-7912  ----------------------------------------------------------------------------------------I-----I   I I
S24-8201  ----------------------------------------------------------------------------------------I         I I------
S20-8008  --------------------------------------------------------------------------------------------------I I
S34-8505  -------------------------------------------------------------------------------I--------------------I
S39-8612  -------------------------------------------------------------------------------I
```

Station: SDIX: Pisaster ochraceus: TOTAL Quads with Data = 29

Quad Range USED 24 to 44 for Total of 21 : Range WITH data 24 to 51: : # Dropped 7 : 24.1%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.806492: Maximum Distance = 12

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604 ------------------------------------------------------------------------------I
S10-7705 ------------------------------------------------------------------------------I
S11-7710 ------------------------------------------------------------------------------I
S13-7805 ------------------------------------------------------------------------------I
S20-8008 ------------------------------------------------------------------------------I
S23-8110 ------------------------------------------------------------------------------I
S27-8212 ------------------------------------------------------------------------------I
S28-8303 ------------------------------------------------------------------------------I---------I
S29-8309 ------------------------------------------------------------------------------I         I
S30-8312 ------------------------------------------------------------------------------I         I
S33-8412 ------------------------------------------------------------------------------I         I
S37-8604 ------------------------------------------------------------------------------I         II
S39-8612 ------------------------------------------------------------------------------I         II
S40-8705 ------------------------------------------------------------------------------I         II
S42-8712 ------------------------------------------------------------------------------I         III
S16-7905 ----------------------------------------------------------------------------------------III
S18-7912 -----------------------------------------------------------------------------------------II
S21-8012 -----------------------------------------------------------------------------------------III
S31-8404 ------------------------------------------------------------------------------I-----------II
S38-8608 ------------------------------------------------------------------------------I           II----I
S34-8505 ------------------------------------------------------------------------------------------II    I
S35-8508 -------------------------------------------------------------------------------------------I    I---------I
S25-8204 ----------------------------------------------------------------------------------------I---I   I         I
S32-8408 ----------------------------------------------------------------------------------------I   I---I         I-I
S41-8708 --------------------------------------------------------------------------------------------I             I I------I
S22-8105 ----------------------------------------------------------------------------------------------------------I I      I------
S24-8201 ------------------------------------------------------------------------------------------------------------I      I
S36-8512 -------------------------------------------------------------------------------------------------------------------I
```

Station: LCIX: Pisaster ochraceus: TOTAL Quads with Data = 181

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 4 to 23: : # Dropped 52 : 28.7%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.493642: Maximum Distance = 7

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702 ----------------------------------I-----------------------------------I
S30-8312 ----------------------------------I                                   I-----------------I
S27-8212 ----------------------------------------------------------------------I                 I----------I
S11-7710 ----------------------------------I-----------------------------------I                 I          I
S15-7812 ----------------------------------I                                   I-----------------I          I
S35-8508 ----------------------------------------------------------------------I                            I
S39-8612 ----------------------------------I-----------------------------------I                            I---------------I
S41-8708 ----------------------------------I                                                                I               I
S16-7905 -----------------I-------------------------I                                                       I               I
S20-8008 -----------------I                         I--I                                                    I               I
S17-7909 -------------------------------------------I  I----------------------------I                       I               I
S23-8110 ----------------------------------I-----------I                            I-----------------------I               I----I
S25-8204 ----------------------------------I                                        I                                       I    I
S28-8303 -----------------------------------------------------I---------------------I                                       I    I
S33-8412 -----------------------------------------------------I                                                             I    I
S10-7705 -----------------------------------------------------I-------------------------------------------I                  I    I------
S42-8712 -----------------------------------------------------I                                           I-----------------I    I
S22-8105 -----------------------------------------------------I-------------------------------------------I                       I
S24-8201 -----------------------------------------------------I                                                                  I
S12-7803 -----------------------------------------------------I------------------------I                                         I
S36-8512 -----------------------------------------------------I                        I-----------------------------------------I
S13-7805 ------------------------------------------------------------------------------I
```

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Strongylocentrotus purpuratus (Purple Sea Urchin). (Stimpson, 1857). Ref. MAH 1980, p 163.
Phylum Echinodermata: **Class** Echinoidea:

Description: Bright purple, occasionally pale green or greenish tinged with purple (mostly juveniles), test diameter 2 - 6+ (10, MAH) cm. (from MAH).

Distribution: Vancouver Island (British Columbia) to Isla Cedros (Baja California), common, lower intertidal (subtidal to 160 m), on wave-swept rocky shores. (from MAH). A warm-tolerant species.

Diablo Area Specific Information: Moderately rare, occurring in about 7% of our quadrats. Uncommon at our Cove stations.

Habitat: On rocks, mostly in nooks, crevices, and depressions under algal mat, and under boulders and ledges, mid to low tide levels. Juveniles in crevices, under rocks, and nestled in algal mats.

Observational Errors: Could be missed when dense algal mat present or organism was under boulders. During early surveys (prior to 1977) group was not always counted, but noted as present. At LCIX the taxon can occur nestled in small depressions or crevices under the algal mat, so missed observations may occur here about 2% of the time.

Field Identification Problems: Smaller urchins (< ~1.5 cm) that were not readily identifiable as this taxon, were identified as *Strongylocentrotus* sp. to avoid possible confusion with *Strongylocentrotus franciscanus* juveniles.

General: n.a.

Station Specific: n.a.

General Comments: LCIX was the only station supporting a stable population of this taxon, occurrences at Cove stations were sporadic and never numerous.

Impacts to Taxon:

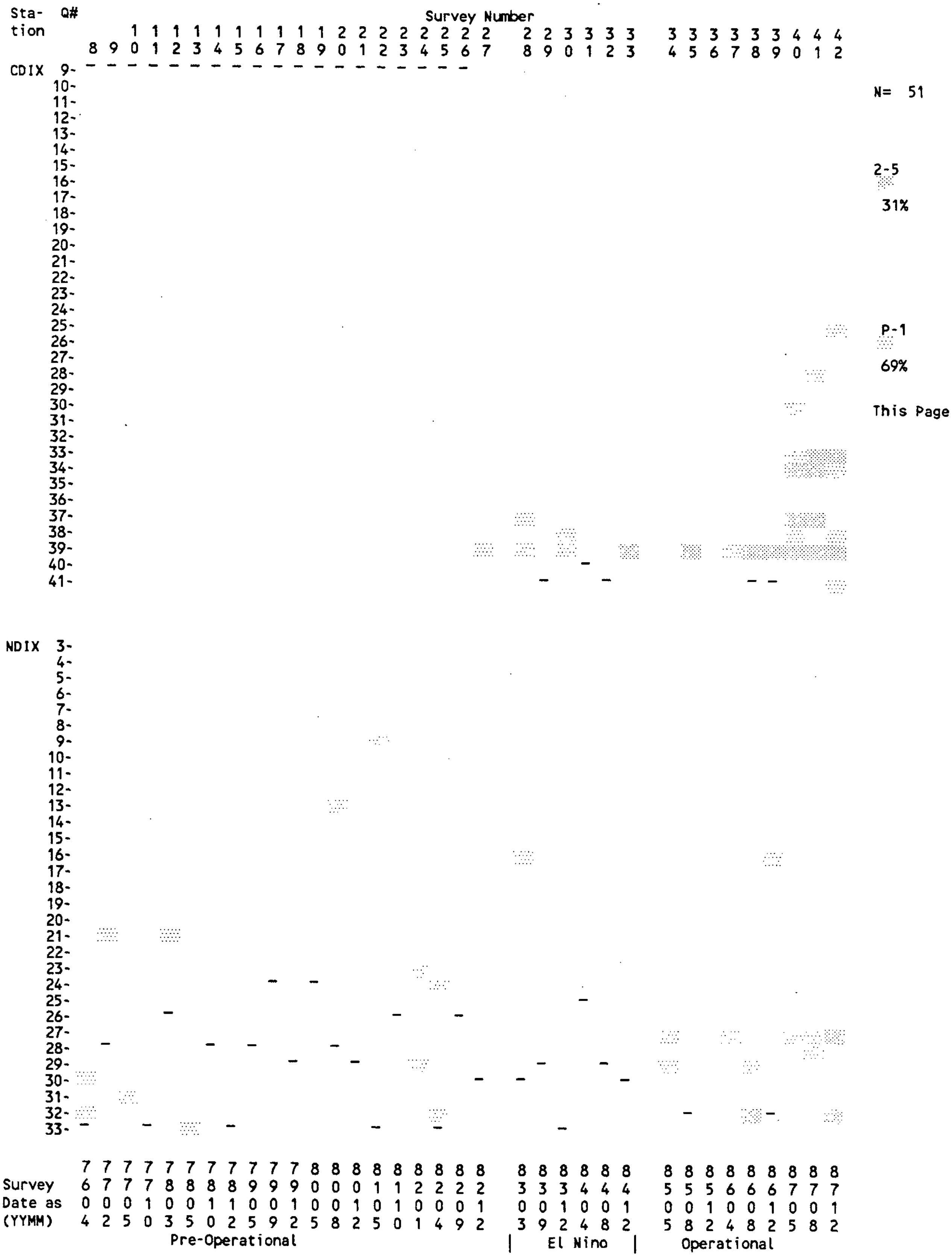
El Niño: 1982-83 winter storm: No identifiable change at any station.

El Niño: No identifiable change at any station. Note that LCIX lost one boulder at the lower intertidal that had appreciable numbers of this taxon.

Diablo DCPP Operation: Cove stations probably increasing in numbers and occurrences at the lower tidal levels and becoming less sporadic, in part due to the reduced algal mat at these stations and the appearance of juveniles. LCIX possibly with a trend towards increasing numbers in the mid tidal (similar to conditions in 1977 to 1978).

Taxon or Category: Strongylocentrotus purpuratus [Mixed P/#]

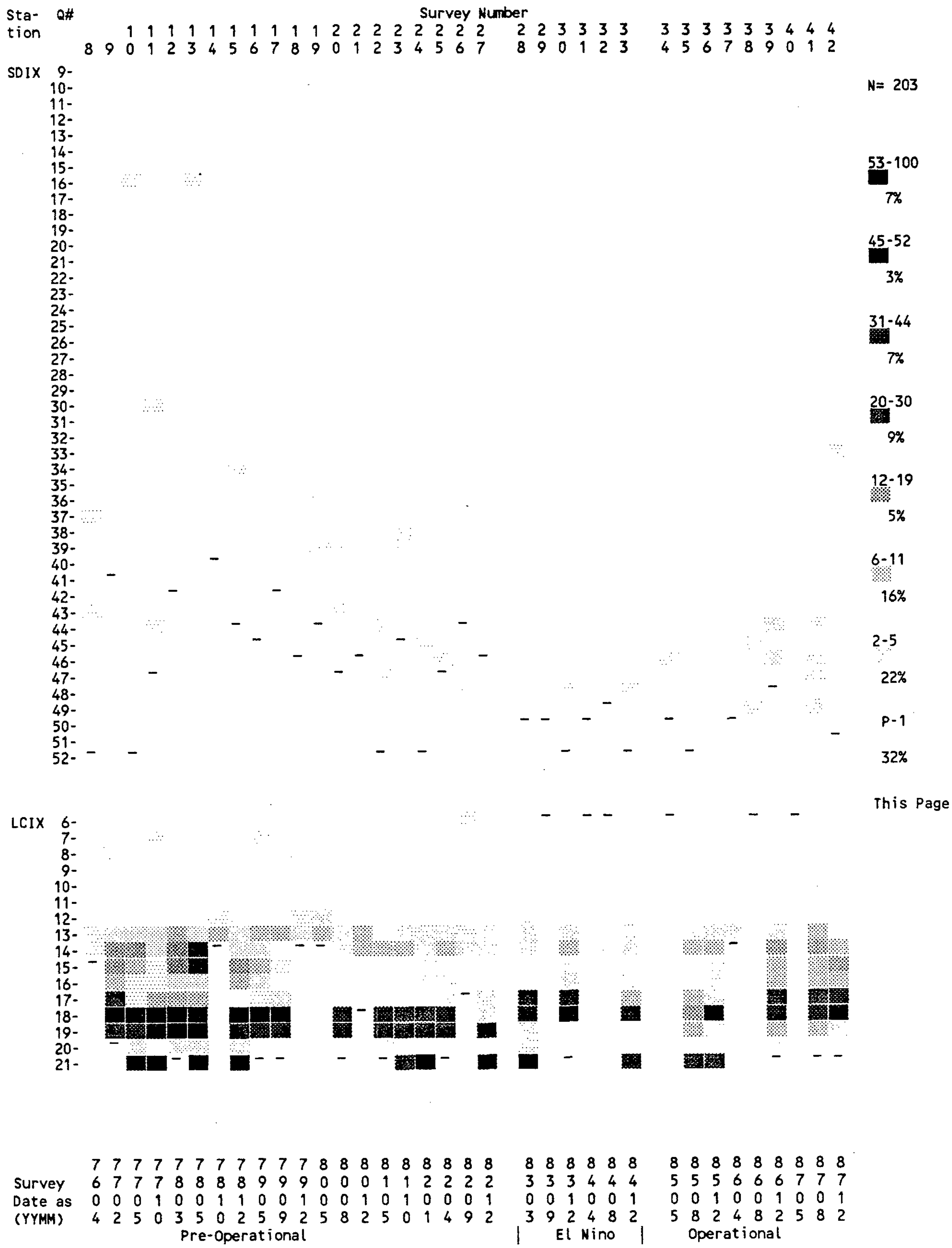
Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Taxon or Category: Strongylocentrotus purpuratus [Mixed P/#]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for STRPUR CSV 5234 3-29-88 8:13a 04-15-1989 06:36

```
Audit: CLUMRG2P: V.1.2: for SSTRPURB CLU     5328   4-23-89   7:59a:   04-27-1989/17:14
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-23-1989/07:53:45 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
      METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = GOWER GEN SIMIL: >> BINARY << Data Used
```

Station: CDIX: Strongylocentrotus purpuratus [Mixed P/#]: TOTAL Quads with Data = 27

```
        Quad Range USED 25 to 39 for Total of 15 : Range WITH data 25 to 41: : # Dropped 1 :  3.7%
        Surveys 16 : Dropped 0 Surveys if quads sampled < 39
        COPHENETIC CORRELATION COEFFICIENT = 0.769879:                  Maximum Distance = 12

S27-8212 ----------------------------------------------------------------I
S33-8412 ----------------------------------------------------------------I
S35-8508 ----------------------------------------------------------------I
S37-8604 ----------------------------------------------------------------I---------I
S38-8608 ----------------------------------------------------------------I         II
S39-8612 ----------------------------------------------------------------I         II
S28-8303 --------------------------------------------------------------------------II--I
S29-8309 ----------------------------------------------------------------I          I  I
S31-8404 ----------------------------------------------------------------I          I  I
S32-8408 ----------------------------------------------------------------I----------I  I----------------------------I
S34-8505 ----------------------------------------------------------------I             I                            I
S36-8512 ----------------------------------------------------------------I             I                            I------
S30-8312 ------------------------------------------------------------------------------I                            I
S40-8705 --------------------------------------------------------------------------------------------I---I          I
S41-8708 --------------------------------------------------------------------------------------------I   I----------I
S42-8712 ------------------------------------------------------------------------------------------------I
```

Station: NDIX: Strongylocentrotus purpuratus [Mixed P/#]: TOTAL Quads with Data = 24

```
        Quad Range USED 16 to 27 for Total of 12 : Range WITH data 9 to 33: : # Dropped 14 :  58.3%
        Surveys 29 : Dropped 6 Surveys if quads sampled < 27
        COPHENETIC CORRELATION COEFFICIENT = 0.668048:                  Maximum Distance = 8

S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604 -------------------------------------------------------------------------------------------I
S10-7705 -------------------------------------------------------------------------------------------I
S11-7710 -------------------------------------------------------------------------------------------I
S13-7805 -------------------------------------------------------------------------------------------I
S14-7810 -------------------------------------------------------------------------------------------I
S15-7812 -------------------------------------------------------------------------------------------I
S16-7905 -------------------------------------------------------------------------------------------I
S18-7912 -------------------------------------------------------------------------------------------I
S20-8008 -------------------------------------------------------------------------------------------I
S21-8012 -------------------------------------------------------------------------------------------I------------I
S22-8105 -------------------------------------------------------------------------------------------I            I
S27-8212 -------------------------------------------------------------------------------------------I            I
S29-8309 -------------------------------------------------------------------------------------------I            I
S30-8312 -------------------------------------------------------------------------------------------I            I
S32-8408 -------------------------------------------------------------------------------------------I            II
S33-8412 -------------------------------------------------------------------------------------------I            II
S35-8508 -------------------------------------------------------------------------------------------I            II
S36-8512 -------------------------------------------------------------------------------------------I            III
S38-8608 -------------------------------------------------------------------------------------------I            III
S 9-7702 --------------------------------------------------------------------------------------------------------IIII
S24-8201 ---------------------------------------------------------------------------------------------------------III
S25-8204 ----------------------------------------------------------------------------------------------------------II
S28-8303 -------------------------------------------------------------------------------------------I--------------II------
S39-8612 -------------------------------------------------------------------------------------------I               I
S34-8505 -------------------------------------------------------------------------------------------I               I
S37-8604 -------------------------------------------------------------------------------------------I               I
S40-8705 -------------------------------------------------------------------------------------------I---------------I
S41-8708 -------------------------------------------------------------------------------------------I
S42-8712 -------------------------------------------------------------------------------------------I
```

Station: SDIX: Strongylocentrotus purpuratus [Mixed P/#]: TOTAL Quads with Data = 31

Quad Range USED 30 to 46 for Total of 17 : Range WITH data 16 to 49: : # Dropped 13 : 41.9%
Surveys 23 : Dropped 12 Surveys if quads sampled < 46
COPHENETIC CORRELATION COEFFICIENT = 0.718342: Maximum Distance = 11

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S16-7905:
S17-7909:
S18-7912:
S19-8005:
S21-8012:
S23-8110:
S26-8209:
S27-8212:  <-End  Dropped Surveys
S 8-7604  -----------------------------------------------------------------------------------------I
S10-7705  ----------------------------------------------------------------I                        I
S13-7805  ----------------------------------------------------------------I                        I
S28-8303  ----------------------------------------------------------------I                        I
S29-8309  ----------------------------------------------------------------I                        I
S30-8312  ----------------------------------------------------------------I                        I
S31-8404  ----------------------------------------------------------------I---------I              I
S32-8408  ----------------------------------------------------------------I         I              I
S33-8412  ----------------------------------------------------------------I         I              I
S35-8508  ----------------------------------------------------------------I         I              I--------I
S36-8512  ----------------------------------------------------------------I         I----I         I        I
S37-8604  ----------------------------------------------------------------I         I    I         I        I
S40-8705  ----------------------------------------------------------------I         I    I         I        I
S22-8105  --------------------------------------------------------------------------I    I--I      I        I
S42-8712  --------------------------------------------------------------------------I    I  I      I        I
S25-8204  ----------------------------------------------------------------I---------I    I  I      I        I------
S34-8505  ----------------------------------------------------------------I         I----I  I--I   I        I
S39-8612  ----------------------------------------------------------------I---------I       I  I   I        I
S41-8708  ----------------------------------------------------------------I                 I  I---I        I
S24-8201  --------------------------------------------------------------------------I-------I  I            I
S38-8608  --------------------------------------------------------------------------I          I            I
S11-7710  -------------------------------------------------------------------------------------I            I
S20-8008  --------------------------------------------------------------------------------------------------I
```

Station: LCIX: Strongylocentrotus purpuratus [Mixed P/#]: TOTAL Quads with Data = 176

Quad Range USED 13 to 19 for Total of 7 : Range WITH data 6 to 22: : # Dropped 50 : 28.4%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.769978: Maximum Distance = 4

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End  Dropped Surveys
S 9-7702  ---------------------------I
S10-7705  ---------------------------I
S11-7710  ---------------------------I
S12-7803  ---------------------------I
S13-7805  ---------------------------I----------------------------I
S16-7905  ---------------------------I                            I
S36-8512  ---------------------------I                            I----I
S39-8612  ---------------------------I                            I    I
S41-8708  ---------------------------I                            I    I---I
S15-7812  ---------------------------I----------------------------I    I   I
S24-8201  ---------------------------I                                 I   II
S25-8204  ---------------------------I---------------------------------I   II
S33-8412  ---------------------------I                                     II----------------------------I
S30-8312  -----------------------------------------------------------------II                            I--I
S42-8712  ------------------------------------------------------------------I                            I  I
S17-7909  -----------------------------------------------------------------------------------------------I  I
S20-8008  ---------------------------I                                                                      I------
S27-8212  ---------------------------I----------------------------I                                         I
S28-8303  ---------------------------I                            I----------------------I                  I
S35-8508  ---------------------------I                            I                      I------------------I
S23-8110  --------------------------------------------------------I                      I
S22-8105  -------------------------------------------------------------------------------I
```

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Space Available for Colonization ("GATGORE" and Bare Rock) **Substrate**
"GATORE" is an acronym for "green algae growing on rock everywhere".

Description: Surface area within quadrat that is judged to be available for colonization by plants or animals. Does NOT include bare mineral surfaces covered by sand or gravel.

Distribution: Probably almost world-wide. "GATGORE" is a probable warm-tolerant group.

Diablo Area Specific Information: Abundant, occurring in almost all our quadrats, with covers to 100+%.

Habitat: Almost all tidal levels.

Observational Errors: As for sand and gravel. We did not start recording bare rock until Survey 9. Observations were somewhat erratic thereafter until Survey 12 (May 1978).

Field Identification Problems:

General: As for sand and gravel.

Station Specific: none.

General Comments:. Upper parts of SDIX (Quadrats 1 to 15) and NDIX (Quadrats 1 to 2) are excluded from comment as these quadrats are either mostly bare rock or have variable amounts of sand and gravel covering them. Upper intertidal areas at CDIX can have relatively large areas covered by a complex of diatoms, *Bangia*, *Porphyra*, etc., that probably should be (but are not) included in this category. Areas in the upper and upper-mid intertidal here are also subject to high erosive action (cobble-gravel scouring) and are probably not available for colonization, but because of data processing convenience they are included within this category.

Impacts to Taxon:

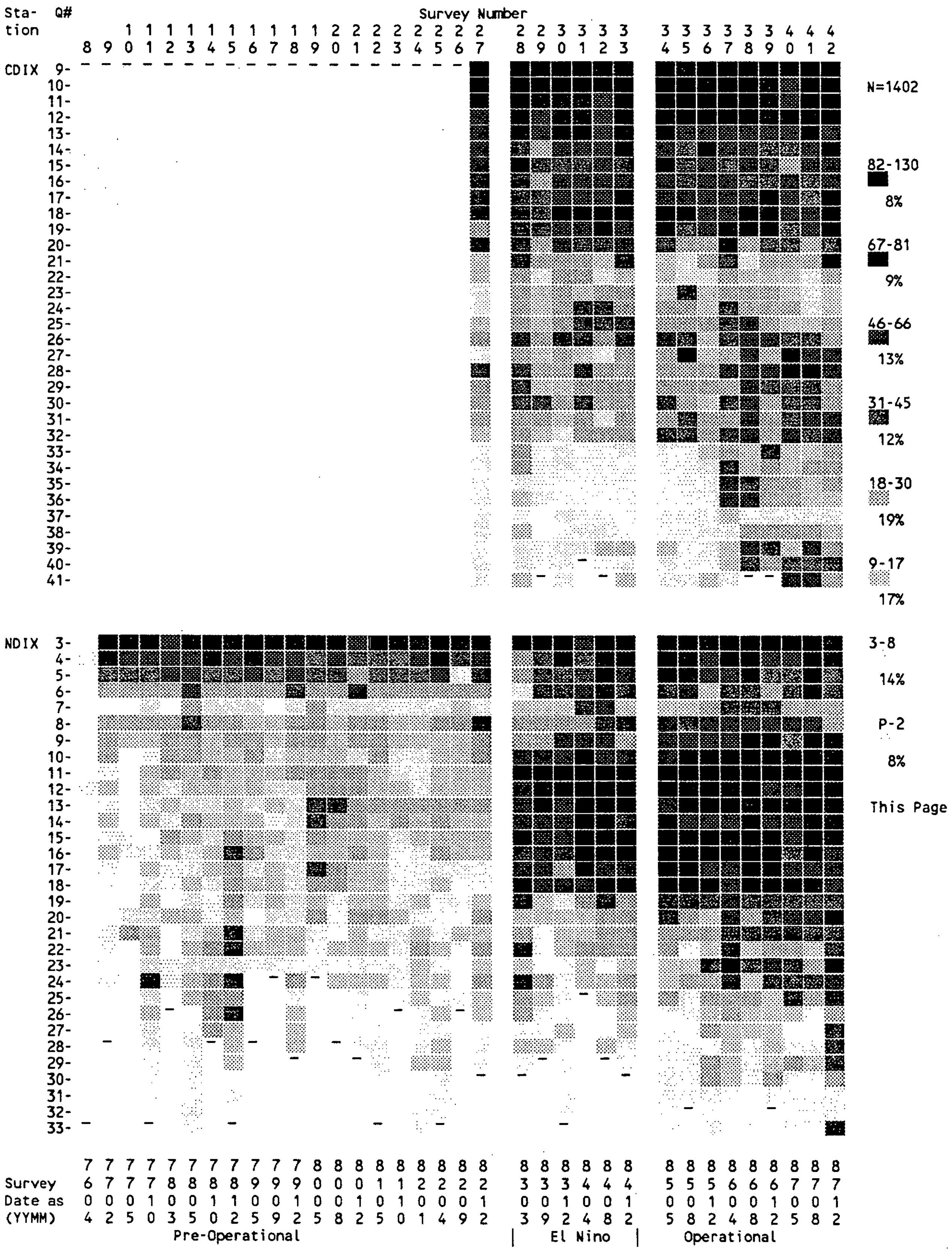
El Niño: 1982-83 winter storm: SDIX with large increase at mid to low tidal levels (i.e., introduced rubble and biota removal). NDIX with increase at mid to upper low tidal levels (introduced boulders and biota removal). CDIX possibly with increase at lower tidal levels (here, mainly due to reduced algal covers). LCIX within normal limits of variation.

El Niño: 1983-1984: SDIX slowly decreasing at lower tidal levels, but still with available space greater than normal throughout mid to low tidal levels (cobble introduced by El Niño storms remaining). NDIX at lower tide levels slowly returning approximately to normal at end of period but with mid to mid-lower levels remaining much greater than normal (introduced boulders in this area were not colonized). CDIX probably returning to normal at lower levels, but possibly somewhat greater than normal at middle tidal levels (Only 1 pre-El Niño survey to compare). LCIX within normal limits (can be somewhat masked here by sporadic moderately dense covers of *Phragmatopoma*/*Sabellaria*).

Diablo DCPP Operation: SDIX possibly returning to within normal limits at mid-intertidal and lowest quadrats. Otherwise, cobble remained greater throughout mid-upper-low intertidal. NDIX at mid to mid-lower remaining higher than normal and the lower levels increasing in cover and by end of period probably above normal. CDIX at mid to lower levels probably normal until April 1986, when lower intertidal experienced a large increase in cover which did not decrease by end of period. LCIX at mid levels slowly increasing in covers to above normal, otherwise normal.

Taxa or Category: Substrate Available for Colonization: (Bare Rock + GATGORE)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

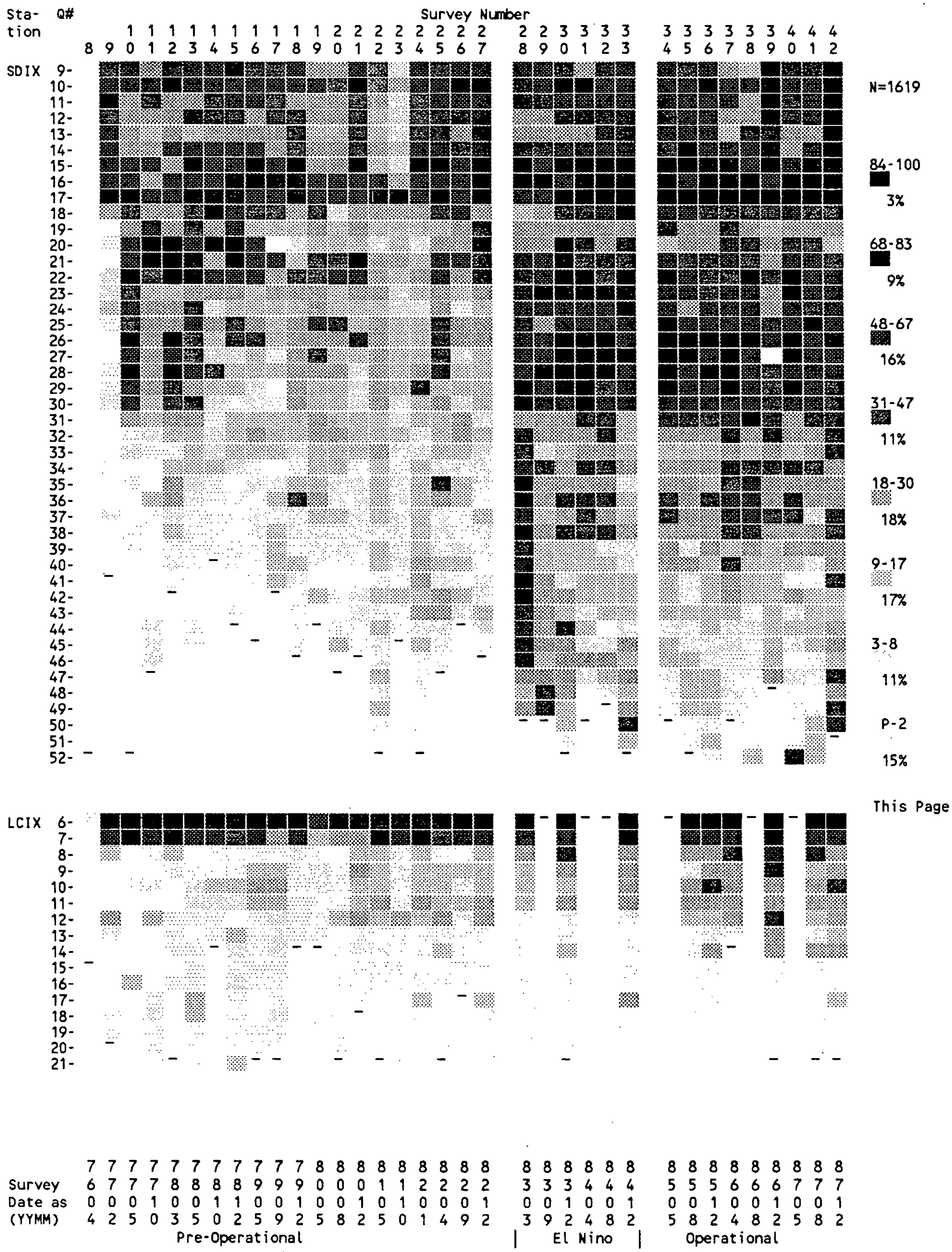


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CAVAIL CSV 3584 4-21-88 10:39a 04-14-1989 09:06

Taxa or Category: Substrate Available for Colonization: (Bare Rock + GATGORE)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CAVAIL CSV 3584 4-21-88 10:39a 04-14-1989 09:06

Audit: CLUMRG2P: V.1.2: for SCAVAIL CLU   6163   4-22-89 10:50a: 04-27-1989/17:35
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:48:19 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Substrate Available for Colonization: (Bare Rock + GATGORE):   TOTAL Quads with Data = 648

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 154 :   23.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.373810:   Maximum Distance = 3741

```
S27-8212  -------------------------------------------I-------------------I
S29-8309  -------------------------------------------I                   I---I
S36-8512  ---------------------------------------------------------------I   I---------I
S28-8303  -------------------------------------------------------------------I         I
S30-8312  -----------------------------------------------I--------I                    I-----------------------I
S31-8404  -----------------------------------------------I        I----------I         I                       I
S32-8408  --------------------------------------------------------I          I----I    I                       I
S33-8412  -------------------------------------------------------------------I    I----I                       I------
S34-8505  ------------------------------------------------------------------------I                            I
S35-8508  --------------------------------------------------------------------------------------------I-------II
S40-8705  --------------------------------------------------------------------------------------------I       II
S37-8604  ------------------------------------------------------------------------------------I----I          I
S39-8612  --------------------------------------------------------------------------------I---I    I----------I
S42-8712  --------------------------------------------------------------------------------I        I
S38-8608  ----------------------------------------------------------------------------I------------I
S41-8708  ----------------------------------------------------------------------------I
```

Station: NDIX: Substrate Available for Colonization: (Bare Rock + GATGORE):   TOTAL Quads with Data = 952

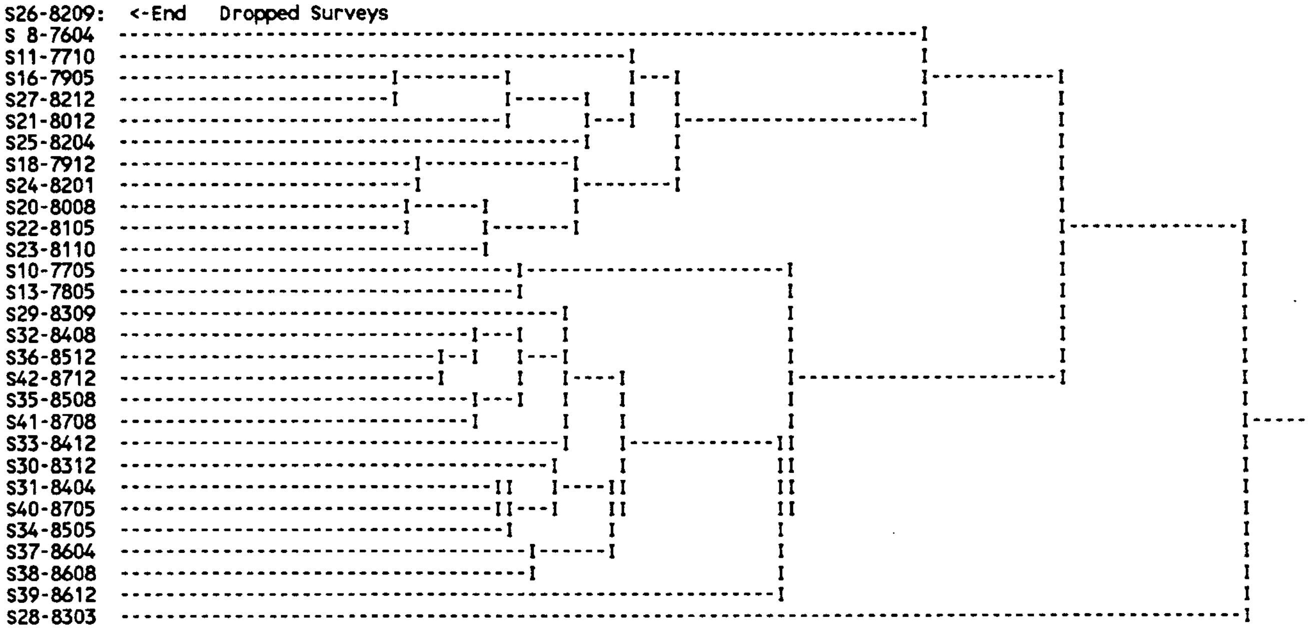
Quad Range USED 4 to 27 for Total of 24 : Range WITH data 1 to 33: : # Dropped 329 :   34.6%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.807017:   Maximum Distance = 5329

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  ---------------------------------------------I
S 9-7702  ----------------I------I                     I
S10-7705  ----------------I      I                     I
S11-7710  ----------------I--I   I                     I
S24-8201  ----------------I  I-I I---I                 I
S14-7810  -------------------I III   I                 I-----------------------------------------------------I
S16-7905  --------------I------III   I                 I                                                     I
S25-8204  --------------I       II   I                 I                                                     I
S13-7805  ----------------I----II    I---------I       I                                                     I
S18-7912  ----------------I    II    I         I       I                                                     I
S22-8105  ---------------I-----I     I         I       I                                                     I
S27-8212  ---------------I           I         I-------I                                                     I
S20-8008  ------------------I--------I         I                                                             I------
S21-8012  ------------------I                  I                                                             I
S15-7812  -------------------------------------I                                                             I
S28-8303  ----------------------------------------------I-----------I                                        I
S29-8309  ---------------------------I------------------I           I                                        I
S30-8312  ---------------------------I                              I                                        I
S32-8408  ------------------------------------I----I                I                                        I
S33-8412  -------------------------------I----I    I                I----------------------------------------I
S35-8508  -------------------------------I         I-I              I
S36-8512  ---------------------------I-------I     I I              I
S39-8612  ---------------------------I       I-----I I----------I   I
S40-8705  -----------------------------------I       I          I   I
S34-8505  --------------------------------------I----I          I---I
S38-8608  --------------------------------I-----I               I
S41-8708  --------------------------------I                     I
S37-8604  ----------------------------------------I-------------I
S42-8712  ----------------------------------------I
```

Station: SDIX: Substrate Available for Colonization: (Bare Rock + GATGORE): TOTAL Quads with Data = 1528

Quad Range USED 15 to 44 for Total of 30 : Range WITH data 1 to 52: : # Dropped 842 : 55.1%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.638556: Maximum Distance = 6341

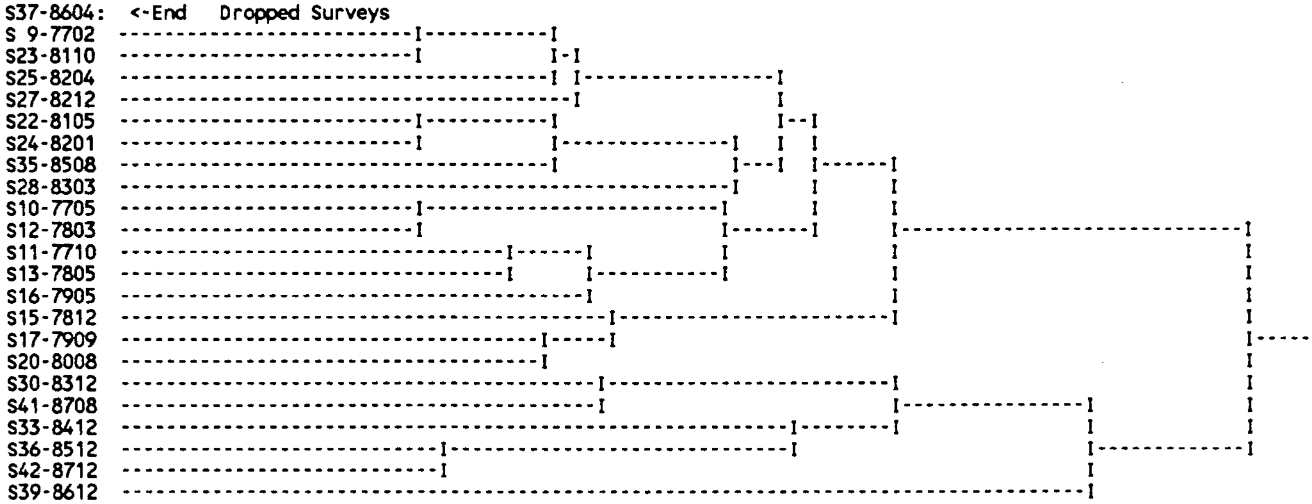
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209: <-End Dropped Surveys



Station: LCIX: Substrate Available for Colonization: (Bare Rock + GATGORE): TOTAL Quads with Data = 488

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 1 to 24: : # Dropped 248 : 50.8%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.572028: Maximum Distance = 893

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End Dropped Surveys



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Unavailable Space for Flora (Sand/Gravel/Animal Cover) **Substrate**

Description: Quadrat surface that is judged to be unavailable for colonization by plants.

Distribution: Almost world-wide in photic zone. Animal cover may or may not be comprised of warm-tolerant species.

Diablo Area Specific Information: Abundant, occurring in >95% of our quadrats with covers to 100%.

Habitat: Almost all tidal levels.

Observational Errors: As for sand and gravel.

Field Identification Problems:

General: As for sand and gravel.

Station Specific: none.

General Comments:. Most common at Cove stations SDIX and NDIX. Moderately common at CDIX and LCIX. Upper parts of SDIX (Quadrats 1 to 15) and NDIX (Quadrats 1 to 7) are excluded from comment as these quadrats are either mostly bare rock or have variable amounts of sand and gravel covering them.

Impacts to Taxon:

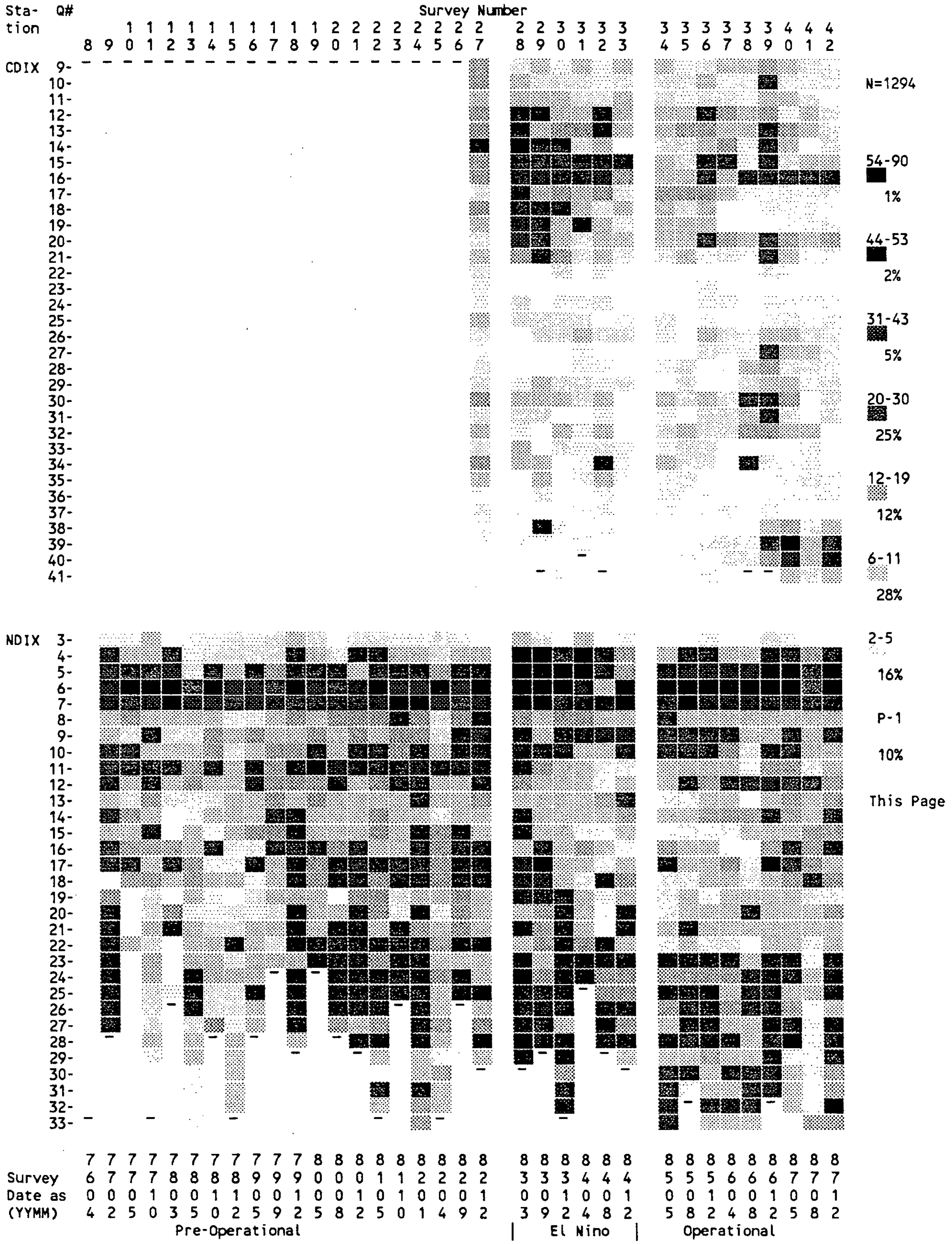
El Niño: 1982-83 winter storm: At SDIX with increase at mid tidal level (i.e., introduced rubble). NDIX with increase at lower tidal levels. CDIX possibly with increase at mid to upper-mid levels. LCIX within normal limits of variation.

El Niño: 1983-1984: SDIX with rapid change to perhaps lower than normal at mid tidal levels. NDIX at low tide levels slowly returning to normal at end of period. CDIX as NDIX, but here at mid to upper-mid levels. LCIX within normal limits, but higher than for surveys immediately preceding.

Diablo DCPP Operation: SDIX returning to within normal limits throughout transect. NDIX within normal limits. CDIX probably within normal limits. LCIX normal.

Taxa or Category: Substrate NOT Available for Algal Colonization: (Sand+Gravel+Animal Cover)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

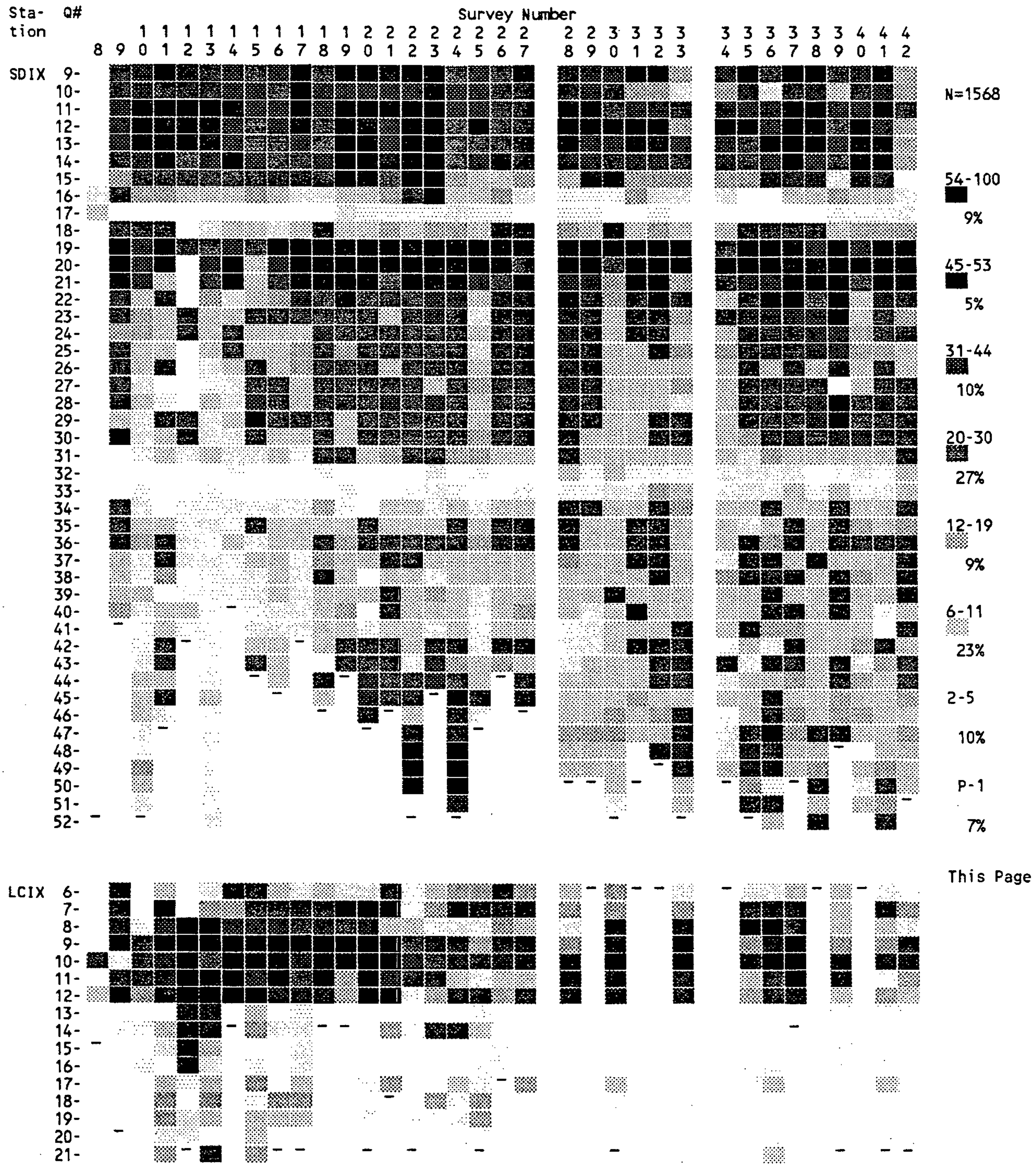


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CUNAVAIL CSV 4608 4-21-88 10:19a 04-14-1989 09:37

Taxa or Category: Substrate NOT Available for Algal Colonization: (Sand+Gravel+Animal Cover)

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey Date as (YYMM)																																		
	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712

Pre-Operational | El Nino | Operational

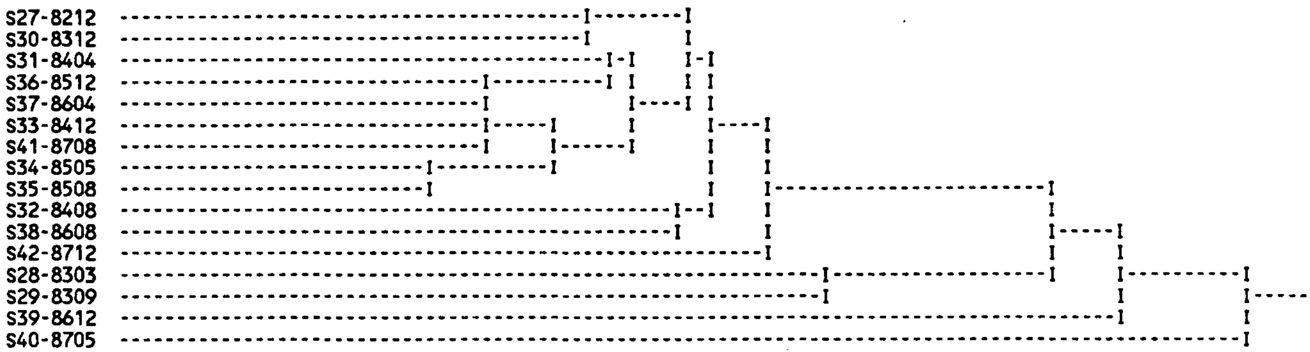
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CUNAVAIL CSV 4608 4-21-88 10:19a 04-14-1989 09:37

Audit: CLUMRG2P: V.1.2: for SCUNAVA CLU 6163 4-22-89 10:58a: 04-27-1989/17:35
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:55:28 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

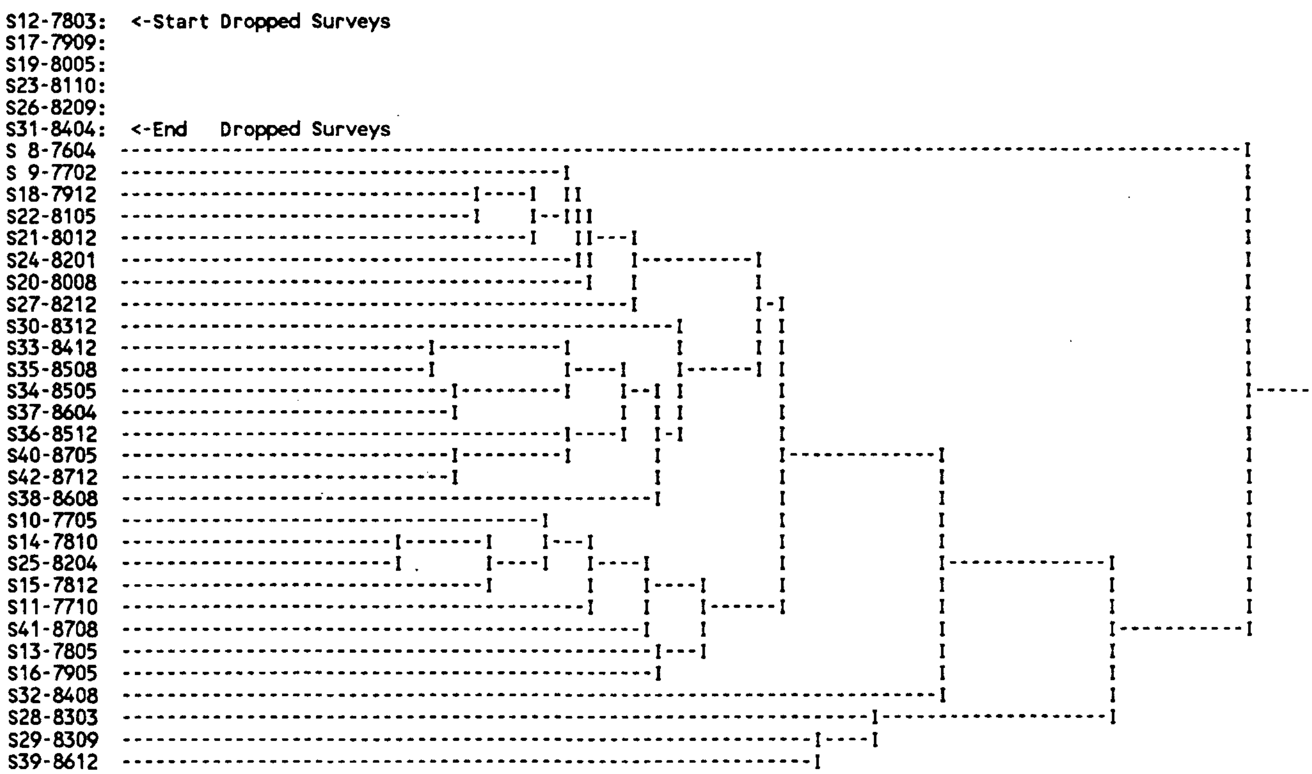
Station: CDIX: L: Substrate NOT Available for Algal Colonization: (Sand+Gravel+Animal Cover): TOTAL Quads with Quant. Data
Abrev. taxon name(s): UnAvail. Space (S,G,Animal)Z"

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 41 : 9.6%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.610585: Maximum Distance = 2477



Station: NDIX: L: Substrate NOT Available for Algal Colonization: (Sand+Gravel+Animal Cover): TOTAL Quads with Quant. Data
Abrev. taxon name(s): UnAvail. Space (S,G,Animal)Z"

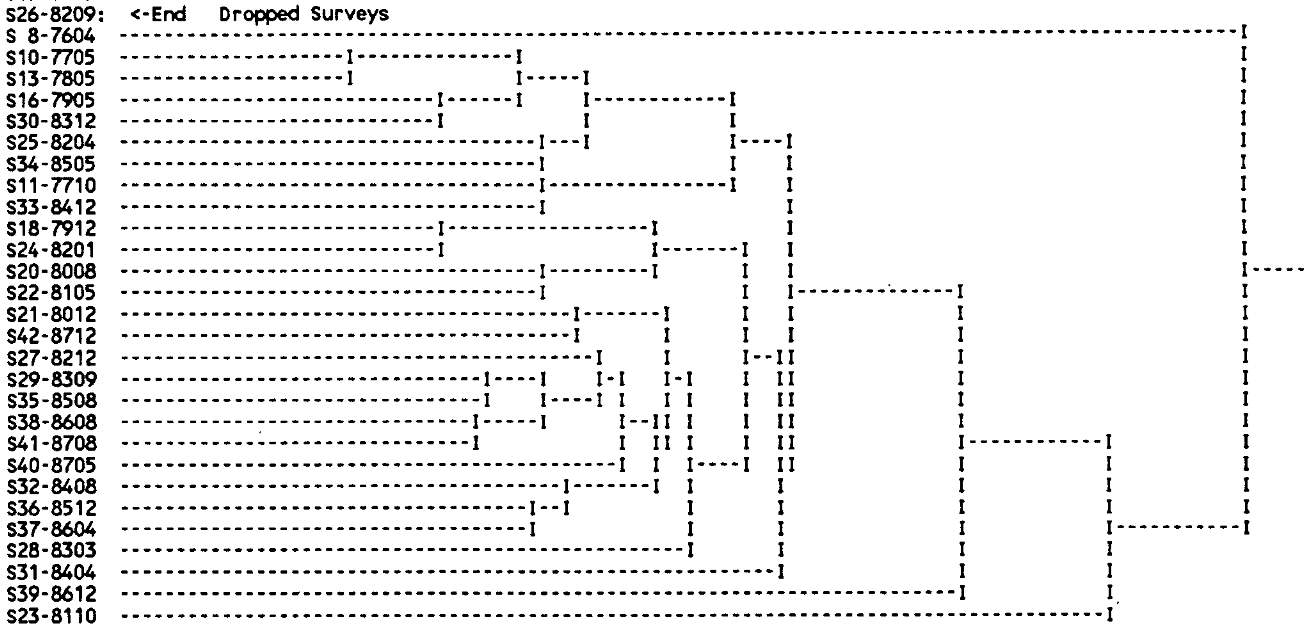
Quad Range USED 4 to 27 for Total of 24 : Range WITH data 2 to 33: : # Dropped 244 : 27.3%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.644132: Maximum Distance = 2587



Station: SDIX: L: Substrate NOT Available for Algal Colonization: (Sand+Gravel+Animal Cover): TOTAL Quads with Quant. Data
Abrev. taxon name(s): UnAvail. Space (S,G,Animal)Z

Quad Range USED 15 to 44 for Total of 30 : Range WITH data 1 to 53: : # Dropped 857 : 56.0%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.619578: Maximum Distance = 4132

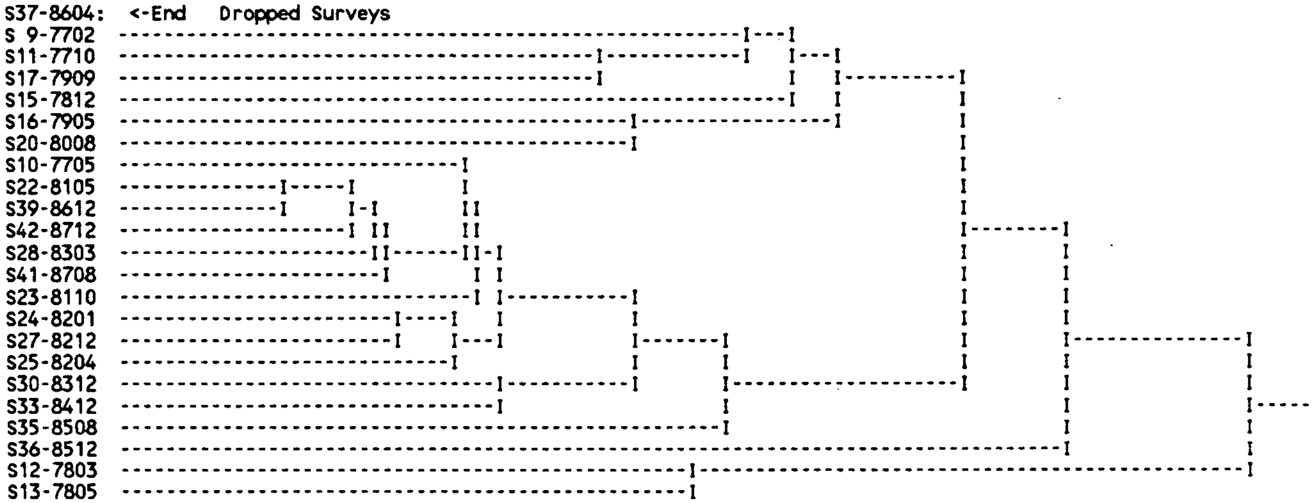
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209: <-End Dropped Surveys



Station: LCIX: L: Substrate NOT Available for Algal Colonization: (Sand+Gravel+Animal Cover): TOTAL Quads with Quant. Data
Abrev. taxon name(s): UnAvail. Space (S,G,Animal)Z"

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 1 to 24: : # Dropped 141 : 36.6%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.704261: Maximum Distance = 1433

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End Dropped Surveys



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Bare Rock **Substrate**

Description: Cobble, boulder, or bedrock that has no obvious biotic overlay. Never includes sand or gravel cover.

Distribution: Almost world-wide. Can be indirectly affected by temperature, i.e., loss of plant and animal cover can increase amount of bare rock.

Diablo Area Specific Information: Abundant, occurring in >95% of our quadrats with covers to 100%.

Habitat: All tidal levels.

Observational Errors: Small patches under dense algal mat or patches possibly under sand and gravel difficult to evaluate. Not identified until early 1977. Missed observations numerous until mid 1978.

Field Identification Problems:

General: Difficult to assess in areas that might have a thin or spotty covers of "unid. diatoms", "GATGORE", "*Calothrix*", or other thin crustose biota.

Station Specific: none.

General Comments:. Occurs to some extent in almost all quadrats, so number of occurrences are not evaluated.

Impacts to Taxon:

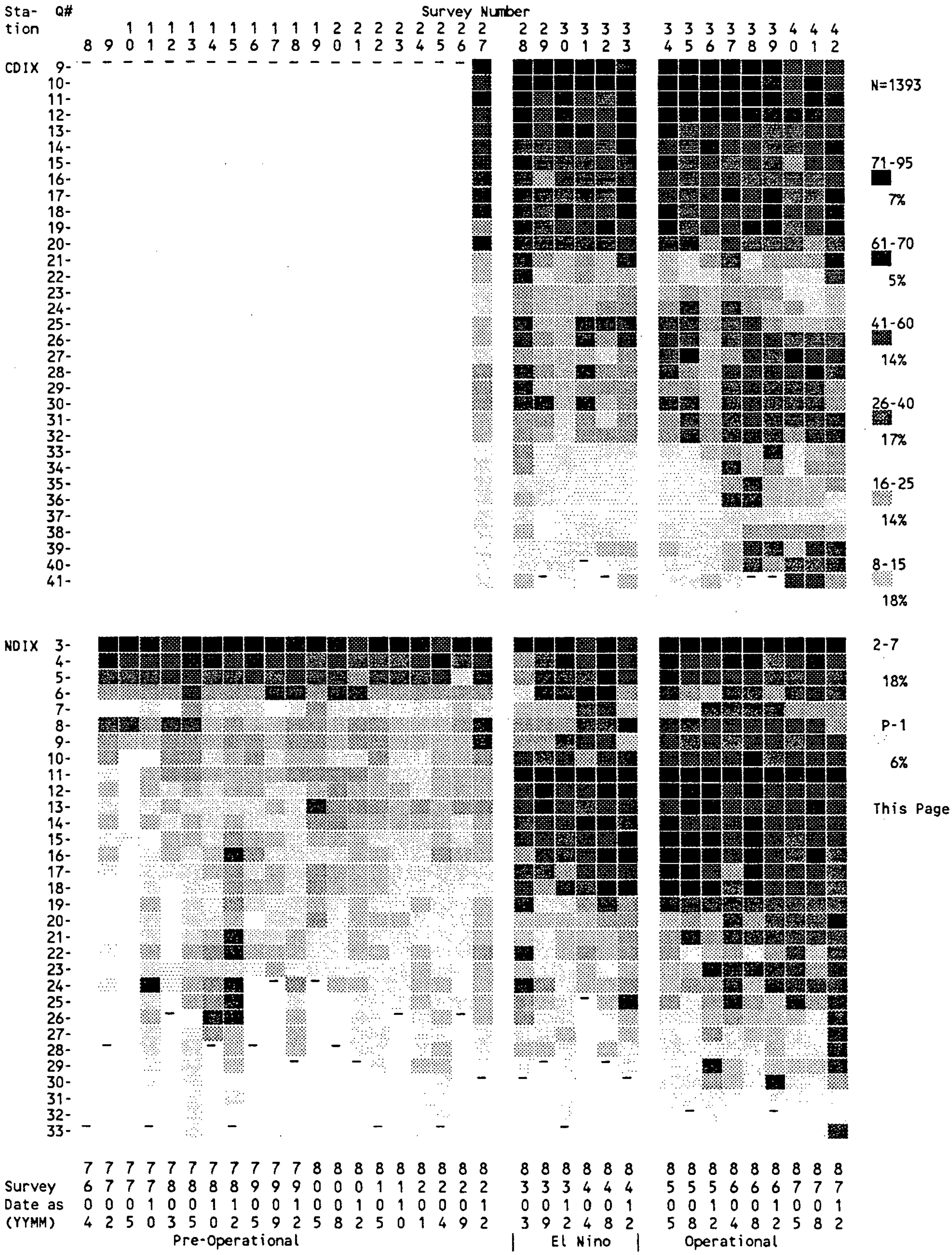
El Niño: 1982-83 winter storm: Large increase in cover at all Cove stations in the mid to lower tidal levels due to storm removal of biota and introduced rubble. (note that high covers at upper intertidal levels here was normal). LCIX remaining normal.

El Niño: 1983-1984: All Cove stations sporadically recovered biotic cover at lower tidal levels, but the mid tidal area still above normal for cover of bare rock. SDIX with higher than normal bare rock cover throughout lower intertidal (mainly due to uncolonized cobble overlay throughout most of the transect). LCIX with increasing amounts of bare rock in the upper-mid tidal zone.

Diablo DCPP Operation: All Cove stations as for El Niño at mid tidal levels. SDIX with decreasing covers of bare rock at lower tidal levels (almost to normal conditions), then increased covers at end of 1987. NDIX and CDIX with slow somewhat sporadic increases in cover of bare rock at lower tidal levels. LCIX with increasing covers of bare rock extending downward to the mid intertidal.

Taxon or Category: Bare Rock (% cover) [N.D. prior to Survey 9]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

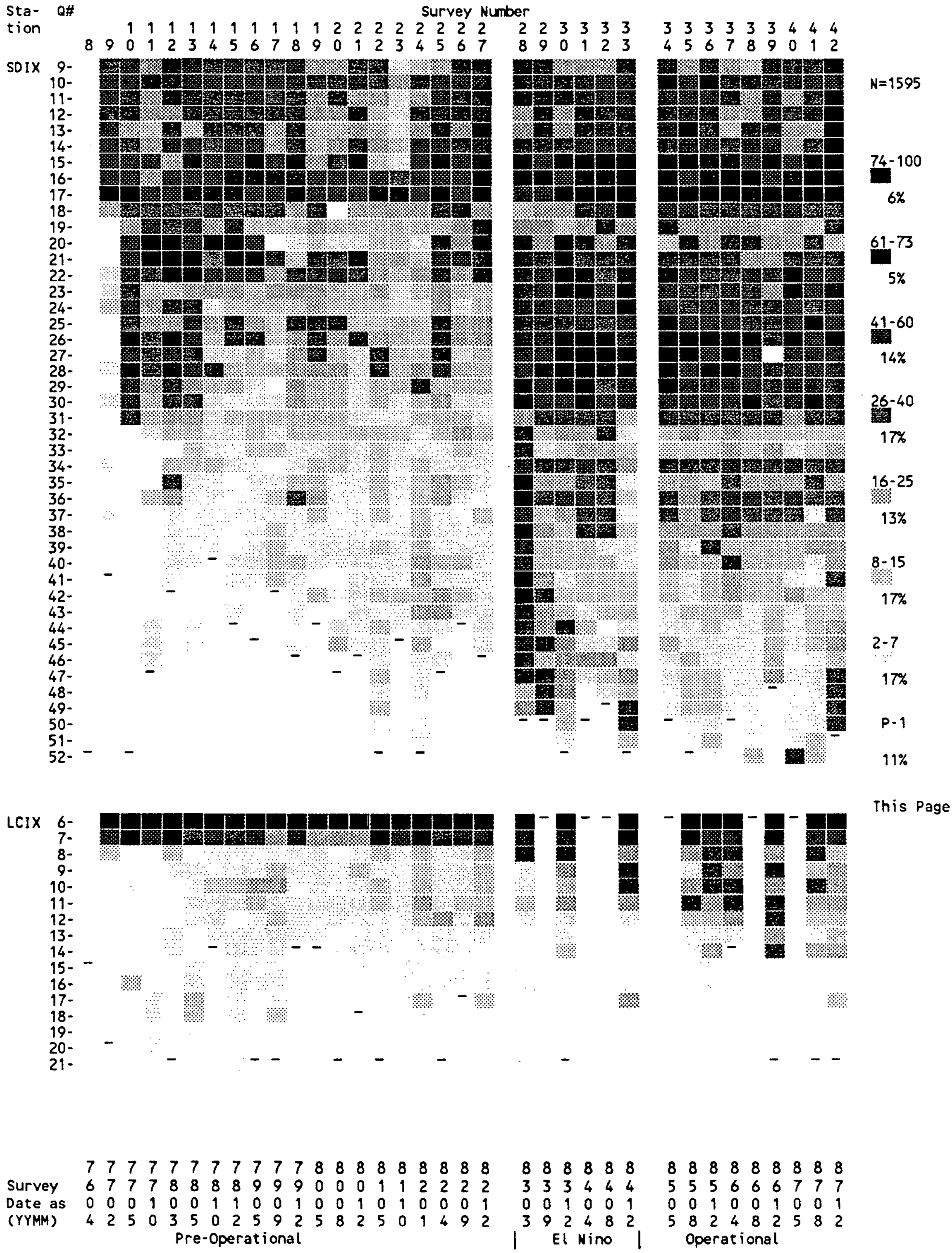


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for ROCK CSV 3467 3-29-88 8:34a 04-14-1989 10:55

Taxon or Category: Bare Rock (% cover) [N.D. prior to Survey 9]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

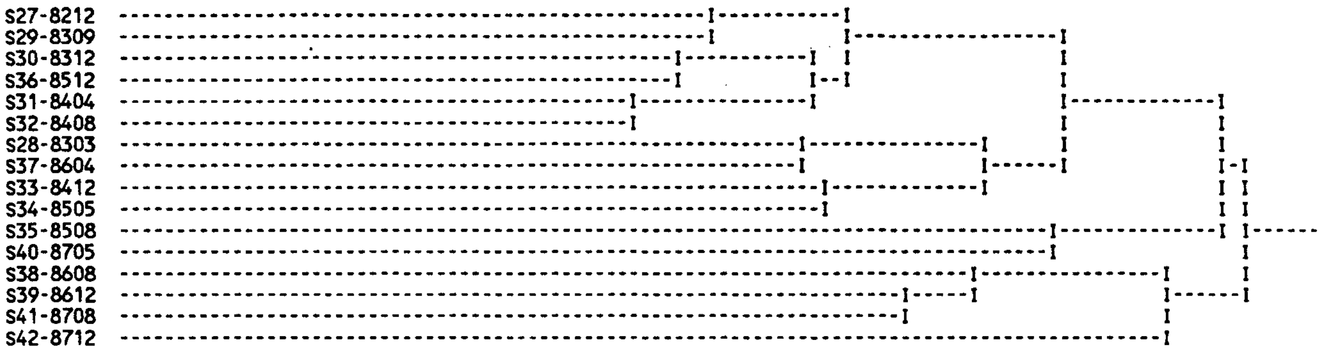


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: CLUMRG2P: V.1.2: for SROCK CLU 6163 4-22-89 11:01a: 04-27-1989/17:35
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:59:35 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Bare Rock (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 648

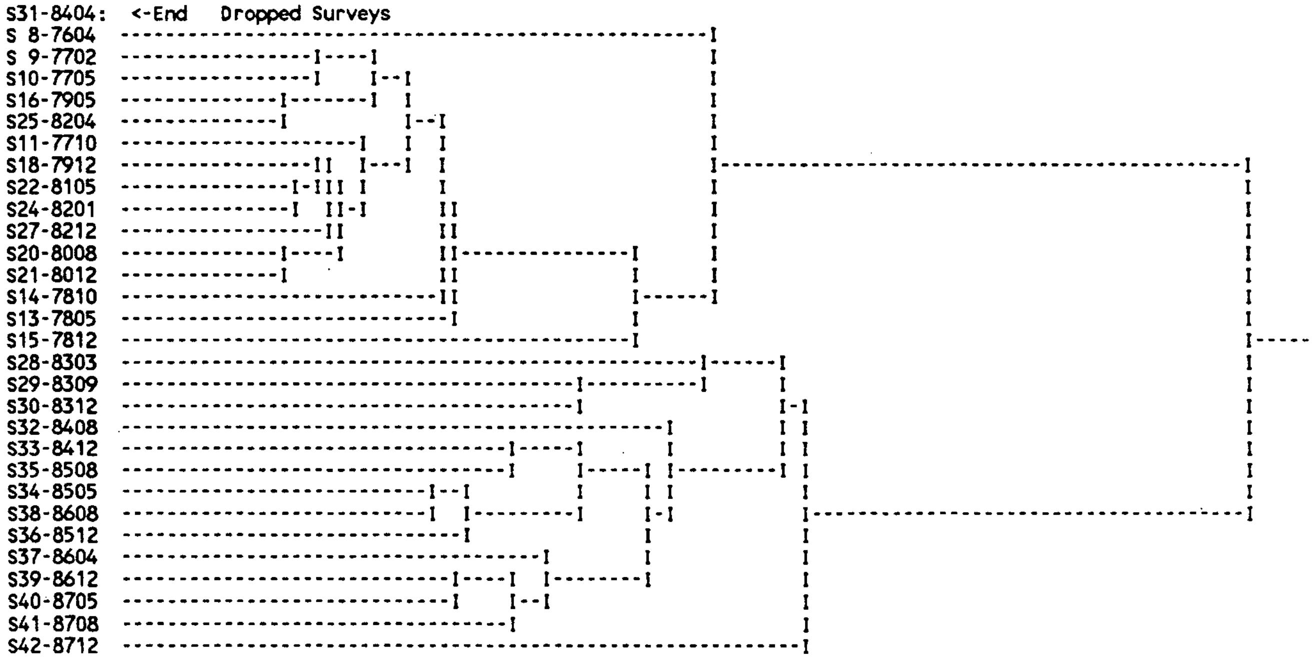
Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 154 : 23.8%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.374120: Maximum Distance = 3672



Station: NDIX: Bare Rock (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 941

Quad Range USED 4 to 27 for Total of 24 : Range WITH data 1 to 33: : # Dropped 325 : 34.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.805351: Maximum Distance = 4301

S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End Dropped Surveys



Station: SDIX: Bare Rock (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 1513

Quad Range USED 15 to 44 for Total of 30 : Range WITH data 1 to 52: : # Dropped 835 : 55.2%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.656373: Maximum Distance = 6343

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604 ---------------------------------------------------------------------------------------------------I
S10-7705 --------------------------------I------------------I                                               I
S13-7805 --------------------------------I                  I------I                                        I
S11-7710 ---------------------------------------------------I      I                                        I
S16-7905 --------------------I--------------I                      I                                        I
S27-8212 --------------------I              I---I                  I                                        I
S21-8012 -----------------------------------I   I----I             I--------------I                         I
S25-8204 ---------------------------------------I    I------I      I              I                         I
S18-7912 -----------------------------I-------I      I      I      I              I                         I
S24-8201 -----------------------------I       I------I      I      I              I                         I
S20-8008 ------------------------------I------I             I------I              I                         I------
S22-8105 ------------------------I-----I                    I                     I                         I
S23-8110 ------------------------I                          I                     I                         I
S39-8612 ---------------------------------------------------I                     I                         I
S29-8309 ------------------------------------I                                    I-----------------I       I
S32-8408 ----------------------------I-----I I--I                                 I                 I       I
S37-8604 ----------------------------I     I I  I                                 I                 I       I
S35-8508 --------------------------I----I  I-I  I                                 I                 I       I
S41-8708 --------------------------I    I  I    I-I                               I                 I       I
S36-8512 ------------------------I------I--I    I I                               I                 I       I
S42-8712 ------------------------I      I       I I                               I                 I-------I
S38-8608 -------------------------------I       I I----I                          I                 I
S33-8412 ------------------------------------I--I I    I                          I                 I
S40-8705 ------------------------------------I    I    I--------------------------I                 I
S31-8404 --------------------------------I--------I    I                                            I
S34-8505 --------------------------------I             I                                            I
S30-8312 ----------------------------------------------I                                            I
S28-8303 -------------------------------------------------------------------------------------------I
```

Station: LCIX: Bare Rock (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 476

Quad Range USED 6 to 19 for Total of 14 : Range WITH data 1 to 24: : # Dropped 245 : 51.5%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.555127: Maximum Distance = 773

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702 ---------------------I--------I
S11-7710 ---------------------I        I---------------I
S23-8110 ------------------------------I               I----I
S25-8204 ----------------------------------------------I    I-I
S13-7805 ---------------------------------------------I-----I I
S16-7905 ---------------------------------------------I       I-------------------I
S15-7812 ----------------------------------------II           I                   I
S17-7909 ----------------------------------------II-----------I                   I
S20-8008 -----------------------------------------I                               I--------------------------I
S10-7705 -------------------------------I---------------------------------------I I                          I
S12-7803 -------------------------------I                                       I I                          I
S22-8105 ----------------------------I---------I                                I-I                          I
S24-8201 ----------------------------I         I---------I                      I                            I
S27-8212 --------------------------------------I         I--------I             I                            I------
S35-8508 ------------------------------------------------I        I-------------I                            I
S28-8303 ----------------------------------------I----------------I                                          I
S30-8312 ----------------------------------------I                                                           I
S33-8412 -------------------------------------------------------------------------------I                    I
S36-8512 --------------------------------------------I-------------I                    I--------------------I
S42-8712 --------------------------------------------I             I-------------I      I
S39-8612 ----------------------------------------------------------I             I------I
S41-8708 ------------------------------------------------------------------------I
```

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Boulder Percent Cover (Rock 25.6 cm and up) **Substrate**

Description: Rocky material equivalent in volume to a sphere with diameter >25.6 cm (10 inches), to material evaluated as bedrock.

Distribution: Almost world-wide.

Diablo Area Specific Information: Abundant, occurring in >75% of our quadrats with covers to 100%.

Habitat: Almost all tidal levels.

Observational Errors: Borderline cases at lower (cobble) or upper (bedrock i.e., material that is immovable) limits are probably sometimes mis-identified. Not identified until early 1977. Missed observations or erroneous categorization numerous until mid 1978. In areas that may have boulders densely covered with algal mat, can be difficult to determine if underlying substrate is cobble, boulder, or bedrock.

Field Identification Problems:

General: Difficult to categorize correctly in areas that have continuum of cobble and boulder.

Station Specific: Very little boulder at LCIX, so correct categorization here was relatively easy.

General Comments:. Most common at Cove stations SDIX and NDIX. Moderately common at CDIX and moderately rare at LCIX. Upper intertidal at SDIX (Quadrats 2-15) and NDIX (Quadrats 3-7) can be sand/gravel covered masking presence of boulders, so these stations not evaluated for changes at upper levels.

Impacts to Taxon:

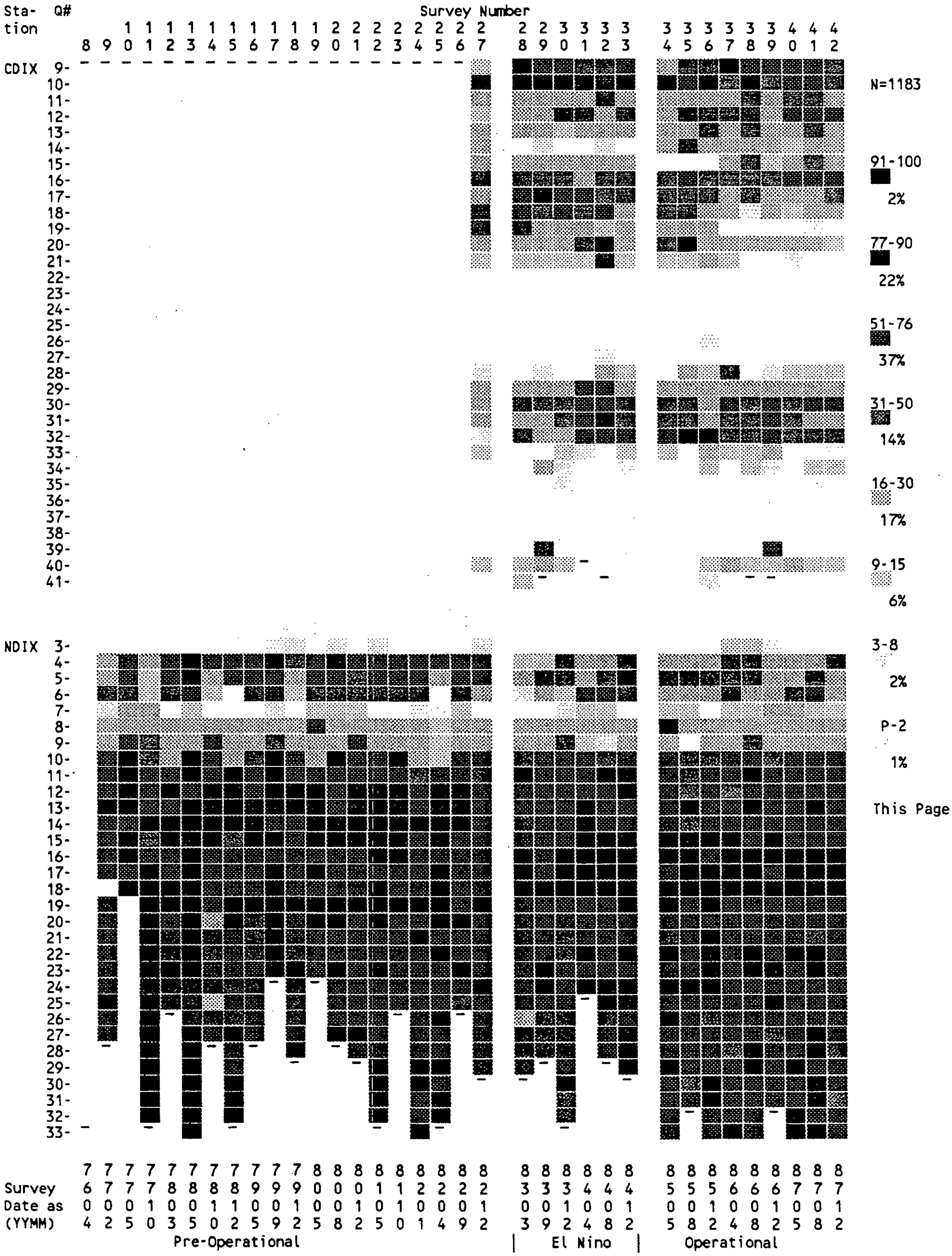
El Niño: 1982-83 winter storm: At SDIX with decrease in cover at lower-mid to low tidal levels (i.e., overlaid with cobble), with some increase at upper-mid tidal level. NDIX within normal limits but data not showing major boulder movement (i.e., large boulders shifted or introduced). LCIX and CDIX? within normal limits of variation.

El Niño: 1983-1984: SDIX at lower-mid to low tide levels with generally lower covers than normal. NDIX normal. CDIX with increase in boulders at upper quadrats. LCIX normal.

Diablo DCPP Operation: SDIX as for El Niño period (i.e., cobble overlay not removed except at extreme lower end of transect). NDIX normal. CDIX relatively stable. LCIX normal.

Taxon or Category: Boulders (% cover) [N.D. prior to Survey 9]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

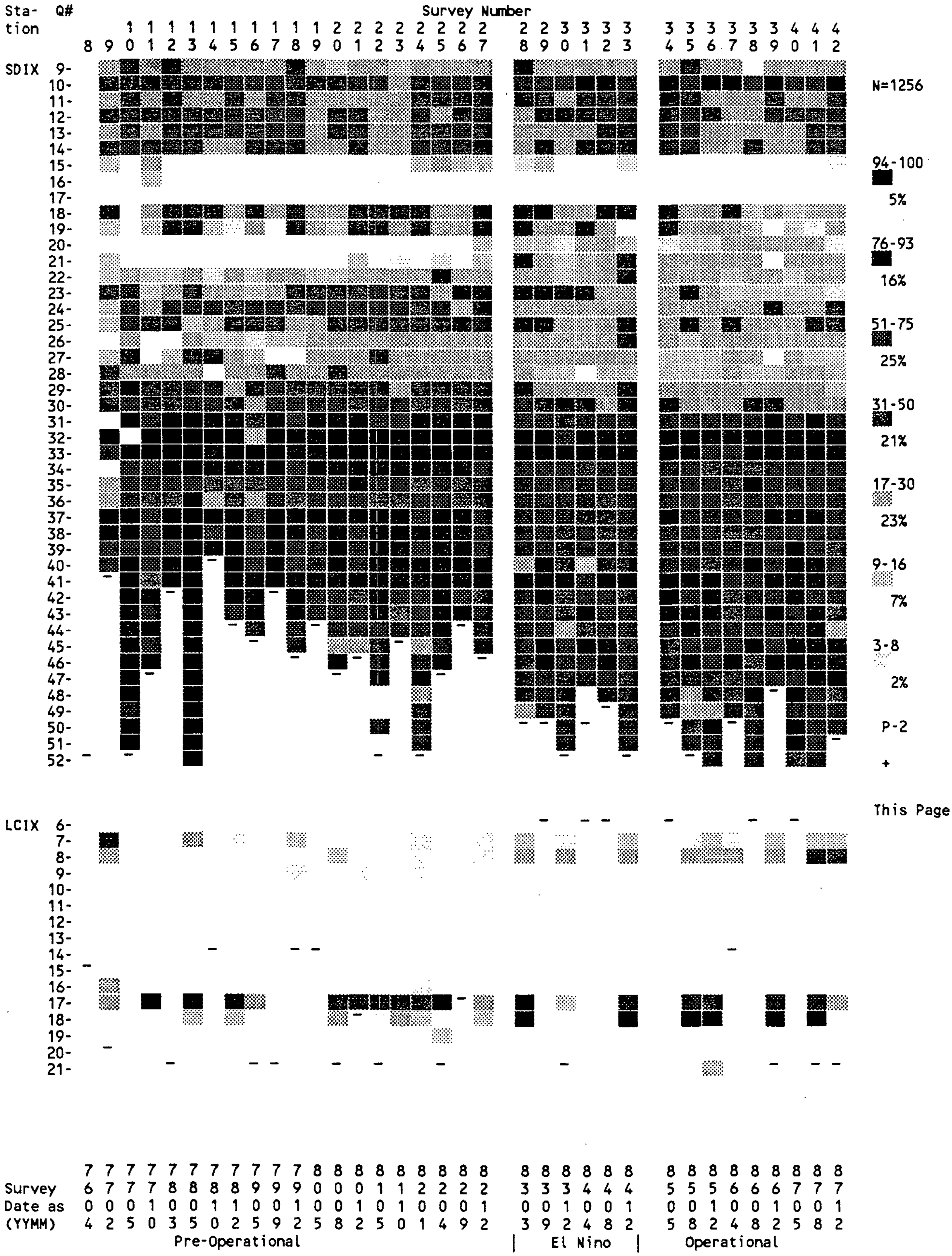


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for BOULDE CSV 2799 5-23-88 6:05a 04-14-1989 10:53

Taxon or Category: Boulders (% cover) [N.D. prior to Survey 9]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for BOULDE CSV 2799 5-23-88 6:05a 04-14-1989 10:53

Audit: CLUMRG2P: V.1.2: for SBOULDE CLU 6163 4-22-89 10:47a: 04-27-1989/17:34
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:41:30 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Boulders (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 388

Quad Range USED 1 to 39 for Total of 39 : Range WITH data 1 to 41: : # Dropped 13 : 3.4%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.456655: Maximum Distance = 5406

```
S27-8212  ---------------------------------------------------------------------------------------------------I
S28-8303  -----------------------------------------------I----I                                              I
S30-8312  -----------------------------------------------I    I----------------------------I                 I
S29-8309  ----------------------------------------------------I                            I-----I           I------
S31-8404  --------------------------------------------------------------I------------------I     I           I
S32-8408  --------------------------------------------------------------I                        I           I
S33-8412  --------------------------------------------------I-------I                            I           I
S34-8505  ------------------------------------I-------------I       I----------------I           I-----------I
S36-8512  ------------------------------------I                     I                I           I
S35-8508  ----------------------------------------------------------I                I-----I     I
S37-8604  -----------------------------------------------------I                     I     I     I
S38-8608  -------------------------------------------I         I---------------------I     I     I
S40-8705  --------------------------I------I         I---------I                           I-----I
S41-8708  --------------------------I      I---------I                                     I
S42-8712  ---------------------------------I                                               I
S39-8612  ---------------------------------------------------------------------------------I
```

Station: NDIX: Boulders (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 880

Quad Range USED 4 to 27 for Total of 24 : Range WITH data 2 to 33: : # Dropped 107 : 12.2%
Surveys 35 : Dropped 0 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.861382: Maximum Distance = 7525

```
S 8-7604  ---------------------------------------------------------------------------------------------------I
S 9-7702  -----------------------------------I                                                               I
S11-7710  ------------------------------I-I  I                                                               I
S15-7812  -------------------------I----I I  I                                                               I
S25-8204  -------------------------I      I  I                                                               I
S16-7905  ---------------------I-I        I  II                                                              I
S24-8201  ---------------------I I        I  II                                                              I
S20-8008  ---------------I-I     I---I    I  II                                                              I
S22-8105  ---------------I I-I   I   I    I  II                                                              I
S27-8212  -----------------I I---I   I    I  II                                                              I
S21-8012  -------------------I       I    I--II                                                              I
S18-7912  ---------------------I     I    I   I                                                              I
S30-8312  -----------------I   II    I    I   I                                                              I
S37-8604  -----------I---I I---II    I--I I   I                                                              I
S42-8712  -----------I   III    I    I  I I   I                                                              I------
S38-8608  --------------IIII    I    I  I I   II                                                             I
S40-8705  --------------I I     I-I  I  I I   II                                                             I
S39-8612  ----------------I     I I  I  I I   II                                                             I
S28-8303  -----------------I-I  I I  I  I I   II                                                             I
S29-8309  -----------------I I--I I--I  I-I   II                                                             I
S36-8512  -------------------I  I I     I     II                                                             I
S35-8508  ----------------------I I     I     II------I                                                      I
S32-8408  ------------------II    I     I     II      I                                                      I
S41-8708  ------------------II----I     I     II      I                                                      I
S33-8412  -------------------I          I     II      I                                                      I
S34-8505  ------------------------------I     II      I------------------------I                             I
S13-7805  ------------------------------------II      I                        I                             I
S14-7810  -------------------------------------I      I                        I                             I
S12-7803  --------------------I----------I            I                        I                             I
S23-8110  --------------I-----I          I---I        I                        I-----------------------------I
S26-8209  --------------I                I   I--------I                        I
S31-8404  -------------------------------I   I                                 I
S17-7909  --------------------------I--------I                                 I
S19-8005  --------------------------I                                          I
S10-7705  ---------------------------------------------------------------------I
```

Station: SDIX: Boulders (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 1373

Quad Range USED 15 to 44 for Total of 30 : Range WITH data 2 to 55: : # Dropped 747 : 54.4%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.849193: Maximum Distance = 8955

```
S 9-7702:  <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209:  <-End   Dropped Surveys
S 8-7604 ---------------------------------------------------------------------------------------------------I
S10-7705 --------------------------------------------------I                                                I
S11-7710 ----------------------------------I               I                                                I
S13-7805 ------------------------------I   I               I                                                I
S18-7912 ---------------------I--I     I--II               I                                                I------
S29-8309 ---------------------I  I     I  II               I                                                I
S20-8008 ---------------I--I     I-----I  II               I                                                I
S23-8110 ---------------I  I-I   I        II----I          I                                                I
S21-8012 ---------------I--I I   I        II    I          I                                                I
S24-8201 ------------I--I    I---I        II    I          I------------------------------------------------I
S27-8212 ------------I       I            II    I          I
S22-8105 -----------------I--I            II    I          I
S25-8204 -----------------I               II    I          I
S28-8303 --------------------I-I          I     I          I
S33-8412 --------------------I I--I       I     I          I
S31-8404 ---------------------II  I       I     I          I
S32-8408 ------------I-I      II  I       I     I          I
S36-8512 ------------I I---I  I   II      I     I----------I
S35-8508 --------------I   I--I   II      I     I
S34-8505 ------------------I      II      I     I
S30-8312 ---------------------I---II------I     I
S37-8604 ------------------I--I    I            I
S42-8712 ------------------I       I            I
S38-8608 -------------------I------I            I
S39-8612 ------------------II                   I
S40-8705 -----------------II                    I
S41-8708 -----------------I                     I
S16-7905 ---------------------------------------I
```

Station: LCIX: Boulders (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 100

Quad Range USED 3 to 19 for Total of 17 : Range WITH data 3 to 21: : # Dropped 11 : 11.0%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.724807: Maximum Distance = 1823

```
S 8-7604:  <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604:  <-End   Dropped Surveys
S 9-7702 --------------------------------------------------------------I
S10-7705 I                                                             I
S12-7803 I-----------------I                                           I
S17-7909 I                 I-----------------------I                   I--------I
S16-7905 ------------------I                       I--------I          I        I
S30-8312 ------------------I-----------------------I        I          I        I
S42-8712 ------------------I                                I----------I        I
S15-7812 -------------I--I                                  I                   I
S23-8110 -------------I  I-----------------------I          I                   I----------------------------I
S24-8201 ----------------I                       I----------I                   I                            I
S20-8008 ------------------------I-I             I                              I                            I
S22-8105 ------------------------I I-------------I                              I                            I
S27-8212 --------------------------I                                            I                            I
S11-7710 ---------------------I--------------------------I                      I                            I------
S25-8204 ---------------------I                          I----------------------I                            I
S13-7805 ------------------------------------------------I                                                   I
S28-8303 ------------------------I----I                                                                      I
S33-8412 ------------I-----------I    I------I                                                               I
S35-8508 ------------I                I      I----------------------I                                        I
S36-8512 -----------------------------I      I                      I----------------------------------------I
S41-8708 ------------------------------------I                      I
S39-8612 -----------------------------------------------------------I
```

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Cobble (Rock 6.5 to <25.6 cm) **Substrate**

Description: Rocky material with equivalent volume of sphere with diameter of 6.5 to <25.6 cm (2.5 to 10 inches).

Distribution: Almost world-wide.

Diablo Area Specific Information: Abundant, occurring in >70% of our quadrats with covers to 100%.

Habitat: Almost all tidal levels.

Observational Errors: Borderline cases at upper (boulder) or lower (gravel) limits are probably often mis-identified. Not identified until early 1977. Missed observations or erroneous categorization numerous until mid 1978. In areas with cobble densely covered with algal mat, can be difficult to determine how much of underlying substrate is cobble or boulder.

Field Identification Problems:

General: Difficult to correctly categorize in areas that have continuum of gravel, cobble, and boulder.

Station Specific: Very little gravel or boulder at LCIX, so correct categorization here was relatively easy.

General Comments:. Most common at Cove stations SDIX and NDIX. Moderately common at CDIX and rare at LCIX.

Impacts to Taxon:

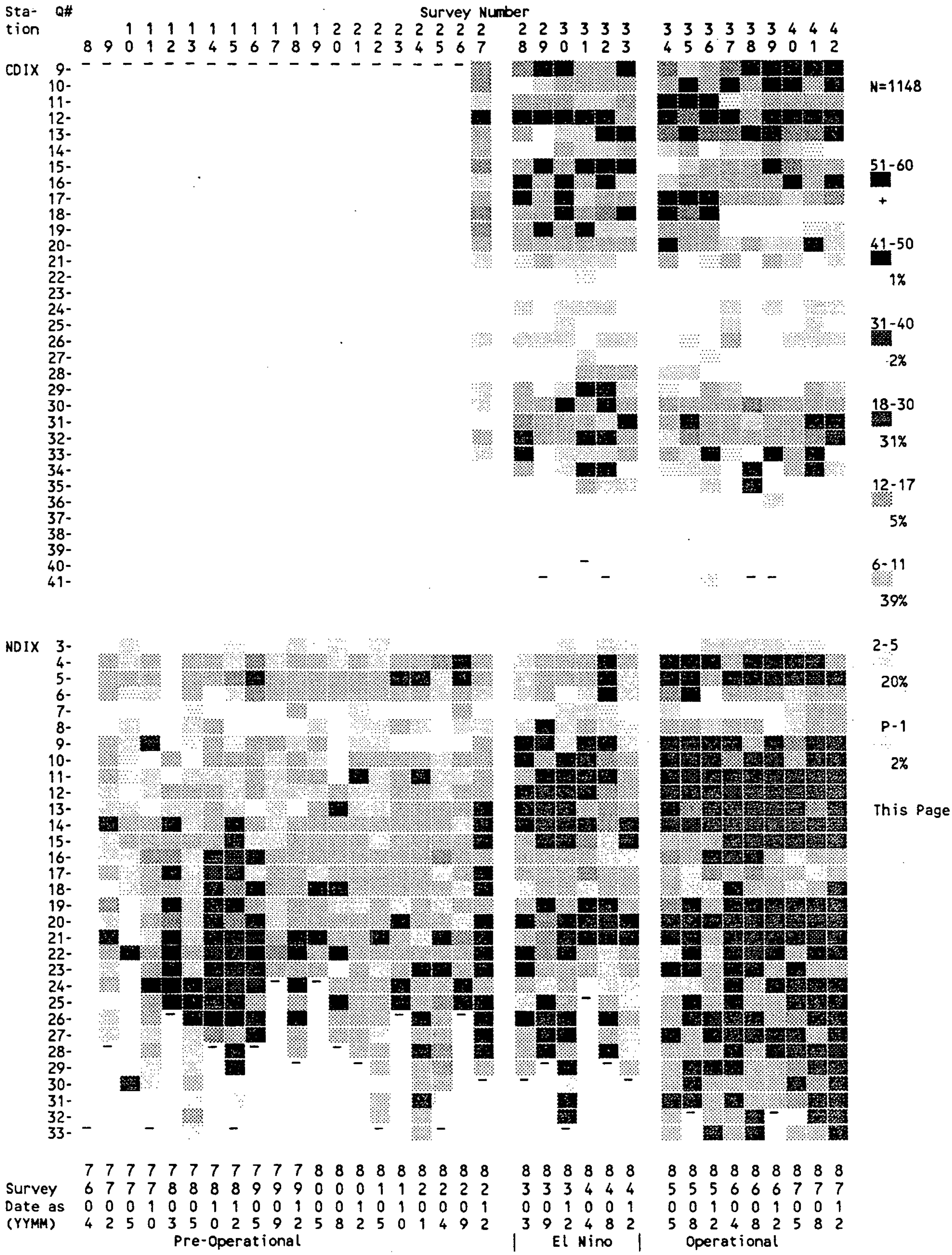
El Niño: 1982-83 winter storm: At SDIX increase in cover at lower tidal levels, with some removal or overlay by gravel at mid tidal levels. NDIX with increased cobble at mid tidal levels and within normal limits at lower ranges. LCIX and CDIX? within normal limits of variation.

El Niño: 1983-1984: SDIX at mid tide levels normal, but higher than normal at lower tidal levels. NDIX at upper-mid and mid tidal levels, higher than normal cobble. CDIX with insufficient pre-El Niño data to evaluate. LCIX normal.

Diablo DCPP Operation: SDIX as for El Niño period. NDIX as for El Niño period, but cobble remaining possibly higher than normal here at lower parts of intertidal considering the time span. CDIX relatively stable for cobble cover. LCIX with increasing covers of bare rock extending downward to the mid intertidal.

Taxon or Category: Cobble (% cover) [N.D. prior to Survey 9]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

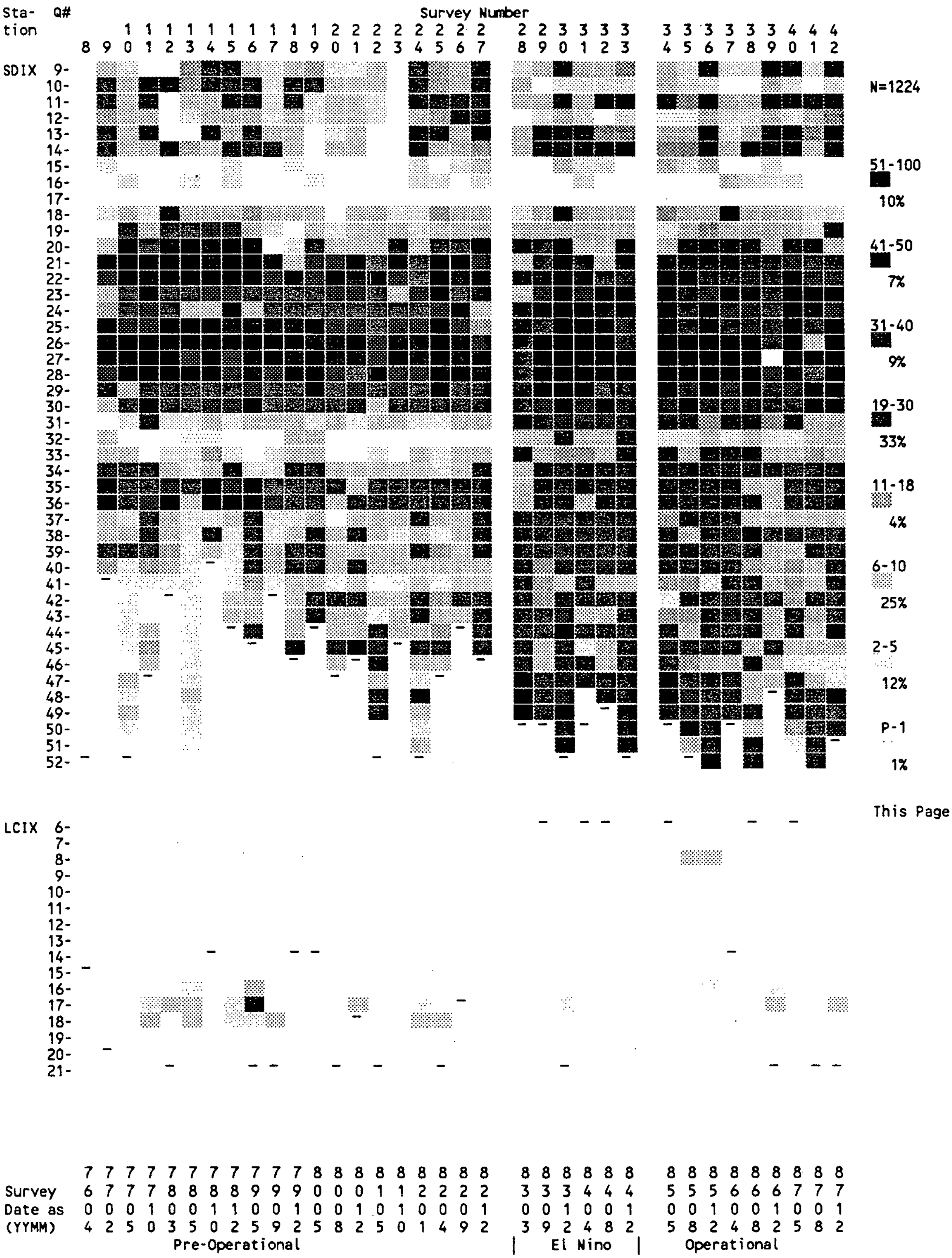


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COBBLE CSV 2653 3-29-88 8:26a 04-14-1989 10:54

Taxon or Category: Cobble (% cover) [N.D. prior to Survey 9]

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for COBBLE CSV 2653 3-29-88 8:26a 04-14-1989 10:54

Audit: CLUMRG2P: V.1.2: for SCOBBLE Key in: 04-29-1989/11:50
Driver Prg. CSVtoDEK: V. 1.9 : Date/Time 04-29-1989/11:45:03 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Cobble (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 356

Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 51 : 14.3%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.355008: Maximum Distance = 1624

```
S27-8212  --------------------------------------------I----------------I
S29-8309  --------------------------------------------I                I----I
S30-8312  -------------------------------------------------------------I    I---I
S33-8412  ------------------------------------------------------------------I   I---I
S34-8505  -------------------------------------------------I--I                 I   I
S36-8512  -------------------------------------------------I  I-----------------I   I------------I
S35-8508  ----------------------------------------------------I                     I            I
S28-8303  ----------------------------------------------------------I---------------I            I
S41-8708  ----------------------------------------------------------I                            I---------I
S37-8604  -----------------------------------------------------------------------I---------I     I         I
S39-8612  --------------------------------------------------------I--------------I         I--I  I         I
S40-8705  --------------------------------------------------------I                        I  I--I         I------
S42-8712  ---------------------------------------------------------------------------------I  I            I
S38-8608  ------------------------------------------------------------------------------------I            I
S31-8404  ------------------------------------------------------------------I------------------------------I
S32-8408  ------------------------------------------------------------------I
```

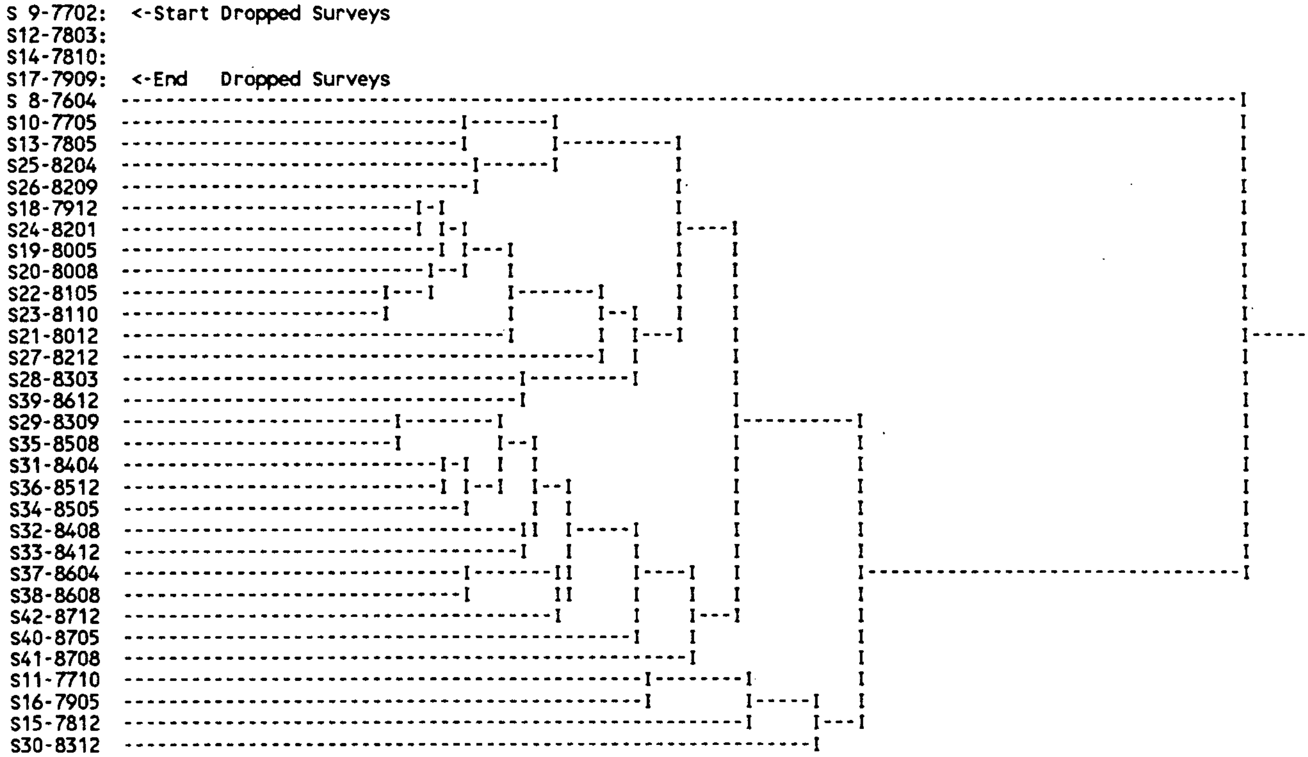
Station: NDIX: Cobble (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 843

Quad Range USED 4 to 27 for Total of 24 : Range WITH data 2 to 33: : # Dropped 223 : 26.5%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.587239: Maximum Distance = 1866

```
S12-7803:  <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404:  <-End   Dropped Surveys
S 8-7604  --------------------------------------I----------------------I
S10-7705  --------------------------------------I                      I
S 9-7702  -----------------------------------II                        I
S33-8412  -----------------------------------II-I                      I
S22-8105  ------------------------------I-----I I------I               I
S25-8204  ------------------------------I       I      I               I-----------------------I
S21-8012  --------------------------I-----------I      I-I             I                       I
S24-8201  --------------------------I                  I I             I                       I
S11-7710  -----------------------------------I-------I I I---------I   I                       I
S13-7805  -----------------------------------I       I-I I         I   I                       I
S18-7912  -------------------------------------------I   I         I---I                       I
S20-8008  -----------------------------------------------I         I                           I-----------I
S27-8212  ---------------------------------------------------------I                           I           I
S28-8303  ----------------------------------------------------------I---------------I          I           I
S36-8512  ----------------------------------------------------------I               I          I           I
S29-8309  ------------------------------------------------------------------I       I          I           I
S30-8312  ---------------------------------------------------II             I       I          I           I
S34-8505  ------------------------------------------I--------II             I       I----------I           I
S38-8608  ------------------------------------------I         I----I        I--I    I                      I
S39-8612  ------------------------------------------I--------II    I        I  I    I                      I------
S42-8712  ------------------------------------------I        II    I------I I  I    I                      I
S40-8705  ---------------------------------------------------I     I      I I  I----I                      I
S35-8508  ------------------------------------------------------I--I      I-I  I                           I
S41-8708  ------------------------------------------------------I         I    I                           I
S37-8604  ----------------------------------------------------------------I    I                           I
S32-8408  ---------------------------------------------------------------------I                           I
S14-7810  -------------------------------------------------I----------------------------I                  I
S15-7812  -------------------------------------------------I                            I------------------I
S16-7905  ------------------------------------------------------------------------------I
```

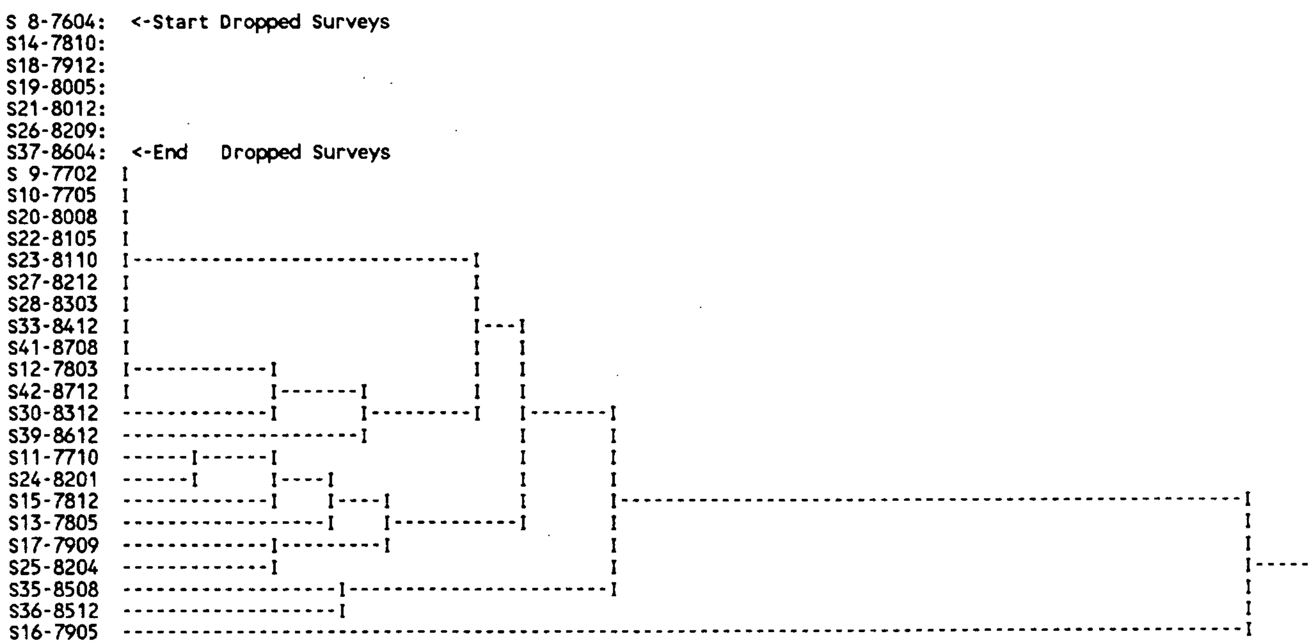
Station: SDIX: Cobble (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 1341

Quad Range USED 15 to 43 for Total of 29 : Range WITH data 1 to 52: : # Dropped 589 : 43.9%
Surveys 31 : Dropped 4 Surveys if quads sampled < 43
COPHENETIC CORRELATION COEFFICIENT = 0.650962: Maximum Distance = 4997



Station: LCIX: Cobble (% cover) [N.D. prior to Survey 9]: TOTAL Quads with Data = 24

Quad Range USED 8 to 19 for Total of 12 : Range WITH data 8 to 18: : # Dropped 2 : 8.3%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.880628: Maximum Distance = 352



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Sand/Gravel Percent Cover (Rock <6.5 cm) **Substrate**

Description: Rocky material with equivalent volume of sphere with diameter <6.5 cm (2.5 inches).

Distribution: Almost world-wide.

Diablo Area Specific Information: Abundant, occurring in >75% of our quadrats with covers to 100%.

Habitat: Almost all tidal levels.

Observational Errors: Borderline cases at upper (cobble) limits are probably sometimes mis-identified. Not identified until early 1977. Missed observations or erroneous categorization numerous until mid 1978. Can be difficult to determine if there is underlying sand or gravel in areas that were densely covered with algal mat.

Field Identification Problems:

General: Difficult to categorize correctly in areas that have continuum of sand, gravel, and cobble.

Station Specific: Very little cobble at LCIX, so correct categorization here was relatively easy.

General Comments:. Most common at Cove stations SDIX and NDIX. Moderately common at CDIX and moderately rare at LCIX. Upper parts of SDIX (Quadrats 1 to 15) and NDIX (Quadrats 1 to 7) are excluded from comment as these quadrats are either mostly bare rock or have extremely variable amounts of sand and gravel.

Impacts to Taxon:

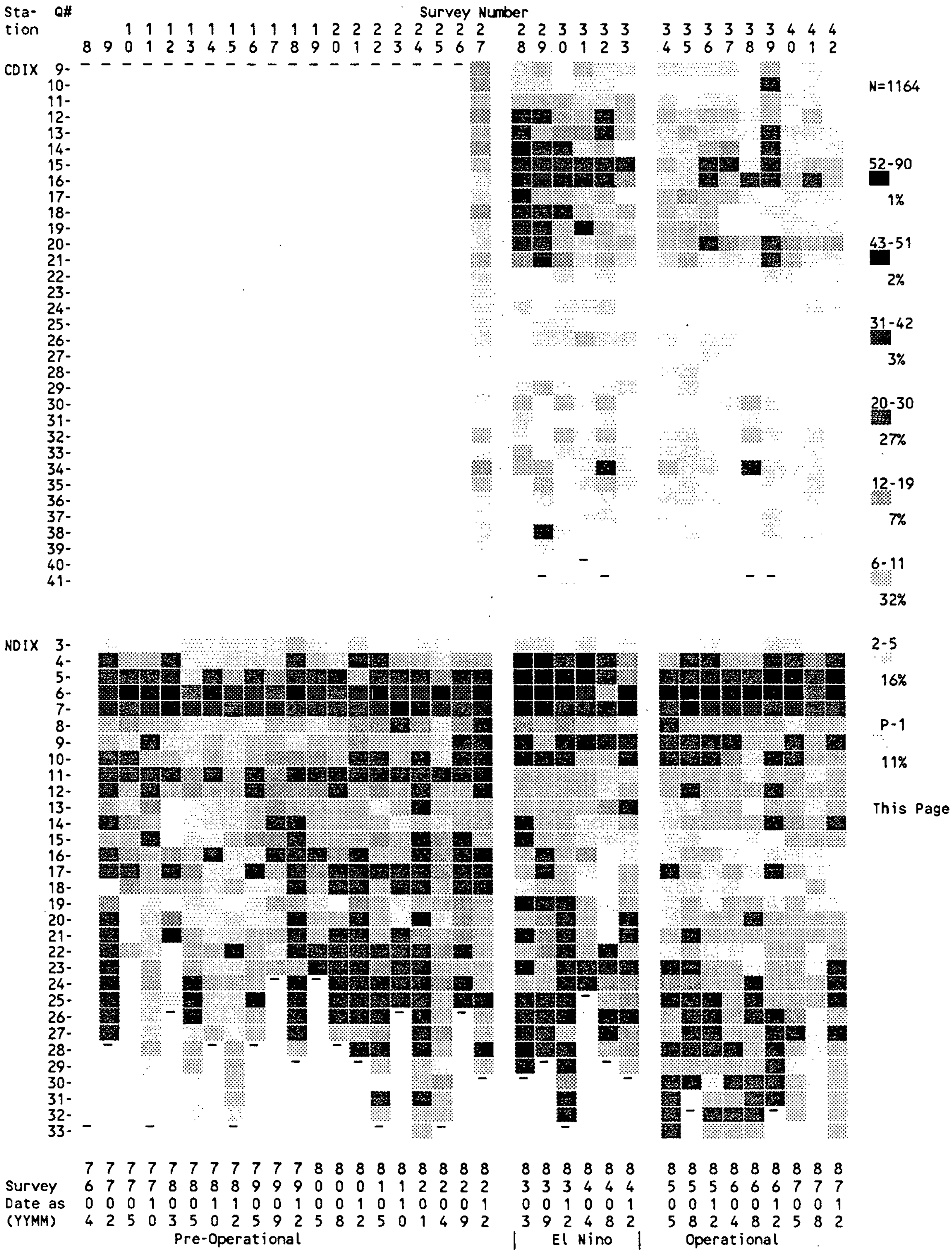
El Niño: 1982-83 winter storm: At SDIX with increase in cover at mid tidal level (i.e., introduced rubble). NDIX with increase at lower tidal levels. CDIX possibly with increased covers at mid to upper-mid levels. LCIX within normal limits of variation.

El Niño: 1983-1984: SDIX quickly losing material introduced, and perhaps lower than normal covers at mid tidal levels. NDIX at low tide levels slowly losing covers introduced and probably normal at end of period. CDIX as NDIX, but here at mid to upper-mid levels. LCIX normal.

Diablo DCPP Operation: SDIX returning to within normal limits throughout transect. NDIX within normal limits. CDIX probably within normal limits. LCIX normal.

Taxon or Category: Sand and Gravel

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.

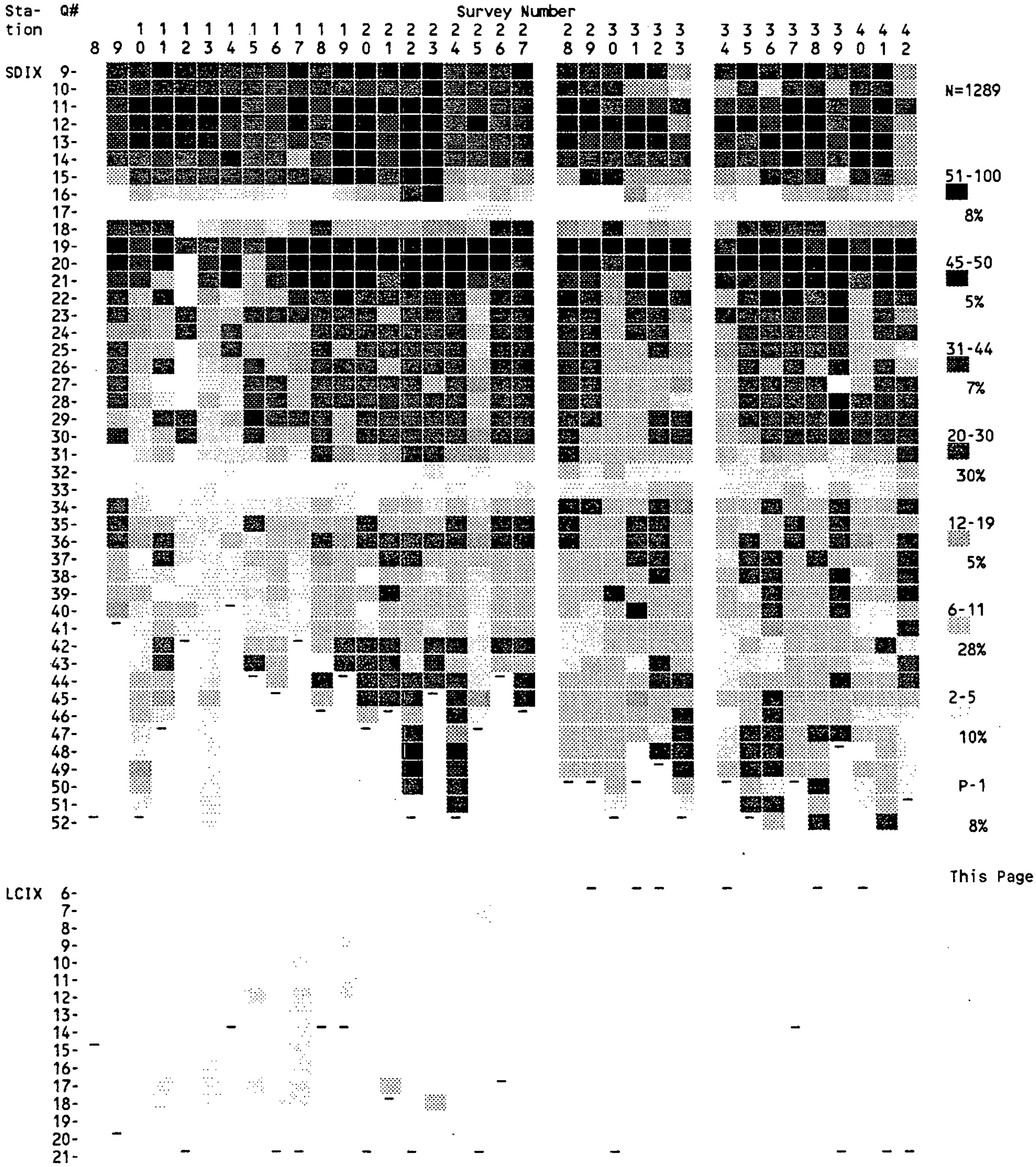


'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CSANGRA CSV 2696 4-21-88 6:19a 04-14-1989 09:09

Taxon or Category: Sand and Gravel

Options: Quad. Range: Part.: Data Scaled: Data Values P to Max.



Survey	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Survey Date as (YYMM)	7604	7702	7705	7710	7803	7805	7810	7812	7905	7909	7912	8005	8008	8012	8105	8110	8201	8204	8209	8212	8303	8309	8312	8404	8408	8412	8505	8508	8512	8604	8608	8612	8705	8708	8712
	Pre-Operational																				El Nino						Operational								

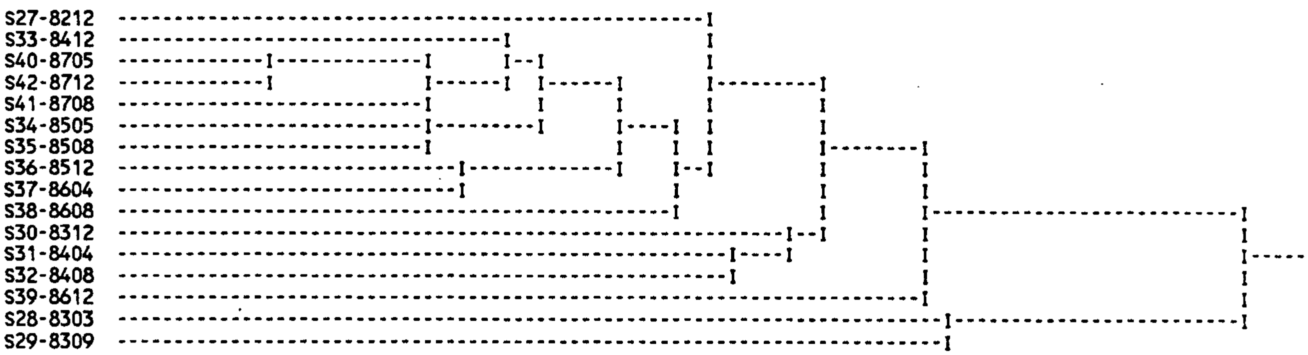
'_' = End of Transect Observations for Survey. Not included if Quadrat range selected < observed

Audit: ALSTAPLT: V.2.4a for CSANGRA CSV 2696 4-21-88 6:19a 04-14-1989 09:10

Audit: CLUMRG2P: V.1.2: for SCSANGRA CLU 6163 4-22-89 10:53a: 04-27-1989/17:35
Driver Prg. CSVtoDEK: V. 1.8 : Date/Time 04-22-1989/10:51:42 and BIOSTAT II Hierarchical Cluster Analysis (V. 2.2)
METHOD: GROUP AVERAGE: ACRONYM FOR ASSOCIATION MATRIX USED = EUCLIDEAN DIST: Quantitative Data Used

Station: CDIX: Sand and Gravel: TOTAL Quads with Data = 310

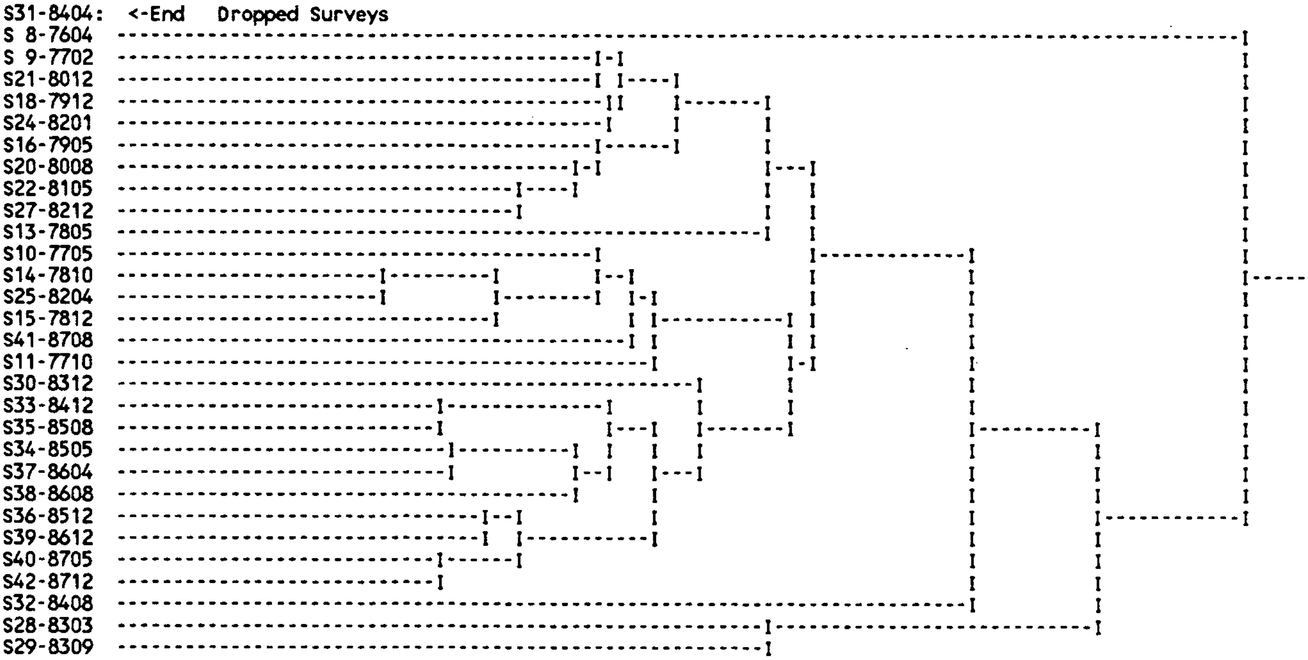
Quad Range USED 9 to 39 for Total of 31 : Range WITH data 1 to 41: : # Dropped 20 : 6.5%
Surveys 16 : Dropped 0 Surveys if quads sampled < 39
COPHENETIC CORRELATION COEFFICIENT = 0.646999: Maximum Distance = 2145



Station: NDIX: Sand and Gravel: TOTAL Quads with Data = 874

Quad Range USED 4 to 27 for Total of 24 : Range WITH data 2 to 33: : # Dropped 233 : 26.7%
Surveys 29 : Dropped 6 Surveys if quads sampled < 27
COPHENETIC CORRELATION COEFFICIENT = 0.597340: Maximum Distance = 2407

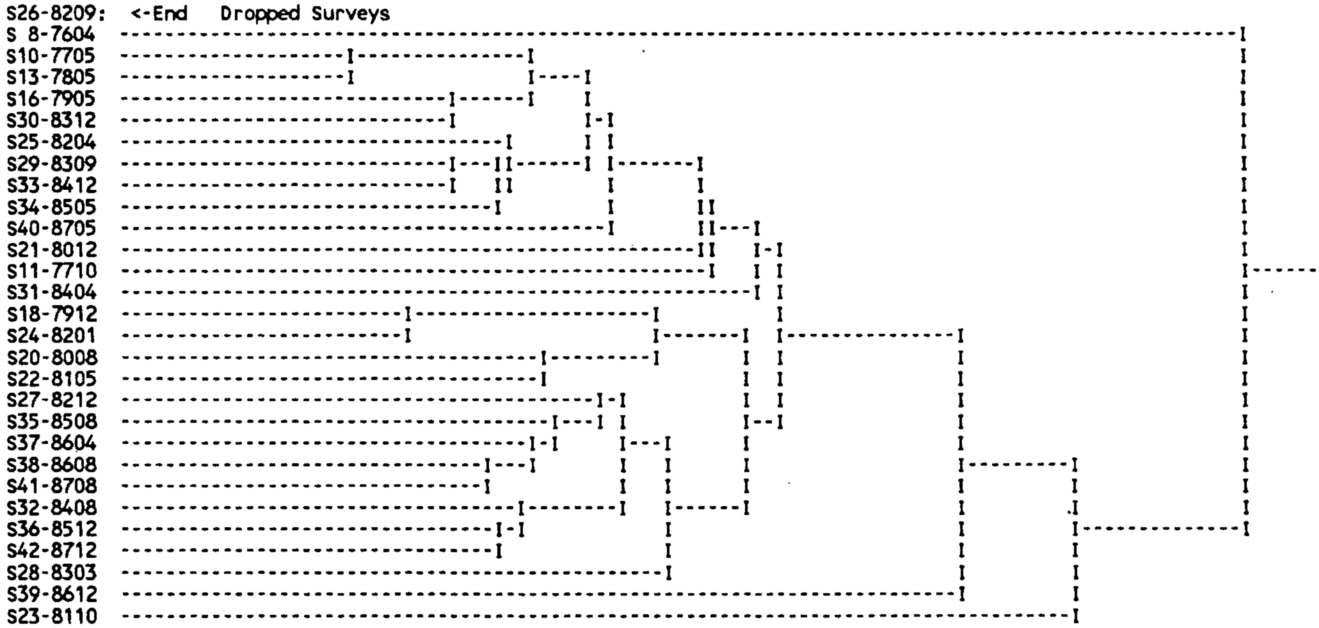
S12-7803: <-Start Dropped Surveys
S17-7909:
S19-8005:
S23-8110:
S26-8209:
S31-8404: <-End Dropped Surveys



Station: SDIX: Sand and Gravel: TOTAL Quads with Data = 1508

Quad Range USED 15 to 44 for Total of 30 : Range WITH data 1 to 53: : # Dropped 853 : 56.6%
Surveys 28 : Dropped 7 Surveys if quads sampled < 44
COPHENETIC CORRELATION COEFFICIENT = 0.627409: Maximum Distance = 4003

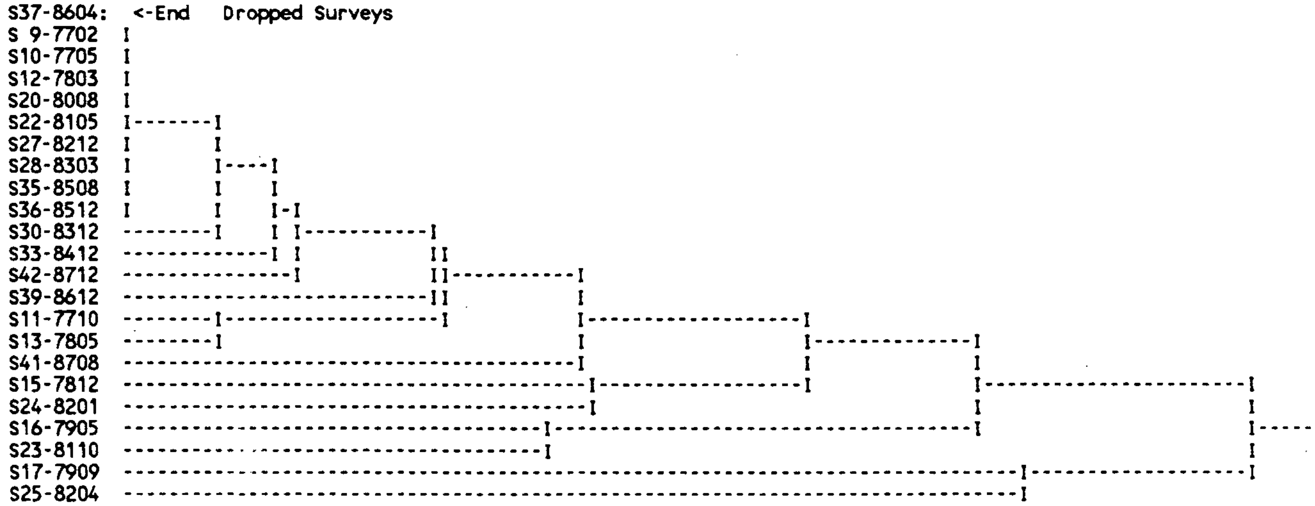
S 9-7702: <-Start Dropped Surveys
S12-7803:
S14-7810:
S15-7812:
S17-7909:
S19-8005:
S26-8209: <-End Dropped Surveys



Station: LCIX: Sand and Gravel: TOTAL Quads with Data = 50

Quad Range USED 7 to 19 for Total of 13 : Range WITH data 7 to 19: : # Dropped 6 : 12.0%
Surveys 22 : Dropped 7 Surveys if quads sampled < 19
COPHENETIC CORRELATION COEFFICIENT = 0.885265: Maximum Distance = 138

S 8-7604: <-Start Dropped Surveys
S14-7810:
S18-7912:
S19-8005:
S21-8012:
S26-8209:
S37-8604: <-End Dropped Surveys



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Chapter 10

SUBTIDAL RESULTS

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Tables

Appendices

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INTRODUCTION

This is the first of three chapters describing subtidal fauna and flora of Diablo Cove and comparing them to nearby communities outside the Cove. The present chapter summarizes our diving observations and also includes results from a modest amount of laboratory work (identifying organisms collected subtidally). The chapter is primarily concerned with presence or absence of species sufficiently large to be easily recognized by a diver. The succeeding chapter deals with subtidal invertebrates that were usually too small to be easily identified under field conditions. The third chapter in this group of subtidal studies is concerned with a few select species of large plants, the kelps, and examines changes in their abundances during the operational period.

The present chapter primarily treats results from 20 years of observations along three permanent transects (see Figure 5-1). We also conducted routine studies at other subtidal locations, as well as occasional special purpose investigations (examples: swimthroughs in shallow parts of Diablo Cove, examination of Intake Cove and of South Cove). We will not present detailed results from these ancillary studies. We will refer to them as necessary, however, when discussing results from the primary studies along the transects.

The two permanent subtidal transects in Diablo Cove were established early in 1968 and a control transect off Pup Rock was laid out in mid-1969. Frequency of surveys was irregular during the first five years, but visits were accomplished on roughly an annual basis thereafter (Table 10-1). We attempted to time the surveys to occur during the final quarter of each year, from 1977 onward. Unfavorable seas sometimes interfered with survey work, so we conducted additional studies in the following spring or summer to compensate for any deficiencies.

Table 10-1: Dates of our surveys along three subtidal transects in the Diablo Canyon region. Survey Numbers are based on subtidal AND intertidal surveys so are not a continuous series.

Year	Survey Number	Station DCSX	DRSX	LRSX
1968	1	06 Jan	06 Jan	
	2		19 Aug	
1969	3	14 Jun	14 Jun	14 Jun
1970				
1971				
1972	6	15 Apr	15 Apr	15 Apr
1973				
1974	7	12 Dec	12-13 Dec	12 Dec
1975	8	17 Nov	17 Nov	17 Nov
1976	9	23 Jun	23 Jun	23 Jun
1977	11	17 Nov	17 Nov	17 Nov
1978				
1979	15	12 Jan	12 Jan	12 Jan
	18	19-20 Dec	19-20 Dec	19-20 Dec
1980				
1981	21	02 Jan	02 Jan	02 Jan
	23	13 Oct	14 Oct	14 Oct
1982	27	29 Dec	29-30 Dec	31 Dec
1983	28	15 Apr	15-16 Apr	16 Apr
	30	20 Dec	20 Dec	20 Dec
1984	33	20 Dec	20 Dec	20 Dec
1985	35	28 Aug	28-29 Aug	29 Aug
	36	11 Dec	11 Dec	11 Dec
1986	37	02 Apr	02 Apr	02 Apr
	39	27 Dec	27 Dec	27 Dec
1987	40	15 Apr, 14 May	15 Apr, 14 May	16 Apr
	41	26-27 Oct	26 Oct	26-27 Oct

SPECIES OF THE SUBTIDAL TRANSECTS

Summary results from all three transects yielded combined totals of 205 plant species and 378 animals for the period 1968 to 1987 (Table 10-2). Both plant and animal totals from the DRSX transect were slightly greater than corresponding values from the other two lines. Totals from DCSX and LRSX were virtually identical. Among plants, DCSX and DRSX had moderately greater numbers of Brown Algae compared to LRSX. DRSX modestly exceeded the other two with respect to numbers of Red Algae. Superiority of DRSX in animals arose primarily from greater numbers of Bryozoa, Mollusca, and Arthropoda at this station. In Chapter 11 (Analysis of Encrusting

Table 10-2: Total numbers of taxa within Phyla or other major taxon, recorded from three subtidal stations in the Diablo Canyon region between 1968 and 1987. Totals include taxa that were laboratory identifications only.

Phylum	DCSX	Station DRSX	LRSX	Total
		PLANTS		
Chrysophyta	1	0	0	1
Chlorophyta	6	7	5	9
Phaeophyta	16	16	12	22
Rhodophyta	108	121	108	173
Total Plants	131	144	125	205
		ANIMALS		
Protozoa	1	1	1	1
Porifera	23	27	20	34
Cnidaria	18	20	18	23
Nemertea	1	0	1	1
Aschelminthes	0	1	1	1
Bryozoa	12	42	15	45
Annelida	20	24	24	38
Mollusca	57	71	46	98
Arthropoda	20	34	20	43
Echinodermata	13	19	17	21
Chordata-Tunicata	17	21	18	23
Chordata-Pisces	38	34	36	50
Total Animals	220	294	217	378
Total Plants + Animals	351	438	342	583
Surveys for Station	21	22	20	

Invertebrates) we will find that LRSX was somewhat richer than DRSX in Bryozoa, Mollusca, and Arthropoda. It thus appears that the moderate differences present between the stations in Table 10-2 probably have little significance. We conclude, rather, that the three stations were remarkably similar as regards broad-scale diversity over an extended period of time.

Survey occurrence (i.e., numbers of surveys where a species was present at a station) varied widely among the subtidal species (Tables 10-3 and 10-4). No single species was recorded from all surveys for all stations. This probably resulted from oversights because some taxa (e.g., *Lithothamnium* sp, which was arbitrarily used to designate all encrusting corallines) were undoubtedly always present but may not have been recorded because of poor survey conditions or

Table 10-3: Numbers of surveys (#S) that the indicated plant species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
CHLOROPHYTA			
Bryopsis corticulans	1	1	1
Cladophora sp.	1		
Enteromorpha linza	1	2	
Derbesia marina	4	3	2
Ulva sp.	10	11	5
Ulva angusta		1	
Ulva expansa			1
Ulva lobata	1	1	1
Ulva rigida		1	
PHAEOPHYTA			
Alaria marginata		1	1
Analipus japonicus			1
Coilodesme californica		3	
Cystoseira sp.	1		
Cystoseira osmundacea	17	19	15
Desmarestia latifrons			1
Desmarestia ligulata var. *ligulata*	12	9	18
Dictyoneuropsis reticulata	1		
Dictyoneurum californicum	16	16	16
Dictyota sp.	8	8	1
Dictyota binghamiae	2	1	
Dictyota flabellata	2	1	
Ectocarpus sp.	1	1	
Ectocarpus acutus		1	
Ectocarpus parvus	1		
Egregia menziesii	3	12	2
Laminaria sp.	1		
Laminaria dentigera	16	22	17
Macrocystis pyrifera	1	4	10
Nereocystis luetkeana	11	14	9
Pterygophora californica	21	17	19
Unid. brown blade		2	
RHODOPHYTA			
Acrochaetium sp.	1	1	
Acrosorium uncinatum	1		
Amplisiphonia pacifica	1		
Anisocladella pacifica			1
Antithamnion sp.	1	3	1
Antithamnion defectum	1	2	1
Antithamnion kylinii			1
Bossiella sp.	11	15	9
Bossiella californica	1	1	
Bossiella californica ssp. *californica*	1	1	3
Bossiella californica ssp. *schmittii*	1	1	
Bossiella chiloensis	1		1
Bossiella orbigniana		1	
Bossiella orbigniana ssp. *orbigniana*	1		1
Bossiella orbigniana ssp. *dichotoma*	2	2	2

Table 10-3: Numbers of surveys (#S) that the indicated plant species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Bossiella plumosa	1		1
Botryoglossum farlowianum	20	20	16
Botryoglossum ruprechtianum		1	2
Branchioglossum undulatum		1	
Branchioglossum woodii	1		
Calliarthron sp.	21	22	18
Calliarthron cheilosporioides	1	2	1
Calliarthron tuberculosum	1	1	1
Callithamnion acutum		1	
Callithamnion pikeanum		1	
Callithamnion rupicolum		1	
Callophyllis sp.		3	2
Callophyllis crenulata	2	2	1
Callophyllis firma	3	6	4
Callophyllis flabellulata	13	19	17
Callophyllis heanophylla	3	3	8
Callophyllis pinnata	4	11	8
Callophyllis violacea	14	17	16
Ceramium sinicola	1	1	
Clathromorphum parcum	1		
Constantinea simplex	1	2	
Corallina officinalis var. *chilensis*	2	1	
Corallina vancouveriensis		7	
Cryptonemia sp.		1	
Cryptopleura sp.	1	3	
Cryptopleura corallinara		1	
Cryptopleura lobulifera			2
Cryptopleura violacea	4	5	2
Endocladia muricata		5	1
Erythrophyllum delesserioides	3	4	1
Fauchea laciniata	1	4	1
Farlowia sp.	3	2	
Farlowia compressa	1	1	
Farlowia mollis		2	
Fryeella gardneri	2	2	4
Gastroclonium coulteri	2		
Gelidium coulteri	1	1	
Gelidium nudifrons			1
Gelidium purpurascens		1	2
Gelidium robustum	7	14	4
Gigartina sp.	1		
Gigartina canaliculata			1
Gigartina corymbifera	10	11	7
Gigartina exasperata	15	20	17
Gigartina harveyana	1		
Gigartina papillata		5	
Gonimophyllum skottsbergii			1
Gracilaria sp.	2	3	4
Grateloupia sp.	1	1	
Griffithsia pacifica	4		1
Gymnogongrus sp.			1
Gymnogongrus leptophyllus		2	1

Table 10-3: Numbers of surveys (#S) that the indicated plant species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Gymnogongrus linearis			1
Gymnogongrus platyphyllus	2	3	6
Halymenia sp.	1	3	4
Halymenia californica	1	5	5
Halymenia coccinea	5	7	10
Halymenia hollenbergii	1	2	1
Halymenia schizymenioides		1	1
Herposiphonia plumula	1	1	
Hildenbrandia sp.	1	1	1
Hildenbrandia occidentalis			1
Hollenbergia subulata			1
Hymenena sp.		1	
Hymenena flabelligera	1	1	1
Iridaea sp.		1	
Iridaea cordata	1	11	
Iridaea cordata var. *cordata*		2	1
Iridaea cordata var. *splendens*	2	1	1
Iridaea flaccida		5	3
Iridaea heterocarpa	2	3	2
Iridaea lineare		3	1
Kallymenia pacifica			1
Laurencia spectabilis	7	5	6
Leptocladia binghamiae	1	2	
Lithophyllum sp.	1		
Lithophyllum imitans	1		
Lithothamnium sp.	20	22	18
Lithothamnium pacificum	1		
Membranoptera sp.	1		
Membranoptera multiramosa	2	2	
Membranoptera weeksiae	2	1	
Melobesia sp.	2		
Mesophyllum lamellatum	1		
Microcladia sp.	1	1	1
Microcladia borealis			1
Microcladia californica		1	
Microcladia coulteri	6	9	6
Neoagardhiella baileyi	5	1	3
Neopolyporolithon reclinatum	1		
Neoptilota densa	14	10	10
Neoptilota hypnoides		1	2
Nienburgia andersoniana		1	4
Odonthalia floccosa		1	
Ophidocladus simpliciusculus	1		
Opuntiella californica	19	15	14
Petrocelis franciscana		9	1
Peyssonellia sp.	21	18	17
Peyssonellia meridionalis	1	1	
Peyssonellia profunda	1		
Phycodrys isabelliae			1
Phycodrys setchellii			2
Pikea californica	5	2	2
Pikea robusta	1	4	2

Table 10-3: Numbers of surveys (#S) that the indicated plant species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Phymatolithon lenormandii		1	1
Platythamnion heteromorphum			2
Platythamnion pectinatum	1		
Platythamnion villosum		1	2
Pleonosporium squarrulosum	1	1	
Pleonosporium vancouverianum			1
Plocamium cartilagineum		2	
Plocamium violaceum			1
Polyneura latissima	14	15	17
Polysiphonia pacifica	2	1	1
Polysiphonia paniculata	1		1
Porphyra sp.	1	3	1
Porphyra occidentalis		1	
Porphyra nereocystis	1	4	
Porphyra perforata		1	
Porphyrella gardneri		1	
Porphyropsis coccinea		1	
Prionitis sp.	1		1
Prionitis angusta	5	5	3
Prionitis australis	6	6	1
Prionitis cornea		1	
Prionitis lanceolata	13	15	5
Prionitis linearis		1	
Prionitis lyallii		1	
Pseudogloiophloea confusa	3	4	3
Pseudolithophyllum neofarlowii	1		
Pterochondria woodii			1
Pterosiphonia baileyi			1
Pterosiphonia bipinnata	1	1	1
Pterosiphonia dendroidea		2	
Ptilota filicina	1	4	1
Pugetia fragilissima	1	1	1
Rhodoglossum sp.		1	1
Rhodoglossum californicum	1		
Rhodoglossum roseum	3	5	2
Rhodoptilum plumosum	4	2	3
Rhodymenia californica	11	17	15
Rhodymenia callophyllidoides			1
Rhodymenia pacifica	14	17	12
Rhodymenia palmata var. *mollis*			1
Rhodymenia sympodiophyllum		1	
Sarcodiotheca furcata	1		1
Schizymenia sp.	2		
Schizymenia epiphytica	2	1	2
Schizymenia pacifica	4	8	3
Smithora naiadum		2	1
Stenogramme interrupta			1
Tiffaniella snyderiae	2	1	1
Weeksia sp.		1	3
Weeksia digitata			4
Weeksia reticulata	8	10	9
Yamadaea melobesioides	1		1

Table 10-3: Numbers of surveys (#S) that the indicated plant species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Unid. red blade	1	1	
CHRYSOPHYTA			
Unid. diatoms	1		
Taxa Listed	131	144	125
# of Taxa	131	144	125
# of Taxa Lab Only	0	0	0
# of Surveys	21	22	20

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
PORIFERA			
Acarnus erithacus			1
Astylinifer arndti	2	4	1
Clathriopsamma? pseudonapya		1	
Cliona celata	11	8	6
Cyamon argon		1	
Halichondria panicea	4	3	1
Haliclona sp.	2	3	1
Haliclona ecbasis			2
Haliclona lunisimilis	5	1	4
Haliclona permollis	1	1	1
Hymenamphiastra cyanocrypta	8	14	13
Hymeniacidon sinapium		1	1
Isociona lithophoenix	2	2	2
Leucetta losangelensis	1	2	
Leucilla nuttingi	12	7	13
Leuconia heathi	11	11	13
Leucosolenia sp.		3	7
Clathrina blanca		1	
Lissodendoryx sp.	1	1	
Microciona sp.	1	1	
Microciona parthena	1		
Ophlitaspongia pennata	1		
Paresperella? sp.	1	1	
Penares sp.	1		
Penares cortius	2		1
Plocamia karykina	6	6	5
Prianos problematicus	5	12	
Prosuberites sisyrnus			1
Sigmadocia sp.		1	
Spheciospongia confoederata	6	3	
Stelletta sp.	1	1	
Tethya aurantia	21	8	17
Tetilla arb		1	
Unid. sponges (num. of spp.)	2	1	2
CNIDARIA			
Abietinaria sp.	1	2	1
Aglaophenia sp.	2	15	6
Anthopleura artemisia	9	12	5
Anthopleura elegantissima	15	12	9
Anthopleura xanthogrammica	6	17	6
Astrangia lajollanensis	3	12	17
Balanophyllia elegans	21	21	18
Campanularia sp.		1	
Corynactis californica	6	17	16
Dynamena sp.		1	
Epiactis prolifera	15	10	2
Eudendrium sp.	1	2	
Halcampa sp.	3		1
Haliplanella sp.	3	4	1
Hydractinia sp.	6	4	5

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Pachycerianthus sp.		1	2
Paracyathus stearnsi		3	17
Pelagia panopyra			2
Sertularella sp.	1	5	3
Sertularia sp.	1	1	
Tealia sp.	7	10	19
Unid. hydroids	5	7	7
Unid. actinarians	1		
NEMERTINEA			
Unid. nemerteans	1		2
ASCHELMINTHES COMPLEX			
Unid. nematodes		1	1
BRYOZOA			
Aplousina major		1	
Bicrisia edwardsiana		1	
Cauloramphus cymbaeformis		1	
Cellaria mandibulata			1
Celleporaria brunnea	1		
Costazia sp.	6	14	12
Costazia costazi		1	
Costazia robertsoniae		1	
Conopeum reticulum		1	
Crisidia cornuta		1	
Crisia sp.	4	16	9
Crisia occidentalis		1	
Diaperoecia californica	3	8	4
Dendrobeania longispinosa		1	
Fenestrulina malusi		1	
Fenestrulina malusi var. *umbonata*		1	
Flustrella sp.		1	2
Hippodiplosia insculpta	2	10	9
Hippoporina sp.	3	3	4
Hippothoa sp.	1	1	1
Hippothoa hyalina		1	
Hippothoa sp. 2		1	
Hippothoa sp. 3		1	
Hippothoa sp. 4		1	
Lagenipora punctulata	4	7	5
Membranipora sp.	6	9	10
Membranipora fusca	1		
Micropora coriacea		1	
Microporella californica		1	
Microporella umbonata		1	
Parasmittina californica		1	1
Phidolopora pacifica	1	12	14
Reginella mucronata		1	
Retevirgula areolata		1	
Rhynchozoon sp.	5	9	13
Rhynchozoon rostratum		1	

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Schizotheca fissurella		1	
Scrupocellaria sp.		1	3
Scrupocellaria californica		1	
Stomatopora granulata		1	
Tegella armifera		1	
Tricellaria occidentalis		1	
Tubulipora tuba		1	
Victorella sp.		1	
Unid. cheilostomatans		1	3
MOLLUSCA			
Acanthodoris lutea	2	1	
Acanthodoris nanaimoensis	1		
Acmaea mitra	18	14	7
Aegires albopunctatus	1		
Alvinia compacta		1	1
Amphissa versicolor		1	
Anisodoris nobilis	5	6	5
Aplysia vaccaria	1		
Archidoris montereyensis	2	1	1
Archidoris odhneri	1		
Astraea gibberosa	11	15	13
Barleeia haliotiphila		1	1
Cadlina sp.	1		
Cadlina flavomaculata	1		1
Cadlina limbaughi	1		
Cadlina luteomarginata	3	2	
Calliostoma sp.	1		1
Calliostoma annulatum	5	10	10
Calliostoma canaliculatum	10	19	11
Calliostoma ligatum	4	6	6
Callistochiton palmulatus		1	
Cerithiopsis sp.		1	
Chama sp.		1	
Collisella sp.		1	
Collisella asmi		1	
Collisella digitalis		6	
Collisella instabilis	2	1	
Collisella ochracea	1	1	
Collisella pelta		4	
Collisella scabra		1	
Conus californicus			1
Cryptochiton stelleri		3	1
Crepidula sp.	3	3	2
Dendrodoris sp.	16	13	13
Diaulula sandiegensis	1	2	11
Diodora sp.	2	3	
Tritonia festiva	5		
Flabellinopsis iodinea	2		6
Fissurella volcano	2	1	
Haliotis cracherodii		1	
Haliotis kamtschatkana	1	1	

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Haliotis rufescens	9	3	1
Hermissenda crassicornis	4	2	1
Hiatella sp.		1	
Hiatella arctica		1	
Hinnites multirugosus	10	15	10
Homalopoma luridum	1	1	
Hopkinsia rosacea	7		
Hypselodoris californiensis	2		
Katharina tunicata		1	
Laila cockerelli	1	1	1
Lepidochitona keepiana		1	
Lepidozona sp.	1		
Lepidozona mertensi		1	
Lepidozona sinudentata	1		
Leptopecten sp.		1	
Lottia gigantea		8	1
Margarites sp.		1	
Margarites pupillus salmoneus	1		
Mitra idae	11	12	15
Mitrella sp.	1		1
Mitrella tuberosa		1	
Modiolus sp.		1	1
Mytilus sp.		4	1
Notoacmea insessa	4	3	1
Notoacmea persona	1	2	
Nuttallina sp.		2	
Ocenebra beta		1	
Octopus sp.	2	1	
Odostomia sp.		1	
Olivella sp.			2
Phidiana pugnax	1	1	3
Placiphorella velata	1		
Pododesmus cepio	2	3	3
Pseudomelatoma sp.		2	
Pteropurpura trialatus	4	4	6
Rictaxis sp.			1
Rissoella sp.		1	
Rostanga pulchra	1	1	
Serpulorbis squamigerus	14	15	14
Sinezona rimuloides		1	
Tegula sp.	20	20	10
Tegula brunnea	1	1	
Tegula pulligo		1	1
Tonicella lineata	14	14	7
Tricolia pulloides	1	1	1
Triopha catalinae	3	5	2
Trivia sp.			1
Trivia californiana			1
Turbonilla kelseyi		1	
Unid. acmaeids	1	2	
Unid. gastropods (neopic)			1
Unid. vermetid		3	1

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Unid. pelecypods		1	
Unid. pectinidae			1
Unid. aeolids	1	1	1
Unid. dorids	1		
Unid. chitons		5	1
ANNELIDA			
egg mass			2
Brania limbata	1		1
Chaetopterus sp.	1		1
Cirriformia sp.			1
Diopatra sp.	15	18	19
Dodecaceria sp.	11	13	9
Eteone sp.		1	
Eudistylia polymorpha	14	18	10
Exogone sp.			1
Halosydna brevisetosa		1	
Hydroides sp.			1
Myxicola infundibulum			2
Nereis sp.			1
Odontosyllis phosphorea			1
Ophiodromus pugettensis			1
Paleanotus bellis			1
Phragmatopoma californica	13	12	2
Phyllochaetopterus sp.	1		
Pista sp.	9	8	11
Platynereis bicanaliculata	1	1	
Sabellaria cementarium	1	2	
Salmacina sp.		1	
Salmacina tribranchiata	3	8	5
Serpula sp.	1		
Serpula vermicularis	2		
Spiochaetopterus costarum	1	2	3
Sphaerosyllis pirifera		1	1
Spirobranchis spinosus	1	3	
Typosyllis sp.		1	
Typosyllis fasciata		1	
Typosyllis variegata		1	
Unid. phyllodocids	1	1	
Unid. chaetopterids			1
Unid. cirratulid	1	1	
Unid. sabellids	10	12	13
Unid. serpulids	4	4	1
Unid. spirorbinids	8	10	9
Unid. terebellids	1	1	1
ARTHROPODA			
Balanus sp.	9	11	5
Balanus glandula		6	
Balanus nubilis	1	6	1
Balanus tintinabulum	7	6	1
Cancer sp.	2	1	4

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Cancer antennarius			1
Caprella sp.		1	
Caprella angusta		1	
Chthamalus sp.		5	
Cirolana sp.		1	
Crangon sp. (old *Crago)*			2
Crangon franciscorum		1	1
Alpheus sp. (old *Crangon)*	2	2	1
Cryptolithodes sp.			1
Idotea sp.		2	
Idotea schmitti		1	
Jaeropsis sp.		1	
Loxorhynchus crispatus	4	2	1
Loxorhynchus grandis		1	
Mimulus sp.	1		
Nymphopsis spinosissimus			1
Pagurus hirsutiusculus	1		
Pagurus samuelis		1	
Petrolisthes sp.		1	
Pollicipes polymerus		6	
Pugettia sp.	1	1	
Pugettia producta	1	3	
Pugettia richii	1	1	1
Scyra acutifrons	3	4	4
Spirontocaris sp.	1		
Tetraclita squamosa var. *rubescens*		7	1
Unid. caprellids			1
Unid. gammarid spp.	1	1	1
Unid. brachyuran juveniles		1	
Unid. pycnogonids		1	
Unid. copepods	1	1	1
Unid. halacarids	1	1	
Unid. cheliferans		1	
Unid. pagurids	14	13	8
Unid. barnacles (lepadomorpha)		1	
Unid. sphaeromids	1	1	1
Unid. ostracods	1	1	1
Unid. mysids	1		
ECHINODERMATA			
Cucumaria sp.	10	7	4
Henricia leviuscula	8	4	3
Leptasterias sp.	10	10	7
Leptasterias hexactis		1	
Ophioderma panamense		1	1
Ophioplocus esmarki		1	
Ophiothrix spiculata	2	6	3
Ophiopteris papillosa			1
Orthasterias koehleri	3	10	10
Patiria miniata	20	22	19
Pisaster brevispinus	13	5	10
Pisaster giganteus	19	18	17

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Pisaster ochraceus	4	19	7
Pycnopodia helianthoides	14	13	12
Sclerasterias heteropaes			3
Solaster dawsoni		1	
Parastichopus sp.	2	7	10
Strongylocentrotus franciscanus	3	10	8
Strongylocentrotus purpuratus	7	9	6
Unid. holothuroids		1	
Unid. ophiuroids		1	2
TUNICATA			
Aplidium sp.	4	2	2
Ascidia ceratodes	1		
Boltenia villosa	10	14	14
Chelyosoma productum		1	1
Clavelina huntsmani	1	6	
Cnemidocarpa finmarkiensis	7	4	6
Cystodytes sp.	4	9	2
Didemnum carnulentum	19	19	13
Diplosoma macdonaldi		1	
Distaplia occidentalis	1	2	2
Archidistoma sp.	6	4	5
Archidistoma diaphenes	4	3	3
Archidistoma molle	1	1	2
Archidistoma psammion	2	8	2
Archidistoma ritteri		1	1
Metandrocarpa sp.		1	
Perophora sp.		1	
Pyura haustor	12	7	11
Salpa sp.			1
Ritterella pulchra	7	8	2
Styela montereyensis	19	19	10
Tridemnum opacum	4	5	2
Unid. tunicates colonial	6	6	3
VERTEBRATA			
Artedius corallinus	2	1	3
Brachyistius frenatus		2	
Cephaloscyllium ventriosum			1
Chilara taylori			1
Chromis punctipinnis		1	
Citharichthys sp.			1
Clinocottus analis		1	1
Coryphopterus nicholsi	6	4	17
Embiotoca sp.	2	1	1
Embiotoca jacksoni	7	13	7
Embiotoca lateralis	14	16	8
Gibbonsia sp.	2		2
Girella nigricans	1		1
Gobiesox maeandricus	1		
Heterostichus rostratus	10	13	13
Hexagrammos decagrammus	2	7	5

Table 10-4: Numbers of surveys (#S) that the indicated animal species (or similar taxon) occurred along our subtidal transects in the Diablo Canyon region from 1968 to 1987. Table includes laboratory identifications. Total Surveys per transect were: DCSX = 21, DRSX = 22, LRSX = 20.

Taxon Name	DCSX #S	DRSX #S	LRSX #S
Hexagrammos stelleri	1	1	
Hypsoblennius sp.	1		
Hypsurus sp.	1	1	2
Jordania zonope	1		
Leiocottis sp.		1	
Lyconema barbatum			1
Medialuna californiensis	1	2	1
Myliobatis californica	1	1	
Ophiodon elongatus	9	1	2
Orthanopias triacis	5	3	6
Oxyjulis californica	7	8	3
Oxylebius pictus	7	9	8
Paralabrax clathratus	1		
Pholis sp.			1
Rathbunella sp.			1
Rhacochilus toxotes	3	4	3
Rhacochilus vacca	7	5	2
Scorpaenichthys marmoratus	5	9	3
Sebastes sp.	1	2	2
Sebastes atrovirens	5	2	12
Sebastes carnatus	1	1	
Sebastes chrysomelas	9	8	15
Sebastes flavidus	1		1
Sebastes melanops	2	3	7
Sebastes miniatus	1		
Sebastes mystinus	14	16	16
Sebastes serranoides	4	1	2
Semicossyphus pulcher	2	3	
Triakis semifasciata	3		
Unid. atherinid	2	1	2
Unid. blennidae	2	2	3
Unid. cottidae	1	2	5
Unid. gobiesocidae			1
Unid. ronquil			1
PROTOZOA			
Gromia sp.	1	1	1

	DCSX	DRSX	LRSX
Taxa Listed	220	294	217
# of Taxa	220	294	217
# of Taxa Lab Only	0	0	0
# of Surveys	21	22	20

from simply an oversight. At the other extreme, there were numerous instances of species only occurring once at a single station. Many of the species could not be positively identified in the field and required laboratory study of a collected specimen (many Red Algae, sponges, and tunicates fell into this category). Probably survey occurrences of this class of organisms are under-represented in Tables 10-3 and 10-4. While we nearly always made collections of non-recognized organisms during our surveys, this category was easily overlooked under difficult operational conditions or if the specimen was small or cryptic.

There are a number of "inclusive listings" in Tables 10-3 and 10-4 (e.g., unid. red blade, unid. gammarids, unid. colonial tunicates, etc). These listings usually involved difficult groups whose identifications would necessitate input from specialists or require considerable laboratory study by the investigators. We were unable to devote the time and effort necessary to identify all these difficult organisms beyond the general classifications presented in these tables as the "inclusive listing".

The shoreward ends of DRSX and LRSX terminated in the intertidal zone where rocky cliff faces fell vertically to the water's edge. We were occasionally able to inspect these portions of DRSX and LRSX during very calm weather. Consequently a few strictly intertidal species appear in the listings of Tables 10-3 and 10-4. We will not include these species in our analyses of responses by biota of our subtidal transects to the operational environment. These species are treated in Chapter 9 where a much more extensive data base was available.

SIMILARITIES AMONG STATIONS

Given our conclusion that the three stations yielded similar numbers of total species, as well as similar totals within Phyla, we also wished to determine whether this similarity extended to the species level of taxonomic ranking. We accordingly segregated the listings of Tables 10-3 and 10-4 into shared and unique species, to assess similarities and dissimilarities among the stations.

About half to two thirds of the total complement of plant and animal species occurred at all three stations (Table 10-5). Unique species comprised roughly a fourth to a fifth of the total complement at each station. Almost all of the unique species were organisms with low survey occurrences (i.e., they were "rare" and were seen only once or twice at a single station during the 20 year survey period). Exceptions were a foliaceous Red Alga, *Weeksia digitata*, which occurred four times during preoperational years only at LRSX, and a sea slug, *Tritonia festiva*, noted five times throughout the entire 20 years only at DCSX. The evidence at hand thus suggested that the three stations were quite similar as to their biota, even when examined at the species level.

Considering those species occurring at only two of the three stations, DCSX and DRSX shared 58 plants and animals, DRSX and LRSX shared 64, while DCSX and LRSX shared only 19 organisms. It appeared that DRSX was the "cosmopolitan" station with strong similarities to both DCSX and LRSX. DCSX and LRSX displayed the least similarities. The differences were rather minor, however, because species shared between only two stations comprised a rather small fraction of the total species present at each station.

VERTICAL DISTRIBUTIONS

All three transects included sections situated above as well as below the thermocline. This broad vertical coverage permitted us to examine areas with and without potential for significant exposure to discharged effluent. During our final survey in October 1987, we made separate tallies of species lying above and below 6 m (20 ft) depths, to provide information on the vertical distributions along the transects (Tables 10-6 and 10-7). This method of separation was fairly arbitrary because thermocline depth was quite variable along DCSX and DRSX. We chose 6 m (20 ft) because this was the depth below which minimal changes had been observed in the palm

Table 10-5: Numbers of subtidal species (or similar taxa) grouped according to Phylum, showing occurences per station as well as numbers of species unique to or shared with other stations. Includes lab identifications from field but not from solid substrate analysis.

	DCSX				DRSX				LRSX				Site	
Phylum	Total species for Station	Unique species for Station	Species shared with DRSX only	Species shared with LRSX only	Total species for Station	Unique species for Station	Species shared with DCSX only	Species shared with LRSX only	Total species for Station	Unique species for Station	Species shared with DCSX only	Species shared with DRSX only	Species occurring at all 3 Stations	Total Species per Phylum
						PLANTS								
CHLOROPHYTA	6	1	1	0	7	2	1	0	5	1	0	0	4	9
PHAEOPHYTA	16	4	3	0	16	3	3	1	12	2	0	1	9	22
RHODOPHYTA	108	20	20	8	121	24	20	17	108	23	8	17	60	173
Total Plants	130	25	24	8	144	29	24	18	125	26	8	18	73	204
						ANIMAL								
PROTOZOA	1	0	0	0	1	0	0	0	1	0	0	0	1	1
PORIFERA	23	3	6	1	27	5	6	3	20	3	1	3	13	34
CNIDARIA	18	1	2	1	20	2	2	2	18	1	1	2	14	23
NEMERTEA	1	0	0	1	0	0	0	0	1	0	1	0	0	1
ASCHELMINTHES	0	0	0	0	1	0	0	1	1	0	0	1	0	1
BRYOZOA	12	2	0	0	42	28	0	4	15	1	0	4	10	45
ANNELIDA	20	3	5	1	24	6	5	2	24	10	1	2	11	38
MOLLUSCA	57	15	12	5	71	25	12	9	46	7	5	9	25	98
ARTHROPODA	20	4	3	0	34	16	3	2	20	5	0	2	13	43
ECHINODERMATA	13	0	0	0	19	4	0	2	17	2	0	2	13	21
CHORDATA-TUNICATA	17	1	1	0	21	3	1	2	18	1	0	2	15	23
CHORDATA-PISCES	38	6	5	2	34	3	5	1	36	8	2	1	25	50
Total Animals	220	35	34	11	294	92	34	28	217	38	11	28	140	378
Total Plants + Animals	350	70	58	19	438	116	58	46	342	64	19	46	213	582

kelp populations. There was a transitional zone between 3 and 6 m (10 and 20 ft) depths where varying degrees of change were apparent. Drastic changes were nearly always present at 3 m (10 ft) depths and shallower, but our DCSX transect terminated at about that depth. Tables 10-6 and 10-7 thus list some "probably sensitive" species as still occurring in shallow waters of Diablo Cove (e.g., *Laminaria*, *Pterygophora*, *Balanophyllia*). With these few exceptions, the vertical distributions determined during our final subtidal survey were helpful in identifying those species believed to be sensitive to the operational environment above the thermocline.

Table 10-6: Plant species (or similar taxon) observed along our subtidal transects during the October 1987 survey in the Diablo Canyon region. Station designations were: a=DCSX, A=DCSX deep, b=DRSX shallow, B=DRSX deep, c=LRSX shallow, C=LRSX deep.

Organism	Station					
	a	A	b	B	c	C
CHLOROPHYTA						
Unid. filamentous			x			
PHAEOPHYTA						
Cystoseira osmundacea	x	x		x	x	x
Desmarestia ligulata	x	x		x		x
Dictyoneurum californicum	x			x		x
Ectocarpus sp			x			
Laminaria dentigera	x	x		x	x	x
Macrocystis pyrifera						x
Nereocystis luetkeana		x				
Pterygophora californica	x	x		x	x	x
RHODOPHYTA						
Antithamnion sp			x			
Bossiella orbigniana	x		x			
Bossiella sp			x			
Botryglossum farlowianum	x	x		x	x	x
Calliarthron cheilosporioides	x	x	x		x	
Callophyllis firma				x		
Callophyllis flabellulata		x		x		x
Callophyllis pinnata					x	
Callophyllis violacea		x		x		x
Corallina officinalis			x			
Cryptopleura violacea	x		x			
Erythrophyllum delesserioides		x				
Farlowia conferta	x					
Gelidium robustum	x	x	x			
Gigartina corymbifera	x	x		x		
Gigartina exasperata	x	x	x	x	x	x
Gracillaria sjoestedtii						x
Halymenia californica					x	
Halymenia coccinea				x		x
Iridaea cordata				x		
Laurencia spectabilis			x			
Leptocladia binghamiae	x			x		
Lithothamnium sp	x	x	x	x	x	x
Microcladia coulteri				x		
Opuntiella californica		x			x	
Petrocelis franciscana			x			
Peyssonellia sp	x	x	x		x	x
Pikea californica	x			x	x	
Polyneura latissima		x			x	x
Prionitis lanceolata	x		x			
Rhodoglossum roseum	x			x		
Rhodymenia californica		x	x		x	
Rhodymenia pacifica		x		x		x
Schizymenia pacifica	x		x			x

Table 10-7: Animal species (or similar taxon) observed along our subtidal transects during the October 1987 survey in the Diablo Canyon region. Station designations were: a=DCSX shallow, A=DCSX deep, b= DRSX shallow, B= DRSX deep, c=LRSX shallow, C=LRSX deep.

Organism	Station					
	a	A	b	B	c	C
PORIFERA						
Cliona celata		x	x			
Hymenamphiastra cyanocrypta		x	x			x
Hymeniacidon siniapum						x
Leucandra heathi		x		x		x
Leucetta losangelensis			x			
Leucilla nuttingi		x				x
Penares cortius		x				
Plocamia karykina					x	
Prianos problematicus						x
Spheciospongia confoederata	x					
Tethya aurantia	x	x			x	x
CNIDARIA						
Aglaophenia sp.				x		
Anthopleura artemisia	x	x		x		
Anthopleura elegantissima	x		x		x	
Astrangia lajollaensis						x
Balanophyllia elegans	x	x		x		x
Corynactis californica	x	x	x		x	
Epiactis prolifica	x			x		
Hydractinia sp.		x				
Paracyathus stearnsi						x
Sertularella sp.		x				
Tealia sp.						x
BRYOZOA						
Crisia sp.		x		x	x	x
Costazia sp.		x		x	x	x
Diaporoecia californica		x		x	x	x
Flustrella corniculata					x	
Hippodiplosia insculpta		x		x		x
Lagenipora punctulata		x		x		x
Membranipora membranacea					x	
Phidolopora pacifica		x			x	
Rhynchozoon sp.						x
Scrupocellaria sp.						x
ANNELIDA						
Diopatra sp.				x		x
Dodecaceria fewkesi					x	
Eudistylia polymorpha	x	x	x			x
Myxicola infundibulum						x
Sabellidae			x			x
Salmacina tribranchiata				x		x

Table 10-7: Animal species (or similar taxon) observed along our subtidal transects during the October 1987 survey in the Diablo Canyon region. Station designations were: a=DCSX shallow, A=DCSX deep, b= DRSX shallow, B= DRSX deep, c=LRSX shallow, C=LRSX deep.

Organism	Station					
	a	A	b	B	c	C
Spirobranchis spinosus			x			
MOLLUSCA						
Acmaea mitra	x					
Anisodoris nobilis				x		
Astraea gibberosa						x
Calliostoma canaliculatum				x		x
Calliostoma ligatum		x	x		x	x
Calliostoma supragranosum	x					x
Collisella digitata			x			
Collisella instabilis	x			x		
Collisella pelta			x			
Collisella scabra			x			
Crepidula sp.	x			x		x
Dendrodoris sp.		x				
Diaulula sandiegensis						x
Flabellina iodinea		x				
Haliotis cracherodii			x			
Hinnites multirugosus		x	x			x
Hypselodoris californiensis	x					
Lottia gigantea			x			
Mitra idae		x		x		x
Mytilus sp.			x			
Pododesmus cepio		x		x		x
Serpulorbis squamigerus	x	x	x			x
Tegula spp.	x	x	x	x	x	x
Tonicella lineata				x		
Triopha carpenteri				x		
ARTHROPODA						
Balanus sp.	x			x		x
Balanus tintinnabulum			x			
Crangon sp.						x
Loxorhynchus crispatus	x		x			
Paguridae		x			x	x
Pollicipes polymerus			x			
Pugettia richii						x
ECHINODERMATA						
Orthasterias kohleri				x		
Patiria miniata	x	x	x	x	x	x
Pisaster brevispinus	x	x	x			x
Pisaster giganteus	x	x	x		x	x
Pisaster ochraceus			x			
Pycnopodia helianthoides	x			x		
Strongylocentrotus purpuratus	x		x			

Table 10-7: Animal species (or similar taxon) observed along our subtidal transects during the October 1987 survey in the Diablo Canyon region. Station designations were: a = DCSX shallow, A = DCSX deep, b = DRSX shallow, B = DRSX deep, c = LRSX shallow, C = LRSX deep.

	Station					
Organism	a	A	b	B	c	C
CHORDATA-Tunicata						
Archidistoma psammion	x					
Archidistoma sp.	x	x		x		
Boltenia villosa		x		x		x
Chelysoma producta				x		
Clavellina huntsmani				x		
Cnemidocarpa finmarkiensis		x				x
Cystodites sp.			x			x
Didemnum carnulentum		x		x	x	x
Pyura haustor		x		x		x
Ritterella pulchra		x				
Styela montereyensis	x	x		x	x	
Trididemnum opacum	x	x	x			x
CHORDATA-Pices						
Artedius corallinus						x
Atherinidae			x			
Chilara taylori						x
Chromis punctipinnis			x			
Coryphopterus nicholsii	x			x		x
Cottidae						x
Damalichthys vacca		x			x	
Embiotoca jacksoni				x	x	
Embiotoca lateralis	x	x	x			
Girella nigricans	x		x			
Gibbonsia sp.						x
Heterostichus rostratus			x		x	x
Hexagrammos decagrammus				x	x	
Hypsurus caryi		x				x
Medialuna californiensis	x		x			
Myliobatis californica	x		x			
Orthanopias triacis						x
Oxyjulis californica	x	x		x		x
Oxylebius pictus		x		x		x
Rachochilus toxotes	x	x	x		x	
Scorpaenichthys marmoratus				x		
Sebastes atrovirens		x				x
Sebastes chrysomelas				x		x
Sebastes mystinus			x		x	x
Sebastes serranoides		x				
Semicossyphus pulcher		x		x		
Triakis semifasciata	x					

CATEGORIZATION OF SUBTIDAL SPECIES

We divided the 20 years of our study into three sections corresponding to background (1968 to 1982), El Niño (1983 to 1984), and operational (1985 to 1987) periods. We then expressed the frequencies of survey occurrences during each of the three periods as percentages of total surveys accomplished during that period and listed results for each species at each station (Appendices 10-1A & 10-1B). The patterns of survey occurrences were used to identify sensitivity among the species to El Niño and to operational conditions. Survey occurrences for most species were too sparse to provide sufficient information for categorizing the organisms. Adequate records, however, did occur for 39 plant and 100 animal species. As noted above, we excluded intertidal organisms from consideration at this point in the analysis.

The majority of these select plants and animals did not appear to have been affected by either El Niño or by the new environment during the operational period (Tables 10-8 and 10-9). Responses to El Niño were frequently good predictors as to behavior during the operational period. Some organisms regarded as cold water species were classified as E (encouraged) or N (neither encouraged or discouraged) when we expected them to fall under the D (discouraged) group. Most of these anomalies arose due to species that maintained populations at subthermocline depths in Diablo Cove but disappeared or occurred as sickly specimens at shallow levels (see Tables 10-6 and 10-7). The sparse and/or sickly shallow species were *Cystoseira*, *Dictyoneurum*, *Laminaria*, *Pterygophora*, *Botryoglossum*, *Rhodymenia californica*, and *Balanophyllia*. Healthy populations of these seven species existed below the thermocline. We have identified these anomalous species in Tables 10-8 and 10-9 by the notation "deep" in the Remarks column. Although they were classified as N species in these tables (because they still occurred in Diablo Cove), the vertical distributions suggested that they were in fact affected by the operational environment and were more properly classed as D organisms.

Table 10-8: Categorization of subtidal plants according to presence/absence patterns along our transects: E = encouraged, D = discouraged, N = neither, by the 1983-84 El Niño and/or the postoperational environment. ? = evidence for categorization was weak. "Deep" indicates a subthermocline population persisted, "variable" indicates response differed between transects.

	El Niño Response			Post-1984 Response			
Species	E	D	N	E	D	N	Remarks
CHLOROPHYTA							
Halicystis ovalis		x					
Ulva sp	x?					x	
PHAEOPHYTA							
Cystoseira osmundacea			x			x	deep
Desmarestia ligulata			x			x	deep
Dictyoneurum californicum			x			x	deep
Dictyota sp		x					
Egregia menziesii		x			x?		
Laminaria dentigera			x			x	deep
Macrocystis pyrifera			x				
Nereocystis luetkeana		x					var. deep
Pterygophora californica			x			x	deep
RHODOPHYTA							
Bossiella sp			x			x	
Botryoglossum farlowianum			x			x	deep
Calliarthron cheilosporioides			x			x	
Callophyllis flabellulata			x			x	deep
Callophyllis heanophylla		x					
Callophyllis pinnata		x?					
Callophyllis violacea			x	x			deep
Cryptopleura violacea				x			
Gelidium robustum			x	x			
Gigartina corymbifera			x			x	
Gigartina exasperata			x			x	
Gymnogongrus platyphyllus		x					
Halymenia californica		x					
Halymenia coccinea		x					
Iridaea cordata				x			deep
Laurencia spectabilis				x			
Lithothamnium sp			x			x	
Microcladia coulteri	x?				x		
Neoagardhiella gaudichaudi	x			x?			
Neoptilota densa		x	x		x		variable
Opuntiella californica		x?	x			x	var, deep
Peyssonellia sp			x			x	
Polyneura latissima			x			x	deep
Prionitis australis						x?	deep
Prionitis lanceolata	x			x			
Rhodoglossum roseum				x?			
Rhodymenia californica	x					x	deep
Rhodymenia pacifica			x			x	deep
Weeksia reticulata			x		x?		deep

Table 10-9: Categorization of subtidal animals according to presence/absence patterns along our transects: E = encouraged, D = discouraged, N = neither, by the 1983-84 El Niño and/or the post-1984 environment. ? = evidence for categorization was weak. "Deep" indicates a subthermocline population persisted, "variable" indicates response differed between transects.

Species	El Niño Response E	D	N	Post-1984 Response E	D	N	Remarks
PORIFERA							
Astylinifer arndti		x					
Cliona celata	x					x	
Haliclona lunisimilis		x					
Hymenamphiastra cyanocrypta			x			x	
Leucandra heathi			x			x	deep
Leucetta losangelensis				x			
Leucilla nuttingi			x		x?		deep
Leucosolenia sp.		x					
Plocamia karykina	x?				x		variable
Prianos problematicus			x		x?		
Spheciospongia confoederata			x			x	
Tethya aurantia			x			x	
CNIDARIA							
Aglaophenia sp.	x?					x	deep
Anthopleura artemisia	x					x	
Anthopleura elegantissima			x			x	
Anthopleura xanthogrammica		x?				x?	variable
Astrangia lajollaensis			x			x	
Balanophyllia elegans			x			x	
Corynactis californica			x			x	
Epiactis prolifica			x			x	
Hydractinia sp.	x					x?	
Paracyathus stearnsi			x				deep
Tealia sp.			x			x	deep
BRYOZOA							
Costazia sp.			x?			x?	variable
Crisia sp.			x			x	deep
Diaporoecia californica						x	deep
Hippodiplosia insculpta			x			x	deep
Lagenipora punctulata		x				x	deep
Phidolopora pacifica			x			x	deep
Rhynchozoon sp.			x		x		
ANNELIDA							
Diopatra sp.			x			x	
Dodecaceria fewkesi		x?			x?		variable
Eudistylia polymorpha			x			x	
Phragmatopoma californica	x?					x	variable
Pista elongata			x		x		
Salmacina tribranchiata			x			x	
Spirobranchis spinosus						x	
MOLLUSCA							
Acmaea mitra			x			x?	
Anisodoris nobilis			x		x?		
Astraea gibberosa		x				x	deep
Calliostoma annulatum			x		x?		
Calliostoma canaliculatum	x					x	deep
Calliostoma ligatum			x			x	

Table 10-9: Categorization of subtidal animals according to presence/absence patterns along our transects: E = encouraged, D = discouraged, N = neither, by the 1983-84 El Niño and/or the post-1984 environment. ? = evidence for categorization was weak. "Deep" indicates a subthermocline population persisted, "variable" indicates response differed between transects.

Species	El Niño Response			Post-1984 Response			Remarks
	E	D	N	E	D	N	
Dendrodoris sp.			x			x	
Diaulula sandiegensis		x?					variable
Flabellina iodinea			x				
Haliotis rufescens			x?			x	otter effect
Hinnites multirugosus			x			x	
Hopkinsia rosacea			x				
Mitra idae			x		x?	x	var., deep
Pododesmus cepio			x			x	
Pteropurpura trialatus			x				
Serpulorbis squamigerus			x			x	
Tegula spp.			x			x	
Tonicella lineata		x?			x?		variable
ARTHROPODA							
Balanus sp.		x				x	variable
Balanus tintinnabulum				x?			
Loxorhynchus crispatus			x			x	
Paguridae			x			x	
ECHINODERMATA							
Cucumaria sp.			x		x		deep
Henricia leviuscula		x					
Leptasterias sp.		x?					variable
Orthasterias kohleri		x					
Parastichopus parvimensis			x		x?		
Patiria miniata			x			x	
Pisaster brevispinus			x?			x	variable
Pisaster giganteus			x			x	
Pisaster ochraceus			x			x	variable
Pycnopodia helianthoides			x			x	
Strongylocentrotus franciscanus		x?					otter effect
Strongylocentrotus purpuratus						x	otter effect
CHORDATA-Tunicata							
Archidistoma psammion		x?					
Boltenia villosa			x			x	deep
Cnemidocarpa finmarkiensis			x		x?		deep
Cystodites sp.			x			x	
Didemnum carnulentum			x			x	
Pyura haustor			x			x	deep
Ritterella pulchra	x					x	deep
Styela montereyensis			x			x	
Trididemnum opacum						x	
CHORDATA-Pisces							
Coryphopterus nicholsi			x?		x?		
Damalichthys vacca		x		x			
Embiotoca jacksoni	x?					x	
Embiotoca lateralis			x			x	
Girella nigricans	x					x	
Heterostichus rostratus		x				x	
Medialuna californiensis	x					x	

Table 10-9: Categorization of subtidal animals according to presence/absence patterns along our transects: E=encouraged, D=discouraged, N=neither, by the 1983-84 El Niño and/or the post-1984 environment. ?=evidence for categorization was weak. "Deep" indicates a subthermocline population persisted, "variable" indicates response differed between transects.

Species	El Niño Response E	D	N	Post-1984 Response E	D	N	Remarks
Myliobatis californica				x			
Ophiodon elongatus			x?			x	deep
Oxyjulis californica	x		x	x			variable
Oxylebius pictus	x?					x?	deep
Rhacochilus toxotes	x?					x?	variable
Scorpaenichthys marmoratus	x					x?	deep
Sebastes atrovirens	x						
Sebastes chrysomelas			x			x	
Sebastes mystinus			x		x?		
Semicossyphus pulcher	x					x	
Triakis semifasciata				x			

One plant, the bull kelp *Nereocystis*, was unique in our sampling in that a single individual could span the entire water column. Basal portions remained at subthermocline levels while the upper portions of adult plants were exposed to warm temperatures of the operational environment. We continually saw numerous examples of adult plants with sickly blade crowns but healthy lower stipes and holdfasts. A small colony of *Macrocystis* in Diablo Cove (located at some distance from any of our sampling areas) behaved similarly. These two large kelp species were able to recruit and maintain populations in the deeper parts of Diablo Cove, but should nonetheless be regarded as affected species.

One Brown Alga, *Dictyota*, appeared fairly commonly in Diablo Cove during preoperational years, but became scarce during El Niño and no longer occurred here. *Dictyota* may have been eliminated by El Niño but apparently was not able to recolonize the Cove afterwards. The disappearance seems to have been general, however, because we have searched for it without success at LRSX and at Intake Cove. Elevated water temperatures do not suffice to explain the disappearance of *Dictyota* here because this species occurs commonly and widely in the southern California intertidal.

A few animals were impacted so seriously by El Niño that they disappeared altogether from Diablo Cove and the surrounding coastline. Some had not reappeared by the end of 1987. Species that disappeared and failed to return were *Astylinifer*, *Haliclona lunisimilis*, *Leucosolenia*, and *Henricia*. *Astraea* and *Orthasterias* also disappeared during El Niño but a few individuals reappeared at subthermocline depths in 1987. Presumably the four species that failed to reappear would have done poorly in the operational environment if a major El Niño had not occurred just before startup operations at DCPP. The bat star, *Patiria*, declined drastically in southern California kelp beds at the beginning of the 1983-84 El Niño, but the populations in the Diablo Canyon region apparently persisted without difficulty.

A number of invertebrates that form turflike cover on rocky substrates were adversely impacted by El Niño. Most of these animals were too small to be easily detected by gross observation while diving and are treated separately in Chapter 11. Many sponges, Bryozoans and colonial tunicates became scarce or disappeared altogether during El Niño. The listings of Tables 10-8 and 10-9 contain only the larger and more easily identified members of the invertebrate turf. Some of the species lost during El Niño were never adequately identified and appeared in our listings only as part of the "inclusive" taxa (examples: unid. sponges, unid. colonial tunicates in Table 10-4). Fairly diverse aggregations of invertebrate turf had returned to Diablo Cove as of the end of 1987, but occurred on deep-lying crevices and ledges. Such assemblages were scarce or greatly modified when they appeared at levels above the thermocline.

One small Cnidarian, the pink anemone *Corynactis*, tolerated El Niño well and seems to have flourished in the operational environment. Many thousand *Corynactis* formed continuous coverage across large areas of overhanging cliff surfaces in the shallows along the lee side of Diablo Rock (i.e., directly exposed to diluted plume waters). Sheets of almost pure *Corynactis* replaced the highly diverse invertebrate turf that formerly occurred on these undercut cliffs. We classified *Corynactis* as an N organism in Table 10-9 because it occurred in only modest numbers along our transects. Based on our extra-limital observations, however, we regard *Corynactis* as belonging in the E category.

A few subtidal species were apparently encouraged by El Niño. Most of the plants and invertebrates in this category occurred sparsely scattered throughout the various Phyla, but the fishes contained a substantial number of species that were enhanced by El Niño. The same species appear to be doing well under operational conditions in Diablo Cove. Three non-indigenous species (*Girella*, *Medialuna*, and *Semicossyphus*) were of special interest. Apparently substantial numbers of juveniles were introduced to the region from southern waters during El Niño. Survivors from this introduction remained as adults in the Diablo Cove shallows at the end of 1987. These three species were rare or absent from surveys conducted prior to 1983 and they are still uncommon outside of Diablo Cove.

Two other fish species (leopard shark, *Triakis*, and bat ray, *Myliobatis*) that were not encountered during our preoperational surveys, now occur commonly in the Diablo Cove shallows. They were probably not introduced as juveniles by El Niño but instead represented individuals native to the region and attracted to the warm plume from sparse and widely distributed local populations.

One noteworthy sponge species, *Leucetta*, was a warm-tolerant form that was probably not indigenous to this stretch of open coast but became introduced from elsewhere during latter 1986 or early 1987. It briefly flourished in Diablo Cove during summer and early fall 1987. Hundreds of colonies encrusted vertical cliffs on the lee side of Diablo Rock. These colonies nearly all disappeared within about a month in September-October 1987. This rather delicate animal apparently was unable to withstand the rough conditions of an open coast environment after the first autumn storms passed through (*Leucetta* is common in protected locations such as bays in southern California). These invasions of the Diablo Cove subtidal by *Leucetta*, *Girella*, *Medialuna*, and *Semicossyphus* demonstrated that introductions of southern species can occur here. It remains doubtful, however, whether such exotics will be able to establish breeding populations capable of maintaining the isolated colonies.

In summary, the analyses displayed in Tables 10-8 and 10-9, identified 8 plant and 6 animal species as being encouraged by the operational environment. Three plants and 15 animals were classed as discouraged. Twenty plants and 65 animals fell in the N category. The latter group, however, included 16 plants and 26 animals that largely or entirely consisted of populations situated at subthermocline depths inside Diablo Cove. Most of these deep-lying species formerly occurred in shallow parts of the Cove. These deeply-occurring species are regarded as more properly belonging in the class of species discouraged by the operational environment of the Cove, rather than residing in the N category. Examples were the forests of palm kelps that disappeared from the shallows but remained at subthermocline depths. The presumably sensitive species still occurring below the thermocline are discussed further in Chapter 13 and are listed under the "O" columns of Tables 13-1 and 13-2.

APPENDIX 10-1

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Appendix 10-1A: Percent of surveys that selected subtidal PLANT species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations. An 'L' entry indicates Lab only.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
CHLOROPHYTA					
Ulva sp.	DCSX	47	41	33	66
	DRSX	50	30	66	83
	LRSX	25	27	66	
PHAEOPHYTA					
Cystoseira osmundacea	DCSX	80	75	100	83
	DRSX	86	76	100	100
	LRSX	75	63	100	83
Desmarestia ligulata var. *ligulata*	DCSX	57	50	66	66
	DRSX	40	38	33	50
	LRSX	90	100	66	83
Dictyoneurum californicum	DCSX	76	83	100	50
	DRSX	72	69	66	83
	LRSX	80	81	100	66
Dictyota sp.	DCSX	38	58	33	
	DRSX	36	61		
	LRSX	5	9		
Egregia menziesii	DCSX	14	25		
	DRSX	54	76	33	16
	LRSX	10	9	16	
Laminaria dentigera	DCSX	76	58	100	100
	DRSX	100	100	100	100
	LRSX	85	72	100	100
Macrocystis pyrifera	DCSX	4	33		
	DRSX	18	66	33	
	LRSX	50	27	66	83
Nereocystis luetkeana	DCSX	52	66	50	
	DRSX	63	76	66	33
	LRSX	45	63	33	16
Pterygophora californica	DCSX	100	100	100	100
	DRSX	77	61	100	100
	LRSX	95	90	100	100
RHODOPHYTA					
Bossiella sp.	DCSX	52	58	66	33
	DRSX	68	69	66	66
	LRSX	45	36	100	33
Botryoglossum farlowianum	DCSX	95	91	100	100
	DRSX	90	84	100	100
	LRSX	80	81	100	66
Calliarthron sp.	DCSX	100	100	100	100
	DRSX	100	100	100	100
	LRSX	90	100	100	66

Appendix 10-1A: Percent of surveys that selected subtidal PLANT species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations. An 'L' entry indicates Lab only.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Callophyllis firma	DCSX	14	L	L	16
	DRSX	27	L	66	50
	LRSX	20	27	16	
Callophyllis flabellulata	DCSX	61	50	66	83
	DRSX	86	92	66	83
	LRSX	85	90	100	66
Callophyllis heanophylla	DCSX	14	16	L	
	DRSX	13	23		
	LRSX	40	72		
Callophyllis pinnata	DCSX	19	16	L	16
	DRSX	50	53	L	50
	LRSX	40	36	L	50
Callophyllis violacea	DCSX	66	41	100	100
	DRSX	77	61	100	100
	LRSX	80	90	100	50
Cryptopleura violacea	DCSX	19	66		
	DRSX	22	L	66	
	LRSX	10	L	L	
Gelidium robustum	DCSX	33	L	33	83
	DRSX	63	38	100	100
	LRSX	20	L	66	16
Gigartina corymbifera	DCSX	47	41	66	50
	DRSX	50	30	100	66
	LRSX	35	45	66	
Gigartina exasperata	DCSX	71	58	66	100
	DRSX	90	84	100	100
	LRSX	85	90	100	66
Gymnogongrus platyphyllus	DCSX	9	8	16	
	DRSX	13	50		
	LRSX	30	45	L	
Halymenia californica	DCSX	4	8		
	DRSX	22	30	L	
	LRSX	25	36	16	
Halymenia coccinea	DCSX	23	16	L	33
	DRSX	31	30	L	33
	LRSX	50	63	L	33
Iridaea cordata	DCSX	4	8		
	DRSX	50	30	L	100
	LRSX				
Laurencia spectabilis	DCSX	33	16	33	66
	DRSX	22	7	66	
	LRSX	30	27	66	16
Lithothamnium sp.	DCSX	95	100	66	100
	DRSX	100	100	100	100
	LRSX	90	100	100	66

Appendix 10-1A: Percent of surveys that selected subtidal PLANT species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations. An 'L' entry indicates Lab only.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Microcladia coulteri	DCSX	28	16	33	50
	DRSX	40	38	100	16
	LRSX	30	27	33	33
Neoptilota densa	DCSX	66	75	100	33
	DRSX	45	69	L	
	LRSX	50	54	66	33
Opuntiella californica	DCSX	90	100	100	66
	DRSX	68	84	33	50
	LRSX	70	81	100	33
Petrocelis franciscana	DCSX				
	DRSX	40	53	33	16
	LRSX	5	9		
Peyssonellia sp.	DCSX	100	100	100	100
	DRSX	81	84	66	83
	LRSX	85	90	100	66
Polyneura latissima	DCSX	66	66	66	66
	DRSX	68	53	100	83
	LRSX	85	90	100	66
Prionitis angusta	DCSX	23	16	66	16
	DRSX	22	30	33	
	LRSX	15	18	33	
Prionitis australis	DCSX	28	25	66	16
	DRSX	27	23	L	33
	LRSX	5	33		
Prionitis lanceolata	DCSX	61	41	66	100
	DRSX	68	46	100	100
	LRSX	25	18	66	16
Pseudogloiophloea confusa	DCSX	14	16	L	
	DRSX	18	30		
	LRSX	15	27		
Rhodoglossum roseum	DCSX	14	L	33	
	DRSX	22	L	L	50
	LRSX	10	L	L	
Rhodymenia californica	DCSX	52	41	100	50
	DRSX	77	69	100	83
	LRSX	75	72	100	66
Rhodymenia pacifica	DCSX	66	58	66	83
	DRSX	77	61	100	100
	LRSX	60	45	100	66
Schizymenia pacifica	DCSX	19	L	L	33
	DRSX	36	30	L	50
	LRSX	15	L	L	16
Weeksia reticulata	DCSX	38	41	66	16
	DRSX	45	46	66	33
	LRSX	45	36	66	50

Appendix 10-1A: Percent of surveys that selected subtidal PLANT species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations. An 'L' entry indicates Lab only.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Number of Taxa Listed	DCSX	42	40	34	36
	DRSX	43	40	37	38
	LRSX	42	40	35	32
Includes ALL Entries					
# of Taxa	DCSX	131	113	54	54
	DRSX	144	114	71	62
	LRSX	125	102	61	50
# of Taxa LabO	DCSX	0	60	21	8
	DRSX	0	44	33	12
	LRSX	0	46	23	14
# of Surveys	DCSX	21	12	3	6
	DRSX	22	13	3	6
	LRSX	20	11	3	6

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
PORIFERA					
Cliona celata	DCSX	52	41	100	50
	DRSX	36	30	66	33
	LRSX	30	27	100	
Haliclona lunisimilis	DCSX	23	41		
	DRSX	4	7		
	LRSX	20	36		
Hymenamphiastra cyanocrypta	DCSX	38	25	66	50
	DRSX	63	53	100	66
	LRSX	65	63	66	66
Leucilla nuttingi	DCSX	57	66	66	33
	DRSX	31	38	33	16
	LRSX	65	63	100	50
Leuconia heathi	DCSX	52	58	66	33
	DRSX	50	46	33	66
	LRSX	65	63	100	50
Leucosolenia sp.	DCSX				
	DRSX	13	23		
	LRSX	35	54	33	
Plocamia karykina	DCSX	28	33	66	
	DRSX	27	38	33	
	LRSX	25	9	66	33
Prianos problematicus	DCSX				
	DRSX	22	30	33	
	LRSX	60	54	100	50
Tethya aurantia	DCSX	100	100	100	100
	DRSX	36	30	66	33
	LRSX	85	90	100	66
CNIDARIA					
Aglaophenia sp.	DCSX	9		33	16
	DRSX	68	69	100	50
	LRSX	30	18	100	16
Anthopleura artemisia	DCSX	42	25	66	66
	DRSX	54	38	66	83
	LRSX	25	9	100	16
Anthopleura elegantissima	DCSX	71	50	100	100
	DRSX	54	46	33	83
	LRSX	45	27	66	66
Anthopleura xanthogrammica	DCSX	28	50		
	DRSX	77	84	100	50
	LRSX	30	54		
Astrangia lajollanensis	DCSX	14	16		16
	DRSX	54	53	66	50
	LRSX	85	90	100	66

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Balanophyllia elegans	DCSX	100	100	100	100
	DRSX	95	92	100	100
	LRSX	90	100	100	66
Corynactis californica	DCSX	28	25		50
	DRSX	77	76	66	83
	LRSX	80	81	100	66
Epiactis prolifera	DCSX	71	50	100	100
	DRSX	45	38	66	50
	LRSX	10	9		16
Hydractinia sp.	DCSX	28	16	66	33
	DRSX	18	15	66	
	LRSX	25	27	66	
Paracyathus stearnsi	DCSX				
	DRSX	13	15		16
	LRSX	85	90	100	66
Tealia sp.	DCSX	33	33	66	16
	DRSX	45	38	100	33
	LRSX	95	100	100	83
Unid. hydroids	DCSX	23	33	33	
	DRSX	31	46	33	
	LRSX	35	54	33	
BRYOZOA					
Costazia sp.	DCSX	28	41		16
	DRSX	63	61	33	83
	LRSX	60	45	100	66
Crisia sp.	DCSX	19	16	33	16
	DRSX	72	69	100	66
	LRSX	45	36	100	33
Diaperoecia californica	DCSX	14	8	33	16
	DRSX	36	23	33	66
	LRSX	20	9	33	33
Hippodiplosia insculpta	DCSX	9	8		16
	DRSX	45	38	33	66
	LRSX	45	18	100	66
Hippoporina sp.	DCSX	14	25		
	DRSX	13	15	33	
	LRSX	20	27	33	
Lagenipora punctulata	DCSX	19	16		33
	DRSX	31	23		66
	LRSX	25	18		50
Membranipora sp.	DCSX	28	33	33	16
	DRSX	40	53	33	16
	LRSX	50	63	33	33
Phidolopora pacifica	DCSX	4			16
	DRSX	54	61	66	33
	LRSX	70	63	100	66

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Rhynchozoon	DCSX	23	41		
sp.	DRSX	40	53	66	
	LRSX	65	72	100	33
MOLLUSCA					
Acmaea	DCSX	85	91	100	66
mitra	DRSX	63	76	66	33
	LRSX	35	54	33	
Anisodoris	DCSX	23	33	33	
nobilis	DRSX	27	30	33	16
	LRSX	25	36		16
Astraea	DCSX	52	83		16
gibberosa	DRSX	68	92	33	33
	LRSX	65	90	33	33
Calliostoma	DCSX	23	25	66	
annulatum	DRSX	45	61	33	16
	LRSX	50	45	100	33
Calliostoma	DCSX	47	33	100	50
canaliculatum	DRSX	86	76	100	100
	LRSX	55	45	100	50
Calliostoma	DCSX	19	8		50
ligatum	DRSX	27	15	33	50
	LRSX	30	27	33	33
Dendrodoris	DCSX	76	75	100	66
sp.	DRSX	59	61	66	50
	LRSX	65	72	100	33
Diaulula	DCSX	4	8		
sandiegensis	DRSX	9	15		
	LRSX	55	54	66	50
Haliotis	DCSX	42	41	33	50
rufescens	DRSX	13	15		16
	LRSX	5	9		
Hinnites	DCSX	47	33	66	66
multirugosus	DRSX	68	76	66	50
	LRSX	50	63	66	16
Mitra	DCSX	52	66	66	16
idae	DRSX	54	53	66	50
	LRSX	75	81	100	50
Pteropurpura	DCSX	19	16	33	16
trialatus	DRSX	18	30		
	LRSX	30	36	33	16
Serpulorbis	DCSX	66	75	33	66
squamigerus	DRSX	68	76	66	50
	LRSX	70	81	66	50
Tegula	DCSX	95	91	100	100
spp.	DRSX	90	84	100	100
	LRSX	50	45	100	33

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Tonicella lineata	DCSX	66	75	100	33
	DRSX	63	76	66	33
	LRSX	35	54		16
Triopha catalinae	DCSX	14	16		16
	DRSX	22	30		16
	LRSX	10	18		
ANNELIDA					
Diopatra sp.	DCSX	71	75	100	50
	DRSX	81	76	100	83
	LRSX	95	100	100	83
Dodecaceria sp.	DCSX	52	66	33	33
	DRSX	59	76	66	16
	LRSX	45	54	33	33
Eudistylia polymorpha	DCSX	66	83	33	50
	DRSX	81	92	66	66
	LRSX	50	45	66	50
Phragmatopoma californica	DCSX	61	66	100	33
	DRSX	54	46	66	66
	LRSX	10		33	16
Pista sp.	DCSX	42	50	66	16
	DRSX	36	53	33	
	LRSX	55	54	100	33
Salmacina tribranchiata	DCSX	14	16	33	
	DRSX	36	23	33	66
	LRSX	25	9	33	50
Unid. sabellids	DCSX	47	50	66	33
	DRSX	54	61	66	33
	LRSX	65	72	66	50
Unid. spirorbinids	DCSX	38	50	33	16
	DRSX	45	38	100	33
	LRSX	45	54	66	16
ARTHROPODA					
Balanus sp.	DCSX	42	41	33	50
	DRSX	50	61		50
	LRSX	25	36		16
Balanus tintinabulum	DCSX	33	33	33	33
	DRSX	27	15	33	50
	LRSX	5	9		
Scyra acutifrons	DCSX	14	16		16
	DRSX	18	23		16
	LRSX	20	27	33	
Unid. pagurids	DCSX	66	58	100	66
	DRSX	59	53	100	50
	LRSX	40	27	66	50

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
ECHINODERMATA					
Cucumaria sp.	DCSX	47	58	66	16
	DRSX	31	38	33	16
	LRSX	20	27	33	
Henricia leviuscula	DCSX	38	58	33	
	DRSX	18	30		
	LRSX	15	18	33	
Leptasterias sp.	DCSX	47	75		16
	DRSX	45	53	66	16
	LRSX	35	54	33	
Ophiothrix spiculata	DCSX	9	16		
	DRSX	27	30	33	16
	LRSX	15		66	16
Orthasterias koehleri	DCSX	14	25		
	DRSX	45	53	33	33
	LRSX	50	90		
Patiria miniata	DCSX	95	100	100	83
	DRSX	100	100	100	100
	LRSX	95	100	100	83
Pisaster brevispinus	DCSX	61	66	66	50
	DRSX	22	15		50
	LRSX	50	63	33	33
Pisaster giganteus	DCSX	90	83	100	100
	DRSX	81	76	100	83
	LRSX	85	90	100	66
Pisaster ochraceus	DCSX	19	25	33	
	DRSX	86	84	66	100
	LRSX	35	63		
Pycnopodia helianthoides	DCSX	66	66	100	50
	DRSX	59	61	66	50
	LRSX	60	72	66	33
Parastichopus sp.	DCSX	9	16		
	DRSX	31	23	100	16
	LRSX	50	54	66	33
Strongylocentrotus franciscanus	DCSX	14	25		
	DRSX	45	69	33	
	LRSX	40	54	33	16
Strongylocentrotus purpuratus	DCSX	33	25		66
	DRSX	40	46	33	33
	LRSX	30	27	33	33
TUNICATA					
Boltenia villosa	DCSX	47	50	33	50
	DRSX	63	61	66	66
	LRSX	70	63	100	66

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Cnemidocarpa finmarkiensis	DCSX	33	41	33	16
	DRSX	18	23	33	
	LRSX	30	18	33	50
Cystodytes sp.	DCSX	19	16		33
	DRSX	40	30	66	50
	LRSX	10	9		16
Didemnum carnulentum	DCSX	90	91	100	83
	DRSX	86	84	100	83
	LRSX	65	72	100	33
Archidistoma sp.	DCSX	28	41		16
	DRSX	18	23		16
	LRSX	25	36	33	
Archidistoma diaphenes	DCSX	19		33	50
	DRSX	13		33	33
	LRSX	15		33	33
Archidistoma psammion	DCSX	9	8		16
	DRSX	36	46	33	16
	LRSX	10	9	33	
Pyura haustor	DCSX	57	58	100	33
	DRSX	31	30		50
	LRSX	55	54	100	33
Ritterella pulchra	DCSX	33	16	66	50
	DRSX	36	15	66	66
	LRSX	10	9	33	
Styela montereyensis	DCSX	90	83	100	100
	DRSX	86	76	100	100
	LRSX	50	36	100	50
Trididemnum opacum	DCSX	19	8	33	33
	DRSX	22	7	33	50
	LRSX	10		33	16
Unid. tunicates	DCSX	28	33	66	
	DRSX	27	30	66	
	LRSX	15	18	33	
VERTEBRATA					
Coryphopterus nicholsi	DCSX	28	41		16
	DRSX	18	15	33	16
	LRSX	85	90	100	66
Embiotoca jacksoni	DCSX	33		100	66
	DRSX	59	38	100	83
	LRSX	35	18	33	66
Embiotoca lateralis	DCSX	66	58	100	66
	DRSX	72	84	66	50
	LRSX	40	36	66	33
Heterostichus rostratus	DCSX	47	58	33	33
	DRSX	59	61	33	66
	LRSX	65	72	33	66

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Hexagrammos decagrammus	DCSX	9	16		
	DRSX	31	30	66	16
	LRSX	25	27	33	16
Ophiodon elongatus	DCSX	42	41	66	33
	DRSX	4			16
	LRSX	10	9	33	
Orthanopias triacis	DCSX	23	25	66	
	DRSX	13	15	33	
	LRSX	30	27	66	16
Oxyjulis californica	DCSX	33	16	33	66
	DRSX	36	7	66	83
	LRSX	15		66	16
Oxylebius pictus	DCSX	33	41	33	16
	DRSX	40	38	66	33
	LRSX	40	27	100	33
Rhacochilus toxotes	DCSX	14	8	33	16
	DRSX	18		66	33
	LRSX	15	18		16
Rhacochilus vacca	DCSX	33	25		66
	DRSX	22	23		33
	LRSX	10	9		16
Scorpaenichthys marmoratus	DCSX	23	8	66	33
	DRSX	40	38	66	33
	LRSX	15	9	33	16
Sebastes atrovirens	DCSX	23	16	66	16
	DRSX	9		66	
	LRSX	60	36	100	83
Sebastes chrysomelas	DCSX	42	50	66	16
	DRSX	36	15	66	66
	LRSX	75	81	100	50
Sebastes melanops	DCSX	9	16		
	DRSX	13	15	33	
	LRSX	35	36	33	33
Sebastes mystinus	DCSX	66	75	100	33
	DRSX	72	69	100	66
	LRSX	80	90	100	50

Appendix 10-1B: Percent of surveys that selected subtidal ANIMAL species occurred for the preoperation surveys, El Niño surveys, and operational surveys in the Diablo Canyon area. Listed only if occurred in 10 or more station / survey combinations.

Taxon Name	Station	All Years Surveys	Pre-1983 Surveys	El Niño Surveys	1985-> Surveys
Number of Taxa Listed	DCSX	96	92	68	76
	DRSX	99	95	83	81
	LRSX	99	94	84	77
Includes **ALL** Entries					
# of Taxa	DCSX	220	176	99	112
	DRSX	294	5	109	116
	LRSX	217	179	104	111
# of Taxa Lab Only	DCSX	0	20		
	DRSX	0	87		
	LRSX	0	24		
# of Surveys	DCSX	21	12	3	6
	DRSX	22	13	3	6
	LRSX	20	11	3	6

Chapter 11

SOLID SUBSTRATE ANALYSES

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Tables

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INTRODUCTION

Our analyses of solid substrates (small cobbles, seaweed blades, shells, miscellaneous debris) was an activity designed to characterize the encrusting invertebrate turf. Most of the members of this biological aggregate are filter-feeders. As such, they probably assist in linking productivity by bacteria and nannoplankton to larger carnivores, including fishes, in the nearshore communities. Invertebrate turf is extremely complex, both in its composition and distribution. We did not attempt to assess abundances quantitatively of the turf or of any of the component species. This would be a large task in most cases and well beyond the scope of our studies. We simply noted occurrences of the various species with notations as to which were commonest in our samples. We also developed some indication of the vertical distributions during the final year of our study (i.e., whether a species occurred above and/or below the thermocline). Lack of quantification, as well as other limitations, left much to be desired. Consequently this analysis is best considered as a preliminary effort toward characterizing what is probably an important element of the nearshore ecosystem. In spite of our simplistic approach, we were nonetheless able to identify responses by many of the invertebrate species to the operational environment in Diablo Cove.

One important limitation to our study was related to our sampling methodology, involving examination of easily collectible material. Small cobbles and debris tend to move during large storms. Substrate movement can affect attached biota by way of crushing or eroding organisms, or the substrate may become deposited in a different, possibly unsuitable, environment or position. Thus encrustations on small moveable substrates are usually substantially less abundant than on nearby bedrock or large boulders. Consequently, the substrates we examined may not have been entirely representative of the large masses of invertebrate turf occurring on stable rocky habitats. We were able to reduce this difficulty to some extent by avoiding obviously unstable and barren cobble when we collected our samples. We selected those rocks and shells that supported the best available coverage by encrusting plants and animals.

A second limitation arose from our method for preserving the samples. They were simply allowed to dry. Drying did not affect the recognition of species with hard skeletons or shells, but it removed most soft-bodied organisms from consideration. Phyla or classes most affected were Cnidaria, Annelida, and Tunicata. Care was also taken to differentiate between shells or skeletal remains that represented living animals at the time of collection, from those that were simply relics from long-dead organisms. Our tallies represented only specimens considered to be living at the time of collection.

Our usual sampling period for collecting solid substrates was the final subtidal survey of each year. We sometimes encountered very unfavorable weather during the normal sampling period. Good underwater visibilities and calm seas were desirable, especially for the DCSX station. In such cases, we made additional collections at other times to compensate for the inability to gather samples during the normal survey period (Table 11-1). These supplemental collections were considered as belonging to the "regular" sampling period, when processing the data. Two sampling sets were affected: August 1985 was combined with December 1985 and May 1987 was combined with December 1986. We advanced our final survey in late 1987 from December to October to avoid possibilities of bad weather (conditions for our October 1987 survey were excellent and this was the best collection of the entire series).

Table 11-1: Year and month when samples of solid substrates were collected from the Diablo Canyon region, segregated according to station and depth.

Collection Year/Month	DCSX 3m Depth	DCSX 8m Depth	DRSX 3m Depth	DRSX 8m Depth	LRSX 5m Depth
1982 December	x	x	x	x	x
1983 December	x		x	x	x
1984 December	x	x	x	x	x
1985 August	x			x	x
1985 December		x		x	x
1986 December		x	x	x	x
1987 May	x		x		
1987 October	x	x	x	x	x

SPECIES ENCOUNTERED

Our six year study yielded a total of 237 species of encrusting invertebrates divided among eight Phyla (Table 11-2). Bryozoa (moss animals) comprised 36 percent of the species, followed by Mollusca (20 percent), then Porifera (sponges, at 18 percent), Arthropoda (11 percent), Annelida (8 percent) Cnidaria (4 percent) and Echinodermata and Chordata-Tunicata, each at 1 percent. We have no measurements to allow comparisons of biomasses among the Phyla, but on the basis of observations we would estimate that Tunicata and Porifera would equal or exceed Bryozoa, followed by Mollusca and Cnidaria, with Arthropoda, Annelida, and Echinodermata comprising but a small fraction of the total. Bryozoans dominated the invertebrate turf from a numerical viewpoint. There were almost twice as many Bryozoan species as occurred for any other Phylum.

Table 11-2 also shows frequencies of occurrences of the species, providing some indication of their relative importance. By 1987 we were observing substantial changes in vertical distributions of many species other than kelps, so we increased our collections of solid substrates to include separate sets of samples from both shallow and deep locations (i.e., above and below the thermocline) for both stations within Diablo Cove. We have used these data to assess vertical distributions within the invertebrate turf.

TEMPORAL RELATIONSHIPS

We also segregated occurrences of species among Phyla by year for each station. The relative importance of most Phyla, described above for all stations and all years combined, was maintained for each individual station (Tables 11-3, 11-4, and 11-5). Comparing station totals for each year, values were always smallest at DCSX. Lowest totals at DCSX may have resulted from small scale topographic differences between DCSX and the other stations. Many of the cobble-bearing locations at DCSX were gentle depressions and shallow ravines. Cobbles usually occurred

Table 11-2: Species of encrusting or turf invertebrates identified from collections of solid substrates (cobbles, shells, algal blades, etc.) at the indicated stations. Numbers represent the total number of years for which a species occurred.

Species	DCSX	Station DRSX	LRSX
PORIFERA			
Acarnus erithacus	0	0	3
Anaata spongigartina	1	3	4
Antho lithophoenix	1	1	2
Astylinifer arndti	1	0	0
Cliona celata	3	5	1
Esperiopsis originalis	1	1	2
Eurypon asodes	0	1	1
Euryponidae	2	0	0
Gellius sp.	0	0	1
Geodia mesotriaeana	0	0	1
Halichondria panicea	1	0	0
Haliclona ecbasis	0	2	3
Haliclona permollis	0	1	1
Haliclona spp.	4	4	6
Haliclonidae	0	0	1
Hymedesmiidae	0	0	1
Hymenamphiastra cyanocrypta	0	0	2
Hymeniacidon siniapum	0	1	0
Leucandra heathi	3	3	5
Leucetta losangelensis	0	1	0
Leucilla nuttingi	0	0	2
Leucosolenia eleanor	0	1	3
Leucosolenia macleayi	0	2	0
Leucosolenia nautilia	0	3	2
Leucosolenia sp.	0	0	2
Lissodendoryx noxiosa	1	0	2
Microciona parthena	1	0	2
Microciona sp.	1	2	0
Microcionidae	1	1	1
Mycale sp.	0	1	1
Myxilla parasitica	1	1	1
Ophlitaspongia pennata	0	0	1
Paresperella psila	1	2	3
Plocamia karykina	1	3	2
Poecillastra sp.	0	1	0
Polymastia pachymastia	0	0	1
Prianos problematicus	0	1	2
Prosuberites sisyrnus	1	3	4
Reniera sp.	0	0	6
Tedanione obscurata	0	0	1
Tethya aurantia	0	0	1
Tetillidae	1	0	0
Theneidae	0	1	0

Table 11-2: Species of encrusting or turf invertebrates identified from collections of solid substrates (cobbles, shells, algal blades, etc.) at the indicated stations. Numbers represent the total number of years for which a species occurred.

Species	Station DCSX	Station DRSX	Station LRSX
CNIDARIA			
Abietinaria sp.	0	0	1
Aglaophenia struthenoides	0	5	4
Balanophyllia elegans	2	5	5
Eucopella sp.	0	0	1
Eudendrium sp.	0	1	0
Paracyathus stearnsi	0	4	3
Plumularia sp.	2	0	4
Sertularella sp.	0	3	3
Sertularia sp.	2	4	4
Unident. Hydroid	5	6	5
ANNELIDA			
Eupomatus gracilis	1	5	5
Janua nipponica	1	1	0
Mesochaetopterus taylori	2	0	2
Paradexiospira vitrea	5	6	5
Pherusa inflata	1	0	2
Phragmatopoma californica	0	2	1
Phyllochaetopterus prolifica	3	4	5
Polynoidae	1	1	1
Protolaeospira capensis	3	6	5
Sabellaria cementarium	5	6	6
Sabellidae	2	5	4
Salmacina tribranchiata	0	1	0
Spirobranchis spinosus	3	4	5
Spirorbis bifurcatus	3	2	3
Spirorbis borealis	1	1	1
Spirorbis rothlisbergi	3	4	5
Spirorbis spatulatus	1	2	3
Spirorbis spirillum	1	1	1
Spirorbidae	1	0	1
Telepsavus costarum	4	4	5
BRYOZOA			
Aetea anguina	0	1	0
Aetea ligulata	0	2	1
Aetea truncata	1	2	2
Antropora tincta	0	2	1
Arthropoma cecili	0	3	2
Bugula californica	0	0	2
Bugula longirostrata	0	0	1

Table 11-2: Species of encrusting or turf invertebrates identified from collections of solid substrates (cobbles, shells, algal blades, etc.) at the indicated stations. Numbers represent the total number of years for which a species occurred.

Species	DCSX	Station DRSX	LRSX
BRYOZOA (cont.)			
Bugula pacifica	0	0	1
Bugula uniserialis	0	0	1
Bugula sp.	1	0	0
Callopora armata	0	0	1
Callopora circumclathrata	0	0	1
Callopora corniculifera	0	1	0
Callopora horrida	1	2	2
Cauloramphus cymbaeformis	0	2	0
Cauloramphus echinus	3	2	1
Cauloramphus sp.	1	0	2
Cauloramphus spiniferum	5	4	3
Chapperia patula	1	3	1
Costazia costazi	2	0	1
Costazia robertsoni	2	4	5
Costazia sp.	1	0	0
Costazia ventricosa	0	1	1
Crisia maxima	0	0	1
Crisia occidentalis	1	2	2
Crisia sp.	2	5	5
Crisulipora occidentalis	0	0	1
Dendrobaenia longispina	0	1	0
Diaperoecia californica	0	2	2
Eurystomella bilabiata	1	0	0
Fenestrulina malusi	3	6	4
Filicrisia sp.	0	2	6
Flustrella corniculata	1	0	1
Heteropora sp.	0	1	1
Hincksina alba	1	1	0
Hincksina sp.	0	2	0
Hincksina velata	2	5	1
Hippodiplosia insculpta	1	3	6
Hippoporella gorgonensis	5	3	4
Hippoporella nitescens	1	0	1
Hippoporinidae	3	0	0
Hippothoa hyalina	5	6	5
Hippothryis emplastra	0	1	0
Holoporella brunnea	1	3	5
Lagenipora lacunosa	0	1	1
Lagenipora punctulata	3	5	5
Lagenipora socialis	1	0	0
Lyrula hippocrepis	2	4	4
Membranipora fusca	2	5	4
Membranipora membranacea	2	4	3
Membranipora tuberculata	1	5	2
Micropora coriacea	0	2	0
Microporella californica	3	5	6
Microporella ciliata	4	6	6

Table 11-2: Species of encrusting or turf invertebrates identified from collections of solid substrates (cobbles, shells, algal blades, etc.) at the indicated stations. Numbers represent the total number of years for which a species occurred.

Species	DCSX	Station DRSX	LRSX
BRYOZOA (cont.)			
Microporella cribrosa	4	6	6
Microporella setiformis	2	5	6
Microporella sp.	0	0	1
Microporella umbonata	4	6	6
Mucronella major	1	3	3
Parasmittina californica	2	1	1
Parasmittina collifera	1	1	5
Parasmittina trispinosa	0	2	4
Phidolopora pacifica	0	3	3
Plagioecia patina	0	0	1
Plagioecia sarniensis	1	0	0
Plagioecia sp.	4	3	4
Porella porifera	1	3	5
Puellina setosa	2	4	4
Retevirgula areolata	3	5	6
Rhyncozoon grandicella	1	0	5
Rhyncozoon rostratum	2	3	0
Rhyncozoon spicatum	4	6	6
Rhyncozoon sp.	1	0	0
Schizoporella cornuta	4	3	4
Schizoporella sp.	0	0	1
Schizotheca fissurella	3	6	6
Scrupocellaria californica	0	0	2
Scrupocellaria sp.	0	1	0
Scrupocellaria varians	0	4	2
Smittina cordata	2	4	4
Tricellaria occidentalis	0	3	2
Tricellaria ternata	0	1	3
Tubulipora pacifica	1	2	0
Tubulipora sp.	4	5	6
Tubulipora tuba	1	0	0
Watersiporia cucullata	0	1	0
MOLLUSCA			
Acmaea personna	1	0	0
Acmaeid, unident.	4	3	3
Barleeia sp.	1	0	1
Calliostoma gloriosum	0	0	1
Calliostoma ligatum	0	0	1
Callistochiton crassicostatus	0	1	2
Chaetopleura sp.	0	0	1
Chama pellucida	0	2	4
Collisella sp.	1	1	0
Crepidula sp.	1	0	0
Crepipatella lingulata	3	5	3
Daphnella fuscoligata	0	0	1

Table 11-2: Species of encrusting or turf invertebrates identified from collections of solid substrates (cobbles, shells, algal blades, etc.) at the indicated stations. Numbers represent the total number of years for which a species occurred.

Species	DCSX	Station DRSX	LRSX
MOLLUSCA (cont.)			
Dendrodoris sp.	0	1	0
Elephantellum sp.	0	1	0
Entodesma sp.	1	1	0
Fissurella volcano	0	0	1
Glans carpenteri	0	0	1
Gregariella sp.	0	1	0
Hinnites multirugosus	0	2	0
Ischnochiton sp.	2	2	4
Kellia laperousi	1	1	1
Lepidozona cooperi	0	0	1
Lepidozona mertensii	0	0	1
Lepidozona sp.	2	1	0
Leptochiton sp.	2	0	1
Leptopecten latiauritus	0	1	0
Lithophaga plumula	1	0	1
Mitrella carinata	0	1	0
Morula sp.	0	1	1
Mopalia sp.	0	1	0
Musculus sp.	1	0	0
Mytilus californianus	0	0	2
Netastomella rostrata	1	0	0
Ocenebra interfossa	0	1	1
Penitella sp.	1	0	0
Petaloconchus compactus	1	4	2
Pododesmus cepio	1	4	2
Pseudochama exogyra	0	0	1
Rissoella sp.	0	1	0
Serpulorbis squamigerus	1	0	1
Siliquaria sp.	0	1	0
Spiroglyphis lituella	1	5	6
Stenoplax sp.	0	0	1
Tegula funebralis	1	0	0
Trachydermon sp.	0	1	0
Unident. Chiton	0	1	0
ARTHROPODA			
Alpheus sp.	1	0	0
Balanus sp.	4	2	1
Balanus tintinnabulum	0	2	0
Cancer antennarius	0	1	0
Cancer sp.	1	0	0
Caprellidae	1	2	1
Crangon dentipes	1	0	0
Gammaridae	4	4	3
Idothea sp.	0	1	1
Isopoda	3	3	3
Jaeropsidae	0	1	0
Mimulus foliatus	1	0	1

Table 11-2: Species of encrusting or turf invertebrates identified from collections of solid substrates (cobbles, shells, algal blades, etc.) at the indicated stations. Numbers represent the total number of years for which a species occurred.

Species	DCSX	Station DRSX	LRSX
ARTHROPODA (cont.)			
Pachycheles rudis	0	0	1
Paguridae	2	0	0
Paraxanthias taylori	1	0	0
Petrolisthes cinctipes	1	0	0
Pugettia dalli	0	0	1
Pugettia gracilis	0	1	0
Pugettia producta	0	1	0
Pugettia richii	0	0	1
Pycnogonidae	0	2	0
Scyra acutifrons	0	0	1
Sphaeromidae	2	0	2
Taliepus nuttalli	0	0	1
Tanystylum duospinum	0	1	0
Tetraclita squamosa rubescens	2	4	2
Valvifera	1	0	1
ECHINODERMATA			
Ophiothrix spiculata	0	1	2
Strongylocentrotus purpuratus	1	1	1
Unident. Ophiuroidea	1	0	1
CHORDATA-TUNICATA			
Didemnum carnulentum	0	0	1
Polyclinum planum	1	0	0
Trididemnum opacum	1	5	4

in these areas as loose aggregates. They were probably unstable during large storms, tumbling about and crushing or eroding any attached encrustations. Cobbles at DRSX and LRSX sooner or later lodged in one of the many crevices common at these two stations, keeping the substrates stable for longer periods. Variability in species totals was greatest at DCSX, probably because of substrate instability. DRSX and LRSX both yielded highest species totals from 1984 onward (i.e., in the post-El Niño period). Totals at DCSX fluctuated widely, even during operational years. The totals provided no indication of a declining trend during the operational period at any of the stations.

Table 11-3: Numbers of species within Phyla for encrusting and turf invertebrates found on solid substrate samples from our subtidal DCSX transect in Diablo Cove for the years from 1982 to 1987.

Phylum	Year						Phylum Total
	1982	1983	1984	1985	1986	1987	
Porifera	5	3	11	1	2	10	18
Cnidaria	3	2	3	2	2	2	4
Annelida	3	5	10	8	6	11	18
Bryozoa	10	9	24	10	25	42	52
Mollusca	0	2	6	3	9	8	20
Arthropoda	0	7	7	2	5	8	14
Echinodermata	0	0	0	0	1	1	2
Chordata-Tunicata	2	0	1	0	0	0	2
Total for year	23	28	62	26	50	82	130

All stations yielded low numbers for the two earliest years, 1982 and 1983. The low values for 1982 probably resulted from the relatively few cobbles collected (this was our first collection and we were still developing the methodology). Low values from 1983 may have resulted from an influence by El Niño, especially the very large storms that were associated with this oceanographic event. Field observations indicated large reductions of invertebrate turf occurred during El Niño. High values for the final survey in October 1987 were probably influenced by the excellent weather conditions during this survey, allowing us to identify the best cobbles for our samples. We also collected about twice the numbers of cobbles as normal at DCSX and DRSX in 1987, because for the first time we sampled both shallow and deep habitats during the same survey (see Table 11-1). The 1987 totals shown in Tables 11-3 and 11-4 represent combined data from the shallow and deep collections at DCSX and DRSX for that year. The 1987 results in these two tables were combined to provide a fairer comparison with the other years.

Table 11-4: Numbers of species within Phyla for encrusting and turf invertebrates found on solid substrate samples from our subtidal DRSX transect in Diablo Cove for the years from 1982 to 1987.

	Year						
Phylum	1982	1983	1984	1985	1986	1987	Phylum Total
Porifera	5	3	13	5	7	13	25
Cnidaria	4	4	6	6	6	2	7
Annelida	6	5	10	12	9	13	17
Bryozoa	13	22	39	41	36	39	61
Mollusca	0	4	11	6	10	13	25
Arthropoda	0	3	5	6	5	6	13
Echinodermata	0	0	1	0	1	0	2
Chordata-Tunicata	1	1	0	1	1	1	1
Total for year	29	42	85	77	75	87	151

Table 11-5: Numbers of species within Phyla for encrusting and turf invertebrates found on solid substrate samples from our subtidal control transect LRSX, off Pup Rock, for the years from 1982 to 1987.

	Year						
Phylum	1982	1983	1984	1985	1986	1987	Phylum Total
Porifera	9	6	9	16	16	15	33
Cnidaria	4	5	5	7	2	7	9
Annelida	6	7	13	12	12	10	18
Bryozoa	30	36	39	42	28	35	66
Mollusca	1	4	12	6	5	17	27
Arthropoda	4	1	5	3	2	5	14
Echinodermata	1	0	1	0	0	2	3
Chordata-Tunicata	0	0	1	1	2	1	2
Total for year	56	50	76	88	70	92	172

SIMILARITIES BETWEEN STATIONS

We examined similarities between the stations by tallying numbers of shared species and their distributions among the Phyla. A third of all species occurred at all three stations (Table 11-6). Likewise about a fifth of the species complement at each station was unique to that location. Most of the "unique" species, however, were single occurrences of uncommon or rare organisms. This category would probably become much smaller if we collected increased numbers of cobbles and shells. Species shared between DRSX and LRSX only were about fourfold greater than those shared between DCSX and DRSX only. This in spite of the fact that DCSX and DRSX were physically much closer to each other than to LRSX. The number of species shared between DRSX and LRSX only was about two thirds greater than the number of species shared between DCSX and LRSX only. There was thus an indication from these totals that species complements at DRSX and LRSX were somewhat more similar to each other than either was to DCSX. This similarity may well have arisen from relative stabilities of cobbles at DRSX and LRSX compared to DCSX. There were also habitat similarities at DRSX and LRSX (i.e., high vertical cliffs) that may have influenced species composition. The bottom at DCSX had much less relief compared to the other two sampling sites. Invertebrate turf is usually best developed at locations with large vertical relief.

These general patterns of similarity and difference were not always confirmed when we compared totals within each Phylum. Annelida and Cnidaria were at one extreme with relatively few species in the unique category and most species being shared between the stations. Arthropoda was at the other extreme, with high proportions of unique species and relatively few shared species. LRSX and DRSX shared a relatively high proportion of Poriferan, Cnidarian, Bryozoan, and Molluscan species.

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Table 11-6: Numbers of species (or similar taxon) of encrusting or turf invertebrates at each subtidal station, or unique to a station, or shared with other stations, grouped according to Phylum.

	DCSX				DRSX				LRSX				Site	
Phylum	Total species for Station	Unique species for Station	Species shared with DRSX only	Species shared with LRSX only	Total species for Station	Unique species for Station	Species shared with DCSX only	Species shared with LRSX only	Total species for Station	Unique species for Station	Species shared with DCSX only	Species shared with DRSX only	Species occurring at all 3 Stations	Total Species per Phylum
PORIFERA	18	4	1	2	25	5	1	8	33	12	2	8	11	43
CNIDARIA	4	0	0	1	7	1	0	3	9	2	1	3	3	10
BRYOZOA	52	7	3	5	61	9	3	12	66	12	5	12	37	85
ANNELIDA	18	0	1	3	17	1	1	1	18	0	3	1	14	20
MOLLUSCA	20	6	3	4	25	11	3	4	27	12	4	4	7	47
ARTHROPODA	14	6	0	3	13	7	0	1	14	5	3	1	5	27
ECHINODERMATA	2	0	0	1	2	0	0	1	3	0	1	1	1	3
CHORDATA-TUNICATA	1	0	0	0	1	0	0	0	2	1	0	0	1	2
Total taxa in category	129	23	8	19	151	34	8	30	172	42	19	30	79	237

VERTICAL DISTRIBUTIONS

Our field observations as time progressed indicated that the invertebrate turf assemblages that had suffered deterioration during El Niño years were returning rather well at our control station and at deep levels in Diablo Cove during 1985 and 1986. Turf densities at shallow levels, however, remained depleted compared to conditions typical of pre-El Niño years. The massive clusters of sponges, tunicates, and arborescent Bryozoans, adorned with hydroids, cup corals, worms, mollusks, and encrusting Bryozoans, were mostly absent. Isolated individuals and small colonies of presumably warm-tolerant species occurred in scattered fashion, leaving substantial amounts of exposed bare rock. This disappearance of invertebrate turf was not expected. Turf usually proliferated in the thermally-impacted areas we had examined. The typical "fouling" community seen in warm bays and within thermal discharge outfalls and around risers, is nearly always a highly developed invertebrate turf. We had anticipated that elevated temperatures in Diablo Cove might enhance fouling organisms, not cause reductions in abundances.

We made separate deep and shallow collections of substrates from the two diving stations within Diablo Cove during our final 1987 survey. Our objective was to determine whether species composition and species totals differed substantially between the turf assemblages at the two depth levels.

Collections from the two shallow locations in Diablo Cove did yield fewer species totals when compared to their deep water counterparts (Table 11-7). None of the Diablo Cove stations matched the total from our control station but results from DRSX8m were somewhat comparable. The primary discrepancies between these two stations arose from differences in totals of Mollusca and Porifera. Unfortunately we were not able to conclude whether the differences between shallow and deep stations arose because of altered conditions in the operational shallow waters or simply represented inherent dissimilarities that had always been present (we would need a historical series of collections from both shallow and deep sites to settle this question). Lower totals at the shallow stations were perhaps indicative, but not conclusive. The greater total from LRSX5m was not considered important because it often occurred during other years (compare Table 11-5 with Tables 11-3 and 11-4).

Table 11-7: Number of species of encrusting or turf invertebrates from the survey of October 1987, grouped according to Phylum and collection site to facilitate comparisons between shallow and deep habitats as well as for sites inside Diablo Cove with the control station (LRSX) outside the Cove.

Phylum	Station: DCSX 3m Depth	DCSX 8m Depth	DRSX 3m Depth	DRSX 8m Depth	LRSX 5m Depth	Yearly Total
Porifera	5	7	9	9	15	27
Cnidaria	1	2	1	3	7	7
Annelida	8	10	12	11	10	13
Bryozoa	20	35	25	33	35	59
Mollusca	5	4	8	10	17	25
Arthropoda	3	7	3	5	5	14
Echinodermata	0	1	0	0	2	2
Chordata-Tunicata	0	0	1	1	1	1
Station Total	42	66	59	72	92	148

Examination of the distributions of individual species provided information identifying those invertebrates that presumably tolerated exposure to plume waters during the latter operational period (i.e., those species that occurred at one or both shallow stations, Table 11-8). Presence of a species at a deeper site but not in the shallows suggested (but did not prove) that the organism was sensitive to the operational environment. Knowledge of absence from the shallows was often useful, however, when combined with other data (e.g., behavior of a species during El Niño and history of occurrence throughout the six year study period; Table 11-9). If, for example, a species was not present in the shallows of Diablo Cove during latter 1987 but had been there earlier, and it also declined during El Niño, the total evidence strongly suggested lack of tolerance for the operational environment above the thermocline in Diablo Cove.

The data in Table 11-9 also provided indications as to which species were most widely distributed during the operational period. Twenty-one species occurred at all five sampling locations. These 21 species were generally also the commonest encrusting invertebrates at the stations. It was noteworthy that there were considerable differences among the Phyla as to the proportions of widespread species within each group. The lowest extreme was Porifera which had only a single widespread species (*Leucandra*) among the 27 species total recorded from 1987. The opposite extreme occurred among Annelida which totaled 13 species, of which seven were present at all five sampling sites.

We were especially interested in vertical distributions of the sponges and arborescent Bryozoans because these two groups formerly produced much of the solid material that encouraged formation of thick mats of invertebrate turf. Eleven sponge species occurred at one or both of the shallow stations. Four of these (*Haliclona*, *Leucandra*, *Microciona*, and *Plocamia*) are capable of producing thick encrustations, although no such masses were present in the shallows at the time of our October 1987 survey. Many of the primary structure-forming sponges such as *Stelleta*, *Halichondria*, *Antho*, and *Paresperella*, were completely missing from these shallows within Diablo Cove. Among the important arborescent Bryozoans, *Hippothoa*, *Holoporella*, and

Table 11-8: Occurrences of encrusting or turf invertebrates on solid substrates collected from the indicated stations on October 26-27 1987.

Species	Station and depth(s)				
	DCSX		DRSX		LRSX
	3m	8m	3m	8m	5m
PORIFERA					
Anaata spongigartina					x
Cliona celata	x		x		
Esperiopsis originalis		x			
Eurypon asodes		x	x	x	
Gellius sp.					x
Haliclona ecbasis					x
Haliclona spp.	x			x	x
Hymedesmiidae					x
Hymeniacidon siniapum				x	
Leucandra heathi	x	x	x	x	x
Leucosolenia eleanor			x		
Leucosolenia macleayi				x	
Leucosolenia nautilia			x	x	
Lissodendoryx noxiosa		x			
Microciona parthena					x
Microciona sp.		x	x		
Microcionidae					x
Ophlitaspongia pennata					x
Paresperella psila		x			x
Plocamia karykina	x		x	x	x
Poecillastra sp.			x		
Polymastia pachymastia	x		x	x	x
Prosuberites sisyrnus	x		x	x	x
Reniera sp.					x
Tedanione obscurata					x
Tethya aurantia					x
Theneidae				x	
CNIDARIA					
Aglaophenia struthenoides					x
Balanophyllia elegans				x	x
Paracyathus stearnsi					x
Plumularia sp.					x
Sertularella sp.					x
Sertularia sp.		x		x	x
Unident. Hydroid	x	x	x	x	x
ANNELIDA					
Eupomatus gracilis			x	x	x
Janua nipponica	x		x		
Paradexiospira vitrea	x	x	x	x	
Phragmatopoma californica				x	
Phyllochaetopterus prolifica	x	x	x	x	x
Protolaeospira capensis	x	x	x	x	x
Sabellaria cementarium	x	x	x	x	x

Table 11-8: Occurrences of encrusting or turf invertebrates on solid substrates collected from the indicated stations on October 26-27 1987.

Species	Station and depth(s) DCSX		DRSX		LRSX
	3m	8m	3m	8m	5m
ANNELIDA (cont.)					
Sabellidae		x	x	x	x
Spirobranchis spinosus	x	x	x	x	x
Spirorbis bifurcatus	x	x	x	x	x
Spirorbis rothlisbergi		x	x		x
Spirorbis spatulatus	x	x	x	x	x
Telepsavus costarum	x	x	x	x	x
BRYOZOA					
Aetea ligulata				x	
Aetea truncata	x				
Antropora tincta			x		
Bugula sp.		x			
Callopora circumclathrata					x
Callopora horrida		x			x
Cauloramphus echinus				x	
Cauloramphus spiniferum	x	x	x	x	x
Costazia costazi		x			
Costazia robertsoni		x			x
Crisia occidentalis		x			x
Crisia sp.				x	x
Eurystomella bilabiata	x				
Fenestrulina malusi	x	x	x	x	x
Filicrisia sp.				x	x
Heteropora sp.				x	
Hincksina alba				x	
Hincksina velata		x	x	x	
Hippodiplosia insculpta		x			x
Hippoporella gorgonensis	x	x		x	
Hippoporella nitescens	x	x			x
Hippoporinidae		x			
Hippothoa hyalina	x	x	x	x	x
Holoporella brunnea	x	x	x	x	x
Lagenipora punctulata		x	x	x	x
Lagenipora socialis		x			
Lyrula hippocrepis	x	x	x	x	x
Membranipora fusca	x		x	x	x
Membranipora membranacea			x		x
Membranipora tuberculata			x		
Micropora coriacea				x	
Microporella californica	x	x	x	x	x
Microporella ciliata	x		x	x	x
Microporella cribrosa	x	x	x	x	x
Microporella setiformis	x		x	x	x
Microporella umbonata	x	x	x	x	x
Mucronella major		x	x	x	x
Parasmittina californica	x				
Parasmittina collifera		x			x
Parasmittina trispinosa	x			x	x
Plagioecia sarniensis		x			

Table 11-8: Occurrences of encrusting or turf invertebrates on solid substrates collected from the indicated stations on October 26-27 1987.

Species	Station and depth(s) DCSX 3m	DCSX 8m	DRSX 3m	DRSX 8m	LRSX 5m
BRYOZOA *(cont.)*					
Plagioecia sp.		x			
Porella porifera		x		x	x
Puellina setosa		x	x	x	x
Retevirgula areolata	x	x	x	x	x
Rhyncozoon grandicella		x			x
Rhyncozoon rostratum		x	x		
Rhyncozoon spicatum	x	x	x	x	x
Schizoporella cornuta	x	x	x		x
Schizotheca fissurella	x		x	x	x
Scrupocellaria varians				x	
Smittina cordata		x	x	x	x
Tricellaria ternata					x
Tubulipora pacifica		x		x	
Tubulipora sp.		x		x	x
Tubulipora tuba		x			
Watersiporia cucullata			x		
MOLLUSCA					
Acmaeid, unident.	x		x		x
Calliostoma ligatum					x
Callistochiton sp.			x		x
Chaetopleura sp.					x
Chama pellucida			x	x	x
Crepipatella lingulata	x		x	x	x
Daphnella fuscoligata					x
Dendrodoris sp.				x	
Elephantellum sp.				x	
Fissurella volcano					x
Glans carpenteri					x
Gregariella sp.			x		
Hinnites multirugosus				x	
Ischnochiton sp.		x			x
Lepidozona cooperi					x
Lepidozona mertensii	x				x
Lithophaga plumula		x			x
Musculus sp.		x			
Ocenebra interfossa					x
Petaloconchus compactus			x	x	x
Pododesmus cepio	x	x	x	x	x
Siliquaria sp.			x	x	
Spiroglyphis lituella				x	x
Tegula funebralis	x				
Unident. Chiton				x	

Table 11-8: Occurrences of encrusting or turf invertebrates on solid substrates collected from the indicated stations on October 26-27 1987.

Species	Station and depth(s) DCSX 3m	DCSX 8m	DRSX 3m	DRSX 8m	LRSX 5m
ARTHROPODA					
Balanus sp.	x				
Balanus tintinnabulum				x	
Caprellidae		x			
Gammaridae	x	x	x	x	
Idothea sp.				x	
Isopoda		x	x		
Jaeropsidae				x	
Mimulus foliatus					x
Pachycheles rudis					x
Paraxanthias taylori		x			
Pugettia richii					x
Tetraclita squamosa rubescens	x	x	x	x	x
Valvifera		x			x
ECHINODERMATA					
Ophiothrix spiculata					x
Unident. Ophiuroidea					x
CHORDATA-TUNICATA					
Trididemnum opacum			x	x	x

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

		Years					
Species	Station	82	83	84	85	86	87
PORIFERA							
Acarnus erithacus	LRSX	X			X	X	
Anaata spongigartina	DCSX			X			
	DRSX		X	X	X		
	LRSX		X		X	X	X
Antho lithophoenix	DCSX			X			
	DRSX			X			
	LRSX	X			X		
Astylinifer arndti	DCSX			X			
Cliona celata	DCSX			X	X		X
	DRSX		X	X	X	X	X
	LRSX		X				
Esperiopsis originalis	DCSX						X
	DRSX			X			
	LRSX				X	X	
Eurypon asodes	DRSX						X
	LRSX	X					
Euryponidae	DCSX			X			
Gellius sp.	LRSX						X
Geodia mesotriaeana	LRSX					X	
Halichondria panicea	DCSX			X			
Haliclona ecbasis	DRSX	X		X			
	LRSX		X		X		X
Haliclona permollis	DRSX		X				
	LRSX				X		
Haliclona spp.	DCSX		X	X		X	X
	DRSX	X		X		X	X
	LRSX	X	X	X	X	X	X
Haliclonidae	LRSX			X			
Hymedesmiidae	LRSX						X
Hymenamphiastra cyanocrypta	LRSX				X	X	
Hymeniacidon sinapium	DRSX						X
Leucandra heathi	DCSX		X	X			X
	DRSX			X	X		X
	LRSX	X		X	X	X	X
Leucetta losangelensis	DRSX						X
Leucilla nuttingi	LRSX	X				X	
Leucosolenia eleanor	DRSX						X
	LRSX			X	X	X	
Leucosolenia macleayi	DRSX					X	X
Leucosolenia nautilia	DRSX			X	X		X
	LRSX			X		X	
Leucosolenia sp.	LRSX				X	X	

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
PORIFERA (cont.)							
Lissodendoryx noxiosa	DCSX						X
	LRSX	X			X		
Microciona parthena	DCSX			X			
	LRSX			X			X
Microciona sp.	DCSX						X
	DRSX			X			X
Microcionidae	DCSX					X	
	DRSX					X	
	LRSX					X	
Mycale sp.	DRSX			X			
	LRSX				X		
Myxilla parasitica	DCSX		X				
	DRSX			X			
	LRSX			X			
Ophlitaspongia pennata	LRSX						X
Paresperella psila	DCSX						X
	DRSX	X		X			
	LRSX	X			X		X
Plocamia karykina	DCSX						X
	DRSX				X	X	X
	LRSX					X	X
Poecillastra sp.	DRSX						X
Polymastia pachymastia	LRSX						X
Prianos problematicus	DRSX	X					
	LRSX		X			X	
Prosuberites sisyrnus	DCSX						X
	DRSX				X	X	X
	LRSX			X	X	X	X
Reniera sp.	LRSX	X	X	X	X	X	X
Tedanione obscurata	LRSX						X
Tethya aurantia	LRSX						X
Tetillidae	DCSX			X			
Theneidae	DRSX						X
CNIDARIA							
Abietinaria sp.	LRSX		X				
Aglaophenia struthenoides	DRSX	X	X	X	X	X	
	LRSX	X		X	X		X
Balanophyllia elegans	DCSX			X		X	
	DRSX	X		X	X	X	X
	LRSX		X	X	X	X	X
Eucopella sp.	LRSX				X		
Eudendrium sp.	DRSX			X			
Paracyathus stearnsi	DRSX	X	X		X	X	
	LRSX		X		X		X
Plumularia sp.	DCSX		X	X			
	LRSX			X	X	X	X
Sertularella sp.	DRSX			X	X	X	
	LRSX	X			X		X

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
CNIDARIA (cont.)							
Sertularia sp.	DCSX				X		X
	DRSX		X	X	X	X	
	LRSX	X		X	X		X
Unident. Hydroid	DCSX		X	X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X		X	X
ANNELIDA							
Eupomatus gracilis	DCSX				X		
	DRSX	X	X	X	X		X
	LRSX		X	X	X	X	X
Janua nipponica	DCSX						X
	DRSX						X
Mesochaetopterus taylori	DCSX			X		X	
	LRSX			X		X	
Paradexiospira vitrea	DCSX		X	X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	
Pherusa inflata	DCSX			X			
	LRSX			X		X	
Phragmatopoma californica	DRSX				X		X
	LRSX			X			
Phyllochaetopterus prolifica	DCSX			X		X	X
	DRSX			X	X	X	X
	LRSX	X		X	X	X	X
Polynoidae	DCSX					X	
	DRSX					X	
	LRSX	X					
Protolaeospira capensis	DCSX			X	X		X
	DRSX	X	X	X	X	X	X
	LRSX		X	X	X	X	X
Sabellaria cementarium	DCSX		X	X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	X
Sabellidae	DCSX				X		X
	DRSX	X		X	X	X	X
	LRSX			X	X	X	X
Salmacina tribranchiata	DRSX				X		
Spirobranchis spinosus	DCSX			X	X		X
	DRSX			X	X	X	X
	LRSX		X	X	X	X	X
Spirorbis bifurcatus	DCSX			X	X		X
	DRSX			X			X
	LRSX				X	X	X
Spirorbis borealis	DCSX		X				
	DRSX	X					
	LRSX		X				
Spirorbis rothlisbergi	DCSX		X	X			X
	DRSX			X	X	X	X
	LRSX	X		X	X	X	X
Spirorbis spatulatus	DCSX						X
	DRSX				X		X
	LRSX			X	X		X
Spirorbis spirillum	DCSX		X				
	DRSX		X				
	LRSX		X				

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
ANNELIDA (cont.)							
Spirorbidae	DCSX				X		
	LRSX				X		
Telepsavus costarum	DCSX			X	X	X	X
	DRSX			X	X	X	X
	LRSX	X		X	X	X	X
BRYOZOA							
Aetea anguina	DRSX			X			
Aetea ligulata	DRSX				X		X
	LRSX			X			
Aetea truncata	DCSX						X
	DRSX			X	X		
	LRSX			X		X	
Antropora tincta	DRSX				X		X
	LRSX		X				
Arthropoma cecili	DRSX		X	X	X		
	LRSX				X	X	
Bugula californica	LRSX			X	X		
Bugula longirostrata	LRSX	X					
Bugula pacifica	LRSX	X					
Bugula uniserialis	LRSX	X					
Bugula sp.	DCSX						X
Callopora armata	LRSX		X				
Callopora circumclathrata	LRSX						X
Callopora corniculifera	DRSX		X				
Callopora horrida	DCSX						X
	DRSX			X	X		
	LRSX		X				X
Cauloramphus cymbaeformis	DRSX				X	X	
Cauloramphus echinus	DCSX			X	X	X	
	DRSX				X		X
	LRSX				X		
Cauloramphus sp.	DCSX			X			
	LRSX			X	X		
Cauloramphus spiniferum	DCSX		X	X	X	X	X
	DRSX		X	X		X	X
	LRSX		X	X			X
Chapperia patula	DCSX					X	
	DRSX	X			X	X	
	LRSX					X	
Costazia costazi	DCSX			X			X
	LRSX		X				
Costazia robertsoni	DCSX					X	X
	DRSX	X		X	X	X	
	LRSX		X	X	X	X	X
Costazia sp.	DCSX					X	

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
BRYOZOA (cont.)							
Costazia ventricosa	DRSX	X					
	LRSX		X				
Crisia maxima	LRSX				X		
Crisia occidentalis	DRSX		X	X			
	LRSX		X				X
Crisia sp.	DCSX		X	X			
	DRSX		X	X	X	X	X
	LRSX	X	X	X	X		X
Crisulipora occidentalis	LRSX	X					
Dendrobaenia longispina	DRSX				X		
Diaporoecia californica	DRSX			X	X		
	LRSX				X	X	
Eurystomella bilabiata	DCSX						X
Fenestrulina malusi	DCSX			X		X	X
	DRSX	X	X	X	X	X	X
	LRSX			X	X	X	X
Filicrisia sp.	DRSX					X	X
	LRSX	X	X	X	X	X	X
Flustrella corniculata	DCSX				X		
	LRSX						X
Heteropora sp.	DRSX						X
	LRSX				X		
Hincksina alba	DCSX			X			
	DRSX						X
Hincksina sp.	DRSX				X	X	
Hincksina velata	DCSX					X	X
	DRSX		X	X	X	X	X
	LRSX			X			
Hippodiplosia insculpta	DCSX						X
	DRSX			X	X	X	
	LRSX	X	X	X	X	X	X
Hippoporella gorgonensis	DCSX		X	X	X	X	X
	DRSX				X	X	X
	LRSX		X	X	X	X	
Hippoporella nitescens	DCSX						X
	LRSX						X
Hippoporinidae	DCSX			X		X	X
Hippothoa hyalina	DCSX		X	X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X		X
Hippothryis emplastra	DRSX			X			
Holoporella brunnea	DCSX						X
	DRSX			X		X	X
	LRSX	X	X	X	X		X
Lagenipora lacunosa	DRSX			X			
	LRSX			X			
Lagenipora punctulata	DCSX		X	X			X
	DRSX		X	X	X	X	X
	LRSX	X	X	X	X		X
Lagenipora socialis	DCSX						X

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
BRYOZOA (cont.)							
Lyrula hippocrepis	DCSX					X	X
	DRSX			X	X	X	X
	LRSX			X	X	X	X
Membranipora fusca	DCSX				X		X
	DRSX	X		X	X	X	X
	LRSX			X	X	X	X
Membranipora membranacea	DCSX			X	X		
	DRSX			X	X	X	X
	LRSX				X	X	X
Membranipora tuberculata	DCSX		X				
	DRSX		X	X	X	X	X
	LRSX		X	X			
Micropora coriacea	DRSX				X		X
Microporella californica	DCSX			X		X	X
	DRSX		X	X	X	X	X
	LRSX	X	X	X	X	X	X
Microporella ciliata	DCSX			X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	X
Microporella cribrosa	DCSX			X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	X
Microporella setiformis	DCSX			X			X
	DRSX	X	X		X	X	X
	LRSX	X	X	X	X	X	X
Microporella sp.	LRSX		X				
Microporella umbonata	DCSX			X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	X
Mucronella major	DCSX						X
	DRSX				X	X	X
	LRSX			X	X		X
Parasmittina californica	DCSX					X	X
	DRSX		X				
	LRSX			X			
Parasmittina collifera	DCSX						X
	DRSX			X			
	LRSX	X	X	X	X		X
Parasmittina trispinosa	DRSX			X			X
	LRSX		X	X	X		X
Phidolopora pacifica	DRSX		X	X	X		
	LRSX		X	X	X		
Plagioecia patina	LRSX				X		
Plagioecia sarniensis	DCSX						X
Plagioecia sp.	DCSX		X	X		X	X
	DRSX			X	X	X	
	LRSX		X	X	X	X	
Porella porifera	DCSX						X
	DRSX				X	X	X
	LRSX		X	X	X	X	X
Puellina setosa	DCSX					X	X
	DRSX			X	X	X	X
	LRSX			X	X	X	X
Retevirgula areolata	DCSX			X		X	X
	DRSX		X	X	X	X	X
	LRSX	X	X	X	X	X	X

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

		Years					
Species	Station	82	83	84	85	86	87
BRYOZOA (cont.)							
Rhyncozoon grandicella	DCSX						X
	LRSX		X	X	X	X	X
Rhyncozoon rostratum	DCSX					X	X
	DRSX			X		X	X
Rhyncozoon spicatum	DCSX			X	X	X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	X
Rhyncozoon sp.	DCSX			X			
Schizoporella cornuta	DCSX		X	X		X	X
	DRSX				X	X	X
	LRSX			X	X	X	X
Schizoporella sp.	LRSX		X				
Schizotheca fissurella	DCSX			X		X	X
	DRSX	X	X	X	X	X	X
	LRSX	X	X	X	X	X	X
Scrupocellaria californica	LRSX		X		X		
Scrupocellaria sp.	DRSX			X			
Scrupocellaria varians	DRSX			X	X	X	X
	LRSX		X		X		X
Smittina cordata	DCSX					X	X
	DRSX			X	X	X	X
	LRSX			X	X	X	X
Tricellaria occidentalis	DRSX	X	X	X			
	LRSX		X		X		
Tricellaria ternata	DRSX					X	
	LRSX		X		X		X
Tubulipora pacifica	DCSX						X
	DRSX				X		X
Tubulipora sp.	DCSX		X	X		X	X
	DRSX		X	X	X	X	X
	LRSX	X	X	X	X	X	X
Tubulipora tuba	DCSX						X
Watersiporia cucullata	DRSX						X
MOLLUSCA							
Acmaea personna	DCSX					X	
Acmaeid, unident.	DCSX			X	X	X	X
	DRSX				X	X	X
	LRSX		X	X			X
Barleeia sp.	DCSX				X		
	LRSX			X			
Calliostoma gloriosum	LRSX			X			
Calliostoma ligatum	LRSX						X
Callistochiton crassicostatus	DRSX						X
	LRSX				X		X
Chaetopleura sp.	LRSX						X
Chama pellucida	DRSX			X			X
	LRSX			X	X	X	X
Collisella sp.	DCSX					X	
	DRSX					X	
Crepidula sp.	DCSX			X			

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
MOLLUSCA (cont.)							
Crepipatella lingulata	DCSX			X		X	X
	DRSX		X	X	X	X	X
	LRSX			X		X	X
Daphnella fuscoligata	LRSX						X
Dendrodoris sp.	DRSX						X
Elephantellum sp.	DRSX						X
Entodesma sp.	DCSX				X		
	DRSX			X			
Fissurella volcano	LRSX						X
Glans carpenteri	LRSX						X
Gregariella sp.	DRSX						X
Hinnites multirugosus	DRSX			X			X
Ischnochiton sp.	DCSX					X	X
	DRSX				X	X	
	LRSX			X	X	X	X
Kellia laperousi	DCSX					X	
	DRSX			X			
	LRSX			X			
Lepidozona cooperi	LRSX						X
Lepidozona mertensii	LRSX						X
Lepidozona sp.	DCSX					X	X
	DRSX			X			
Leptochiton sp.	DCSX			X		X	
	LRSX		X				
Leptopecten latiauritus	DRSX			X			
Lithophaga plumula	DCSX						X
	LRSX						X
Mitrella carinata	DRSX					X	
Morula sp.	DRSX			X			
	LRSX			X			
Mopalia sp.	DRSX					X	
Musculus sp.	DCSX						X
Mytilus californianus	LRSX			X	X		
Netastomella rostrata	DCSX					X	
Ocenebra interfossa	DRSX			X			
	LRSX						X
Penitella sp.	DCSX		X				
Petaloconchus compactus	DCSX		X				
	DRSX		X		X	X	X
	LRSX				X		X
Pododesmus cepio	DCSX						X
	DRSX			X	X	X	X
	LRSX			X			X

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
MOLLUSCA (cont.)							
Pseudochama exogyra	LRSX		X				
Rissoella sp.	DRSX		X				
Serpulorbis squamigerus	DCSX			X			
	LRSX					X	
Siliquaria sp.	DRSX						X
Spiroglyphis lituella	DCSX			X			
	DRSX		X	X	X	X	X
	LRSX	X	X	X	X	X	X
Stenoplax sp.	LRSX			X			
Tegula funebralis	DCSX						X
Trachydermon sp.	DRSX					X	
Unident. Chiton	DRSX						X
ARTHROPODA							
Alpheus sp.	DCSX			X			
Balanus sp.	DCSX			X	X	X	X
	DRSX				X	X	
	LRSX			X			
Balanus tintinnabulum	DRSX			X			X
Cancer antennarius	DRSX			X			
Cancer sp.	DCSX			X			
Caprellidae	DCSX						X
	DRSX				X	X	
	LRSX	X					
Crangon dentipes	DCSX				X		
Gammaridae	DCSX		X	X		X	X
	DRSX		X		X	X	X
	LRSX			X	X	X	
Idothea sp.	DRSX						X
	LRSX			X			
Isopoda	DCSX			X		X	X
	DRSX				X	X	X
	LRSX	X			X	X	
Jaeropsidae	DRSX				X		
Mimulus foliatus	DCSX			X			
	LRSX						X
Pachycheles rudis	LRSX						X
Paguridae	DCSX			X		X	
Paraxanthias taylori	DCSX						X
Petrolisthes cinctipes	DCSX						X
Pugettia dalli	LRSX	X					
Pugettia gracilis	DRSX				X		

Table 11-9: Occurrences of encrusting or turf invertebrates for the indicated years on solid substrates collected from the indicated stations.

Species	Station	Years 82	83	84	85	86	87
ARTHROPODA (cont.)							
Pugettia producta	DRSX			X			
Pugettia richii	LRSX						X
Pycnogonidae	DRSX		X	X			
Scyra acutifrons	LRSX			X			
Sphaeromidae	DCSX		X			X	
	LRSX	X	X				
Taliepus nuttalli	LRSX			X			
Tanystylum duospinum	DRSX		X				
Tetraclita squamosa rubescens	DCSX					X	X
	DRSX			X	X	X	X
	LRSX				X		X
Valvifera	DCSX						X
	LRSX						X
ECHINODERMATA							
Ophiothrix spiculata	DRSX					X	
	LRSX			X			X
Strongylocentrotus purpuratus	DCSX					X	
	DRSX			X			
	LRSX	X					
Unident. Ophiuroidea	DCSX						X
	LRSX						X
CHORDATA-TUNICATA							
Didemnum carnulentum	LRSX					X	
Polyclinum planum	DCSX	X					
Trididemnum opacum	DCSX			X			
	DRSX	X	X		X	X	X
	LRSX			X	X	X	X

Lagenipora were still present but occurred only as flat encrustations in the Cove shallows. The arborescent forms that provide a third dimension to the colony were, however, present at the deep stations. Other arborescent Bryozoans that were formerly abundant in these shallows (i.e., *Hippodiplosia*, *Phidolopora*, *Diaporoecia*, *Crisia*, *Filicrisia*, *Tricellaria*, and *Scrupocellaria*) were now either scarce or absent.

CATEGORIZATION OF INVERTEBRATE SPECIES

Our final classification of encrusting invertebrates utilized the spatial distributions (i.e., both vertical and horizontal), temporal relationships for each species from the various surveys, and responses to the 1983-84 El Niño, to assess and categorize selected species with respect to tolerance to the operational environment within Diablo Cove. Species selection for this analysis was based on frequency of occurrence. While each species was examined, with few exceptions we selected those species that occurred 3 or more times at a given station, as listed in Table 11-9. Species were classified as encouraged, discouraged, or neither encouraged or discouraged by El Niño and by the operational environment within Diablo Cove (Table 11-10).

Our analysis yielded only a single species encouraged by El Niño (the Bryozoan *Tricellaria occidentalis*). Ten species ranked as discouraged by El Niño and 47 species were classed as neutral. It appears that El Niño had a substantially depressive effect on the invertebrate turf. As noted above, this conclusion was amply confirmed by our field observations. Interestingly, an opposite effect was noted among southern California kelp beds during the same El Niño. Invertebrate turf became very common during 1983-4 but declined as El Niño abated.

Fourteen species of encrusting invertebrates fell in the enhanced category during the operational years. Six species were classified as discouraged and 49 were assigned to the neutral category. It appeared from these results that response to the operational environment was mixed, but in many cases differed from responses to El Niño. Almost all the species classed as enhanced

Table 11-10: Categorization of encrusting invertebrates based on presence/absence patterns at our three subtidal stations before and during the 1983 El Niño and during the operation years, as well as their vertical distributions during late 1987. Codes used: (E) seemed to be encouraged, (D) discouraged, (N) neither. (?) following entry means evidence for categorization was weak.

	Response to El Niño			Response to Operational		
Species	E	D	N	E	D	N
PORIFERA						
Acarnus erithacus		x				
Anaata spongigartina			x		x?	
Cliona celata			x			x
Esperiopsis originalis		x?				
Haliclona spp.			x			x
Leucandra heathi			x			x
Leucosolenia eleanor		x				x
Plocamia karykina						x
Prosuberites sisyrnus						x
Reniera sp.			x			
CNIDARIA						
Aglaophenia sp.			x			x?
Balanophyllia elegans			x		x	
Paracyathus stearnsi			x			x?
Sertularia sp.			x			x
ANNELIDA						
Eupomatus sp.			x			x
Paradexiospira vitrea			x			x
Phyllochaetopterus prolifica						x
Protolaeospira capensis			x			x
Sabellaria cementarium			x			x
Spirobranchis spinosus			x			x
Spirorbis bifurcatus						x
Spirorbis rothlisbergi			x			x
Spirorbis spatulatus						x
Telepsavus costarum			x?			x
BRYOZOA						
Arthropoma cecili			x		x	
Cauloramphus echinus				x?		
Cauloramphus spiniferum			x			x
Chapperia patula		x?				x?
Costazia robertsoni			x			x?
Diaporoecia californica		x?			x	
Fenestrulina malusi			x			x
Hincksina velata			x			x
Hippodiplosia insculpta			x		x	
Hippoporella gorgonensis			x			x
Hippoporella nitescens						x
Hippothoa hyalina			x			x
Holoporella brunnea			x			x
Lagenipora punctulata			x			x?
Lyrula hippocrepis		x?		x		

Table 11-10: Categorization of encrusting invertebrates based on presence/absence patterns at our three subtidal stations before and during the 1983 El Niño and during the operation years, as well as their vertical distributions during late 1987. Codes used: (E) seemed to be encouraged, (D) discouraged, (N) neither. (?) following entry means evidence for categorization was weak.

	Response to El Niño			Response to Operational		
Species	E	D	N	E	D	N
BRYOZOA (cont.)						
Membranipora fusca		x?		x?		
Membranipora membranacea						x
Membranipora tuberculata			x			x
Microporella californica			x	x		
Microporella ciliata			x	x		
Microporella cribrosa			x	x		
Microporella setiformis			x			x
Microporella umbonata			x	x		
Mucronella major						x
Parasmittina collifera			x			
Parasmittina trispinosa			x			
Phidolopora pacifica			x		x?	
Plagioecia sp.			x			
Porella porifera			x			x?
Puellina setosa						x
Retevirgula areolata			x	x?		
Rhyncozoon grandicella			x	x?		
Rhyncozoon rostratum						x?
Rhyncozoon spicatum			x	x		
Schizoporella cornuta			x			x
Schizotheca fissurella			x			x
Scrupocellaria varians						x?
Smittina cordata		x?		x?		
Tricellaria occidentalis	x					
Tubulipora sp.			x			
MOLLUSCA						
Acmaeid, unident.			x			x
Chama pellucida		x?				x
Crepipatella lingulata			x			x
Ischnochiton sp.						x?
Lepidozona mertensii						x
Petaloconchus compactus			x			x
Pododesmus cepio				x		
Spiroglyphis lituella			x			x
ARTHROPODA						
Balanus sp.				x?		
Gammaridae			x			x
Isopoda						x
Tetraclita squamosa rubescens				x		
CHORDATA-TUNICATA						
Trididemnum opacum			x			x

in Table 11-10 were closely encrusting microscopic forms. Their presence and status would be difficult to assess during the course of a diving survey. The results indicate that many species of encrusting invertebrates persisted in the Diablo Cove shallows during the operational period. Field observations indicated that abundances of certain turf organisms had declined but we were not able to confirm these findings by means of our laboratory analyses.

This discrepancy between field observations and laboratory analyses may find at least two different explanations. One possibility might involve a time lag in response by sensitive invertebrates to the new operational environment. Three years may not be sufficiently long for all changes to proceed to completion. One small colony in our analyses (perhaps the last of its kind) carried just as much weight as thousands of colonies at any given station. These remnant colonies might eventually disappear, given sufficient time.

Alternatively, the primary adjustment by many invertebrate species to the operational environment might simply involve shifts in abundance. Perhaps abundances of many of the conspicuous species declined, as recorded by our field observations. Small patches were, however, able to survive. Any such changes would remain undetected by a presence/absence analysis. If this hypothesis is valid, the small patches may perhaps persist indefinitely.

Persistence of sensitive species would be encouraged if "microclimates" were present (i.e., small regions where environmental conditions differed substantially from the gross state representative of most of Diablo Cove). Existence of at least one microclimate was observed by us near the DCSX3m sampling site. The general area here lost nearly all of the dense coverage of palm kelp during 1986 and 1987. One small patch of palm kelps persisted, however, at a depth of about 3 m (10 ft) at the seaward base of a pinnacle ridge lying directly across the plume path. Apparently the pinnacle created hydrodynamic conditions such that cold water was drawn into the base for at least part of the time. We noted three healthy *Laminaria* and about half a dozen healthy *Pterygophora* remaining here, during our final visit on December 21 1987. We measured a water temperature of 15°C (59°F) at this location on October 26 1987, when the ambient value at that depth throughout the remainder of the Cove was 16.7°C (62°F) or greater. Thus microclimates can occur in Diablo Cove and they may continue to harbor small patches of sensitive species.

We concluded that substantial declines had occurred in abundances of invertebrate turf above the thermocline within Diablo Cove. Most of the species occurring on our solid substrates remained during the operational period. A few species were encouraged and a few seemed discouraged by the operational conditions but most did not appear to be influenced. The final equilibrium state may not have been reached as of the end of 1987. Microclimates may allow survival and persistence of small colonies of sensitive encrusting invertebrates above the thermocline.

Chapter 12

STUDIES of PHAEOPHYTA POPULATIONS

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INTRODUCTION

Certain members of the subtidal Phaeophyta (i.e., the larger kelps) are of considerable ecological importance in many California coastal areas including the Diablo Canyon region. Kelps provide shelter for many animal species and food for certain invertebrates. The kelps influence abundance and species composition of understory algae by forming canopies that shade the bottom. Dense kelp stands (especially palm kelps) may also protect these small plants, which are often fairly delicate, from intense water motion associated with storm swell. Within Diablo Cove, two cold-water species of palm kelp (*Laminaria dentigera* and *Pterygophora californica*) had dominated much of the bottom since approximately 1976. This was after sea otters returned to the region and the initial climax community of *Nereocystis* began disappearing. *L. dentigera* occurs rarely, if at all, in the warm regions of the Southern California Bight. *Pterygophora* typically colonizes only cold waters in subthermocline portions of the Bight (i.e., below about 10 to 15 m [33-50 ft] depths). *Pterygophora* nonetheless dominates wide areas of the sea floor in southern California. Both of these palm kelps were thus believed to be sensitive to elevated temperatures, with *Laminaria* probably being more sensitive than *Pterygophora*.

Because palm kelp populations in the Diablo Cove region had apparently been so stable, we conjectured that monitoring their status could be done easily by periodic measurements of abundances of adult plants. We quickly discovered, however, that most of these populations were dynamic entities. Effects of natality and mortality were often significant and also required assessment.

Our primary indicator of natality was derived from recording abundances of juvenile plants during our surveys. In the Diablo Canyon region, both *Laminaria* and *Pterygophora* displayed seasonal fluctuations in reproductive capacity. Sori appeared on adult plants during winter and spring but were rare or absent in summer and fall. This cyclical pattern usually led to corresponding fluctuations in abundances of juvenile plants. There was, however, a several-month time lag during which small plants developed from their microscopic predecessors. Thus, highest densities of juvenile plants usually occurred during the latter half of each year.

Mortality among palm kelps occurred from several causes during our studies. In some cases we were able to identify the cause. As we shall see below, cause identification was of special interest to our work. We observed significantly high mortalities at some stations during the operational period when heated effluent was being discharged to Diablo Cove. There were also natural losses occurring among some of our control populations. We thus needed capabilities for distinguishing mortality due to natural causes from mortality possibly associated with exposure to heated effluent.

Although some of the large kelp species such as *Nereocystis* were thought to be annuals, *Pterygophora* is known to be perennial. *L. dentigera* is probably also a long-lived species. Dayton et al. (1984) followed survival among a population of tagged *Pterygophora* plants in the Point Loma kelp bed. Although the tagged group did not represent a cohort, the data clearly indicated that the lifespan can extend over many years, although a small but steady attrition may occur (Table 12-1). The same was true for *Cystoseira*, another Phaeophytan species common in Diablo Cove. In certain instances we were able to identify storm-caused removal in our experimental populations.

Table 12-1: Survivorship values for *Pterygophora californica* and *Cystoseira osmundacea* at 15 m depths off Point Loma, California, according to Dayton et al. (1984). Initial data from observations on tagged plants were interpolated to a hypothetical population starting at 1000 individuals.

Age (years)	Number of Plants Remaining *Pterygophora*	*Cystoseira*	Age (years)	Number of Plants Remaining *Pterygophora*	*Cystoseira*
0-0.2	1000	1000	5	424	15
0.5		682	5.5		10
1	838	384	6	404	5
1.5		212	6.5		0
2	750	146	7	322	
2.5		111	8	281	
3	725	76	9	240	
3.5		61	10	189	
4	525	35	11	107	
4.5		25			

For example, we sometimes recorded significant declines in abundances directly following passage of large storms. We established several criteria for diagnosing mortality associated with proximity to the DCPP discharge structure. Plant appearance became sickly prior to death (blades became discolored and tattered and shortened; they also displayed lesions and *Streblonema* infections). Turban snails frequently aggregated near the stipe apex, presumably concentrating their grazing on the critical apical meristem (plants cannot survive without an apical meristem). Prevalence of remains of dead palm kelps (i.e., deteriorating stipes and holdfasts) increased markedly and often significantly during initial phases of the population decline. This contrasted with populations experiencing slow mortality rates from natural attrition such as senescence and grazing. Prevalence of dead plants in such populations remained more or less constant.

Thus in reaching conclusions, we have drawn on four principal informational sources besides our abundance data for adult Phaeophyta:

- We took account of the environmental background,noting occurrences of significant disturbances.
- We monitored reproductive success among target populations of palm kelps, as well as changes in prevalence of dead palm kelp remains.
- We studied plant appearances to identify adverse physiological symptoms associated with proximity to the DCPP discharge structure. This helped us distinguish this type of stress from damage arising from other causes.
- We monitored shallow water areas throughout the inner Cove by periodic swimthroughs to determine how well our sampling sites represented bottom conditions elsewhere.

We began quantitatively sampling populations of adult palm kelps in the Diablo Canyon region in December 1982, when the stands had been in place for about six years. Many of the plants were unusually large adults, 1 to 2 m (about 3 to 7 ft) tall, and probably represented recruits that appeared shortly after otters freed the area from domination by urchins. We extended the scope of our study to other large Phaeophyta and to juvenile plants in September 1983. Thus we had data from about two years of preoperational studies by the time the power plant became fully operational. Most of our preoperational data, however, came from a somewhat anomalous oceanographic period because of occurrence of the 1983-84 El Niño condition. Our data indicated that the primary influence from El Niño on the adult palm kelps was associated with exceptionally severe storms during February and March 1983. The storms caused substantial losses of adult plants at some sites, removing inhibitory effects due to shading by substory canopies. Canopy disappearances were followed by extensive recruitment of juvenile palm kelps in the newly-opened areas.

We recorded a total of eight species of Phaeophyta in our quantitative sampling during the preoperational surveys and nine during the operational period. *Laminaria* and *Pterygophora* were always the most abundant and frequent species of Brown Algae present in the preoperational period (Table 12-2).

Table 12-2: Number of occurrences of eight major species of Phaeophyta during seven pre-operational surveys at five stations in the Diablo Canyon region.

Genus	DCSX 3m	DCSX 8 m	Station DRSX 3m	DRSX 8m	LRSX 8m
Cystoseira	5	2	5	7	6
Desmarestia	1	3	2	2	3
Dictyoneurum	5	0	3	1	2
Dictyota	0	0	0	1	0
Laminaria	7	7	7	7	7
Macrocystis	1	0	0	0	2
Nereocystis	0	0	4	2	0
Pterygophora	7	7	7	7	7

PROCEDURAL NOTES

We will primarily emphasize results from studies of the *Laminaria* and *Pterygophora* populations. We will give some consideration to *Cystoseira* and we will briefly discuss other Phaeophyta of minor ecological importance in Diablo Cove. Our primary approach will involve comparisons of preoperational and operational data to assess impacts, if any, from the operational environment. We have employed several techniques for drawing these comparisons.

Green (1979) points out that the first step in analysis of abundance data such as ours is to test whether the error variation is homogeneous, normally distributed, and independent of the mean. Results of such testing will determine the pathway to be taken by further analysis. A substantial portion of the present report is devoted to analyzing characteristics of the error variation in our preoperational data sets to rank them according to their suitability for conventional statistical analysis. Presumably the ranking would provide information as to which sets were most stable and useful for comparisons with the operational data sets.

We also computed means and 95 percent confidence intervals (95%CI) for all of the 195 data sets involved (3 species X 5 stations X 13 surveys). The 95%CI were useful for assessing abrupt changes from one survey to the next (for example, storm-caused mortality).

We also employed a nested (hierarchical) analysis of variance (nANOVA, Zar, 1974) to determine significance of longer-term changes among certain data sets, occurring over the course of several surveys. Details of the comparisons were presented in Chapman et al. (1987) and we will show only results (i.e., significance or non-significance) in this chapter.

We assessed natality by tallying numbers of juvenile plants of the various species during our surveys. We arbitrarily defined palm kelp juveniles as plants with stipes not more than 0.2 to 0.3 m (0.75 to 1 ft) long and stipe diameters of 1 cm or less at the base near the holdfast. This definition was convenient for separating juveniles from adults in the field, but it suffered from one drawback. Sometimes juvenile plants encountered shading when neighboring juveniles outgrew them. Such shading was often severe because juveniles tended to occur in dense clusters. The smaller juveniles in such clusters, deprived of sunlight, grew slowly, if at all. These stunted, darkly-colored young plants probably persisted for many months in an arrested status. We frequently found them under dense substory canopies during spring and early summer, long after the normal summer-fall "bloom" of juveniles had subsided. We classified such plants as juveniles but will refer to them as "stunted" as they were not truly indicative of recent recruitment success.

We used two methods for assessing mortality. Our most direct assessment involved counting numbers of dead plants occurring in the quadrats. A "dead plant" was defined as remains of an individual lacking any vestige of an apical meristem at the top of the stipe. Stipes without apical meristems probably persist for many months. Populations suffering from unusually high mortalities should thus produce a steadily rising mean concentration of dead plants over a period of several surveys. Normally, however, attrition was slow in our experimental populations and concentrations of dead plants remained approximately constant. Presumably rates of decay among the stipe and holdfast remains were approximately equal to the slow prevailing mortalities, so no buildup of dead plants occurred.

Counting of dead plants in the quadrats did not detect population losses from disruptions such as storms where the holdfast attachment is destroyed and the entire plant disappears. We assessed such losses indirectly by noting abrupt changes in population abundances for surveys immediately following occurrence of a disruptive event.

RESULTS AND ANALYSES

Basic Data

Appendices 12-1a through 1f list the adult plant tallies for each quadrat as well as means and standard deviations of the 195 data sets for *Laminaria*, *Pterygophora*, and *Cystoseira*. Similar compilations for juvenile *Laminaria* and *Pterygophora* are also shown in Appendices 12-2a through 2d, as well as tallies of dead plant remains (Appendix 12-3a-b). Dead *Pterygophora* were difficult to distinguish from dead *Laminaria* after a few months of decaying. Hence we did not attempt to segregate plant remains as to species. These 12 tables contain all the basic data used in our analyses below. We have not shown occurrences or abundances of the six other species of Phaeophyta that entered our quadrats from time to time. Individual occurrences have been presented in our Field Notes (included as appendices) in our various annual reports. Interested readers are referred to these reports for basic data on minor species. The minor species usually occurred irregularly, often as isolated entries in the quadrats. The data were not suited to statistical treatment, but they will be discussed briefly below.

Analysis of Preoperational Data Sets

Seven surveys were conducted during the 24 month preoperational period of December 1982 to December 1984. Numbers of adult *Laminaria*, *Pterygophora*, and *Cystoseira* found in each quadrat cast are shown in Appendices 12-1a, 12-1c and 12-1e. These values constituted the basic data for analyzing characteristics of the preoperational data base.

Distributional Characteristics

Our first task involved examining characteristics of the distributions for each composite data set (we will use the term "composite data set" as representing data from all surveys for a given species at a given station) but using only the preoperational portion of the composite data sets. We wished to determine whether serious departures from normality existed in the distributions. This approach combined all data for a species and station from all of the seven preoperational surveys. In so doing, we assumed that abundances remained constant over time so we were always sampling from stable populations. Validity of this assumption will be discussed further as our analysis proceeds. Each composite preoperational data set was divided into size classes based on numbers of plants occurring in the quadrats. Two size class intervals were employed. An interval of five was used for the high-density plant populations while an interval of one proved appropriate for low-density populations. The resulting distributions were all unimodal with varying degrees of skewness (Table 12-3).

Each distribution was analyzed by the Kolmogorov-Smirnov goodness of fit test to assess degrees of departure from normality (data were not grouped into size-classes for this analysis). For this test, the lower the computed value of D, the better the fit to normality. Widest departures from normality were associated with sparse populations in Table 12-4 (i.e., those distributions

Table 12-3: Sparse and dense population size class distributions of numbers per quadrat for three Phaeophyte genera at five subtidal stations near Diablo Canyon, tallied during seven pre-operational surveys between December 1982 and December 1984. N = total number of quadrats for a given genus at the designated station.

No.	*Laminaria*					*Pterygophora*					*Cystoseira*				
per	DCSX		DRSX		LRSX	DCSX		DRSX		LRSX	DCSX		DRSX		LRSX
Quad.	3m	8m	3m	8m	8m	3m	8m	3m	8m	8m	3m	8m	3m	8m	8m
Sparse															
0					27	36					37	18	27	15	42
1					15	10					4	1	6	8	13
2					10	13					4		5	7	4
3					11	6					2	1	1	7	
4					9	3					1			5	1
5					1						1		1	7	
6						1							3	5	1
7						1							2	3	1
8													1		
9											1			4	
10														2	
11													2		
12													2	2	
13														1	
14														2	
Dense															
0		5						25	12						
1-		47	7	6			3	21	22	2					
6-	7	10	9	4			18	7	8	23					
11-	9	11	9	8			24	5	5	25					
16-	8	2	8	11			19	1	6	16					
21-	13		8	13			10	1	6	4					
26-	12		12	13			1		1	1					
31-	6		6	5				1	2	1					
36-	8		2	5				1	2						
41-	2		2						1						
46-	3		3	2					1						
51-				1				1	1	1					
56-	1							2							
61	1		2					2							
66-															
71-								1							
76-			1												
81-															
86-			1												
91-															
101-															
106-								1							
110-								1	1						
N	70	75	70	68	73	70	75	70	68	73	50	20	50	68	62

Table 12-4: Sample sizes (N), means ($\overline{X}$), standard deviations (s), and goodness of fit to a normal distribution (D and the associated significance level, P, as determined by the Kolmogorov-Smirnov test) for abundance data combined from seven surveys for each of three Phaeophyte species at five subtidal stations near Diablo Cove. Date were collected from December 1982 to December 1984 (pre-operational) except that LRSX-Abbreviated represents only six surveys starting April 1983. Null hypothesis: the experimental distribution came from a normally-distributed population.

Station/Depth	N	$\overline{X}$	s	D	P
		Laminaria dentigera			
DCSX 3m	70	26.14	12.22	0.0930	>0.10
DCSX 8m	75	5.08	4.45	0.3044	<0.01
DRSX 3m	70	23.91	16.94	0.1268	<0.01
DRSX 8m	68	22.88	11.34	0.0741	>0.15
LRSX 8m	73	2.05	4.85	0.4106	<0.01
		Pterygophora californica			
DCSX 3m	70	1.10	1.43	0.4155	<0.01
DCSX 8m	75	14.23	5.30	0.1114	>0.025
DRSX 3m	70	13.56	30.36	0.3145	<0.01
DRSX 8m	68	12.63	19.36	0.1973	<0.01
LRSX 8m	73	13.88	7.08	0.1234	<0.01
LRSX Abbrev.	62	13.05	5.29	0.0746	>0.15
		Cystoseira osmundacea			
DCSX 3m	50	0.70	1.56	0.4136	<0.01
DCSX 8m	20	0.20	0.70	0.5129	<0.01
DRSX 3m	50	2.12	3.34	0.2912	<0.01
DRSX 8m	68	3.85	3.65	0.1367	<0.01
LRSX 8m	62	0.61	1.32	0.3557	<0.01

containing relatively high numbers of zero values in Table 12-3 and for which a larger sampling quadrat would have been desirable).

Poor correspondence to normality in Table 12-4 may simply be an artifact of the methodology and did not necessarily indicate that the data might not be satisfactorily fitted to a normal curve. The method specifically tested goodness of fit between an experimental data set and that normal distribution having a mean and standard deviation identical with the data set. For example, we obtained a D-value of 0.1367 for *Cystoseira* at DRSX8m in Table 12-4 by the conventional test. Computing goodness of fit for a normal curve with the same standard deviation but a mean of 2.00 instead of 3.85 (i.e., shifting the normal curve towards the origin by 1.85 units) gave a D-value of 0.0901 with an associated probability of >0.15. The null hypotheses was thereby easily accepted instead of convincingly rejected.

The question we needed to answer: were these distributions sufficiently close to normality to justify use of parametric statistics? This was considered important because we wished to compare results from successive surveys by means of 95 percent confidence intervals. Harris (1985) noted that strict assumptions of normality are not true for most real data sets but are nonetheless nearly valid in many instances. Likewise, although an assumption of normality may not be entirely correct, violation of the assumption by using a parametric test may not necessarily invalidate the test. Zar (1984) summarizes methods for assessing departures from normality and states that "most of the commonly employed tests are sufficiently robust to allow us to disregard all but severe deviations from the theoretical assumptions." Green (1979) shares this viewpoint and offers several guidelines: distributions should be unimodal with sample sizes approximately equal and larger than ten. Ratios of the largest to the smallest sample variances should not exceed 20. Our data sets lay close to or within these guidelines, with few exceptions.

<u>Correlations Between Means and Variances</u>

Green (1979) noted that heterogeneity of variances can be caused by functional dependence of the variance on the mean. We calculated Pearson product moment coefficients of correlation to assess whether variances within each of our data sets were independent of the means. Our null hypothesis assumed the two statistics were independent. Eleven data sets failed to yield significant correlation coefficients (i.e., null hypothesis accepted), while three coefficients were significant, indicating correlation between variances and means (Table 12-5). We did not calculate a correlation coefficient for the data set representing *Cystoseira* at DCSX8m because this species only occurred in two quadrats out of twenty casts (see Appendix 12-1e).

<u>Variance Homogeneity</u>

Green (1979) states that the most serious violation of assumptions occurs from heterogeneity among the error variances (this problem is correctable by data transformation). Consequences of heterogeneity are loss of efficiency in estimating treatment effects and loss of sensitivity (higher rates for Type II or beta errors). We have used Bartlett's test to assess the null

Table 12-5: Significance of correlation between mean abundances (u) and their variances (s^2) for Phaeophyta sampled at five stations near Diablo Canyon on the indicated dates. Null hypothesis H_o: u was not correlated with s^2. When the number of correlated pairs (N) was 7, the product moment correlation coefficient (r) was significant at $r \geq 0.75$ ($P \geq 0.05$). For N =6, $r_{0.05}$ = 0.81. For n =5, $r_{0.05}$ =0.88.

Station /Depth	Para-meter	Dec 1982	Apr 1983	Sep 1983	Dec 1983	May 1984	Aug 1984	Dec 1984	Corr. coef. r	Disposition of null hypothesis
					Laminaria					
DCSX 3m	u	22.8	30.0	25.2	22.6	30.2	25.1	23.5	0.20	Accept
	s^2	228.6	57.6	244.9	47.3	131.6	168.2	202.8		
DCSX 8m	u	8.5	2.6	3.3	4.0	5.5	6.1	6.0	0.47	Accept
	s^2	24.9	4.04	17.7	18.7	29.2	19.6	9.36		
DRSX 3m	u	31.8	6.1	17.9	16.6	22.5	26.0	46.5	0.59	Accept
	s^2	497.5	14.7	110.3	61.8	91.4	53.0	295.5		
DRSX 8m	u	32.0	17.9	16.3	24.0	23.6	22.4	23.2	0.19	Accept
	s^2	60.1	122.5	119.7	58.8	276.2	83.5	87.4		
LRSX 8m	u	1.2	1.5	0.8	1.5	2.2	1.5	2.0	0.40	Accept
	s^2	1.96	1.82	1.80	2.04	3.27	2.04	2.43		
					Pterygophora					
DCSX 3m	u	1.3	2.3	0.4	1.8	0.3	1.2	0.4	0.82	Reject
	s^2	2.46	3.57	0.49	2.19	0.45	1.51	0.94		
DCSX 8m	u	13.4	11.9	14.8	14.1	15.3	15.9	14.1	0.47	Accept
	s^2	25.3	43.8	35.5	31.5	30.5	12.5	21.4		
DRSX 3m	u	1.2	0.2	0.3	3.8	11.6	23.7	54.1	0.84	Reject
	s^2	2.86	0.40	0.45	41.5	304.2	839.3	3265.0		
DRSX 8m	u	19.4	1.8	1.3	0.9	28.8	17.6	18.1	0.70	Accept
	s^2	143.3	5.66	1.99	1.66	1398.8	203.4	244.0		
LRSX 8m	u	18.5	13.6	11.4	14.1	12.6	14.5	12.4	0.82	Reject
	s^2	162.3	32.0	26.6	25.2	22.7	47.2	21.8		
					Cystoseira					
DCSX 3m	u	-	-	1.0	0.1	0.5	1.2	0.7	0.44	Accept
	s^2	-	-	6.45	0.10	2.50	1.74	1.56		
DRSX 3m	u	-	-	3.0	2.7	1.4	2.0	1.5	0.71	Accept
	s^2	-	-	14.9	19.7	6.25	12.7	5.15		
DRSX 8m	u	3.2	3.8	1.6	3.8	6.1	3.2	5.5	0.58	Accept
	s^2	5.95	8.41	3.28	14.8	11.6	14.0	28.3		
LRSX 8m	u	-	0.1	0.1	1.0	0.5	1.2	0.9	0.60	Accept
	s^2	-	0.10	0.084	4.88	0.28	4.41	0.77		

hypothesis that variances from the seven surveys contained in each of our data sets were homogeneous. Results from testing indicated that the null hypothesis was accepted for seven data sets and rejected for the other eight (Table 12-6). Again, no testing was attempted for *Cystoseira* at DCSX8m because of paucity of data.

Table 12-6: Results using Bartlett's test for homogeneity among the variances obtained from our Phaeophyte abundance sampling at various times for five stations in the Diablo Canyon region. Our null hypothesis was H_o: $s_1^2=s_2^2=s_3^2 \cdots s_i^2$ (s=sigma). The criteria for accepting or rejecting the null hypotheis at p = 0.05 were: Chi-squared = 12.529 (6 df), Chi-squared = 11.070 (5 df), and Chi-squared = 9.488 (4 df).

Station /Depth	Bartlett's B_c	Degrees of freedom df	Level of p	Disposition of null hypothesis
	Laminaria dentigera			
DCSX 3m	9.6709	6	>0.1	Accept
DCSX 8m	9.5819	6	>0.1	Accept
DRSX 3m	30.8932	6	<0.001	Reject
DRSX 8m	8.1111	6	>0.2	Accept
LRSX 8m	3.4958	6	>0.7	Accept
	Pterygophora californica			
DCSX 3m	15.0814	6	~0.02	Reject
DCSX 8m	3.9690	6	>0.6	Accept
DRSX 3m	178.842	6	<<0.001	Reject
DRSX 8m	101.931	6	<<0.001	Reject
LRSX 8m	107.469	6	<<0.001	Reject
	Cystoseira osmundacea			
DCSX 3m	26.022	4	<0.001	Reject
DCSX 8m	-	-	-	-
DRSX 3m	5.3410	4	>0.2	Accept
DRSX 8m	10.9370	6	~0.1	Accept
LRSX 8m	58.024	5	<0.001	Reject

<u>Population Stability</u>

Usefulness of a Phaeophyta population for our objectives depended in large part on its stability. Drastic effects from exposure to heated effluent might be apparent even among populations with widely fluctuating abundances, but stability was desirable if we hoped to assess moderate effects. We examined stability characteristics of the composite preoperational data sets by using a one-way analysis of variance (ANOVA) to test the null hypothesis that all abundance means from the surveys were equal for a given species at a given station. While our other tests had indicated that parametric testing might not be suitable for some data sets, we wanted to examine stabilities of all the data sets by the same methodology. Results from our ANOVA analyses indicated acceptance of the null hypothesis for ten data sets (i.e., satisfactory stability) and rejection for five sets (Table 12-7). *Cystoseira* was the most stable species while *Pterygophora* was least stable.

Table 12-7: Testing similarities among mean abundances (u) of Phaeophyte species from various dates at a given station near Diablo Canyon, by a one-way analysis of variance. Null hypothesis H_o: $u_1 = u_2 = u_3 \cdots u_i$. TSS = Total Sum of Squares, GSS = Groups Sum of Squares, ESS = Error Sum of Squares, df = degrees of freedom, df_1 = Groups df, df_2 = Error df, df_3 = Total df, GMS = Groups Mean Square, EMS = Error Mean Square, F = GMS / EMS with df_1 and df_2 degrees of freedom.

Station /Depth	TSS	GSS	ESS	df_1	df_2	df_3	GMS	EMS	F	$F_{0.05}$	Disposition of null hypothesis
					Laminaria						
DCSX 3m	10307.77	533.97	9773.80	6	63	69	89.00	155.14	0.57	2.24	Accept
DCSX 8m	1471.52	264.14	1207.38	6	68	74	44.02	17.76	2.48	2.23	Reject
DRSX 3m	19844.64	9821.14	10023.50	6	63	69	1636.85	159.10	10.29	2.24	Reject
DRSX 8m	8499.24	1401.94	7097.30	6	61	67	233.66	116.35	2.01	2.25	Accept
LRSX 8m	160.25	14.57	145.68	6	66	72	2.43	2.21	1.10	2.23	Accept
					Pterygophora						
DCSX 3m	140.30	36.00	104.30	6	63	69	6.00	1.66	3.62	2.24	Reject
DCSX 8m	2079.15	106.54	1972.60	6	68	74	17.75	29.01	0.61	2.23	Accept
DRSX 3m	63611.27	23524.97	40086.30	6	63	69	3920.83	636.29	6.16	2.24	Reject
DRSX 8m	25117.81	7276.19	17841.62	6	61	67	1212.70	292.49	4.15	2.25	Reject
LRSX 8m	3611.89	355.65	3256.24	6	66	72	59.27	49.34	1.20	2.23	Accept
					Cystoseira						
DCSX 3m	118.50	7.40	111.10	4	45	49	1.85	2.47	0.75	2.57	Accept
DCSX 8m	9.20	0.20	9.00	1	18	19	0.20	0.50	0.40	4.41	Accept
DRSX 3m	547.28	20.28	527.00	4	45	47	5.07	11.71	0.43	2.57	Accept
DRSX 8m	892.53	113.05	779.48	6	61	67	18.84	12.78	1.47	2.24	Accept
LRSX 8m	105.93	11.93	94.00	5	54	59	2.39	1.74	1.37	2.38	Accept

Summary of Analytical Results

We tabulated conclusions from each of the studies and tests as described above, for each composite preoperational data set, employing five criteria as a basis for assessing utility of the sets.

Three data sets (*Laminaria* at DCSX3m and DRSX8m, and *Pterygophora* at DCSX8m) were favorable as regards all criteria (Table 12-8). These three data sets also were among the best as regards closeness of fit to normality as shown by Table 12-4. Four others were clearly unusable (i.e., *Laminaria* at DRSX3m, *Pterygophora* at DCSX3m and DRSX3m, and *Cystoseira* at DCSX8m). Seven of the preoperational data sets were questionable. Some of these might be useable, depending upon results from further analysis. Two factors were largely responsible for causing data sets to be classified as questionable or unacceptable. Some of the populations such as

Table 12-8: Summary of distributional characteristics and of conclusions from statistical tests of the data sets representing abundances of three major Phaeophyte species at our five diving stations near Diablo Canyon. The last entry for each genus in the Table states our conclusion as to probable utility of each data set, based on results from the other entries.

Genus and Distributional Characteristics	Station / Depth DCSX 3m	DCSX 8m	DRSX 3m	DRSX 8m	LRSX 8m
Laminaria					
Distributional Modality	unimodal	unimodal	unimodal	unimodal	unimodal
Distributional Skewness	moderate	mod.->high	moderate	moderate	high
Non-correlation of Variance and Mean	accept	accept	accept	accept	accept
Bartlett's Test	accept	accept	reject	accept	accept
Stability of Mean Abundance	accept	reject	reject	accept	accept
Estimated Utility	good	questionable	poor	good	prob. good
Pterygophora					
Distributional Modality	unimodal	unimodal	unimodal	unimodal	unimodal
Distributional Skewness	high	moderate	high	mod.->high	moderate
Non-correlation of Variance and Mean	reject	accept	reject	accept	reject
Bartlett's Test	reject	accept	reject	reject	reject
Stability of Mean Abundance	reject	accept	reject	reject	accept
Estimated Utility	poor	good	poor	questionable	questionable
Cystoseira					
Distributional Modality	unimodal	uncertain	unimodal	unimodal	unimodal
Distributional Skewness	high	very high	high	mod.->high	high
Non-correlation of Variance and Mean	accept	--	accept	accept	accept
Bartlett's Test	reject	--	accept	accept	reject
Stability of Mean Abundance	accept	uncertain	accept	accept	reject
Estimated Utility	questionable	unuseable	prob. good	prob. good	questionable

Cystoseira at DCSX8m were so sparse that data were insufficient to support the analyses (a larger sampling quadrat would be needed to assess these populations). More commonly, disruptions from El Niño-associated events caused dramatic changes in abundances (e.g., *Laminaria* and *Pterygophora* at DRSX3m). We were able to use later portions of data sets from the disrupted populations in cases where abundances stabilized at some point following recovery from effects of the great storm in March 1983.

Discussion of Analysis of Preoperational Data Sets

The useable data sets for *Laminaria* at DCSX3m and DRSX8m provided the most reliable basis for assessing operational changes in this species for shallows in Diablo Cove, as well as assessing influence of depth on effects related to the plume. Comparisons of fates of sensitive Phaeophyta inside and outside of Diablo Cove could best be accomplished using *Pterygophora* populations at DCSX8m and LRSX8m. *Pterygophora* at LRSX8m, however, yielded only a marginally usable data set because the March 1983 storm moderately reduced abundance of the species. Quality of these data was greatly improved when we ignored the pre-El Niño survey of December 1982 and examined an abbreviated data set of six surveys (i.e., April 1983 to December 1984). The null hypothesis was then accepted for Bartlett's test and for the Kolmogorov-Smirnoff goodness of fit test for normality. Thus although our original experimental design was to some extent vitiated by events beyond our control, there was sufficient redundancy in the design to allow us to fulfill our objectives of assessing possible changes (or lack of changes) in abundances of sensitive Phaeophyta during the operational period in Diablo Cove.

The data also provided some insights as to influences from the 1983-84 El Niño. Storm-associated damage did not entirely correspond with our expectations. The most exposed transect was DCSX in the center of Diablo Cove, having minimal lee (see Figure 5-1). Reductions in Phaeophyta abundances along this line consisted only of a possible decline in *Laminaria* abundance at the deep end of the transect. By contrast, depletion among palm kelps was typically substantial at our supposedly protected stations in the lee of Diablo Rock and Pup Rock.

Pterygophora at both DRSX and LRSX was the most vulnerable but *Laminaria* populations at DRSX also experienced reductions following the great storm of March 1983.

Proximity to deep water may have been an important factor affecting destructiveness by wave surge. The DRSX and LRSX transects were situated on or near sloping bottom that descends to deep water nearby. In contrast, waves reaching the shoreward end of the DCSX transect must first traverse some 60 to 70 m (200 to 230 ft) of shoals that were 3 to 6 m (10 to 20 ft) deep. Apparently these shoals attenuated water motion more effectively than the barriers created by the two islets. This presumption was supported by our general observations along the transects immediately following the March 1983 storm. Vegetation in the shallows at DCSX3m was tattered and obviously pruned but any losses of individual plants were not dramatic and easily discernible. Cover by plant and animal turf was judged as lying within the range of normality. In particular, the small sprawling kelp, *Dictyoneurum*, appeared entirely normal with no evidence of pruning or of tattered blades. In stark contrast, much of the bottom at DRSX3m was barren except for encrusting corallines and a few closely-encrusting hard-shelled animals. Most of the luxuriant plant and animal turf here had vanished. Remaining large plants were primarily individuals protruding from the undersides of huge overturned boulders. Storm-related effects at DRSX extended down to below 8 m (26 ft) depths. Plant turf was also severely damaged in the shallows at LRSX but animal turf survived well. LRSX had somewhat more lee than DRSX because it lay behind two islets instead of one (see Figure 5-1).

Our observations usually suggested that *Pterygophora* was more severely impacted than *Laminaria* by the March 1983 storm. This differential sensitivity to storm damage may explain the vertical distributions typically found in the Diablo Canyon region for the two palm kelps. *Pterygophora* is generally a rather minor component of the flora at shallow depths (i.e., 4.5 m [15 ft] or less). *Laminaria* dominates at these shallow levels and our data indicated this species survived storm effects as well as or better than *Pterygophora* at all stations but one (DCSX8m). *Pterygophora* tended to become dominant at depths of 7.5 to 9 m (25 to 30 ft), probably because the less-violent water movements at deeper levels enhanced its survival. There were exceptions, however, as illustrated by our station at DRSX8m. *Laminaria* was dominant here at depths where *Pterygophora* usually prevailed. Possibly wave motion at DRSX8m was still a controlling factor at these depths because the site was only semi-protected and was quite close to deep water.

While the great storm of March 1983 was associated with significant reductions in Phaeophyta abundances at several of our study sites, the data failed to indicate any further effects from El Niño as waters warmed (and nutrient concentrations presumably fell) during the remainder of 1983. Daily measurements of water temperatures at 0800 hours and 3 m (10 ft) depths in South Cove during 1983, indicated values of 17°C (62.6°F) or more occurred for 26 days during the period September 12 to October 12 1983, with a maximum of 18.2°C (65.2°F) on the latter date (see Figure 8-7). Laboratory studies have indicated that significant mortality might be expected among adult *Pterygophora* held for 96 hours at temperatures above 19.1°C (67°F) and that fertility of *Laminaria* gametophytes is inhibited at temperatures of about 17 to 18°C (62.6 to 64.4°F; TERA 1982; Luning and Neushul, 1978). Our data did not reveal any influences on Phaeophyta abundances from El Niño conditions during latter 1983. Paucity of nutrients at that time was suggested by widespread paling among intertidal and subtidal Red Algae in the Diablo Canyon region.

Excellent recruitment by small *Pterygophora* on all the barren rocky surfaces created at our DRSX transect (both shallow and deep) by the March 1983 storm was observed during our September 1983 visit. Juvenile *Pterygophora* concentrations at DRSX3m were estimated at 5 per m^2 in September 1983, rising to 11 per m^2 in December 1983. Occasional small *Laminaria* were also seen in September. All these juvenile Phaeophyta were probably germinated during the preceding spring and summer, but nonetheless did survive well during the unusually warm summer and fall of 1983.

Comparisons of Preoperational and Operational Data Sets

95 Percent Confidence Intervals

We have depicted our computations of 95%CI graphically (Figures 12-1 to 12-5). Significance of changes are more easily comprehended and compared when seen as graphs, rather than from tabulations of long lists of numbers. There were several instances where significant changes in abundances were associated with natural events (for example, substantial declines between December 1982 and April 1983 for *Laminaria* at DCSX8m, DRSX3m, DRSX8m, and for *Pterygophora* at DRSX8m; these declines almost certainly resulted from exceptionally severe winter storms marking El Niño's onset that year). The 95%CI findings will be considered further in the discussion.

Natality

Occurrences of juvenile palm kelps at our three deep water stations, DCSX8m, DRSX8m, and LRSX8m, was usually spotty so we did not statistically analyze the data for these stations. Plots of the abundance data vs time for juvenile *Laminaria* and *Pterygophora* at Stations DCSX3m and DRSX3m, clearly showed seasonal influences (Figure 12-6). Quite interestingly, both *Laminaria* and *Pterygophora* recruited at DRSX3m during latter 1983, but not at DCSX3m. 1983 was an El Niño year with water temperatures ranging from 2 to 4°C (3.6 to 7.2°F) above the ten year mean, for many days during fall. A thick substory kelp canopy existed at DCSX3m at that time, but not at DRSX3m (see Figures 12-1 and 12-3). Thus palm kelps recruited on a well-illuminated bottom, but not on a poorly-illuminated bottom at the same depth, during a period of abnormally high water temperatures. Dean and Deysher (1984) found a similar relationship affecting *Macrocystis* recruitment in the San Onofre region. Enhanced bottom illumination permitted *Macrocystis* to recruit at slightly higher water temperatures compared to locations having low illumination. Judging from relative heights of the peaks shown in Figure 12-6, conditions at DRSX3m in 1983 were marginal for recruitment by *Laminaria*, but quite favorable for *Pterygophora*. We will defer our

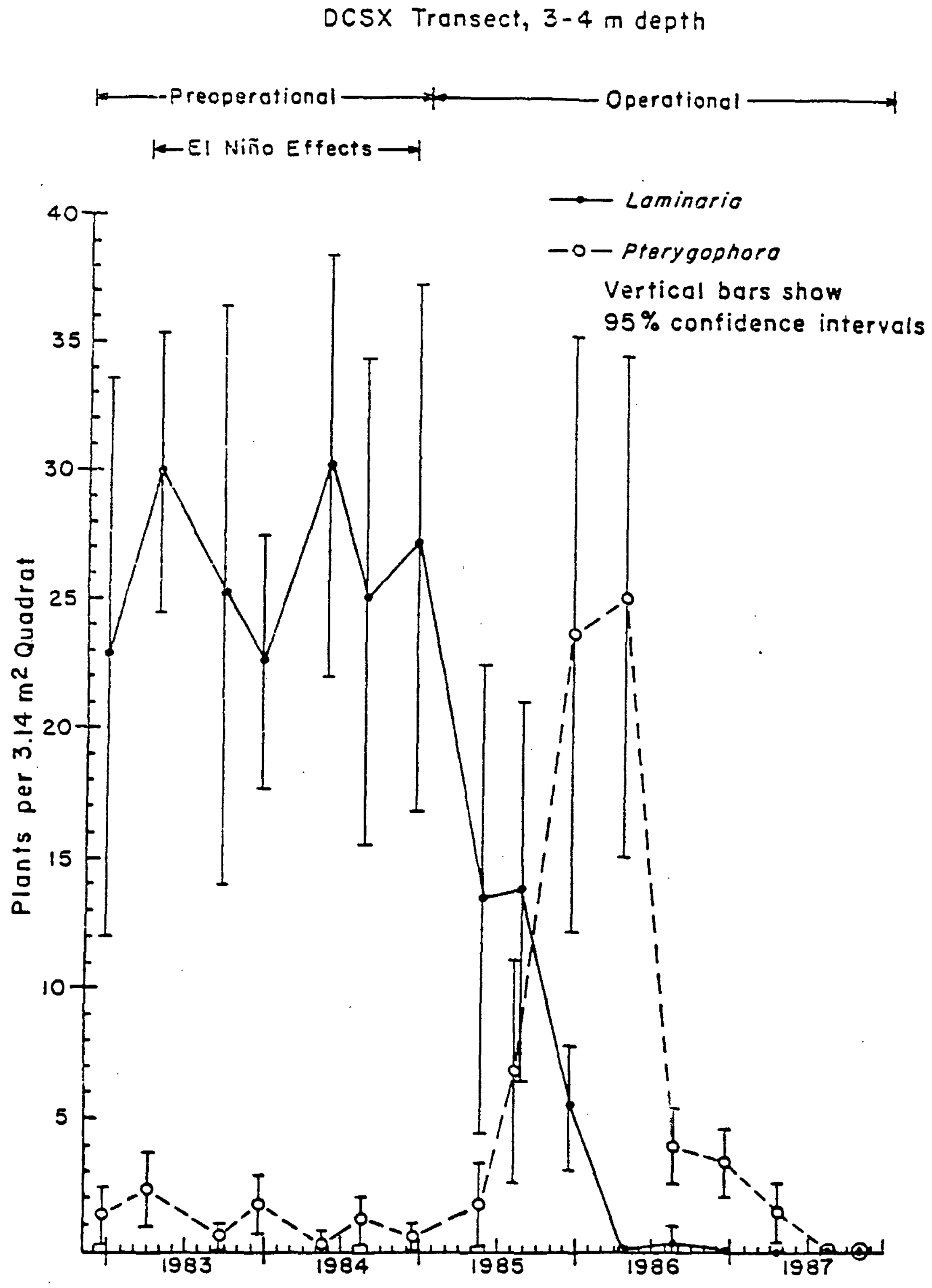

Figure 12-1. History of adult palm kelp abundances, DCSX3m, 95%CI.

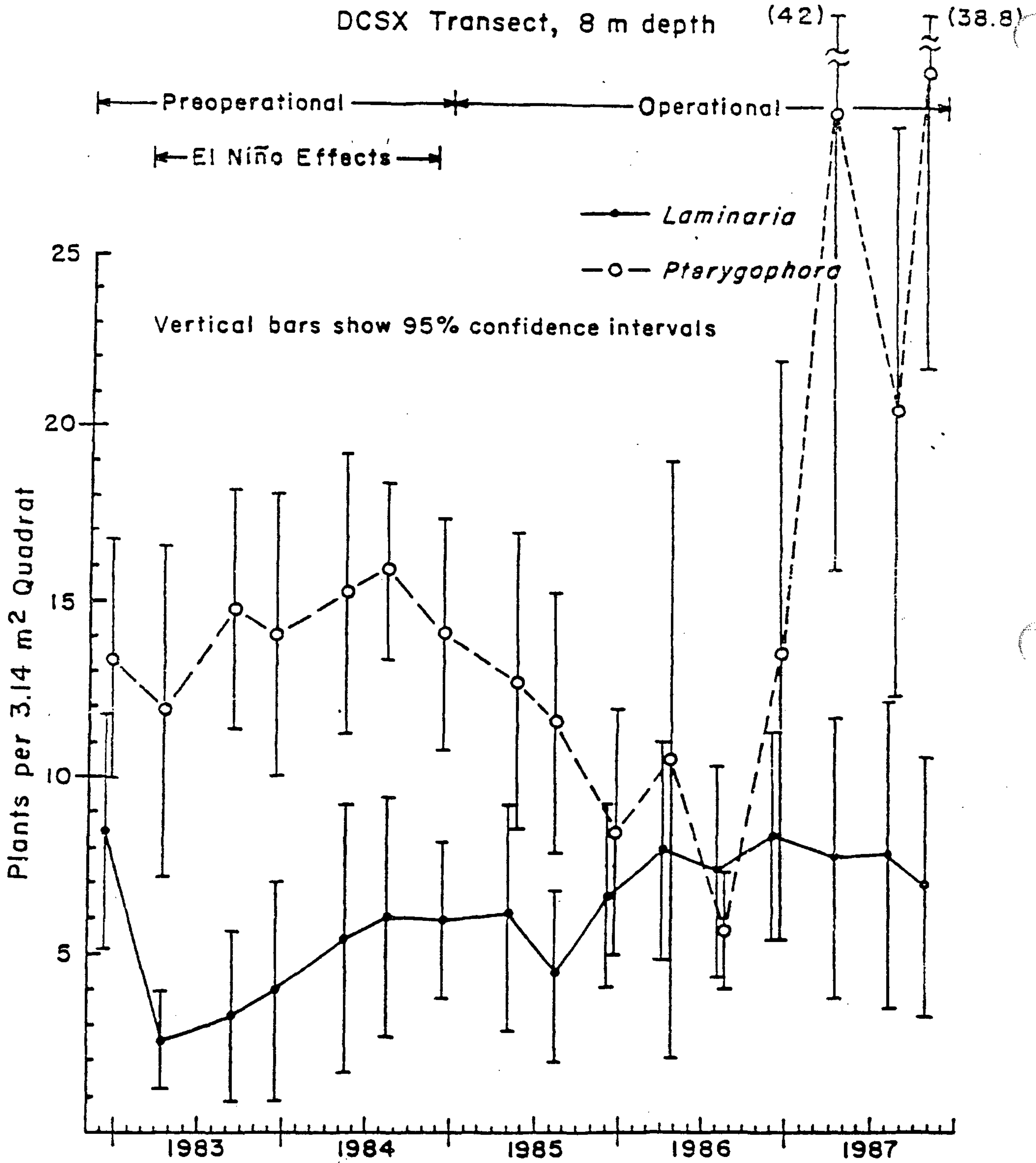

Figure 12-2. History of adult palm kelp abundances, DCSX8m, 95%CI.

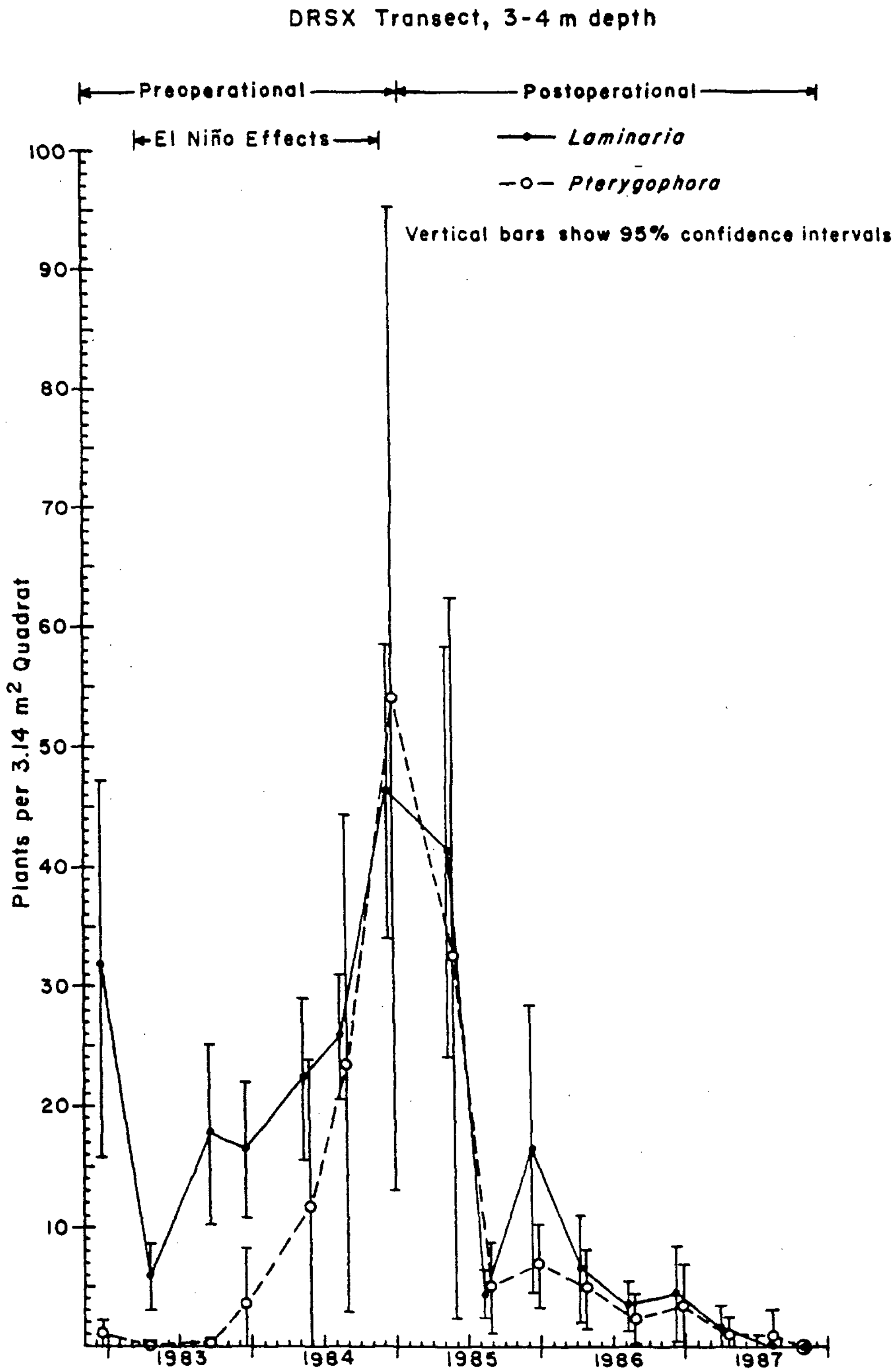

Figure 12-3. History of adult palm kelp abundances, DRSX3m, 95%CI.

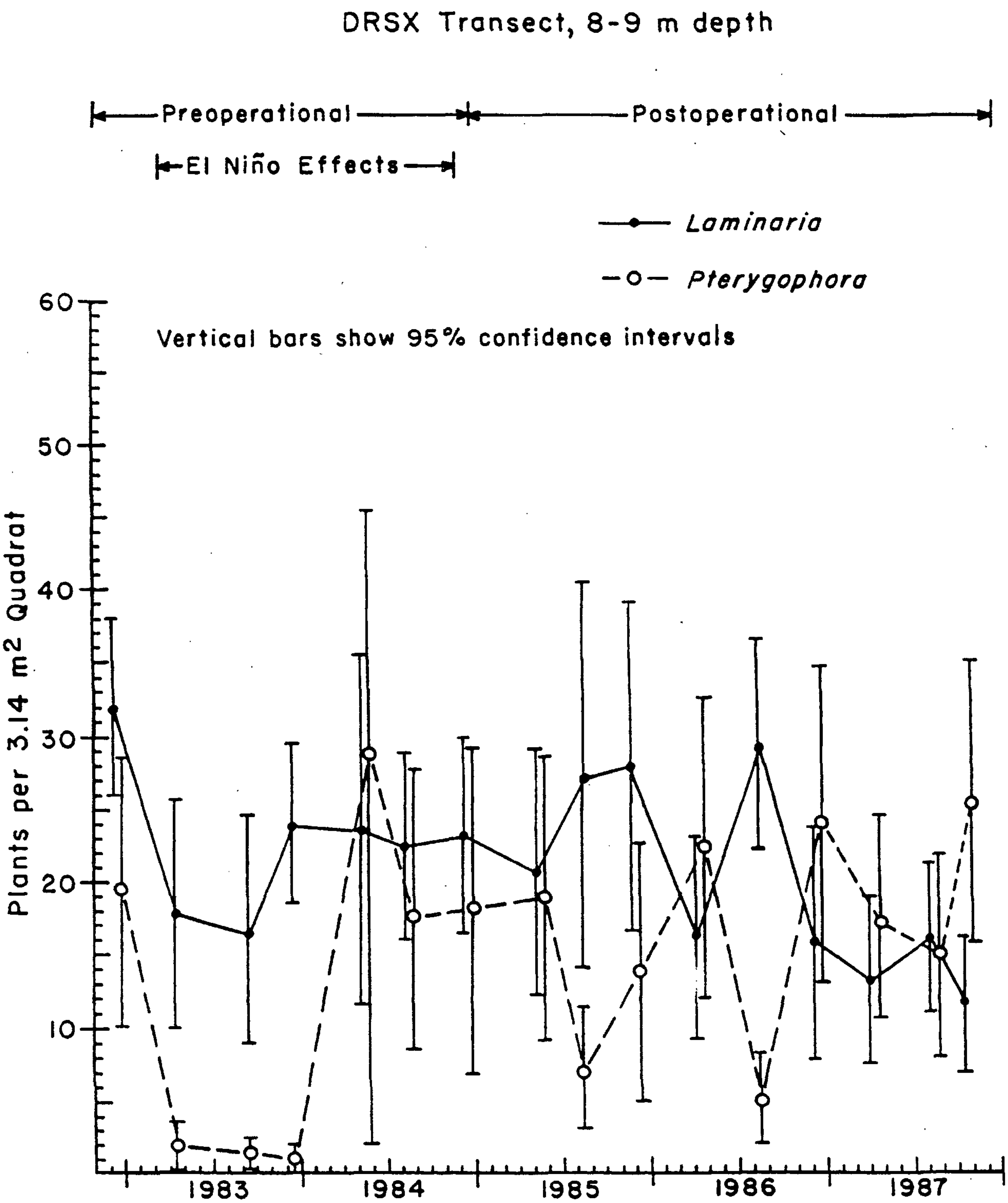

Figure 12-4. History of adult palm kelp abundances, DRSX8m, 95%CI.

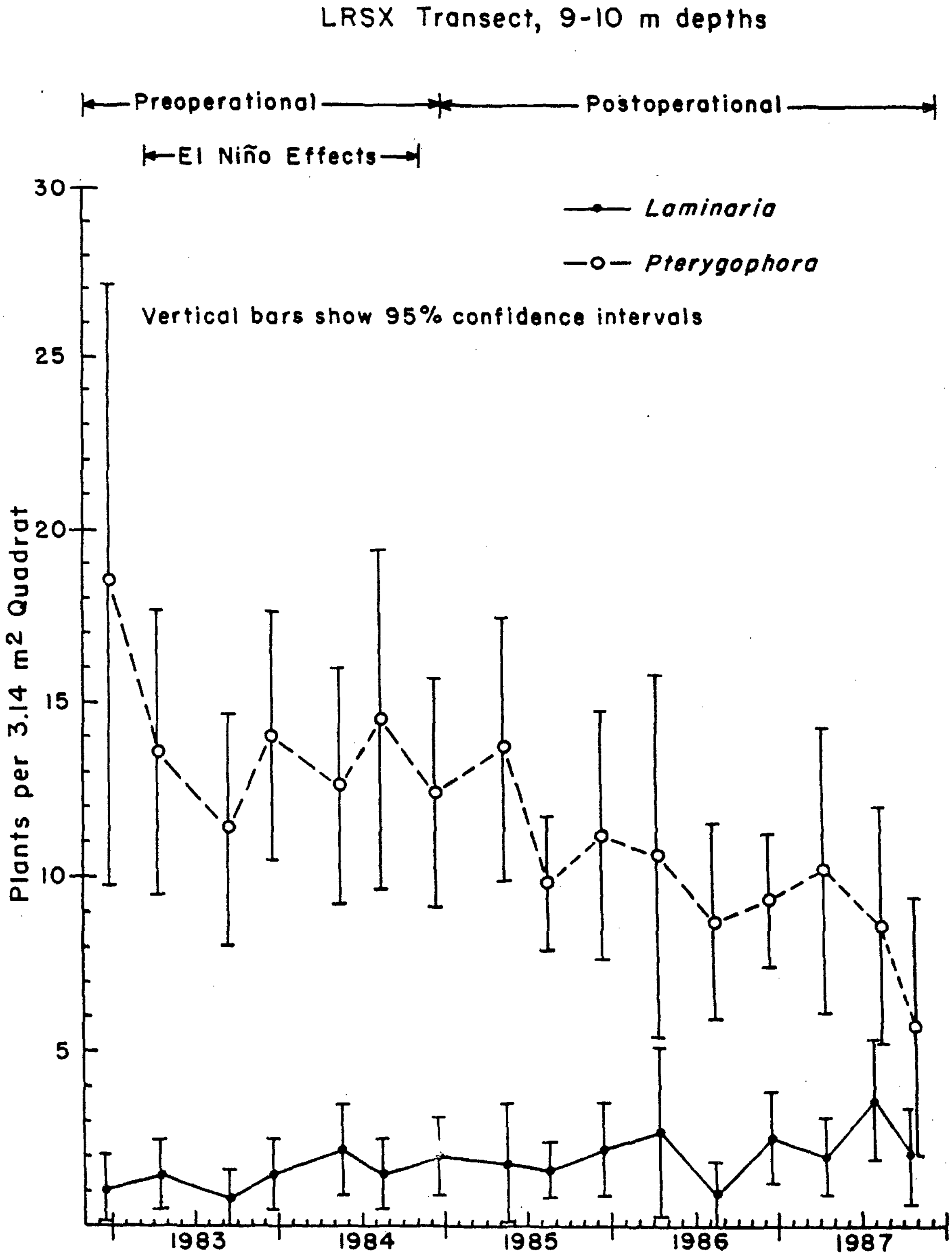

Figure 12-5. History of adult palm kelp abundances, LRSX8m, 95%CI.

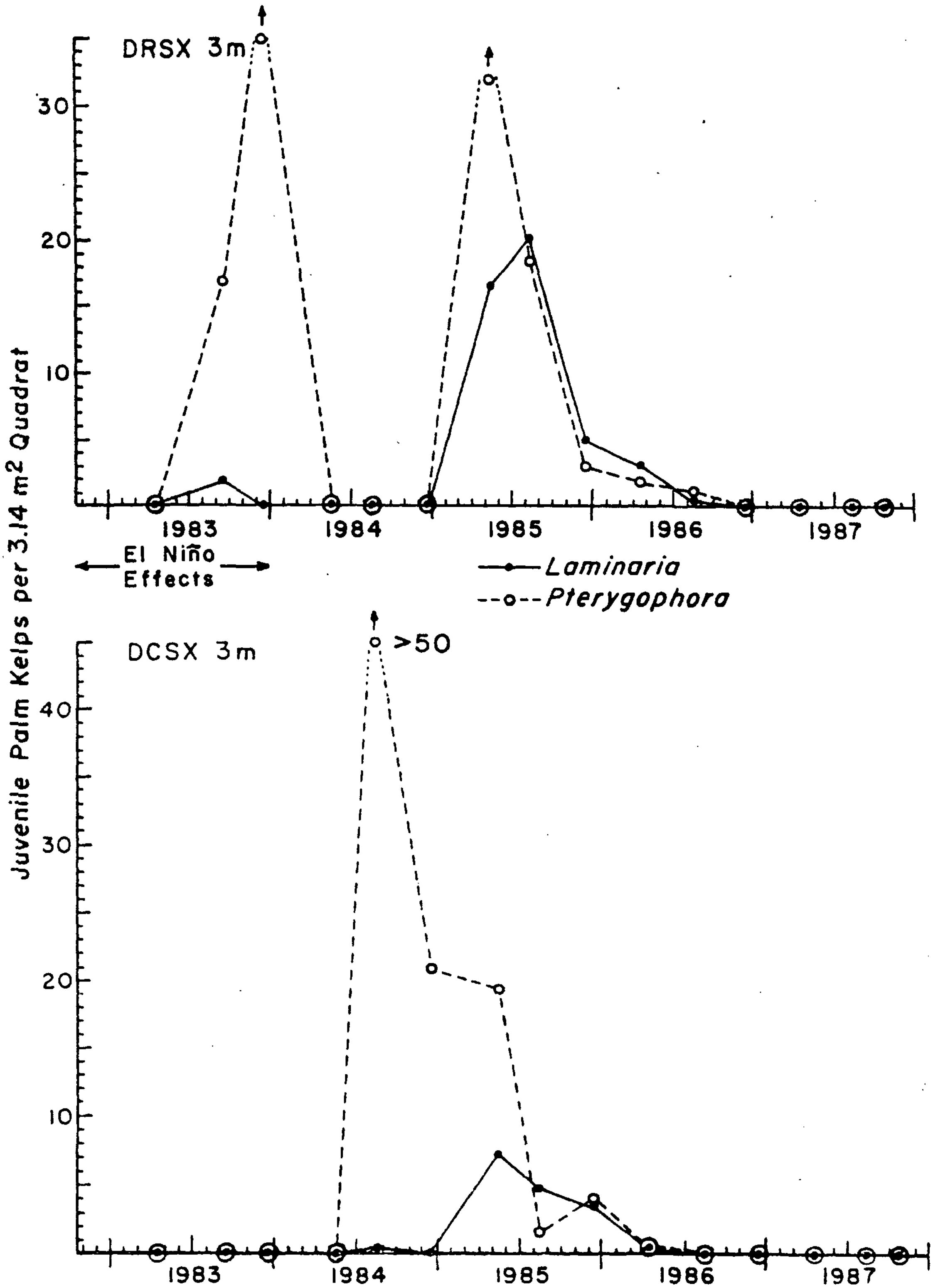

Figure 12-6. History of juvenile kelp abundances, DCSX3m and DRSX3m.

analysis of possible effects from heated effluent on palm kelp recruitment in Diablo Cove to the discussion below.

Mortality

Prevalence of dead palm kelps held constant at our three deep water stations (DCSX8m, DRSX8m, and LRSX8m) throughout the operational period, but increased many-fold at the two shallow stations, DCSX3m and DRSX3m (Figure 12-7). Abundances began declining at both DCSX3m and DRSX3m from 1986 onward. The decline probably occurred because of the decreasing supplies of adult palm kelps (see Figures 12-1 and 12-3). Gradual disappearance of living plants thus cut down the supply needed to maintain a high concentration of dead remains in the face of losses from slow decay. Changes in dead palm kelps at these two shallow stations were

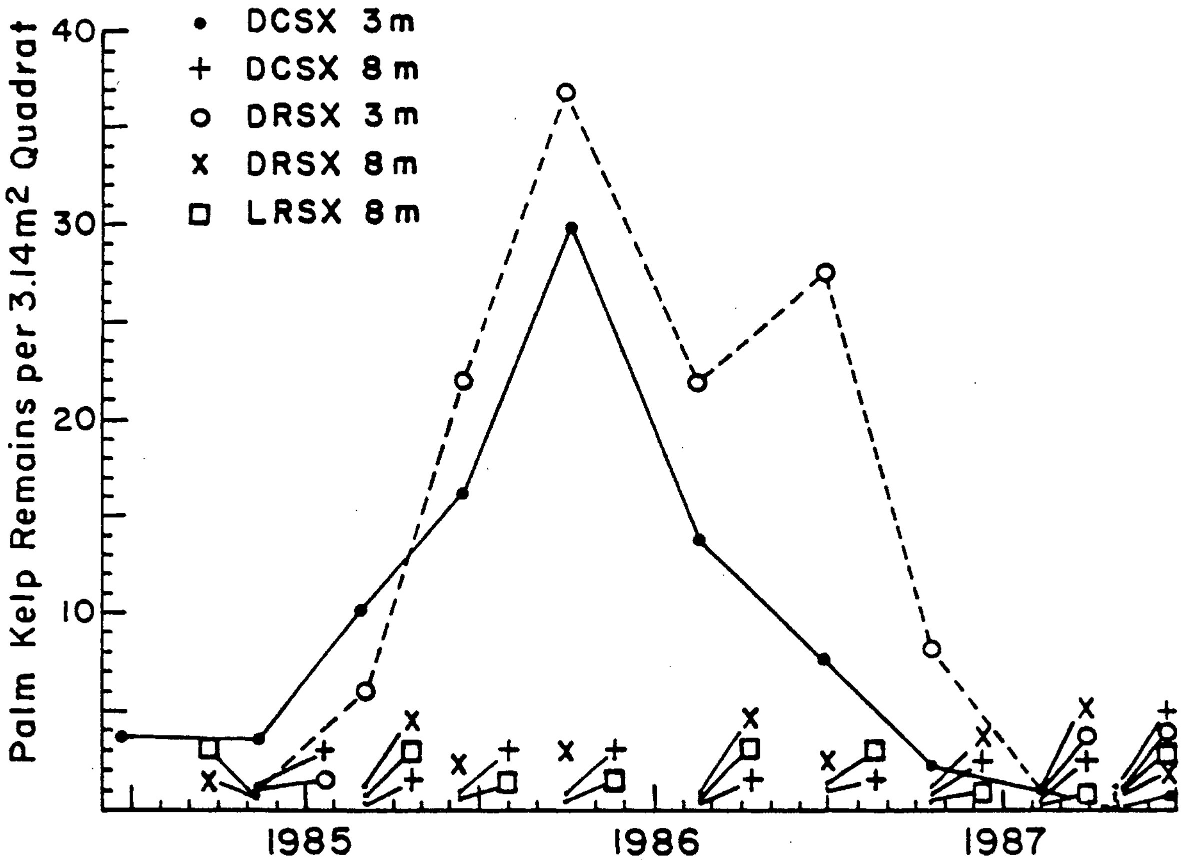

Figure 12-7. Abundances of dead stipe remains, all stations.

often significant from one survey to the next (Figure 12-8). Our data thus suggest that unusually high mortality occurred among palm kelps at our shallow stations within Diablo Cove during the operational period, but not at any of our deep water stations whether inside or outside the Cove. We will refer to these data further in the discussion below.

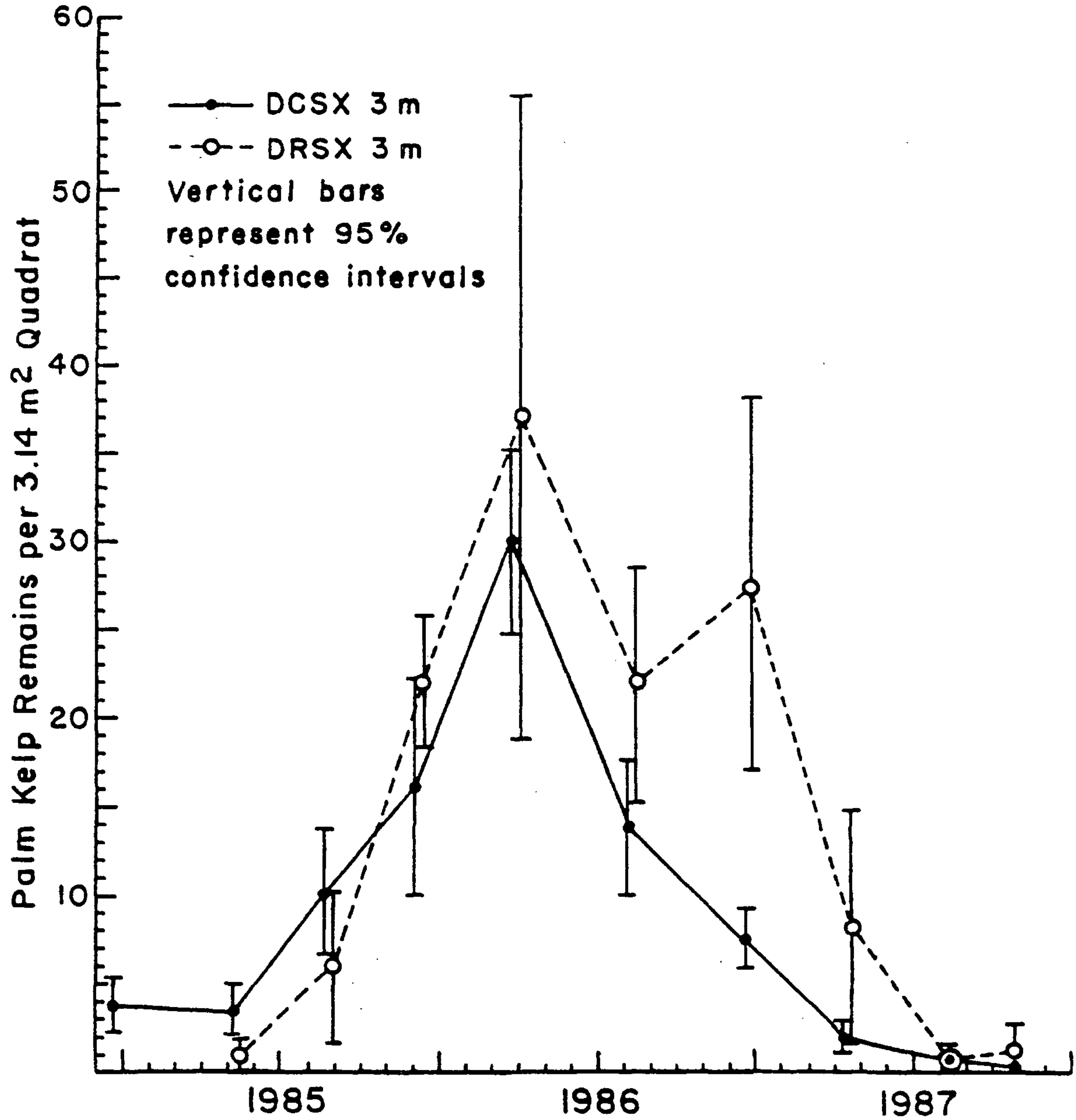

Figure 12-8. Abundances of dead stipe remains, DCSX3m and DRSX3m, 95%CI.

Discussion of Composite Data Sets

In this section, we will synthesize our various results, one station at a time, to provide an overview of events and fates of palm kelp populations exposed to heated effluent. Data from continuous temperature recorders suggest that any exposures at the depths of our shallow stations were not uniform. Bottom temperatures at 3 m (10 ft) depths fluctuated widely, depending in part on tidal heights (Figure 12-9). To assist the reader in following our discussion, we have included the graphs showing time changes in abundances of adult *Laminaria* and *Pterygophora* at the various stations (already presented as Figures 12-1 to 12-5), but omitting the vertical bars depicting the 95%CIs.

Control Station Outside Diablo Cove

LRSX8m

The *Laminaria* population at LRSX was characterized by low abundances, but remained very stable throughout the four-year observational period (Figure 12-10). There was no detectable effect on *Laminaria* abundances from El Niño. Results from our nANOVA analysis indicated that preoperational abundances were similar to those from operational surveys (data not shown). Sparse occurrences of *Laminaria* at our LRSX control station were probably due to deepness of the sampling site and low bottom illumination at the site. The bottom here consisted of rocky outcrops projecting up through a fine sand bottom. Projecting rocktops enhance turbulence during passage of waves, bringing sediment and debris into suspension. The suspensoids increased light absorption and scattering, leading to low bottom illumination. The general area became increasingly colonized by *Macrocystis* and *Nereocystis* during operational years, further reducing submarine light levels. *Laminaria* had always been abundant at 3 to 4.5 m (10 to 15 ft) depths along the LRSX transect (i.e., up on the cliff where the transect begins). The area where *Laminaria* was abundant lay horizontally only a few meters away from the sampling site, which was 7.5 to 9 m (25 to 30 ft) deep (see Figure 5-12 for sampling site). Thus it appeared that depth-related

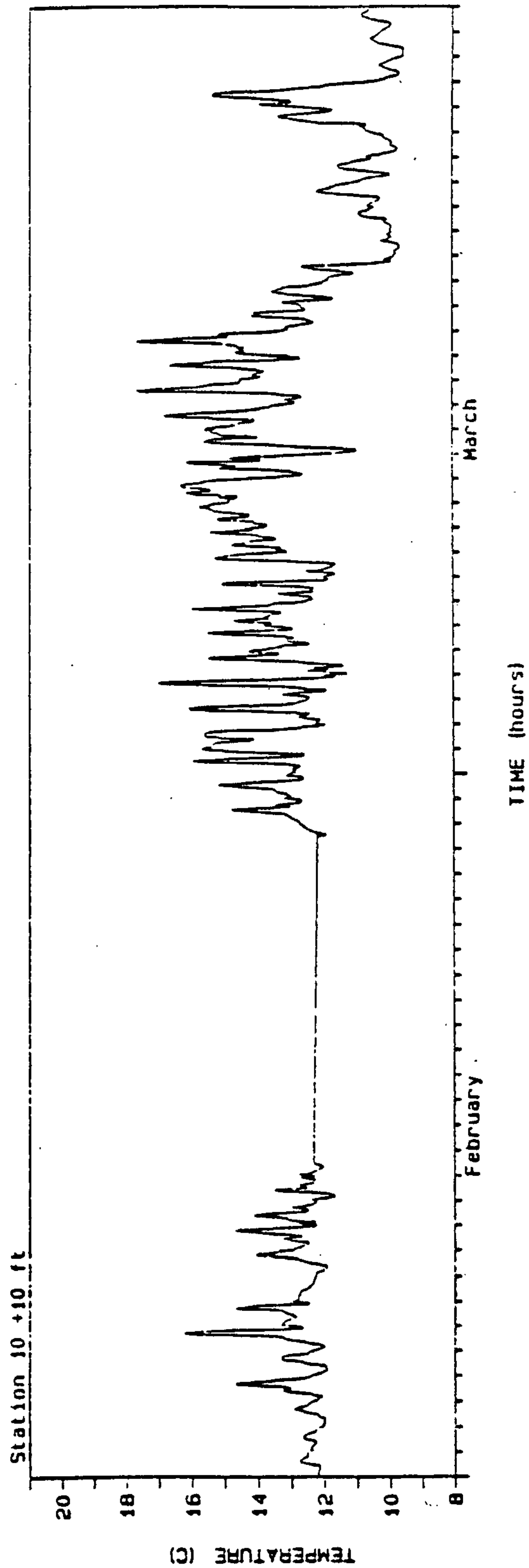

Figure 12-9. Temperature record provided by a continuously recording device located near our DCSX3m sampling site in Diablo Cove. Time period represents early 1985. (TERA, 1986).

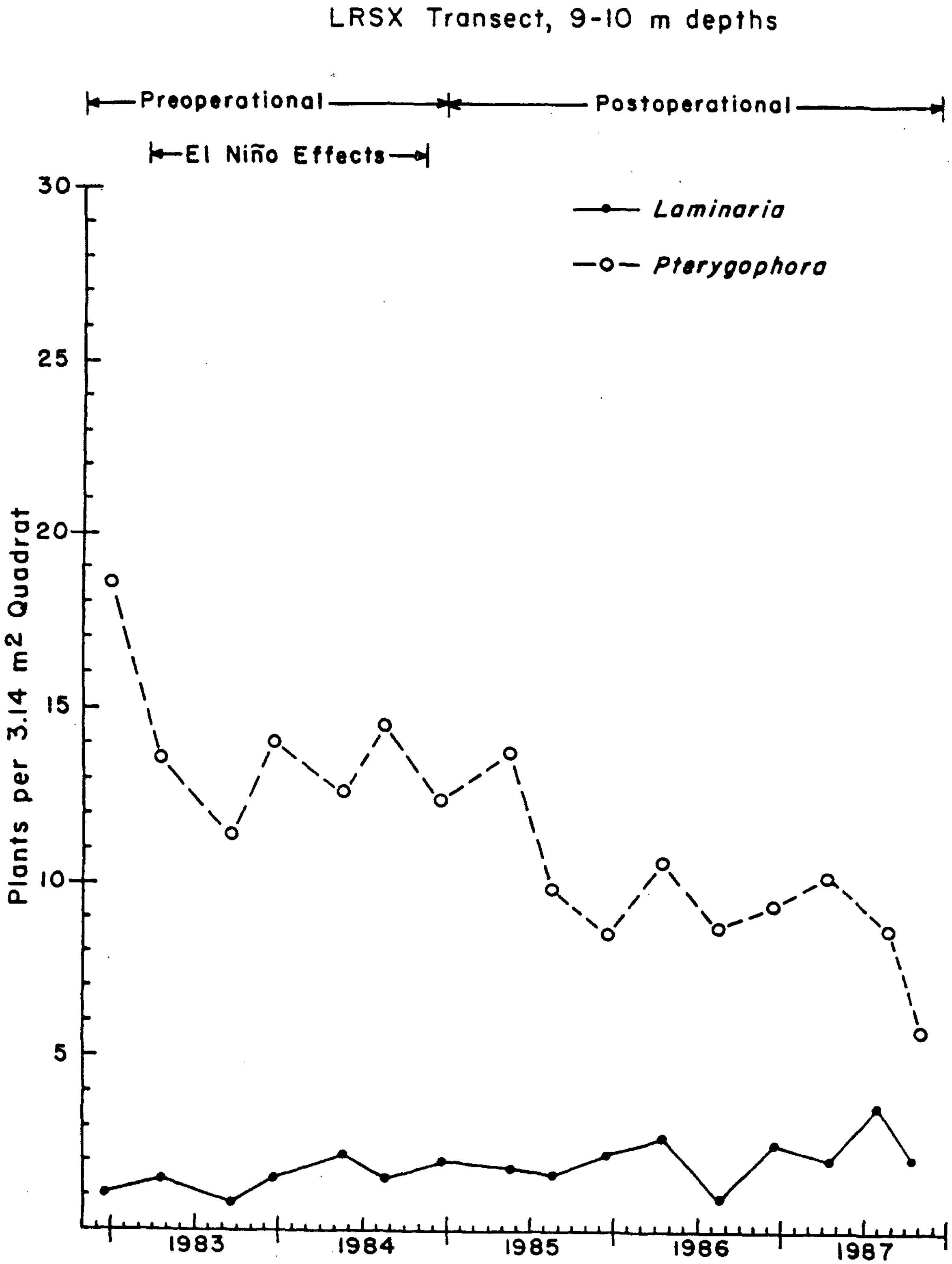

Figure 12-10. History of adult palm kelp abundances, LRSX8m.

factors were responsible for low abundances of *Laminaria* along the deep portion of the LRSX transect.

Pterygophora abundance at our LRSX control declined moderately but significantly (one way ANOVA, sixth column in Table 12-8) following the extreme storms of February-March 1983, marking El Niño's onset. This initial decline was not, however, significant in terms of 95 percent confidence intervals. Abundances then stabilized through spring 1985, declining significantly thereafter to a lower level of stability (nANOVA, data not shown). It does not seem reasonable to suppose that the decline following spring 1985 was due to power plant operation in nearby Diablo Cove. There was no corresponding decline in *Laminaria* abundances at the LRSX sampling site and dense stands of healthy *Laminaria* persisted in shallow waters there. We consider *Laminaria* to be a better indicator than *Pterygophora* of elevated water temperatures and would expect any effects from the power plant to be manifested more intensely at shallow than at deep levels. Additionally, there was no dramatic increase in palm kelp remains at LRSX8m (Figure 12-7). We found scattered juvenile *Pterygophora* at this station during 1986 and 1987, so adult abundances may increase somewhat in the near future. The LRSX target population initially consisted almost entirely of very old plants (sometimes 2m [6 ft] or more tall) but became a mixture of young and old. It appeared to be a climactic climax type of dominance where dying old individuals were replaced by juveniles of the same species. If, however, *Macrocystis* and *Nereocystis* abundances continued to increase here, populations of palm kelps might disappear entirely due to light limitation. In any case, there did not appear to be any clearly identifiable change in *Pterygophora* abundance that could logically be related to power plant operations.

<u>Control Stations Inside Diablo Cove</u>

DCSX8m

This sampling site lay at the offshore end of our DCSX transect in central Diablo Cove (see Figure 5-12). The DCSX transect was designed to follow approximately along the centerline of the discharge plume. The inshore 70 m (230 ft) of the DCSX line lay in shallow water 3 to 4.5 m

(10 to 15 ft) deep. A rather steep cliff occurred about 65 m (215 ft) offshore from the transect origin, with a deepening of the bottom to about 8 m (26 ft ; i.e., well below the predicted lower boundary of the plume). The control station sampling area encompassed this deep-lying 30 m (100 ft) of outer DCSX. Its primary purpose was to test the prediction about maximum plume depth within the near-field portion of the plume by recording whether palm kelp abundances changed significantly during the operational period.

Patterns of changes in *Laminaria* abundances at DCSX8m differed from those for *Pterygophora* (Figure 12-11). The great storms of early 1983 caused a significant decline in *Laminaria* abundance (one way ANOVA and comparison of 95 percent confidence intervals, Table 12-7 and Figure 12-2). *Pterygophora* abundance did not change significantly at this time. The *Laminaria* population increased slowly but significantly during the next four years (nANOVA, data not shown). *Pterygophora* abundances were stable up to mid-1984, then began a significant two-year downward trend that apparently bottomed during summer 1986. This decline resembled the situation described above for *Pterygophora* at LRSX. The *Pterygophora* population at DCSX8m initially consisted of very old plants, some more than two meters tall. These large old plants slowly disappeared, beginning in latter 1984. During the last half of 1986, a dense bloom of juvenile *Pterygophora* appeared throughout the DCSX8m sampling area. By December 1986, many of the juveniles had grown sufficiently to be classed as adults and *Pterygophora* abundance began rising sharply at the time of our final 1986 survey, leveling off in mid-1987. Simultaneous losses of large old *Pterygophora* at both the LRSX and DCSX control areas suggested that perhaps the species has a maximum lifespan. These large plants probably germinated at roughly similar times around 1975 when urchin dominance was eliminated by appearance of otters. Coincidental disappearances at two different stations after many years of dominating the bottom supports the concept that a maximum lifespan for the species exists.

As at LRSX, commencement of the decline in *Pterygophora* abundance at DCSX8m coincided rather closely with onset of heated effluent discharge into Diablo Cove. As for LRSX, we

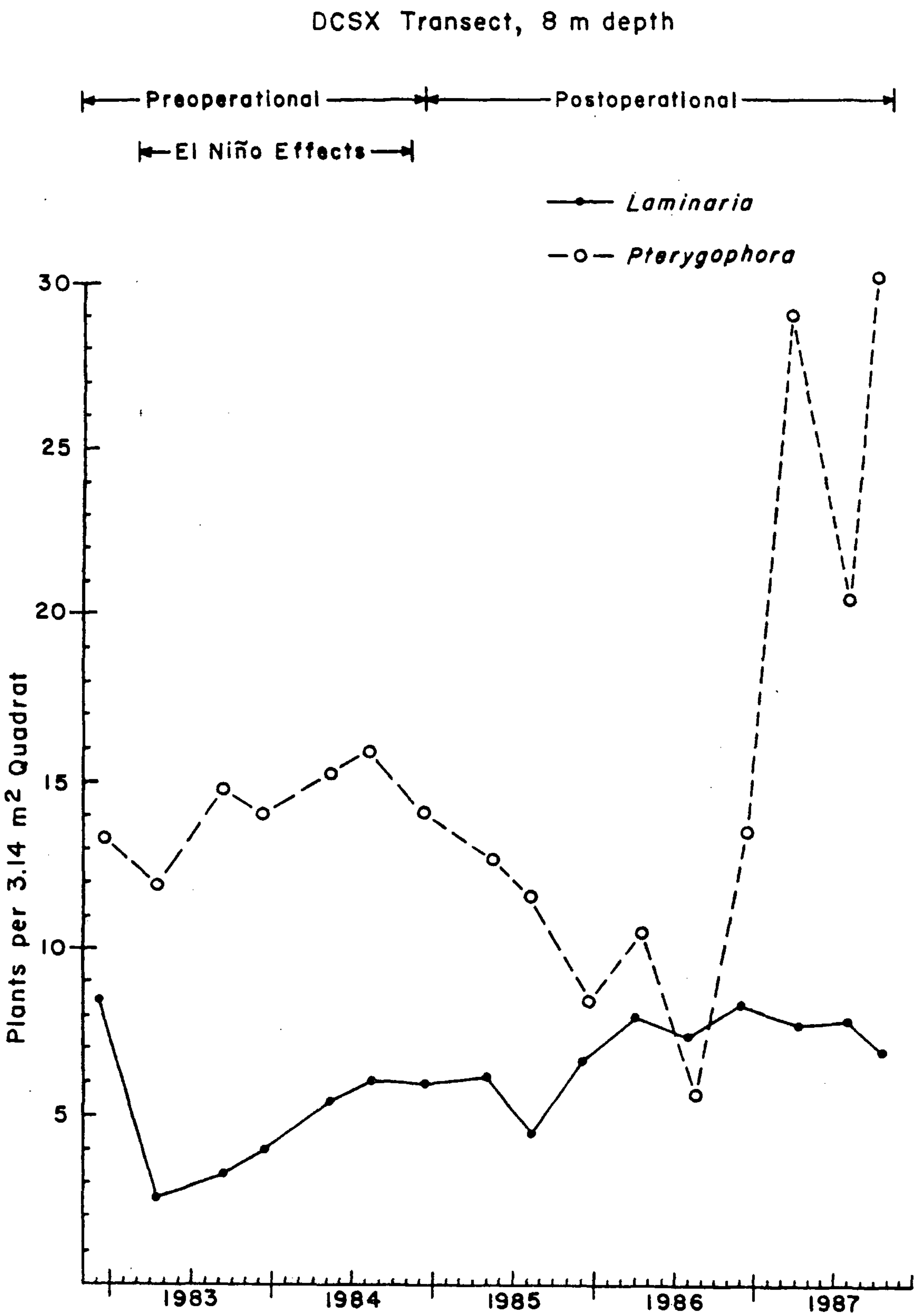

Figure 12-11. History of adult palm kelp abundances, DCSX8m.

believe that the timing at DCSX8m was coincidental and did not represent a cause-effect relationship between effluent and survival of *Pterygophora*. We noted above that *Laminaria* appears to be more sensitive to elevated water temperatures than *Pterygophora* (also see discussion below for results from sampling at our two shallow stations). The significantly rising trend at DCSX8m in *Laminaria* abundance from 1983 to 1986 would argue strongly against the hypothesis that there was effective exposure to heated effluent at this location. Likewise there was no sharp increase in abundance of palm kelp remains here (Figure 12-7). It seems likely that the very old *Pterygophora* at both LRSX8m and DCSX8m were affected by similar natural causes of slow attrition. A point was finally reached when the substory canopy thinned sufficiently to allow development of juvenile *Pterygophora*. Recruitment occurred but was much more abundant at DCSX8m than at LRSX because of shading by *Macrocystis* and presence of suspensoids at LRSX. The bloom of juveniles at DCSX8m apparently reversed the declining trend for *Pterygophora* at this station. A trend reversal will apparently require more time at LRSX, if it occurs at all.

DRSX8m

This was one of two sampling sites on the lee side of Diablo Rock, athwart the DRSX transect (see Figure 5-12). Both sampling sites experienced very strong wave surge in spite of their locations behind Diablo Rock. Waves refract around the Rock with only moderate attenuation. Much of the bottom here experiences surge at twice the frequency of the wave trains entering the Cove. This arose because onset of the surge coming from one side of the Rock did not coincide in time with onset of surge coming from the opposite side of the Rock. Turbulence was enhanced by presence of Diablo Rock and the highly irregular bottom here. We have sensed swirls of warm water at depths of 6 to 7 m (20 to 23 ft) while diving here, substantially deeper than the 3 to 4.5 m (10 to 15 ft) lower level of the plume at our other shallow diving station, DCSX3m. Possibly Diablo Rock served as an impediment for the outgoing plume, depressing the thermocline in the immediate vicinity.

Abundances of both *Laminaria* and *Pterygophora* declined at DRSX8m after the great storms during early 1983 (Figure 12-12). Losses by *Pterygophora* were highly significant (one way ANOVA, Table 12-7, and 95%CI, Figure 12-3) and were possibly significant for *Laminaria* (95%CI comparison, Figure 12-3). Recruitment by *Pterygophora* occurred each year except 1984 at this station. Adult *Pterygophora* abundances here fluctuated widely, but continuing recruitment was able to maintain a moderate-to-substantial population of older plants. Moderate *Laminaria* recruitment occurred from 1985 to 1987. Abundances of adult *Laminaria* remained stable from survey to survey through 1986, though never quite attaining the densities first recorded in December 1982. The lowest abundance value for *Laminaria* was recorded at the end of 1987. A new and lower "steady state" may have prevailed from 1986 onward.

Thus even though there may be mild and occasional exposures to diluted effluent of palm kelps at DRSX8m, our data did not reveal any evidence suggesting large changes associated with first appearances of heated effluent around the beginning of 1985. The populations of *Laminaria* and *Pterygophora* here combined to produce the densest, most persistent coverage of any of our stations. Wave surge tended to prune the blade crowns constantly, hindering formation of a solid substory canopy. Water clarity at the DRSX transect also was usually better than at our other stations. These factors may explain ability of both species to recruit successfully and continuously within such dense concentrations of adults. Probably mortality rates were high for palm kelps at DRSX8m. We never found large old *Pterygophora* here as we had at LRSX8m and DCSX8m.

Shallow Stations Inside Diablo Cove

DCSX3m

The sampling area at this station lay in shallow water at the shoreward end of our DCSX transect, centrally beneath the plume (see Figure 5-12). The site was chosen to provide information on any changes that might occur within the near-field portion of the dispersing plume. Depth here was such that most of the sampling area usually lay near the bottom of the plume and occasionally even below the plume. Sometimes we experienced swirls of cold water while diving

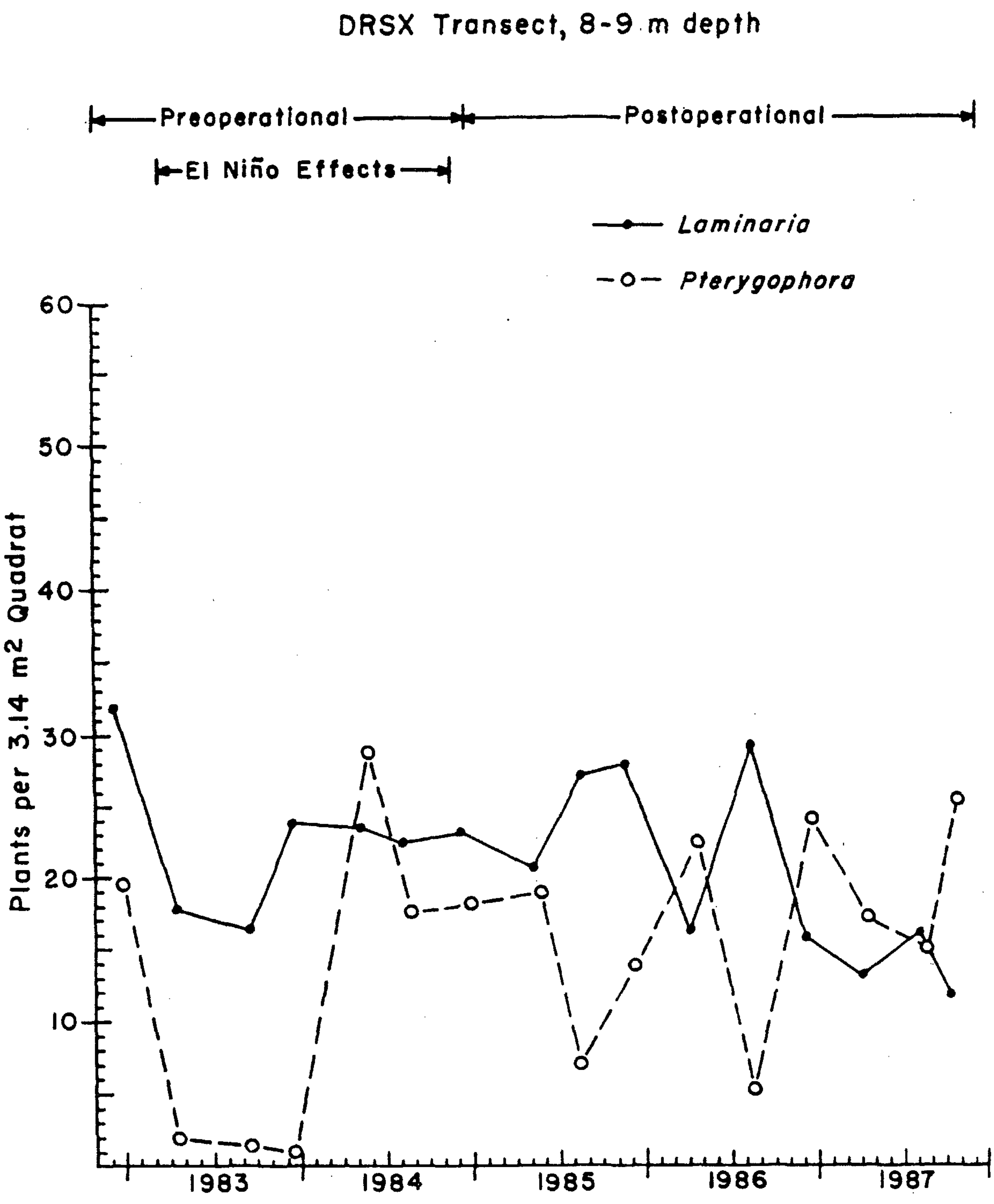

Figure 12-12. History of adult palm kelp abundances, DRSX8m.

here, particularly in the lower parts of channels traversing the sampling area in an onshore-offshore direction. Bottom temperatures were often a few degrees colder than surface temperatures, again indicating that the sampling area was not continuously exposed to completely undiluted effluent (see Figure 12-9).

Our preoperational data revealed that this station was strongly dominated by *Laminaria* (Figure 12-13). *Laminaria* abundances here were extremely stable during the preoperational period, yielding the best of all of our data sets (Table 12-8). *Pterygophora* occurred as a persistent but minor component of the flora. Other Phaeophyta such as *Cystoseira* and *Dictyoneurum* were also minor components. The arborescent coralline, *Calliarthron*, was formerly a major substory species at the station, but we did not attempt to quantify its abundance during the early surveys here.

The great storms of 1983 quite unexpectedly had no effect on abundances of *Laminaria* or *Pterygophora* at DCSX3m. We had presumed that these populations would be highly vulnerable to major storms because of the exposed location and relatively shallow depth. Possibly the 50 to 60 m (165 to 200 ft) of shallows lying seaward from the sampling area modified waves sufficiently to prevent destruction of palm kelps at the inshore end of the DCSX transect. Subsequent temperature increases during later phases of El Niño (as one example: temperatures at 3 m [10 ft] depths in the Cove reached 17°C [62.2°F] or more during 26 days from September 12 to October 12 1983) also failed to produce significant changes in palm kelp abundances at DCSX3m. Dense canopies of the palm kelps, plus thick mats of *Calliarthron* beneath, prevented recruitment by juvenile *Laminaria* and *Pterygophora* here.

Calliarthron was adversely impacted by an unknown influence sometime during late-spring or early-summer in 1984. Most of this population disappeared from our sampling area at DCSX3m and it remained a minor component of the flora to the end of our study. Disappearance of *Calliarthron* was accompanied almost immediately by palm kelp recruitment. Juvenile

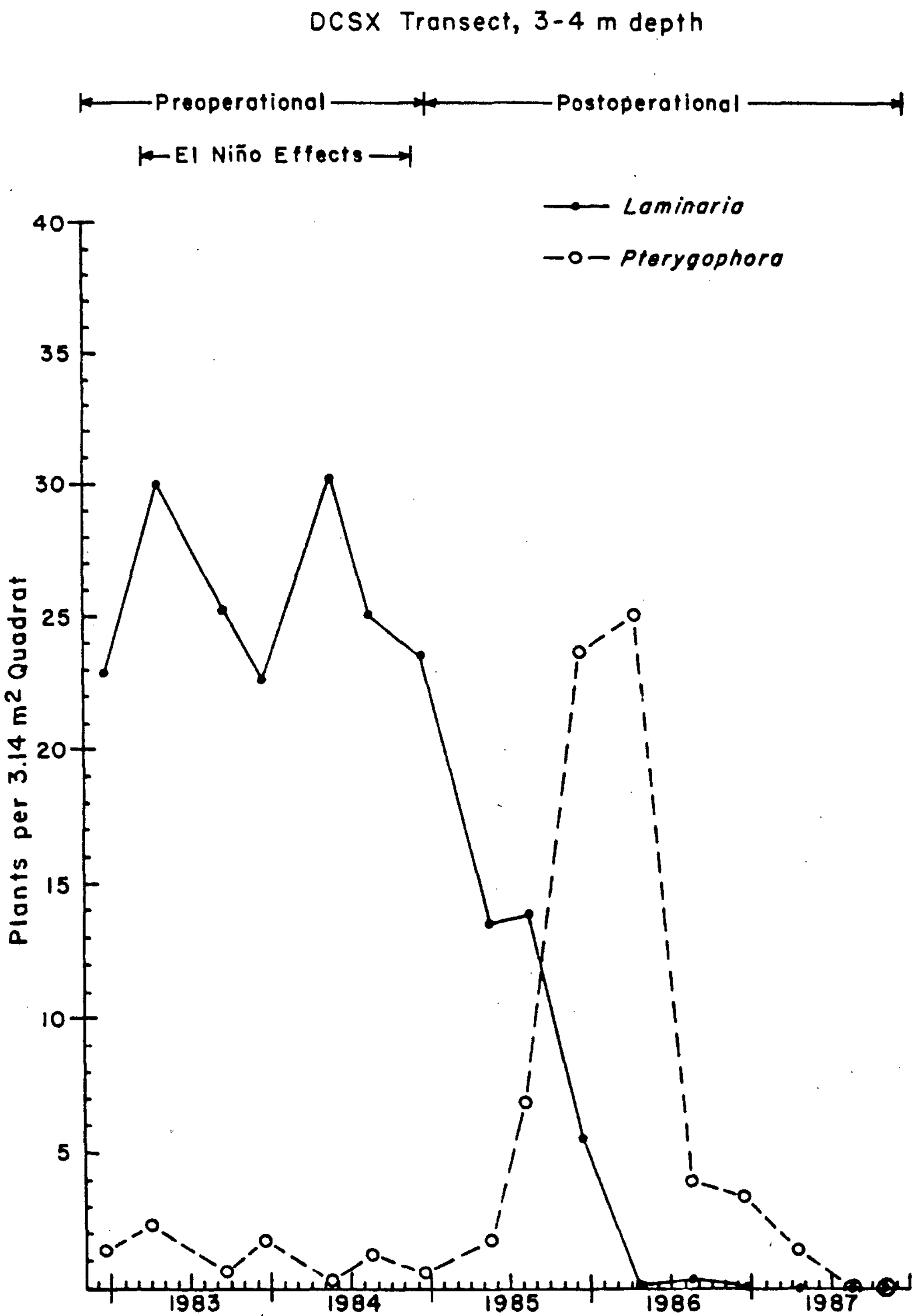

Figure 12-13. History of adult palm kelp abundances, DCSX3m.

Pterygophora were especially abundant. Apparently recruitment here had been prevented more by presence of *Calliarthron* rather than by shading from substory canopies of adult palm kelps.

Abundances of both adult and juvenile *Laminaria* began declining at the onset of the operational period (Figures 12-6 and 12-13). The declining trend for adult *Laminaria* was highly significant (nANOVA, data not shown). Numbers of palm kelp remains rose dramatically (Figure 12-8). Young *Pterygophora*, however, grew vigorously and began entering the adult category in summer 1985 (Figure 12-13). These young plants replaced *Laminaria* as the dominant species during ensuing months, suggesting that young *Pterygophora* sporophytes are more resistant to heated effluent than their *Laminaria* counterparts. The temporary rise in *Pterygophora* abundances was registered as a significant increase in the operational population (nANOVA, data not shown). This population declined in mid-1986, however, a change that was also significant (95%CI, Figure 12-1). *Pterygophora* finally disappeared from this sampling area in mid-1987.

Although juvenile *Laminaria* and *Pterygophora* sporophytes continued to be found at DCSX3m during our surveys through April 1986, most were probably stunted older juveniles remaining from the large blooms occurring here in latter 1984 and early 1985, at the time when *Calliarthron* was declining. Very small plants, representing new recruits, were found only occasionally during early operational phases and not at all during later phases. It appeared that recruitment here had ceased. Abundances of adult *Laminaria* declined to nil during 1986. Only a few sickly young adult *Pterygophora* still remained at the end of 1986. A severe decline in spring 1986 had greatly reduced population abundance here. Probably most of the young adult *Pterygophora* had poor holdfast attachments and were torn out by severe winter storms during early 1986. Appearances of most of these plants in latter 1985 were unhealthy and their losses had been expected. Without replacements from recruitment, declines in adult abundances were inevitable.

History of the palm kelp populations at DCSX3m was thus complex and not entirely in accord with expectations. Nonetheless, our data strongly suggest that the operational environment severely impacted both juveniles and adults of *Laminaria* and *Pterygophora*. Juveniles survived longer than adults and *Pterygophora* was clearly more resistant than *Laminaria*.

DRSX3m

DRSX3m was the far-field counterpart of DCSX3m. Like DRSX8m, this station lay in the lee of Diablo Rock but, notwithstanding, experienced severe water motion when storm waves were present (see Figure 5-12). Our five years of sampling at DRSX3m convinced us that wave action was greater here than at any of our other stations. Surge nearly always interfered with our sampling operations at DRSX3m, even when sea conditions at all other stations were fairly calm so that operations were conducted with ease. Effects from the exceptional 1983 storms were much more evident at DRSX3m than elsewhere. Bottom temperatures at DRSX3m were similar to those at DCSX3m during the operational period, but swirls of cold water were less common at DRSX3m than at DCSX3m. Probably the plume was deflected to greater depths at DRSX3m by the nearby presence of Diablo Rock. This presence also seemed to have a damming action, possibly stabilizing the base of the plume and preventing lateral entry by parcels of cold water along the bottom.

Results from our first survey at DRSX3m in December 1982 indicated close similarities between DRSX3m and DCSX3m (compare Figures 12-13 and 12-14). *Laminaria* was the dominant plant at both stations while *Pterygophora* was a minor component of the flora. Effects of the great 1983 storms, however, were quite different for palm kelp populations at the two shallow stations. The storms wreaked havoc at DRSX3m, while we noted above that no significant abundance changes were recorded at DCSX3m. The decline in *Laminaria* abundance at DRSX3m was significant (95%CI, Figure 12-3). *Pterygophora* abundance also declined in early 1983, but the difference was not significant because concentration of this species was very low initially. Good recruitment at DRSX3m quickly restored the *Laminaria* population (see Figure 12-6). *Pterygophora* also recruited strongly in spring 1983 and high abundances of both species coexisted here by the end of 1984 (see Figures 12-6 and 12-14). These populations were comprised primarily of young

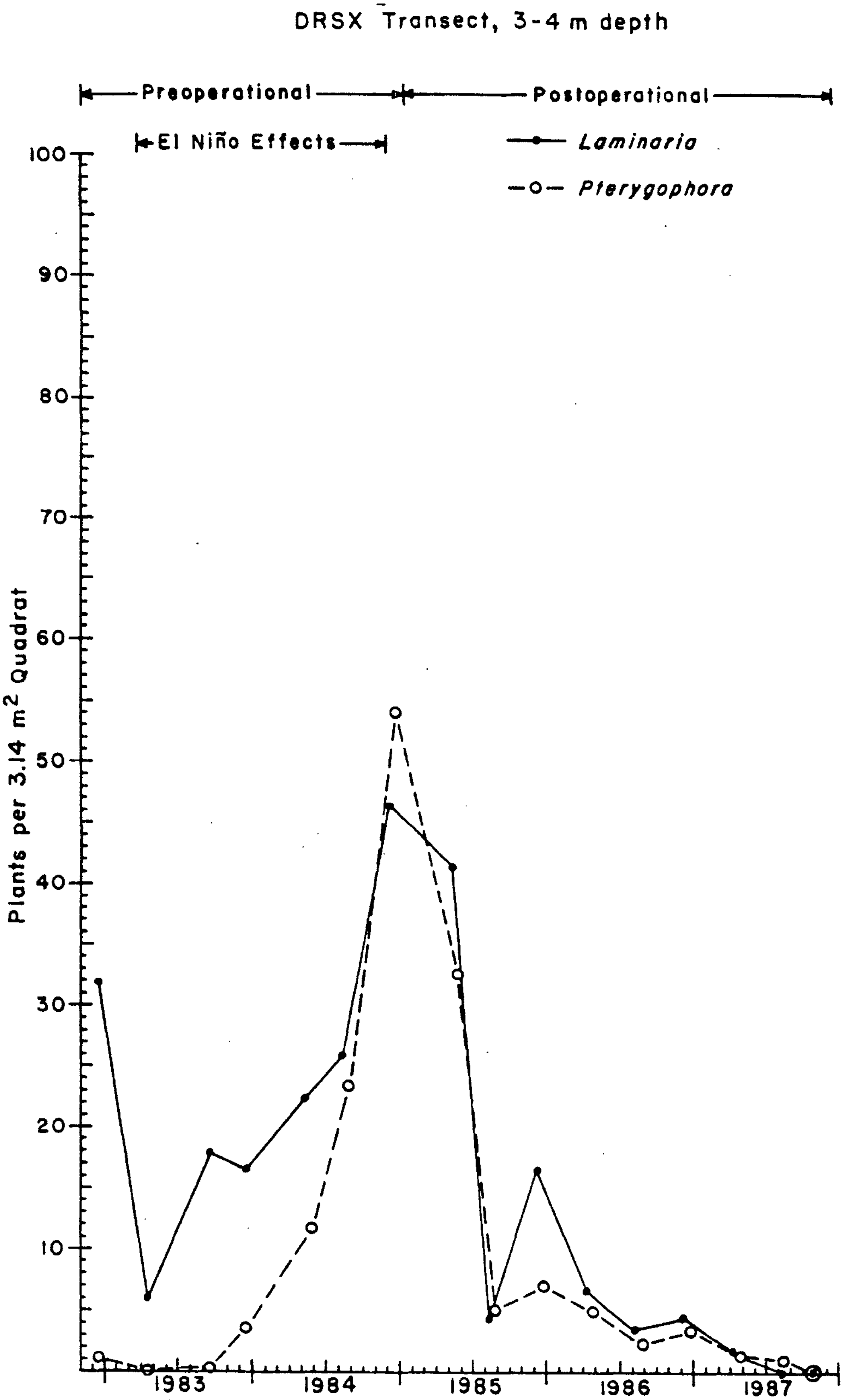

Figure 12-14. History of adult palm kelp abundances, DRSX3m.

adults about one to two years old at the time heated effluent began appearing in Diablo Cove. Plants tended to occur in tight clusters (especially true for *Pterygophora*) so variances resulting from the quantitative sampling were very large.

Power plant operations began in late 1984. The major fluctuations in abundances of juvenile and palm kelps at DRSX3m seriously interfered with statistical testing. Our detailed analyses of the preoperational data base at DRSX3m had indicated that both the *Laminaria* and *Pterygophora* data sets were poorly suited for statistical analysis (see Table 12-8). Consequently any nANOVA analysis seemed futile. Living *Laminaria* no longer occurred at DRSX3m by August 1987 and *Pterygophora* had vanished entirely some two months later. We have noted above that palm kelp populations at DCSX3m disappeared completely during the operational years. There is little doubt that palm kelp populations at DRSX3m suffered the same fate that befell the two species at DCSX3m, even though we were not able to demonstrate significance of the observed decline at DRSX3m by statistical testing.

History of the palm kelp populations at DRSX3m was quite similar to changes occurring at DCSX3m. Steep abundance declines were in progress by mid-1985 (Figure 12-3). Only the *Laminaria* decline was significant (95%CI). Numbers of palm kelp remains increased sharply and significantly (95%CI, Figure 12-8). Remaining plants were nearly always unhealthy. The last major recruitment of juvenile *Laminaria* here occurred during latter 1984 and in spring-summer 1985 for *Pterygophora* (Figures 12-15 and 12-16). A few very small plants were seen occasionally thereafter, but most of the plants classed as juveniles in our tallies were probably stunted individuals representing the 1985 year class. Recruitment apparently ceased during 1986 at both DRSX3m and DCSX3m.

The plots of juvenile and adult *Laminaria* at DRSX3m shown in Figure 12-15 indicated an unexplained feature during 1983 and 1984. Abundance of adult *Laminaria* increased almost eightfold between April 1983 and December 1984. We failed, however, to record any large recruitment of juvenile plants throughout this period. A rather minor *Laminaria* recruitment episode

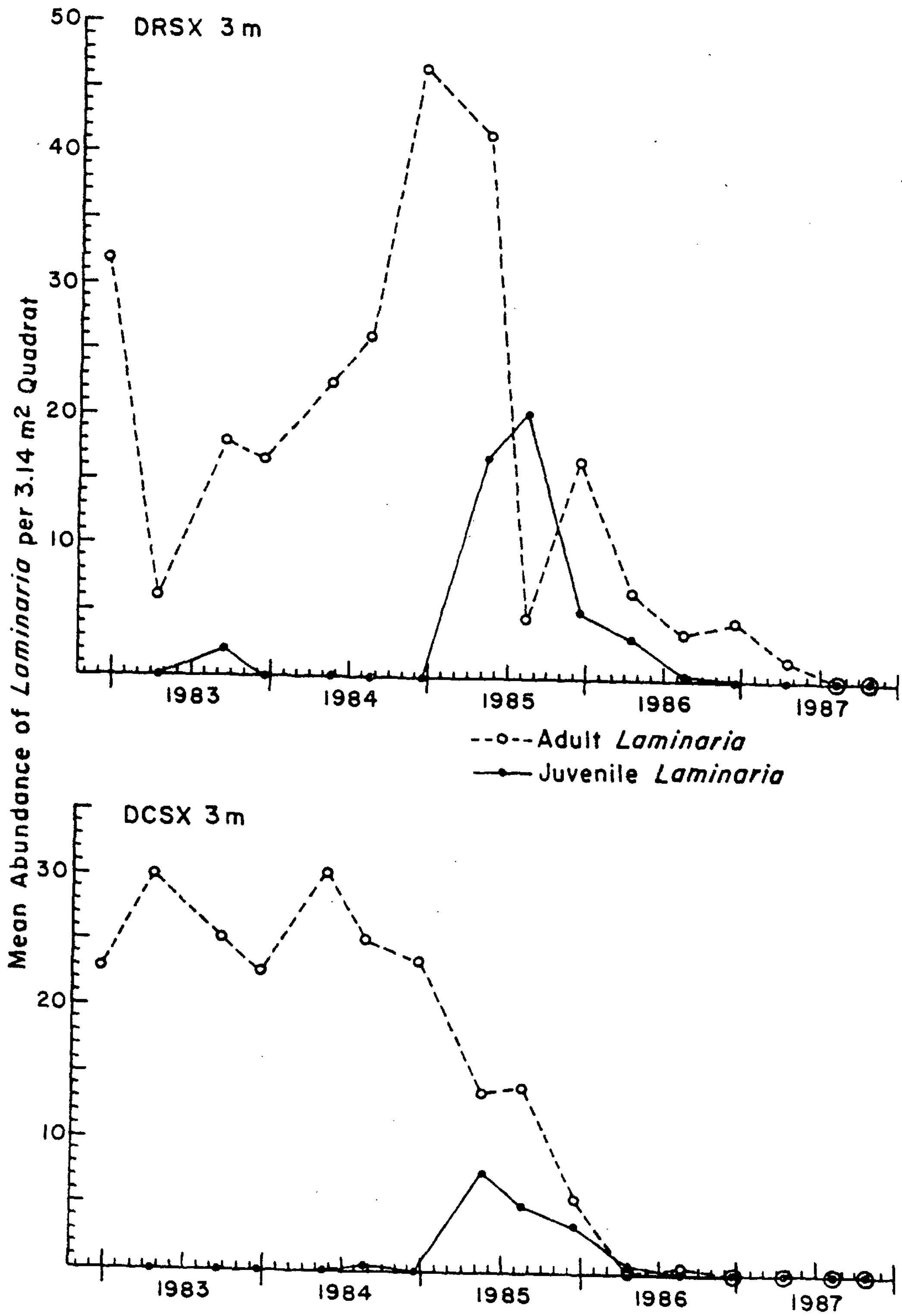

Figure 12-15. History of adult and juvenile *Laminaria*, DCSX3m and DRSX3m.

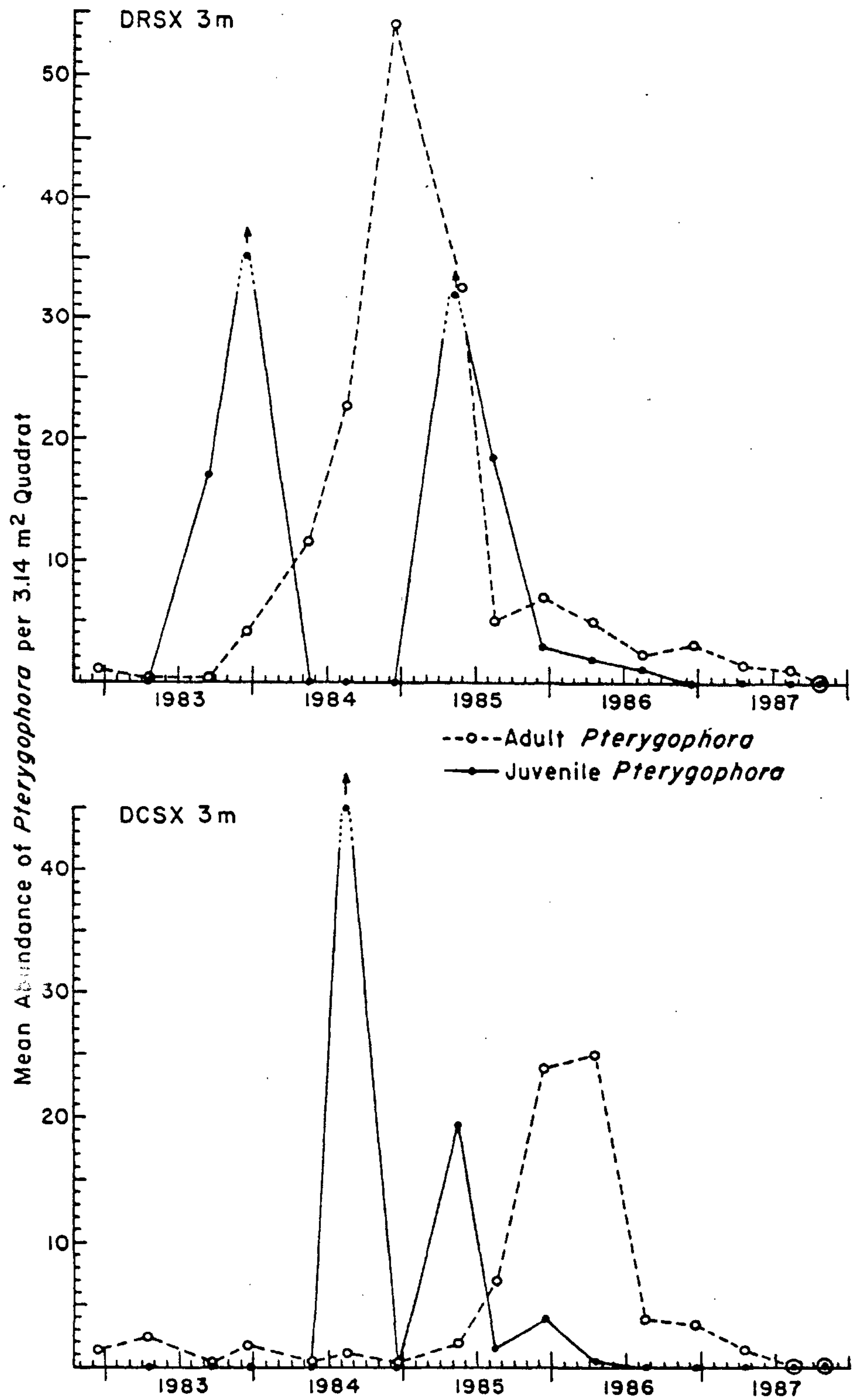

Figure 12-16. History of adult and juvenile *Pterygophora*, DCSX3m and DRSX3m.

was observed in September 1983, but the low concentrations of small plants measured during that survey could hardly have supported the tremendous rise in adult abundances that occurred over the succeeding fifteen months. We found a similar situation in our plots of juvenile and adult Pterygophora for DRSX3m (Figure 12-16). A large recruitment of juvenile *Pterygophora* did occur in latter 1983, explaining the rising trend in abundances of adult *Pterygophora* that commenced that fall. The rising trend in numbers of adult plants persisted until December 1984, however, even though we observed no recruitment by *Pterygophora* during any of our 1984 surveys. The best explanation for these discrepancies is that growth rates of small plants may be very rapid at these shallow depths. Surveys conducted only every three or four months may miss a bloom of juveniles and instead record a large and unexplained increase among young adult plants.

Cystoseira and Minor Species of Phaeophyta

A total of nine species of large Phaeophyta have entered our quadrats during the four years embraced by our study. As noted above, *Laminaria* and *Pterygophora* historically have been the dominant forms at all stations (in terms of abundance and persistence). Other species occasionally rivaled the palm kelps in abundances, but their populations did not persist (for example, ephemeral blooms of *Desmarestia*). We computed frequencies of occurrence for the nine species separately for the preoperational and operational periods at each station and survey (Table 12-9). We used the preoperational information to rank the species in descending order of importance: *Laminaria* and *Pterygophora* > *Cystoseira* > *Desmarestia* and *Dictyoneurum* > *Nereocystis* > *Macrocystis* > *Dictyota* > *Egregia*. Three of these species (*Cystoseira*, *Dictyota*, and *Egregia*) occur in shallow water in the Southern California Bight and might be expected to proliferate within Diablo Cove in areas where palm kelp populations have declined or disappeared. *Dictyota* and *Egregia* were quite scarce in our quadrat sampling, but *Cystoseira* was moderately common and provided sufficient data to allow statistical comparisons between the pre-operational and operational data sets.

Table 12-9: Comparisons between pre-operational and operational surveys for frequencies of occurrence of the nine major species of Phaeophyta entering our quadrats. Numbers represent surveys encountered divided by total number of surveys for the 'phase'. Pre-operational surveys totaled five to seven. Operational surveys totaled six.

Genus	Power Plant phase	Station / Depth DCSX 3m	DCSX 8m	DRSX 3m	DRSX 8m	LRSX 8m
Cystoseira	Pre-op.	1.00	0.40	1.00	1.00	1.00
	Operational	0.89	0.67	1.00	1.00	1.00
Desmarestia	Pre-op.	0.20	0.60	0.40	0.40	0.60
	Operational	0	0.78	0.17	0.44	0.89
Dictyoneurum	Pre-op.	1.00	0	0.60	0.20	0.40
	Operational	0.50	0	0.17	0.50	0.44
Dictyota	Pre-op.	0	0	0	0.20	0
	Operational	0	0	0	0.17	0
Egregia	Pre-op.	0	0	0	0	0
	Operational	0	0	0.17	0	0
Laminaria	Pre-op.	1.00	1.00	1.00	1.00	1.00
	Operational	0.44	1.00	0.89	1.00	1.00
Macrocystis	Pre-op.	0.20	0	0	0	0.40
	Operational	0	0.17	0	0	0.89
Nereocystis	Pre-op.	0	0	0.80	0.40	0
	Operational	0	0.44	0.33	0.17	0.22
Pterygophora	Pre-op.	1.00	1.00	1.00	1.00	1.00
	Operational	0.78	1.00	0.89	1.00	1.00

Cystoseira Comparisons

Operational abundances for *Cystoseira* declined significantly at DRSX 3m and increased significantly at LRSX8m (nANOVA, data not shown). Our earlier analysis of utility of the preoperational data had indicated that the data set for *Cystoseira* at DCSX8m was unusable (see Table 12-8). The increase recorded for LRSX8m may have been associated with the significant decline noted there for the dominant *Pterygophora* population. Possibly average bottom illumination increased as shading by *Pterygophora* canopies declined, stimulating *Cystoseira* recruitment (there were also small increases in abundances of *Pterygophora* and *Laminaria* juveniles at LRSX8m in 1986 and 1987; this would strengthen our presumption of a late increase in bottom illumination). We concluded that, as for *Laminaria*, there were no indications of declines by *Cystoseira* at our deep water stations, DCSX8m, DRSX8m, and LRSX8m.

Data from DCSX3m were quite variable and we were reluctant to employ conventional statistical tests of significance (for example, we listed the preoperational data for *Cystoseira* from DCSX3m as questionable in Table 12-8 and Bartlett's test was unsuccessful). The population here was never abundant. Healthiness of the few remaining plants was very poor as of the end of 1987 and the population was almost certainly in an imperiled state. Plants typically consisted primarily of stipe remains with only a few tattered fragments of epiphytized blade tissue. We expected that these plants would eventually vanish as natural causes of mortality took their toll. Certainly there was no evidence that warm-tolerant *Cystoseira* was proliferating and taking over territories formerly dominated by *Laminaria* and *Pterygophora*.

Minor Species

Desmarestia, *Dictyoneurum*, and *Nereocystis* at times occurred in sufficient numbers to deserve some discussion here. *Desmarestia ligulata* usually occurred much more abundantly at our three deep water stations than at shallow levels, where it was sparse and infrequent. The species was thus not very useful for our purposes because the likelihood of exposure to heated effluent was small. Massive quantities of *Desmarestia* were observed at DCSX8m, DRSX8m, and LRSX8m during summer 1986 (extensive populations also appeared at this time in the Southern California Bight, so the "bloom" may have occurred on a very widespread scale). *D. ligulata* produces large amounts of foliage but has a tiny holdfast. It is thus vulnerable to removal by strong wave surge. Most of the huge *Desmarestia* biomass we had observed throughout the Diablo Canyon region the preceding summer had disappeared by December 1986, torn out by winter storms. It was a minor component of the flora in 1987.

Dictyoneurum californicum is a cold-water plant, rarely, if at all, occurring within the Southern California Bight. *Dictyoneurum* was moderately abundant in shallow waters of Diablo Cove during the preoperational period. Plants with unhealthy appearances were noted during the first operational year here and the species apparently disappeared from these shallow habitats. We occasionally noted sickly specimens at 3 to 4 m (10 to 13 ft) depths at the extreme northwesterly portion of Diablo Cove in 1986. These disappeared and in 1987 shallow *Dictyoneurum* occurred only well outside the Cove in the north channel. Healthy plants occurred at 6 to 8 m (20 to 26 ft) depths near DRSX8m and were also present along the LRSX transect. *Dictyoneurum* distribution was thus apparently affected within Diablo Cove.

Nereocystis luetkeana is also a cold water species. Most of the entries in our shallow water quadrats within the Cove during the operational period were juveniles or young plants. Blades and pneumatocysts of both shallow and deeply-situated plants became unhealthy and showed signs of deterioration when stipes elongated and allowed the upper parts of plants to reach depths of 1 to 2 m (3 to 6 ft). Pneumatocysts with rich blade foliage were never seen in operational near-surface waters of Diablo Cove although they were always present during the preoperational period, albeit sometimes quite sparsely. The changed environment thus impacted the adult form. *Nereocystis* recruitment apparently continued in deep water within the Cove. Large populations of *Nereocystis* persisted up and down the coast outside Diablo Cove and healthy specimens with fertile sori occurred near the breakwater inside Intake Cove. Judging by appearances and distributions of *Nereocystis* canopies, power plant operation had no detectable effect on this temperature sensitive species much beyond the immediate confines of Diablo Cove. S. Kimura (personal communication), however, noted deterioration among adult *Nereocystis* canopies in Field's Cove during latter 1987, an unusually warm period.

Dictyota, *Egregia*, and *Macrocystis* were encountered only infrequently or rarely. A small cluster of *Macrocystis* plants existed centrally within Diablo Cove for several years, but the little group was not near any of our study areas so we had no quantitative data on changes that may have occurred for this species. *Macrocystis* seemed to be increasing throughout the LRSX region. During the operational period we found occasional juveniles and young plants in our quadrats at this station. Young *Macrocystis* plants also occurred very sparsely in shallow water along our DCSX3m and DRSX3m transects during the operational period. These plants typically had tattered appearances and did not survive to become large adults. They were probably destroyed by storm surge. The small *Macrocystis* colony persisting in central Diablo Cove was located in deep water, which may have offered some protection from wave action. *Macrocystis* proliferated in Intake Cove, an area well-protected by a breakwater. No *Macrocystis* existed in the Intake Cove area before installation of the breakwater. A large *Macrocystis* population developed between Pup Rock and the mainland to the northeast. This area received protection from coastline orientation and presence of offshore islands (see Figure 5-12). Thus protection from waves appears to be an important factor controlling *Macrocystis* distribution in the Diablo Canyon region. Storm-related mortality and not heated effluent probably controlled distribution of *Macrocystis* within Diablo Cove. Causes of appearances and disappearances of *Dictyota* and *Egregia* were unknown. A zone of dense *Egregia* plants occurred at the top of the DRSX transect throughout the preoperational period but disappeared sometime during the operational period. There was thus good observational evidence that *Egregia* at Diablo Rock did not tolerate the operational environment well. *Dictyota* declined severely during El Niño and failed to return thereafter. Failure by *Cystoseira*, *Dictyota*, and *Egregia* to proliferate throughout Diablo Cove during the operational period is a mystery. *Dictyota* and *Egregia* disappeared from within Diablo Cove, so absence of reproductive spores may have been a controlling factor for these two species. *Cystoseira*, however, remained quite common below the thermocline. Apparently some unknown factor was interfering with recruitment by *Cystoseira*.

PHAEOPHYTA DISCUSSION

Our quantitative sampling of Phaeophyta in the Diablo Canyon region clearly indicated that population abundances of most major kelp species were very dynamic entities, frequently undergoing substantial changes even under entirely natural conditions. Our task involved separating possible effects due to discharged effluent from the sometimes large fluctuations caused by disturbances associated with changing background conditions in the environment.

It now seems clear that extensive losses of kelp forest habitat occurred within Diablo Cove during the first three years of the operational period down to depths of 4 to 4.5 m (13 to 15 ft). We were probably still in a transitional period as of the end of 1987. Two important relationships between the depleted kelp forests and the remaining flora changed significantly. Shading by substory canopies became virtually nonexistent in shallow waters of Diablo Cove. This was considered as a stimulatory effect. There was also an opposite or deleterious effect: protection by the kelp forest from wave surge ceased, resulting in abnormally large amounts of drift during winter storms and loss of most delicate small-statured vegetation from exposed rocky surfaces. The net effect from the two oppositely-directed consequences of kelp forest disappearance was probably not yet resolved by the end of our project. The bottom may become populated by tough, surge-resistant seaweeds such as *Prionitis lanceolata* and *Bossiella orbigniana* which, through 1987 at least, seemed able to tolerate the elevated water temperatures. Alternatively, the coverages by somewhat more diverse algal assemblages that we observed during calm seasons, may prove to be the ultimate replacement flora. The latter situation seems to have an element of instability because most of these plants are somewhat delicate and disappear during winter storms. Fauna that require seaweeds for food and/or shelter will probably differ between a stable floral coverage and an unstable one. Thus far during our three years of operational observations, the unstable type of community structure prevailed. It is possible, however, that the toughest, temperature-resistant plants are also slow-growing and slow to reproduce. These species were certainly present and it remains to be seen whether or not they will proliferate and assume dominance within shallow areas of the inner cove.

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APPENDIX 12-1

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Appendix 12-1a: Numbers of *Laminaria dentigera* tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **pre-operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat														N	Mean	Std. Dev.
DCSX	3	12/82	26	26	20	10	18	9	57	15	38	9					10	22.8	15.12
		4/83	40	26	26	39	25	35	31	37	17	24					10	30.0	7.59
		9/83	14	17	15	37	30	19	13	25	18	64					10	25.2	15.65
		12/83	29	17	23	11	22	23	24	28	15	34					10	22.6	6.88
		5/84	29	20	35	35	14	28	45	14	46	36					10	30.2	11.47
		8/84	30	49	10	28	11	21	21	34	10	37					10	25.1	12.97
		12/84	24	6	24	49	23	40	44	7	29	25					10	27.1	14.24
DCSX	8	12/82	5	8	5	11	1	0	12	14	11	13	13				11	8.5	4.99
		4/83	3	2	2	1	7	4	0	4	2	1					10	2.6	2.01
		9/83	1	1	1	17	2	5	4	3	4	0	3	1	1	3	14	3.3	4.21
		12/83	2	0	1	5	2	3	9	2	2	14					10	4.0	4.32
		5/84	7	3	2	2	3	18	3	3	12	2					10	5.5	5.40
		8/84	3	4	11	3	0	[illegible]	5	4	6	9					10	6.1	4.43
		12/84	7	9	6	5	5	3	5	13	4	3					10	6.0	3.06
DRSX	3	12/82	18	29	32	22	14	12	47	87	26	31					10	31.8	21.90
		4/83	4	4	9	1	9	5	3	4	14	8					10	6.1	3.84
		9/83	9	28	21	15	8	12	15	39	26	6					10	17.9	10.50
		12/83	18	15	9	8	27	28	18	21	4	18					10	16.6	7.86
		5/84	44	19	10	16	19	25	15	24	22	31					10	22.5	9.56
		8/84	36	26	19	12	23	35	23	31	27	28					10	26.0	7.26
		12/84	30	29	32	46	31	80	61	63	50	43					10	46.5	17.19
DRSX	8	12/82	39	27	26	36	33	32	24	24	47						9	32.0	7.75
		4/83	5	27	39	11	20	2	19	25	20	11					10	17.9	11.07
		9/83	17	25	14	9	18	39	3	17	5						9	16.3	10.94
		12/83	21	23	35	29	28	24	6	21	24	29					10	24.0	7.67
		5/84	14	26	50	9	17	3	20	30	14	53					10	23.6	16.62
		8/84	29	24	19	30	30	11	5	23	19	34					10	22.4	9.14
		12/84	10	15	14	18	34	26	40	22	28	25					10	23.2	9.35
LRSX	8	2/82	0	0	0	2	2	4	0	0	0	1	3				11	1.1	1.45
		4/83	3	2	1	0	4	0	2	2	1	0					10	1.5	1.35
		9/83	1	3	0	0	0	0	1	4	0	1	0	0			12	0.8	1.34
		12/83	2	0	1	0	4	0	3	3	1	1					10	1.5	1.43
		5/84	1	4	1	4	5	1	3	0	0	3					10	2.2	1.81
		8/84	0	2	2	3	2	2	0	0	0	4					10	1.5	1.43
		12/84	1	3	0	0	1	4	3	4	1	3					10	2.0	1.56

Appendix 12-1b: Numbers of *Laminaria dentigera* tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat											N	Mean	Std. Dev.
DCSX	3	5/85	6	15	5	45	11	11	4	24	4	10		10	13.5	12.64
		8/85	12	25	18	25	5	0	3	26	20	4		10	13.8	10.22
		12/85	2	3	1	4	8	6	6	13	6	6		10	5.5	3.41
		4/86	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		8/86	0	0	0	0	0	0	0	0	0	3		10	0.3	0.95
		12/86	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		4/87	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		8/87	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		10/87	0	0	0	0	0	0	0	0	0	0		10	0.0	---
DCSX	8	5/85	6	3	7	7	3	10	2	6	16	1		10	6.1	4.43
		8/85	8	10	5	1	2	0	8	4	3	3		10	4.4	3.31
		12/85	10	14	3	5	5	4	9	2	7	8		10	6.7	3.65
		4/86	6	18	11	3	3	6	9	7	9	8		10	8.0	4.35
		8/86	12	5	5	2	4	12	8	15	6	5		10	7.4	4.22
		12/86	5	8	10	2	11	12	6	17	7	6		10	8.4	4.25
		4/87	13	5	2	4	9	2	7	20	6	10		10	7.8	5.53
		8/87	3	3	4	7	15	7	11	20	0	9		10	7.9	6.10
		10/87	14	10	3	4	8	2	1	2	14	12		10	7.0	5.21
DRSX	3	5/85	37	25	30	29	57	69	67	11	76	13		10	41.4	23.95
		8/85	1	3	4	3	0	7	9	8	5	5		10	4.5	2.92
		12/85	32	22	34	17	26	12	3	1	4	16		10	16.7	11.86
		4/86	1	6	13	5	2	1	4	2	17	16		10	6.7	6.25
		8/86	6	6	10	0	4	1	2	3	3	1		10	3.6	3.03
		12/86	0	6	0	0	2	0	8	4	17	9		10	4.6	5.56
		4/87	1	0	0	0	0	4	0	0	7	5		10	1.7	2.63
		8/87	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		10/87	0	0	0	0	0	0	0	0	0	0		10	0.0	---
DRSX	8	5/85	15	37	4	21	10	33	38	10	18	20		10	20.6	11.85
		8/85	35	23	8	33	2	2	56	44	26	43		10	27.2	18.60
		12/85	46	27	22	63	20	22	16	19	33	10		10	27.8	15.85
		4/86	7	16	6	17	10	26	20	9	13	38		10	16.2	9.86
		8/86	36	21	27	38	48	29	27	24	35	38		10	32.3	8.14
		12/86	3	1	13	9	3	22	27	29	25	26		10	15.8	11.19
		4/87	22	19	16	7	19	12	5	0	7	25		10	13.2	8.24
		8/87	13	17	10	17	20	1	13	27	21	22		10	16.1	7.29
		10/87	22	15	9	4	13	1	19	6	18	15	6	11	11.6	6.85
LRSX	8	5/85	0	0	3	1	8	0	3	1	1	1		10	1.8	2.44
		8/85	3	1	3	1	2	1	0	2	3	0		10	1.6	1.17
		12/85	5	2	1	0	1	1	5	4	2	1		10	2.2	1.81
		4/86	2	2	5	1	1	0	7	1	6	2		10	2.7	2.41
		8/86	4	0	1	0	2	0	0	0	1	1		10	0.9	1.29
		12/86	3	0	1	1	1	3	3	3	4	6		10	2.5	1.78
		4/87	0	4	1	0	3	1	4	3	2	2		10	2.0	1.49
		8/87	0	5	3	2	1	4	2	7	7	5		10	3.6	2.41
		10/87	1	0	1	0	2	2	1	6	3	4		10	2.0	1.89

Appendix 12-1c: Numbers of *Pterygophora californica* tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **pre-operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat	N	Mean	Std. Dev.
DCSX	3	12/82	0 0 4 2 0 1 0 3 0 3	10	1.3	1.57
		4/83	5 6 2 2 0 2 2 2 0 2	10	2.3	1.89
		9/83	1 0 0 1 0 0 2 0 0 0	10	0.4	0.70
		12/83	0 0 4 3 2 3 3 2 1 0	10	1.8	1.48
		5/84	1 0 0 0 0 0 0 2 0 0	10	0.3	0.67
		8/84	0 0 2 2 4 1 1 0 1 1	10	1.2	1.23
		12/84	0 0 0 0 1 0 0 0 0 3	10	0.4	0.97
DCSX	8	12/82	17 16 13 16 13 12 19 4 11 20 6	11	13.4	5.03
		4/83	13 5 7 10 12 17 4 21 7 23	10	11.9	6.62
		9/83	9 13 8 18 18 9 13 13 18 22 10 21 8 27	14	14.8	5.96
		12/83	12 8 13 7 9 15 21 23 13 20	10	14.1	5.61
		5/84	13 12 11 19 23 10 17 14 25 9	10	15.3	5.52
		8/84	10 11 21 14 17 16 17 15 18 20	10	15.9	3.54
		12/84	14 11 9 13 17 16 15 22 18 6	10	14.1	4.63
DRSX	3	12/82	5 1 3 0 0 0 2 0 0 1	10	1.2	1.69
		4/83	0 0 0 0 0 2 0 0 0 0	10	0.2	0.63
		9/83	0 0 0 0 0 0 0 0 1 2	10	0.3	0.67
		12/83	0 1 7 0 0 4 3 1 1 21	10	3.8	6.44
		5/84	3 3 2 60 14 8 9 2 9 6	10	11.6	17.44
		8/84	12 63 14 2 2 9 56 3 75 1	10	23.7	28.97
		12/84	13 10 65 110 14 32 37 17 52 191	10	54.1	57.14
DRSX	8	12/82	5 12 13 31 18 43 23 22 8	9	19.4	11.97
		4/83	0 7 1 0 1 0 5 2 1 1	10	1.8	2.35
		9/83	4 1 2 3 1 0 0 1 0	9	1.3	1.41
		12/83	0 0 0 0 0 3 0 3 1 2	10	0.9	1.29
		5/84	4 8 2 39 19 129 18 36 24 9	10	28.8	37.40
		8/84	7 22 16 7 4 49 15 34 6 16	10	17.6	14.26
		12/84	13 16 28 6 1 25 14 22 54 2	10	18.1	15.62
LRSX	8	12/82	16 20 52 26 8 22 14 9 14 18 5	11	18.5	12.74
		4/83	13 14 8 25 9 7 17 11 20 12	10	13.6	5.66
		9/83	18 15 6 9 8 21 16 6 9 14 6 9	12	11.4	5.16
		12/83	14 15 14 6 16 17 23 16 14 6	10	14.1	5.02
		5/84	10 10 15 9 5 17 19 9 13 19	10	12.6	4.77
		8/84	14 33 9 14 11 12 11 13 17 11	10	14.5	6.87
		12/84	11 15 15 10 13 19 6 19 6 10	10	12.4	4.67

Appendix 12-1d: Numbers of *Pterygophora californica* tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat											N	Mean	Std. Dev.
DCSX	3	5/85	4	5	0	1	6	1	0	0	1	1		10	1.9	2.23
		8/85	3	2	4	9	20	5	10	1	2	13		10	6.9	6.08
		12/85	31	50	52	27	8	21	9	15	14	11		10	23.8	16.19
		4/86	7	22	11	16	49	29	31	34	38	12		10	24.9	13.57
		8/86	4	2	8	5	3	6	1	4	4	3		10	4.0	2.00
		12/86	3	1	3	7	5	3	3	3	1	5		10	3.4	1.84
		4/87	0	0	0	0	2	1	3	4	3	2		10	1.5	1.51
		8/87	0	0	0	0	0	0	0	0	0	0		10	0.0	—
		10/87	0	0	0	0	0	0	0	0	0	0		10	0.0	—
DCSX	8	5/85	14	10	8	16	6	19	7	15	24	9		10	12.8	5.83
		8/85	15	12	7	5	10	16	11	13	17	10		10	11.6	3.84
		12/85	12	1	11	8	15	16	5	5	5	7		10	8.5	4.86
		4/86	4	4	11	2	12	5	42	16	3	3		10	10.2	12.13
		8/86	6	3	3	6	6	5	9	3	6	10		10	5.7	2.41
		12/86	5	2	6	11	7	17	14	14	43	18		10	13.7	11.61
		4/87	58	14	1	39	52	17	35	32	34	10		10	29.2	18.42
		8/87	24	47	21	25	22	17	12	3	21	14		10	20.6	11.40
		10/87	16	32	47	29	19	36	52	20	29	26		10	30.6	11.76
DRSX	3	5/85	4	9	12	14	32	74	15	0	29	136		10	32.5	42.08
		8/85	0	4	11	0	4	0	17	4	5	6		10	5.1	5.36
		12/85	6	4	9	11	6	17	2	0	5	9		10	6.9	4.86
		4/86	2	2	3	14	1	1	5	2	9	11		10	5.0	4.67
		8/86	0	3	1	1	10	0	2	3	1	2		10	2.3	2.91
		12/86	2	0	1	2	2	2	1	8	16	1		10	3.5	4.90
		4/87	0	0	1	0	2	5	0	0	1	4		10	1.3	1.83
		8/87	0	0	0	0	10	0	0	0	0	0		10	1.0	3.16
		10/87	0	0	0	0	0	0	0	0	0	0		10	0.0	—
DRSX	8	5/85	10	1	34	40	31	3	7	18	19	27		10	19.0	13.66
		8/85	1	7	10	7	17	16	2	1	7	3		10	7.1	5.80
		12/85	1	0	17	0	21	18	37	26	8	10		10	13.8	12.29
		4/86	22	21	37	12	25	14	54	23	10	5		10	22.3	14.36
		8/86	2	14	8	3	5	10	5	1	3	0		10	5.1	4.38
		12/86	37	35	7	29	52	27	13	9	5	25		10	23.9	15.29
		4/87	13	3	12	22	8	20	21	32	34	7		10	17.2	10.44
		8/87	6	5	8	12	13	27	21	3	28	26		10	14.9	9.76
		10/87	24	19	62	24	19	32	18	39	20	15	10	11	25.6	14.43
LRSX	8	5/85	13	5	14	19	19	12	10	23	11	11		10	13.7	5.27
		8/85	11	7	10	6	12	13	8	7	11	13		10	9.8	2.62
		12/85	6	11	10	8	12	13	13	5	23	11		10	11.2	4.98
		4/86	8	5	18	13	12	7	18	8	14	3		10	10.6	5.21
		8/86	4	19	7	7	7	8	9	8	10	8		10	8.7	3.95
		12/86	6	8	8	7	12	13	7	8	13	11		10	9.3	2.67
		4/87	3	10	21	3	9	7	16	8	15	10		10	10.2	5.71
		8/87	4	10	8	14	6	3	7	18	11	5		10	8.6	4.72
		10/87	2	3	3	19	2	5	6	2	9	6		10	5.7	5.21

Appendix 12-1e: Numbers of *Cystoseira osmundacea* tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **pre-operational** conditions.

Sta-tion	Depth m	Month/ Year	Number per Quadrat										N	Mean	Std. Dev.
DCSX	3	12/82	no			data									
		4/83	no			data									
		9/83	0	0	0	0	8	0	2	0	0	0	10	1.0	2.54
		12/83	0	1	0	0	0	0	0	0	0	0	10	0.1	0.32
		5/84	0	0	0	0	0	0	0	5	0	0	10	0.5	1.58
		8/84	2	0	0	3	3	0	0	2	0	2	10	1.2	1.32
		12/84	0	0	1	0	0	4	0	1	1	0	10	0.7	1.25
DCSX	8	12/82	no			data									
		4/83	no			data									
		9/83	no			data									
		12/83	0	1	0	0	0	0	0	0	0	0	10	0.1	0.32
		5/84	no			data									
		8/84	no			data									
		12/84	0	0	0	0	0	0	0	0	0	3	10	0.3	0.95
DRSX	3	12/82	no			data									
		4/83	no			data									
		9/83	7	0	10	0	0	0	1	3	1	8	10	3.0	3.86
		12/83	0	11	2	11	0	1	1	0	0	1	10	2.7	4.42
		5/84	0	0	2	0	0	0	6	0	6	0	10	1.4	2.50
		8/84	2	0	0	1	7	0	0	0	0	10	10	2.0	3.56
		12/84	5	6	2	2	0	0	0	0	0	0	10	1.5	2.27
DRSX	8	12/82	4	3	2	1	2	1	3	9	4		9	3.2	2.44
		4/83	5	8	7	7	2	0	4	2	0	3	10	3.8	2.90
		9/83	3	3	5	0	1	2	0	0	0		9	1.6	1.81
		12/83	1	3	11	5	0	0	1	2	6	9	10	3.8	3.85
		5/84	5	8	6	1	3	1	6	5	8	13	10	5.6	3.60
		8/84	7	0	4	4	0	0	0	5	11	1	10	3.2	3.74
		12/84	6	14	14	6	8	5	0	0	0	2	10	5.5	5.32
LRSX	8	12/82	no			data									
		4/83	0	0	0	0	0	0	1	0	0	0	10	0.1	0.32
		9/83	1	0	0	0	0	0	0	0	0	0	10	0.1	0.32
		12/83	1	0	0	7	2	0	0	0	0	0	10	1.0	2.21
		5/84	1	0	0	1	0	1	0	0	1	1	10	0.5	0.53
		8/84	6	0	4	0	1	1	0	0	0	0	10	1.2	2.10
		12/84	2	1	0	2	2	0	0	0	1	1	10	0.9	0.88

Appendix 12-1f: Numbers of *Cystoseira osmundacea* tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat											N	Mean	Std. Dev.
DCSX	3	5/85	0	0	0	0	0	0	0	9	0	0		10	0.9	2.85
		8/85	0	0	0	0	0	0	0	5	0	0		10	0.5	1.58
		12/85	0	0	0	0	5	0	0	0	0	0		10	0.5	1.58
		4/86	0	0	2	4	0	1	1	1	2	0		10	1.1	1.29
		8/86	0	1	1	0	0	0	0	0	0	0		10	0.2	0.42
		12/86	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		4/87	1	0	0	0	1	0	0	0	0	0		10	0.2	0.42
		8/87	0	0	0	0	0	0	0	0	0	0		10	0.0	—
		10/87	0	1	0	0	0	0	0	0	0	0		10	0.1	0.32
DCSX	8	5/85	0	1	9	3	6	1	4	3	9	7		10	4.3	3.30
		8/85	0	0	0	0	0	0	0	0	1	0		10	0.1	0.32
		12/85	0	0	5	0	0	0	0	0	0	0		10	0.5	1.58
		4/86	0	17	3	0	0	0	6	1	0	0		10	2.7	5.40
		8/86	0	0	0	0	0	0	0	0	0	0		10	0.0	—
		12/86	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		4/87	2	4	0	0	0	0	5	9	4	1		10	2.5	2.99
		8/87	0	0	0	0	0	0	0	0	0	0		10	0.0	---
		10/87	3	0	0	0	0	0	0	0	0	1		10	0.4	0.97
DRSX	3	5/85	3	3	0	2	0	0	0	4	0	0		10	1.2	1.62
		8/85	0	0	0	0	0	0	0	2	0	2		10	0.4	0.84
		12/85	0	0	0	0	0	0	0	1	0	2		10	0.3	0.67
		4/86	2	0	0	1	0	0	8	1	0	0		10	1.2	2.49
		8/86	0	1	0	0	0	0	0	0	1	1		10	0.3	0.48
		12/86	0	2	5	2	0	0	0	0	0	0		10	0.9	1.66
		4/87	3	5	4	1	0	0	0	0	0	0		10	1.3	1.95
		8/87	0	0	0	0	0	0	0	0	1	1		10	0.2	0.42
		10/87	0	1	0	0	0	0	0	0	3	1		10	0.5	0.97
DRSX	8	5/85	8	5	0	3	1	10	1	2	11	3		10	4.4	3.95
		8/85	7	3	0	2	1	1	6	5	2	1		10	2.8	2.39
		12/85	3	4	6	1	1	4	4	4	2	7		10	3.6	1.96
		4/86	2	3	0	1	0	3	0	1	3	3		10	1.6	1.35
		8/86	3	2	2	1	2	0	7	3	0	0		10	2.0	2.11
		12/86	1	3	23	1	5	1	6	3	3	7		10	5.3	6.57
		4/87	0	3	4	2	4	0	0	1	0	4		10	1.8	1.81
		8/87	1	0	3	2	6	0	4	6	4	3		10	2.9	2.18
		10/87	2	3	0	0	0	0	3	3	1	5	5	11	2.0	1.95
LRSX	8	5/85	1	3	0	0	1	0	0	1	5	1		10	1.2	1.62
		8/85	2	2	0	2	2	1	0	1	2	1		10	1.3	0.82
		12/85	0	0	3	1	1	0	0	0	0	4		10	0.9	1.45
		4/86	1	1	0	2	0	1	0	1	0	2		10	0.8	0.79
		8/86	1	1	0	0	0	1	1	0	1	3		10	0.8	0.92
		12/86	0	2	0	0	2	0	4	1	0	3		10	1.2	1.48
		4/87	3	1	1	8	0	0	1	1	3	0		10	1.8	2.44
		8/87	5	3	0	0	2	0	0	1	1	1		10	1.3	1.64
		10/87	1	3	0	0	0	0	2	1	0	0		10	0.7	1.06

APPENDIX 12-2

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Appendix 12-2a: Numbers of *Laminaria dentigera* juveniles tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **pre-operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat														N	Mean	Std. Dev.
DCSX	3	12/82	0	0	0	0	0	0	0	0	0	0					10	0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		9/83	0	0	1	0	0	0	0	0	0	0					10	0.10	0.32
		12/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		8/84	2	0	0	0	0	0	0	0	0	0					10	0.20	0.63
		12/84	0	0	0	0	0	0	0	0	0	0					10	0	---
DCSX	8	12/82	0	0	0	0	0	0	0	0	0	0					10	0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		9/83	0	0	0	0	0	0	0	0	1	1	0	0	0	0	14	0.14	0.36
		12/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		8/84	0	0	0	0	0	0	0	0	1	0					10	0.10	0.32
		12/84	0	1	0	0	0	0	0	1	0	1					10	0.30	0.48
DRSX	3	12/82	0	0	0	0	0	0	0	0	0	0					10	0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		9/83	0	20	0	0	0	0	0	0	0	0					10	2.0	6.32
		12/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		8/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		12/84	0	0	0	0	0	0	0	0	0	0					10	0	---
DRSX	8	12/82	0	0	0	0	0	0	0	0	0	0					10	0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		9/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		12/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		8/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		12/84	0	0	0	0	0	0	0	0	0	0					10	0	---
LRSX	8	12/82	0	0	0	0	0	0	0	0	0	0					10	0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		9/83	0	0	1	0	0	0	0	0	0	0					10	0.10	0.32
		12/83	0	0	0	0	0	0	0	0	0	0					10	0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		8/84	0	0	0	0	0	0	0	0	0	0					10	0	---
		12/84	0	0	0	0	0	0	0	0	0	0					10	0	---

Appendix 12-2b: Numbers of *Laminaria dentigera* juveniles tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat										N	Mean	Std. Dev.
DCSX	3	5/85	7	7	16	5	5	7	6	2	6	14	10	7.5	4.25
		8/85	3	0	6	6	4	11	5	2	5	7	10	4.9	3.00
		12/85	6	5	2	4	4	7	1	1	3	3	10	3.6	2.01
		4/86	0	1	1	0	0	0	0	2	0	1	10	0.5	0.71
		8/86	0	0	0	0	0	0	0	0	0	0	10	0	---
		12/86	0	0	0	0	0	0	0	0	0	0	10	0	---
		4/87	0	0	0	0	0	0	0	0	0	0	10	0	---
		8/87	0	0	0	0	0	0	0	0	0	0	10	0	---
		10/87	0	0	0	0	0	0	0	0	0	0	10	0	---
DCSX	8	5/85	3	10	21	8	4	7	4	11	2	6	10	7.6	5.56
		8/85	1	0	3	0	5	5	1	1	0	0	10	1.6	2.01
		12/85	5	0	6	2	4	3	0	0	1	0	10	2.1	2.28
		4/86	1	1	3	0	0	1	3	2	0	2	10	1.3	1.16
		8/86	0	3	2	0	4	3	0	0	0	2	10	1.4	1.58
		12/86	0	0	0	0	0	0	0	0	0	0	10	0	---
		4/87	0	2	0	3	3	0	8	3	1	1	10	2.1	2.42
		8/87	0	0	1	0	0	0	0	0	0	3	10	0.4	0.97
		10/87	0	1	0	0	0	1	2	0	0	2	10	0.6	0.84
DRSX	3	5/85	2	0	18	3	3	4	29	5	0	100	10	16.4	30.80
		8/85	16	10	68	7	1	3	12	43	25	17	10	20.2	20.72
		12/85	5	0	1	0	22	8	4	1	3	6	10	5.0	6.55
		4/86	13	0	0	0	5	2	1	0	9	2	10	3.2	4.49
		8/86	0	0	0	0	3	0	0	0	0	0	10	0.3	0.95
		12/86	0	0	0	0	0	0	0	0	0	0	10	0	---
		4/87	0	0	0	0	0	0	0	0	0	0	10	0	---
		8/87	0	0	0	0	0	0	0	0	0	0	10	0	---
		10/87	0	0	0	0	0	0	0	0	0	0	10	0	---
DRSX	8	5/85	7	4	4	0	3	0	3	2	2	0	10	2.5	2.22
		8/85	1	0	0	0	20	9	5	1	7	0	10	4.3	6.43
		12/85	0	0	3	1	1	0	0	0	0	0	10	0.5	0.97
		4/86	1	0	0	24	4	0	5	2	3	0	10	3.9	7.29
		8/86	5	8	0	2	0	1	0	0	0	0	10	1.6	2.76
		12/86	5	0	0	0	2	3	3	0	0	0	10	1.3	1.83
		4/87	5	1	42	6	5	8	3	2	7	7	10	8.6	11.96
		8/87	0	0	3	3	2	1	6	9	0	7	10	3.1	3.21
		10/87	0	0	3	0	1	1	1	0	0	0	10	0.6	0.97
LRSX	10	5/85	0	1	0	0	0	0	0	0	1	0	10	0.2	0.42
		8/85	0	1	2	2	0	2	1	2	1	0	10	1.1	0.88
		12/85	0	3	0	0	0	0	0	2	1	7	10	1.3	2.26
		4/86	0	0	2	0	0	0	0	0	2	0	10	0.4	0.84
		8/86	1	0	8	0	0	2	3	1	0	0	10	1.5	2.51
		12/86	0	0	0	0	0	0	0	0	0	0	10	0	---
		4/87	0	1	0	0	0	0	0	0	7	0	10	0.8	2.20
		8/87	0	0	0	0	0	0	0	3	0	0	10	0.3	0.95
		10/87	0	0	1	1	0	0	0	0	0	0	10	0.2	0.42

Appendix 12-2c: Numbers of *Pterygophora californica* juveniles tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **pre-operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat														N	Mean	Std. Dev.
DCSX	3	12/82	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		9/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		12/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		8/84	50	50	50	50	50	50	50	50	0	50					10	45.0	15.81
		12/84	13	13	49	6	22	6	50	12	27	12					10	21.0	16.34
DCSX	8	12/82	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		9/83	0	0	0	0	0	0	3	1	0	0	0	0	1	2	14	0.5	0.94
		12/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		8/84	2	0	2	0	0	3	0	0	0	0					10	0.7	1.16
		12/84	0	0	0	3	0	1	4	1	0	51					10	6.0	15.87
DRSX	3	12/82	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		9/83	34	20	50	22	15	10	10	10	0	0					10	17.1	15.42
		12/83	200	0	0	100	45	0	0	0	0	0					10	34.5	66.77
		5/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		8/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		12/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
DRSX	8	12/82	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		9/83	0	0	0	0	0	0	40	30	44						9	12.7	19.34
		12/83	4	7	4	1	4	67	9	0	0	1					10	9.7	20.35
		5/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		8/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		12/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
LRSX	8	12/82	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		4/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		9/83	0	0	3	6	0	0	0	0	0	0	2	0			12	0.9	1.88
		12/83	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		5/84	0	0	0	0	0	0	0	0	0	0					10	0.0	---
		8/84	0	0	0	0	0	1	1	2	0	0					10	0.4	0.70
		12/84	0	0	0	0	0	0	1	0	19	9					10	2.9	6.31

Appendix 12-2d: Numbers of *Pterygophora californica* juveniles tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **operational** conditions.

Station	Depth m	Month/ Year	Number per Quadrat	N	Mean	Std. Dev.
DCSX	3	5/85	0 19 82 5 9 17 26 1 19 16	10	19.4	23.59
		8/85	0 5 3 0 0 2 4 0 0 2	10	1.6	1.90
		12/85	12 9 3 6 0 4 0 3 0 2	10	3.9	4.04
		4/86	0 0 0 0 1 1 0 2 1 0	10	0.5	0.71
		8/86	0 0 0 0 0 0 0 0 0 0	10	0	---
		12/86	0 0 0 0 0 0 0 0 0 0	10	0	---
		4/87	0 0 0 0 0 0 0 0 0 0	10	0	---
		8/87	0 0 0 0 0 0 0 0 0 0	10	0	---
		10/87	0 0 0 0 0 0 0 0 0 0	10	0	---
DCSX	8	5/85	2 2 2 1 2 0 56 10 2 3	10	8.0	17.08
		8/85	0 0 2 5 0 0 0 1 0 0	10	0.8	1.62
		12/85	0 0 5 0 0 0 0 0 1 1	10	0.7	1.57
		4/86	0 0 0 0 0 0 0 4 0 0	10	0.4	1.26
		8/86	24 9 15 10 50 20 30 40 40 50	10	28.8	15.59
		12/86	116 150 150 150 150 150 150 150 150 150	10	146.6	10.75
		4/87	72 8 151 48 100 54 80 10 5 17	10	54.5	47.59
		8/87	6 0 3 0 0 67 0 0 0 0	10	7.6	20.97
		10/87	0 7 16 0 0 7 2 1 3 0	10	3.6	5.15
DRSX	3	5/85	0 0 6 1 6 100 2 0 4 200	10	31.9	66.60
		8/85	3 6 57 74 0 0 9 31 4 0	10	18.4	26.75
		12/85	0 0 1 0 2 0 0 0 1 25	10	2.9	7.80
		4/86	4 0 0 2 0 4 0 0 7 2	10	1.9	2.42
		8/86	0 0 0 0 12 0 0 0 0 0	10	1.2	3.79
		12/86	0 0 0 0 0 0 0 0 0 0	10	0	---
		4/87	0 0 0 0 0 0 0 0 0 0	10	0	---
		8/87	0 0 0 0 0 0 0 0 0 0	10	0	---
		10/87	0 0 0 0 0 0 0 0 0 0	10	0	---
DRSX	8	5/85	0 0 8 10 16 0 0 4 2 1	10	4.1	5.51
		8/85	0 20 8 1 10 19 0 0 7 17	10	8.2	8.11
		12/85	0 0 2 0 2 0 9 0 0 0	10	1.3	2.83
		4/86	3 0 6 1 0 0 2 0 0 0	10	1.2	1.99
		8/86	9 222 75 5 24 9 8 2 8 4	10	36.6	68.66
		12/86	4 29 21 26 9 0 59 53 14 69	10	28.4	24.12
		4/87	21 153 6 6 11 16 17 21 25 21	10	29.7	43.81
		8/87	20 3 23 61 5 17 57 6 7 33	10	23.2	21.12
		10/87	2 0 43 0 2 11 3 2 8 6 0	11	7.0	12.46
LRSX	8	5/85	0 2 0 0 0 0 2 1 3 0	10	0.8	1.14
		8/85	0 3 2 3 0 1 2 1 0 2	10	1.4	1.17
		12/85	0 2 0 0 0 0 0 1 3 0	10	0.6	1.07
		4/86	0 0 1 0 0 0 0 0 0 0	10	0.1	0.32
		8/86	2 19 9 1 1 0 1 2 1 1	10	3.7	5.95
		12/86	1 2 0 1 0 0 4 1 1 0	10	1.0	1.25
		4/87	1 0 2 2 1 0 0 0 3 3	10	1.2	1.23
		8/87	0 1 0 2 0 0 0 0 1 7	10	1.1	2.18
		10/87	0 0 1 3 0 0 0 0 0 0	10	0.4	0.97

APPENDIX 12-3

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Appendix 12-3a: Numbers of dead Palm Kelps tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **pre-operational** conditions. No data collected prior to Dec 1984.

Sta-tion	Depth m	Month/ Year	Number per Quadrat										N	Mean	Std. Dev.
DCSX	3	12/84	4	8	5	5	3	4	5	0	3	1	10	3.8	2.25
DCSX	8	12/84	0	0	0	0	0	0	0	0	0	0	10	0	---
DRSX	3	12/84	0	0	0	0	0	0	0	0	0	0	10	0	---
DRSX	8	12/84	0	0	0	0	0	0	0	0	0	0	10	0	---
LRSX	8	12/84	0	0	0	0	0	0	0	0	0	0	10	0	---

Appendix 12-3b: Numbers of dead Palm Kelps tallied within 3.14 m^2 quadrats positioned by blind casting at the indicated stations and dates in the Diablo Cove region. Data represent **operational** conditions.

Sta-tion	Depth m	Month/ Year	Number per Quadrat													N	Mean	Std. Dev.
DCSX	3	5/85	3	4	1	2	1	2	5	4	6	7				10	3.5	2.07
		8/85	10	6	11	18	15	9	8	17	4	4				10	10.2	5.07
		12/85	3	6	13	14	10	23	21	28	16	27				10	16.1	8.54
		4/86	22	38	29	22	41	28	37	32	30	20				10	29.9	7.23
		8/86	15	10	11	19	15	19	3	13	21	12				10	13.8	5.29
		12/86	6	7	12	7	11	9	6	5	5	8				10	7.6	2.41
		4/87	2	1	2	2	1	1	3	1	5	3				10	2.1	1.29
		8/87	0	0	1	0	0	0	2	2	2	0				10	0.7	0.95
		10/87	2	5	2	0	1	0	0	0	0	1	0	0	0	13	0.8	1.46
DCSX	8	5/85	2	0	1	1	1	0	0	3	3	0				10	1.1	1.20
		8/85	1	0	0	0	0	0	0	0	0	2				10	0.3	0.67
		12/85	2	1	0	3	0	2	0	1	0	0				10	0.9	1.10
		4/86	2	3	1	0	0	0	0	0	0	2				10	0.8	1.14
		8/86	0	0	0	0	0	0	1	2	1	0				10	0.4	0.70
		12/86	2	2	2	2	1	0	0	1	0	0				10	1.0	0.94
		4/87	2	0	1	0	1	3	0	0	0	3				10	1.0	1.25
		8/87	0	4	0	1	0	0	1	1	1	0				10	0.8	1.23
		10/87	0	1	0	1	1	2	2	0	0	0				10	0.7	0.82
DRSX	3	5/85	0	0	3	0	1	0	2	2	2	0				10	1.0	1.15
		8/85	2	0	4	14	21	2	0	6	6	5				10	6.0	6.65
		12/85	24	28	19	23	22	27	13	18	29	17				10	22.0	5.23
		4/86	27	44	26	33	34	30	31	12	107	27				10	37.1	25.83
		8/86	15	13	29	11	35	22	21	29	33	11				10	21.9	9.19
		12/86	31	9	12	9	33	27	28	57	31	39				10	27.6	14.84
		4/87	3	5	3	2	5	24	2	7	27	4				10	8.2	9.27
		8/87	2	1	1	0	1	0	0	2	1	0				10	0.8	0.79
		10/87	0	0	0	4	7	0	0	0	0	0				10	1.1	2.42
DRSX	8	5/85	0	0	0	2	2	1	0	0	0	2				10	0.7	0.95
		8/85	3	0	0	1	2	0	3	1	0	1				10	1.1	1.20
		12/85	0	0	8	0	4	5	2	0	0	0				10	1.9	2.85
		4/86	0	1	2	6	7	4	5	2	2	1				10	3.0	2.36
		8/86	0	2	0	3	0	0	0	0	1	0				10	0.6	1.07
		12/86	6	4	1	4	2	6	0	0	1	0				10	2.4	2.41
		4/87	3	0	3	0	1	0	1	1	2	2				10	1.3	1.16
		8/87	0	0	1	0	0	0	2	0	2	0				10	0.5	0.85
		10/87	1	0	1	1	0	0	1	1	0	1	0			11	0.5	0.52
LRSX	8	5/85	0	1	0	1	2	1	1	0	1	1				10	0.8	0.63
		8/85	0	0	0	2	2	0	0	0	0	0				10	0.4	0.84
		12/85	0	1	3	0	1	0	0	2	0	0				10	0.7	1.06
		4/86	0	0	1	0	0	0	1	1	0	0				10	0.3	0.48
		8/86	1	0	1	0	1	0	0	1	1	0				10	0.5	0.53
		12/86	1	3	0	0	1	1	2	1	0	3				10	1.2	1.14
		4/87	1	0	0	0	0	2	0	1	0	2				10	0.6	0.84
		8/87	1	1	0	1	0	0	0	0	0	0				10	0.3	0.48
		10/87	1	1	0	1	0	1	0	0	1	1				10	0.6	0.52

Chapter 13

SPECIES of PARTICULAR INTEREST

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Figures

Tables

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LISTINGS OF AFFECTED ORGANISMS

In the results section, we have categorized the species of Diablo Cove into depressed, enhanced, or neutral classifications, depending on trends of abundances and frequencies of occurrence during the operational years. Criteria employed in classifying organisms were applied rigidly. The lack of flexibility in some cases led to conflicting conclusions (i.e., a species might be classed as depressed at one location and as enhanced at another) or to incorrect classifications (e.g., a sensitive subtidal species might still occur at subthermocline depths and therefore be identified as "present" along a transect, putting it into the neutral category). We will now introduce flexibility into the categorization process, making adjustments as needed to reflect true responses by organisms to the operational environment.

A species was classified as an affected organism if substantial changes in status (examples: greatly changed abundance, clearly altered distributional pattern, evidence of ill health) were measured at a single location within Diablo Cove, even though it may have been classified as neutral for other locations. Subtidal organisms that disappeared from locations lying above the thermocline were classed as depressed even though healthy populations may have remained below the thermocline. We have also included some species whose abundances and/or frequencies were too low to permit classification by the methods employed above in the Results Section. The resulting listings (Tables 13-1 and 13-2) thus incorporated an element of judgment for certain species. Where substantial judgment was involved, the symbol for a species was placed beneath the "O" column to signify that the decision relied to a considerable extent on observational data.

The listings of Tables 13-1 and 13-2 agreed generally with findings from the Results Section. A large majority of the affected plant species fell in the depressed category. Only a minority of animal species were classed as depressed. There were only two instances of a

Table 13-1: Response of plant species in Diablo Cove (for various study types) whose abundances and/or vertical distributions were enhanced (E) or decreased (D) after 1984, based on presence/absence criteria, quantitative abundance estimates, or simply general observations. Study type key: I = intertidal, S = subtidal or Phaeophyta studies, SS = solid substrate collections, O = observations.

	Study Types				
	I	S	SS	O	Remarks
CHLOROPHYTA					
Codium setchelli	D				
Halicystis ovalis		D			
Ulva sp.	D				
PHAEOPHYTA					
Cystoseira osmundacea		D		D	Warm water species
Desmarestia ligulata		D			
Dictyoneurum californicum		D		D	
Dictyota sp.		D			Warm water species
Egregia menziesii	D	D		D	Warm water species
Fucus / Hesperophycus	D				
Laminaria dentigera	D	D		D	
Macrocystis pyrifera				D	Canopy only
Nereocystis luetkeana		D		D	
Pterygophora californica	D	D		D	
RHODOPHYTA					
Bossiella orbigniana				E	
Botryoglossum farlowianum				D	
Callophyllis firma				D	
Callophyllis flabellulata				D	
Callophyllis pinnata				D	
Callophyllis violacea				D	
Corallina officinalis	D				Warm water species
Corallina vancouveriensis	D				Warm water species
Coralline crusts	D				
Cryptopleura / Hymenena	DE				
Cryptopleura violacea		E			Dominant at DCSX 3m
Endocladia muricata	D				
Gastroclonium coulteri	D				but flourishing shallow subtidal
Gelidium coulteri/pusillum	D				
Gigartina canaliculata	D				Warm water species
Gigartina corymbifera				E	
Gigartina cory./exasp.	DE				
Gigartina exasperata				E	
Gigartina leptorhyncos	E				
Gigartina papillata	D				
Gymnogongrus platyphyllus		D			
Iridaea cordata		E			
Iridaea flaccida	D				
Laurencia spectabilis	D				No change subtidally
Microcladia coulteri	D				
Neoagardhiella gaudichaudi		E			
Peyssonellia sp.				E	
Pikea californica				E	
Porphyra perforata	D				
Prionitis lanceolata	E			E	
Pseudolithophyllum neofarlowii	D				
Rhodoglossum affine	D				
Rhodoglossum roseum		E		E	
Rhodymenia californica		D			
Rhodymenia pacifica		D			
Schizymenia pacifica				E	

Table 13-2: Response of animal species in Diablo Cove (for various study types) whose abundances and/or vertical distributions were enhanced (E) or decreased (D) after 1984, based on presence/absence criteria, quantitative abundance estimates, or simply general observations. Study type key: I = intertidal, S = subtidal or Phaeophyta studies, SS = solid substrates collections, O = observations. * indicates cryptics that may have been more easily observed in intertidal due to overstory pruning.

	Study Types				
	I	S	SS	O	Remarks
PORIFERA					
Anaata spongigartina			D		
Leucandra heathi			D	D	
Leucetta losangelensis			E	E	warm water species
Leucilla nuttingi				D	
CNIDARIA					
Aglaophenia sp.			D?		
Astrangia lajollaensis				D	
Balanophyllia elegans				D	
Paracyathus stearnsi				D	
BRYOZOA					
Arthropoma cecili			D?		
Cauloramphus sp.			E?		
Chapperia patula			D?		
Crisia sp.				D	
Diaperoecia californica			D?	D	
Hippodiplosia insculpta				D	
Lagenipora punctulata				D	
Lyrula hippocrepsis			E		
Microporella californica			E?		warm water species
Microporella ciliata			E?		warm water species
Microporella cribrosa			E?		warm water species
Microporella umbonata			E?		warm water species
Porella porifera			E?		
Puellina setosa			E?		
Rhynchozoon sp.		D			
Scrupocellaria varians			E		warm water species
Smittina cordata			E?		D by El Niño
Tricellaria occidentalis			D?		
ANNELIDA					
Dodecaceria fewkesi		D			
**Phragmatopoma californica*	E				warm water species
Spirorbis bifurcatus			D?		
MOLLUSCA					
Anisodoris nobilis				D	
Calliostoma canaliculatum				D	
Collisella digitalis	E				warm water species
Collisella limatula	E?				warm water species
Collisella scabra	E				warm water species
Cyanoplax sp.	E				
**Fissurella volcano*	E				warm water species
Haliotis cracherodii	D				
Littorina scutulata	E				warm water species
Mitra idae				D	

Table 13-2: Response of animal species in Diablo Cove (for various study types) whose abundances and/or vertical distributions were enhanced (E) or decreased (D) after 1984, based on presence/absence criteria, quantitative abundance estimates, or simply general observations. Study type key: I = intertidal, S = subtidal or Phaeophyta studies, SS = solid substrates collections, O = observations. * indicates cryptics that may have been more easily observed in intertidal due to overstory pruning.

	Study Types				
	I	S	SS	O	Remarks
MOLLUSCA (cont.)					
**Mopalia* sp.	E?				
**Mytilus* sp.	E				warm water species
Notoacmea scutum	E				warm water species
Nuttallina californica	E				warm water species
Ocenebra circumtexta	E				
Pododesmus cepio		E	E		
Pteropurpura trialatus				D	
**Serpulorbis squamigerus*	E				
Tegula brunnea	D?				
ARTHROPODA					
Balanus sp.		E?			
Chthamalus sp.	E				warm water species
Pachygrapsus crassipes	E				
Pollicipes polymerus	E				warm water species
Tetraclita squamosa rubescens	E				warm water species
ECHINODERMATA					
Cucumaria sp.				D	
Orthasterias koehleri				D	
Strongylocentrotus purpuratus	E				
CHORDATA-TUNICATA					
Boltenia villosa				D	
Cnemidocarpa finmarkiensis				D	
Pyura haustor				D	
Ritterella pulchra				D	
CHORDATA-PISCES					
Embiotoca jacksoni		E			warm water species
Girella nigracans				E	warm water species
Medialuna californiensis				E	warm water species
Myliobatis californica				E	warm water species
Oxyjulis californica		E			warm water species
Semicossyphus pulcher				E	warm water species
Triakis semifasciata				E	warm water species

conflicting classification. *Gigartina corymbifera/exasperata* and *Cryptopleura/Hymenena* displayed declining trends at CDIX in the intertidal but were apparently enhanced throughout much of the shallow subtidal. The decline of *G. corymbifera/exasperata* at CDIX seemed indisputable (Table 13-3). In view of the large populations occurring subtidally, we hesitated to ascribe disappearance of *G. corymbifera/exasperata* and *Cryptopleura/Hymenena* at CDIX solely to sensitivity to heated effluent. The two species clearly tolerated elevated temperatures in the shallow subtidal. These unusual cases are discussed further in the subsection "Downward shifts in Distributions" where we consider possibilities of sensitivity to more than one factor.

Table 13-3: History of estimated percent coverages in one m^2 quadrats by *Gigartina corymbifera/exasperata* along the CDIX intertidal transect, about 200m (650ft) north of the discharge structure within Diablo Cove. P indicates species was present at <1 percent cover.

	Dates															
Quadrat Number	Dec 82	Mar 83	Sep 83	Dec 83	Apr 84	Aug 84	Dec 84	May 85	Sep 85	Dec 85	Apr 86	Aug 86	Dec 86	Apr 87	Aug 87	Dec 87
32	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	P	-	-	-	-	-	P	5	1	-	-	-	-	-	-	-
35	-	P	-	2	1	3	P	P	-	2	-	-	-	-	-	-
36	-	-	-	-	-	-	-	1	-	5	-	-	-	-	-	-
37	P	-	10	2	7	10	5	-	P	-	-	-	-	-	-	-

PROPOSED INDICATOR ORGANISMS AND THEIR DISTRIBUTIONS

Selection of Indicator Organisms

The species listed in Tables 13-1 and 13-2 were described as "affected" organisms. Their populations had shown substantial changes in abundance, distribution, healthiness, etc, during DCPP operational years. Appearance of such a change, however, did not necessarily imply knowledge of the causative factor(s) such as a direct or indirect impact from heated effluent. An indicator organism should be "affected" and there should also be evidence that any change represented an impact due to DCPP operations. A direct impact would presumably be preferred over an indirect effect.

Our criterion for selecting indicator species from the listings of affected species consisted of evidence of an inverse relationship between distance from the point of discharge and the magnitude of any change (i.e., presence of gradients in observed impacts). We also required that good indicator organisms be fairly abundant species. Sparse or infrequent species might provide results difficult to interpret. Extremely abundant species may be poorly suited as indicator organisms (particularly if the response was one of enhancement). Small and numerous animals such as barnacles, for example, required too much effort to measure abundances accurately and we usually estimated such parameters roughly. Any abundance changes in such species would need to be large in order to detected with confidence.

The best indicator organisms in our listings were considered to be a few species of Brown and Red Algae. Intertidal candidates were *Iridaea flaccida* and *Corallina vancouveriensis*. Good subtidal indicators were *Laminaria dentigera* and *Pterygophora californica*. All four of these algal species displayed declining trends during operational years, and there were indications that depressions were greatest at stations closest to the discharge structure.

A third intertidal Red Alga, *Gigartina canaliculata*, displayed large declines within Diablo Cove but not at our control transect LCIX. We hesitate, however, to propose *G. canaliculata* as an indicator organism because it is considered a warm-tolerant species and occurs at many intertidal locations in southern California. Consequently, abundance declines among the stands in Diablo Cove may have been caused by some unknown effect that may or may not have been associated with DCPP operations but was probably not directly related to temperature. Until the cause(s) of declines among *G. canaliculata* stands are better understood, we prefer not to classify it as an indicator organism.

Dictyoneurum californicum might also qualify as a good subtidal indicator organism except that its abundance was low. The species formerly occurred in shallow water throughout most of most of Diablo Cove. Our observations indicated it first began disappearing near the discharge, then subsequently at increasing distances from that structure. Few, if any, *Dictyoneurum* plants remained in shallow areas within Diablo Cove by the end of 1987. Our preoperational sampling of Phaeophyta yielded a mean abundance of 0.2 plants per m^2 for *Dictyoneurum* at DCSX3m (50 quadrats from five survey dates). Distributions were highly aggregated. Clusters of a few plants might occur every 5 to 30 m (16 to 100 ft) during a swimthrough. The low abundances and clumped distributions clearly weighed against selection of *Dictyoneurum* as an indicator organism even though there was good evidence of sensitivity to heated effluent.

Bull kelp, *Nereocystis luetkeana*, was also sensitive to elevated temperatures characteristic of plume waters in Diablo Cove. Like *Dictyoneurum*, abundance of bull kelp was usually low inside the Cove. It was therefore not considered as a good indicator species for this particular area. Large and easily defined *Nereocystis* beds occurred up and down the coast from Diablo Cove. These populations persisted during the operational years. They were considered excellent indicators as to possible far-field effects from DCPP operations.

There were many other species that would also probably serve as good indicator organisms, but our data were not sufficient to propose them for such usage. We have emphasized species whose abundances declined, but several flourished in the operational environment and might be considered as positive indicators. *Gigartina leptorhynchos* in the intertidal and *Prionitis lanceolata*, *Gigartina exasperata*, *Cryptopleura violacea*, and *Bossiella orbigniana* in the shallow subtidal, were good examples. These species were probably stimulated by disappearances of competitors, not by higher water temperatures. Relationships to heated effluent were thus indirect. Organisms directly influenced by the changed environment were considered preferable as indicator organisms.

Comments on Intertidal Indicator Organisms

Iridaea flaccida was a dominant plant throughout most of the mid-intertidal in Diablo Cove during the entire preoperational period. As of December 1987, *I. flaccida* had essentially disappeared from most of the Cove. We observed a scattering of plants at the extreme north and south ends and one individual centrally (about 100 m or 330 ft south of the discharge structure). This distribution was suggestive of a gradient with respect to distance from the point of discharge. Tiny bits of *Corallina vancouveriensis* were detected on the CDIX transect in December 1987. Moderate amounts appeared in mid-intertidal pools farther north (Sectors 3, 4 and 5, see Figure 5-7). Again, there were indications of a gradient in abundance in relation to the discharge structure.

Disappearances by *Iridaea flaccida* populations were anticipated because the species is rare in southern California's warm waters, but prefers the colder regimes of central California. Laboratory studies by the Thermal Effects Monitoring Program showed that young sporophytic plants survived water temperatures of 21.7°C (71°F) for two months (TERA, 1982). This was quite a high temperature, which might be expected to occur only occasionally in Diablo Cove during periods of strong Davidson Current regimes. We found both sporophytic and gametophytic specimens of *I. flaccida* at NDIX in May 1987. Nearly all individuals examined had healthy tissues, yet abundances declined steadily at NDIX and CDIX. Possibly the microscopic stages in the *I. flaccida* life cycle were more sensitive to elevated water temperatures than the young or adult plants.

The microscopic stages, however, were also studied in the TERA laboratory work. Peak performances occurred at mean temperatures of 17.5°C (63.5°F), declining slightly at 19.4°C (66.9°F) and drastically at 22.3°C (72.1°F). Thus microscopic stages should survive most temperatures occurring within Diablo Cove. There was consequently some uncertainty as to precise causes of the declines in *I. flaccida*, but its general absence from southern California, history of the declines within Diablo Cove, and presence of luxuriant stands throughout Field's Cove nearby, all suggested that there was a close relationship between the DCPP discharge and persistence of *I. flaccida* populations. We therefore considered this species as the best indicator organism among the intertidal fauna and flora.

Corallina vancouveriensis was prominent during preoperational years both within tidepools as well as subaerially in the mid-intertidal. The subaerial portions of the populations tended to be impacted most severely during the operational period. Disappearance of neighboring foliose algal cover may have left the subaerial stands of *C. vancouveriensis* more exposed to sunlight during daytime low tides, producing stresses such as desiccation or damage from ultraviolet radiation. Extensive losses of subaerial *C. vancouveriensis* stands were first noticed during our surveys and shorewalks of April 1986, after substantial amounts of associated foliose algae in the mid-intertidal had disappeared. *C. vancouveriensis* does occur in the intertidal in southern California, so like *Gigartina canaliculata*, it probably tolerates any elevated water temperatures occurring in Diablo Cove. Thus the cause(s) of declines by *Corallina vancouveriensis* within Diablo Cove seemed indirectly related to DCPP operations and *Iridaea flaccida* was considered to be a better intertidal indicator organism.

Comments on Subtidal Indicator Organisms

Laboratory work by TERA (1982) showed lack of growth for *Pterygophora* gametophytes at 22.6°C (72.7°F) and for sporophytes at 19.9°C (67.8°F). The temperature considered as representing 50 percent of optimal performance by *Laminaria* sporophytes was <20.6°C (<69.1°F). We noted in Chapter 12 that palm kelps in Diablo Cove during operational years frequently succumbed to diseases such as *Streblonema* infections. Our transplant experiments with *Laminaria* indicated that outplants to Newport Bay in southern California fared poorly when ambient temperatures rose to 17 to 18°C (62 to 64°F). Thus, although laboratory findings and transplant experiments suggested that conditions in shallow areas of Diablo Cove would probably sustain *Pterygophora* and might be marginal for *Laminaria*, both species of palm kelp all but disappeared from this habitat between 1985 and 1987.

During spring, 1987, we developed a scheme for classifying subtidal floral associations in the Diablo Cove shallows into five categories(Table 13-4). Stage 1 represented no perceptible change. Stage 5 constituted the largest changes we had observed as of the end of 1987, in the depth range of 2 to 5 m (6 to 17 ft). The most important criteria in our scheme involved status of the palm kelp populations (Figures 13-1 to 13-4). The scheme also used presence or absence of certain sensitive and tolerant Red Algae as co-indicators.

Laminaria was considered to be a more sensitive indicator organism than *Pterygophora*. Our quantitative studies at DCSX3m and DRSX3m found that *Laminaria* was the first species of palm kelp to disappear completely. Large old adults of both species seemed more sensitive than young individuals. Recruitment processes were even more sensitive, ceasing well before young and adult palm kelps had disappeared.

Table 13-4: Descriptions of well-defined subtidal floral associations observed in the operational environment within Diablo Cove. We have ranked the associations in a hierarchy representing different degrees of influence from exposure to power plant effluent. Stage 1 = no detectable effects, Stage 5 = most severe effects thus far seen in the subtidal.

Stage	Description
1	Dense stands of healthy palm kelps with moderate to sparse substory flora (due to shading). Very few dead stipes and almost no *Streblonema* infections among palm kelps. Substory flora diverse, often dominated by *Botryoglossum, Callophyllis* spp., and/or *Rhodymenia* spp. Pinnacle tops support crowded stands of healthy young *Laminaria* plus a few *Pterygophora*. Scattered patches of healthy *Dictyoneurum* present and juvenile kelps may occur at the proper season. Some *Cystoseira* present.
2	Dense thickets of healthy palm kelps predominant at 3-5m depths, with a few dead stipes and some *Steblonema* infections. Occasional small aggregates of dead or moribund palm kelps. Substory flora as for Stage 1. Pinnacle tops within 1-2m of the surface display many dead or moribund palm kelps. Juvenile kelps, *Dictyoneurum* and *Cystoseira* as for Stage 1.
3	Palm kelp density reduced from Stage 2. Moribund plants and dead stipes fairly common throughout the populations down to 3-4m depths. *Gigartina corymbifera, G. exasperata,* and sometimes *Cryptopleura violacea* predominant among substory flora and dominant in open areas where palm kelps are sparse or absent. *Botryoglossum* still moderately abundant. Pinnacle tops display primarily dead stipes and most palm kelps at 3m depths have reduced blade crowns and many infections and lesions. *Cystoseira* may be common but juvenile kelps and *Dictyoneurum* clusters only occasionally present.
4	Living palm kelps sparse and have partial or almost no blade crowns. Blades with severe lesions. Dead stipes may be scattered or numerous. Pinnacle tops sometimes have a few dead stipes present. Bottom dominated by *Gigartina exasperata, G. corymbifera,* and sometimes *Cryptopleura* and *Schizymenia*. *Botryoglossum* scarce to moderate, usually young plants. *Dictyoneurum* scarce and sickly when present. Juvenile kelps very infrequent but healthy *Cystoseira* may be common.
5	Living palm kelps very infrequent, when present sickly, and confined to low spots or depressions. Occasional dead stipes. *Dictyoneurum* absent, *Cystoseira* infrequent and often sickly. Juvenile kelps very sparse and only in the lowest spots. Little or no *Botryoglossum*. Bottom dominated by the two *Gigartina*s and sometimes also *Cryptopleura* and *Schizymenia* (the later two much more common in the north part of the Cove than in the southern section).

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Figure 13-1. **Stage 1 floral community.** Note dense healthy kelp forest with substory *Botryoglossum*, on a pinnacle top.

Figure 13-2. **Stage 2 floral community.** Plant and canopy density reduced from Stage 1 and some disease manifestations present.

Figure 13-3. **Stage 3 floral community.** Kelp density greatly reduced, plants dead or sickly. *Gigartina* spp. prominent. Note healthy *Cystoseira* at lower right corner.

Figure 13-4. **Stage 4 floral community.** Living palm kelps scarce. *Gigartina* spp. very common.

Chapter 14

OVERVIEW of CHANGES in the BIOTA

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CHANGES IN INTERTIDAL BIOTA

A casual observer looking at the Diablo Cove shoreline in 1987 could hardly fail to notice a rather broad black zone extending across most of the mid-intertidal. Close examination would reveal that the black hues resulted from dense coverages by non-coralline crust, primarily *Petrocelis franciscana*. This relatively barren zone was formerly densely covered by stands of *Iridaea flaccida*, *Gigartina papillata*, *Endocladia muricata*, *Corallina vancouveriensis*, and numerous other short-statured Red Algae. These species did not disappear entirely but their abundances frequently declined, especially the upper portions of the vertical distributions.

After these larger Red Algae declined, biota situated beneath the former foliose coverages became much more exposed to desiccation and to sunlight during low tides. Polne and Gibor (1982) found that exposure to ultraviolet-A radiation affected photosynthesis among all ten intertidal and subtidal algal species tested. Intertidal algae and Red Algae in general were least sensitive. Natural sunlight, however, contains both UV-A and UV-B radiation. The latter is more harmful to living tissues than the wavelengths used by Polne and Gibor. Loss of the foliose algae might also affect some epiphytic plants such as *Microcladia coulteri*. Such epiphytes might tolerate the new environment without difficulty but simply lack suitable substrates. Loss of the foliose cover might eliminate habitat for certain small animals. The same losses, however, might expose others (e.g., small chitons, limpets, snails), giving the false impression that their numbers had increased. All these possibilities must be considered when assessing changes and their underlying causes.

Our analyses of the select group of intertidal species yielded 22 plants and 2 animals as showing decreased abundances during operational years (see Tables 13-1 and 13-2). Abundances of 4 plant and 17 animals increased. The plant species displaying increased abundances were *Cryptopleura/Hymenena*, *Gigartina corymbifera/exasperata*, *G. leptorhynchos*, and *Prionitis lanceolata*. The two declining animal species were *Tegula brunnea* at CDIX (no change for this turban snail at SDIX and LCIX, possibly enhanced at NDIX) and *Haliotis cracherodii* at NDIX and SDIX (the latter because of habitat disruption from the 1983-84 El Niño). Thus, among the affected species, most of the intertidal plants showed declines during operational years, while abundances of most intertidal animals increased. Changes were frequently specific to a particular station and were not necessarily similar everywhere.

Decreases among plant populations were not confined to those species occupying the mid-intertidal zone. Changes also occurred among plants of the upper intertidal (i.e., *Fucus/Hesperophycus*, *Porphyra*) and the low intertidal (*Rhodymenia* spp., *Laminaria*, *Pterygophora*). Some of the declines included plants considered as warm-water species (e.g., *Egregia*, *Corallina vancouveriensis*), based on their distributions in southern California. Abundance declines in some cases were probably not directly caused by exposure to heated effluent. For example, our observations indicated high mortality only for that portion of the *Corallina vancouveriensis* population exposed to air during low tides. *C. vancouveriensis* situated in tidepools or similar moist locations did not suffer obvious mortality (as indicated by bleached white remains of recently dead plants). The largest mortalities were associated with low tides during sunny days in winter of 1986. This was a period when cover provided by associated foliaceous species was rapidly dwindling. Possibly, exposed *C. vancouveriensis* was vulnerable to UV radiation and/or desiccation, but was able to tolerate the elevated water temperatures from plume exposures. We have observed *C. vancouveriensis* well exposed to air at the top of the mid-intertidal in La Jolla Bay (an environment slightly warmer than most of the surrounding exposed coast). It always occurred in a complex mixture of other plant species, never as isolated plants or in pure stands. The stands in La Jolla Bay clearly tolerated water temperatures comparable to those in Diablo Cove, but the species apparently required protection by associated foliage when it occurred subaerially.

Several of the abundance declines noted among plant species within specific quadrats along our transects resulted from downward shifts in the vertical distributions or from losses of the upper portions of the distributions, or from both processes (e.g., *Gastroclonium*, *Cryptopleura/Hymenena*, *Botryoglossum*, *Laminaria*, *Pterygophora*, and possibly *Gigartina corymbifera/exasperata*). Some of these probably represented failure to tolerate plume exposures because we noted similar regressions among populations of these species in the shallow subtidal, but survival at depths below 4.5 m (15 ft).

Nearly all of the affected intertidal plants still occurred in Diablo Cove as of the end of 1987 (one possible exception was *Egregia*). The populations were either sparse or the species remained at subthermocline depths. Our detailed analysis covered only 32 of the 103 plant species or similar categories present in our master listings (i.e., roughly a third of all plant species observed intertidally). We observed declines in 22 of the 32 categories, or about 68 percent of the select plant species. While there is no assurance that the group of select species was entirely representative of the remainder of the flora, it seemed likely that a relatively high proportion of the intertidal plant life of Diablo Cove changed substantially during the operational years. There were 20 known cold water plants among the non-select grouping. The select group included the most abundant and frequently-recurring species. The demonstrated high proportion of declining trends within this group of important plants suggested that possibilities were likely to be high for indirect effects among other species associated with the affected flora.

Trends among intertidal select animals differed from those seen among plants. Of 34 animal species in our select group, only one (*Tegula brunnea*) displayed a declining tendency and that only for a single station (CDIX). The remainder were equally divided between those showing no change and those displaying increased abundances (see Table 9-8). A number of the affected animals were small (1 cm [about 0.5 in] or less). Some of these may have been concealed by foliage during preoperational surveys, becoming more conspicuous after biomasses of dominant plants declined in the mid-intertidal during the final two years of our study. Most of the species in the enhanced category were either filter feeders or grazers of encrusting microalgae (i.e., animals whose food supplies would not be affected by declines among foliose plants). One enhanced animal, *Ocenebra circumtexta*, was a carnivore (Morris, Abbott, and Haderlie, 1980). Two enhanced animals consume both encrusting algae and certain foliaceous algae (*Littorina scutulata* and *Strongylocentrotus purpuratus*). All of the enhanced group were species seen commonly in the intertidal in southern California, thus qualifying as being warm water species.

Of the 19 select animal species in the "neutral" category, only three were considered as possible cold water organisms (*Acmaea mitra*, *Eurystomella bilabiata*, and *Corynactis californica*). None of the three occur commonly in shallow waters of southern California but have been observed at depths well below the thermocline. We were somewhat uncertain about the status of intertidal *Corynactis* within Diablo Cove because although it continued to occur at NDIX during operational years, frequencies had always been low. It remained common subtidally, however, so it clearly tolerated the operational environment. We thus concluded it was a neutral species.

One select animal, *Patiria* , was affected by the 1983 El Niño to such an extent that responses to the operational environment could not clearly be determined. Eliminating *Corynactis* and *Patiria* from the listing left 17 intertidal species that appeared to be indifferent to the operational environment. If we add these indifferent species to the enhanced animals, we obtain 34 enhanced or indifferent species compared to only one that was depressed. Two of the 34 enhanced/indifferent group were considered cold water species but the remainder were animals present in warm-water environments. The large preponderance of warm-water species among these select animals probably explained the almost complete absence of depressed faunal species within Diablo Cove.

There were two animals among the enhanced/indifferent category that may graze foliose algae: black abalone (*Haliotis cracherodii*) and purple urchins (*Strongylocentrotus purpuratus*). They can also capture and consume drift seaweeds. Although supplies of intertidal attached plants may have become less available, considerable drift was generated from macroalgal productivity in the subtidal and a portion thereof may have supplemented the diets of intertidal urchins and abalone.

Our shorewalks revealed that large colonies of mussels (*Mytilus*) and gooseneck barnacles (*Pollicipes*) developed in the intertidal in the immediate vicinity of the DCPP discharge structure. *Mytilus* and *Pollicipes* are well known as fouling organisms. There were indications of increased abundances of these two species at CDIX, some 180 m (600 ft) north of the discharge structure, but not at SDIX or NDIX which lay about 300 m (1000 ft) and 400 m (1300 ft) away respectively. The large masses of mussels and barnacles at the discharge structure were indicative of a favorable and highly specialized habitat (elevated temperature and extreme turbulence). Increased abundances at CDIX may simply have been a response to a combination of a slightly enhanced environment for these two species, plus availability of larvae from the nearby large populations at the discharge structure.

In addition to the group of 34 common intertidal animal species selected for detailed analyses, the master list contained 101 minor species whose abundances and/or frequencies were insufficient to support further analysis. The group of minor species contained 33 considered as tolerant of warm water, 14 considered as confined to cold-water habitats, while preferences for the remainder were uncertain.

CHANGES IN SUBTIDAL BIOTA

Like the intertidal, disappearance of cover by certain plant species was the most obvious change seen in the shallow subtidal, down to depths of about 4.5 m (15 ft). The two palm kelps, *Laminaria* and *Pterygophora* had dominated the sea floor here for about eight years before operations by DCPP commenced. The first indications of change were deterioration among blade crowns of adult palm kelps receiving greatest exposures to plume waters (i.e., at our shallow Phaeophyta-sampling stations DCSX3m and DRSX3m, see Chapter 12). Extent of the affected palm kelps gradually increased and we also observed reductions in abundances of certain other seaweeds. Effects among animals were more subtle, but reductions or disappearances of some invertebrates occurred. A few plant and some animal species tolerated, and in some cases proliferated in, the changed environment. By the end of 1987, most of the shallow-water kelp forest had vanished north of the discharge structure within Diablo Cove. Other sensitive species also disappeared or became sparse, while tolerant species became prominent. Changes south of the discharge structure were not as severe as to the north and graded to almost no effects out in the southwest channel. Biota at subthermocline depths remained in a natural condition except for tall kelps such as *Nereocystis* and *Macrocystis* which displayed indications of stress in the upper foliage when it penetrated the thermocline.

Deterioration Patterns Among Palm Kelps

The first indication of stress among *Laminaria* plants was appearance of darkened areas caused by an infecting Brown Alga, *Streblonema evagatum*. The infected areas eventually deteriorated completely and that part of the blade sloughed away. Blades with numerous lesions became weakened and broke off during periods of rough seas. Infections near the blade base could lead to loss of the meristem, killing the plant.

A different degradation pattern occurred for *Pterygophora*. Blade tips became riddled with small holes, probably weakening the structure so that this part of the blade eventually broke off. The process continued with blade crowns becoming smaller and smaller. Finally only the basal blade parts remained and ultimately disappeared.

We often observed concentrated grazing occurring on the small remaining bits of meristematic tissues of *Pterygophora* and *Laminaria*. Clusters of limpets and especially turban snails (*Tegula brunnea*, *T. pulligo*, and *T. montereyi*) topped the stipes, consuming the last available fragments of blade tissue. When all blade material was gone, the grazers moved lower, stripping off the brown dermis and leaving a yellowish core of stipe that gradually decayed during the next few months.

Narrative History of Deterioration Among Palm Kelps

The decay patterns described above appeared first among older *Laminaria* plants and a few large *Pterygophora* in the immediate vicinity of DCSX3m and DRSX3m in early 1985. Slightly deteriorated individual blades were seen occasionally in other shallow parts of Diablo Cove. Our notes from a swimthrough on May 9 1985 (from off NDIX to off CDIX) described the deterioration patterns seen as "not excessive and were well within the range of normality". Healthy *Nereocystis* and *Dictyoneurum* (two sensitive cold-water algae) were noted in the shallows north of the discharge structure.

Deteriorating juvenile *Laminaria* were recorded at DCSX3m and DRSX3m in August 1985. Blade losses were well advanced among adult *Laminaria* and many large *Pterygophora*. Swimthroughs north and south of the discharge structure revealed serious deterioration among *Laminaria* stands clustered on pinnacle tops (i.e., quite shallow habitat). Healthy young *Laminaria* remained in depressions. Some deterioration was observed among *Pterygophora* blades. Proportions of deteriorated to healthy *Laminaria* showed a clear gradient north of the discharge structure. A southward gradient was also noted but encompassed a shorter distance. Parasitic *Acrochaetium* infections were seen at DRSX among a few Red Algae.

All adult *Laminaria* and *Pterygophora* and juveniles on ridges at DCSX3m and DRSX3m were dead or blade crowns greatly depleted when surveyed in December 1985. Young plants in depressions still appeared healthy. We did not conduct any swimthroughs because of rough seas.

Almost all adult palm kelps were dead at DCSX3m by April 1986. Most juvenile plants had only portions of blades remaining. Palm kelps at DRSX3m were in slightly better condition. North and south swimthroughs revealed a similar status for populations throughout the north part of the Cove. A few living adult *Laminaria* and most *Pterygophora* survived in the south part of the Cove. North and south swimthroughs in May 1986 found some meristematic growth developing atop stipes of plants previously considered dead, but densities of living plants were low compared to preoperational days and no coherent canopies were seen.

The status of palm kelps at our Phaeophyta sampling stations remained approximately unchanged at the time of our August 1986 survey. Little or no recruitment was seen in the shallows (a few stunted small plants were recorded at DRSX3m). Palm kelps had completely disappeared from high areas in the north part of the Cove. Sickly individuals (mostly juvenile *Pterygophora*) remained in the depressions. Nearly all *Laminaria* and most *Pterygophora* had vanished from the south part of the Cove.

We were unable to conduct any swimthroughs in December 1986 because of rough seas. No juvenile recruitment was seen at our Phaeophyta sampling stations at this time (or on any subsequent surveys). Living *Laminaria* no longer occurred at DCSX3m but a few straggly specimens survived at DRSX3m. These consisted of stipes plus small bits of meristematic tissue. A few similarly straggly young *Pterygophora* remained in depressions at both DCSX3m and DRSX3m.

Status of palm kelp populations remained unchanged at our Phaeophyta sampling stations as of April 1987. Our quadrats contained a few *Pterygophora* with closely cropped blade crowns. A few barely living *Laminaria* lingered on at DRSX3m. We expanded our springtime swimthroughs of May 1987 to include the north channel and the entire southern border of Diablo Cove. As noted in Chapter 13, we divided the status of the shallow subtidal flora into five categories where stage 1 represented unaffected kelp forests and stage 5 was defined by complete absence of living palm kelps (see Table 13-4). This scheme was used to lay out a status chart of Diablo Cove, showing approximate geographical distributions and boundaries of the five stages (Figure 14-1). It appeared that changes in the subtidal flora were confined to shallow substrates within Diablo Cove.

The only living palm kelps encountered among the quadrats from our shallow Phaeophyta sampling stations in August 1987 were some near-moribund *Pterygophora* at DRSX3m. Live *Laminaria* did not occur at either station. Boundaries of the five stages of deterioration were

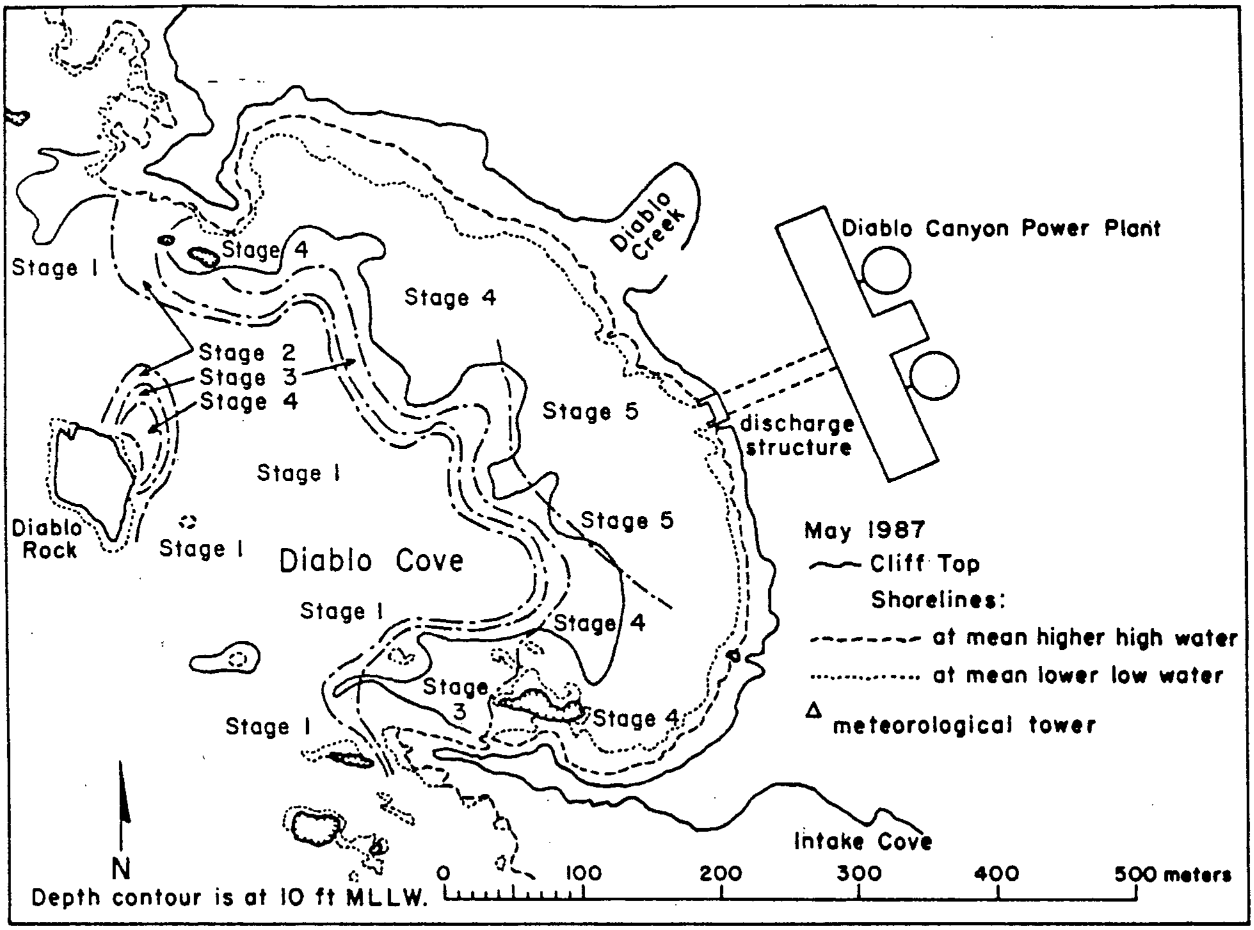

Figure 14-1. Chart of Diablo Cove, with approximate boundaries of the five zones of floral associations (described as stages in Table 13-4), shown by dot-dashed lines. From observations and swimthroughs conducted May 14-15 1987.

essentially as they had existed three months earlier in May. Apparently there was little change in status of palm kelps during the first half of 1987.

We conducted an extended swimthrough pattern in October 1987. Important changes had occurred during the intervening eleven weeks in condition and distributions of the palm kelp populations. Diseased and dying *Laminaria* and *Pterygophora* now occurred well out in the north channel and along the south shore at 3 to 4.5 m (10 to 15 ft) depths (Figure 14-2). We saw only a few *Pterygophora* with closely cropped blade crowns in the north and south interior parts of the Cove and no *Laminaria*. Adult *Laminaria* with large and seriously damaging *Streblonema* infections were even seen at our control station LRSX off Pup Rock and at our deep sampling stations in Diablo Cove (DCSX8m and DRSX8m). Apparently a well-developed Oceanic Current Period had occurred during late summer and early fall of 1987. We measured background water temperatures of 16.7°C (62°F) at depths of 20 m (67 ft) in the south channel. We noted *Laminaria* with initial phases of *Streblonema* infections down to depths slightly less than 20 m (65 ft). Exposures to diluted plume water could not have occurred at such depths. The high background temperatures were apparently sufficient to induce *Streblonema* infections even in the absence of exposures to plume waters. Both units of DCPP were operating simultaneously at this time and water temperatures of 21.1°C (70°F) or more prevailed at shallow depths within Diablo Cove. The unusually warm background conditions persisted into the first week of December 1987 (see Appendix 3-2f). Apparently a strong Davidson Current Period combined with simultaneous operation of both DCPP units caused considerable stress at shallow depths. This led to substantial mortalities among palm kelps, affecting distributions of the different stages of community deterioration.

We further examined palm kelp populations at depths of 3 to 7.5 m (10 to 25 ft) in the outer north channel on December 21 1987, about two weeks after the unusually warm conditions of summer and fall had abated. It appeared that considerable mortalities had indeed occurred among both *Laminaria* and *Pterygophora* populations here. Perhaps 50 percent of the plants still had meristems and were recovering, but substantial numbers were moribund. Thus the expanded zones of distribution of the four deterioration stages as determined the preceding October (Figure 14-2) appeared to be confirmed. *Laminaria* at our Pup Rock control station seemed to be recovering from the *Streblonema* infections and no excessive mortalities were noted.

If we accept *Laminaria* and *Pterygophora* as indicators of ecological change in Diablo Cove, we find a pattern of intermittently spreading effects. *Laminaria* was more sensitive than *Pterygophora* and older plants succumbed earlier than juveniles. Juvenile recruitment declined and then ceased long before young and adult plants had vanished. Effects at any point in time

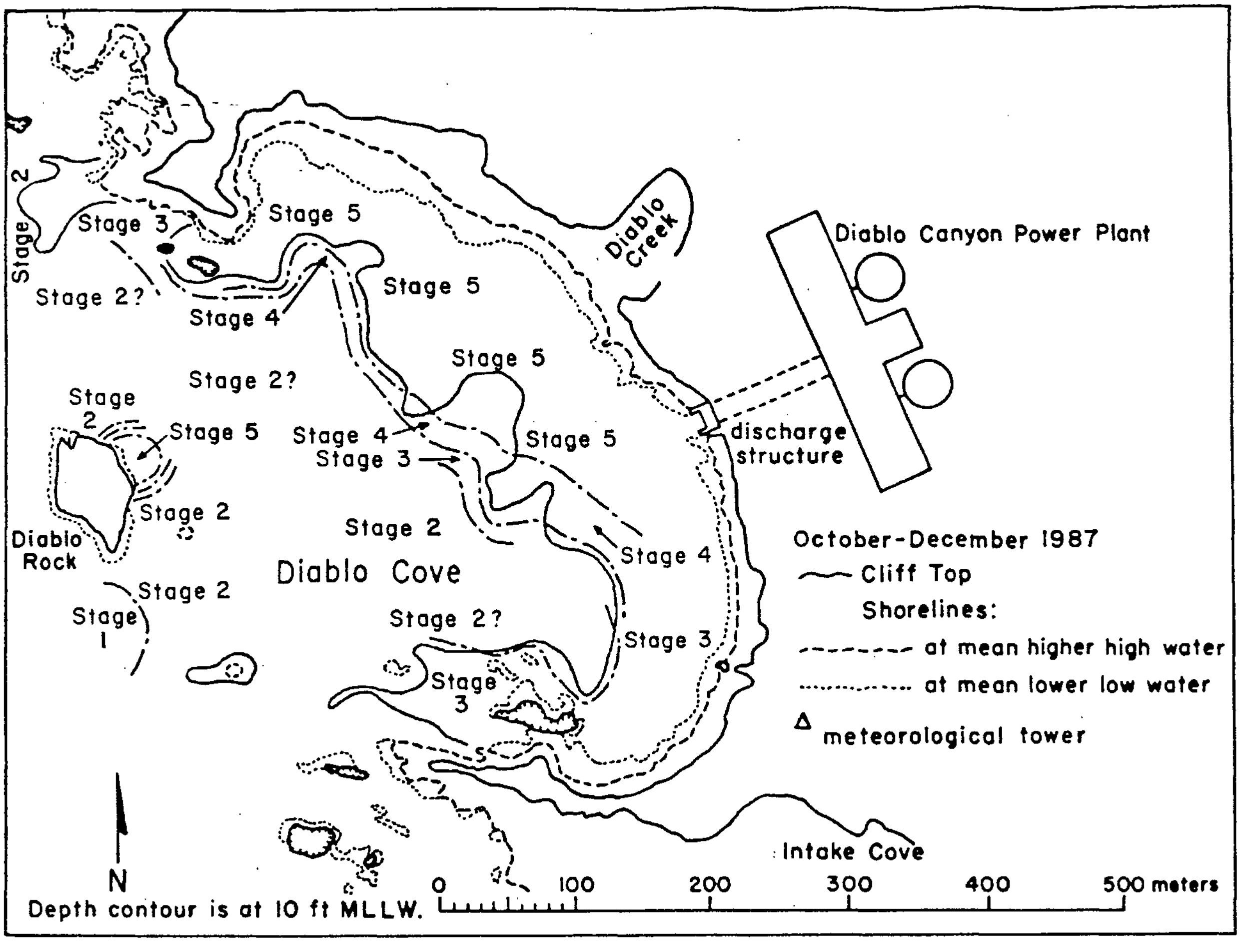

Figure 14-2. Chart of Diablo Cove showing approximate boundaries of the five zones with the associated stages of floral associations, indicated by dot-dashed lines. From swimthroughs and observations on October 27-28 1987, and December 21 1987.

were more severe and far-reaching north of the discharge structure than towards the south. Plants on flat bottom were impacted earlier than plants growing in areas of highly irregular topography. We consistently observed gradients in ratios of diseased to healthy palm kelps with highest ratios occurring near the discharge site. Patterns and trends of deterioration seen at DCSX3m and DRSX3m, lying in the plume path, were generally representative of similar processes occurring later in other shallow parts of Diablo Cove. Timing of the different stages of deterioration varied from one location to another. As of the end of 1987, no other species of Brown Algae appeared to be replacing the vanished forests of palm kelp in the Cove shallows.

Ecological Consequences from Disappearance of Kelp Forests

We would expect that disappearance of two dominant algal species such as *Laminaria* and *Pterygophora* from the Cove shallows should alter relationships of competition and control among associated organisms. Effects on competition were clear-cut. The substory canopies of palm kelps had been very dense during the preoperational years and almost certainly shaded the bottom significantly. The bottom became flooded with sunlight as these canopies dwindled. Many understory algae developed luxurious displays of foliage. Algal diversity appeared to be high during 1985 and 1986, but declined in 1987. Species such as *Gigartina exasperata* and *Cryptopleura violacea* flourished, seemingly favored by the new environment. Several other species disappeared.

The kelp forest probably also provided shelter for animals as well as some delicate plants. Holdfasts of palm kelps create specialized habitats rich in crevices and crannies. Thick stipes and blades create solid structures up off the bottom, considered attractive for fishes (Quast, 1968). Extensive blade surfaces add very substantially to solid substrate available for encrusting animals. The high densities of sturdy stipes generated considerable small scale turbulence as waves passed by and may have reduced destructiveness by wave surge during storms.

Kelps also provide food for certain grazing invertebrates, especially turban snails and limpets. Invertebrates may show preferences for certain kinds of algae (Leighton, 1971). The Red Algal species that replaced the kelp forests in Diablo Cove might not necessarily be acceptable or nutritious food for grazers accustomed to *Laminaria* and *Pterygophora*.

Consequences for Flora

Although *Laminaria* and *Pterygophora* dominated the sea floor during preoperational years, other species of Brown Algae also occurred in Diablo Cove, sometimes fairly abundantly (see Chapter 12). We had expected that some (e.g., *Egregia*, *Cystoseira*, *Dictyota*, *Macrocystis*) would do well in the operational environment because they were judged as being warm-water species. The operational environment, however, proved unsuitable for almost all Brown Algae and favored some Red Algae. Green Algae were never very frequent, so it was difficult to assess their status. The only Phaeophytan species remaining at DCSX3m and DRSX3m by the end of 1987 was *Cystoseira*, occurring as a few small straggly plants. Although small, the plants were not juveniles but tattered and epiphytized remains of adults. These *Cystoseira* usually had many *Tegula* snails grazing on them. The snails may have remained from the days when *Laminaria* and *Pterygophora* were abundant here. Possibly *Tegula* preferred *Cystoseira* to Red Algae as food and were seeking out and destroying these remaining Brown Algae by concentrated grazing. *Cystoseira* was uncommon or absent from shallows in the north part of the Cove but did occur sparsely south of the discharge structure. Distributions and fates of some of the minor species of Phaeophyta were discussed in Chapter 12.

A number of Red Algal species initially appeared to survive and indeed flourish in Diablo Cove, but then gradually disappeared from shallow depths (e.g., *Botryoglossum*, *Callophyllis flabellulata*, *Callophyllis violacea*, *Rhodymenia californica*, *R. pacifica*, and *Neoagardhiella*). Possibly young and adult members of these species tolerated the new environment but reproduction and recruitment was eliminated. We observed dense stands of these six species during our swimthroughs in 1985 and early 1986 but not afterwards. Perhaps the plants we were seeing were holdovers from preoperational days. They may have been small when the kelp forest existed, unable to grow because of shading. Growth was no longer light-limited as the kelp forest disappeared and we then witnessed development of luxurious stands of what had been large numbers of stunted Red Algae. The new stands became vulnerable to removal by storm waves as they grew, and surge along the bottom perhaps became more forceful as the kelp forest vanished. If our hypothesis was correct, adults were lost to storms and inability to reproduce in the shallows prevented replacement by recruits. Although lost from shallow water habitat, these species persisted at subthermocline depths in Diablo Cove and at our control station off Pup Rock.

Five species of Red Algae grew well in the shallow subtidal of Diablo Cove during operational years (*Gigartina corymbifera*, *G. exasperata*, *Cryptopleura violacea*, *Prionitis* *lanceolata*, and *Bossiella orbigniana*, listed approximately in an order representing susceptibility to removal by large waves). These short-statured Red Algae were much more susceptible to removal by storm waves compared to the palm kelps that proceeded them. We observed very large amounts of drift weeds along the DRSX transect during winters of operational years. Quantities of drift were much greater than seen previously when kelp forests occurred here. Stubs of these plants were often all that remained on the bottom during winter on the wave-swept open terraces of DCSX3m and the irregular boulder bottom at DRSX3m. At such times, we experienced difficulty discerning anything in our quadrats because swirls of drift obscured the bottom at DCSX3m and DCSX8m. Consequently, habitat created during spring and summer by the short foliose Red Algae disappeared during late fall and winter. This contrasted with the relatively stable environment produced by the kelp forests. Drift arising from pruning away the stands of Red Algae may have benefited animals such as urchins and abalone that can capture and consume such materials.

In summary, disappearances of the kelp forests in Diablo Cove caused large changes in the physical and biological structure of the flora, with possible effects on fauna. A relatively stable forest-like habitat was replaced by a foliose carpet or turf of short-statured seaweeds that largely disappeared during each stormy season. Any effects from heated effluent were superimposed on these seemingly substantial shifts within the dominant vegetation.

Consequences for Fauna

Major changes in floral composition and in physical characteristics of the floral biomass might be expected to influence animal life dependent on macroalgae for food and shelter. Our information on status of the fauna came from two types of investigation: periodic species tallies along the subtidal transects and analyses of encrusting species on collections of small cobbles and algal fragments (solid substrates). Animals encrusting on cobbles generally do not depend on macroalgae for food or shelter. Certain species encrusting on seaweeds might be influenced by changes in algal composition, but these constituted only a small minority of the total number of encrusting species encountered in our solid substrate analyses. If disappearance of kelp forests affected the fauna, we would therefore be more likely to detect such effects among data from the subtidal transects. Consequently we will here consider only the transect data and defer discussion of the solid substrate analyses to a subsequent section.

Our subtidal transect studies revealed declines for only two animal categories for stations inside Diablo Cove (a rock-encrusting Bryozoan, *Rhynchozoon* spp., and a small Polychaete worm, *Dodecaceria fewkesi*, also forming colonies on rocks). Both are filter feeders and may be warm water species. It was difficult to ascribe their declines either to presence of heated effluent or to changes among the macroalgae.

Several animal Phyla or Classes contained species in the enhanced category (Bryozoa, Mollusca, Crustacea, and Pisces). We will discuss Bryozoa under solid substrate analyses. The enhanced mollusk and crustacean were *Pododesmus* and *Balanus*, respectively. Again, both were rock-encrusting filter feeders, not likely to be directly influenced by changes among macroalgae. Enhanced fishes included two indigenous species, *Oxyjulis* and *Embiotoca jacksoni*. There were also a number of fishes that first appeared in the region as juveniles during the 1983-84 El Niño. They probably arrived as larvae, transported by the strong poleward currents present at that time. These juveniles lingered on after El Niño subsided, apparently finding a highly favorable environment in the shallows of Diablo Cove. Enhancement of fish species in Diablo Cove thus probably arose from attraction to the warm temperatures and was not related to changes in the flora.

The profound changes in species composition of the shallow subtidal flora within Diablo Cove apparently did not lead to large changes in general composition of the subtidal fauna as monitored along our transects, by the end of 1987. These subtidal data were thus in general agreement with results from the intertidal. During the first three years of power plant operations, changes in abundance and composition of the flora were large and easily documented. Changes in the fauna were primarily population enhancements. Declines were recorded for only a few animals.

The Invertebrate Turf and Solid Substrate Analyses

Most of the invertebrate species showing declining trends were animals conspicuous in the complex aggregates referred to as invertebrate turf. We noted in Chapter 2 that the Diablo Canyon region displayed outstandingly dense and diverse invertebrate turf up to about 1983. A major El Niño occurred at that time, affecting much biota including the invertebrate turf. Some turf species persisted but most declined or disappeared. Some of the reduced or lost populations reappeared near the end of El Niño or later. Arborescent Bryozoans (e.g., *Crisia*, *Diaporoecia*, *Hippodiplosia*, *Lagenipora*, and the erect forms of *Hippothoa* and *Holoporella*), for example, became scarce or disappeared from shallow areas of the region during El Niño. They returned to the shallows at Pup Rock in 1985 and 1986 but not to the shallows in Diablo Cove.

Tunicates, hydroids, sponges, and Polychaetes were also important structural components of invertebrate turf during preoperational years. Well-developed invertebrate turf always occurred beneath overhangs and on vertical faces of rocky outcrops throughout Diablo Cove. The densest and richest aggregates, however, appeared on the cliff walls of Diablo Rock and Pup Rock, especially near the bases where algal stands were sparse. A small tunnel at m6 on the DRSX transect created an ideal habitat for invertebrate turf. The tunnel walls were always lined with carpets of encrustations 1 to 5 cm (about 0.5 to 2 in.) thick.

Much of the turf returned to LRSX between 1985 and 1987, after El Niño abated. We also noted excellent aggregates at depths of 9 to 18 m (30 to 60 ft) in the southwest channel to Diablo Cove during 1987, as well as along the north side of Diablo Rock. Turf in shallow areas within Diablo Cove was usually poorly developed during operational years. The tunnel walls at m6 on DRSX were bare rock in latter 1987, except for a scattering of small barnacles. We did find extensive clusters of the small pink anemone, *Corynactis*, along undercut faces of Diablo Rock, but otherwise numbers and diversity of encrusting invertebrates were greatly reduced in shallow areas here.

The solid substrate analyses utilized only presence/absence criteria and did not examine abundances of encrusting invertebrates. Thus our above remarks about changed abundances of invertebrate turf were based only on observations.

Graphs of changes in total numbers of encrusting invertebrates vs time indicated that general patterns were similar for DRSX and LRSX but both differed from DCSX (Figure 14-3). The differences may have arisen because of topographical differences at DCSX vs the others (small cobbles tended to be unstable on the flat bottom at DCSX whereas cobbles at DRSX and LRSX were typically trapped in crevices and remained stable for long periods; encrustations on rolling unstable cobbles would suffer much greater erosion compared to growths on stable substrates).

Ignoring results from DCSX, the two remaining graphs in Figure 14-3 suggest that a substantial increase in encrusting species occurred at DRSX and LRSX between latter 1983 and 1984, leveling off thereafter. This might represent recovery from a depleted condition caused by El Niño. If so, there should have been a steep decline in 1983 from the pre-El Niño samples of 1982. No such decline was evident. The low values from the 1982 sampling probably arose from the relatively few solid substrates collected during that survey (we were still developing methodology at the time of the 1982 collection). We included the 1982 data in Figure 14-3 for the sake of completeness, but believe it was probably not truly representative of the total numbers of encrusting species actually present during that year. Consequently the substantial increases in total species between 1983 and 1984 at DRSX and LRSX may well represent recovery from the devastating effects of storms during winter-spring 1983.

We next subdivided the encrusting species totals according to major Phyla comprising these totals and plotted results against time. Bryozoans always comprised a large portion of the encrusting species. The three graphs for Bryozoan totals thus resembled the records for total encrusting species rather closely (compare Figures 14-3 and 14-4). There were no indications at either DCSX or DRSX that Bryozoan numbers had plummeted during the operational period. The post-El Niño increase was evident for Bryozoans at DCSX and DRSX but less so for LRSX. Storm

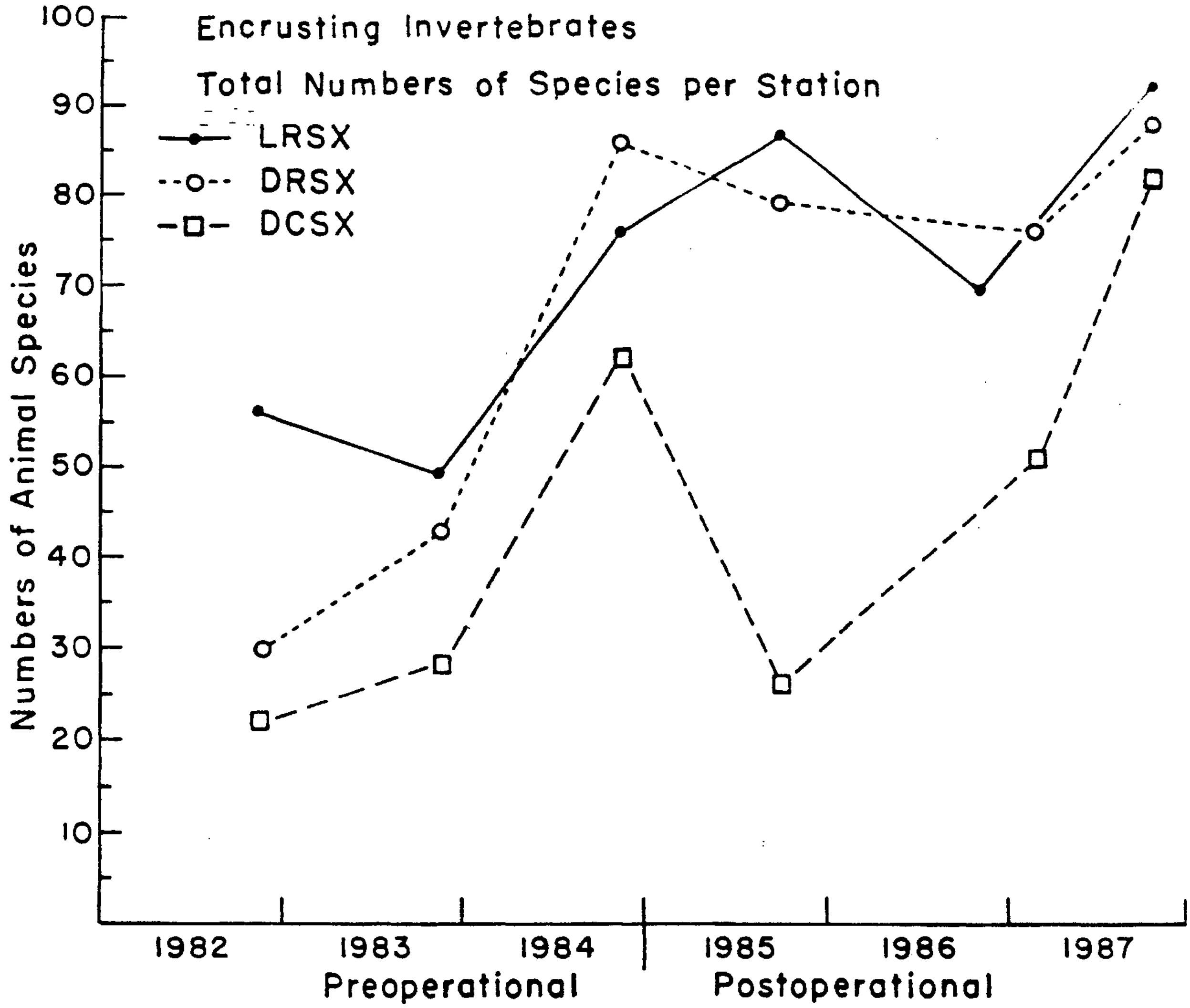

Figure 14-3. Changes in total numbers of encrusting species vs time, 3 subtidal stations.

damage at LRSX was not as severe as at DRSX in spring 1983. Apparently a large proportion of the Bryozoan fauna at LRSX escaped destruction.

A similar comparison for segmented marine worms (Polychaeta) also failed to reveal either downward or upward trends from 1985 onward (Figure 14-4). If anything, polychaetes increased somewhat at both DRSX and LRSX throughout the operational period. Polychaetes also increased at DCSX at the onset of the operational period but then trended downward toward background (i.e., the only pre-El Niño datum obtained). Possibly the rises in 1984 represented recovery from a depression associated with El Niño. Most of the Polychaeta entering our samples were spirorbids.

Plots of species of sponges (Porifera) vs time showed the possible post-El Niño recovery in 1984 at all three stations (Figure 14-4). The recovery at LRSX persisted up to 1985, then leveled off in 1986. Numbers of sponge species declined, however, at both subtidal sampling sites in Diablo Cove during operational years. This suggested that an unfavorable environment for several sponges had developed within the shallows of Diablo Cove. This conclusion was amply confirmed by observation.

There were exceptions, however, and certain indigenous sponges persisted in the Cove shallows (i.e., *Tethya* and *Spheciospongia*, both considered as warm-water species). Likewise during spring and summer of 1987, a brief population explosion occurred of a sponge, *Leucetta losangelensis*, common in bays in southern California. Most of the *Leucetta* individuals occurred on the vertical inshore face of Diablo Rock but there were also scattered specimens elsewhere in the Cove. We had not previously collected *Leucetta* in the Diablo Canyon region. De Laubenfels (1932) described it as a common sponge collected only from southern California. Hartman (1975) did not include *Leucetta* in his listings of intertidal sponges of central California (most of which also occur subtidally). The epidemic appearance of *Leucetta* in Diablo Cove subsided about as rapidly as it developed. The primary site at Diablo Rock supported hundreds or possibly thousands of *Leucetta* sponges when we examined the cliff face on September 30 1987. A diligent search for the species on October 26 1987 recovered only one specimen. Possibly an early storm destroyed populations of this rather delicate animal. Its occurrence was considered as a possible example of a warm-water exotic species introduced by natural processes from the Southern California Bight. Occurrences of a few sponge species operationally in Diablo Cove indicated that the environment here was not unfavorable to the entire Phylum Porifera, but only to cold-water species.

Observations also suggested that another group of encrusting invertebrates, the tunicates, declined during El Niño and like the sponges, largely disappeared from shallow water habitats within Diablo Cove during operational years. Tunicates are soft-bodied animals without any enduring skeletal structures. Our procedure of preserving our solid substrate samples by drying,

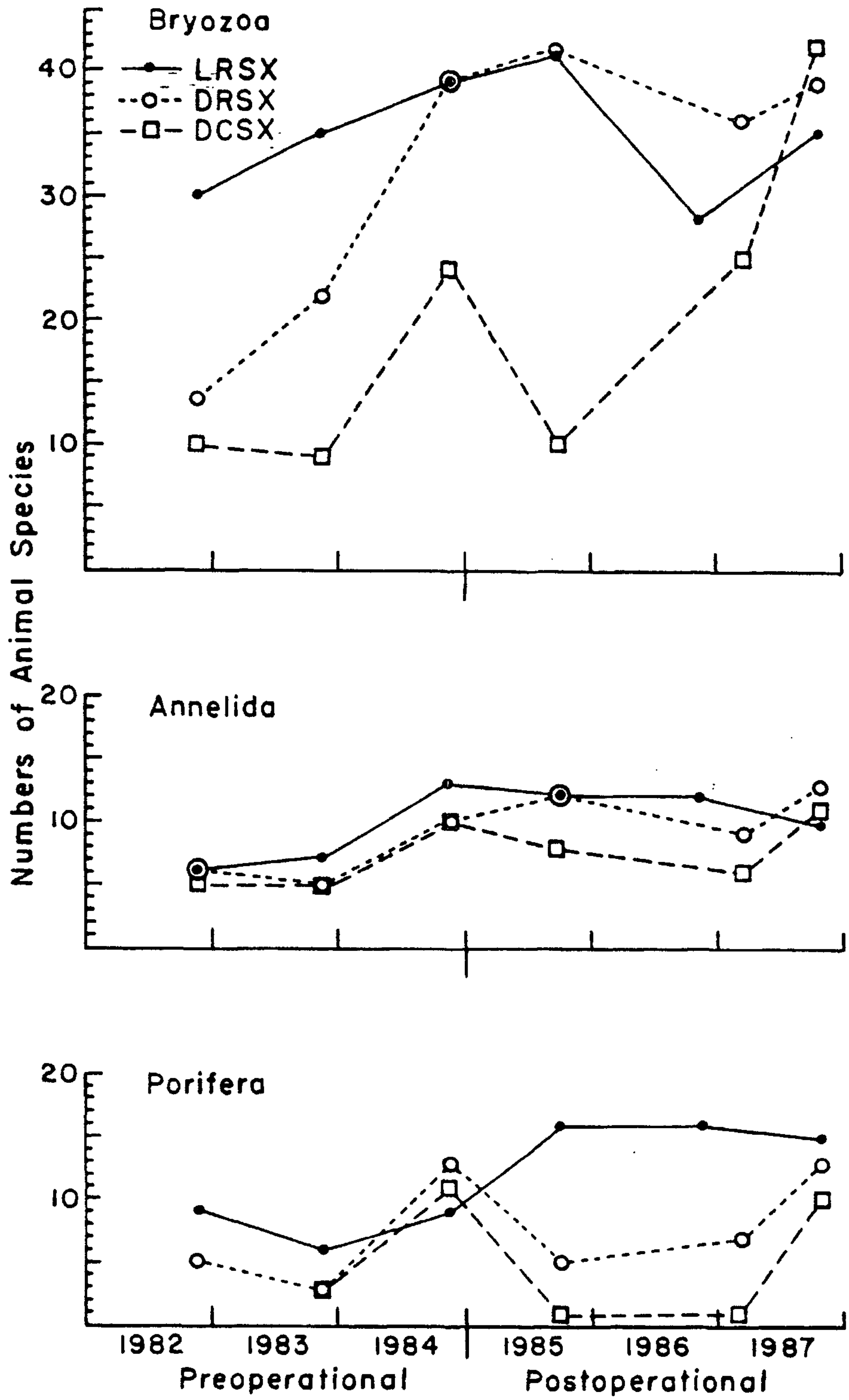

Figure 14-4. **Top**: Total Bryozoan species vs time, 3 subtidal stations. **Middle**: Total Annelid species vs time, 3 subtidal stations. **Bottom**: Total Porifera species vs time, 3 subtidal stations.

prevented collection of data on soft-bodied animals. Even though analytical data from our solid substrate analyses were lacking, changes in abundances of tunicates were so dramatic that we feel confident in stating that many members of this component of the invertebrate turf were unable to recolonize shallow habitat within Diablo Cove following subsidence of El Niño. Observations from our subtidal transects indicated that many of these species still remained in deep water within the Cove during operational years. Furthermore, three indigenous Tunicata species persisted in the shallows (*Boltenia*, *Didemnum*, and *Trididemnum*, with the latter two also occurring in the low intertidal).

Data from observations of invertebrate turf and from analyses of solid substrates thus indicated that abundance declines among certain encrusting animals apparently occurred at shallow depths inside Diablo Cove during operational years. Most of the species persisted, however, although only microscopic-size colonies may have survived. Groups suffering higher-than-average losses included arborescent Bryozoans, sponges, and tunicates. Many of these highly sensitive species still occurred at subthermocline depths in the Cove and at both shallow and deep levels along our control transect off Pup Rock.

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Chapter 15

UNANTICIPATED CHANGES, CONCLUDING DISCUSSION

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UNANTICIPATED CHANGES

Nonconforming Species

As noted elsewhere, we had used geographical distributions, when known, to predict responses by the various species of Diablo Cove to discharge of heated effluent. We presumed that plants and animals occurring in shallow water habitats of southern California would persist at Diablo Cove under operational conditions. Organisms characteristic of central and northern California might decline or disappear from the immediate vicinity of the plume. We also had available the TERA (1982) laboratory studies assessing thermal tolerances of about forty plant and animal species common in Diablo Cove.

The majority of Diablo Cove's biota performed reasonably in accord with our expectations. Our attention here is directed toward the nonconforming species, i.e., the warm-water biota that flourished and the cold-water organisms that declined or disappeared. In most cases we will not attempt to explain these anomalies, we simply propose to identify them as best we can. Many were unexplainable at this time but could well provide subjects for future research.

We classified eight plant and nine animal species as not conforming with our expectations (Table 15-1). Among the declining warm water species, we have already discussed *Corallina vancouveriensis* and *Gigartina canaliculata* (see subsection on indicator organisms, Chapter 13). The three species of nonconforming Brown Algae were puzzling as we had expected that they would be highly successful in the operational environment of Diablo Cove. It is noteworthy that the only species of Phaeophyta in the intertidal and shallow subtidal that remained entirely healthy were *Pelvetia*, *Hesperophycus* and *Ralfsia* in the high intertidal. Sickly *Cystoseira* plants did occur sparsely in the shallow subtidal near the discharge structure. They appeared to be affected more by grazing than by other adverse factors. Possibly the large populations of *Tegula* spp. remaining from times when dense kelp forests occurred here were diverting their feeding activities to

Table 15-1: Plant and animal species not conforming to our expectations with respect to their ability to tolerate or not tolerate changed environmental conditions within Diablo Cove during the operational period.

Plant species	Animal Species
Warm Water Species that Declined or Disappeared	
PHAEOPHYTA	PORIFERA
Cystoseira osmundacea *Dictyota flabellata* *Egregia menziesii*	*Leucandra heathi* *Leucilla nuttingi*
RHODOPHYTA	
Corallina vancouveriensis *Gigartina canaliculata*	
Cold Water Species that Persisted or Increased	
RHODOPHYTA	CNIDARIA
Cryptopleura violacea *Gastroclonium coulteri* *Iridaea cordata*	*Corynactis californica*
	BRYOZOA
	Eurystomella bilabiata
	MOLLUSCA
	Acmaea mitra *Haliotis rufescens* *Tegula brunnea* (NDIX and SDIX) *Tonicella lineata*
	ECHINODERMATA
	Pycnopodia helianthoides

Cystoseira in preference to the abundant Red Algal species also present. *Cystoseira* was not seen reproducing at DCSX3m near the discharge structure but we did find adult plants with reproductive inflorescences in the shallows of the north and south parts of Diablo Cove during summer 1987.

Cystoseira and *Pelvetia* both harbor the gametophytic stages of the life cycle within conceptacles (microscopic enclosures within the adult tissues). If some factor in Diablo Cove were harmful to motile reproductive cells (i.e., zoospores and antherozooids) of Phaeophyta or to their gametophytes, brooding these stages within conceptacles might have a protective action that would favor species with such mechanisms over species that disperse their zoospores and have free-living gametophytes. One might object to this hypothesis because a third Phaeophytan species, *Fucus*, that also broods the microscopic stages in conceptacles, declined in the Diablo Cove intertidal. *Fucus*, however, was judged to be a cold water species. A decline in the population was thus explainable for reasons other than failure to recruit.

Two small sponges, *Leucandra* and *Leucilla*, occurred sparsely at subthermocline depths in Diablo Cove during latter 1987 but not in shallow water. Both occur at shallow locations in southern California. We observed *Leucilla* at Morro Rock in 1968 in a region exposed to heated effluent from the Morro Bay Power Plant.

Most of the persisting cold-water species were neither enhanced or depressed. The Red Alga, *Cryptopleura violacea*, was observed to be greatly enhanced in the vicinity of the discharge structure. This was a high-energy environment and it was surprising to find a rather delicately-structured form such as *Cryptopleura* proliferate here where the only other Rhodophyta surviving well were species with thick or tough thalli (e.g., *Gigartina exasperata*, *Prionitis lanceolata*, and *Bossiella orbigniana*).

Persistence of red abalone (*Haliotis rufescens*) in the shallows of the DCSX transect was confirmed from numerous surveys. Some of these animals unfortunately succumbed during latter 1987 (J. Blecha, personal communication). Cause of the loss was probably the unusually high water temperatures that occurred at that time.

Downward Shifts in Distributions

A number of populations disappeared from the upper ranges of their vertical distributions, leaving the lower portions unchanged. At least one intertidal Red Alga, *Gastroclonium coulteri*, exhibited a downward shift in its distribution, losing the upper portion but extending its territory farther down into zones where it had been sparse or absent during the pre-El Niño years. Changes in the *Gastroclonium* distributions were best suited for analysis at the NDIX and SDIX intertidal transects which both sloped fairly evenly down into the subtidal. The final few quadrats at CDIX and LCIX lay on steep slopes. These were obviously unsuited for analyzing downward shifts in

Even an unusually large disruptive event such as the 1983 series of large storms and a major El Niño that caused considerable biological damage at some locations was generally followed by restorative processes that, with few exceptions, represented reestablishment of the pre-existing dominant organisms (i.e., kelp forests, surfgrass meadows, patches of worm tubes, mussels, barnacles, etc).

As we have seen above, onset of DCPP operations was followed by important changes in abundances and species composition of the biota. We expected that a new equilibrium would soon appear with a different set of dominants maintaining their populations within a fixed range of abundances. As of the end of 1987, however, an equilibrium state had apparently not developed. Instead we continued to observe intermittent patterns of further deterioration. Seasonal factors were probably involved in producing the intermittent patterns. We have termed the phenomenon "intermittently spreading disturbances".

Our temperature analyses indicated that sea water temperatures tended to be highest during the latter part of each year, associated with a seasonal oceanographic event, the Oceanic Period (described in Chapter 1). Any organism sensitive to elevated water temperature would experience greatest stress during this seasonally warm period. Our observations indicated that intermittently spreading disturbances tended to occur during the Oceanic Period. An equilibrium was not achieved because any restoration occurring during the ensuing winter and spring was often inadequate to compensate for losses from the preceding summer and fall. Each Oceanic Period would therefore witness an expansion of losses incurred during the previous period. The situation was illustrated by disappearance patterns observed among kelp forests in shallow waters of Diablo Cove (described in detail in the subsection "Changes in the Subtidal Biota", Chapter 14). A similar pattern occurred for *Iridaea flaccida* at NDIX. Each succeeding winter survey during the operational period revealed a smaller population of *I. flaccida* here.

High background seawater temperatures during the 1987 Oceanic Period coincided with continuous operation of both DCPP units and apparently produced an unusually severe intermittent disturbance in this final year of our study. New losses occurred among palm kelps (see Figures 14-1 and 14-2). It seemed likely that these losses might not be reconstituted for at least one of the palm kelps, *Laminaria*. Few *Laminaria* plants displayed reproductive sori when we examined them December 21 1987, even at our subtidal control station LRSX. We normally find abundant sori on adult *Laminaria* plants by December. Hence recruitment by this palm kelp in 1988 may be impaired and inadequate to restore populations to their status as of summer 1987. Thus it appeared that the intermittently spreading disturbance phenomenon was still occurring as of the end of our study.

CONCLUDING DISCUSSION

The majority of biological changes we observed in Diablo Cove appeared to be directly or indirectly the consequence of temperature-related impacts. Populations of temperature-sensitive dominants such as *Laminaria*, *Pterygophora*, and *Iridaea flaccida* declined as expected. These changes led to indirect effects which we also presumed would occur, although the exact consequences were difficult to predict (for example, disappearance of shading and protective effects which led to adjustments among remaining cold-water species). The timing, locations, and distributional patterns shown by these direct and indirect changes supported the presumption that we were observing effects associated with exposure to the DCPP plume.

As of the close of our studies, we were still observing substantial changes in species composition as well as in horizontal and vertical distributions among dominant organisms at our study sites. It appeared that we were not yet seeing the final quasi-equilibrium condition even at sites such as DCSX3m and DRSX3m where changes had occurred earliest and had been most profound. The intermittent characteristics associated with patterns of change added considerable uncertainty to any predictions we might make.

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