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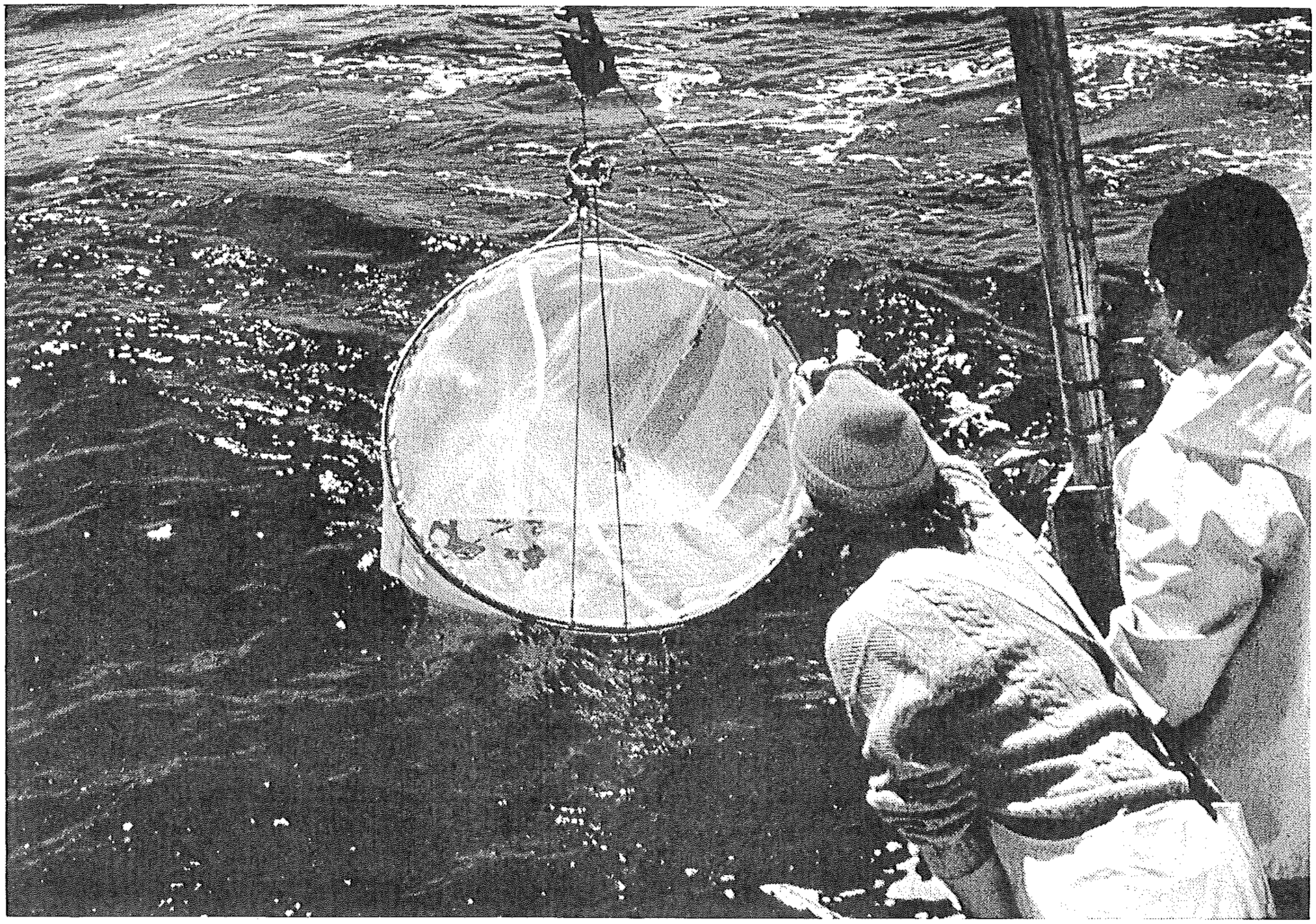
Seasonal Distribution of Plankton in the Nearshore Marine Environment of Diablo Canyon Nuclear Power Plant

by J. W. Icanberry and J. W. Warrick



Researchers Sampling Plankton and Larval Fish off Diablo Canyon

Report Issued: APR 13 1977

Report 7846.13-76

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH

SEASONAL DISTRIBUTION OF PLANKTON IN THE NEARSHORE MARINE ENVIRONMENT OF DIABLO CANYON NUCLEAR POWER PLANT

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ABSTRACT

A 15-month study was conducted to describe the seasonal distribution trends of total zooplankton and phytoplankton densities, dry weight and ash-free dry weight densities (organisms > 150 μm), and ATP (adenosine triphosphate) concentrations (representative of live biomass $\leq$ 150 μm).

Samples were collected at two stations, designated Inshore and Offshore, located 300 m and 1500 m southwest of the seaward perimeter of Diablo Cove, respectively. A 150 μm mesh 30 cm D net was hauled obliquely through the upper mixed layer. Three replicate hauls were made at each station at approximately biweekly intervals.

Statistical comparisons of total zooplankton and phytoplankton densities and ATP concentrations between the Inshore and Offshore Stations found in no significant differences. Thus, the data were combined to describe the nearshore seasonal distributions.

During the study, 168 hauls were taken and 94 zooplankton and 46 phytoplankton taxa were indentified. Five zooplankton taxa comprised 75.0 percent of the total zooplankton density and six phytoplankton taxa comprised 83.4 percent of the total phytoplankton density.

Seasonally, the greatest zooplankton densities occurred in June and July 1974. The average zooplankton density was 9,580 $(m^3)^{-1}$ for the study period. Dry weights and ash-free dry weights peaked twice during the study period, March 1974 to July 1974, and January 1975 to April 1975. The average dry weight density was 92.27 μg l^{-1}, approximately the same as the average (104.02 μg l^{-1}) reported in an earlier zooplankton study of Diablo Cove. The average ash-free dry weight was 29.75 μg l^{-1}.

The seasonal ATP distribution revealed two major peaks. The first one, April 1974 to July 1974, correlated with peak zooplankton densities and probably represents predominant zooplankton $\leq$ 150 μm. The second peak, September 1974 to February 1975, correlated with the period of peak phytoplankton densities and inversely correlated with dry weight and ash-free dry weight peak abundance periods. Thus, the second peak probably represents the increased phytoplankton density present from October 1974 to February 1975.

INTRODUCTION

To assess potential impacts on zooplankton and phytoplankton populations from Diablo Canyon Nuclear Power Plant operations, a study was conducted to determine the seasonal distribution trends of total zooplankton and phytoplankton densities, densities by species, and species composition in the nearshore marine environment of Diablo Cove. Additionally, zooplankton dry and ash-free weights and live biomass estimates were measured. Diablo Cove is located at 35°14' north latitude and 120°51' west longitude (Figure 1).

Waters (1969) conducted vertical net tows of zooplankton from 228 m to 4480 m offshore from the mouth of Diablo Cove on one date, December 5, 1967. Icanberry (1974) reported the seasonal distribution of zooplankton from Intake Cove at Diablo Canyon. There are no other known plankton studies from the immediate vicinity of Diablo Canyon. Monthly zooplankton densities were reported for Morro Bay, 19 km north of Diablo Canyon (Icanberry 1974).

METHODS

Two sampling stations, designated Inshore and Offshore, were established at 300 m and 1500 m southwest of the seaward perimeter of Diablo Cove, respectively.

Zooplankton was collected using a 30 cm, 150 μm mesh net (Kramer et al. 1972). A calibrated flowmeter (General Oceanic Model 2030) was used to quantify the water volume filtered. Three replicate hauls were made approximately biweekly at each station.

For each station occupied, surface temperature, salinity, and dissolved oxygen were measured in the surface layer (1 m). Methodology for these procedures was previously described (Icanberry and Adams 1974). Larval fish

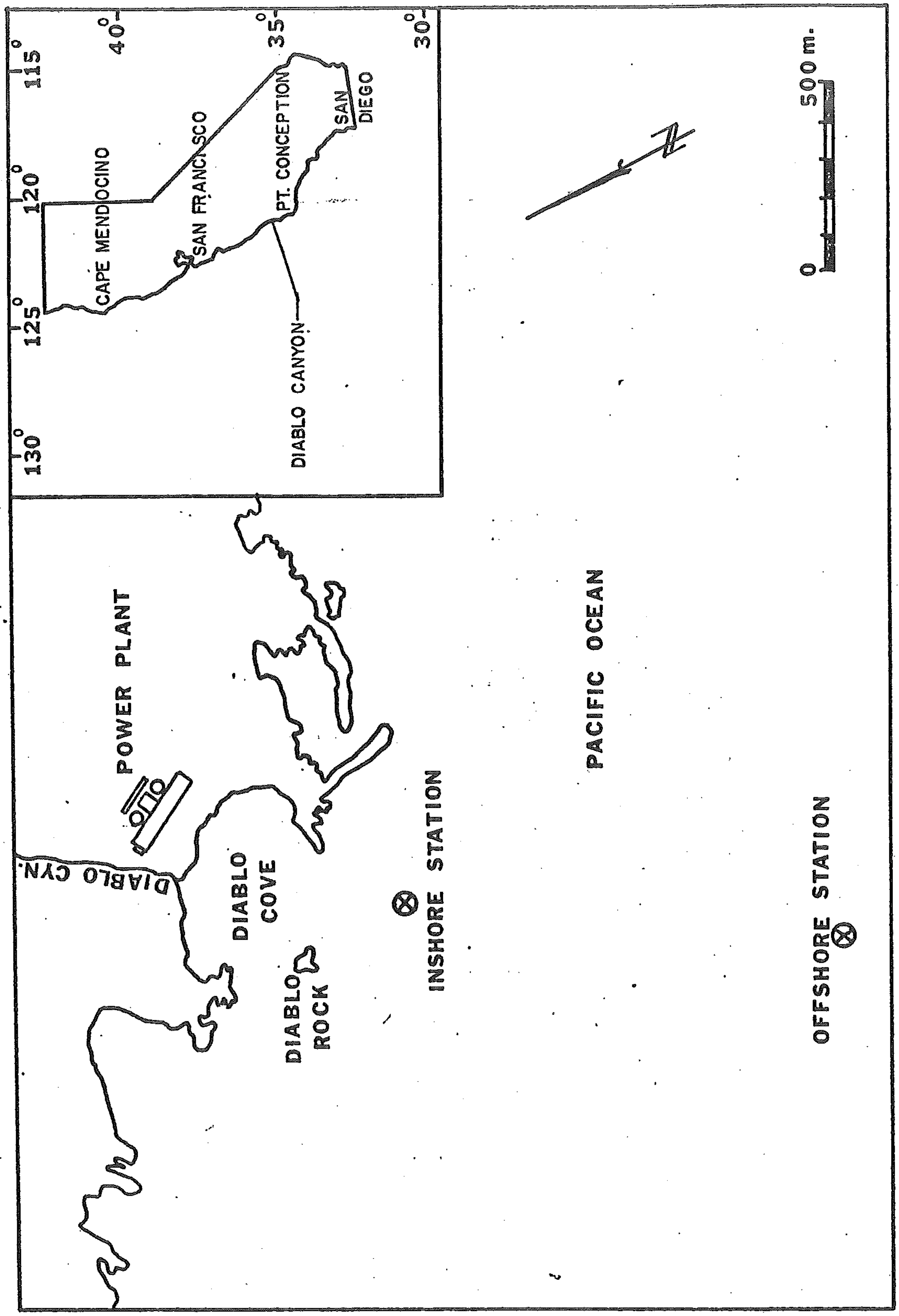

Figure 1 Diablo Canyon area showing locations of the Inshore and Offshore Stations

and fish eggs were simultaneously sampled in oblique hauls. The results of that study have been described by Icanberry and Warrick (1976).

The criteria for establishing net haul depths were maximum existing Inshore and Offshore Station depths, the annual range of the thermocline depth at both stations, and the need to standardize as nearly as possible the sampling depths at both stations. The depths of the Inshore and Offshore Stations were approximately 20 m and 60 m, respectively. The depth of the upper mixed layer down to the thermocline within the sampling area varies seasonally, approximately 5-25 m (Doyle 1974). The net was fished obliquely through the upper mixed layer from average depths of 17 m and 25 m at the Inshore and Offshore Stations, respectively, to the surface, insuring adequate sampling above the thermocline throughout the study.

Towing speeds were 1.6 m $(sec)^{-1}$ or slower. The net was attached to a towing cable about 4 m above a 6.8 kg wire depressor. The net was lowered to its fishing depth in about one minute. During each haul, while the net was fishing at depth, an inclinometer was used to measure the angle-of-stray of the tow wire from the vertical. The maximum depth of the haul was estimated as the product of the amount of tow wire out and the cosine of the angle-of-stray. The net was fished at depth for one minute and hauled to the surface at a slow but constant rate. After washing down the net contents from the outside, the samples were placed in plastic containers, labelled, and preserved in a 10.0 percent formalin solution of seawater.

In the laboratory, zooplankton samples were split with a Folsom Plankton Splitter. One half of the sample was taxonomically identified* and quantitatively enumerated. The remaining sample half was processed to determine dry

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*Consultant taxonomist, Sylvia A. Murray, T.V.A., Muscle Shoals, Alabama.

weight and ash-free dry weight (Soeder and Tolling 1971). During this procedure the amount of the half sample filtered was adjusted as a fraction of the sample half and reported as μg l^{-1} for both dry weights and ash-free dry weights. The half samples were filtered through an 8.0 μm nucleopore membrane filter.

At the time of sampling, one liter of unfiltered seawater was collected from ≤ 1.0 m below the surface at each station and preserved with Lugol's solution. In the laboratory, phytoplankton cells were concentrated by allowing them to settle in fabricated glass settling chambers. The cells were then identified and enumerated.

Live biomass (organisms < 150 μm) was determined by ATP (adenosine triphosphate) analysis. At each station, three replicate 1.0 l samples were collected from ≤ 1.0 m below the surface, initially filtered through a 150 μm mesh nylon net , and then through a 8.0 μm nucleopore membrane filter. The filtrate was then placed into test tubes containing 5.0 ml of boiling Tris buffer solution, thus fixing the ATP into solution. After heating for 5.0 min at 100°C, the test tubes were cooled and frozen at -20°C until analyzed. The ATP content was measured with a JRB-ATP photometer (Holm-Hansen and Booth 1966).

A grouped t-test for independent samples was used to test for differences in total zooplankton and phytoplankton densities, densities of zooplankton and phytoplankton species, and biomass, between the Inshore and Offshore Stations.

RESULTS AND DISCUSSION

General

During the 15-month study period, 168 hauls were taken, 94 taxonomic and life stage zooplankton categories and 46 phytoplankton genera were identified.

The average haul time (total time net was fishing) was 3.29 min at the Inshore Station and 3.75 min at the Offshore Station. The average volume of water sampled in each haul was 8.4 m^3, (S.D. = 3.01) at the Inshore Station and 9.0 m^3, (S.D. = 3.01) at the Offshore Station.

Physical and Chemical Data

Upwelling indices indicated two peaks during the study period, April to June 1974 and March to May 1975 (Figure 2). Since there were no apparent differences between Inshore and Offshore Station physical and chemical measurements, the data from both stations for each parameter were combined and averaged (Figure 3). High salinities and low temperatures correlated closely with periods of upwelling (April 1974 to August 1974 and March 1975 to May 1975). Dissolved oxygen concentrations were too variable to evaluate relative to upwelling (Figure 3). The variability associated with dissolved oxygen probably resulted from the natural mixing at the surface interface, thus masking expected lower dissolved oxygen concentrations normally associated with upwelled waters.

Zooplankton Species Composition and Occurrence

Percent composition and occurrence of all zooplankton taxa identified in this study are shown in Table 1. Table 2 shows those taxa comprising 75.0 percent of the total zooplankton numbers. All of the most abundant species in this study, except *Oikopleura* spp., were reported as comprising 96.8 percent of the total zooplankton numbers in a previous study at Diablo Canyon (Icanberry 1974). Sixty-six additional zooplankton taxa were identified, thus expanding Icanberry's (1974) nearshore Diablo Canyon taxonomic list by 70.2 percent.

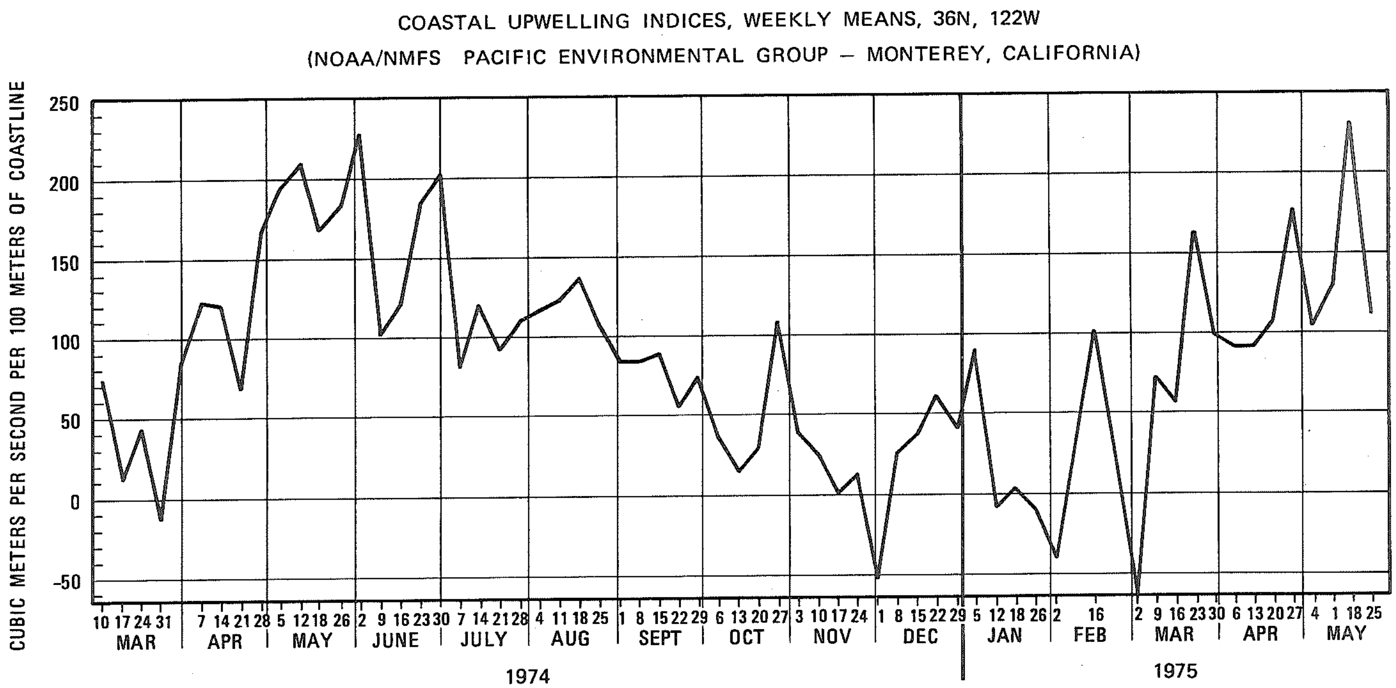

Figure 2 Weekly means of coastal upwelling values derived from the Coastal Upwelling Indices for 36 N lat. and 122 W long., as recorded by NOAA/NMFS Pacific Environmental Group, Monterey, California.

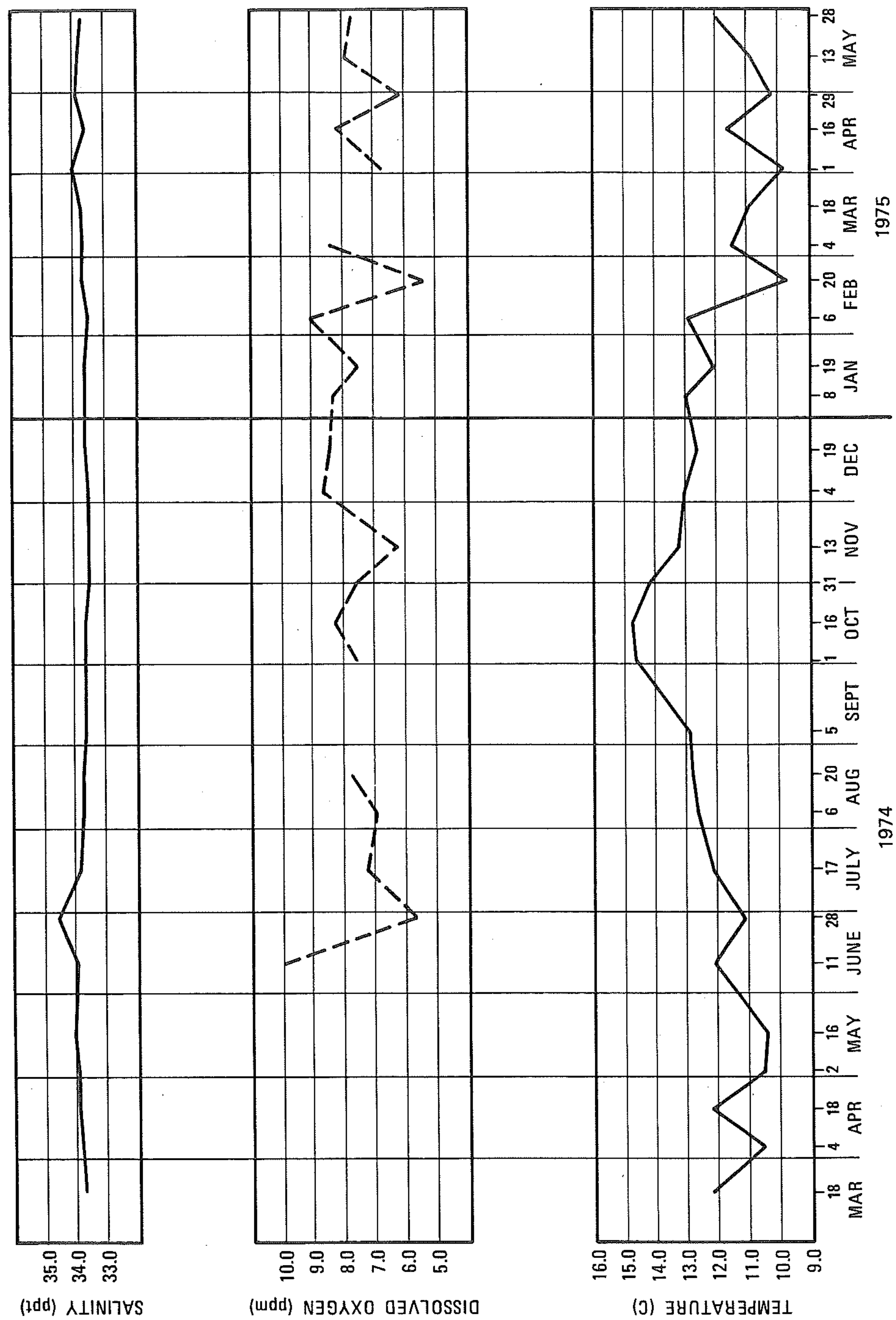

Figure 3 Distribution of mean Inshore and Offshore Station salinites, dissolved oxygens, and temperature values recorded at Diablo Canyon, California.

Table 1. Taxonomic category, percent composition and percent occurrence of zooplankton collected March 18, 1974 to May 28, 1975 at Diablo Canyon.

Taxonomic Category	Percent Composition	Percent Occurrence
Sagoscena spp.	0.0*	4.8
Sagosphaera spp.	0.0	5.4
Hydromedusa	0.1	33.3
Obelia spp.	0.1	22.0
Leptomedusa	0.0	0.6
Siphonophora	0.2	37.5
Ctenophora	0.0	9.5
Platyhelminthes	0.0	10.1
Pilidium larvae	0.0	6.0
Keratella spp.	0.0	1.8
Nematoda	0.0	3.0
Polychaeta (larvae)	1.2	82.1
Tomopteris spp.	0.0	0.6
Trochophore larvae	0.2	49.4
Veliger larvae (mollusca)	0.0	2.4
Podon spp.	0.7	12.5
Evadne spp.	1.7	53.0
Ostracoda	0.0	5.4
Calanoida nauplii	35.4	94.6
Unknown parasitic calanoida	0.0	3.6
Calanoida copepodites	22.3	97.6
Calanus spp.	0.0	1.8
Calanus finmarchicus	0.5	52.4
Eucalanus spp.	0.0	12.5
Euchaeta spp.	0.0	4.2
Eucalanus bungii bungii	0.0	6.0
Rhincalanus spp.	0.0	5.4

Table 1 - contd.

Taxonomic Category	Percent Composition	Percent Occurrence
Rhincalanus nasutus	0.0	8.9
Para-, *Pseudocalanus* spp. copepodites	0.0	4.2
Pseudocalanus minutus	0.2	18.5
Metridia pacifica	0.0	13.1
Clausocalanus spp.	0.0	1.2
Pleuromamma spp.	0.0	3.0
Centropages spp.	0.0	6.5
Labidocera spp.	0.0	1.8
Acartia spp. copepodites	0.0	0.6
Acartia clausi	1.0	25.0
Acartia tonsa	2.4	54.2
Acartia longiremis	1.6	44.6
Tortanus discaudatus	0.0	13.1
Harpacticoida	0.2	33.3
Copilia spp.	0.0	1.2
Unknown cyclopoida copepods	2.8	47.6
Cyclops spp.	0.0	3.0
Microsetella spp.	0.3	63.1
Macrosetella spp.	0.2	44.0
Euterpina spp.	1.5	57.1
Oithona spp.	0.0	1.8
Oithona similis	1.8	64.9
Oithona spinerostrus	0.3	56.0
Corycaeus spp.	1.6	76.8
Clytemnestra spp.	0.0	0.6
Cyclop-, Harpacticoida copepodites	4.5	95.2
Microcyclops spp.	0.0	9.5
Cirripedia nauplii	6.9	92.9
Mysidae	0.0	1.2
Cumacea	0.0	0.6

Table 1 - contd.

Taxonomic Category	Percent Composition	Percent Occurrence
Isopoda	0.0	9.5
Amphipoda	0.0	1.8
Caprellidae	0.0	0.6
Euphausia spp. zoea	0.0	7.1
Euphausia spp. nauplii	0.1	17.3
Euphausia spp. calyptopis	2.6	51.2
Euphausia spp. furcilia	0.7	13.7
Unknown anomuran larvae	0.0	0.6
Emerita spp. zoea	0.0	0.6
Paguridae zoea	0.0	2.4
Solenocera spp. zoea	0.0	0.6
Sergestes spp. zoea	0.0	1.2
Crangon spp. zoea	0.0	8.3
Spirontocaris spp. zoea	0.0	8.9
Hippolyte spp. zoea	0.0	3.6
Callianassa spp. zoea	0.0	15.5
Munida spp. zoea	0.0	3.0
Blepharipoda spp. zoea	0.0	0.6
Lithodes spp. zoea	0.0	0.6
Cancer spp. zoea	0.6	39.3
Cancer spp. megalopa	0.0	1.2
Porcellanidae zoea	0.0	8.9
Pinnotheridae zoea	0.0	7.1
Pinnixa spp. zoea	0.3	31.5
Hemigrapsus spp. zoea	0.0	8.9
Xanthidae zoea	0.0	1.8
Caridean zoea	0.0	17.3
Pontophilis spp.	0.0	0.6

Table 1 - contd.

Taxonomic Category	Percent Composition	Percent Occurrence
Unknown crustacean larvae	0.0	1.8
Phoronis spp. (larvae)	0.0	11.9
Tunicate larvae	0.0	3.6
Appendicularia	0.0	9.5
Doliolum	0.1	20.2
Salpa spp.	0.0	5.4
Oikopleura spp.	5.9	70.8
Fritillaria spp.	1.1	48.8
Chaetognatha	0.4	63.1

* Zero values indicate percent composition to be <0.1 percent.

Table 2. Percent composition and percent occurrence of taxa comprising 75.0% of the zooplankton densities from hauls conducted March 18, 1974 to May 28, 1975, at Diablo Canyon.

Taxon	Percent Composition	Percent Occurrence
Calanoida nauplii	35.4	94.6
Calanoida copepodites	22.3	97.6
Cirripedia nauplii	6.9	92.9
Oikopleura spp.	5.9	70.8
Cyclopoida and Harpacticoida Copepodites	4.5	95.2

Seasonal Zooplankton Distribution

There were no statistically significant differences at the 95 percent confidence level between Inshore and Offshore Station densities of total zooplankton, individual zooplankton species, dry weights, and ash-free dry weights (Table 3).

The seasonal distribution of total zooplankton densities is shown in Figure 4. The peak zooplankton densities correlated with peak upwelling periods (Figures 2 and 4). The peak density, 127,662 $(m^3)^{-1}$, occurred June 11, 1974, and densities remained high from June 11, 1974, to July 16, 1974. Not enough samples were taken to verify the period of peak zooplankton densities in 1975. The seasonal period of peak abundance (June 11, 1974) coincided with that of 1973 reported by Icanberry (1974) to have been on June 6, 1973 (62,000 $(m^3)^{-1}$). The mean total zooplankton concentration during the study was 9,881 $(m^3)^{-1}$, S.D. 23,865 $(m^3)^{-1}$ or 2.6 times that of 3,794 $(m^3)^{-1}$, the 13-month mean total zooplankton density reported by Icanberry (1974) from zooplankton collections taken at the Intake Cove of Diablo Canyon. This 2.6 times greater difference found in the present study may be explained by: (1) low zooplankton populations existing in the relatively quiet, noncirculating waters of the Intake Cove (Icanberry 1974); (2) avoidance by zooplankters of the pump sampling device used by Icanberry (1974) as compared with the more efficient 30 cm D towed net used in the present study; or (3) zooplankton numbers were possibly lower in 1972-73 than in 1974-75. Since no towed net samples were taken during the Icanberry (1974) study, we cannot verify any of these possible explanations.

Table 3. Statistical comparisons of inshore and offshore concentrations of taxa comprising 75.0% of the zooplankton densities from samples collected March 18, 1974 to May 28, 1975 at Diablo Canyon.

Taxon	d.f.	t-Value*	Calculated Two-Tailed Probability	Probability 0.05	0.01(α)
Calanoida nauplii	30	0.71	0.485	NS	
Calanoida copepodites	54	0.16	0.875	NS	
Cirripedia nauplii	32	2.16	0.038	S	NS
Oikopleura spp.	50	0.15	0.882	NS	
Cyclopoida and Harpacticoida copepodites	54	0.12	0.904	NS	
Total zooplankton	54	0.64	0.525	NS	
Dry weights	54	-0.81	0.420	NS	
Ash-free dry weights	54	-0.05	0.960	NS	

*Positive t-values indicate that greater densities occurred at the Inshore Station; negative t-values indicate the opposite.

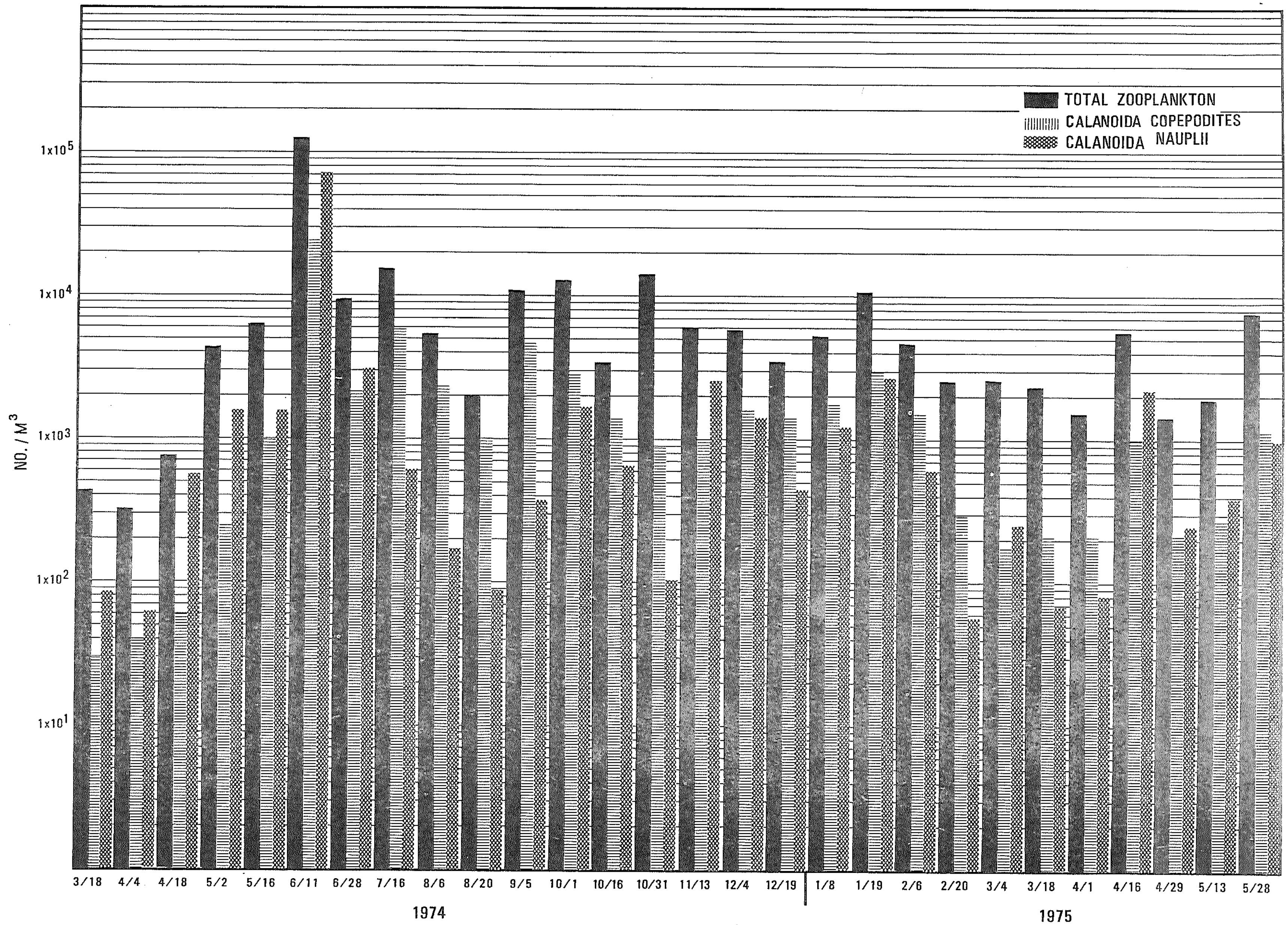

Figure 4 Seasonal distribution of total zooplankton, calanoida copepodites and calanoida nauplii represented as means of combined Inshore and Offshore sample densities for each biweekly sampling effort.

Calanoida nauplii were present throughout the study period (Table 2, Figure 4) and represented 35.4 percent of the total zooplankton density. Their period of greatest abundance coincided with that of total zooplankton, May 2, 1974 to June 28, 1974. During this period, calanoida nauplii constituted 53.9 percent of the total density. As a general distributional trend, they were most abundant during the Upwelling season, then declined and maintained variable populations throughout the Oceanic and Davidson Current seasons.

Calanoida copepodites were present throughout the study period (Table 2, Figure 4) and represented 22.3 percent of the total zooplankton density. Their period of greatest abundance coincided with that of total zooplankton, and they paralleled the seasonal distribution of calanoida nauplii. The copepodites, expectedly, showed less variability than the nauplii because, as the densities of nauplii stages declined in the samples, they essentially grew into the more advanced copepodite stages and declined through natural mortality.

Cirripedia nauplii showed significantly greater densities throughout the study at the Inshore Station (Table 3, Figure 5). Their peak density at the Inshore Station occurred March 4, 1975. Cirripedia nauplii comprised 6.9 percent of the total density but occurred in 92.9 percent of the samples (Table 2).

Oikopleura spp. densities peaked on June 11, 1974 (Upwelling season) and September 5, 1974 (Oceanic season). They comprised only 5.9 percent of the total density but occurred in 70.8 percent of the samples (Table 2).

Cyclopoida and harpacticoida copepodites reached their period of greatest abundance from April 18, 1974, to August 6, 1974, the Upwelling period (Figure 6). Their densities peaked June 11, 1974. Although they comprised only 4.5 percent of the total zooplankton density, they occurred in 95.2 percent of the samples.

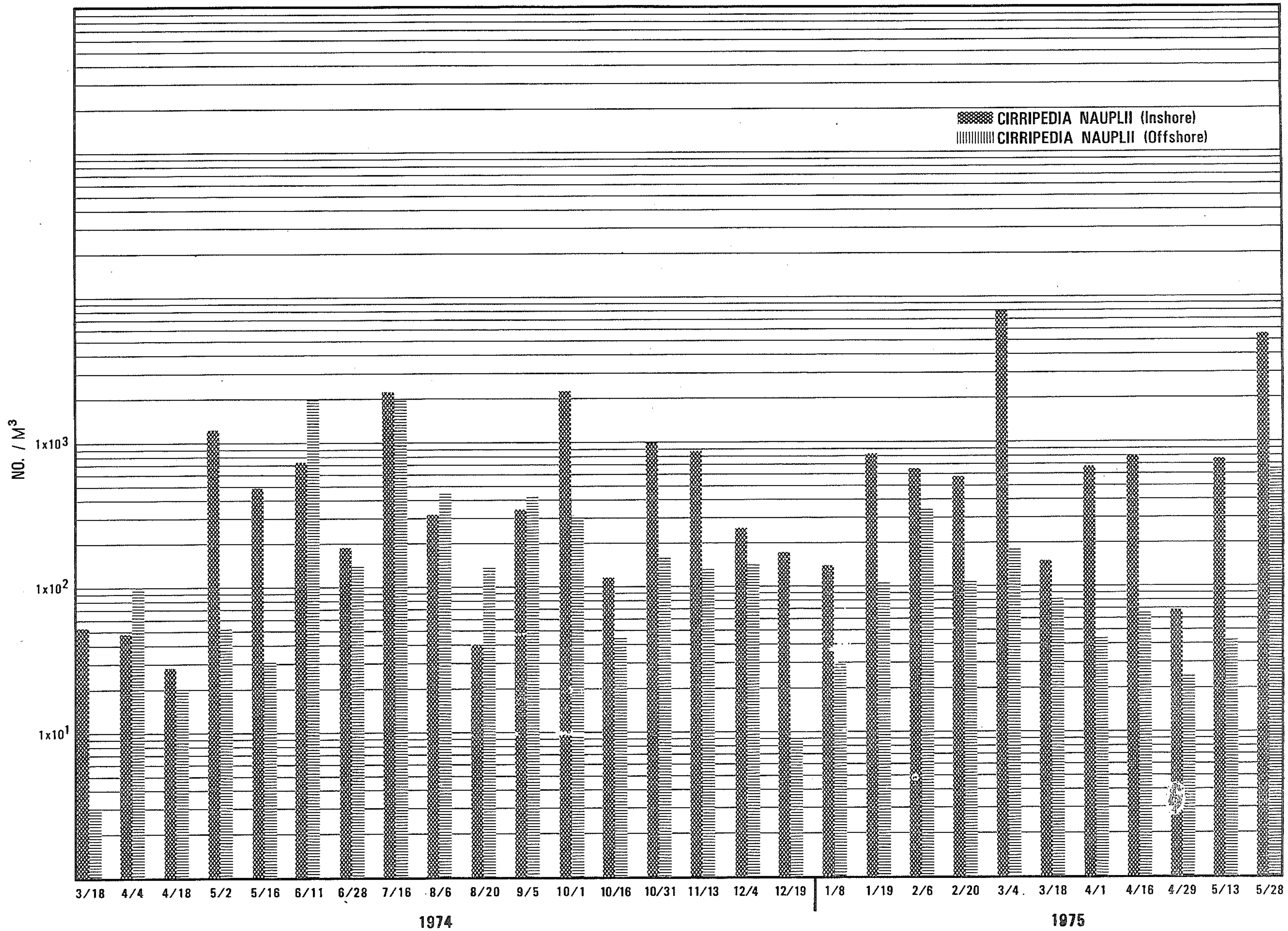

Figure 5 Quantitative seasonal distribution of the mean biweekly densities of Cirripedia nauplii at the Inshore and Offshore Stations collected for each biweekly sampling effort.

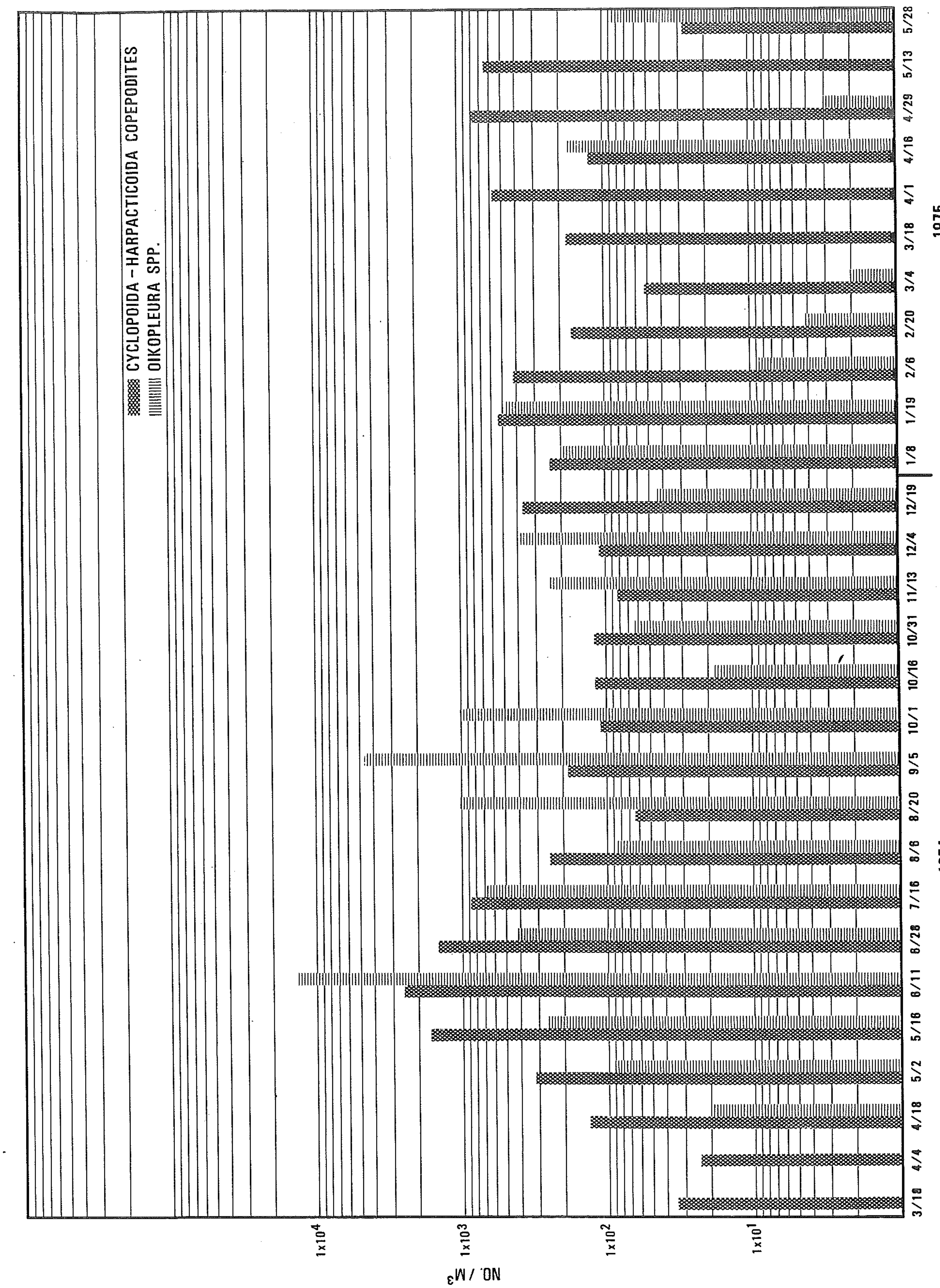

Figure 6 Seasonal distribution of Cyclopoida-Harpacticoida copepodites and Oikopleura spp. represented as means of combined Inshore and Offshore sample densities for each biweekly sampling effort.

Seasonal Distribution of Dry Weight Biomass

The seasonal distribution of dry weight biomass measurements is shown in Figure 7. The peak biomass 607.4 $\mu g\ l^{-1}$, occurred June 11, 1974. The highest concentrations occurred from May 2, 1974 to July 16, 1974. A second peak began January 19, 1975 and extended through April 16, 1975 (peak biomass: 368.54 $\mu g\ l^{-1}$). These periods of peak biomass correlated with the two periods of upwelling documented during the 15-month study (Figure 2). The first peak period, May 2, 1974 to July 16, 1974, correlated with that of total zooplankton (Figure 4). The second biomass peak (February 6, 1975) occurred at the beginning of the second period of upwelling and probably represented a response to the increased volumes of phytoplankton present seasonally at that time (Figure 8).

The average dry-weight biomass during the study period was 92.29 $\mu g\ l^{-1}$, S.D. 126.09 $\mu g\ l^{-1}$, approximately the same as the yearlong average, 104.02 $\mu g\ l^{-1}$, reported by Icanberry (1974).

Seasonal Distribution of Ash-Free Dry Weight Biomass

The seasonal distribution of ash-free dry weights (weight of organic matter) is shown in Figure 7. The distribution parallels that of the dry weight estimates in the same figure, but the values are generally an order of magnitude lower, reflecting the smaller fraction of organic content. The average ash-free dry weight was 29.75 $\mu g\ l^{-1}$, S.D. 54.31 $\mu g\ l^{-1}$. This average is 18.86 percent, S.D. 3.04 percent, of the total dry weights. Peak biomass occurred April 4, 1974 to July 16, 1974 (peak biomass: 91.35 $\mu g\ l^{-1}$) and February 6, 1975 to April 16, 1975 (peak biomass: 280.18 $\mu g\ l^{-1}$).

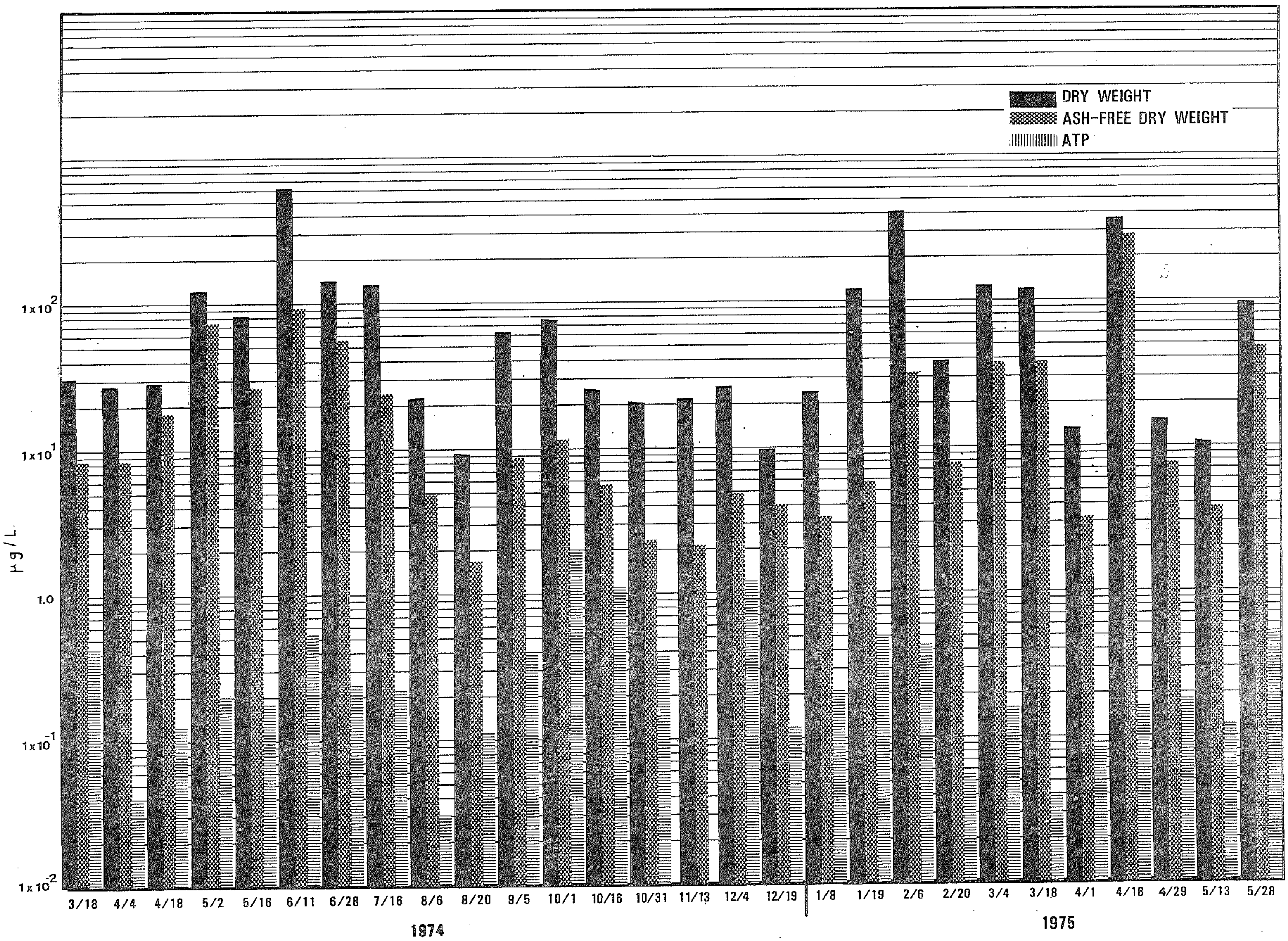

Figure 7 Seasonal distribution of dry weights, ash-free dry weights, and ATP concentrations represented as means of combined Inshore and Offshore sample biomass for each biweekly sampling effort.

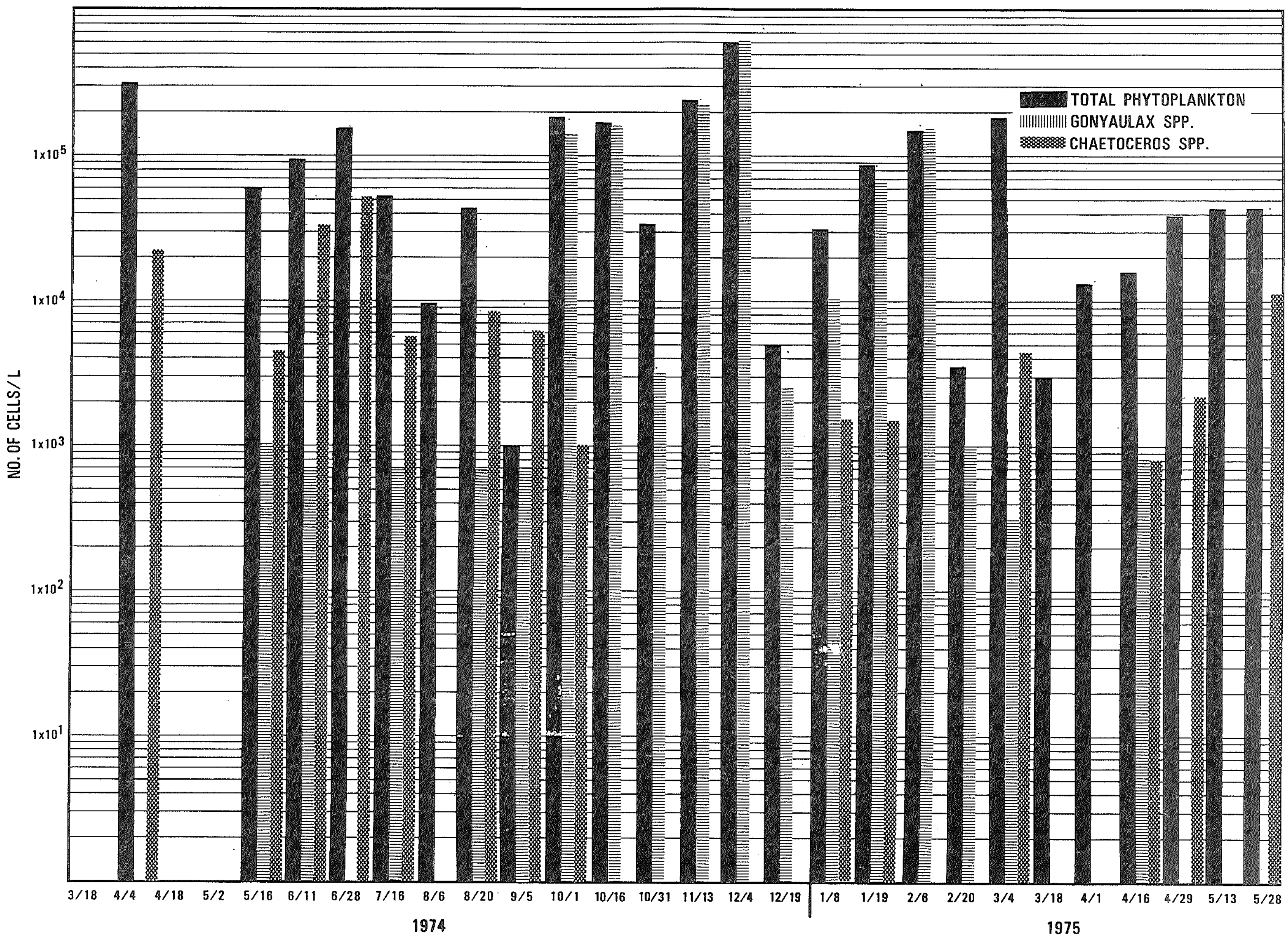

Figure 8 Seasonal distribution of total phytoplankton, Gonyaulax spp. and Chaetoceros spp. represented as means of combined Inshore and Offshore sample densities for each biweekly sampling effort. (Data for 3/18, 4/18, and 5/2 are missing.)

Phytoplankton Species Composition and Occurrence

Percent composition and occurrence of all phytoplankton taxa identified in this study are shown in Table 4. Table 5 shows those taxa comprising 83.4 percent of the total phytoplankton numbers. Dinoflagellata comprised 65.1 percent of the total biomass during the study. Of this total, *Gonyaulax* spp. comprised 60.6 percent. Bacillariaceae (diatoms) was the second most abundant taxonomic group, comprising 32.9 percent. Mastigophora comprised 4.2 percent, and Foraminifera, of which only one species was identified, showed insignificant numbers.

There are no phytoplankton studies for the Diablo Canyon vicinity reported in the literature.

Seasonal Phytoplankton Distribution

There were no statistically significant differences at the 95 percent confidence level between Inshore and Offshore Station densities of total phytoplankton and individual phytoplankton species; ATP values of organisms $\leq$ 150 μm in size showed no significant differences between the Inshore and Offshore Stations (Table 6).

The seasonal distribution of total phytoplankton densities is shown in Figure 8. The densities remained relatively high from October 16, 1974 through February 6, 1975, exhibiting wide fluctuations (4,500 - 594,500 cells l^{-1}). The peak density, 594,500 cells l^{-1}, occurred December 4, 1974. This peak abundance period was inversely correlated with maximum upwelling and maximum peak zooplankton abundance periods (Figures 2 and 4). Not enough samples were taken to verify the period of peak phytoplankton densities in 1975. The mean total phytoplankton concentration for the study period was 90,820 cells l^{-1}, S.D. 128,313 cells l^{-1}.

Table 4. Taxonomic category, percent composition and percent occurrence of phytoplankton species collected April 4, 1976 to May 28, 1976 at Diablo Canyon.

Taxonomic Category	Percent Composition	Percent Occurrence
BACILLARIACEAE		
Rhizosolenia spp.	3.3	19.7
Rhizosolenia alata	0.1	2.8
Rhizosolenia styliformis	0.0*	0.7
Coscinodiscus spp.	1.9	25.4
Coscinodiscus marginatus	0.5	11.3
Chaetoceros spp.	6.4	40.1
Biddulphia spp.	0.2	3.5
Skeletonema costatum	0.9	9.9
Thalassiosira spp.	2.8	21.8
Eucampia spp.	0.0	0.7
Eucampia zoodiacus	1.2	12.0
Eucampia cornuta	0.0	0.7
Lauderia spp.	0.1	0.7
Melosira spp.	0.1	4.2
Ditylum brightwellii	0.2	4.2
Stephanodiscus spp.	0.1	2.8
Nitzschia spp.	6.0	36.6
Nitzschia closterium	0.1	4.9
Nitzschia seriata	0.1	2.8
Nitzschia longissima	0.1	5.6
Navicula spp.	4.3	51.4
Pleurosigma spp.	0.3	4.9
Licmorpha spp.	0.5	3.5
Synedra spp.	0.3	1.4
Striatella spp.	0.6	2.8
Fragillaria spp.	1.3	14.8
Asterionella japonica	1.0	9.9
Thalassiothrix spp.	0.5	12.0

Table 4 - contd.

Taxonomic Category	Percent Composition	Percent Occurrence
MASTIGOPHORA		
Distephanus spp.	0.2	5.6
Dichtyocha spp.	0.1	5.6
Phacus spp.	0.4	12.0
Trachelomonas spp.	0.0	0.7
Euglena spp.	1.1	16.9
DINOFLAGELLATA		
Prorocentrum spp.	1.2	19.0
Haplodinium spp.	0.0	0.7
Noctiluca scintillans	0.0	1.4
Dinophysis spp.	0.0	0.7
Gonyaulax spp.	60.6	44.4
Ceratium spp.	0.1	2.8
Ceratium hirundinella	2.1	21.8
Ceratium tricips	0.0	0.7
Peridinium spp.	0.9	23.9
Polykrikos spp.	0.1	2.8
Gymnodinium spp.	0.1	2.8
Pyrocystis spp.	0.0	0.7
FORAMINIFERA		
Globigerina bulloides	0.0	0.7

* Zero values indicate percent composition to be <0.1 percent.

Table 5. Percent composition and percent occurrence of taxa comprising 83.4% of the phytoplankton densities from samples collected April 4, 1976 to May 28, 1975, at Diablo Canyon.

Taxon	Percent Composition	Percent Occurrence
Gonyaulax spp.	60.6	44.4
Chaetoceros spp.	6.4	40.1
Nitzschia spp.	6.0	36.6
Navicula spp.	4.3	51.4
Rhizosolenia spp.	3.3	19.7
Thalassiosira spp.	2.8	21.8

Table 6. Statistical comparisons of inshore and offshore concentrations of taxa comprising 75.0% of the phytoplankton densities from samples collected March 18, 1974 to May 28, 1975 at Diablo Canyon.

Taxon	d.f.	t-Value*	Calculated Two-Tailed Probability	Probability (α) 0.05	0.01
Gonyaulax spp.	46	-0.61	0.543	NS	
Chaetoceros spp.	48	-0.72	0.474	NS	
Nitzschia spp.	46	0.49	0.623	NS	
Navicula spp.	46	0.41	0.682	NS	
Rhizosolenia spp.	42	-0.04	0.965	NS	
Thalassiosira spp.	42	-0.79	0.432	NS	
Total Phytoplankton	46	-0.04	0.965	NS	
ATP Values	51	-0.38	0.704	NS	

*Positive t-values indicate that greater densities occurred yearlong at the Inshore Station; negative t-values indicate the opposite.

Gonyaulax spp. were present throughout the study period (Table 5, Figure 8), and represented 60.6 percent of the total phytoplankton density. Their period of greatest abundance, expectedly, coincided with that of total phytoplankton cell numbers, November 11, 1974 to December 12, 1974, with an additional peak January 8, 1975 to February 6, 1975. As a general distributional trend, they were most abundant during the Oceanic and Davidson Current seasons and least abundant during the Upwelling.

Chaetoceros spp. were present intermittently throughout the study period, absent only during late October through December 1974 and, generally, scarce in the early spring of 1974 and 1975 (Table 5, Figure 8). They comprised 6.4 percent of the total density.

Nitzschia spp. were present throughout the study period (Table 5, Figure 8) and represented 6.0 percent of the total phytoplankton density. Their greatest density occurred in June 1974.

Navicula spp. were present throughout the study period (Table 5, Figure 9) and represented 4.3 percent of the total phytoplankton density. Their densities peaked sporadically throughout the year, July 1974, January, April, and May 1975.

Rhizosolenia spp. comprised 3.3 percent of the total phytoplankton density and were present throughout the study period, but in only 19.7 percent of the total samples (Table 5, Figure 10).

Thalassiothrix spp., the sixth most abundant phytoplankton genus, comprised only 2.8 percent of the total phytoplankton density (Table 5). They were sporadically distributed throughout the study period (Figure 10) and reached their greatest densities in May and June 1974.

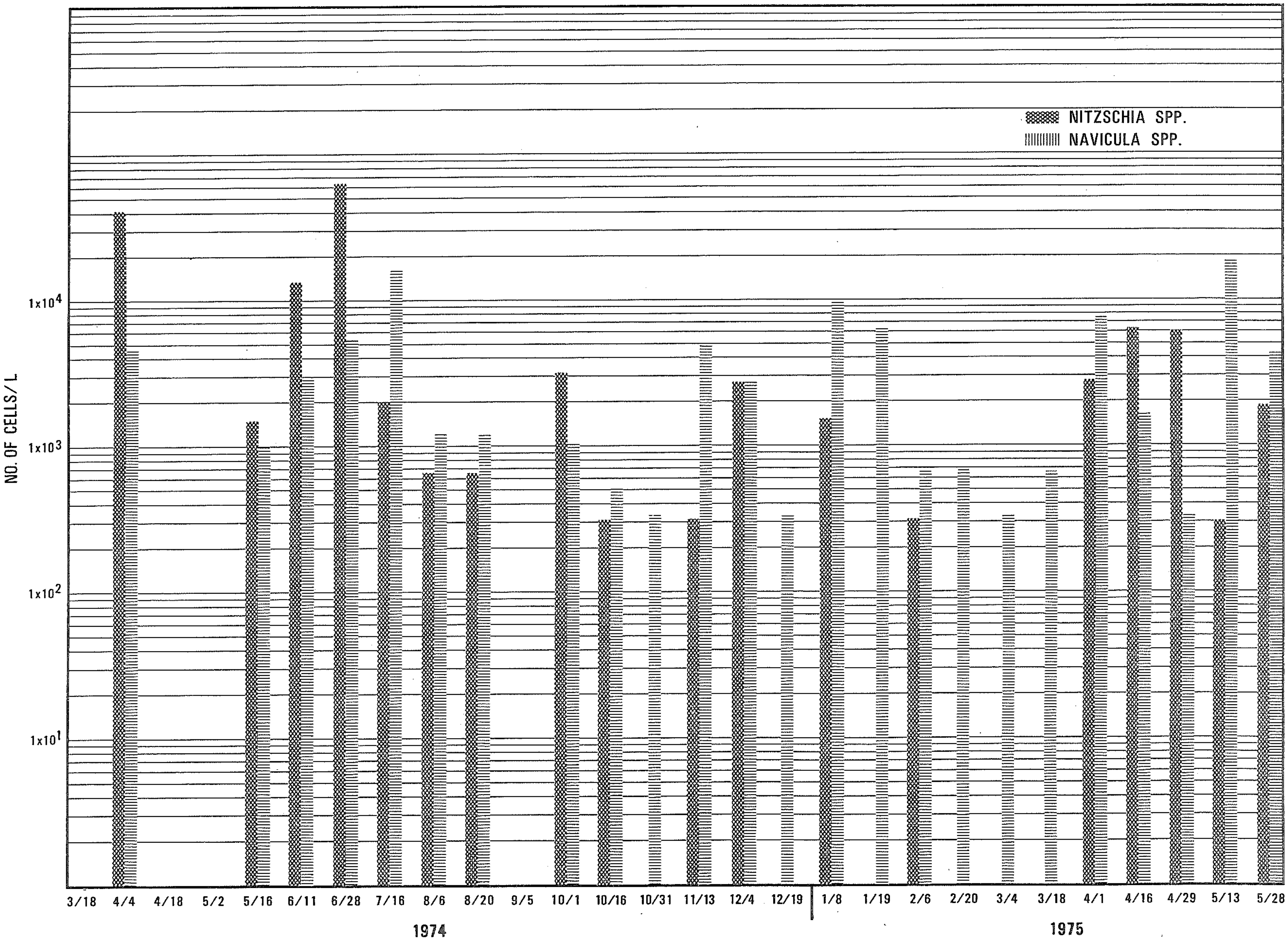

Figure 9 Seasonal distribution of Nitzschia spp. and Navicula spp. represented as means of combined Inshore and Offshore sample densities for each biweekly sampling effort. (Data for 3/18, 4/18 and 5/2 are missing.

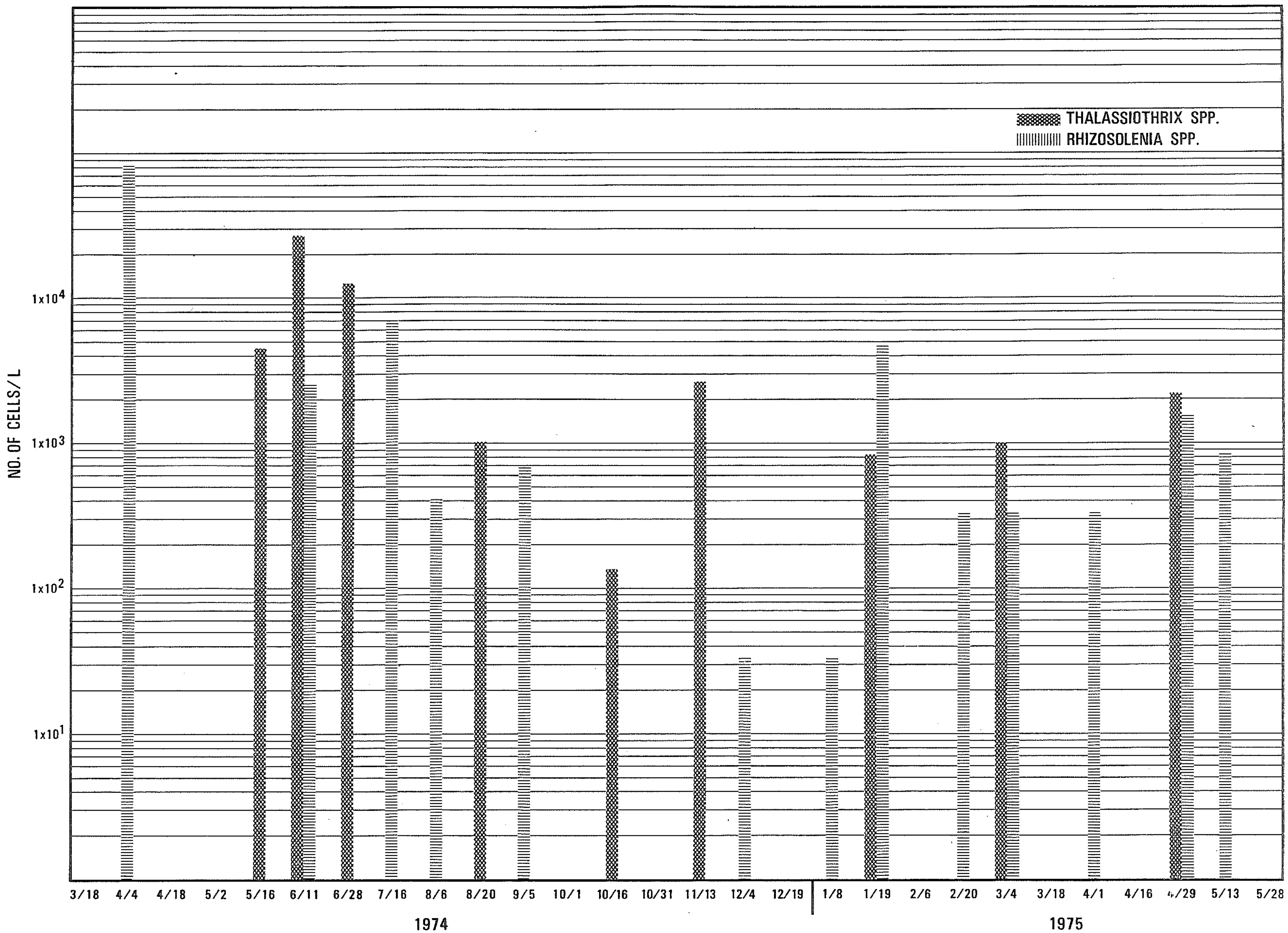

Figure 10 Seasonal distribution of Thalassiothrix spp. and Rhizosolenia spp. represented as means of combined Inshore and Offshore sample densities for each biweekly sampling period. (Data for 3/18, 4/18 and 5/2 are missing.)

Seasonal Distribution of ATP Biomass

The seasonal distribution of ATP (adenosine triphosphate) concentrations is depicted in Figure 7. The results show large fluctuations between biweekly samples. Generally, there were two major peak periods of ATP (live biomass) indentified: (1) April 18, 1974 to July 16, 1974 with ATP concentrations ranging from 0.139 to 0.532 μg l^{-1}; and (2) September 5, 1974 to February 6, 1975 with ATP concentrations ranging from 0.119 to 1.89 μg l^{-1}.

The mean ATP live biomass concentration for the study period was 0.359 μg l^{-1}, S.D. 0.416 μg l^{-1}.

The initial peak period of ATP concentrations (April 18, 1974 to July 16, 1974) correlated with the first upwelling period (April 1974 to August 1974) (Figure 2), the period of peak zooplankton densities (June 1974 to July 1974) (Figure 4), and the first of two peak periods of dry weights and ash-free dry weights (May 1974 to July 1974) (Figure 7). Thus, the initial ATP peak probably represents zooplankton sizes less than 150 μm.

The second peak period of ATP (September 1974 to February 1975) (Figure 7) is directly correlated with the period of peak phytoplankton densities (October 1974 to Feburary 1975) (Figure 8) and inversely correlated with dry weight and ash-free dry weight peak periods (March 1974 to July 1974 and January 1975 to April 1975) (Figure 7). Thus, the second peak period of ATP biomass probably represents the increased phytoplankton density present from October 1974 to February 1975 (Figure 8).

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