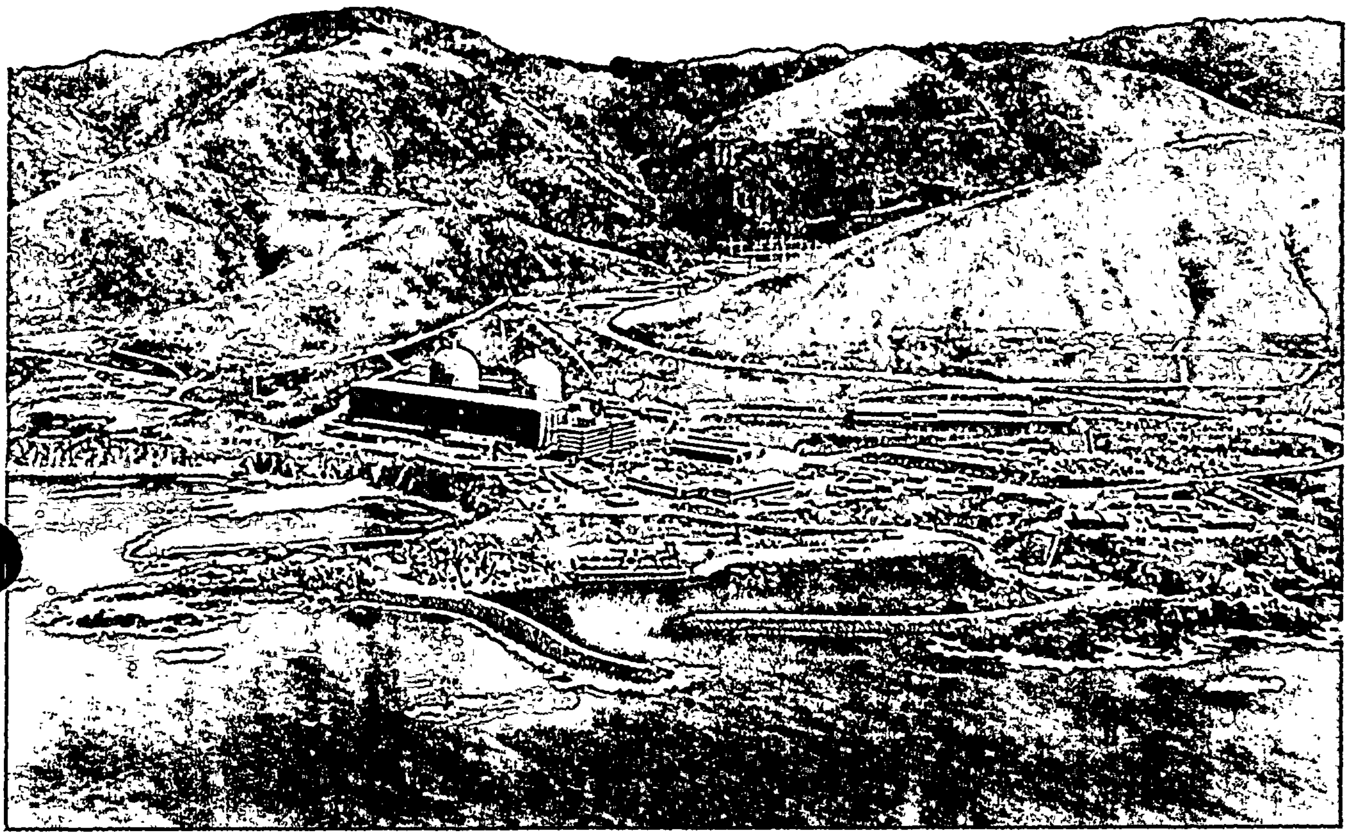
Ocean Water Studies

Summary 1975–1994



Pacific Gas and Electric Company

Diablo Canyon Power Plant

Contents

Background

This report is a summary of findings from the thermal-effects studies of the Diablo Canyon Power Plant cooling-water discharge. The studies were performed over a period of nearly 20 years (1975–95), by a team of professional engineers and scientists from universities and industry, at a cost of over $40,000,000. The published accounts of these efforts occupy several shelves in the project library and represent one of the largest studies of their kind in the United States. This summary is a guide to the studies' major findings and a reference to the project's reports and publications.

Predictions and Findings

Present biological conditions in Diablo Cove correspond with a number of those predicted to result from power plant operations. During the 20-year study, the cove's marine community has been subjected to the effects of sea otter predation, severe storms, and El Niño warming that were all as important as the effects of the power plant's operation. The cove's marine community reflects the natural adaptability and the persistence of many of its resident species. The rate of change in the abundance and distribution of some species has declined in many areas of the cove. However, communities of species in contact with the plume are still adjusting to both physical and biological changes in their environment.

Biological changes, observed in Diablo Cove's marine community since power plant operations began, generally correspond with changes forecasted before plant startup. Field information from an ongoing monitoring program suggests that biological changes continue to occur. The persistence of the cove's populations also suggests the resident species are continuing to adjust to the new water temperatures and to the new, warm-water colonizers.

Background Changes

Natural forces in the marine environment constantly shape and regulate the abundance and distribution of species. Fluctuations in wave force, tide, temperature, and water quality combine to produce nearly continuous modification of marine populations. The degree of biological change is a direct reflection of the magnitude and the duration of these combined forces. PG&E's studies of Diablo Cove and reference-area populations have not only documented the ability of these marine species to adjust to continually changing environmental conditions but have measured their resiliency to several natural catastrophes.

PG&E's thermal-effects monitoring program focuses on the ecologically significant changes in Diablo Cove before and after power plant operations began. The account of these changes compares conditions in the cove after nine years of power plant operations to conditions and changes observed in the cove during the 10 years preceding plant startup.

Three events significantly altered the abundance of the cove's plant and animal populations prior to power plant operations: the arrival of the sea otter, the winter storms of 1982–83, and the advent of El Niño. Since the otter's foraging reduces the number of kelp-consuming sea urchins, its arrival in Diablo Cove, in the mid-1970s, resulted in a rapid expansion of the cove's kelp forest.

A decade later, the winter storms of 1982–83 collapsed part of a cliff, causing cobble and gravel-sized rock fragments to bury plant and animal life along the cove's south shore. Subsequent recovery has been slow due to increased water temperatures and the instability of the cobble, increasing the storm's impact in south Diablo Cove on the species' abundance. The storm also affected the abundance of several underwater species.

In late 1983, the El Niño caused short-term declines in some algae and an increase in the diversity of the cove's fish. The changes caused by the El Niño event were apparent in shoreline and underwater marine communities when the power plant became operational.

Cooling Water Changes

A Thermal Discharge Assessment Report, prepared by PG&E in 1982, forecasted a number of changes in the cove's shoreline and underwater communities produced by discharge temperature and velocity changes. Warm-water-tolerant species living in the cove and certain warm-water-tolerant species transported by currents, were expected to increase in number, replacing some of the colder-water species that had come in contact with plume temperatures.

By the end of 1987, this replacement process had begun, though not exactly as had been predicted. Thermally affected kelp species, from the shallow areas of the cove, were not replaced by other kelp species, but by a dense stand of low-growing red algae. Motile, temperature-sensitive species had been expected to move away from the plume, and some did: rockfish, snail, and crab species, for example, moved to deeper areas of the cove. Rockfish, which had been found in the shallow-water kelp habitat, now occupy areas of more abundant kelp in the deeper parts of the cove.

It had been predicted that the velocity and turbulence of the discharge would scour the bottom and remove all but the most firmly attached animals and the smallest plants. The bedrock shelf in this area, which was occupied by algae, is now largely colonized by barnacles, mussels, and anemones. Shell materials, residue of the barnacles and mussels removed from the cooling-water system, in combination with naturally occurring shell debris, have created a new substrate beneath the plume.

Predicted vs. Observed

A comparison of the representative species listed below indicates the observed population changes that matched those predicted from laboratory tests* †.

Species	Prediction/Observed
SHORELINE	
Algae	
Iridescent Seaweed	Decrease/Decrease
Surf Grass	Decrease/Decrease
Invertebrates	
Aggregating Anemone	Increase/Increase
Black Abalone	No change/Decrease
Rough Limpet	No change/Increase
Black Turban Snail	No change/Increase
Fish	
Rock Prickleback	Decrease/Decrease
UNDERWATER	
Algae	
Ruffled Seaweed	Decrease/Decrease
Articulated Seaweed	No change/No change
Bladder Chain Kelp	Increase/Decrease
Red Seaweed	Decrease/Increase
Oar Kelp	Decrease/Decrease
Bull Kelp	Decrease/Decrease
Surf Grass	Decrease/Decrease
Tree Kelp	Decrease/Decrease
Invertebrates	
Aggregating Anemone	Increase/Increase
Rock Crab	Decrease/Decrease
Hermit Crabs	No change/Decrease
Kelp Crabs	Decrease/Decrease
Red Abalone	Inc & Dec/Decrease
Dunce Cap Limpet	Decrease/Decrease
Red Top Snail	No change/Decrease
Brown Turban Snail	Inc & Dec/Decrease
Bat Star	No change/Decrease
Sea stars	Decrease/Decrease
Sunflower Star	Decrease/Decrease
Sea Urchins	Decrease/Increase
Fish	
Black Surfperch	Decrease/Increase
Cabezon	Decrease/Decrease
Black & Yellow Rockfish	Decrease/Decrease
Blue Rockfish	Inc & Dec/Inc & Dec
Olive Rockfish	Inc & Dec/Inc & Dec

New congregations of fish occur in an area 100 yards offshore from the discharge structure, where discharge flow is slowed and deflected by underwater rock ridges. Señoritas, bat rays, and leopard sharks are attracted to this area by the warmer-water temperatures, plume velocities, and particulates suspended by the plume's motion.

Three hundred yards from the discharge, where water depths increase to 25 feet, the center of the plume separates from the bottom and rises to the surface. The thermal plume separates from the bottom at a depth of about 15 feet in north Diablo Cove, and at a depth of about 10 feet in south Diablo Cove. Plants and animals living beneath the plume in these deeper areas have not been affected by the plume's temperatures.

As the plume encounters Diablo Rock, its downward motion increases the bottom temperatures and causes localized declines in the abundance of bull kelp, oar kelp, and tree kelp in the area. Red algae has occupied the open space created by the decline in the number of kelp plants.

Outside Diablo Cove, the discharge plume's buoyancy lifts and spreads it into a thinning layer as it is cooled by the processes of mixing and evaporation. Contact between the plume and the surface portion of bull kelp plants located to the north of Diablo Cove, causes an early, annual sloughing of the plants' fronds. This preseasonal senescence has also been observed each year inside Diablo Cove, the result of late-summer discharge water temperatures.

A number of biological changes, caused by preoperational natural events interacting with changes resulting from power plant operations, had not been anticipated. During the 1982–83 El Niño episode, the abundance of warm-water fish species in Diablo Cove increased. Several of these fish species have stayed in the cove, sustained by the warmth of the discharge plume. The Diablo Cove community will continue to change as species adapt to natural events (species invasions, storms, El Niño), and local discharge conditions.

The ongoing thermal-effects studies continue to monitor changes in composition, abundance, and distribution of the cove's species as plants and animals adjust to natural events, water quality, and the flow of the power plant's discharge.

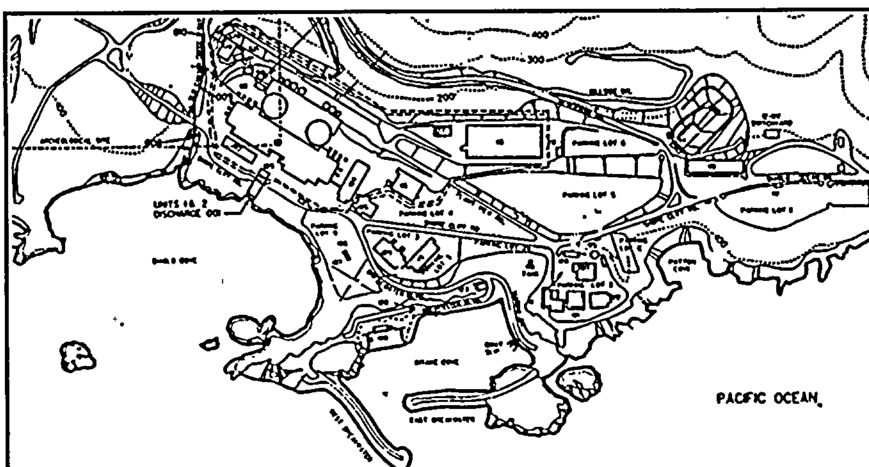


Figure 1 — Plant Layout

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* Diablo Canyon Thermal Discharge Assessment, TERA 1982.

† Thirty of the 40 species tested in thermal studies are shown in the table.

Cooling Water

High-pressure steam is used to drive the Diablo Canyon Power Plant's turbine generators, producing 2,200 megawatts of electricity. The steam is recycled by condensing it with cold ocean water, which is warmed 20°F by the process. From 1987 through 1994, the average daily discharge water temperature for normal two-unit operations varied seasonally between 51°F and 83°F. The discharge plume's thermal buoyancy floats it to the surface where it spreads into an increasingly thinner layer.

Studies of the Diablo Canyon Power Plant discharge's effects span 20 years, and include 10 years of baseline studies, which preceded the startup of power plant operations. The studies focused on the movement and the mixing of the discharge plume and on related changes in the marine organisms living in the vicinity of the power plant.

Power Plant

The Diablo Canyon Power Plant was built on a 750-acre site located on a coastal marine terrace (Figure 1). It consists of two units, which generate a total of 2,200 megawatts of electricity. Diablo Canyon began its commercial operations with the startup of Unit 1 in May 1985, followed by Unit 2 in March 1986.

Cooling Water

Cooling water for the Diablo Canyon Power Plant is pumped from a small cove 1,000 feet south of the power plant. Although each unit has an independent seawater cooling system, they share common intake and discharge structures.

During normal operation of the power plant, approximately 1.6 million gallons of seawater are drawn from the intake cove per minute and pumped approximately 85 feet uphill to the power plant. As it passes through the steam condensers, the seawater (48 to 62°F, 1987 through 1994) is heated approximately 20°F.

The warmed cooling water is returned by gravity from a shoreline conduit at the base of the cliff in Diablo Cove. An underwater barrier, at the base of the cliff, slows and mixes the flow from each unit before it enters the cove. The returning cooling water stream is 60 feet wide at the point of discharge, and its depth in the cove varies daily with the tide.

Temperatures

The returning discharge water temperature varies seasonally according to the temperature of the incoming ocean water. On the average, monthly discharge water temperatures, for normal two-unit operations, range from 51°F to 83°F; the warmest temperatures occur between August and December. The seasonal changes in intake and discharge temperatures are illustrated in Figure 2. The cooling-temperature increase can also be seen in the difference between the intake and outlet temperatures.

The difference between the temperature of the discharge and the temperature of the surrounding ocean water decreases the density of the discharge, making it buoyant and causing it to rise and spread on the ocean surface in a thinning, spreading plume (Figure 3). The plume also becomes progressively thinner as it cools by the mixing action of waves and the evaporating force of the wind.

As the plume's surface flow moves out of Diablo Cove, it causes a counterflow of cold ocean water to develop beneath it. The inflowing

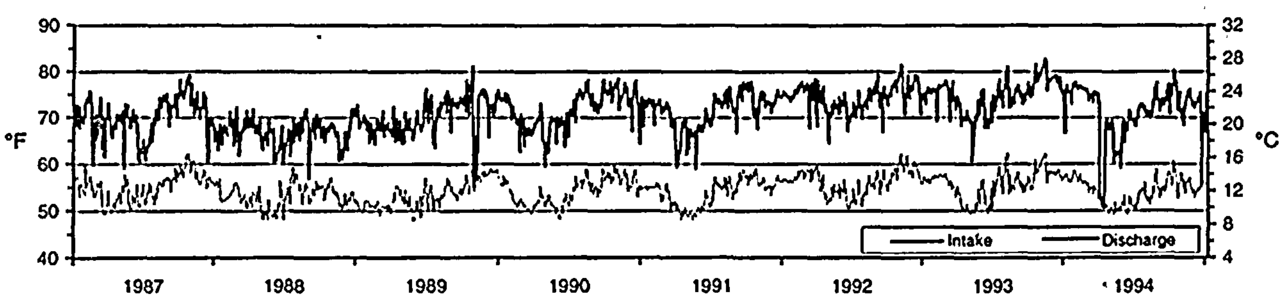


Figure 2 — Mean Monthly Temperatures, 1987–94

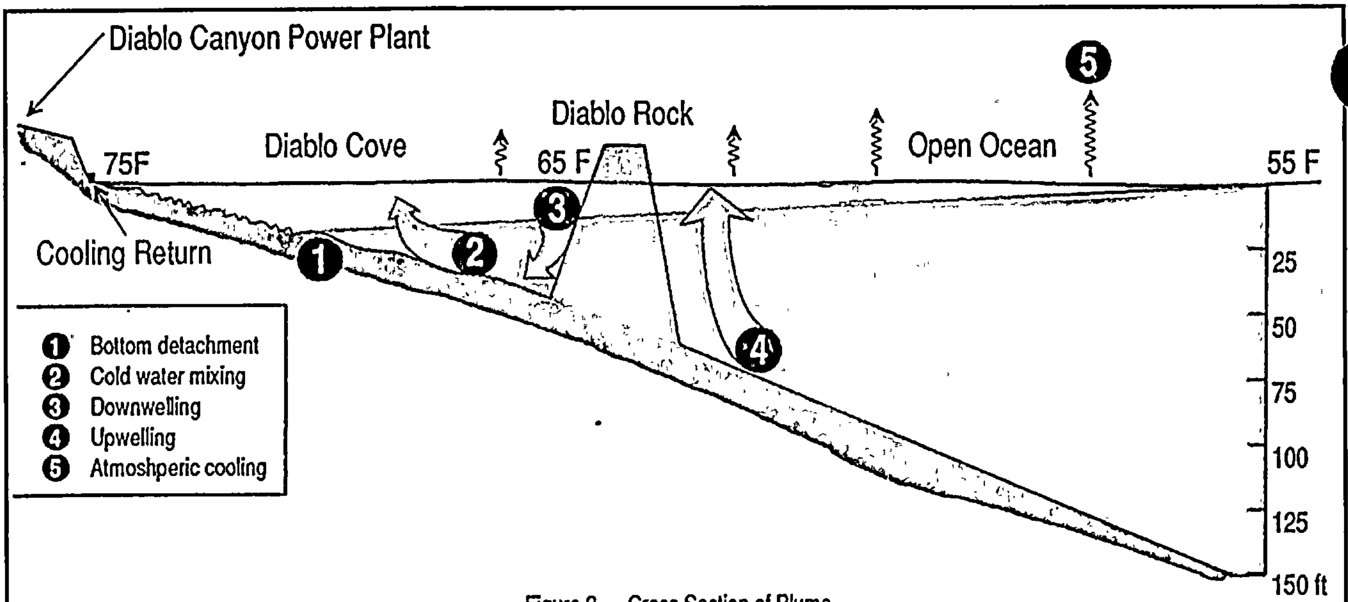


Figure 3 — Cross Section of Plume

ocean water replaces the cove water, which is removed by the drag of the plume's outflow. As seen in Figure 4, certain areas of the cove are warmed by the discharge water while other areas remain cool due to ocean water counterflows. During average tidal conditions, the plume loses contact with the bottom in the center of Diablo Cove, at depths greater than 25 feet, as its own buoyancy lifts it to the surface.

Movement

The surface plume flows seaward for one quarter of a mile, across the shallows of Diablo Cove. In the next one quarter of a mile, it enters the Pacific Ocean's nearshore zone where depths increase to 100 feet+. The velocity of the plume slows outside the cove, and its movement becomes subject to offshore-wind and offshore-ocean currents.

In the offshore area, the plume continues to rise and spread on the ocean surface. By the time the plume's temperature is within 2°F of the ocean's temperature, it is less than three feet thick.

Shoreline and bottom contact of the discharge plume is confined to Diablo Cove, except during certain tidal and offshore-current conditions. Underwater ridges in the cove swing the plume north as the tide ebbs, causing the plume to contact the shoreline north of Diablo Cove. Offshore currents flowing north under these tidal conditions can carry the plume into contact with the shoreline of Field's Cove and the open-ocean kelp beds between Diablo Cove and Lion Rock.

The plume's contact with the bottom is also caused by a "downwelling" effect in front of Diablo Rock. When the offshore, surface-plume flow encounters the shoreward side of Diablo Rock, the plume rolls underwater (downwells) toward the bottom. Bottom water temperatures in this area are significantly warmer than temperatures in other areas of the cove that are at the same depth and distance from the discharge. On the ocean side of Diablo Rock, the plume's wake induces an "upwelling" of cold bottom water.

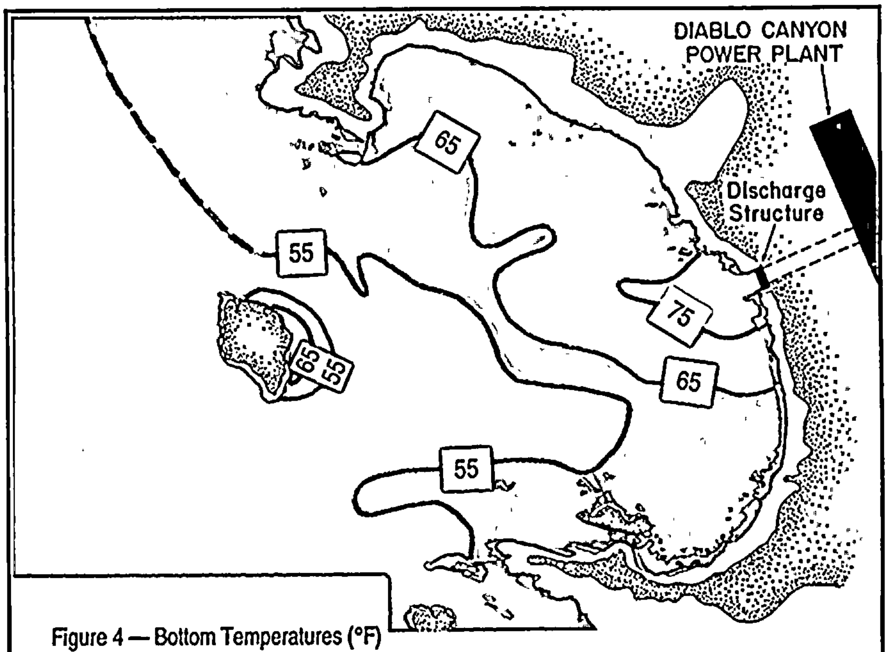


Figure 4 — Bottom Temperatures (°F)

Temperature Effects Studies

In 1982, data from a computer model and from laboratory temperature tests of Diablo Cove species indicated that discharge temperatures would alter the abundances of several temperature-sensitive species and favor their replacement by new, warm-water species. Over 200,000 hours of shoreline and SCUBA studies of the cove's 1,200 species of algae, invertebrates, and fish continue to provide data on the 1982 predictions.

In the 1981–82 Regional Water Quality Control Board (Board) review of the Diablo Canyon discharge permit, the Board asked PG&E to reassess its earlier thermal-effects predictions. Based on available scientific literature and estimates of expected plume temperatures, certain discharge temperature effects had been predicted in the power plant's 1973 Final Environmental Statement. In the intervening nine years, PG&E built an onsite laboratory to conduct temperature tolerance tests on Diablo Cove species and developed new thermal-plume computer simulation models. In 1982, PG&E submitted a thermal-discharge assessment report to the Board based on the laboratory test results and the new computer model data.

The report concluded, as in 1973, that discharge temperatures in Diablo Cove did not represent significant risks to the cove's fish and invertebrates. However, the report did find that the discharge temperatures would place certain populations of the cove's shoreline and underwater algae at risk during warm-water periods of the year. The report also affirmed the earlier prediction that species from warmer, southern waters would colonize space made available by expected reductions of some colder-water algal species and by emigrations of fish and invertebrates to preferred temperatures.

The permit adopted by the Board required PG&E to submit a report, after two years of operations, describing the thermal effects that occurred in the cove. Based on the results of the operational monitoring program, a summary report was prepared and submitted to the Board in 1988. These studies are briefly described here; reported results are summarized in following sections.

Field Studies

Field studies of Diablo Cove's marine species, which began in 1965, have continued for almost 30 years and have become one the largest studies of their kind. To augment the available thermal-effects literature, PG&E constructed an onsite seawater laboratory (Figure 5) and performed detailed experiments on 47 of the species living in Diablo Cove. Field studies, underway during the period of laboratory testing, gathered baseline data on the distribution and abundance of the cove's marine populations, were compared to post-power plant startup abundances.

Diablo Cove's marine populations are now observed every quarter, in a sequence that alternates between the permanently marked underwater locations and the shoreline locations. Both sets of locations are shown in Figure 6. Since many of the locations have been visited over 100 times, the abundances are estimated by nondestructive*, in-place counting techniques. The underwater surveys can only be conducted during reasonable weather and clear water conditions; the shoreline surveys generally require minus low tides.

Sampling locations were selected to represent major types of habitat and to allow comparisons between locations inside and outside the influence of the thermal plume. While the before startup abundances of species in Diablo Cove habitats are relatively similar to the abundances found in comparable, nearby habitats, differences in local wave and substrate conditions prevent an exact

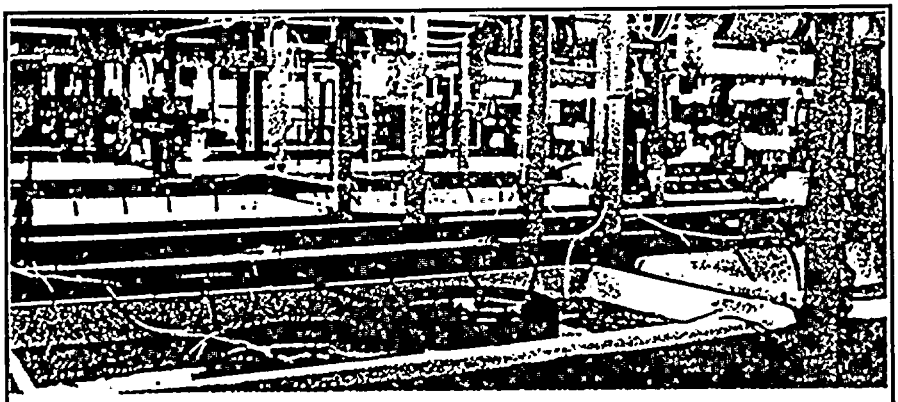


Figure 5 — Thermal Effects Laboratory

* Algal scrapes are the only destructive method.

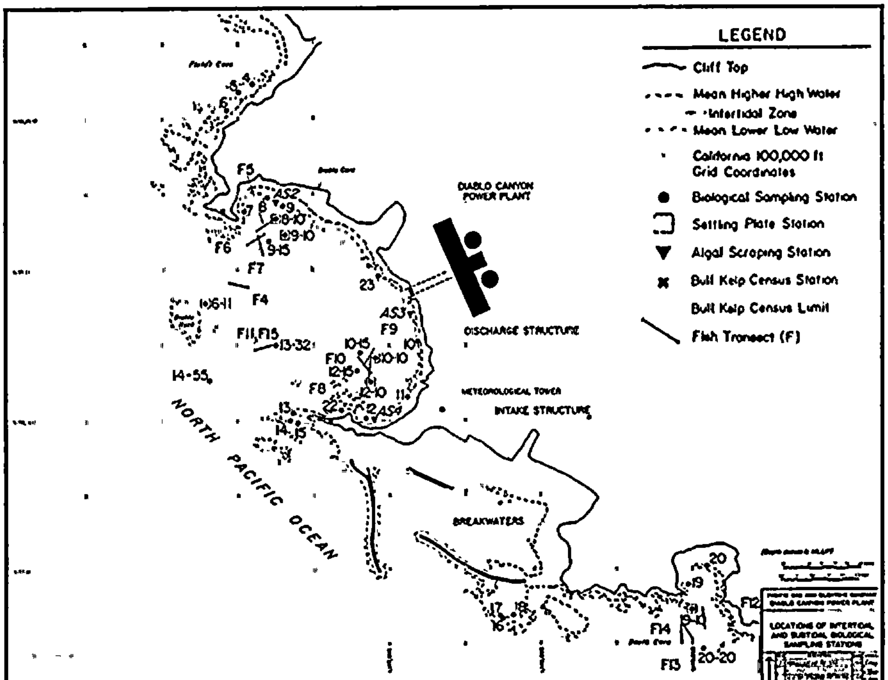


Figure 6 — Sampling Station Map

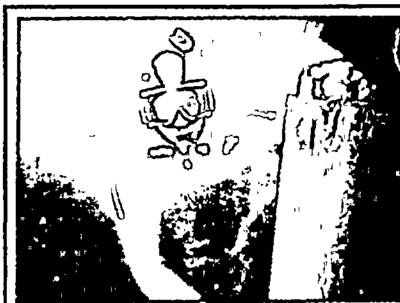


Figure 8 — Temperature Recorders

comparison. For this reason, the sampling design emphasizes a "before-and-after" comparison of the historical patterns recorded at each site.

Shoreline species were sampled on a 3 x 100 foot-strip of beach along the same tide level (Figure 7). The area covered by algae and invertebrates in each strip was observed in 10 separate samples. The procedure was repeated at two tide levels and at 19 shoreline locations, as shown in Figure 6. Shoreline populations were similarly sampled at five locations in a vertical strip of beach from the high-tide mark to the water's edge. A temperature recorder was attached to beach rocks at each site.

Underwater populations were observed at the 13 permanent locations shown in Figure 6. Subtidal invertebrates and algae were counted within circular areas outlined on the bottom, centered by railroad wheel anchors, equipped with temperature recorders (Figure 8). The abundances of various fish species were estimated at the 12 locations shown in Figure 6 by divers counting fish in midwater and along the bottom in a 13 x 165 foot-observation band.

Rock crabs were trapped on a bimonthly schedule through 1984 at 49 locations. Data were collected on the size, weight, sex, and reproductive condition of each crab. The crabs were marked with coded tags to assess their movement and growth between the time of release and the time of recapture (Figure 9).

The number of red abalone in Diablo Cove was estimated from annual diver counts at a variety of randomly selected underwater locations. Changes in the black abalone shoreline population were similarly estimated from annual census data collected in random beach samples.

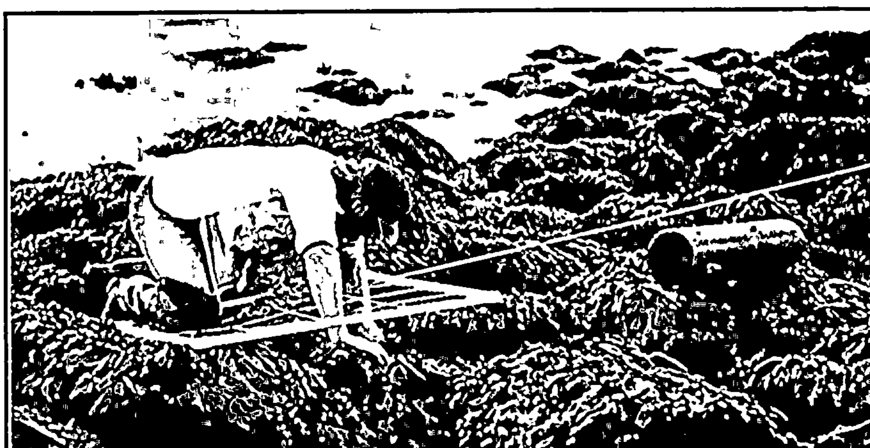


Figure 7 — Shoreline Sampling

Figure 9 — Crab Tagging

Diablo Cove Shoreline

Following power plant startup in 1985, the abundance of shoreline turban snails, limpets, and barnacles increased, while several species of shoreline algae declined in the warmer areas of Diablo Cove. The abundance of black abalone in Diablo Cove has been affected recently by an abalone disease, first observed in southern California. The occurrence of species of shoreline fish, the rock prickleback and the black prickleback, declined inside Diablo Cove.

Diablo Cove's shoreline is partially protected from waves by rocky headlands and by Diablo Rock, a small island at its entrance. Interspersed with large boulder and cobble fields, bedrock outcroppings along the cove's north shore are a marked contrast to the south shore's bedrock benches, mixed with cobble, gravel, and sand deposits.

Natural disturbances in the north- and south-shoreline habitats accentuated the substrate differences; wave impact is greater on the north shore and sand erosion is common along the south shore. A cliff on the south shore collapsed during a severe winter storm in 1982–83 and buried the shoreline habitat under 1 to 3 feet of new cobble and gravel. The cove's north- and south-shore habitats remain distinctly different today.

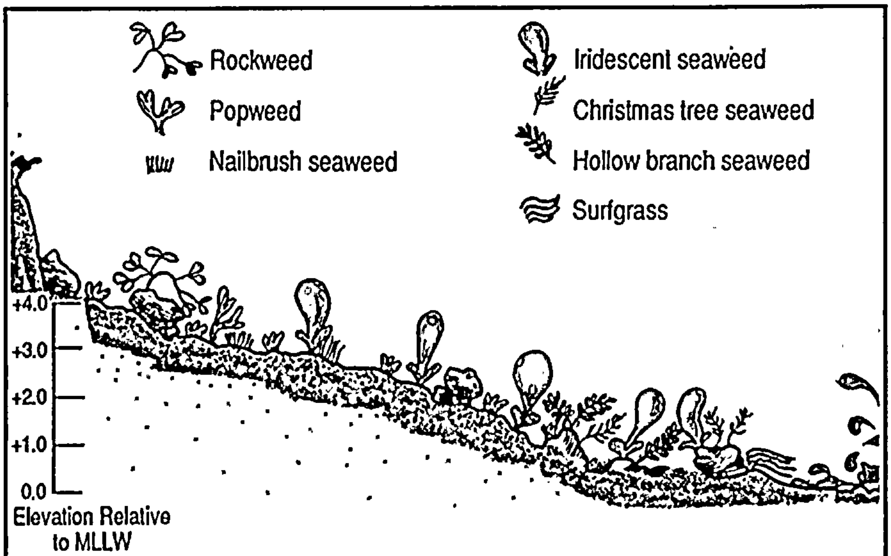


Figure 10 — Shoreline Cross Section

Algae

Algae common to Diablo Cove prior to the power plant's discharge included *Pelvetia fastigiata, Fucus gardneri, Iridaea flaccida, Endocladia muricata, Gigartina canaliculata, Gastroclonium coulteri,* and the flowering plant, *Phyllospadix spp.* (Figure 10). Declines were observed in populations of the most common of these species: *I. flaccida, G. canaliculata,* and *E. muricata.* Although several other species also declined, the changes in their populations were relatively small due to their initially low abundance levels and their low frequency of occurrence, particularly in south Diablo Cove. Recently, the density of *G. canaliculata* has increased.

The 1982–83 winter storms damaged large areas of the cove's south shore, removing nearly all of the algae before the power plant began operating. Discharge temperature effects could not be distinguished in this part of Diablo Cove due to the storm damage. Recovery has occurred in all but the temperature-sensitive species.

Open space on rocks and on other stable surfaces along Diablo Cove's shoreline is in constant demand by colonizing algae and animals. Declines in the surface coverage of *Iridaea flaccida* was followed by increases in *Gastroclonium coulteri,* replacing *Phyllospadix spp.* at lower tidal elevations, in many areas of the cove. The algae's initial increase appears to have now returned to levels of its abundance lower than those observed prior to power plant operations.

While temperature changes caused the abundance of some algal species to increase and some to decrease, many of the species exhibited no change. The abundance of the persistently dominant *Gigartina papillata,* initially unchanged by the elevated discharge temperatures, has increased in the lower intertidal.

Over the past several years, an expanding sea urchin population (500 urchins/m^2) has severely overgrazed the intertidal algal species in an area of Diablo Cove north of Diablo Creek. This condition became more apparent in 1994.

In 1994, the kelp species *Sargassum spp.* was found growing in the discharge effluent next to the discharge structure. Previously, the only plants of this species found in Diablo Cove were growing in a protected tidepool.

The coverage of ephemeral algae in Diablo Cove has increased where other species have declined since plant startup. The first occurrence of the ephemeral *Derbesia spp.* in Diablo Cove was in 1994. A non-ephemeral species, *Gelidium coulteri*, increased in cover after power plant startup at most of the Diablo Cove stations. However, *G. coulteri* has not continued to increase at these stations in recent years, leaving areas open which have not been recolonized since power plant operations began.

Invertebrates

Invertebrates commonly found along the Diablo Cove shoreline include rock-encrusting barnacles, snails, limpets, anemones, hermit crabs, and black abalone. Abundance changes were analyzed for six important and representative species of shoreline invertebrates which had been tested in temperature-tolerance experiments. Three of the species increased in abundance, and two species remained unchanged; a recent decline in the shoreline black abalone is discussed separately in this report. The abundances of the aggregating sea anemone, the black turban snail, the rough limpet, and the acorn barnacle gradually increased after power plant startup. The significant increases in these species appear related to coincident increases in open space, resulting from declines in algae cover due to grazing or temperature.

The abundance and distribution of hermit crabs was unaffected by discharge temperatures.

Limpets, including *Collisella pelta, C. scabra,* and *C. limatula,* have increased in abundance at many of the Diablo Cove stations since power plant startup and through 1994, while the abundance of limpet species has not changed appreciably outside the cove. The number of keyhole limpets *(Fissurella volcano)* increased from 1990 through 1994, but only in north Diablo Cove.

Black Abalone

The black abalone is commonly found beneath boulders and in bedrock crevices along Diablo Cove's shoreline (Figure 11). Densities of over two abalone per square meter have been recorded inside Diablo Cove. Studies from 1973 to 1982, by California Department of Fish and Game (CDF&G), showed black abalone were most abundant along the northern shoreline and the headlands of Diablo Cove.

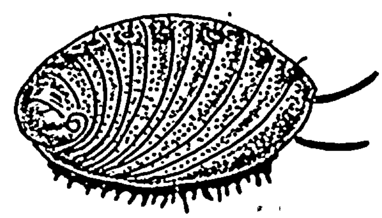


Figure 11 — Black Abalone

Black abalone remained relatively stable in Diablo Cove through 1988, when a few abalone along the cove shoreline were found to be afflicted with withering syndrome (WS). This condition was first observed in black abalone populations in the southern California Channel Islands and is characterized by an abalone shrinking in size, and then eventually dying, or becoming so weak it is subject to predation. WS resulted in a mass mortality of black abalone in the Channel Islands and later in Diablo Cove, where the abalone population reached its lowest level in the winter of 1991.

During 1994, the abundance of Diablo Cove black abalone *(Haliotis cracherodii)* continued a trend of within-year increases, a yearly pattern (also noticed in the Channel Islands) that began in the summer of 1991. In 1994, 145 abalone were found in the winter survey, and 676 abalone were found in the summer survey. The increase in the summer was largely due to recruitment of juveniles (<25 mm shell length). The total number of juveniles observed in the year represents the strongest recruitment event of black abalone in Diablo Cove to date.

Summer recruitment for 1990–94 has resulted in a population of mostly small abalone. However, during these years, winter declines in abalone abundance indicate that mortality has generally remained high, some of which may be related to the continued presence of WS-related disease in the population. The recruitment events, however, indicate that Diablo Cove provides a favorable habitat for the settlement of abalone larvae, once the WS disease subsides.

Two of the 821 black abalone found in Diablo Cove during the 1994 surveys were observed to have WS, and fresh empty shells were fairly common. These observations confirm that WS-related mortality was still present in the black abalone population in the study area during 1994. Individual abalone with WS were also found in Diablo Cove on other occasions and beyond the influence of the plume at the North Reference abalone transect and Cayucos, CA.

Shoreline Changes in Common Algae, Invertebrate, and Fish Species Abundances

Species	Effect
Algae	
Coralline Seaweed	Decrease
Feather Boa Kelp	Decrease
Nailbrush Seaweed	Decrease
Hollow Branch Seaweed*	Increase then Decrease
Red Seaweed *Ga*	Decrease
Christmas Tree Seaweed	Decrease then Increase
Iridescent Seaweed*	Decrease
Grapestone Seaweed	Increase
Crustose Red Seaweed	Increase
Surf Grass*	Decrease
Red Seaweed *Pl*	Increase
Red Seaweed *Ra*	No change
Invertebrates	
Aggregating Anemone	Increase
Acorn Barnacle	Increase
Hermit Crabs*	Decrease
Black Abalone*	Decrease
Rough Limpet	Increase
Black Turban Snail*	Increase
Dove Snails*	No change
Sea stars*	Increase
Fish	
High Cockscomb	No change
Rock Prickleback*	Decrease

* Tested for thermal tolerance in onsite laboratory.

Diablo Cove Underwater

After startup of the power plant, twice as many underwater species of algae, invertebrates, and fish increased in abundance as declined. Red algae generally replaced the cove's kelp species. Snails, sea urchins, and sea anemones increased while the abundance of crabs declined slightly. Fish species that are new to the area have been attracted to the plume's temperature and flow, and the resident species of fish have adjusted to changes in the cove's algal habitats.

Algae

Underwater populations of red and brown algae provide habitat and food for the Diablo Cove marine communities. The algal community was altered, prior to power plant startup, by the sea otter's predatory removal of algae-eating urchins and abalone. Further alterations occurred as a result of the increased ocean temperatures and the severe storm waves associated with El Niño. The abundance and distribution of the cove's underwater algal species, as illustrated schematically in Figure 12, are affected by depth and bottom substrate.

Surfgrass, which forms a transition zone between the cove's shoreline and underwater habitat, is limited by its underwater light requirements, to depths of less than 10 feet. Many intertidal areas in the cove that were dominated by *Phyllospadix spp.* before the 1982–83 winter storms have since become overgrown with other species, such as hollow branch seaweed *Gastroclonium coulteri.* Below the surfgrass zone, a mat of coral-like algae forms a habitat for numerous small snails and crustaceans. The intertwined branches of the turf-like mat also provide substrate for a leafy red algae that is common in depths up to 25 feet. Below the surfgrass zone, the majority of the cove's algae are red-colored, containing pigments that capture the lowest levels of penetrating sunlight.

Tree kelp and oar blade kelp are perennial algae that occur below the surfgrass and coralline algae zones throughout Diablo Cove. In the deepest portions of the cove (25 to 50 feet), tree kelp and oar kelp, three feet tall, form a light-shading canopy above a sparse understory of red algae.

Bladder chain and bull kelps, shown in Figure 13, commonly form surface canopies in the rocky areas of Diablo Cove that are deeper than 10 feet. The growth rate of both species slows each fall, due to declining light and nutrient levels and warming ocean temperatures. The accumulated spring and summer growth is detached by winter storm waves and carried onshore to form beach wrack or offshore to the deep-ocean food chains.

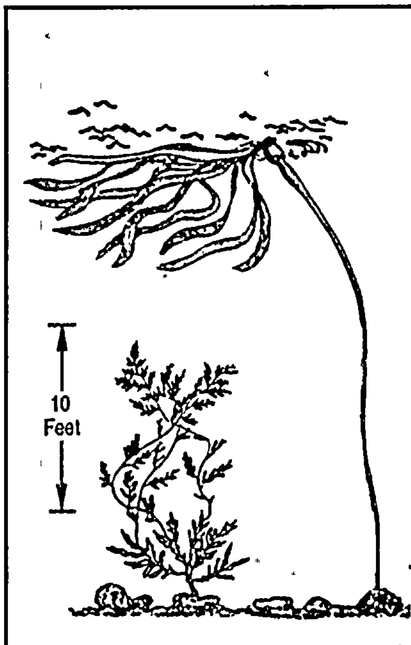


Figure 13 — Bladder Chain & Bull Kelp

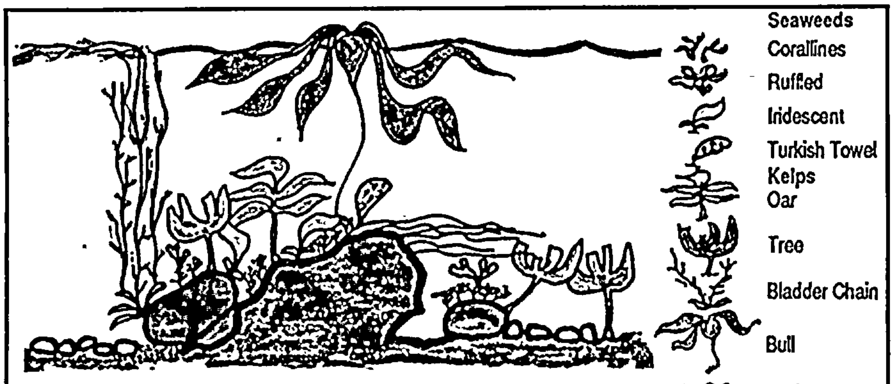


Figure 12 — Underwater Cross Section

Temperature related changes in the algal populations are generally confined to shallow areas of the cove (<20 feet) that are persistently in contact with the warm-water plume, as in north Diablo Cove. A species of red algae, which was relatively sparse in the cove prior to power plant startup, flourished in the shallow areas favored by warm discharge temperatures. This species of red algae is now declining, possibly due to the shading effects of the increasingly abundant giant kelp *(Macrocystis pyrifera).*

Kelp species (bladder chain, feather boa, oar, bull, and tree) have declined in their abundances while the red algae have either increased (hidden rib algae) or remained unchanged (ruffled algae and articulated coralline algae).

Bull kelp blades, contacted by the warm surface plume, have exhibited senesence in early August, which normally occurs in October. Preseasonal senesence has been observed in early August, in plants inside Diablo Cove, and in plants located approximately one mile to the north. Because the bull kelp disappears annually, their habitat-forming and bottom-shading effects are seasonal. The denser and longer-lived, warm-water giant kelp, has become established in warm areas of Diablo Cove and may replace part of the cove's bull kelp habitat.

Invertebrates

Twelve subtidal-invertebrate species were reviewed in the quantitative and the qualitative records. Four of the species were not affected by the thermal plume. Of the eight species affected, the abundances of six increased and the abundances of two declined. The number of large rock crabs declined in the shallow areas of north Diablo Cove when the animals moved into the deeper north-channel areas.

Following startup of the power plant, bat stars appeared in greater numbers inshore of Diablo Rock, an area of Diablo Cove consistently contacted by the plume. This localized concentration has subsequently disappeared.

Brown turban snails *(Tegula brunnea)*, formerly the most abundant motile invertebrate on the subtidal fixed benthic stations, have declined in abundance since power plant startup and remained in low abundance in Diablo Cove during 1994, compared to areas sampled outside the cove.

The California sea hare increased in the shallows of Diablo Cove. Although individuals of this species live for only a year, the increase has appeared each year following plant startup.

Red Abalone

Red abalone are commonly found, at depths of 20 to 50 feet, along the coast from Oregon to Baja California. In Diablo Cove's underwater habitat, the red abalone lives beneath boulders or wedged into rocky crevices (Figure 14).

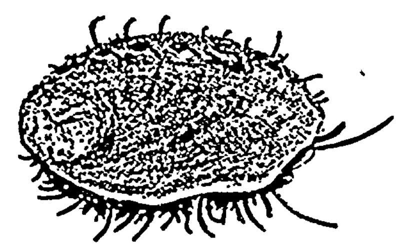


Figure 14 — Red Abalone

CDF&G biologists who monitored the 1974 sea otter invasion of Diablo Cove reported a decline in red abalone that summer. They estimated that the 40 otters that took up residence in the vicinity of Diablo Cove consumed 50 to 70 abalone per day.

The density of red abalone in Diablo Cove has declined steadily from averages of five to ten per station in the sample years of 1984, 1986, and 1987, to about two per station in 1990 and 1991. In 1992 and 1993, the density was about one per station, and in 1994, the density averaged 0.6 abalone per station. Based on laboratory thermal tolerance studies (Figure 15), the red abalone was predicted to be at risk from discharge temperatures expected in the shallow areas of Diablo Cove. Declines that began in 1984, before power plant operations, may be related to the 1983 El Niño changes in ocean temperatures and currents.

Thirty-seven red abalone *(Haliotis rufescens)* were counted on 65 random 30 m^2 sites sampled in Diablo Cove during 1994. This total represents about a 50% reduction from the total number counted in 1993 at a similar number of sample sites. No red abalone were found at depths less than 10 feet, and for the first time since this study began in 1984, none were found in north Diablo Cove at depths of less than 20 feet. Prior to 1990, red abalone were most abundant in the shallow areas of Diablo Cove.

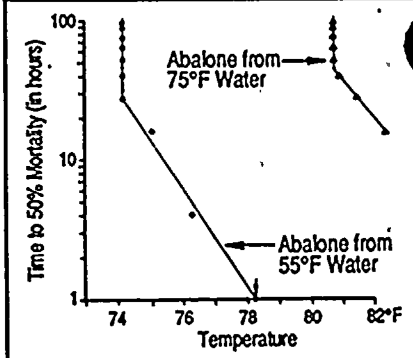


Figure 15
Red Abalone Temperature Tolerance

No red abalone with WS disease were observed in any of the study areas inside or outside Diablo Cove during 1994. The continued decline in the number of red abalone in Diablo Cove relative to areas outside the cove indicates that discharge temperatures directly, or in conjunction with WS, are affecting the present population in the cove. The pattern of greater declines in the shallow and warmer areas of Diablo Cove support this hypothesis. The roles of WS disease and water temperatures in the decline of the cove's red abalone are being investigated.

Fish

In 1994, warm-water tolerant species, such as opaleye and kelp bass, were most often, and sometimes exclusively seen in north Diablo Cove. Other common or characteristic species included blackeye goby, black surfperch, señoritas, and halfmoon. Pile perch were more abundant in north Diablo Cove in 1994, than in any previous year since 1976. As in previous years of power plant operation, bat rays, leopard sharks, and white seabass, were some of the abundant warm-water tolerant species observed in the discharge plume. Increased kelp canopy coverage in north Diablo Cove continued to provide habitat for kelp surfperch, kelp bass, and several other rockfish species. Bat rays, rare to Diablo Cove prior to power plant startup, were consistently observed in large numbers in the south Diablo Cove channel.

Diablo Cove Rockfish

Over 70 species of rockfish occur in California, and they are important to the state's commercial and sport fisheries. The most common diver-observed rockfish species in Diablo Cove include the blue, the olive, the black, the yellow, the grass, and the kelp rockfish (Figure 16). In a 1980–87 PG&E survey, the blue rockfish was the most abundant sport species caught by fishermen between Morro Bay and Port San Luis.

Fourteen species of rockfish were observed in Diablo Cove. In standard underwater samples, olive, blue, black, and yellow rockfish, and bocaccio species represented 99.7% of all adults and juveniles observed. Over 81% of the individual rockfish observed in Diablo Cove were juveniles.

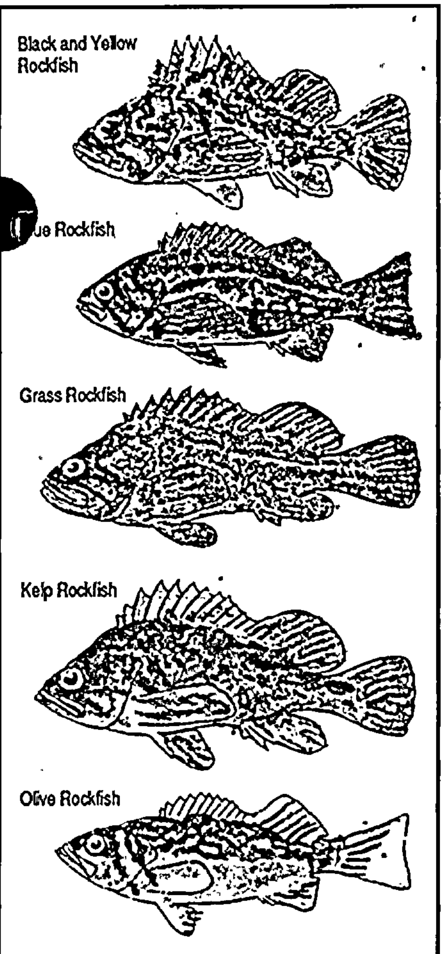


Figure 16 — Rockfish

Blue rockfish abundance in near-shore areas is related to the presence of bull kelp, which provides shelter for both juveniles and adults. Within Diablo Cove, blue rockfish were most abundant in the deeper, high-relief areas of the north and south channels.

Since power plant startup, most rockfish have remained outside the thermal plume, although both adults and juveniles are commonly observed feeding on plume-entrained materials in the interface between warm and cool water. The abundance of blue rockfish in Diablo Cove declined steadily between 1983 and 1987 coincident with El Niño-induced warming.

Olive rockfish increased in abundance in 1986 and 1994. Increases were most noticeable in areas of north Diablo Cove, where blue rockfish declines had also been observed. Adult and juvenile olive rockfish were observed feeding on suspended material in the discharge plume interface. Abundances have remained relatively unchanged in south Diablo Cove and Patton Cove.

Black and yellow rockfish abundances were generally low and quite variable in both north and south Diablo Cove, but they have increased steadily in the Patton Cove area. Abundance declined slightly in north Diablo Cove from 1983 to 1994, although, compared with south Diablo Cove, the numbers were relatively high. Black and yellow rockfish, living directly in the discharge flow, were unaffected by plume temperatures.

Grass rockfish were present in low abundances in all areas from 1976 to 1987, and they have persisted in thermally affected areas since power plant operations began.

Kelp rockfish, which were even less abundant than the grass rockfish, were most often seen adjacent to giant kelp plants, or among understory tree kelps in the deeper channels of Diablo Cove. As the shallower kelp plants were displaced by plume temperatures, the kelp rockfish selected the deeper tree kelp and oar kelp habitat in Diablo Cove.

Underwater Changes in Common Algae, Invertebrates, and Fish Species Abundances

Species	Effect
Algae	
Ruffled Seaweed*	Decrease
Articulated Seaweed*	No change
Hidden Rib Seaweed	Increase
Bladder Chain Kelp	Decrease
Brown Seaweed	Increase
Red Seaweed *Fc*	Increase
Red Seaweed *Gr*	Increase
Red Seaweed *Ge*	Increase
Red Seaweed *H/S*	Increase
Red Seaweed *Ic*	Increase
Oar Kelp*	Decrease
Bull Kelp*	Decrease
Surf Grass*	Decrease
Red Seaweed *Pl*	Increase
Tree Kelp*	Decrease
Red Seaweed *Rs*	Increase
Invertebrates	
Aggregating Anemone	Increase
Rock Crab*	Decrease
Hermit Crabs*	Decrease
Kelp Crabs*	Decrease
Red Abalone*	Decrease
Dunce Cap Limpet*	Decrease
Red Top Snail*	Decrease
Brown Turban Snail*	Decrease
Dove Snails*	Decrease
Bat Star*	Decrease
Sea stars*	Increase
Sunflower Star*	Decrease
Sea Urchins*	Increase
Fish	
Black Surfperch*	Increase
Striped Surfperch	Increase
Pile Perch	Increase
Bat Ray	Increase
Lingcod	Decrease
Señorita	Increase
Convict Fish	No change
Cabezon*	Decrease
Kelp Rockfish	Dec & Inc
Black & Yellow Rockfish*	Decrease
Blue Rockfish*	Inc & Dec
Grass Rockfish	No change
Olive Rockfish*	Inc & Dec
Sheephead	Increase
Leopard Shark	Increase
Gopher Rockfish*	Decrease

* Tested for thermal tolerance in onsite laboratory.

Summary

Thermal-effects studies of the Diablo Canyon Power Plant's operations began in 1985. An onsite team of 12 marine scientists, has measured, analyzed, and reported on a number of biological changes caused by the velocity and temperature of the DCPP discharge. Their research efforts represent thousands of hours of careful observations, often made under very demanding field conditions. The team's collective findings have been described comprehensively in eight thermal assessment reports to the Regional Water Quality Control Board, published in 1986, 1987, May 1988, April 1989, April 1990, March 1991, March 1992, and March 1993. These reports describe the condition of the cove's marine community, and were reviewed by representatives of both resource and regulatory agencies, who made recommendations for additional thermal-assessment studies and analyses.

Significant population changes have been observed in many of Diablo Cove's shoreline and underwater species since startup of the power plant's discharge. The changes include both increases and decreases in the cove's resident species and the appearance of warmer-water species. The most evident changes have occurred in areas of the cove that are consistently exposed to the warmest discharge temperatures. Natural fluctuations in the abundances of species found in the study area were widely observed before power plant operations began and continued to be observed at reference locations during power plant operation. Continuing changes in the cove's key species will lead to new interactions, abundances, and distributions of other species in the cove's marine community.

The information gathered over the past 30 years in the power plant's studies of Diablo Cove represent one of the country's largest sources of information on the ecology of open-coast, rocky-shore species. In a detailed analysis of this information, it is possible to separate the changes in the cove's populations that are due to seasonal effects from the changes that are discharge-related. This kind of analysis is made possible by the statistical power of the collected data. Relatively small population changes in many of the cove's species can now be detected by utilizing the study's massive background of historical information on these species. A comprehensive set of such analyses are planned for the coming year in conjunction with continued monitoring of thermal effects in Diablo Cove and in other reference areas.

References

Chronology and brief description of various Diablo Canyon Power Plant marine studies (1966–Present). Literature cited references citations in 1988 Thermal Effects Monitoring Program Report.

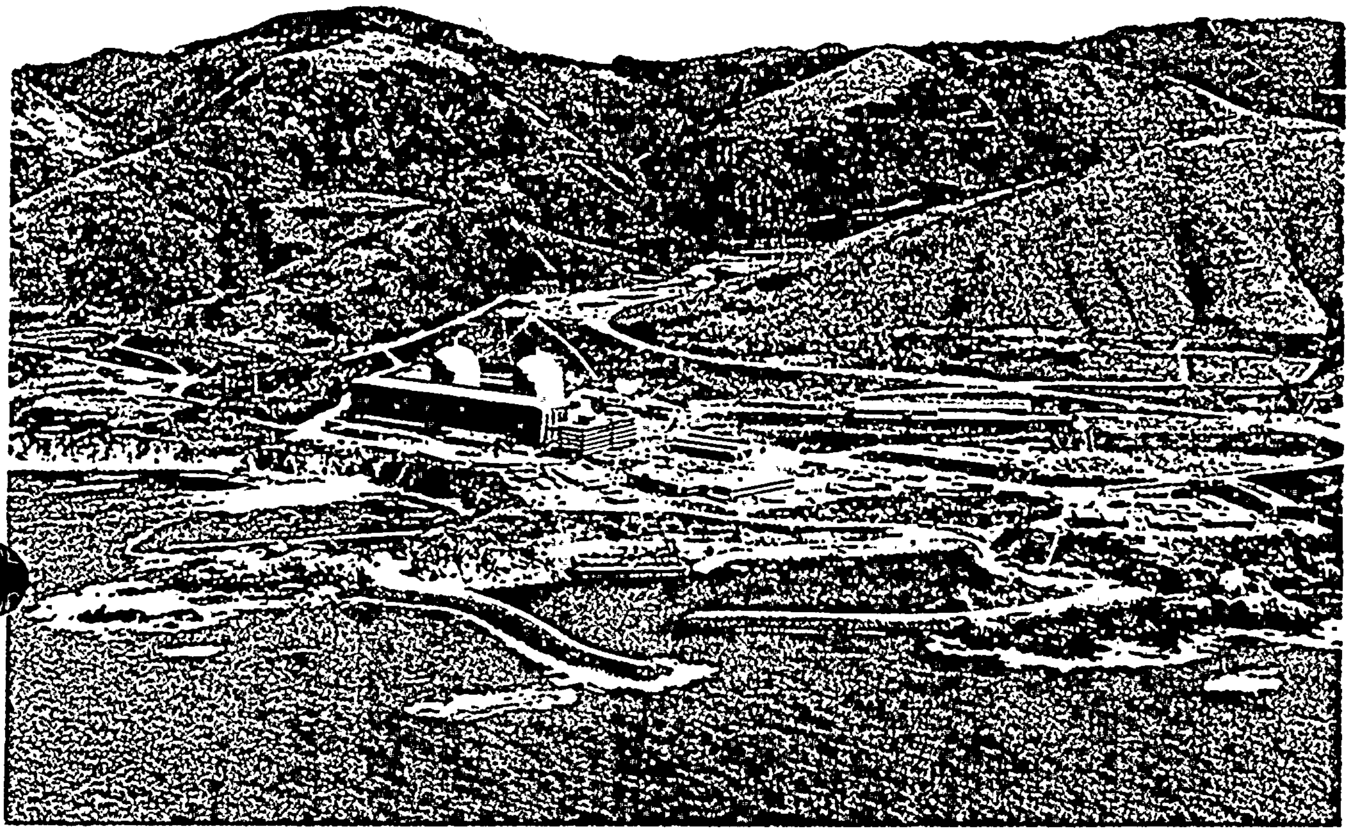
Program Title	Year	Description	Conducting Organization	Selected References
Field Biological Monitoring				
Preliminary Site Survey of Diablo Cove	1966	Qualitative inventory of invertebrates, fishes, and algae in Diablo Cove, subtidal and intertidal.	PG&E, CDF&G	Ebert (1966), North (1969), PG&E (1971)
Marine Biological Surveys of Diablo Cove and Vicinity	1968–87	Quantitative subtidal and intertidal permanent transects sampled semi-annually; intertidal photography on vertical transects.	Wheeler J. North	North et al. (1974, 1986)
Preliminary Baseline Study of Diablo Cove	1969–71	General quantitative and qualitative species inventory with emphasis on abalones, fishes, and bull kelp; extensive fish collections; and intake cofferdam investigations.	CDF&G	Burge and Schultz (1973)
Aerial Photography of Kelp Beds	1969–87	Color infrared aerial photography of kelp beds from Pt. San Luis to Pt. Buchon, annual surveys.	PG&E	Stephan (1978)
Zooplankton Studies	1972–73	Weekly zooplankton tows to establish baseline data on zooplankton composition and abundance.	PG&E	Icanberry et al. (1978)
Pre-operational Baseline Studies of Selected Marine Plants and Animals	1973–82	Quantitative quarterly sampling at random subtidal and intertidal locations and permanent abalone transects, algal biomass, baited-station fish counts, and bull kelp counts.	CDF&G	Gotshall et al. (1984, 1986)
Intertidal Algal and Invertebrate Association	1979–95	Quarterly algal scrapes to determine abundance of associated invertebrate and fish species (algal/faunal associations).	PG&E, TENERA	Behrens and Kelly (1986)
Gray Whale Migration	1981–95	Observation and census of gray whales within an offshore corridor; annually from December–April.	PG&E, TENERA	Behrens and Shaffer (1986)
Peregrine Falcon Observations	1982–95	Observations of Peregrine falcon activity in the Diablo Canyon area.	Santa Cruz Predatory Bird Research Group, TENERA	SCPBRG (1994)
Elephant Seal Observations	1987–95	Observations of Northern Elephant Seal at mainland haulout at Diablo Canyon Power Plant intake cove.	TENERA	King et al. (1989)
316(a) Demonstration	1976–82	Quantitative bimonthly sampling of permanent intertidal and subtidal stations. Other tasks: quantitative fish observations, algal biomass, settling plates, rock crab population studies, subtidal and intertidal photography, and fish gut analysis.	Lockheed/ TENERA/ Kaiser Engineers	LCMR (1978) PG&E (1978, 1979)
Thermal Effects Monitoring Program (TEMP)	1983–87	Continuation of 316(a): annual bull kelp census, intertidal algal biomass studies, subtidal video transects, and red and black abalone census.	TENERA/ Kaiser Engineers	PG&E (1988)
Marine Ecological Monitoring Program (MEMP)	1988–89	Reduced 316(a): intertidal and subtidal stations, annual bull kelp census, subtidal video transects, and red and black abalone census.	TENERA	PG&E (1989)
Thermal Effects Monitoring Program (TEMP)	1990–95	Resumed 316(a) 4x/year sampling of intertidal and subtidal stations, annual bull kelp census, intertidal algal/faunal association study, and red and black abalone census.	TENERA	PG&E (1994)
Intertidal Fish Surveys	1979–95	Quantitative survey of intertidal fishes in Diablo Cove at permanent vertical transects; concurrent algal and invertebrate data (algal/faunal associations).	PG&E, TENERA	Pimentel and Bowker (1984)
Fisheries Investigations	1978–89	Underwater fish tagging, blue rockfish tagging, and partyboat sportfishing sampling.	PG&E, RSI Services Corp.	Sommerville and Krenn (1983)
Observations of Sea Otter Populations in Vicinity of Diablo Canyon	1973–95	Direct monthly counts and behavioral observations of sea otters from permanent clifftop vantage points; annual census of urchin and abalone populations near Pecho Rock.	Ecomar, Benech Biological and Associates	Benech and Colson (1976)

References — *Continued*

Program Title	Year	Description	Conducting Organization	Selected References
Field Biological Monitoring — *Continued*				
State Mussel Watch Program	1982–95	Tri-annual collection of mussels emplaced at permanent subtidal stations near DCPP discharge; analysis for trace metals and selected chemicals.	CDF&G	Martin et al. (1985)
San Luis Obispo County Artificial Reef (SLOCAR) Project	1984–90	Monitoring of biotic development of artificial reef (SLOCAR) with emphasis on young rockfish.	PG&E, RSI Services Corp.	Krenn and Wilson (1986), Danner et al. (1994)
316(b) Demonstration	1985–87	Sampling of impinged and entrained organisms in the power plant seawater cooling system; special consideration of larval fishes; weekly plankton tows nearshore and near intake structure.	TENERA	PG&E (1987a)
Laboratory Experimental Studies				
Thermal Effects Laboratory Experiments	1978–80	Heat tolerance experiments on 45 species of fishes, invertebrates, and seaweeds; effects of temperature on growth and early development of 16 species; and behavioral responses to elevated temperatures.	Lockheed/ TENERA/ Kaiser Engineers	PG&E (1983)
Heat Treatment Laboratory Experiments	1982	Exposure of 34 species of fishes, invertebrates, and seaweeds to temperatures simulating field conditions under power plant heat treatment.	TENERA	PG&E (1985b)
Chlorination Experiments	1977	Effects of chlorine residuals on selected indigenous marine animals.	PG&E	Wilson (1978), Behrens (1978)
NPDES Bioassay Experiments	1976–95	Toxicity bioassay studies on organisms using discharged seawater from power plant.	PG&E	Behrens (1982)
Physical Monitoring				
Physical Oceanography	1966–87	Studies on nearshore currents, temperature, and salinity relationships and dissolved oxygen.	PG&E	White (1983)
Subtidal Temperature Monitoring	1972–84	Temperature measurement at permanent stations in Diablo Cove and at control stations.	PG&E	Warrick (1979)
Temperature and Light Monitoring	1976–95	Continuous recording of temperatures at permanent intertidal and subtidal locations; light and tide measurements at selected subtidal stations in Diablo Cove.	Lockheed/ TENERA/ Kaiser Engineers	PG&E (1986a, 1986b, 1987b)
Nearshore Current Monitoring	1978–95	Continuous current measurement at a permanent station outside of Diablo Cove.	ECOMAR, TENERA	Meek (1983)
Offshore Wave Monitoring	1983–95	Continuous wave height and period monitoring with telemetered wave gauge.	PG&E, TENERA	White (1985)
Predictive Analyses and Models				
Thermal Plume Mapping	1985–86	Three-dimensional temperature mapping of near-field and far-field plume behavior under a variety of oceanographic and operational regimes.	PG&E	Leighton et al. (1986), PG&E (1988)
Thermal Discharge Assessment Report	1982	Predictive assessment of the effects of power plant thermal discharge on distributions and abundance of selected species; integration of physical model data and known species distributions.	TENERA	PG&E (1982a)
Assessment of Alternatives to the Existing Cooling Water System. Diablo Canyon Power Plant	1982	Alternative designs and their cost-benefit analyses for the DCPP cooling water system and its effects on the marine biota.	TENERA/ Kaiser Engineers	PG&E (1982c)
Hydraulic Model Verification	1985–86	Verification of physical model under a variety of simulated oceanographic and operational conditions.	PG&E	Ryan et al. (1986)

Ocean Water Studies

Summary 1975–1994



Pacific Gas and Electric Company

Diablo Canyon Power Plant

Contents

Background

This report is a summary of findings from the thermal-effects studies of the Diablo Canyon Power Plant cooling-water discharge. The studies were performed over a period of nearly 20 years (1975–95), by a team of professional engineers and scientists from universities and industry, at a cost of over $40,000,000. The published accounts of these efforts occupy several shelves in the project library and represent one of the largest studies of their kind in the United States. This summary is a guide to the studies' major findings and a reference to the project's reports and publications.

Predictions and Findings

Present biological conditions in Diablo Cove correspond with a number of those predicted to result from power plant operations. During the 20-year study, the cove's marine community has been subjected to the effects of sea otter predation, severe storms, and El Niño warming that were all as important as the effects of the power plant's operation. The cove's marine community reflects the natural adaptability and the persistence of many of its resident species. The rate of change in the abundance and distribution of some species has declined in many areas of the cove. However, communities of species in contact with the plume are still adjusting to both physical and biological changes in their environment.

Biological changes, observed in Diablo Cove's marine community since power plant operations began, generally correspond with changes forecasted before plant startup. Field information from an ongoing monitoring program suggests that biological changes continue to occur. The persistence of the cove's populations also suggests the resident species are continuing to adjust to the new water temperatures and to the new, warm-water colonizers.

Background Changes

Natural forces in the marine environment constantly shape and regulate the abundance and distribution of species. Fluctuations in wave force, tide, temperature, and water quality combine to produce nearly continuous modification of marine populations. The degree of biological change is a direct reflection of the magnitude and the duration of these combined forces. PG&E's studies of Diablo Cove and reference-area populations have not only documented the ability of these marine species to adjust to continually changing environmental conditions but have measured their resiliency to several natural catastrophes.

PG&E's thermal-effects monitoring program focuses on the ecologically significant changes in Diablo Cove before and after power plant operations began. The account of these changes compares conditions in the cove after nine years of power plant operations to conditions and changes observed in the cove during the 10 years preceding plant startup.

Three events significantly altered the abundance of the cove's plant and animal populations prior to power plant operations: the arrival of the sea otter, the winter storms of 1982–83, and the advent of El Niño. Since the otter's foraging reduces the number of kelp-consuming sea urchins, its arrival in Diablo Cove, in the mid-1970s, resulted in a rapid expansion of the cove's kelp forest.

A decade later, the winter storms of 1982–83 collapsed part of a cliff, causing cobble and gravel-sized rock fragments to bury plant and animal life along the cove's south shore. Subsequent recovery has been slow due to increased water temperatures and the instability of the cobble, increasing the storm's impact in south Diablo Cove on the species' abundance. The storm also affected the abundance of several underwater species.

In late 1983, the El Niño caused short-term declines in some algae and an increase in the diversity of the cove's fish. The changes caused by the El Niño event were apparent in shoreline and underwater marine communities when the power plant became operational.

Cooling Water Changes

A Thermal Discharge Assessment Report, prepared by PG&E in 1982, forecasted a number of changes in the cove's shoreline and underwater communities produced by discharge temperature and velocity changes. Warm-water-tolerant species living in the cove and certain warm-water-tolerant species transported by currents, were expected to increase in number, replacing some of the colder-water species that had come in contact with plume temperatures.

By the end of 1987, this replacement process had begun, though not exactly as had been predicted. Thermally affected kelp species, from the shallow areas of the cove, were not replaced by other kelp species, but by a dense stand of low-growing red algae. Motile, temperature-sensitive species had been expected to move away from the plume, and some did: rockfish, snail, and crab species, for example, moved to deeper areas of the cove. Rockfish, which had been found in the shallow-water kelp habitat, now occupy areas of more abundant kelp in the deeper parts of the cove.

It had been predicted that the velocity and turbulence of the discharge would scour the bottom and remove all but the most firmly attached animals and the smallest plants. The bedrock shelf in this area, which was occupied by algae, is now largely colonized by barnacles, mussels, and anemones. Shell materials, residue of the barnacles and mussels removed from the cooling-water system, in combination with naturally occurring shell debris, have created a new substrate beneath the plume.

Predicted vs. Observed

A comparison of the representative species listed below indicates the observed population changes that matched those predicted from laboratory tests* †.

Species	Prediction/Observed
SHORELINE	
Algae	
Iridescent Seaweed	Decrease/Decrease
Surf Grass	Decrease/Decrease
Invertebrates	
Aggregating Anemone	Increase/Increase
Black Abalone	No change/Decrease
Rough Limpet	No change/Increase
Black Turban Snail	No change/Increase
Fish	
Rock Prickleback	Decrease/Decrease
UNDERWATER	
Algae	
Ruffled Seaweed	Decrease/Decrease
Articulated Seaweed	No change/No change
Bladder Chain Kelp	Increase/Decrease
Red Seaweed	Decrease/Increase
Oar Kelp	Decrease/Decrease
Bull Kelp	Decrease/Decrease
Surf Grass	Decrease/Decrease
Tree Kelp	Decrease/Decrease
Invertebrates	
Aggregating Anemone	Increase/Increase
Rock Crab	Decrease/Decrease
Hermit Crabs	No change/Decrease
Kelp Crabs	Decrease/Decrease
Red Abalone	Inc & Dec/Decrease
Dunce Cap Limpet	Decrease/Decrease
Red Top Snail	No change/Decrease
Brown Turban Snail	Inc & Dec/Decrease
Bat Star	No change/Decrease
Sea stars	Decrease/Decrease
Sunflower Star	Decrease/Decrease
Sea Urchins	Decrease/Increase
Fish	
Black Surfperch	Decrease/Increase
Cabezon	Decrease/Decrease
Black & Yellow Rockfish	Decrease/Decrease
Blue Rockfish	Inc & Dec/Inc & Dec
Olive Rockfish	Inc & Dec/Inc & Dec

New congregations of fish occur in an area 100 yards offshore from the discharge structure, where discharge flow is slowed and deflected by underwater rock ridges. Señoritas, bat rays, and leopard sharks are attracted to this area by the warmer-water temperatures, plume velocities, and particulates suspended by the plume's motion.

Three hundred yards from the discharge, where water depths increase to 25 feet, the center of the plume separates from the bottom and rises to the surface. The thermal plume separates from the bottom at a depth of about 15 feet in north Diablo Cove, and at a depth of about 10 feet in south Diablo Cove. Plants and animals living beneath the plume in these deeper areas have not been affected by the plume's temperatures.

As the plume encounters Diablo Rock, its downward motion increases the bottom temperatures and causes localized declines in the abundance of bull kelp, oar kelp, and tree kelp in the area. Red algae has occupied the open space created by the decline in the number of kelp plants.

Outside Diablo Cove, the discharge plume's buoyancy lifts and spreads it into a thinning layer as it is cooled by the processes of mixing and evaporation. Contact between the plume and the surface portion of bull kelp plants located to the north of Diablo Cove, causes an early, annual sloughing of the plants' fronds. This preseasonal senescence has also been observed each year inside Diablo Cove, the result of late-summer discharge water temperatures.

A number of biological changes, caused by preoperational natural events interacting with changes resulting from power plant operations, had not been anticipated. During the 1982–83 El Niño episode, the abundance of warm-water fish species in Diablo Cove increased. Several of these fish species have stayed in the cove, sustained by the warmth of the discharge plume. The Diablo Cove community will continue to change as species adapt to natural events (species invasions, storms, El Niño), and local discharge conditions.

The ongoing thermal-effects studies continue to monitor changes in composition, abundance, and distribution of the cove's species as plants and animals adjust to natural events, water quality, and the flow of the power plant's discharge.

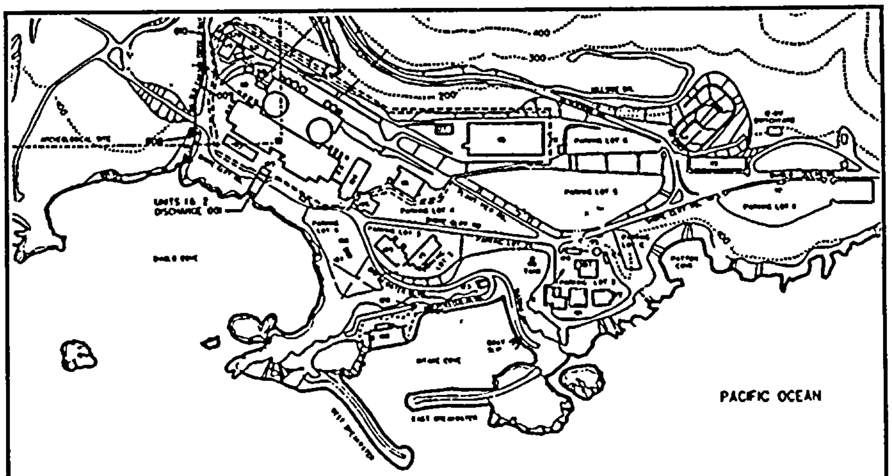


Figure 1 — Plant Layout

* Diablo Canyon Thermal Discharge Assessment, TERA 1982.

† Thirty of the 40 species tested in thermal studies are shown in the table.

Cooling Water

High-pressure steam is used to drive the Diablo Canyon Power Plant's turbine generators, producing 2,200 megawatts of electricity. The steam is recycled by condensing it with cold ocean water, which is warmed 20°F by the process. From 1987 through 1994, the average daily discharge water temperature for normal two-unit operations varied seasonally between 51°F and 83°F. The discharge plume's thermal buoyancy floats it to the surface where it spreads into an increasingly thinner layer.

Studies of the Diablo Canyon Power Plant discharge's effects span 20 years, and include 10 years of baseline studies, which preceded the startup of power plant operations. The studies focused on the movement and the mixing of the discharge plume and on related changes in the marine organisms living in the vicinity of the power plant.

Power Plant

The Diablo Canyon Power Plant was built on a 750-acre site located on a coastal marine terrace (Figure 1). It consists of two units, which generate a total of 2,200 megawatts of electricity. Diablo Canyon began its commercial operations with the startup of Unit 1 in May 1985, followed by Unit 2 in March 1986.

Cooling Water

Cooling water for the Diablo Canyon Power Plant is pumped from a small cove 1,000 feet south of the power plant. Although each unit has an independent seawater cooling system, they share common intake and discharge structures.

During normal operation of the power plant, approximately 1.6 million gallons of seawater are drawn from the intake cove per minute and pumped approximately 85 feet uphill to the power plant. As it passes through the steam condensers, the seawater (48 to 62°F, 1987 through 1994) is heated approximately 20°F.

The warmed cooling water is returned by gravity from a shoreline conduit at the base of the cliff in Diablo Cove. An underwater barrier, at the base of the cliff, slows and mixes the flow from each unit before it enters the cove. The returning cooling water stream is 60 feet wide at the point of discharge, and its depth in the cove varies daily with the tide.

Temperatures

The returning discharge water temperature varies seasonally according to the temperature of the incoming ocean water. On the average, monthly discharge water temperatures, for normal two-unit operations, range from 51°F to 83°F; the warmest temperatures occur between August and December. The seasonal changes in intake and discharge temperatures are illustrated in Figure 2. The cooling-temperature increase can also be seen in the difference between the intake and outlet temperatures.

The difference between the temperature of the discharge and the temperature of the surrounding ocean water decreases the density of the discharge, making it buoyant and causing it to rise and spread on the ocean surface in a thinning, spreading plume (Figure 3). The plume also becomes progressively thinner as it cools by the mixing action of waves and the evaporating force of the wind.

As the plume's surface flow moves out of Diablo Cove, it causes a counterflow of cold ocean water to develop beneath it. The inflowing

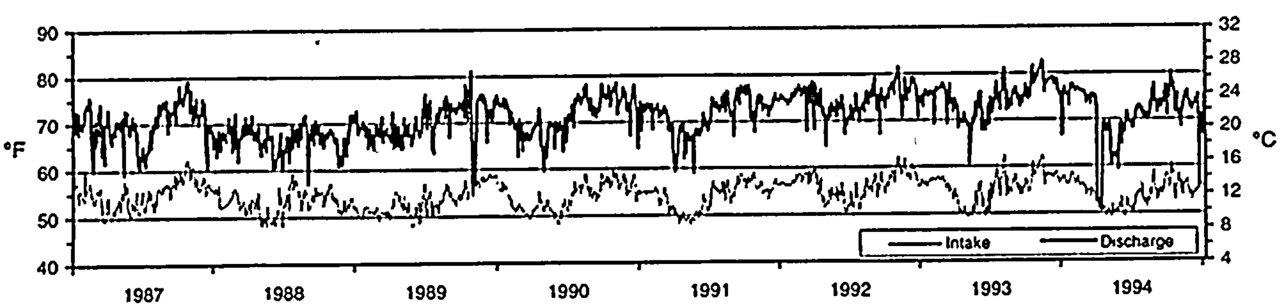


Figure 2 — Mean Monthly Temperatures, 1987–94

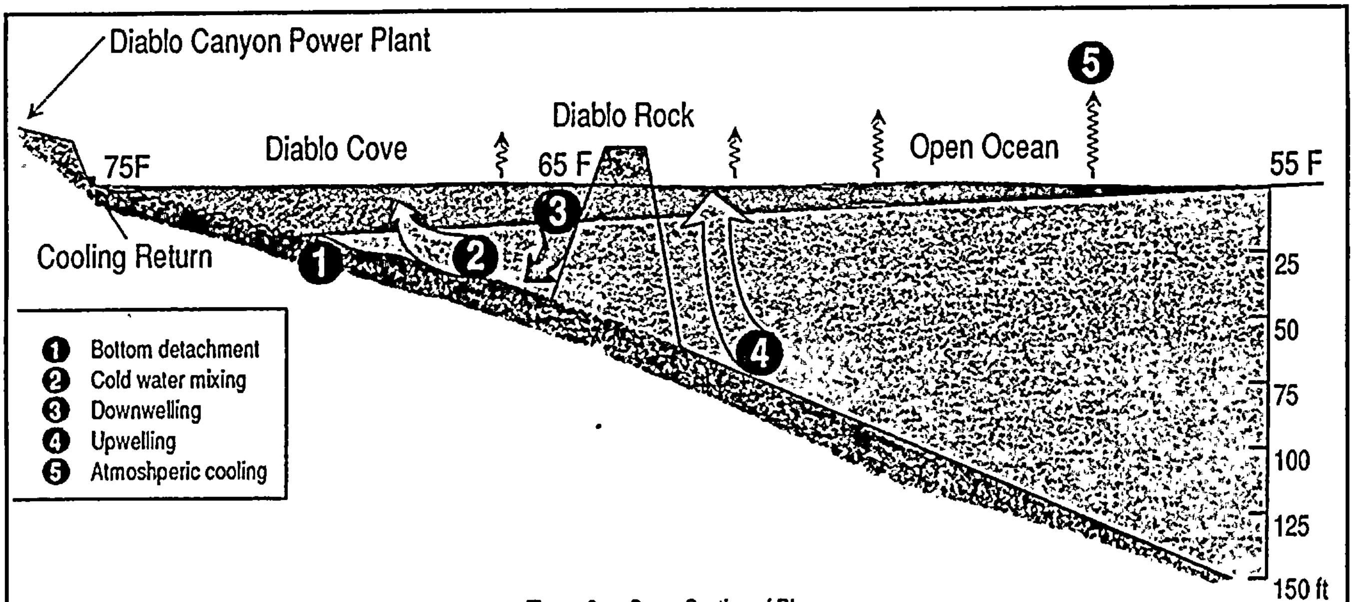


Figure 3 — Cross Section of Plume

ocean water replaces the cove water, which is removed by the drag of the plume's outflow. As seen in Figure 4, certain areas of the cove are warmed by the discharge water while other areas remain cool due to ocean water counterflows. During average tidal conditions, the plume loses contact with the bottom in the center of Diablo Cove, at depths greater than 25 feet, as its own buoyancy lifts it to the surface.

Movement

The surface plume flows seaward for one quarter of a mile, across the shallows of Diablo Cove. In the next one quarter of a mile, it enters the Pacific Ocean's nearshore zone where depths increase to 100 feet+. The velocity of the plume slows outside the cove, and its movement becomes subject to offshore-wind and offshore-ocean currents.

In the offshore area, the plume continues to rise and spread on the ocean surface. By the time the plume's temperature is within 2°F of the ocean's temperature, it is less than three feet thick.

Shoreline and bottom contact of the discharge plume is confined to Diablo Cove, except during certain tidal and offshore-current conditions. Underwater ridges in the cove swing the plume north as the tide ebbs, causing the plume to contact the shoreline north of Diablo Cove. Offshore currents flowing north under these tidal conditions can carry the plume into contact with the shoreline of Field's Cove and the open-ocean kelp beds between Diablo Cove and Lion Rock.

The plume's contact with the bottom is also caused by a "downwelling" effect in front of Diablo Rock. When the offshore, surface-plume flow encounters the shoreward side of Diablo Rock, the plume rolls underwater (downwells) toward the bottom. Bottom water temperatures in this area are significantly warmer than temperatures in other areas of the cove that are at the same depth and distance from the discharge. On the ocean side of Diablo Rock, the plume's wake induces an "upwelling" of cold bottom water.

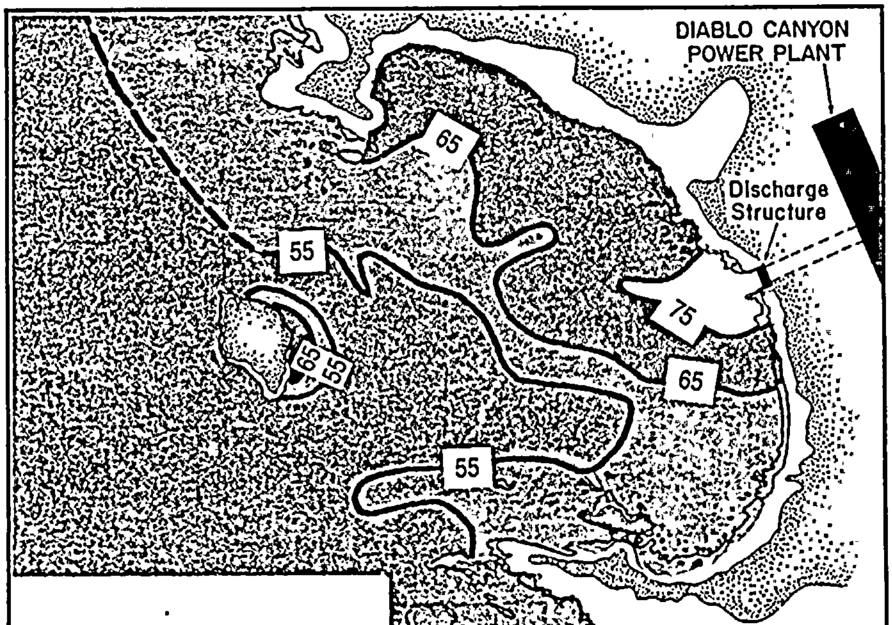


Figure 4 — Bottom Temperatures (°F)

Temperature Effects Studies

In 1982, data from a computer model and from laboratory temperature tests of Diablo Cove species indicated that discharge temperatures would alter the abundances of several temperature-sensitive species and favor their replacement by new, warm-water species. Over 200,000 hours of shoreline and SCUBA studies of the cove's 1,200 species of algae, invertebrates, and fish continue to provide data on the 1982 predictions.

In the 1981–82 Regional Water Quality Control Board (Board) review of the Diablo Canyon discharge permit, the Board asked PG&E to reassess its earlier thermal-effects predictions. Based on available scientific literature and estimates of expected plume temperatures, certain discharge temperature effects had been predicted in the power plant's 1973 Final Environmental Statement. In the intervening nine years, PG&E built an onsite laboratory to conduct temperature tolerance tests on Diablo Cove species and developed new thermal-plume computer simulation models. In 1982, PG&E submitted a thermal-discharge assessment report to the Board based on the laboratory test results and the new computer model data.

The report concluded, as in 1973, that discharge temperatures in Diablo Cove did not represent significant risks to the cove's fish and invertebrates. However, the report did find that the discharge temperatures would place certain populations of the cove's shoreline and underwater algae at risk during warm-water periods of the year. The report also affirmed the earlier prediction that species from warmer, southern waters would colonize space made available by expected reductions of some colder-water algal species and by emigrations of fish and invertebrates to preferred temperatures.

The permit adopted by the Board required PG&E to submit a report, after two years of operations, describing the thermal effects that occurred in the cove. Based on the results of the operational monitoring program, a summary report was prepared and submitted to the Board in 1988. These studies are briefly described here; reported results are summarized in following sections.

Field Studies

Field studies of Diablo Cove's marine species, which began in 1965, have continued for almost 30 years and have become one the largest studies of their kind. To augment the available thermal-effects literature, PG&E constructed an onsite seawater laboratory (Figure 5) and performed detailed experiments on 47 of the species living in Diablo Cove. Field studies, underway during the period of laboratory testing, gathered baseline data on the distribution and abundance of the cove's marine populations, were compared to post-power plant startup abundances.

Diablo Cove's marine populations are now observed every quarter, in a sequence that alternates between the permanently marked underwater locations and the shoreline locations. Both sets of locations are shown in Figure 6. Since many of the locations have been visited over 100 times, the abundances are estimated by nondestructive*, in-place counting techniques. The underwater surveys can only be conducted during reasonable weather and clear water conditions; the shoreline surveys generally require minus low tides.

Sampling locations were selected to represent major types of habitat and to allow comparisons between locations inside and outside the influence of the thermal plume. While the before startup abundances of species in Diablo Cove habitats are relatively similar to the abundances found in comparable, nearby habitats, differences in local wave and substrate conditions prevent an exact

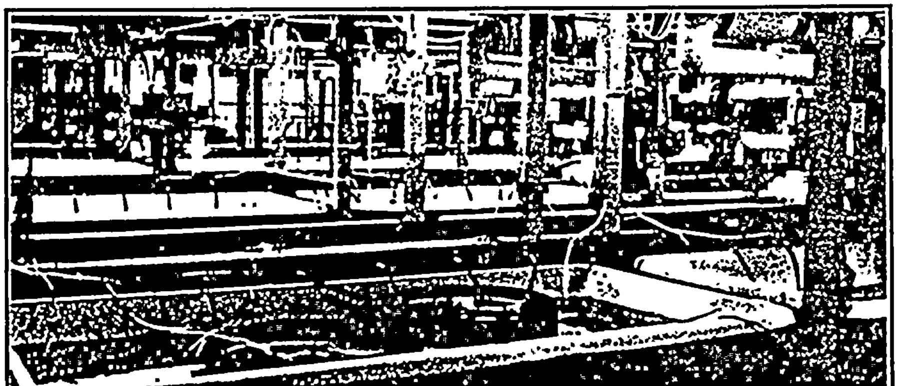


Figure 5 — Thermal Effects Laboratory

* Algal scrapes are the only destructive method.

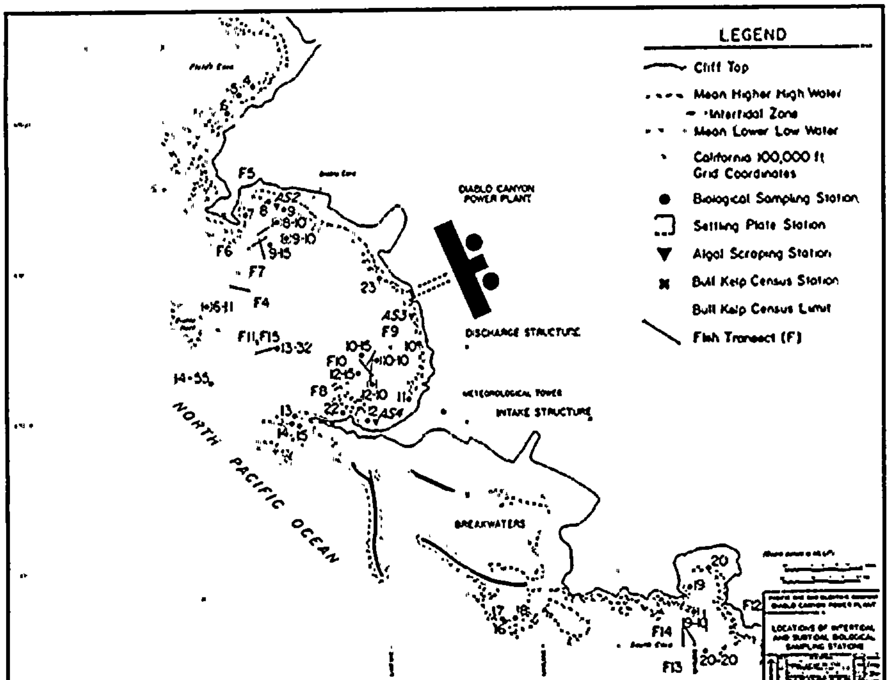


Figure 6 — Sampling Station Map


Figure 8 — Temperature Recorders

comparison. For this reason, the sampling design emphasizes a "before-and-after" comparison of the historical patterns recorded at each site.

Shoreline species were sampled on a 3 x 100 foot-strip of beach along the same tide level (Figure 7). The area covered by algae and invertebrates in each strip was observed in 10 separate samples. The procedure was repeated at two tide levels and at 19 shoreline locations, as shown in Figure 6. Shoreline populations were similarly sampled at five locations in a vertical strip of beach from the high-tide mark to the water's edge. A temperature recorder was attached to beach rocks at each site.

Underwater populations were observed at the 13 permanent locations shown in Figure 6. Subtidal invertebrates and algae were counted within circular areas outlined on the bottom, centered by railroad wheel anchors, equipped with temperature recorders (Figure 8). The abundances of various fish species were estimated at the 12 locations shown in Figure 6 by divers counting fish in midwater and along the bottom in a 13 x 165 foot-observation band.

Rock crabs were trapped on a bimonthly schedule through 1984 at 49 locations. Data were collected on the size, weight, sex, and reproductive condition of each crab. The crabs were marked with coded tags to assess their movement and growth between the time of release and the time of recapture (Figure 9).

The number of red abalone in Diablo Cove was estimated from annual diver counts at a variety of randomly selected underwater locations. Changes in the black abalone shoreline population were similarly estimated from annual census data collected in random beach samples.


Figure 7 — Shoreline Sampling


Figure 9 — Crab Tagging

Diablo Cove Shoreline

Following power plant startup in 1985, the abundance of shoreline turban snails, limpets, and barnacles increased, while several species of shoreline algae declined in the warmer areas of Diablo Cove. The abundance of black abalone in Diablo Cove has been affected recently by an abalone disease, first observed in southern California. The occurrence of species of shoreline fish, the rock prickleback and the black prickleback, declined inside Diablo Cove.

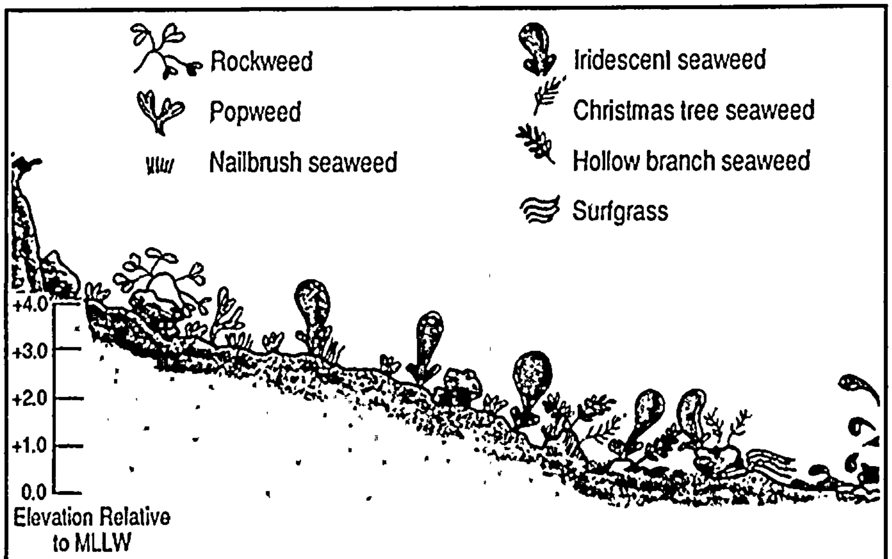


Figure 10 — Shoreline Cross Section

Diablo Cove's shoreline is partially protected from waves by rocky headlands and by Diablo Rock, a small island at its entrance. Interspersed with large boulder and cobble fields, bedrock outcroppings along the cove's north shore are a marked contrast to the south shore's bedrock benches, mixed with cobble, gravel, and sand deposits.

Natural disturbances in the north- and south-shoreline habitats accentuated the substrate differences; wave impact is greater on the north shore and sand erosion is common along the south shore. A cliff on the south shore collapsed during a severe winter storm in 1982–83 and buried the shoreline habitat under 1 to 3 feet of new cobble and gravel. The cove's north- and south-shore habitats remain distinctly different today.

Algae

Algae common to Diablo Cove prior to the power plant's discharge included *Pelvetia fastigiata, Fucus gardneri, Iridaea flaccida, Endocladia muricata, Gigartina canaliculata, Gastroclonium coulteri,* and the flowering plant, *Phyllospadix spp.* (Figure 10). Declines were observed in populations of the most common of these species: *I. flaccida, G. canaliculata,* and *E. muricata.* Although several other species also declined, the changes in their populations were relatively small due to their initially low abundance levels and their low frequency of occurrence, particularly in south Diablo Cove. Recently, the density of *G. canaliculata* has increased.

The 1982–83 winter storms damaged large areas of the cove's south shore, removing nearly all of the algae before the power plant began operating. Discharge temperature effects could not be distinguished in this part of Diablo Cove due to the storm damage. Recovery has occurred in all but the temperature-sensitive species.

Open space on rocks and on other stable surfaces along Diablo Cove's shoreline is in constant demand by colonizing algae and animals. Declines in the surface coverage of *Iridaea flaccida* was followed by increases in *Gastroclonium coulteri,* replacing *Phyllospadix spp.* at lower tidal elevations, in many areas of the cove. The algae's initial increase appears to have now returned to levels of its abundance lower than those observed prior to power plant operations.

While temperature changes caused the abundance of some algal species to increase and some to decrease, many of the species exhibited no change. The abundance of the persistently dominant *Gigartina papillata,* initially unchanged by the elevated discharge temperatures, has increased in the lower intertidal.

Over the past several years, an expanding sea urchin population (500 urchins/m^2) has severely overgrazed the intertidal algal species in an area of Diablo Cove north of Diablo Creek. This condition became more apparent in 1994.

In 1994, the kelp species *Sargassum spp.* was found growing in the discharge effluent next to the discharge structure. Previously, the only plants of this species found in Diablo Cove were growing in a protected tidepool.

The coverage of ephemeral algae in Diablo Cove has increased where other species have declined since plant startup. The first occurrence of the ephemeral *Derbesia spp.* in Diablo Cove was in 1994. A non-ephemeral species, *Gelidium coulteri,* increased in cover after power plant startup at most of the Diablo Cove stations. However, *G. coulteri* has not continued to increase at these stations in recent years, leaving areas open which have not been recolonized since power plant operations began.

Invertebrates

Invertebrates commonly found along the Diablo Cove shoreline include rock-encrusting barnacles, snails, limpets, anemones, hermit crabs, and black abalone. Abundance changes were analyzed for six important and representative species of shoreline invertebrates which had been tested in temperature-tolerance experiments. Three of the species increased in abundance, and two species remained unchanged; a recent decline in the shoreline black abalone is discussed separately in this report. The abundances of the aggregating sea anemone, the black turban snail, the rough limpet, and the acorn barnacle gradually increased after power plant startup. . The significant increases in these species appear related to coincident increases in open space, resulting from declines in algae cover due to grazing or temperature.

The abundance and distribution of hermit crabs was unaffected by discharge temperatures.

Limpets, including *Collisella pelta, C. scabra,* and *C. limatula,* have increased in abundance at many of the Diablo Cove stations since power plant startup and through 1994, while the abundance of limpet species has not changed appreciably outside the cove. The number of keyhole limpets *(Fissurella volcano)* increased from 1990 through 1994, but only in north Diablo Cove.

Black Abalone

The black abalone is commonly found beneath boulders and in bedrock crevices along Diablo Cove's shoreline (Figure 11). Densities of over two abalone per square meter have been recorded inside Diablo Cove. Studies from 1973 to 1982, by California Department of Fish and Game (CDF&G), showed black abalone were most abundant along the northern shoreline and the headlands of Diablo Cove.

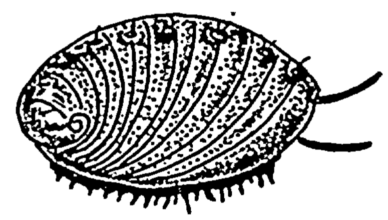


Figure 11 — Black Abalone

Black abalone remained relatively stable in Diablo Cove through 1988, when a few abalone along the cove shoreline were found to be afflicted with withering syndrome (WS). This condition was first observed in black abalone populations in the southern California Channel Islands and is characterized by an abalone shrinking in size, and then eventually dying, or becoming so weak it is subject to predation. WS resulted in a mass mortality of black abalone in the Channel Islands and later in Diablo Cove, where the abalone population reached its lowest level in the winter of 1991.

During 1994, the abundance of Diablo Cove black abalone *(Haliotis cracherodii)* continued a trend of within-year increases, a yearly pattern (also noticed in the Channel Islands) that began in the summer of 1991. In 1994, 145 abalone were found in the winter survey, and 676 abalone were found in the summer survey. The increase in the summer was largely due to recruitment of juveniles (<25 mm shell length). The total number of juveniles observed in the year represents the strongest recruitment event of black abalone in Diablo Cove to date.

Summer recruitment for 1990–94 has resulted in a population of mostly small abalone. However, during these years, winter declines in abalone abundance indicate that mortality has generally remained high, some of which may be related to the continued presence of WS-related disease in the population. The recruitment events, however, indicate that Diablo Cove provides a favorable habitat for the settlement of abalone larvae, once the WS disease subsides.

Two of the 821 black abalone found in Diablo Cove during the 1994 surveys were observed to have WS, and fresh empty shells were fairly common. These observations confirm that WS-related mortality was still present in the black abalone population in the study area during 1994. Individual abalone with WS were also found in Diablo Cove on other occasions and beyond the influence of the plume at the North Reference abalone transect and Cayucos, CA.

Shoreline Changes in Common Algae, Invertebrate, and Fish Species Abundances

Species	Effect
Algae	
Coralline Seaweed	Decrease
Feather Boa Kelp	Decrease
Nailbrush Seaweed	Decrease
Hollow Branch Seaweed*	Increase then Decrease
Red Seaweed *Ga*	Decrease
Christmas Tree Seaweed	Decrease then Increase
Iridescent Seaweed*	Decrease
Grapestone Seaweed	Increase
Crustose Red Seaweed	Increase
Surf Grass*	Decrease
Red Seaweed *Pl*	Increase
Red Seaweed *Ra*	No change
Invertebrates	
Aggregating Anemone	Increase
Acorn Barnacle	Increase
Hermit Crabs*	Decrease
Black Abalone*	Decrease
Rough Limpet	Increase
Black Turban Snail*	Increase
Dove Snails*	No change
Sea stars*	Increase
Fish	
High Cockscomb	No change
Rock Prickleback*	Decrease

* Tested for thermal tolerance in onsite laboratory.

Diablo Cove Underwater

After startup of the power plant, twice as many underwater species of algae, invertebrates, and fish increased in abundance as declined. Red algae generally replaced the cove's kelp species. Snails, sea urchins, and sea anemones increased while the abundance of crabs declined slightly. Fish species that are new to the area have been attracted to the plume's temperature and flow, and the resident species of fish have adjusted to changes in the cove's algal habitats.

Algae

Underwater populations of red and brown algae provide habitat and food for the Diablo Cove marine communities. The algal community was altered, prior to power plant startup, by the sea otter's predatory removal of algae-eating urchins and abalone. Further alterations occurred as a result of the increased ocean temperatures and the severe storm waves associated with El Niño. The abundance and distribution of the cove's underwater algal species, as illustrated schematically in Figure 12, are affected by depth and bottom substrate.

Surfgrass, which forms a transition zone between the cove's shoreline and underwater habitat, is limited by its underwater light requirements, to depths of less than 10 feet. Many intertidal areas in the cove that were dominated by *Phyllospadix spp.* before the 1982–83 winter storms have since become overgrown with other species, such as hollow branch seaweed *Gastroclonium coulteri.* Below the surfgrass zone, a mat of coral-like algae forms a habitat for numerous small snails and crustaceans. The intertwined branches of the turf-like mat also provide substrate for a leafy red algae that is common in depths up to 25 feet. Below the surfgrass zone, the majority of the cove's algae are red-colored, containing pigments that capture the lowest levels of penetrating sunlight.

Tree kelp and oar blade kelp are perennial algae that occur below the surfgrass and coralline algae zones throughout Diablo Cove. In the deepest portions of the cove (25 to 50 feet), tree kelp and oar kelp, three feet tall, form a light-shading canopy above a sparse understory of red algae.

Bladder chain and bull kelps, shown in Figure 13, commonly form surface canopies in the rocky areas of Diablo Cove that are deeper than 10 feet. The growth rate of both species slows each fall, due to declining light and nutrient levels and warming ocean temperatures. The accumulated spring and summer growth is detached by winter storm waves and carried onshore to form beach wrack or offshore to the deep-ocean food chains.

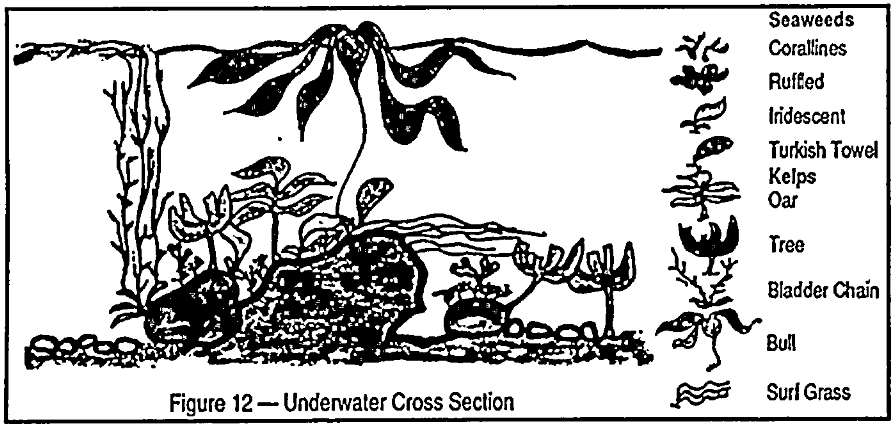


Figure 12 — Underwater Cross Section

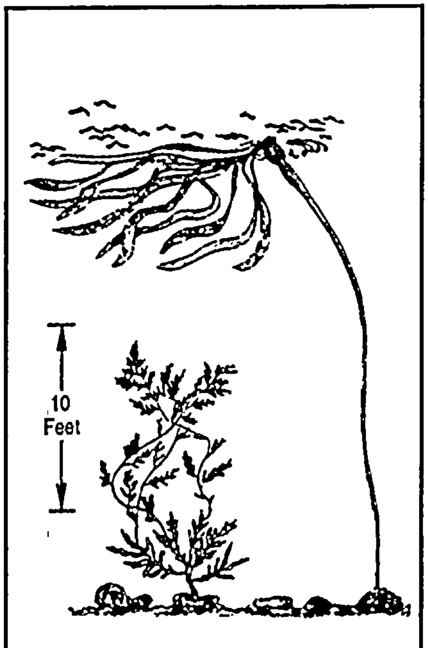


Figure 13 — Bladder Chain & Bull Kelp

Temperature related changes in the algal populations are generally confined to shallow areas of the cove (<20 feet) that are persistently in contact with the warm-water plume, as in north Diablo Cove. A species of red algae, which was relatively sparse in the cove prior to power plant startup, flourished in the shallow areas favored by warm discharge temperatures. This species of red algae is now declining, possibly due to the shading effects of the increasingly abundant giant kelp *(Macrocystis pyrifera).*

Kelp species (bladder chain, feather boa, oar, bull, and tree) have declined in their abundances while the red algae have either increased (hidden rib algae) or remained unchanged (ruffled algae and articulated coralline algae).

Bull kelp blades, contacted by the warm surface plume, have exhibited senescence in early August, which normally occurs in October. Presesonal senesence has been observed in early August, in plants inside Diablo Cove, and in plants located approximately one mile to the north. Because the bull kelp disappears annually, their habitat-forming and bottom-shading effects are seasonal. The denser and longer-lived, warm-water giant kelp, has become established in warm areas of Diablo Cove and may replace part of the cove's bull kelp habitat.

Invertebrates

Twelve subtidal-invertebrate species were reviewed in the quantitative and the qualitative records. Four of the species were not affected by the thermal plume. Of the eight species affected, the abundances of six increased and the abundances of two declined. The number of large rock crabs declined in the shallow areas of north Diablo Cove when the animals moved into the deeper north-channel areas.

Following startup of the power plant, bat stars appeared in greater numbers inshore of Diablo Rock, an area of Diablo Cove consistently contacted by the plume. This localized concentration has subsequently disappeared.

Brown turban snails *(Tegula brunnea),* formerly the most abundant motile invertebrate on the subtidal fixed benthic stations, have declined in abundance since power plant startup and remained in low abundance in Diablo Cove during 1994, compared to areas sampled outside the cove.

The California sea hare increased in the shallows of Diablo Cove. Although individuals of this species live for only a year, the increase has appeared each year following plant startup.

Red Abalone

Red abalone are commonly found, at depths of 20 to 50 feet, along the coast from Oregon to Baja California. In Diablo Cove's underwater habitat, the red abalone lives beneath boulders or wedged into rocky crevices (Figure 14).

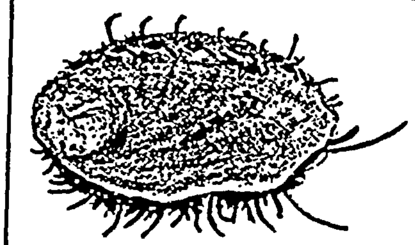


Figure 14 — Red Abalone

CDF&G biologists who monitored the 1974 sea otter invasion of Diablo Cove reported a decline in red abalone that summer. They estimated that the 40 otters that took up residence in the vicinity of Diablo Cove consumed 50 to 70 abalone per day.

The density of red abalone in Diablo Cove has declined steadily from averages of five to ten per station in the sample years of 1984, 1986, and 1987, to about two per station in 1990 and 1991. In 1992 and 1993, the density was about one per station, and in 1994, the density averaged 0.6 abalone per station. Based on laboratory thermal tolerance studies (Figure 15), the red abalone was predicted to be at risk from discharge temperatures expected in the shallow areas of Diablo Cove. Declines that began in 1984, before power plant operations, may be related to the 1983 El Niño changes in ocean temperatures and currents.

Thirty-seven red abalone *(Haliotis rufescens)* were counted on 65 random 30 m^2 sites sampled in Diablo Cove during 1994. This total represents about a 50% reduction from the total number counted in 1993 at a similar number of sample sites. No red abalone were found at depths less than 10 feet, and for the first time since this study began in 1984, none were found in north Diablo Cove at depths of less than 20 feet. Prior to 1990, red abalone were most abundant in the shallow areas of Diablo Cove.

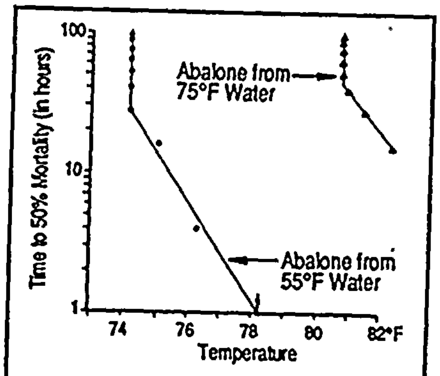


Figure 15
Red Abalone Temperature Tolerance

No red abalone with WS disease were observed in any of the study areas inside or outside Diablo Cove during 1994. The continued decline in the number of red abalone in Diablo Cove relative to areas outside the cove indicates that discharge temperatures directly, or in conjunction with WS, are affecting the present population in the cove. The pattern of greater declines in the shallow and warmer areas of Diablo Cove support this hypothesis. The roles of WS disease and water temperatures in the decline of the cove's red abalone are being investigated.

Fish

In 1994, warm-water tolerant species, such as opaleye and kelp bass, were most often, and sometimes exclusively seen in north Diablo Cove. Other common or characteristic species included blackeye goby, black surfperch, señoritas, and halfmoon. Pile perch were more abundant in north Diablo Cove in 1994, than in any previous year since 1976. As in previous years of power plant operation, bat rays, leopard sharks, and white seabass, were some of the abundant warm-water tolerant species observed in the discharge plume. Increased kelp canopy coverage in north Diablo Cove continued to provide habitat for kelp surfperch, kelp bass, and several other rockfish species. Bat rays, rare to Diablo Cove prior to power plant startup, were consistently observed in large numbers in the south Diablo Cove channel.

Diablo Cove Rockfish

Over 70 species of rockfish occur in California, and they are important to the state's commercial and sport fisheries. The most common diver-observed rockfish species in Diablo Cove include the blue, the olive, the black, the yellow, the grass, and the kelp rockfish (Figure 16). In a 1980–87 PG&E survey, the blue rockfish was the most abundant sport species caught by fishermen between Morro Bay and Port San Luis.

Fourteen species of rockfish were observed in Diablo Cove. In standard underwater samples, olive, blue, black, and yellow rockfish, and bocaccio species represented 99.7% of all adults and juveniles observed. Over 81% of the individual rockfish observed in Diablo Cove were juveniles.

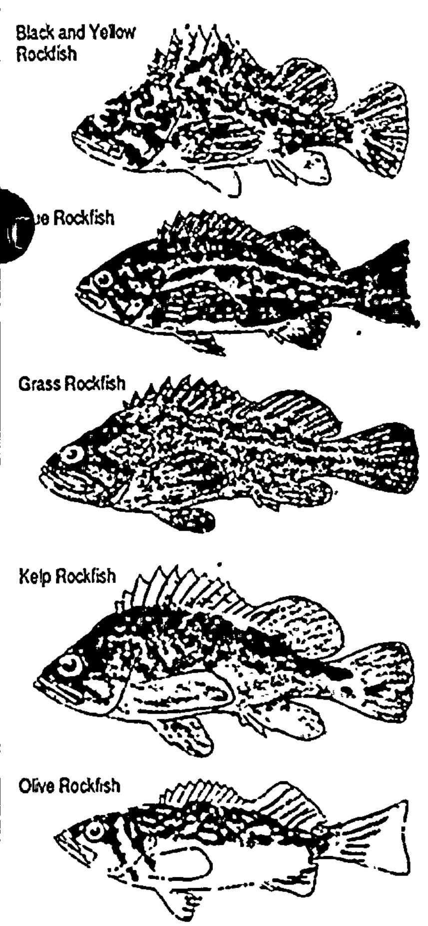


Figure 16 — Rockfish

Blue rockfish abundance in nearshore areas is related to the presence of bull kelp, which provides shelter for both juveniles and adults. Within Diablo Cove, blue rockfish were most abundant in the deeper, high-relief areas of the north and south channels.

Since power plant startup, most rockfish have remained outside the thermal plume, although both adults and juveniles are commonly observed feeding on plume-entrained materials in the interface between warm and cool water. The abundance of blue rockfish in Diablo Cove declined steadily between 1983 and 1987 coincident with El Niño-induced warming.

Olive rockfish increased in abundance in 1986 and 1994. Increases were most noticeable in areas of north Diablo Cove, where blue rockfish declines had also been observed. Adult and juvenile olive rockfish were observed feeding on suspended material in the discharge plume interface. Abundances have remained relatively unchanged in south Diablo Cove and Patton Cove.

Black and yellow rockfish abundances were generally low and quite variable in both north and south Diablo Cove, but they have increased steadily in the Patton Cove area. Abundance declined slightly in north Diablo Cove from 1983 to 1994, although, compared with south Diablo Cove, the numbers were relatively high. Black and yellow rockfish, living directly in the discharge flow, were unaffected by plume temperatures.

Grass rockfish were present in low abundances in all areas from 1976 to 1987, and they have persisted in thermally affected areas since power plant operations began.

Kelp rockfish, which were even less abundant than the grass rockfish, were most often seen adjacent to giant kelp plants, or among understory tree kelps in the deeper channels of Diablo Cove. As the shallower kelp plants were displaced by plume temperatures, the kelp rockfish selected the deeper tree kelp and oar kelp habitat in Diablo Cove.

Underwater Changes in Common Algae, Invertebrates, and Fish Species Abundances

Species	Effect
Algae	
Ruffled Seaweed*	Decrease
Articulated Seaweed*	No change
Hidden Rib Seaweed	Increase
Bladder Chain Kelp	Decrease
Brown Seaweed	Increase
Red Seaweed *Fc*	Increase
Red Seaweed *Gr*	Increase
Red Seaweed *Ge*	Increase
Red Seaweed *H/S*	Increase
Red Seaweed *Ic*	Increase
Oar Kelp*	Decrease
Bull Kelp*	Decrease
Surf Grass*	Decrease
Red Seaweed *Pl*	Increase
Tree Kelp*	Decrease
Red Seaweed *Rs*	Increase
Invertebrates	
Aggregating Anemone	Increase
Rock Crab*	Decrease
Hermit Crabs*	Decrease
Kelp Crabs*	Decrease
Red Abalone*	Decrease
Dunce Cap Limpet*	Decrease
Red Top Snail*	Decrease
Brown Turban Snail*	Decrease
Dove Snails*	Decrease
Bat Star*	Decrease
Sea stars*	Increase
Sunflower Star*	Decrease
Sea Urchins*	Increase
Fish	
Black Surfperch*	Increase
Striped Surfperch	Increase
Pile Perch	Increase
Bat Ray	Increase
Lingcod	Decrease
Señorita	Increase
Convict Fish	No change
Cabezon*	Decrease
Kelp Rockfish	Dec & Inc
Black & Yellow Rockfish*	Decrease
Blue Rockfish*	Inc & Dec
Grass Rockfish	No change
Olive Rockfish*	Inc & Dec
Sheephead	Increase
Leopard Shark	Increase
Gopher Rockfish*	Decrease

* Tested for thermal tolerance in onsite laboratory.

Summary

Thermal-effects studies of the Diablo Canyon Power Plant's operations began in 1985. An onsite team of 12 marine scientists, has measured, analyzed, and reported on a number of biological changes caused by the velocity and temperature of the DCPP discharge. Their research efforts represent thousands of hours of careful observations, often made under very demanding field conditions. The team's collective findings have been described comprehensively in eight thermal assessment reports to the Regional Water Quality Control Board, published in 1986, 1987, May 1988, April 1989, April 1990, March 1991, March 1992, and March 1993. These reports describe the condition of the cove's marine community, and were reviewed by representatives of both resource and regulatory agencies, who made recommendations for additional thermal-assessment studies and analyses.

Significant population changes have been observed in many of Diablo Cove's shoreline and underwater species since startup of the power plant's discharge. The changes include both increases and decreases in the cove's resident species and the appearance of warmer-water species. The most evident changes have occurred in areas of the cove that are consistently exposed to the warmest discharge temperatures. Natural fluctuations in the abundances of species found in the study area were widely observed before power plant operations began and continued to be observed at reference locations during power plant operation. Continuing changes in the cove's key species will lead to new interactions, abundances, and distributions of other species in the cove's marine community.

The information gathered over the past 30 years in the power plant's studies of Diablo Cove represent one of the country's largest sources of information on the ecology of open-coast, rocky-shore species. In a detailed analysis of this information, it is possible to separate the changes in the cove's populations that are due to seasonal effects from the changes that are discharge-related. This kind of analysis is made possible by the statistical power of the collected data. Relatively small population changes in many of the cove's species can now be detected by utilizing the study's massive background of historical information on these species. A comprehensive set of such analyses are planned for the coming year in conjunction with continued monitoring of thermal effects in Diablo Cove and in other reference areas.

References

Chronology and brief description of various Diablo Canyon Power Plant marine studies (1966–Present). Literature cited references citations in 1988 Thermal Effects Monitoring Program Report.

Program Title	Year	Description	Conducting Organization	Selected References
Field Biological Monitoring				
Preliminary Site Survey of Diablo Cove	1966	Qualitative inventory of invertebrates, fishes, and algae in Diablo Cove, subtidal and intertidal.	PG&E, CDF&G	Ebert (1966), North (1969), PG&E (1971)
Marine Biological Surveys of Diablo Cove and Vicinity	1968–87	Quantitative subtidal and intertidal permanent transects sampled semi-annually; intertidal photography on vertical transects.	Wheeler J. North	North et al. (1974, 1986)
Preliminary Baseline Study of Diablo Cove	1969–71	General quantitative and qualitative species inventory with emphasis on abalones, fishes, and bull kelp; extensive fish collections; and intake cofferdam investigations.	CDF&G	Burge and Schultz (1973)
Aerial Photography of Kelp Beds	1969–87	Color infrared aerial photography of kelp beds from Pt. San Luis to Pt. Buchon, annual surveys.	PG&E	Stephan (1978)
Zooplankton Studies	1972–73	Weekly zooplankton tows to establish baseline data on zooplankton composition and abundance.	PG&E	Icanberry et al. (1978)
Pre-operational Baseline Studies of Selected Marine Plants and Animals	1973–82	Quantitative quarterly sampling at random subtidal and intertidal locations and permanent abalone transects, algal biomass, baited-station fish counts, and bull kelp counts.	CDF&G	Gotshall et al. (1984, 1986)
Intertidal Algal and Invertebrate Association	1979–95	Quarterly algal scrapes to determine abundance of associated invertebrate and fish species (algal/faunal associations).	PG&E, TENERA	Behrens and Kelly (1986)
Gray Whale Migration	1981–95	Observation and census of gray whales within an offshore corridor; annually from December–April.	PG&E, TENERA	Behrens and Shaffer (1986)
Peregrine Falcon Observations	1982–95	Observations of Peregrine falcon activity in the Diablo Canyon area.	Santa Cruz Predatory Bird Research Group, TENERA	SCPBRG (1994)
Elephant Seal Observations	1987–95	Observations of Northern Elephant Seal at mainland haulout at Diablo Canyon Power Plant intake cove.	TENERA	King et al. (1989)
316(a) Demonstration	1976–82	Quantitative bimonthly sampling of permanent intertidal and subtidal stations. Other tasks: quantitative fish observations, algal biomass, settling plates, rock crab population studies, subtidal and intertidal photography, and fish gut analysis.	Lockheed/ TENERA/ Kaiser Engineers	LCMR (1978) PG&E (1978, 1979)
Thermal Effects Monitoring Program (TEMP)	1983–87	Continuation of 316(a): annual bull kelp census, intertidal algal biomass studies, subtidal video transects, and red and black abalone census.	TENERA/ Kaiser Engineers	PG&E (1988)
Marine Ecological Monitoring Program (MEMP)	1988–89	Reduced 316(a): intertidal and subtidal stations, annual bull kelp census, subtidal video transects, and red and black abalone census.	TENERA	PG&E (1989)
Thermal Effects Monitoring Program (TEMP)	1990–95	Resumed 316(a) 4x/year sampling of intertidal and subtidal stations, annual bull kelp census, intertidal algal/faunal association study, and red and black abalone census.	TENERA	PG&E (1994)
Intertidal Fish Surveys	1979–95	Quantitative survey of intertidal fishes in Diablo Cove at permanent vertical transects; concurrent algal and invertebrate data (algal/faunal associations).	PG&E, TENERA	Pimentel and Bowker (1984)
Fisheries Investigations	1978–89	Underwater fish tagging, blue rockfish tagging, and partyboat sportfishing sampling.	PG&E, RSI Services Corp.	Sommerville and Krenn (1983)
Observations of Sea Otter Populations in Vicinity of Diablo Canyon	1973–95	Direct monthly counts and behavioral observations of sea otters from permanent clifftop vantage points; annual census of urchin and abalone populations near Pecho Rock.	Ecomar, Benech Biological and Associates	Benech and Colson (1976)

Program Title	Year	Description	Conducting Organization	Selected References
Field Biological Monitoring — *Continued*				
State Mussel Watch Program	1982–95	Tri-annual collection of mussels emplaced at permanent subtidal stations near DCPP discharge; analysis for trace metals and selected chemicals.	CDF&G	Martin et al. (1985)
San Luis Obispo County Artificial Reef (SLOCAR) Project	1984–90	Monitoring of biotic development of artificial reef (SLOCAR) with emphasis on young rockfish.	PG&E, RSI Services Corp.	Krenn and Wilson (1986), Danner et al. (1994)
316(b) Demonstration	1985–87	Sampling of impinged and entrained organisms in the power plant seawater cooling system; special consideration of larval fishes; weekly plankton tows nearshore and near intake structure.	TENERA	PG&E (1987a)
Laboratory Experimental Studies				
Thermal Effects Laboratory Experiments	1978–80	Heat tolerance experiments on 45 species of fishes, invertebrates, and seaweeds; effects of temperature on growth and early development of 16 species; and behavioral responses to elevated temperatures.	Lockheed/ TENERA/ Kaiser Engineers	PG&E (1983)
Heat Treatment Laboratory Experiments	1982	Exposure of 34 species of fishes, invertebrates, and seaweeds to temperatures simulating field conditions under power plant heat treatment.	TENERA	PG&E (1985b)
Chlorination Experiments	1977	Effects of chlorine residuals on selected indigenous marine animals.	PG&E	Wilson (1978), Behrens (1978)
NPDES Bioassay Experiments	1976–95	Toxicity bioassay studies on organisms using discharged seawater from power plant.	PG&E	Behrens (1982)
Physical Monitoring				
Physical Oceanography	1966–87	Studies on nearshore currents, temperature, and salinity relationships and dissolved oxygen.	PG&E	White (1983)
Subtidal Temperature Monitoring	1972–84	Temperature measurement at permanent stations in Diablo Cove and at control stations.	PG&E	Warrick (1979)
Temperature and Light Monitoring	1976–95	Continuous recording of temperatures at permanent intertidal and subtidal locations; light and tide measurements at selected subtidal stations in Diablo Cove.	Lockheed/ TENERA/ Kaiser Engineers	PG&E (1986a, 1986b, 1987b)
Nearshore Current Monitoring	1978–95	Continuous current measurement at a permanent station outside of Diablo Cove.	ECOMAR, TENERA	Meek (1983)
Offshore Wave Monitoring	1983–95	Continuous wave height and period monitoring with telemetered wave gauge.	PG&E, TENERA	White (1985)
Predictive Analyses and Models				
Thermal Plume Mapping	1985–86	Three-dimensional temperature mapping of near-field and far-field plume behavior under a variety of oceanographic and operational regimes.	PG&E	Leighton et al. (1986), PG&E (1988)
Thermal Discharge Assessment Report	1982	Predictive assessment of the effects of power plant thermal discharge on distributions and abundance of selected species; integration of physical model data and known species distributions.	TENERA	PG&E (1982a)
Assessment of Alternatives to the Existing Cooling Water System. Diablo Canyon Power Plant	1982	Alternative designs and their cost-benefit analyses for the DCPP cooling water system and its effects on the marine biota.	TENERA/ Kaiser Engineers	PG&E (1982c)
Hydraulic Model Verification	1985–86	Verification of physical model under a variety of simulated oceanographic and operational conditions.	PG&E	Ryan et al. (1986)

ENCLOSURE 2

CORRESPONDENCE RELATED TO NPDES PERMIT

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April 30, 1996

PG&E Letter DCL-96-512

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
1995 Annual Nonradiological Environmental Operating Report

Dear Commissioners and Staff:

Enclosed is the 1995 Annual Nonradiological Environmental Operating Report for Diablo Canyon Units 1 and 2, submitted in accordance with Subsection 5.4.1 of the Environmental Protection Plan, Appendix B to the Facility Operating Licenses DPR-80 and DPR-82.

Sincerely,

Gregory M. Rueger

cc: Steven D. Bloom
Roger W. Briggs, CCRWQCB
L. J. Callan
Ross Lopez, SLO-EH
Michael D. Tschiltz
Diablo Distribution

Enclosure

DCL96512/HXR

bcc:	Glen G. Caruso	245/N10A
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	Jerry Timiraos	Moss Landing PP
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	ACTS-GO	333/1092

Enclosure
PG&E Letter DCL-96-512

1995 ANNUAL NONRADIOLOGICAL ENVIRONMENTAL OPERATING REPORT
DIABLO CANYON POWER PLANT

Pacific Gas And Electric Company
April 1996

PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON POWER PLANT
1995 ANNUAL NONRADIOLOGICAL ENVIRONMENTAL OPERATING REPORT
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1. INTRODUCTION

The 1995 Annual Nonradiological Environmental Operating Report is submitted in accordance with the requirements of the Environmental Protection Plan (EPP), Appendix B of Facility Operating Licenses DPR-80 and DPR-82 for Diablo Canyon Canyon Power Plant (DCPP) Units 1 and 2. The report describes implementation of the EPP and demonstrates that the plant is operating in an environmentally acceptable manner. PG&E remains committed to minimizing the environmental impact of operating DCPP.

2. ENVIRONMENTAL MONITORING

2.1 AQUATIC ISSUES

Aquatic issues are addressed by the effluent limitations, receiving water monitoring data, and reporting requirements contained in the DCPP National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit includes applicable requirements of the State Water Resources Control Board's Ocean Plan and Thermal Plan.

2.1.1 Routine Monitoring

Quarterly NPDES reports containing routine influent, effluent, and receiving water monitoring data and permit compliance summaries were submitted to the Regional Water Quality Control Board, Central Coast (CCRWQCB) by the 20th day of the month following the end of the respective quarter. An annual NPDES report was also submitted to the CCRWQCB on February 22, 1996. This report contained both tabular and graphical summaries of the monitoring data obtained during 1995. A summary of permit compliance for 1995, including corrective actions for deviations from requirements, was also contained in the 1995 annual NPDES report. Copies of the 1995 NPDES quarterly and annual reports were submitted concurrently to the NRC.

No enforcement actions were taken by the CCRWQCB under the NPDES permit during 1995.

2.1.2 Thermal Effects Monitoring Program

During the first half of 1995, the NPDES ecological studies program, as required by the CCRWQCB, continued as the Thermal Effects Monitoring Program (TEMP). A revised program, the Ecological Monitoring Program (EMP), was approved by the CCRWQCB February 10, 1995. PG&E initiated the EMP on July 1, 1995. Ecological monitoring programs (TEMP and EMP) have recorded biological changes in the discharge area since plant start-up. The programs monitored intertidal and subtidal communities of invertebrates, algae, and fish in the discharge

cove and at stations north and south of DCPP. Sampling was conducted four time annually for most subtasks under TEMP. Sampling frequency decreased to twice annually for most subtasks under EMP. The final TEMP report is currently being prepared. The first EMP semiannual report was submitted to the CCRWQCB on February 16, 1996. This report described biological studies of the near-shore marine environment related to the DCPP thermal discharge during the eleventh year of commercial operation.

During 1995, DCPP receiving water community continued to change from the pre-operational community and from reference communities monitored beyond the influence of DCPP. Abundance of some species, usually warmer water species, have increased; while others, typically cold water species, have declined. Natural fluctuations in biological communities were also observed. The continuing change observed can be attributed to new and constantly varying sets of environmental conditions. The response dynamics of the receiving water community can be expected to change with time due to continuous variations in ambient oceanographic and thermal plume temperature regimes:

A. Physical Studies

Physical measurements continue to document the extent and location of the thermal plume. As in past years of plant operation, the warmest water temperatures were recorded in Diablo Cove, but warming caused by the thermal plume was detected at some stations north of the cove. During 1995, the Unit 1 seventh refueling outage occurred during October and part of November. Additional unscheduled outages occurred in September and December. During these outages, water temperatures in Diablo Cove and vicinity were closer to ambient than during other periods of the year.

B. Intertidal Studies

Diablo Cove stations remained different in species composition and abundance in comparison to reference station species assemblages. This continues the trend that started after plant startup. In 1995, Diablo Cove stations were characterized by having lower abundances of perennial algal species, and higher abundances of annual algal species than non-Diablo Cove stations. Over the past several years, an expanding sea urchin population has severely overgrazed large areas of the intertidal in north Diablo Cove of all non-crustose algae. This condition became more apparent in 1995. Increases in sea urchin populations were also seen in Field's Cove. Black abalone densities remained low and continued to decrease from their 1994 levels at most stations inside Diablo Cove. The withering foot syndrome, which appeared in Diablo Cove in 1988, continues to cause large reductions in black abalone populations. Strong summer recruitment for black abalone did not occur in 1995.

C. Subtidal Studies

Subtidally, differences were observed in algal and invertebrate species composition and abundance between Diablo Cove and non-Diablo Cove stations. The differences continued the pattern of changes that began after plant start-up. Expansion of urchin barren areas noted in Diablo Cove intertidal areas has also occurred in the subtidal. Dense stands of giant kelp that had developed over the past several years in Diablo Cove persisted through 1995. In contrast, bull kelp in Diablo Cove was still limited in abundance and location. It is confined to areas around headlands where cooler water temperatures allow survival of this species. Large recruitment events of young-of-the-year rockfishes were observed in association with kelp canopies inside and outside Diablo Cove. Fish species attracted to the warm water discharge, including bat rays, leopard sharks, and white sea bass were still present during 1995. Red abalone densities in areas of north Diablo Cove increased during 1995 as a result of recruitment. No unusual changes in red abalone density were noted outside Diablo Cove. No red abalone with withering foot syndrome were observed during 1995.

2.1.3 Onsite Toxicity Studies

Acute and chronic bioassay toxicity studies were conducted quarterly on DCPP effluent at the onsite Biological Laboratory. Toxicity found in the second and fourth quarter chronic tests measured 1.8 and 3.13, respectively. These measurements were below the calculated effluent chronic toxicity limit (5.11) from the 1990 California Ocean Plan. The first and third quarter chronic toxicity tests and all quarters for acute toxicity tests indicated that no toxicity was present.

2.1.4 State Mussel Watch Program

The California Department of Fish and Game (CDF&G) maintains an in-situ mussel assay at several stations in the vicinity of DCPP. Results are reported directly to the CCRWQCB by CDF&G.

2.1.5 Oceanographic Studies

During February and June 1995, stratified water temperature, dissolved oxygen, and pH were monitored at six stations in the vicinity of the discharge plume. On July 1, 1995, the revised monitoring program was initiated. Stratified water temperature and pH sampling are no longer required. Dissolved oxygen sampling continued at eight new stations in September and December 1995. The results of oceanographic sampling were reported in quarterly NPDES reports and the first EMP semiannual report. All values were within expected levels.

Nearshore wave conditions were monitored offshore of DCPP. Significant wave heights and peak periods for each 6-hour period and joint frequency distribution o. wave height and period were calculated and recorded in daily onsite weather records.

2.2 TERRESTRIAL ISSUES

The DCPP Land Stewardship Program continued to evaluate biodiversity in 1995 on the land that surrounds DCPP.

Work in 1995 included the continuation of the Native Perennial Grass Study, which involved plantings, planting data evaluation, and plot monitoring.

The Native Perennial Grass Study concluded at the end of 1995.

2.2.1 Herbicide Application and Fire Control

During 1995, wildlands fuel management methods within the Diablo Creek watershed included primary and secondary treatments. These methods were targeted at approximately 400 acres located in the lower watershed immediately east of the 500 kV switchyard and within a fire-sensitive area where several transmission lines converge.

Primary treatments involve stands of vegetation that are mature and include:

1) Hand clearing - since 1991 crews have been using hand tools and chain saws to cut vegetation to ground level. (In 1995 this effort cleared 80 acres of brush.)

2) Mechanical mower/mulchers - in December 1995, seven acres of mature chaparral under the 500 kV transmission lines and on the north facing slope of the watershed were cleared by a brontosaurus. (A track vehicle with a boom-mounted cutting head.)

3) Crush and burn - allowing cut vegetation to dry months prior to burning. No acres were crushed and burned in 1995 due to the lack of fire-ready equipment. However, ten acres of dry vegetation collected from the hand clearing crews was laid in windrows and burned.

Secondary treatments are designed to control resprouting vegetation and include:

1) Chemical herbicides as described below.

2) Livestock - In spring 1995, 1000 goats were used to browse 10 areas that

totaled approximately 140 acres of vegetation.

Herbicide application within the plant site vicinity was performed by The Weed Works, California State License 02055-00000. The following areas were treated during 1995:

Date	Location	Product*	Total Applied
02/18/95	Dog Runs	Round-up	6 gal.
02/25/95	Roadsides	Round-up	1.5 gal.
03/19/95	Spot Spray Roadsides	Round-up	2 gal.
03/28/95	Hillside by 500 kV Yard	Round-up	4 gal.
04/15/95	Electrician Dept. Storage	Round-up	2 gal.
04/24/95	Scaffold Yards, Storage	Round-up	6 gal.
04/26/95	Spot Spray Roadsides	Round-up	4 gal.
04/27/95	Parking Lot	Round-up	2 gal.
05/01/95	Steel Storage Yard	Round-up	4 gal.
06/7/95	Culverts; Milemark 3.6 to 6.7	Round-up	17 gal.
06/17/95	Culverts; Milemark 3.5 to gate	Round-up	44 gal.
06/25/95	Roadsides	Round-up	2 gal.
07/05/95	Hillside by 500 kV yard	Round-up	2 gal.
08/20/95	Spot Spray Roadsides	Round-up	2 gal.
08/27/95	Spot Spray Roadsides	Round-up	2 gal.
11/25/95	Access Road	Karmex Simazine 80 W	8 lb. 10 lb.
11/26/95	Access Road	Karmex Simazine 80 W	8 lb. 10 lb.
11/26/95	Storage Area by Ponds	Karmex Simazine 80 W	4 lb. 5 lb.
11/28/95	South of Dog Kennels	Karmex Simazine 80 W	4 lb. 5 lb.
11/29/95	Upper Level Roadsides	Karmex Simazine	12 lb. 15 lb.
11/30/95	230 kV Yard	Karmex Simazine 80 W	8 lb. 10 lb.
12/02/95	Access Road	Oust	8 oz.
12/03/95	230 kV Yard	Karmex Simazine	16 lb. 20 lb.
12/04/95	Storage by Dog Kennels and Area Behind Shop	Karmex Simazine 80 W	8 lb. 10 lb.
12/05/95	Gun Range and Scaffold Yard	Karmex Simazine 80 W	8 lb. 10 lb.

Date	Location	Product*	Total Applied
12/07/95	500 kV Yard	Karmex Simazine 80 W	40 lb. 32lb.
12/09/95	500 kV Yard	Karmex Simazine 80 W	40 lb. 32 lb.
12/10/95	500 kV Yard	Karmex Simazine 80 W	32 lb. 40 lb.
12/10/95	Met Tower 2, Sewer Plant, Plant Yard and 12 kV	Karmex Simazine 80 W	12 lb. 15 lb.
12/17/95	500 kV Yard	Karmex Simazine 80 W	32lb. 40 lb.
12/17/95	Overflow Parking & Doppler Cones	Karmex	12 lb.

* Herbicide	Mfg.	EPA#	Rate Of application
Simazine	Drexel	19713-46	As specified on label
Karmex	DuPont	352-247	1 1/2 lb/acre
Round-up	Monsato	524-445	As specified on label

2.2.2 Preservation of Archaeological Resources

A. CA-SLO-2 Site Management

Archaeological Resources Management Plan (ARMP):

In January 1995, the PG&E archaeologist was notified by DCPP that winter rains had washed portions of the SLO-2 roadcut stabilization onto the adjacent roadway. As in the past, the PG&E archaeologist agreed that the debris could be removed and that monitoring was not necessary.

In March 1995, the PG&E archaeologist was notified that additional soil had washed on to the road within the SLO-2 boundaries. As in January 1995, the debris was removed without monitoring.

In April 1995, storms from the previous month had damaged a portion of a large culvert leading from a road through SLO-2 and then down to Diablo Creek. The surface culvert, located on the SLO-2 side of Diablo Creek, was proposed for removal and replacement. The PG&E archaeologist met at this location with DCPP personnel. A decision was made to remove only

the broken portion of the culvert and to leave the remaining piece in place. The broken culvert was removed by a crane sitting on an adjacent road. This work was not monitored by the PG&E archaeologist since there would be no disturbance to SLO-2.

In May 1995, a land survey of the SLO-2 area was conducted. Since this work would not impact SLO-2, the PG&E archaeologist concurred that the work did not need to be monitored. The PG&E archaeologist did meet the surveyors during the course of their work. Also, the PG&E archaeologist examined the work performed on the culvert in April 1995. No impact occurred to SLO-2 due to either project.

In June 1995, a 12 kV overhead distribution power line pole was removed within the SLO-2 boundaries. The work, which consisted of cutting one pole off at the ground level, was monitored by the PG&E archaeologist. In conjunction with the removal of this overhead line, the 12 kV overhead line and communication wires were relocated underground using existing, buried pipes. The PG&E archaeologist monitored work to locate the ends of the buried pipe. From this exploratory work, it was deemed necessary to only monitor this project in one area, since it was the only area within SLO-2 that was in a relatively undisturbed portion. The PG&E archaeologist monitored the work and noted that no cultural deposits were encountered.

In September 1995, photo-monitoring of the 23 SLO-2 photo monitoring stations was conducted by the PG&E archaeologist. The photo monitoring was conducted in accordance with the Building and Land Service Department's "Cultural Resources Management Procedures for Archaeological Site CA-SLO-2," which implements policies of the ARMP. In general, no new areas of erosion or impacts to SLO-2 were noted. The area where the human remains (discussed in section 2.2.2B.) had eroded in July 1995 is located in an extremely steep portion of the ocean bluff. This area is difficult to observe from the surface of SLO-2 and is unsafe to approach from below. No remedial action is anticipated for this area. Currently, the Chumash have informed PG&E that they agree with allowing the burial at this portion of SLO-2 to wash out to the sea.

An area along a cut bank of the access road through SLO-2, noted during the 1993 and 1994 photo-monitoring visits, had experienced continued erosion at the top of the bank. The revegetation stabilization methods installed in the winter of 1994 had been completely eroded off the face of the roadcut, as noted in the 1994 Annual Environmental Operating Report (submitted to the NRC in DCL-95-098, on April 28, 1995). These stabilization methods were employed below the cultural deposit. No substantive new erosion occurred to the roadcut; the newly planted vegetation merely washed off the roadcut.

In November 1995, a two person archaeological contract crew conducted an examination of the eroding roadcut through SLO-2. The crew's study consisted of cleaning the face of the existing roadcut in the upper area where the archaeological deposit is located. A report entitled "Archaeological Investigations for Road Cutbank Stabilization at CA-SLO-2, Diablo Canyon, San Luis Obispo County, California," is currently being drafted. An interim status report indicates that this study found that the area of the roadcut contained only sparse amounts of marine shell fragments and stone tool debris. The cultural deposit containing these materials is approximately 60 centimeters in depth and appears to represent sporadic use of a peripheral portion of SLO-2. Based on these conclusions, the PG&E archaeologist has recommended that monitoring of this area continue on a quarterly basis.

B. Chumash Indian Visits and Correspondence

On six occasions, communications occurred between PG&E and the Northern Chumash Indians.

On June 1, 1995, a Northern Chumash Council representative was notified that work was anticipated within the boundaries of SLO-2. The removal of an overhead 12 kV line (one pole within the SLO-2 boundaries) and its subsequent burial using an existing buried pipe through SLO-2 was the proposed project, which was explained to the representative.

On June 10, 1995, the Northern Chumash Council representative was notified of the date for work on the 12 kV overhead removal and burial. The Chumash representative stated that monitoring would not be necessary since the majority of work was being undertaken in areas where the entire archaeological deposit had already been removed.

On July 20, 1995, the California Native American Heritage Commission (CNAHC) was notified by the San Luis Obispo County Coroner and by the PG&E archaeologist, that human remains had been found on the beach and slope below SLO-2. CNAHC returned the PG&E archaeologist's call and informed PG&E that the most likely Native American Chumash Tribe descendant (hereafter referred to as descendant) would be called. In accordance with California Health and Safety Code, Section 7050.5, the descendant has 48 hours to respond to the CNAHC's call. The descendant was also called by the PG&E archaeologist. A message was left on the answering machine of the descendant's daughter.

On July 21, 1995, the CNAHC called the PG&E archaeologist and informed him that the descendant did not respond within the mandatory 48 hours. The next descendant on the CNAHC's list was then called.

On July 22, 1995, the descendant called and informed the PG&E archaeologist that he and some family members would come out to examine the human remains.

On July 22, 1995, the descendant, his wife, and son came to SLO-2 to perform a ceremony and view the remains. PG&E and the descendant agreed to leave the burial site as found, to be washed out by the sea. Subsequently, several alternative methods to deal with the remains were discussed. The descendant stated that he would inform the Chumash elders of the exposed burial. The descendant also stated that he would notify the PG&E archaeologist of the elder's desire as to how they would like the final disposition of the remains to be handled.

On July 31, 1995, the descendant called the PG&E archaeologist and informed him that the Chumash elders had agreed to leaving the burial where it was found. The descendant also informed the PG&E archaeologist that the first descendant called by the CNAHC was also notified.

3. UNUSUAL OR IMPORTANT ENVIRONMENTAL EVENTS (EPP 4.1)

No unusual or important event that would indicate or could result in a significant environmental impact causally related to station operations occurred in 1995. Environmental studies have been performed at DCPP since 1966. Results of these studies are tracked to identify unusual or important environmental events.

Monitoring of endangered or threatened species conducted during 1995 is summarized in the following sections. There is no indication that plant operation adversely affected any of the endangered or threatened species studied.

3.1 PEREGRINE FALCON

During the 1995 nesting season, the Santa Cruz Predatory Bird Research Group conducted peregrine falcon observations at DCPP. The nesting pair of falcons on Diablo Rock were incubating eggs by mid-March. Unfortunately, the first clutch of eggs failed due to flooding of the nest site caused by late seasonal rains. In May, the peregrines moved the nest site to a new location on Diablo Rock, and a second clutch of eggs produced one male chick. The Santa Cruz Predatory Bird Research Group banded the male fledgling in June. In July they captured the adult female peregrine for examination, banding, and blood samples. She was subsequently released unharmed at the site of capture.

3.2 SOUTHERN SEA OTTER

Sea otters in the vicinity of DCPP property were observed two times per month from January through December. The core population increased from 60 to 70 individuals. Sightings ranged from a high of 113 in the spring to a low of 36 in the winter. Females and pups continue to dominate, representing about 95 percent of the resident population. Otters continued to use the Intake Cove at DCPP as one of their major resting and haulout sites. In addition to normal observations, a dead adult female otter was found floating in the Intake Cove on March 20, 1995. The otter was turned in to the CDF&G. A necropsy revealed that the otter died of an infectious disease (valley fever or *coocidiomycosis*), and its death was unrelated to plant operations.

3.4 CALIFORNIA GRAY WHALE

California Gray Whales were monitored three times a week during the migratory period. A total of 193 whales were observed in the DCPP study area. The first southerly migrating whale was sighted December 29, 1994, and the last northerly migrating whale was observed April 27, 1995. The 1994/1995 gray whale migration was similar in abundance and migration patterns to the previous season.

3.5 BROWN PELICAN

Weekly brown pelican counts were conducted between May and November 1995. The average number of brown pelicans observed was 22.8 birds per hour, with a minimum of 0 and a maximum of 173 birds per hour. Monthly averages ranged from 3.0 birds per hour in May to 47.6 pelicans per hour in September. Brown pelican abundances were lower than levels observed in previous years.

3.6 ELEPHANT SEALS

No elephant seals were observed in the haulout site within the Intake Cove at DCPP during 1995. In addition, no ancillary observations of elephant seals were reported in the vicinity of DCPP. Elephant seals began using the Intake Cove haulout site in 1986. The absence of seals since the end of 1992 appears to be unrelated to plant operations. Increased use of an established haulout site at Point Piedras Blancas may help explain the lack of use of the DCPP haulout site.

4. PLANT CONSISTENCY REQUIREMENTS

4.1 DESIGN CHANGES

No design changes, tests, or procedures involved an unreviewed environmental question in 1995 as determined by the Plant Staff Review

Committee (PSRC). Ten design changes were considered to have the potential to affect the environment. A summary of the environmental evaluations for each of the design change packages (DCPs) is presented below:

DCP-E-049099/050099: These DCPs provided the replacement of 60 batteries in Units 1 and Unit 2 battery rooms with larger cell batteries to increase the capacity (ampere-hours) available. The new batteries contain a larger amount of sulfuric acid in each cell. The increase in amount of sulfuric acid for each units' battery room was approximately 60 gallons. The change did not result in the creation of a new significant waste stream and did not result in a change to the DCPP Hazardous Waste Operations Plan.

DCP-P-049149: This DCP provided the modification of the emergency diesel fuel oil (DFO) transfer piping after discovery of a potential nuclear safety seismic design deficiency. After review by the PSRC and the NRC, Operability Evaluation 94-15 was issued on December 23, 1994. During installation of the expansion joints to correct the deficiency, no environmental hazards were added.

DCP-M-49184: This DCP provided the repair of corrosion pits discovered in the walls of both DFO Storage Tanks (DFOST) 0-1 and 0-2 during installation of the expansion joints described above in DCP-P-049149. The change provided for the non-structural repair of one through wall hole at the top of DFOST 0-1 and the application of Belzona to the pitted areas of both tanks. No DFO leaks had occurred and no contaminated soil was discovered. During repair to the tanks, no environmental hazards were added. Both DFOST 0-1 and 0-2 are scheduled to be replaced during the summer of 1996.

DCP-C-50158: This DCP provided the installation of a galvanic cathodic protection (CP) system and a CP monitoring system inside the Unit 2 circulating water conduits. The aluminum anodes installed will emit trace levels of copper, aluminum, indium, and zinc to the cooling water. The calculated concentrations are below NPDES permit levels. No environmental hazards were added by this change.

DCP-A-50234: This DCP provided the application of a non-toxic anti-fouling coating to the circulating water forebays in the 2,500 square feet before each circulating water pump. The coating in the forebay will control the growth of barnacles which grow and slough, eventually requiring a generation curtailment to clean the plugged condenser. No environmental hazards were added by this change.

<u>DCP-E-49249:</u> This DCP provided the temporary installation of two new transformers "piggy backed" together to step down voltage from 25 kV to 12 kV; thereby, replacing the Unit 1 Auxiliary Transformer (AT) 1-1 destroyed in October 1995. The amount of transformer oil stored onsite increased by 3,300 gallons as a result of this design change.

<u>DCP-M-49225:</u> This DCP moved the sodium hypochlorite and sodium bromide storage tanks at the intake structure to an adjacent area. The tanks were relocated to support the routing for the new auxiliary salt water (ASW) bypass piping that was passing under the existing storage tank locations. No environmental hazards were added by this change.

<u>DCP-E-49254:</u> This DCP provided the permanent installation of AT 1-1 to replace the "piggy backed" transformers installed with DCP-E-49249. The replacement transformer was installed in March 1996. The amount of transformer oil in the new transformer is 1146 gallons more than the amount in the destroyed transformer.

<u>DCP-C-49147:</u> This DCP provided release detection monitoring for the DFO piping located in the DFO pump vault. No environmental hazards were added by this change.

5. PLANT REPORTING REQUIREMENTS

5.1 EPP NONCOMPLIANCE

There were no EPP noncompliances during 1995.

5.2 CHANGES IN STATION DESIGN

None of the changes in plant design or performance of tests, or experiments involved an unreviewed environmental issue or a change to the EPP as determined by the PSRC.

5.3 NONROUTINE REPORTS

There were two nonroutine reports made to the NRC of environmental events during 1995:

1) A sodium hypochlorite spill of approximately 3700 gallons occurred at the Ionics make-up water treatment facility located directly east of the power plant. The sodium hypochlorite flowed to an asphalt culvert leading to Diablo Creek. The spill apparently only reached the dry portion of the creek bed. This was verified by three water samples taken at the creek near the culvert. In two samples,

chlorine was not detected. In the third sample, chlorine was detectable at just above the detection limit. An additional sample taken at the discharge of the creek into the ocean detected no chlorine. A biologist performed an inspection to analyze the condition of the creek. No adverse effect to flora and fauna was noted in the vicinity of the creek water.

2) Near the end of the Unit 1 seventh refueling outage, AT 1-1 failed due to a ground fault. The AT 1-1 case ruptured, releasing coolant oil.

Hazardous materials personnel responded, as well as the fire brigade, to contain oil loss from AT 1-1. The transformer oil (AT 1-1 normally contains 3,400 gallons of mineral oil), combined with fire water, was collected in the oily water separator (OWS) leading to NPDES Discharge 009. A very small amount of oil remained in the water discharged from the OWS. This water flowed into Diablo Creek producing a sheen on water in lowflow areas of Diablo Creek. No sheen was visible in Diablo Cove. With the support of a contract disposal firm, the oil remaining in the OWS was loaded into vacuum trucks and transported offsite for disposal. The hazardous material team performed cleanup activities to remove residual oil in the yard and drainage path areas during the next several days.

PG&E placed oil booms and oil absorbent pads across Diablo Creek downstream of the entrance of Discharge 009 into the creek bed. Several samples were taken to measure concentrations of oil and grease (O&G) downstream of the last boom, as well as one sample taken before the first boom and directly from Discharge 009. Of the samples taken, 2 of the 11 samples were higher than the allowable daily maximum of 20 mg/l. The sample concentrations were 24 mg/l and 75 mg/l. The remainder of the sample results were less than 8 mg/l and all were reported in the 1995 4th Quarter NPDES Report for DCPP.

5.4 1995 NPDES Report Summary

DCPP experienced the following eight additional discharges during 1995. The discharges were reported to the CCRWQCB in accordance with the NPDES permit.

1) Approximately 125 gallons of Acti-Brom 1338 Biodispersant (sodium-bromide) was released onto the asphalt at DCPP's cooling water intake structure. Of the 125 gallons released, approximately

50 gallons of Acti-Brom was released to the Pacific Ocean. The DCPP Hazardous Materials Response Team was immediately activated. Immediate mitigation included placement of absorbent material on and around the contaminated area.

2) Approximately 1 cubic foot of ion exchange resin was transported to NPDES Discharge 014 (a storm drain leading to Diablo Creek) as a result of heavy rains. The resin was not hazardous and no visible traces of the resin were observed in Diablo Creek.

3) During one manual circulating water conduit chlorination evolution, the chlorination injection time exceeded the permitted limit of 2 hours by 20 minutes. Simultaneous injections also occurred during this time period, violating the requirement of a 30 minute time period between chlorinations of individual conduits. The discharge concentration limits for chlorine were not exceeded.

4) During two 20 minute chlorination cycles, the chlorine discharge limit was exceeded. The concentration for these time periods at the discharge were 149 ppb while the limit was 89 ppb.

5) The sanitary wastewater treatment system, Discharge 001N, exceeded NPDES O&G effluent limits. One O&G sample was measured at 147 mg/l; thereby, exceeding the NPDES daily maximum limit of 20 mg/l. The high daily maximum result caused the 30-day average limit of 15 mg/l to be exceeded during that month. The 30-day average concentration reported for O&G for that month was 29 mg/l.

6) 1150 gallons of Intake Cooling Water (ICW) containing the microbiocides glutaraldehyde and isothiazoline was drained out NPDES Discharge 002. In a PG&E letter dated July 19, 1995 (DCL-95-156), to the CCRWQCB, PG&E had committed to directing all future ICW discharges to NPDES Discharge 001 when the new microbiocide isothiazoline was used in conjunction with glutaraldehyde.

7) During an equipment inspection prior to initial operation of the kelp harvester for the day, the operator noticed a small oil sheen on the water under the kelp harvester. The source of the oil was determined to be a leaky hydraulic fitting on the motor. It was estimated that only a few drops (less than an ounce) of hydraulic fluid actually reached the Intake Cove.

8) 120 gallons of the ICW system were drained to Discharge 002, instead of Discharge 001, as was committed by PG&E in a letter dated July 19, 1995 (DCL-95-156), to the CCRWQCB. In this letter, PG&E had committed to directing all future ICW drainage to Discharge 001 as new chemicals were to be added to this system as part of an effort to eliminate microbiological growth and corrosion deposits.

6. EPP AUDIT.

The PG&E Nuclear Quality Services Department performs an audit of the implementation of the EPP each year. The audit of the EPP implementing activities performed in 1994 was conducted during March 14 - March 29, 1995. This audit was conducted in accordance with Section 5.1 of the EPP. The results of the audit indicated that the plant is meeting the requirements of the EPP and its associated documents. Results of the audit are available for inspection.

Pacific Gas and Electric Company

Diablo Canyon Power Plant
P.O. Box 56
Avila Beach, CA 93424
805/545-6000

John D. Townsend
Vice President–Diablo Canyon
Operations and Plant Manager

CENTRAL COASTAL REGIONAL WATER QUALITY CONTROL BOARD
RECEIVED
MAY 17 1993
SAN LUIS OBISPO CALIFORNIA

May 13, 1993

PG&E Letter No. DCL-93-117

William R. Leonard, Executive Officer
California Regional Water Quality Control Board
Central Coast Region
81 Higuera, Suite 200
San Luis Obispo, CA 93401-5414

Dear Mr. Leonard:

Removal of Intake Screen Wash System Refuse Collection Baskets
Diablo Canyon Power Plant---EPA ID No. CA0003751

PG&E is requesting permission to remove the corroded refuse collection baskets assemblies from the seawater intake screen wash system, Discharge 003. These baskets, which are located on the refuse sump (collection pit) screen, act to collect debris (mostly kelp) washed from the traveling screens. Removal of the baskets will allow the material that is native to the ocean to be pumped back to the ocean via Discharge 003. Removal of the baskets would return the screen wash system to the original design configuration.

Review of the 316(b) Study Plan indicated that these baskets were installed for sample collection during the impingement studies. The baskets were described in the 1985 NPDES permit when the impingement studies were underway and remained in the 1990 NPDES permit; however, they were not described in the 1982 NPDES permit prior to the 316(b) Study. The 1982 NPDES permit (Order 82-24) described Discharge 003 as "Solid material collected on the intake screens that is native to the ocean will be pumped back to the ocean at a point located at the foot of the west breakwater of the intake cove."

Presently, PG&E is evaluating the various options to remedy the corroded refuse collection basket assemblies. PG&E is seeking your advance aproval to remove the refuse collection basket assemblies in the event this option is selected. Please indicate approval by signing in the space provided below and returning a copy of this letter in the enclosed self-addressed envelope.

If you have any questions, please contact Thomas Wilson at (805) 545-4439 or Valarie Gill at (415) 973-8086.

Sincerely,

Dave Mikliush for
John D. Townsend
JDT

Approval Granted Medley E. Hagemeyer Date 7/7/93
Sr. Engineer

6095S/85K/ERK/935

STATE OF CALIFORNIA PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD —
NTRAL COAST REGION
IGUERA STREET, SUITE 200
SAN LUIS OBISPO, CA 93401-5414
(805) 549-3147

February 21, 1995

Mr. James A. Sexton, Manager
Pacific Gas & Electric Company
Nuclear Regulatory Services, A10A
Post Office Box 770000
San Francisco, CA 94177

Dear Mr. Sexton:

Enclosed is a copy of Monitoring and Reporting Program No. 90-09, which was adopted by this Board on February 10, 1995. This program replaces the Monitoring and Reporting Program attached to Order 90-09, NPDES Order No. CA0003751, Waste Discharge Requirements for Pacific Gas and Electric Company, Diablo Canyon Nuclear Power Plant, Units 1 and 2, San Luis Obispo County.

Sincerely,

CALIFORNIA REGIONAL WATER QUALITY
CONTROL BOARD, CENTRAL COAST REGION

BY________________________
for ROGER W. BRIGGS
Executive Officer

jmdcmp

Enclosures

cs: Jim Kassel
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Jennifer Soloway,
Office of Chief Counsel
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Regional Administrator, Reg. IX
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John S. Stephens, Jr.
Vantuna Research Group
Occidental College
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Mr. Laurence L. Laurent
Board of Supervisors
County Government Center
San Luis Obispo, CA. 93408

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

MONITORING AND REPORTING PROGRAM NO. 90-09

FOR
PACIFIC GAS & ELECTRIC COMPANY
DIABLO CANYON POWER PLANT
UNITS 1 AND 2
SAN LUIS OBISPO COUNTY

Influent Monitoring

A sampling station shall be established at a point upstream of any treatment process where representative samples of the influent can be obtained. The following shall constitute the influent monitoring program:

Parameter	Units	Type of Sample	Minimum Frequency of Analysis
Temperature	°F	Metered	Continuously*
pH	-	Grab	Monthly
Arsenic	mg/l	Grab	Annually (Oct)
Cadmium	mg/l	Grab	Annually (Oct)
Total Chromium	mg/l	Grab	Quarterly (Jan.Apr.Jul.Oct.)
Nickel	mg/l	Grab	" " "
Copper	mg/l	Grab	" " "
Lead	mg/l	Grab	Annually (Oct)
Mercury	mg/l	Grab	Annually (Oct)
Silver	mg/l	Grab	Annually (Oct)
Zinc	mg/l	Grab	Annually (Oct)
Cyanide	mg/l	Grab	Annually (Oct)
Phenolic Compounds (Non-chlorinated)	mg/l	Grab	Annually (Oct)
Chlorinated Phenolics	mg/l	Grab	Annually (Oct)
Ammonia (as N)	mg/l	Grab	Quarterly (Jan,Apr,Jul,Oct)

*In the event continuous temperature measurement systems are <u>temporarily</u> inoperative, an alternate means of measurement or calculating providing equivalent information may be used during this period.

Effluent Monitoring

A sampling station shall be established for each waste discharge and shall be located where representative samples of the discharge can be obtained. The following shall constitute the effluent monitoring program:

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Temperature	°F	001	Metered	Continuously***
Flow	MGD	001	Recorded from pump operating data	Daily
pH	-	001P, 002, 003, & 004	Grab	Monthly
pH	-	001	Grab	Daily when discharging chemical cleaning wastes from 001D F,I,L, and/or M Otherwise monthly grab sample.
Grease & Oil	mg/l	001F	Grab	Monthly
Grease & Oil	mg/l	001N	Composite	Weekly during one discharge cycle
Grease & Oil	mg/l	001D,001G 001H,001I, 001J,001K, 001L,001M, 001P**** 002, 003*****, & 004	Grab	Quarterly (Jan.Apr.Jul.Oct.)
Suspended Solids*	mg/l	001D,001F 001G,001H, 001I,001J, 00lK, 001L, 001M, 001P**** & 002	Grab	Monthly
Suspended Solids	mg/l	001N	Composite	Weekly during one discharge cycle

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Suspended Solids	mg/l	003	Grab	Monthly when 001P discharges to 003. Weekly when 001N and 001P discharge to 003
Settleable Solids	ml/l	001N	Grab	Weekly
Arsenic	mg/l	001	Grab	Annually
Grease & Oil	mg/l	005, 008, 009, 013, 015, 016, & 017	Grab	Annually
Cadmium	mg/l	001	Grab	Annually
Total Chromium	mg/l	001	Grab	Monthly
Copper	mg/l	001	Grab	Monthly
Copper	mg/l	001D, 001F, 001I, 001L, & 001M	24-hr. Composite	Daily during metal cleaning operations
Lead	mg/l	001	Grab	Annually
Mercury	mg/l	001	Grab	Annually
Nickel	mg/l	001	Grab	Monthly
Silver	mg/l	001	Grab	Annually
Zinc	mg/l	001	Grab	Monthly
Cyanide	mg/l	001	Grab	Annually
Phenolic Compounds (non-chlorinated)	mg/l	001	Grab	Annually
Chlorinated Phenolics	mg/l	001	Grab	Annually
Total Chlorine Residual	mg/l	001	Grab	At least twice during each chlorination cycle
Chlorine Used	lbs/day	001	Record of actual amount used	Monthly
Ammonia	mg/l	001	Grab	Quarterly
Toxicity Concentration**	tu	001	Grab	Quarterly
PCB's	mg/l	001	Grab	Annually

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Iron Cleaning	mg/l	001D,001F, 001I,001L, & 001M	24-hr. Composite	During metal operations
Titanium	mg/l	001	Grab	Annually
Lithium, Boron Hydrazine	mg/l	001D	Grab	Annually
Cadmium, chromium, copper, lead, mercury nickel, silver, zinc	mg/l	001D,001H & 001L	Quarterly Composite	Quarterly (Jan,Apr,Jul,Oct)
Cadmium, chromium copper, lead, mercury, nickel, silver, zinc	mg/l	001F	Weekly Composite	Quarterly (Jan,Apr,Jul,Oct)

Intake and discharge samples, when required, shall be coordinated so as to sample the same water mass (intake sampling time plus plant and conduit detention time yields discharge sampling time).

*The suspended solids analysis of waste streams with a high concentration of dissolved solids shall be modified as follows: after determination of the suspended matter by the Standard Methods Technique, a second determination using the identical procedure shall be made of the suspended matter in the filtrate. Both the first and second determinations as well as the difference between the two amounts shall be reported. The calculated difference shall be considered the concentration of suspended solids in the effluent.

**Static bioassays (96-hr. TLm) using species indigenous to Diablo Cove (including red abalone and blue rock fish, when available), but obtained elsewhere, shall be conducted using water being discharged to Diablo Cove.

***In the event continuous temperature measurement systems are <u>temporarily</u> inoperative, an alternate means of measurement or calculating providing equivalent information may be used during this period.

****Minimum frequency of analysis shall be weekly when 001N discharges to 001P.

*****Minimum frequency of analysis shall be weekly when 001P discharges to 003.

The State Water Resources Control Board and the Department of Fish and Game have issued <u>Guidelines for Performing Static Acute Toxicity Bioassays.</u> The guidelines contain the following reference to sample collection:

> "Samples must be collected in thoroughly cleaned containers. Containers should be completely filled with the effluent before capping. Sample degradation by biological action can be minimized by storing samples at 4 degrees C. Tests should begin as soon as possible after collecting the sample. Where samples are known to contain volatiles that may be toxic, or where samples may undergo rapid changes, bioassay tests must be conducted within 24 hours after the samples are collected."

Note that 24 hours is the total maximum time allowed from sample collection to the <u>start</u> of the test including all transit time and is allowed <u>only</u> for refrigerated samples.

Sludge Monitoring

A representative sample of sanitary wastewater treatment system residual solids (sludge) as obtained from the last point in the handling process before disposal (i.e., in the drying beds just prior to removal) shall be analyzed for the following constituents at the frequencies listed below. All constituents shall be analyzed for total concentrations for comparison with TTLC criteria. The Waste Extraction Test shall be performed on any constituent when the total concentration of the waste exceeds ten times the STLC limit for that substance.

Constituent	Units	Type of Sample	Minimum Frequency of Analysis
Quantity	Tons or yds^3 Location of Disposal	measured	During Removal
Moisture Content	%	Grab	Annually (October)
Total Kjeldahl Nitrogen	mg/kg	Grab	" "
Ammonia (as N)	mg/kg	Grab	" "
Nitrate (as N)	mg/kg	Grab	" "
Total Phosphorus	mg/kg	Grab	" "
pH	-	Grab	" "
Grease & Oil	mg/kg	Grab	" "
Boron	mg/kg	Grab	
Cadmium	mg/kg	Grab	" "
Copper	mg/kg	Grab	" "
Chromium	mg/kg	Grab	" "
Lead	mg/kg	Grab	" "
Nickel	mg/kg	Grab	" "
Mercury	mg/kg	Grab	" "
Zinc	mg/kg	Grab	" "

Receiving Water Monitoring

Receiving Water Monitoring shall be conducted as outlined below:

1. The Ecological Monitoring Program (Attachment One) shall be conducted to assess possible impacts due to sources of pollution, including elevated temperature. Thermal effects studies, targeted to supply information not previously generated by the Thermal Effects Monitoring Program (TEMP), will be designed and conducted after completion of a comprehensive assessment by a committee of interested parties. The committee will include Pacific Gas and Electric (and/or their consultant) biological personnel, Department of Fish and Game biologists, Regional Board personnel, and possibly other interested parties. They will assess all previous data and design studies as needed. Proposed studies will be in addition to the present monitoring program.

2. Water temperature shall be measured as noted in the Ecological Monitoring Program in Attachment One.

3. Dissolved oxygen measurements shall be recorded at the same stations as 2 above, at ocean surface, mid-water, and bottom depths.

4. An acceptable monitoring program shall be designed and conducted to determine the effects of shell debris and foam, generated by the discharge, on the Diablo Cove environment.

5. In-situ bioaccumulation monitoring, as approved by the Executive Officer, shall continue until such time that the Board determined it is no longer of benefit. Results shall be transmitted simultaneously to the Regional Board and the State Water Resources Control Board. (Deviations from the sampling schedule is permissible if specimen cannot be collected due to: hazardous sea conditions, seasonal unavailability, or inability to locate with reasonable effort).

6. For the duration of a discharge from 001N to 003, grab samples shall be collected four times per week along the ocean-side of the western-most breakwater. Samples shall be collected at the water's surface, within ten feet of either side of discharge 003, on an incoming tide. Samples shall be analyzed for total and fecal coliform.

Reporting

The Discharger shall comply with the following:

1. Influent and effluent monitoring shall be submitted Quarterly by the 20th day of the month following the end of each quarter.

2. Receiving water monitoring shall be submitted twice annually within two months following completion of surveys.

3. Notwithstanding Standard Provision C.4, details of any bypass or damage of the five-micron filters in the liquid rad-waste system shall be reported to the Executive Officer immediately.

4. A copy of information contained in reports to the Nuclear Regulatory Commission and/or the California Department of Health Services related to the marine environment shall be submitted to the Executive Officer. Results of radiological monitoring of the receiving water shall be reported at the same time reports are made to the Nuclear Regulatory Commission.

5. Pump station failures resulting in discharges of sewage effluent from 00lN to the intake cove or 003 shall be reported to Regional Board staff within 24 hours. Written confirmation of this discharge or rerouting to the existing leachfield shall be included in the next regular monitoring report.

6. Written confirmation of a temporary rerouting of 001P to 003 shall be included in the next regular monitoring report with an explanation of the need for the rerouting.

7. By February 28 of each year, the discharger shall submit an annual report to the Regional Board. The report shall contain both tabular and graphical summaries of the monitoring data obtained during the previous year. The discharger shall discuss the compliance record and corrective actions taken, or which may be needed, to bring the discharge into full compliance. The report shall inform the Board of the date of the Facility's Operation and Maintenance Manual (including contingency plans as described in Provision A.21.), of the date the manual was last reviewed, and whether the manual is complete and valid for the current facility. The report shall restate, for the record, the laboratories used by the discharger to monitor compliance with effluent limits and provide a summary of performance relative to section B, General Monitoring Requirements.

ORDERED BY Paul Jorgensen
for Executive Officer

February 10, 1994
Date

JRN/pgediabl.mr1

DIABLO CANYON POWER PLANT
ECOLOGICAL MONITORING PROGRAM

This program includes a scaled down version of TEMP and is designed to discern possible impacts due to the discharge. The program components provide continuity with methodology and sampling locations used in the previous Thermal Effects Monitoring Program (TEMP) studies. The biological database from the 19 year TEMP studies provide a sound historical basis for assessing any perturbations detected by this program. If a problem is detected, a follow-up monitoring program will be designed to determine the extent of impact. Thermal effects studies, targeted to supply information not previously generated by the Thermal Effects Monitoring Program (TEMP), will be designed and conducted, after completion of a comprehensive assessment by a committee of interested parties. The committee will include Pacific Gas and Electric and/or their consultant, Department of Fish and Game biologists, Regional Board personnel, and possibly other interested parties. They will assess all previous data and design studies as needed.

INTERTIDAL MONITORING

The intertidal monitoring program includes horizontal band transects and black abalone studies within Diablo Cove, in Field's Cove, and at reference stations located to the north and south of Diablo Canyon. Surveys for horizontal transects will be conducted twice annually. Scheduling of surveys will be adjusted to coincide with the annual peaks and lows in algal abundance. A summer survey will usually be conducted during the period of June-July and a winter survey will be conducted during the period of December-February. Vertical band transect surveys (not part of the base monitoring program) will be implemented as necessary to verify or explain changes'in abundance organisms along the horizontal band transects that may be attributed to shifts in vertical distribution. Temperat monitoring is conducted continuously at the 7 horizontal band transect stations.

Data collection for the horizontal band transect tasks will focus on a set of species selected by agreement among CDF&G, PG&E, and RWQCB staff. These species will be selected based on their numerical dominance in the community, and their ecological or commercial importance. The presence and condition of other species will also be noted during each survey.

Horizontal Band Transects

The horizontal band transect stations consist of ten-1m^2 quadrants located along permanent 30m transects at the +3 foot (MLLW) and +1 foot (MLLW) tide levels. Sampling will be conducted at four locations in Diablo Cove; at Stations 8 and 9 in the north area of the cove, and at Stations 10 and 12 in south Diablo Cove. Sampling will also be conducted at Station 6 in Fields Cove and in reference areas north of Diablo Cove at Station 1, and south of Diablo Cove in Patton Cove at station 19 (see accompanying map for station locations). The abundance of selected dominant algae and invertebrates will be monitored twice annually at each station.

Black Abalone Census

Black Abalone (*Haliotus cracherodii*) within and outside Diablo Cove will be surveyed annually to determine their abundance, size frequency distribution, and condition. The Diablo Cove population will be monitored using ten permanent transects which extend through the mid-intertidal along the entire shoreline of the cove (see attached map showing black abalone stations <u>within</u> Diablo Cove). Random distances above and below the transect will be used to position 1 m^2 quadrants between the 0 and +4ft tide levels. Black abalone in each quadrant will be counted and their size estimated. Black abalone, at ten locations outside Diablo Cove, (see attached map showing abalone stations <u>outside</u> of Diablo Cove) will be monitored using fixed 2x10m transects at each site. All abalone along each trans

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will be counted and their size estimated. Additionally, qualitative surveys will be conducted to determine the geographical extent of the atrophied foot condition.

Supplemental Intertidal Task
Vertical Band Transects

Vertical band transects, located at Stations H, C and L (see accompanying map) are surveyed as necessary as a supplement to the horizontal band transect task. Each station consists of three vertically oriented transects which contain twelve one-meter square quadrants. Each transect runs from approximately the +4 to the -1 foot (MLLW) elevation. The presence and general condition of dominant algae and invertebrates are recorded in each quadrant.

SUBTIDAL MONITORING

The subtidal monitoring consists of an annual kelp survey, and twice annual red abalone and fish transect surveys. Assessments of subtidal kelp, algae, and invertebrate populations in Diablo Cove and other locations will be recorded during the red abalone surveys. The two annual subtidal fish transect surveys are scheduled during late spring (May-June) and late summer (August-September) when juvenile rockfish recruitment is normally occurring.

Habitat Forming Kelp Surveys

An annual census of habitat forming kelp at the above areas will be performed to count surface bull kelp *(Nereocystis luetkeana)* and estimate the areal coverage of giant kelp *(Macrocystis spp.)* and other species. The survey will be conducted each fall (September-October) to reflect peak surface canopy development. Counts and coverage estimates will be made from permanently marked vantage points above the areas. A composite map of the visible kelp stands will be constructed.

Red Abalone Census

Red abalone *(Haliotis rufescens)* in Diablo Cove and other areas will be monitored twice annually to estimate the abundance and condition of the populations. The study design uses a random sampling design stratified by depth. During each survey 20 stations will be monitored in Diablo Cove and 10 stations will be monitored at locations outside Diablo Cove. Each station consists of a $30m^2$ area subdivided into four quadrants. All the red abalone at each station will be counted and classified into four size categories.

Subtidal Fish Assessment

The composition and abundance of fish communities will be monitored twice annually during late spring (May-June) and late summer (August-September) when rockfish recruitment is usually occurring. Ten fish observation stations located in north and south Diablo Cove, and in areas outside Diablo Cove (see accompanying map) will be monitored each survey. Each station consists of a midwater and benthic transect line deployed prior to the survey. Each transect will be monitored twice, using two divers who monitor each area independently. The station transects are typically sampled a second time within one to two weeks of the initial effort to provide two replicate fish counts within a survey for each station. Divers will identify and enumerate all adult and juvenile fish species observed and identify the components of the habitat forming kelp associated with fish observed.

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Temperature Monitoring

Temperature is continuously monitored at hourly intervals from fixed intertidal and subtidal stations in Diablo Cove and reference areas. Intertidal temperatures are recorded at the +2 ft MLLW tidal level at the seven horizontal band transect stations. Subtidal temperatures are monitored at a total of 8 stations: 5 stations in Diablo Cove, 3 at -10 ft depth and 2 at the -15 ft depth, and in Fields Cove, Patton Cove and North Control, all at the -10 ft depth. All temperature monitoring stations are shown on the accompanying map.

TEMP Data Assessment

As part of this revision, the TEMP data will be statistically analyzed to determine the extent of change due to the warm water discharge. The schedule for completing the assessment follows:

By March 31, 1995--Interested agencies will present to Pacific Gas and Electric Company (PG&E) questions they want to see answered by the TEMP data and statistical methods to be used derive the information.

By May 31, 1995--PG&E Will submit to interested agencies a study plan designed to fulfill the requests regarding questions and statistical methods.

By June 30, 1995--Interested agencies will review and comment on the adequacy of the study plan.

By July 31, 1995--PG&E will finalize study plan and begin work on the assessment.

By December 31, 1995--PG&E will present a draft TEMP Assessment Report to interested agencies for review and comments.

By January 31, 1996--Interested agencies will review and comment on the adequacy of the TEMP Assessment Report.

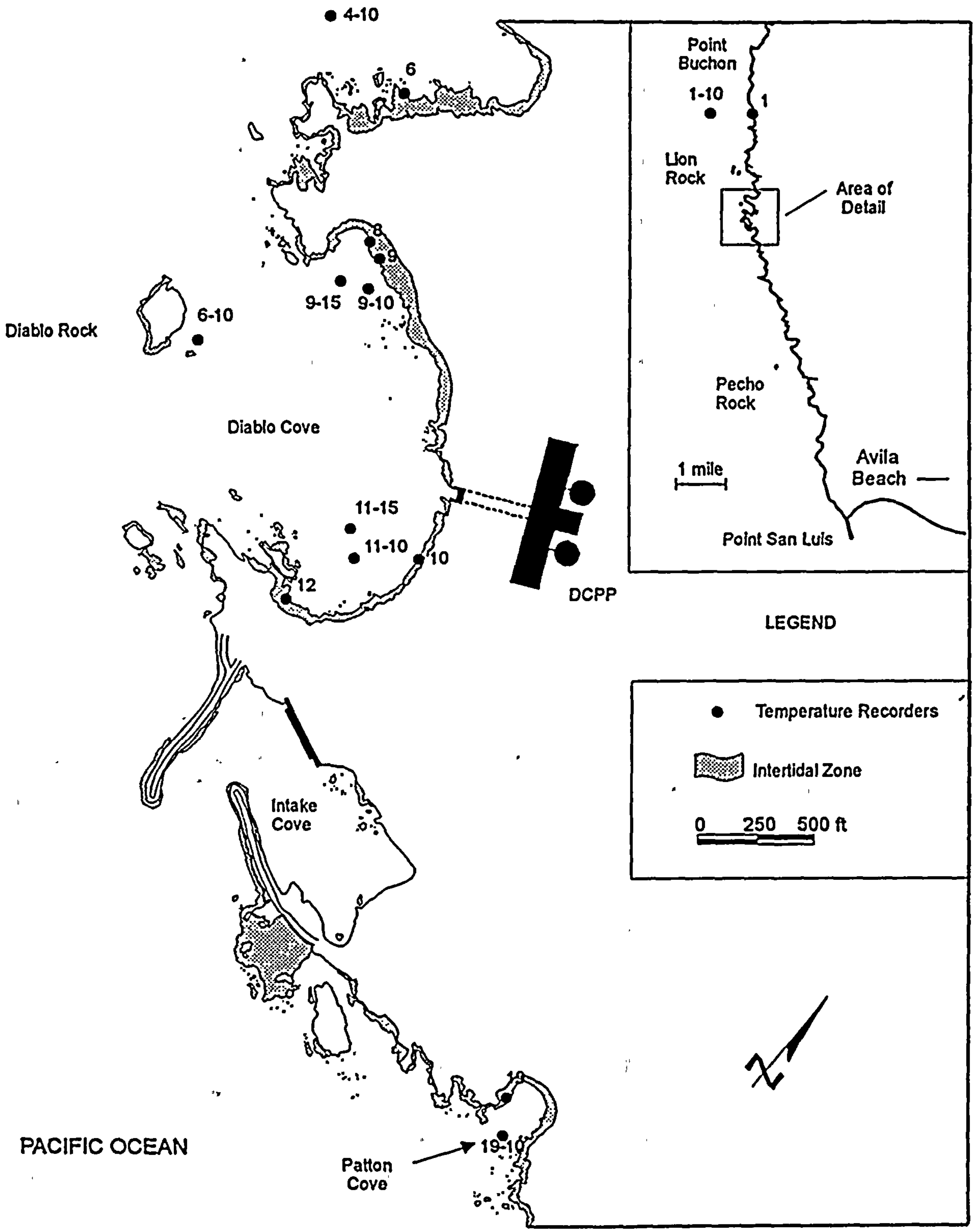
By March 31, 1996--PG&E will submit a final TEMP Assessment Report to interested agencies.

Reporting

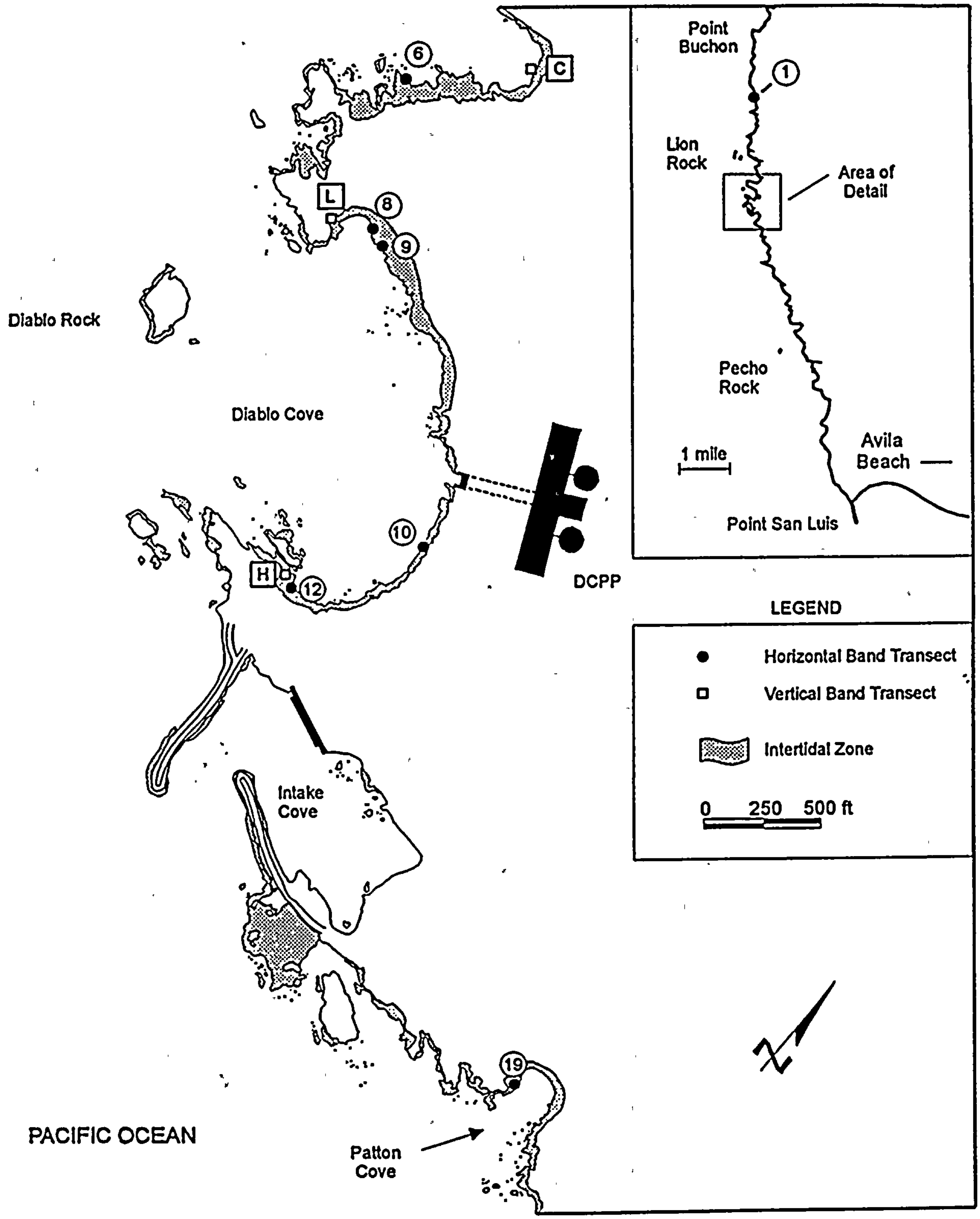
Summary reports shall be submitted to the Regional Board within two months of completion of the summer and winter surveys. Substantive changes in community composition from historical trends or the presence of adverse condition factors shall be reported immediately to the Regional Board.

JRN/attch.one

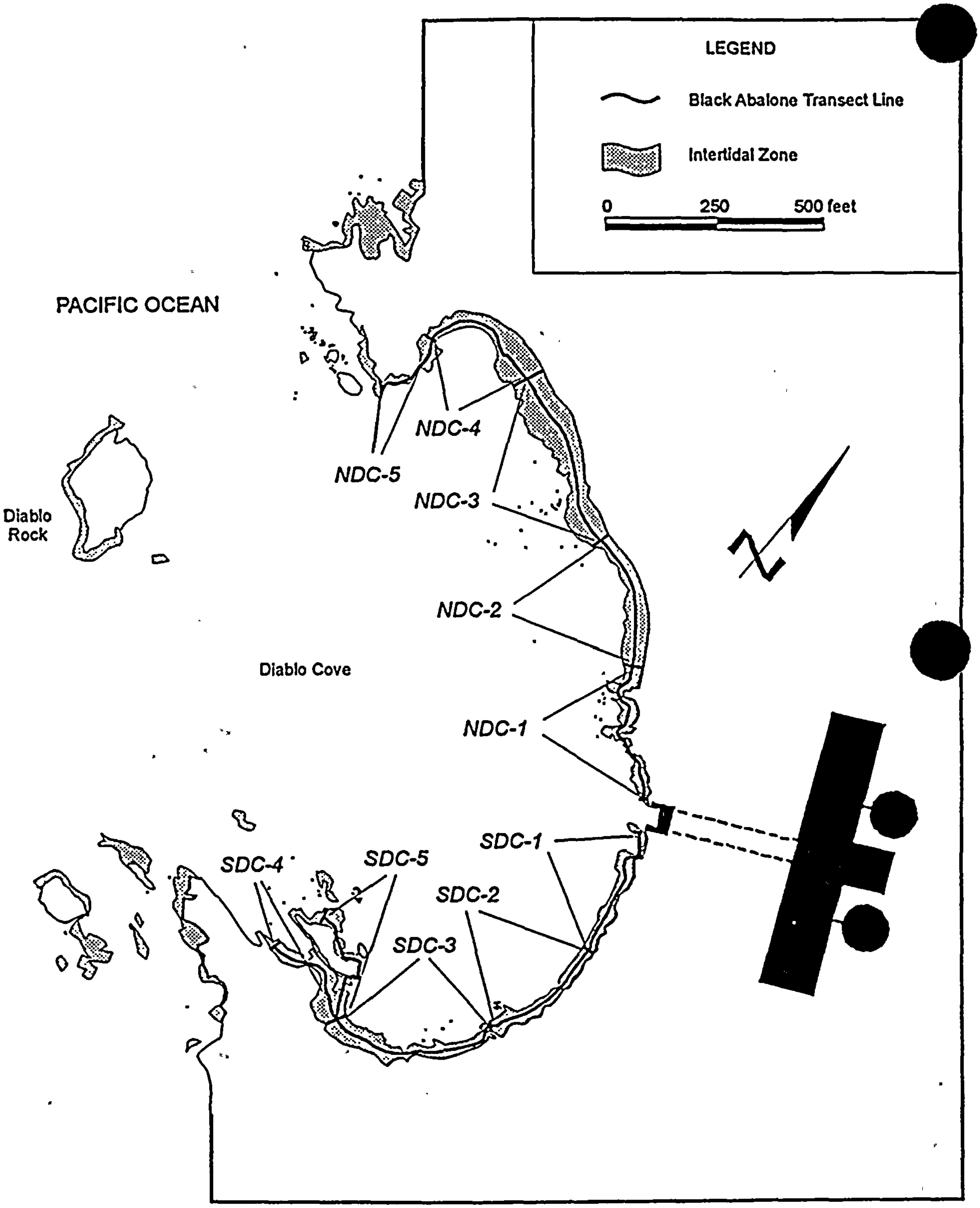
ATTACHMENT ONE



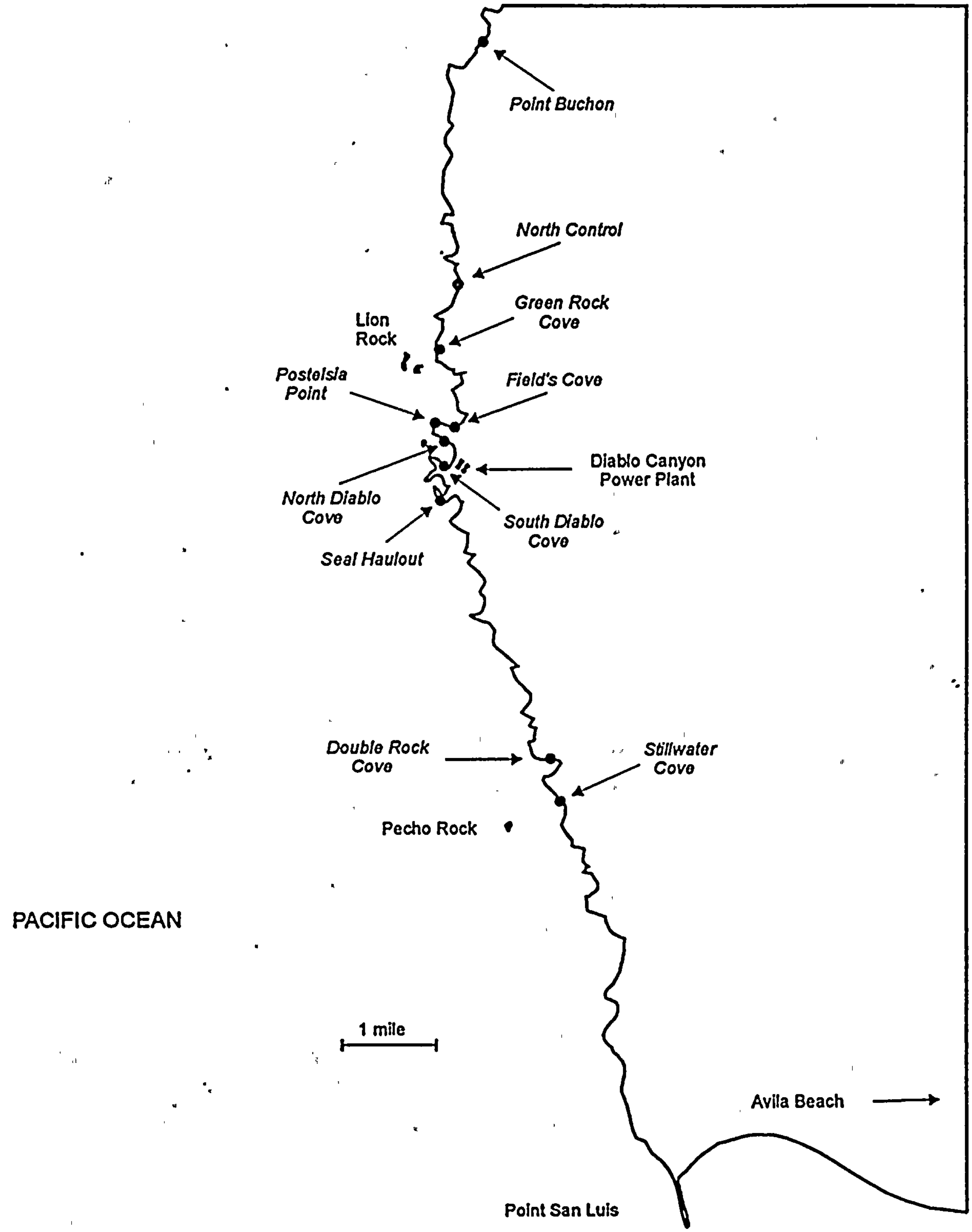
Locations of Temperature Stations



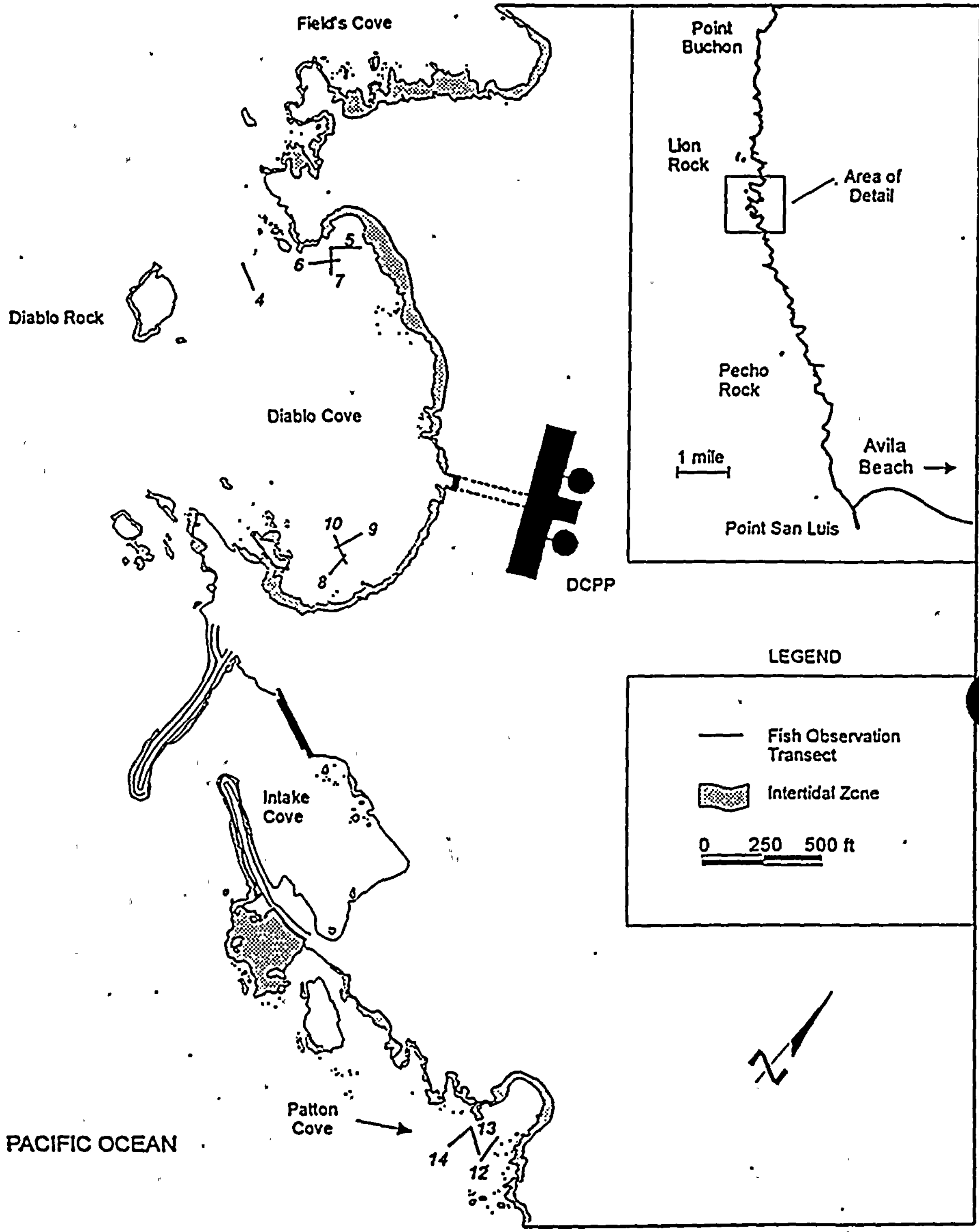
Locations of Intertidal Sampling Stations



Locations of Black Abalone, *Haliotis cracherodii*,
Diablo Cove-Wide Transect Sampling Stations



Locations of Black Abalone, *Haliotis cracherodii*, 10-Meter Transect Stations



Locations of Fish Observation Transects

STATE OF CALIFORNIA PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD —
CENTRAL COAST REGION
81 HIGUERA STREET, SUITE 200
SAN LUIS OBISPO, CA 93401-5414
(805) 549-3147

Diablo Canyon
Vice President &
Plant Manager

JAN 1 1996

RIP

Hays, Squyres

January 4, 1996

Warren Fujimoto, Plant Manager
Diablo Canyon Power Plant
Pacific Gas and Electric Company
P. O. Box 56
Avila Beach, CA 93424

Dear Mr. Fujimoto:

PG&E DIABLO CANYON; DISSOLVED OXYGEN MONITORING, CHLORINATION AND REPORT DUE DATES (NPDES CA0003751, ORDER 90-09)

This letter is to address several requirements specified in your NPDES Permit and Monitoring and Reporting Program (MRP) which need clarification and/or revision.

Receiving Water Monitoring for Dissolved Oxygen

Monitoring and Reporting Program 90-09 (Revised February 10, 1995) specifies Receiving Water Monitoring requirements for dissolved oxygen measurements at each temperature monitoring station (specified in the Ecological Monitoring Program) at the ocean surface, midwater and bottom depths. According to the Ecological Monitoring Program (Attachment One of MRP No. 90-09), temperature monitoring stations include seven intertidal and eight subtidal locations. This wording inadvertently included the intertidal locations as dissolved oxygen monitoring stations. The intent was that each of the subtidal temperature monitoring stations should be monitored for dissolved oxygen at surface, midwater and bottom depths on a quarterly basis.

Please modify your monitoring practices to reflect this correction. Each of the subtidal temperature monitoring stations should be monitored for dissolved oxygen at the three depth intervals. I apologize for any inconvenience this error may have caused.

Chlorination Requirements

Order No. 90-09 (page 14) specifies (in a footnote on Page 14) the following restrictions of operations resulting in discharges of chlorine:

> ***TRC may not be discharged from any single generating unit for more than two hours per day. At least thirty minutes must separate the chlorine discharge from each one-half condenser unit.

The two hour per unit per day (first sentence of the footnote) implements federal regulations (40 CFR 423). However, the 30-minute separation of discharges (second sentence of the footnote) is not based on any known regulation, plan or policy. Furthermore, the 30-minute separation appears inappropriate in light of the cooling water flow pattern at your facility. Implementation of this requirement may increase the amount of chemicals discharged by forcing longer chlorination cycles and chemical addition for dechlorination in order to comply with the first part of the footnote. Federal regulations (40 CFR 423) allow for simultaneous multiunit discharges of chlorine.

Therefore, this requirement (30-minute separation) does not appear to further our mission to protect water quality and should be eliminated, effective immediately.

Monitoring Report Due Dates

Your Ecological Monitoring Program specifies summary reports to be submitted within two months of completion of the summer and winter surveys and that the final TEMP Assessment Report shall be submitted by March 31, 1996. These dates did not account for the lengthy delays caused by implementing the multiagency workgroup. It has become evident that the dates specified in MRP No. 90-09 are not attainable and should be replaced by the schedule developed by the multiagency workgroup.

Each of the revisions described above shall be incorporated into your Waste Discharge Requirements when they are drafted for Board consideration of reissuance, anticipated next year.

If you have questions, please contact Sorrel Marks (549-3695) or Michael Thomas (542-4623) of my staff between the hours of 8:30-5:00, Tuesday through Friday.

Sincerely,

Bradley E. Hagemann

FOR Roger W. Briggs
Executive Officer

SJM/Q:diablo.ltr