State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

DIABLO CANYON POWER PLANT SITE

ECOLOGICAL STUDY

ANNUAL REPORT

July 1, 1976 - June 30, 1977

and Quarterly Report No. 16

April 1, 1977 - June 30, 1977

by

Daniel W. Gotshall
Laurence L. Laurent
and
John J. Grant

PACIFIC GAS AND ELECTRIC COMPANY

COOPERATIVE RESEARCH AGREEMENT 5-26-77

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ABSTRACT

More stations were surveyed during this report period than during any previous period. A total of 818 man-days was spent surveying 18 permanent and 67 random subtidal stations, 19 permanent and 50 random intertidal stations, and 64 sportfish catch-per-unit-of-effort stations, as well as conducting corollary laboratory work.

In the subtidal areas, *Laminaria dentigera* and *Pterygophora californica*, both important subsurface kelp species, increased in their combined total numbers from the 1976 survey. However, *Nereocystis luetkeana*, the bull kelp, declined substantially in all study areas.

Population trends of many of the dominant subtidal macro-invertebrates have varied depending on the species and on the type of method utilized. Regression analyses have been performed on selected species for numbers versus depth. Red algal abundance and diversity appear to have increased in both subtidal study areas.

Of the three observation areas, sea otters were observed least frequently in Diablo Cove. However, there continues to be fresh evidence of otter foraging within Diablo Cove.

Several seasons' data for intertidal algae and invertebrates have been summarized for one study area. While

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1/ Marine Resources, Administrative Report No. 79-2, December 1978.

2/ Operations Research Branch, P.O. Box 98, Avila Beach, CA 93424.

the algae biomass shows a fairly clear seasonality of abundance, the trends in numbers of the six invertebrate species considered are not as well defined.

Because of high variability in the data, the sportfish catch-per-unit-of-effort and hook-and-line study was cancelled in December.

Populations of intertidal red and black abalones, *Haliotis rufescens* and *H. cracherodii*, respectively, appear to have remained fairly stable during the 1976-77 period.

Two other ancillary studies were also terminated during this period: interviews of commercial abalone and urchin fishermen, and observations of foam in Diablo Cove.

This is the fourth annual report submitted in partial fulfillment of Research Contract No. 5-26-77 between the Department of Fish and Game and the Pacific Gas and Electric Company. Through this contract the Department of Fish and Game is to conduct ecological monitoring studies to determine what changes have occurred since 1970 and 1971 in the base line inventory of the marine biota, with special reference to fishes and abalones.

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INTRODUCTION

We have made several changes in our field methods during this fourth year of our base line quantitative studies of the intertidal and subtidal communities of the Diablo Canyon area. The sportfish catch-per-unit-of-effort study initiated in September 1974 was dropped in December 1976 due to the large variability encountered in the data. A review of the catch-per-pole data indicated that we would have to increse our fishing effort substantially in order to decrease the variability.

Efforts to interview commercial abalone and sea urchin divers were also discontinued because of the lack of effort due to the decline in populations of abalone and sea urchins and marketing problems in the sea urchin fishery.

In January, PG&E installed an automated time-lapse camera on the Meteorological Tower to record foam abundance and distribution in Diablo Cove. Our daily foam observations ceased in late January because of the greater efficiency of the new camera.

We continued our surveys of randomly selected one-quarter meter (1/4-m^2) quadrats in Diablo Cove and the North Control initiated in 1975. A large amount of time was spent on preparing our field data for keypunching and eventual storage in the computer.

This report includes discussions of our random and permanent subtidal studies, random and permanent intertidal studies in North Diablo Cove, sea otter (*Enhydra lutris*) observations, and fish studies.

Our annual reports usually contain only partially analyzed data, therefore they should not be considered as final reports or as Department of Fish and Game environmental impact reports.

Because we are now preparing the final report of all of our preoperational studies, this annual report will be limited to short narrative discussions of some results of the year's studies and will not include the large number of data tables as in previous annual reports. Examples of graphs are included to demonstrate how some of the field data will be analyzed and presented in the final report. The statistical goals of our studies are to be able to determine if observed changes in numbers of animals or biomass of algae before the plant goes into operation are statistically significant and to determine the average (or "expectedness") of species composition, abundance, associations and seasonality.

In our 1975/76 annual report (Gotshall et al. 1977), we indicated that the report would be submitted in two parts, Part I to include narrative and tables of collated and partially analyzed data, and Part II to include the computer-produced tables of all raw data. Because of the very high cost of computer time and based on our limited budget, we have decided to forego production of Part II. However, if anyone should desire to obtain copies of the raw data, a set of computer cards are available at cost.

This report also includes Quarterly Report No. 16 covering the period April 1 through June 30, 1977.

OPERATIONS

A total of 818 man-days was spent conducting field and laboratory studies at the site. This year we were able to increase the number of permanent and random subtidal and intertidal stations completed; 18 permanent and 67 random subtidal stations, 19 permanent and 50 random intertidal stations, and 64 sportfish catch-per-unit-of-effort stations were surveyed this year as compared to 189 stations of all types during the 1975/76 budget year.

Processing of algae samples from intertidal and subtidal stations continued to take up a large share of our laboratory time. In addition, we spent considerable amounts of time preparing our field data for keypunching. In December, we resumed observations of sea otters within the Diablo Cove area (Lion Rock south to South Cove) on a daily basis, time and weather conditions permitting.

METHODS

Subtidal Permanent Stations

Permanent stations are surveyed as follows: two divers swim along a 30-m transect counting or estimating abundance of selected invertebrates, algae, and fish 1 m to either side of the transect line. The presence of schooling fishes over and around the stations is also noted as visibility allows.

Subtidal Random Stations

Random stations are selected from a grid of numbered blocks 30.5-m on a side. Random number tables are used to select the station numbers. We attempt to complete 24 random 30-m^2 stations in both Diablo Cove and the North Control area each year during the summer and early fall (July through October). In Diablo Cove, the 24 stations are divided equally between North Diablo Cove and South Diablo Cove (Figure 1). The 12 stations in each section of the cove are further stratified as follows: eight stations from shallow depth blocks of 2.1 to 7.6 m and four stations from blocks with depths ranging from 7.5 to 18.3 m. Stations are located with a fathometer and by triangulation with a hand-held compass sighted on known fixed objects on land. At each station, counts are made of selected invertebrates and brown algae using an arc-transect

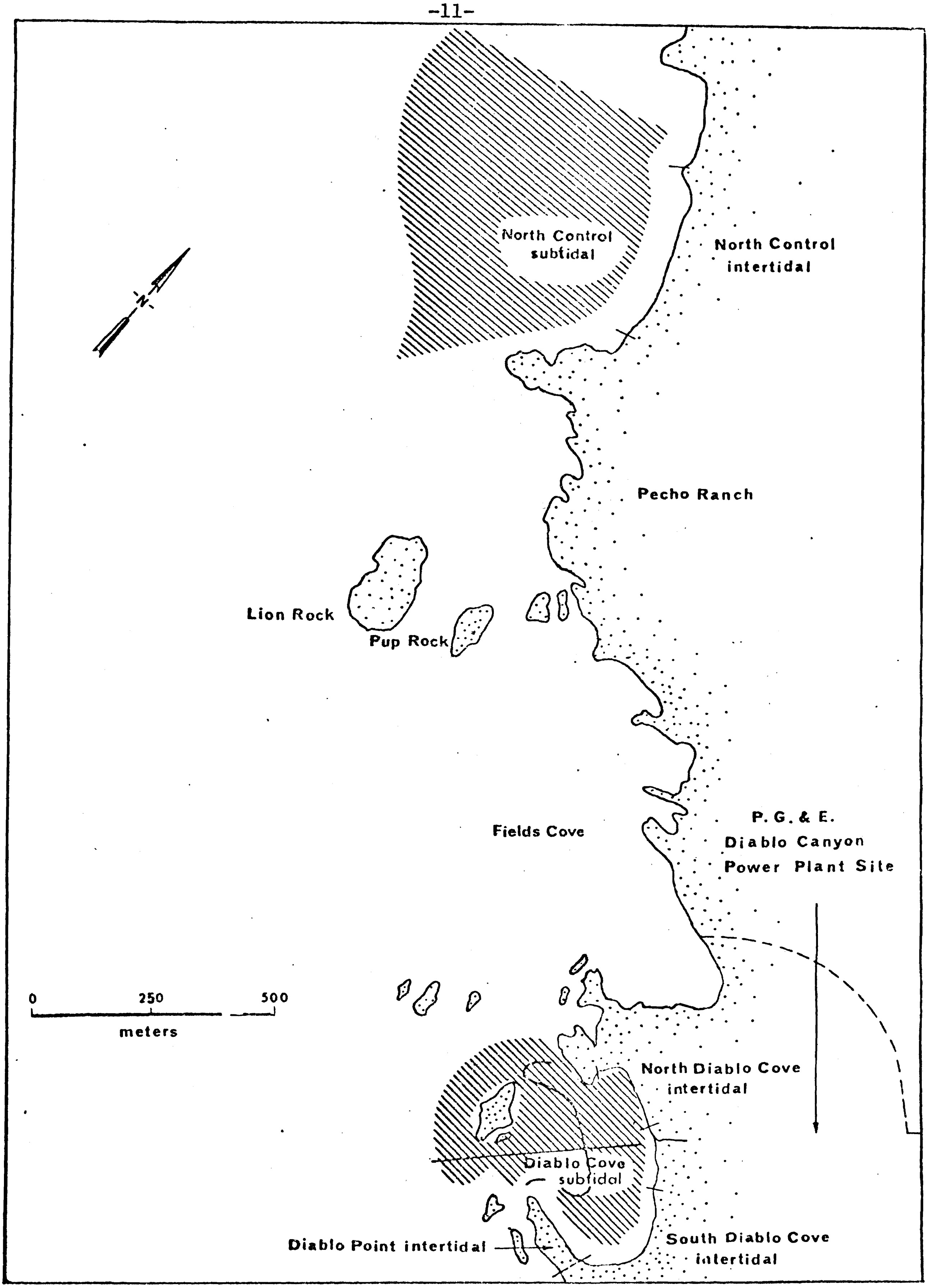


FIGURE 1. Location of random subtidal and intertidal areas -- Diablo Canyon Power Plant Site. (Dark lines in Diablo Cove designate deep and shallow strata and North Cove and South Cove strata).

method which describes a 30-m^2 circular area; the boat's anchor serves as the center of the circle. Soft red algae were quantified by collecting all plants from a one-quarter square meter (1/4-m^2) quadrat within the 30-m^2 area. Divers place stainless steel 1/4-m^2 quadrats on the substrate and remove all foliose red algae into plastic bags. Samples are sorted to species in the laboratory, weighed wet, and placed into desiccating ovens. Samples are reweighed when dry for a water-free weight used as an index of biomass. Incidence of occurrence and dry weight are tabulated for each species.

Physical data including depth, substrate, visibility, and surface and bottom temperatures are recorded at each station.

Selection of random stations in the North Control area (Figure 1) is accomplished in a different manner because of a lack of a bathymetric map. The 24 stations are chosen by selecting 24 numbers from 20 to 60 (representing compass bearings from a prominent landmark in the center of the area) from random number tables. Depths in three zones ranging from 2.1 to 18.3 m are then selected from another random number table; 12 numbers from 2.1 to 6.1 m, eight from 6.4 to 12.2 m, and four from 12.5 to 18.3 m. Stations are located as before with hand-held compass and fathometer. The two depth strata in Diablo Cove are comparable to the shallow depth strata in North Control.

Surveys of 1/4-m^2 quadrats are conducted as follows: at the random 30-m^2 stations, a 30-m transect line is laid out parallel to shore. At four points along the transect line all identifiable invertebrates and brown algae are counted. These points are selected from a random number table. All foliose red algae are removed for laboratory processing before counts are made. In addition to counts of invertebrates, the divers also make a count of all bull kelp plants, *Nereocystis luetkeana*, within 1 m to either side of the transect line.

Random Intertidal Stations

Survey methods for sampling intertidal invertebrate and algae populations have been standardized since 1974 and remain consistent with earlier reports. Those methods will be reiterated briefly here.

There are four study areas: three in the area of the future discharge and one in a control area. The three in the discharge area (Diablo Cove) are referred to as North Diablo Cove Intertidal (NDCI), South Diablo Cove Intertidal (SDCI), and Diablo Point Intertidal (DPI). At each Diablo Cove study area, there are, respectively, a total of 9, 9, and 4 stations which are permanent fixed. The control area, North Control Intertidal (NCI), is well removed from potential influence by the thermal discharge at a site approximately 3 km north of Diablo Cove. There are 10 fixed stations at the control area.

Within each station, regardless of location, sampling is conducted at four randomly chosen points along a 30-m transect line which is laid parallel to the shoreline. Should a point occur partially or wholly below water level, an alternate random point along the line is sampled. The points are preselected from random number tables.

Sampling periodicity is twice yearly: once during the minus tides of winter (known generally as the "Davidson Period") and once during the minus tides of summer (the "Upwelling Period"). During each period, all stations are sampled once (Table 1).

Quadrat size at each sample point is 1/4 m^2, making a total of 1 m^2 of sampled area along the 30-m transect line at each station.

TABLE 1. Intertidal Stations Surveyed, Diablo Canyon Power Plant Site, October 1976 Through August 1977.

Area	Season	Station No.	Date
NCI	Davidson	2, 3	19 Dec. 76
		4, 5, 6	18 Jan. 77
		7, 8, 9	19 Jan. 77
		10	3 Mar. 77
	Upwelling	2, 3	1 June 77
		4, 5	2 June 77
		6, 7	3 June 77
		8, 9	4 June 77
		1	5 June 77
		10	6 June 77
DPI	Davidson	No winter surveys due to rough seas during sampling occasions.	
	Upwelling	5, 6	7 May 77
		7	1 Aug. 77
SDCI	Davidson	1, 2	22 Oct. 76
		3, 4	23 Oct. 76
		5	24 Oct. 76
		6	17 Feb. 77
		7, 8	17 Jan. 77
		9	18 Dec. 76
	Upwelling	1, 2	5 May 77
		3, 4	6 May 77
		5	3 July 77
		6, 7	1 July 77
		8	30 June 77
		9	29 June 77
NDCI	Davidson	1, 2	19 Nov. 76
		3	20 Nov. 76
		4	5 Dec. 76
		5	2 Feb. 77
		6	3 Feb. 77
		7, 8	13 Feb. 77
		9	14 Feb. 77
	Upwelling	1, 3	4 May 77
		2	3 May 77
		4, 5	4 July 77
		6, 7	30 July 77
		8, 9	29 July 77

At each quadrat, the following samples and/or data are collected:

1. All foliose and filamentous red and green algae are collected in appropriately labelled plastic bags for later laboratory processing (described in the following section).

2. All solitary, non-cryptic macroinvertebrates (>10 mm) are identified, counted and selected species are measured.

3. Time at collecting and position (height) of each quadrat relative to water level is noted.

4. Percentage cover of articulated corallines and surfgrass are estimated.

In addition, abalones in a 1-m swath to either side of the 30-m transect line (=60 m^2) are counted. Since 1975, we have also performed a perpendicular-to-shoreline transect to assess abalone populations in higher regions. The length of this transect varies with shoreline width.

Once the algal samples are collected, they are preserved in 4% seawater formalin and stored until they can be processed. Processing of samples consists of sorting to species, obtaining a wet weight to 0.1 g accuracy, drying the sorted sample at 60° to 70°C for two or three days (depending on the water retention nature and quantity of a species), and obtaining a dry weight figure for each species. It is this water-free weight we use to represent biomass. All samples are then inventoried and stored at least until the study ends.

The statistical goal of this study is to be able to depict how much algae (total biomass) occurred before thermal impact begins, and to determine average (or "expected") algal species composition, abundance, associations, and seasonality.

Sea Otters

Sea otter observations are made by scanning each of the three study areas with binoculars from vantage points on the surrounding cliffs. Otters are counted, behavior noted, and an attempt is made to identify any item being consumed. Most observations were made in the early afternoon, time and weather permitting.

Fish Collections and Food Habits

Intertidal fish sampling is conducted by draining a selected tidepool using a small portable bilge pump connected to a 12-volt battery. This equipment allows us to pump out a pool averaging 7.5 m^3 in about 30 minutes.

Fish are captured by hand and dip net, identified, measured (TL), and released alive in adjacent tidepools. Unidentifiable fish are returned to the laboratory for final identification. We also collect certain species for stomach content analysis: these include *Gibbonsia metzi*, *G. elegans*, *G. montereyensis*, *Gobiesox maeandricus*, *Oligocottus snyderi*, *Xiphister atropurpureus*, and *X. mucosus*. The stomachs are removed and preserved in 70% Isopropyl for later examination under a dissecting microscope.

Fishing was conducted at random and permanent subtidal stations, time and weather conditions permitting, throughout the year to determine sportfish catch-per-unit-of-effort. We used standard terminal tackle consisting of "Wonder Jigs" with and without strips of cut squid. Wonder Jigs are commercially produced rockfish lures with four hooks covered with yellow and red yarn attached to a 30-pound test leader. Fishing took place with one or two rods for 30 minutes. During this time we attempted to catch as many fish as possible regardless of size or species. Records were kept of the station location; depth; bottom and surface temperatures; secchi disc reading; and number, size, and sex (if identifiable) of each species caught. Most fishes were returned to the water; however, we usually retained all gopher and black-and-yellow rockfishes, *Sebastes carnatus* and *S. chrysomelas*, respectively, to examine their stomach contents.

CONTROL STATIONS

Subtidal Activities

The four permanent subtidal stations established in 1970 are located in the coves immediately north and south of Diablo Cove (Figure 2). Stations 6 and 7 were surveyed twice during the year, station 15 was surveyed three times, and station 8 was reestablished and surveyed once (Tables 2A and 2B). In the North Control (Figure 1), all 24 of the random 30-m^2 stations were completed and 12 of the $1/4\text{-m}^2$ stations (four quadrats per station) were also surveyed.

Algae

Results

Twenty-three $1/4\text{-m}^2$ samples of red algae were taken from random 30-m^2 subtidal stations during the 1976 Upwelling period. The samples were subjectively selected from areas of densest algal growth within randomly selected stations which ranged in depth from 12 to 55 feet. Twelve stations were shallow ($\leq$25 feet) and 11 were deep (25 to 55 feet). *Botryoglossum farlowianum* and *Hymenena* spp. were the most common red algae, each occurring in 17 (73.9%) of the 23 samples (Table 3). *Microcladia coulteri*, occurring in 14 (60.9%) of the samples, was next most common. Twenty-six species of red algae were identified from North Control stations. Species occurring in our samples for the first time were: *Callophyllis megalocarpa*, *Rhodoptilum plumosum*, *Fauchea media*,

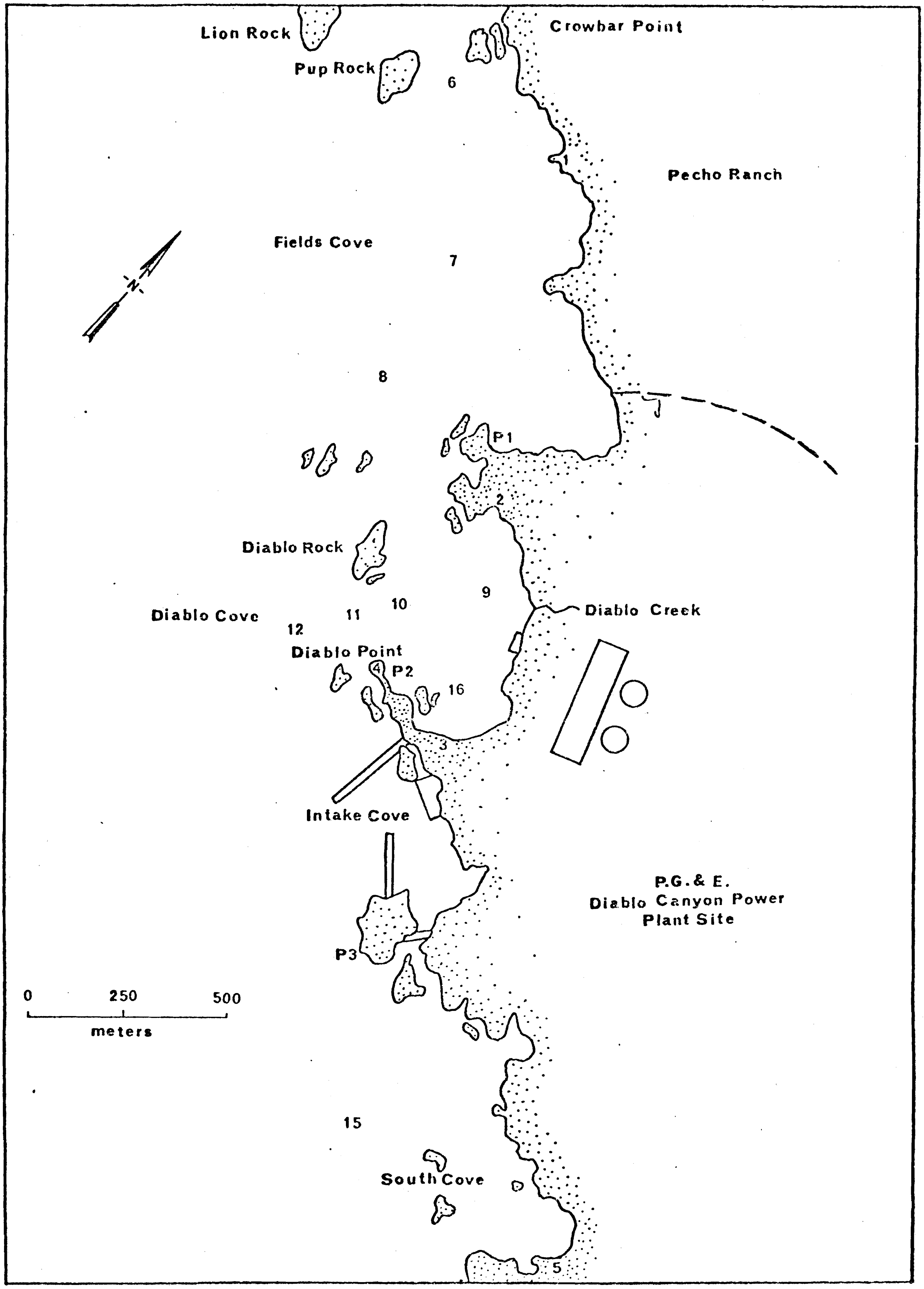


FIGURE 2. Locations of permanent subtidal and intertidal stations -- Diablo Canyon Power Plant Site. Stations 1, 2, 3, P1, P2, P3 are intertidal; Stations 6, 7, 8, 9, 10, 11, 12, 15, 16 are subtidal; Stations 4, 5, 13 and 14 are abandoned.

TABLE 2A. Summary of Subtidal Sampling Effort, Permanent Stations, Diablo Canyon Power Plant Site, July 1973 Through June 1977.

	1973	1974	1975	1976	1977
Permanent Stations (60-m^2)		Number of Surveys			
Station 6	--	2	2	2	1
7	1	3	2	2	1
8	1	2	--	--	1
9	1	2	3	2	1
10	1	2	1	2	1
11	1	3	3	2	1
12	1	2	3	2	1
15	1	1	3	2	2
16	1	1	3	2	1

TABLE 2B. Summary of Subtidal Sampling Effort, Random Stations, Diablo Canyon Power Plant Site, July 1973 Through June 1977.

	30-m^2 Stations			1/4-m^2 Stations*		
	0-25	26-50	51-75	0-25	26-50	51-75
			South Diablo Cove			
1974	6	2	--	--	--	--
1975	8	4	--	--	3	--
1976	8	4	--	5	1	--
1977	+	+	+	1	2	--
			North Diablo Cove			
1974	5	1	--	--	--	--
1975	8	4	--	3	2	--
1976	8	4	--	5	1	--
1977	+	+	+	3	1	--
			North Control			
1974	8	5	1	--	--	--
1975	15	9	--	--	--	--
1976	14	9	1	7	5	--
1977	+	+	+	+	+	+

*We sample four quadrats at each 1/4-m^2 station.

+Surveys completed after this report period.

TABLE 3. Mean Weights (Dry Weight in Grams) and Percent Frequency of Occurrence of Dominant Subtidal Red Algae at Random Stations, Diablo Canyon Power Plant Site, July Through November 1976.

	Diablo Cove (N=12)		North Control (N=23)	
Species	Mean Dry Wt. (g)/1/4m^2	Percent Frequency	Mean Dry Wt. (g)/1/4m^2	Percent Frequency
Botryoglossum farlowianum	53.1	91.7	79.9	73.9
Callophyllis violacea	2.6	41.7	0.6	26.1
Gigartina exasperata	26.5	41.7	36.7	30.4
Hymenena spp.	14.1	66.7	30.8	73.9
Iridaea cordata v. splendens	3.0	41.7	0.2	4.3
Microcladia coulteri	1.6	91.7	1.4	60.9

Pleonosporium vancouverianum, and *Rhodymenia callophyllidoides*.

The most abundant alga, in terms of mean dry weight, was *B. farlowianum*, followed by *Gigartina exasperata* and *Hymenena* spp. The mean dry weight of all random North Control samples was 156.9 g. Samples from shallow stations had a greater mean dry weight and slightly greater species diversity than deeper stations (Table 4).

Pterygophora californica was the most numerically abundant brown algae found on random subtidal stations in our North Control area (Figure 3) in 1977. The mean of 48.9 plants per 30-m^2 represents a considerable increase over the 1976 figure of 13.6. *Laminaria dentigera* was next most common with 27.8 plants per 30-m^2. This represented an increase over the 1976 mean per 30-m^2 of 21.3. Least abundant of the brown algae tabulated was *Nereocystis luetkeana*, which averaged 1.3 plants per station. This was a decrease from the 1976 peak of 5.2 plants per station (Figure 4).

P. californica was the most abundant brown algae at permanent stations (mean of 144.3 plants per station), followed by *L. dentigera* (58.3 plants per station) and *N. luetkeana* (20.5 plants per station). *Laminaria* and *Nereocystis* both showed increases over the 1976 figures of 50.7 and 1.3 plants per station, respectively (Figure 3). *Pterygophora*, on the other hand, declined from the 1976 level of 153.3 plants per station (Figure 4).

Invertebrates

Results

As mentioned in the introduction, we will not present tables of collated data in this annual report as we have done in the past. Instead, the discussion which follows includes the more abundant quantified species. We also present some preliminary analyses utilizing some of the methods we will be presenting in the final report of preoperational studies. In

TABLE 4. Mean Dry Weights and Numbers of Species of Red Algae by Depth From Random 1/4-m^2 Quadrat Samples, Diablo Canyon Power Plant Site, July Through November 1976.

	Diablo Cove			North Control		
	No. of Stations	Mean No. of Species	Mean Dry Wt. per 1/4m^2	No. of Stations	Mean No. of Species	Mean Dry Wt. per 1/4m^2
Shallow Stations (< 25 feet)	8	7.2	141.9	12	5.6	220.8
Deep Stations (25 to 55 feet)	4	10.0	90.4	11	4.8	87.1
TOTALS	12	8.2	124.3	23	5.2	156.9

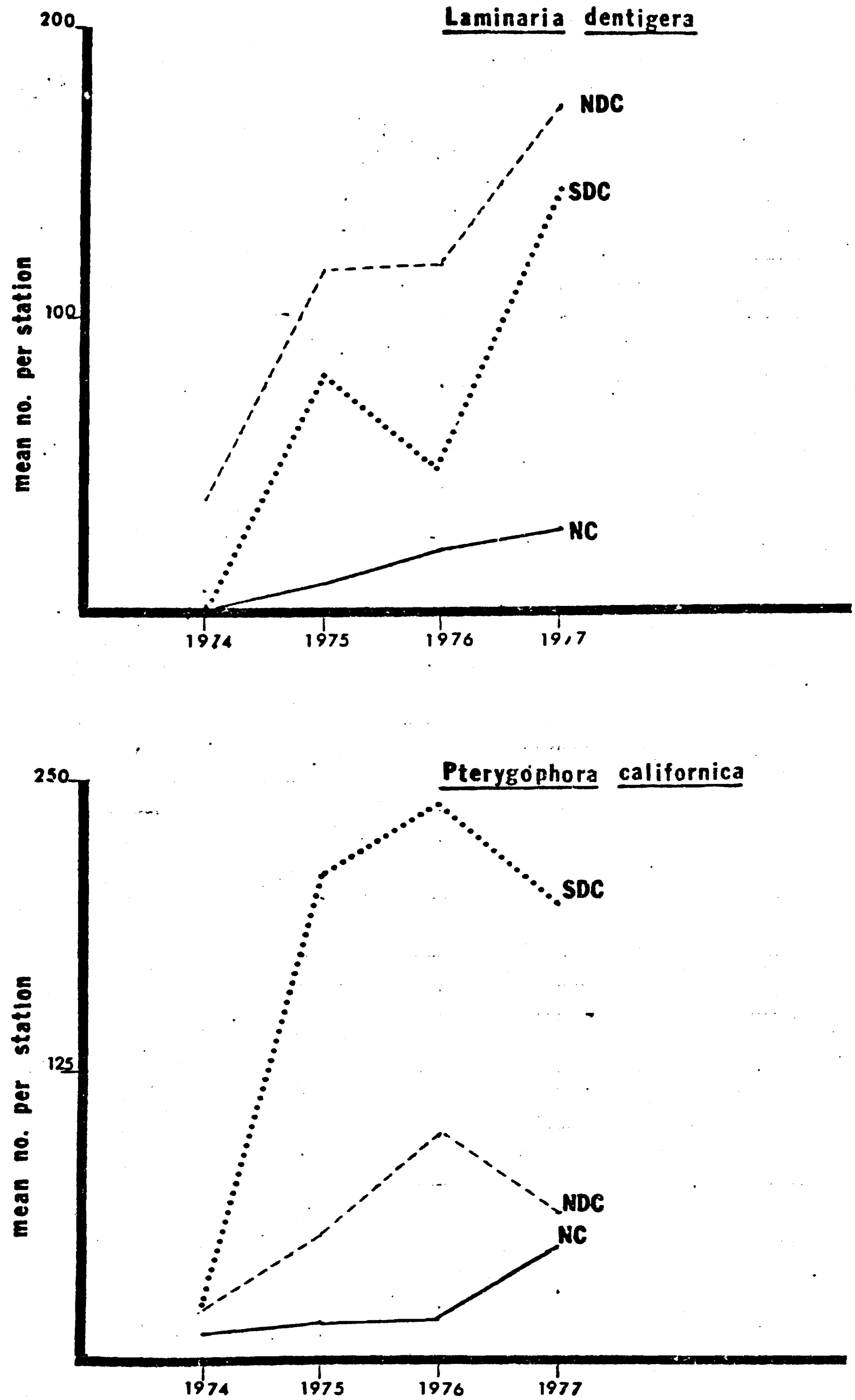


FIGURE 3. Mean counts of *Laminaria* and *Pterygophora* at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant. NDC-North Diablo Cove, SDC-South Diablo Cove, NC-North Control. (Refer to Tables 2A and 2B for level of effort.)

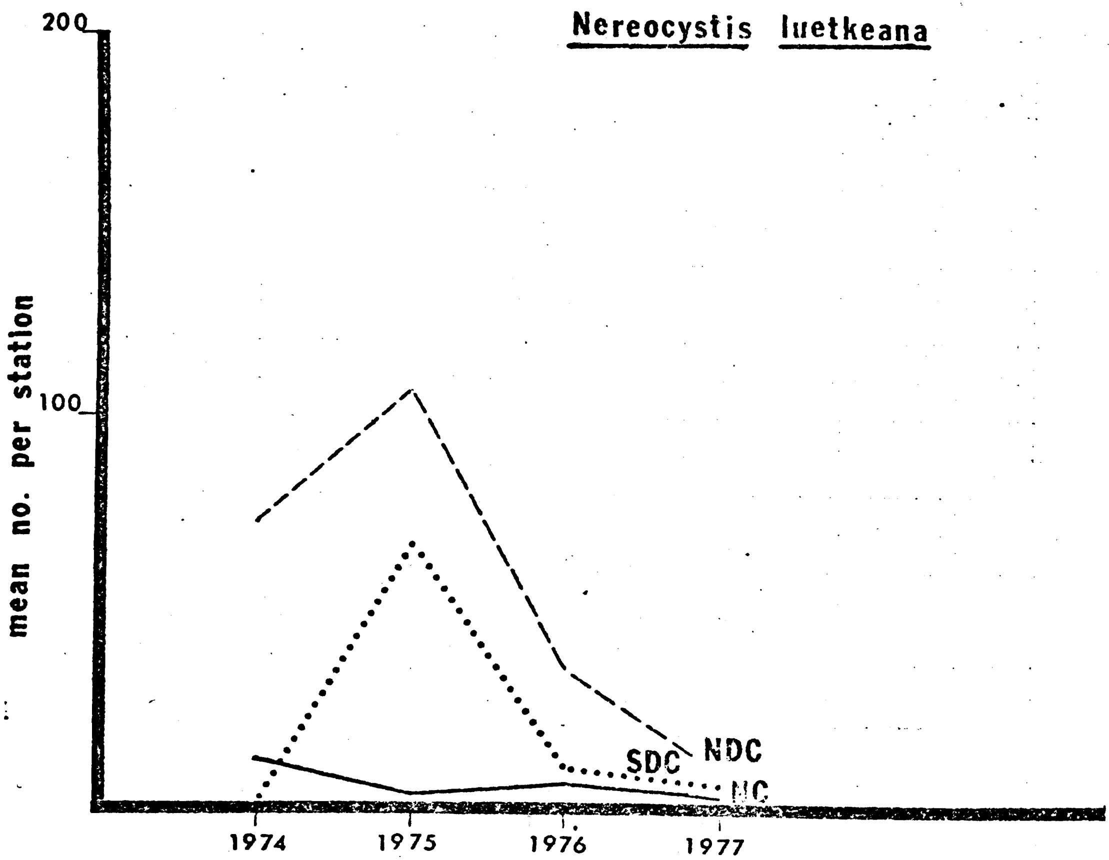


FIGURE 4. Mean counts of bull kelp at random 30-m^2 stations, Diablo Canyon Power Plant Site. NDC-North Diablo Cove, SDC-South Diablo Cove, NC- North Control.

order to provide more data points, we are including some random station data collected from July through October 1977 that usually would not be included.

Leucilla nuttingi: an increase in the frequency of occurrence of the aggregating urn sponge at random stations in the North Control follows the same pattern observed at Diablo Cove stations (Figure 5). This apparent increase may be due to increased diver recognition over the years.

Tethya aurantia: *Tethya* abundance at permanent stations has been comparatively stable (Figure 6), but at random North Control stations (30-m^2) the abundance of the orange puffball sponge has increased since the initial 1974 surveys (Figure 7). The regression analysis of *Tethya* numbers and depth indicated a significant relationship; the calculated r value is 0.88 (Table 5).

Anthopleura xanthogrammica: permanent control stations have produced relatively stable counts of green anemones over the years (Figure 8). Conversely, counts of green anemones have increased dramatically at North Control random stations (Figure 9). *Anthopleura* numbers per station tend to decrease with depth at North Control random stations (Table 5).

Balanophyllia elegans: the frequency of occurrence of orange cup corals has increased slightly at North Control random stations (Figure 10). The increase in abundance at deeper stations was significant (Table 5).

Epiactis prolifera: the proliferating anemones' frequency of occurrence has increased substantially at random North Control stations. The decrease in abundance with increasing depth was significant at the 95% level (Figure 11).

Henricia leviuscula: at permanent control stations, *Henricia* numbers have remained fairly stable (Figure 12). However, the density of red sea

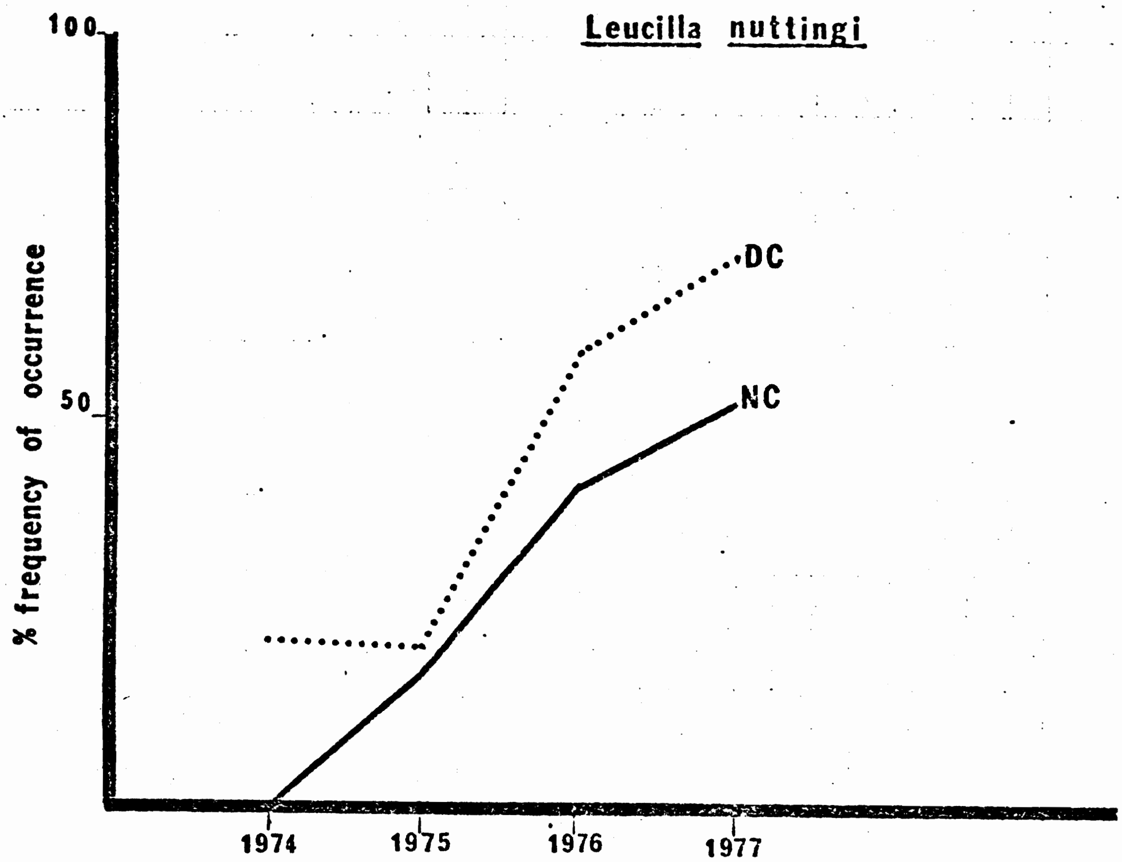


FIGURE 5. Frequency of occurrence of aggregating urn sponge at random 30-m^2 subtidal stations, Diablo Canyon Power Plant. DC-Diablo Cove, NC-North Control.

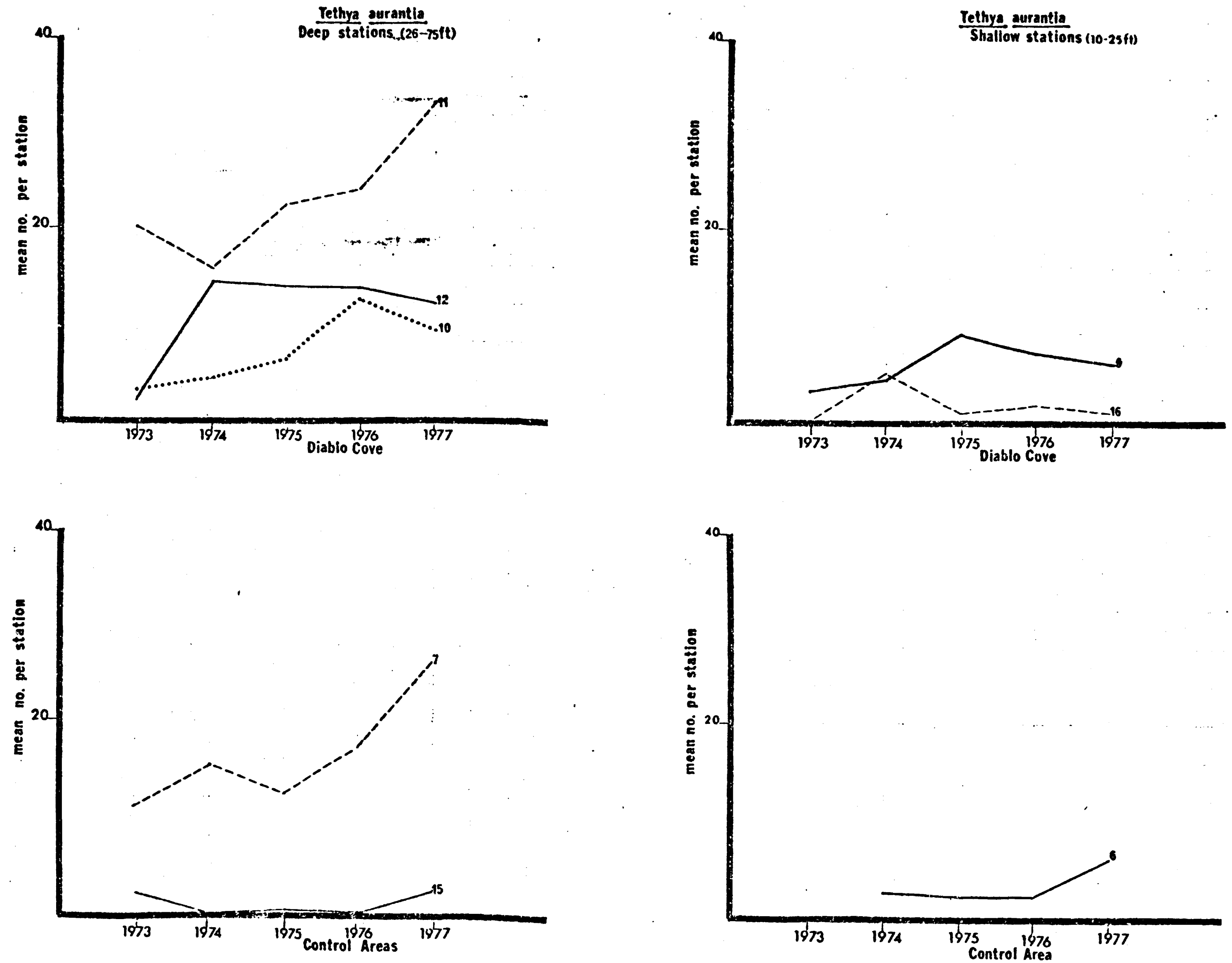


FIGURE 6. Mean counts of orange puffball sponges at permanent subtidal stations, Diablo Canyon Power Plant Site. Stations are identified by number at the end of each line. (See Figure 2 for station locations.)

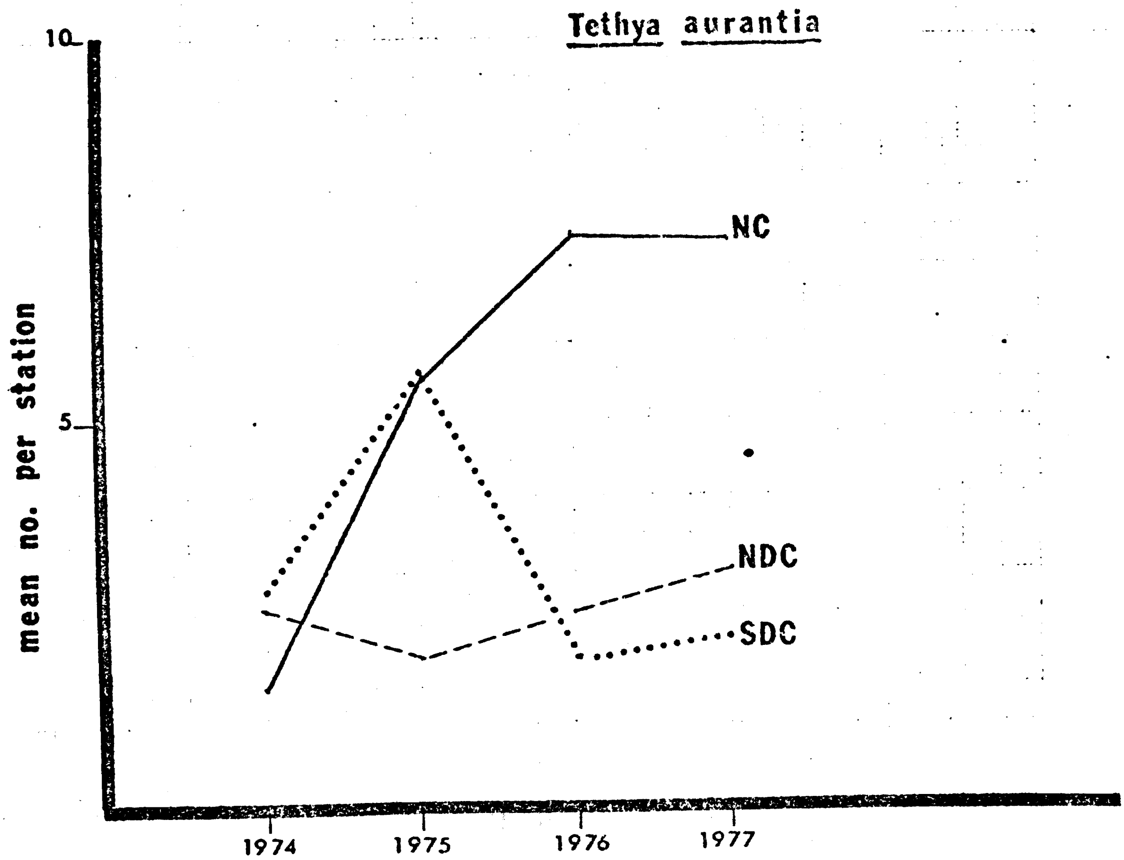


FIGURE 7. Mean counts of orange puffball sponges at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, NDC-North Diablo Cove, SDC-South Diablo Cove.

TABLE 5. Least Square Regression Analyses (Y = a + bX) of Numbers Per Station (Y) and Depth (X) of Selected Brown Algae and Invertebrates, Diablo Canyon Power Plant Site, 1976.

	DIABLO COVE					NORTH CONTROL				
Species	No. of Observations	a	b	σ of b	r	No. of Observations	a	b	σ of b	r
Brown Algae										
Laminaria dentigera	24	25.57	5.33	2.30	0.44	24	24.31	-0.71	0.51	-0.30
Nereocystis luetkeana	24	25.78	2.38	0.97	0.46	24	14.29	0.75	0.32	0.45
Pterygophora californica	24	333.68	-8.33	3.82	-0.42	24	1.10	0.48	0.35	0.28
Invertebrates										
Acmaea mitra	40	1.22	0.32	0.42	0.12	48	-0.14	0.29	0.13	0.32
Anthopleura xanthogrammica	24	4.76	0.20	0.26	0.16	24	41.19	-0.80	0.36	-0.42
Astraea gibberosa	24	8.16	-0.13	0.18	-0.16	24	20.92	-0.29	0.18	-0.32
Balanophyllia elegans	40	14.66	1.10	0.29	0.52	48	15.03	1.01	0.20	0.59
Doriopsilla albopunctata	24	1.72	0.18	0.57	0.58	24	1.29	0.96	0.60	0.32
Epiactis prolifera	40	5.59	-0.13	0.10	-0.20	48	2.00	-0.44	0.16	-0.38
Henricia leviuscula	24	3.40	-0.45	0.13	-0.75	24	12.42	-0.14	0.12	-0.25
Homalopoma luridum	40	0.94	0.64	0.34	0.29	48	-0.22	0.35	0.14	0.35
Patiria miniata	24	29.53	4.53	1.84	0.46	24	5.66	2.72	0.50	0.75
Pisaster giganteus	24	36.86	2.59	1.87	0.28	24	-1.68	0.16	0.31	0.74
Strongylocentrotus franciscanus	24	88.59	6.17	3.02	0.40	24	-0.94	0.19	0.81	0.45
Styela montereyi	24	-10.35	1.12	0.34	0.57	24	5.60	0.90	0.16	0.12
Tethya aurantia	24	3.50	0.29	0.10	0.51	24	10.61	0.69	0.78	0.88
Tonicella lineata	40	-0.12	0.60	0.32	0.29	48	-0.14	0.43	0.20	0.31

a = intercept; b = slope; r = correlation coefficient; σ = standard deviation
+ slope = an increase in abundance with increasing depth   - slope = a decrease in abundance with increasing depth
95% significance level for 24 stations with two degrees of freedom = 0.47; for 40 stations = 0.36; for 48 stations = 0.33

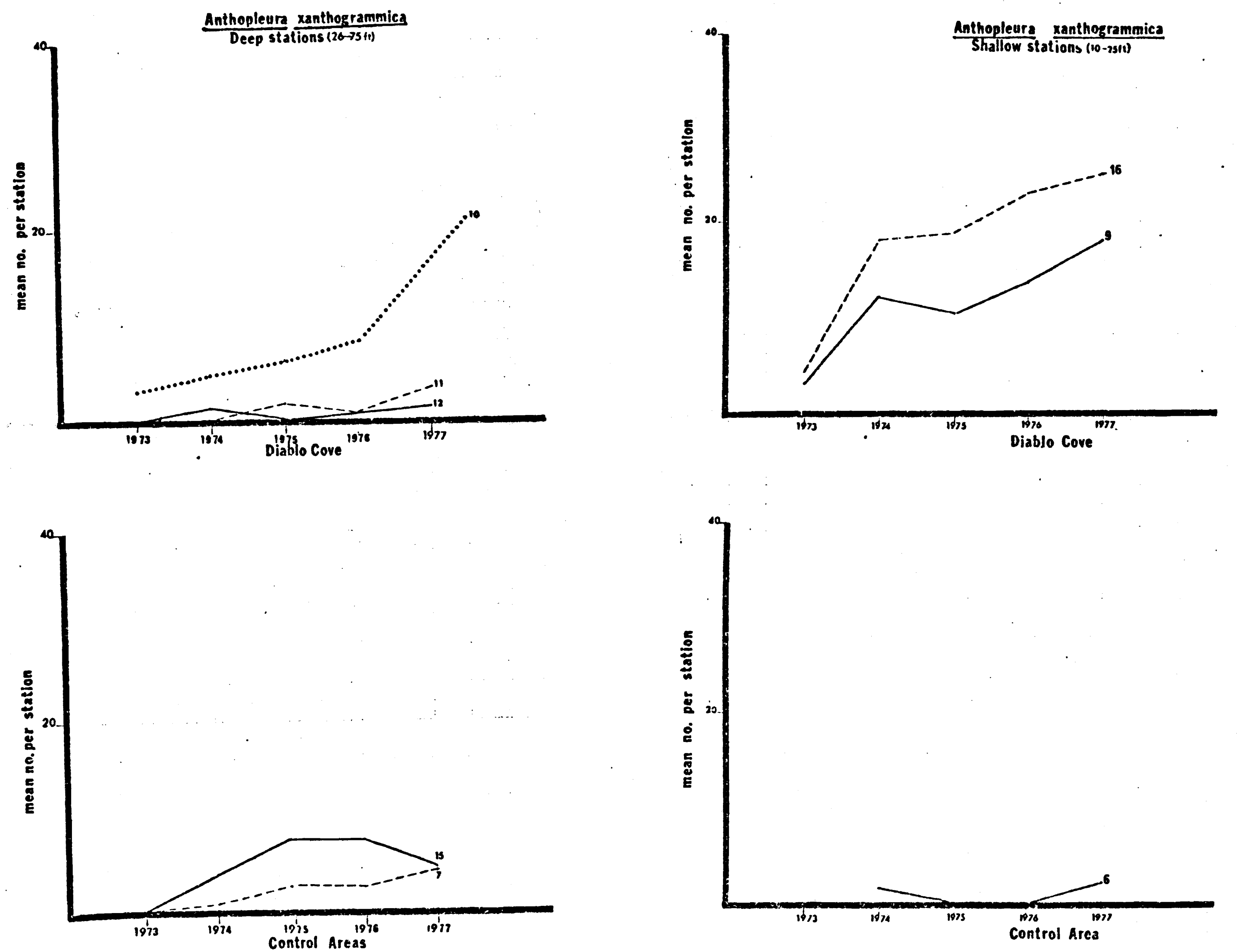


FIGURE 8. Mean counts of green anemones at permanent subtidal stations, Diablo Canyon Power Plant Site.

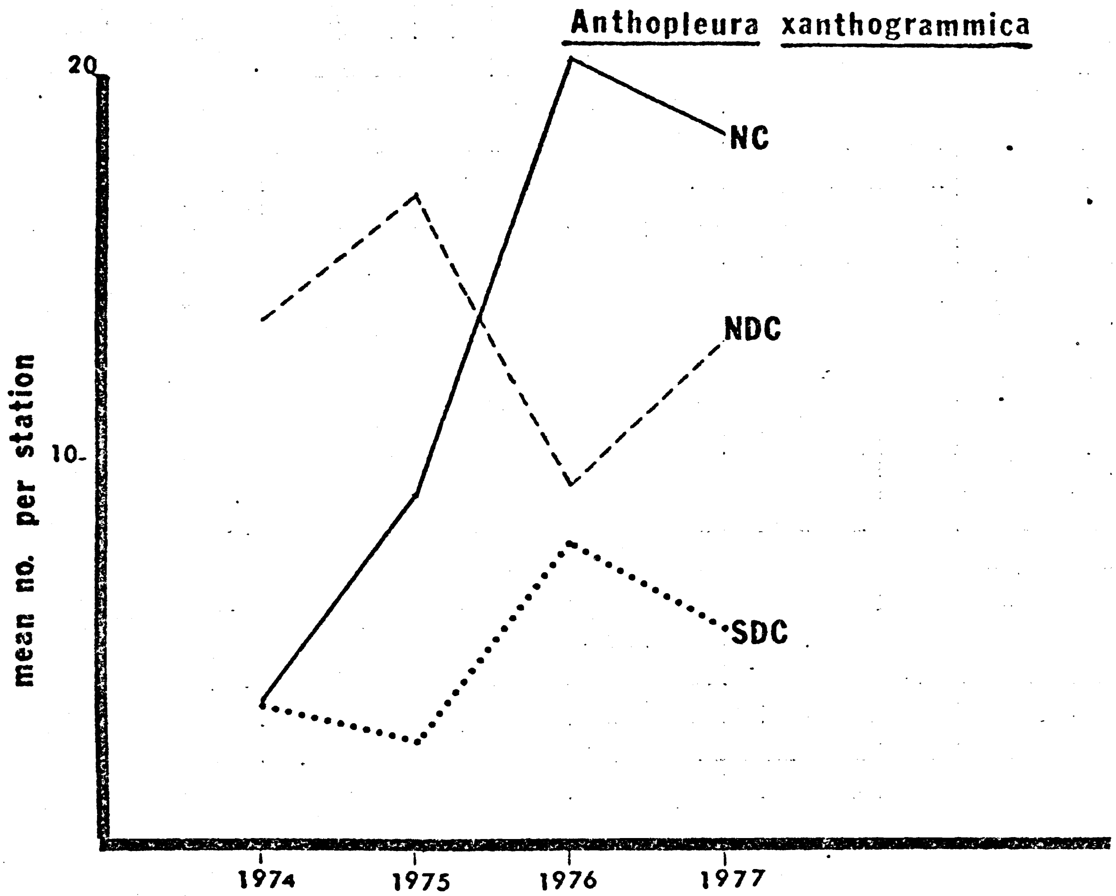


FIGURE 9. Mean counts of green anemones at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, NDC-North Diablo Cove, SDC-South Diablo Cove.

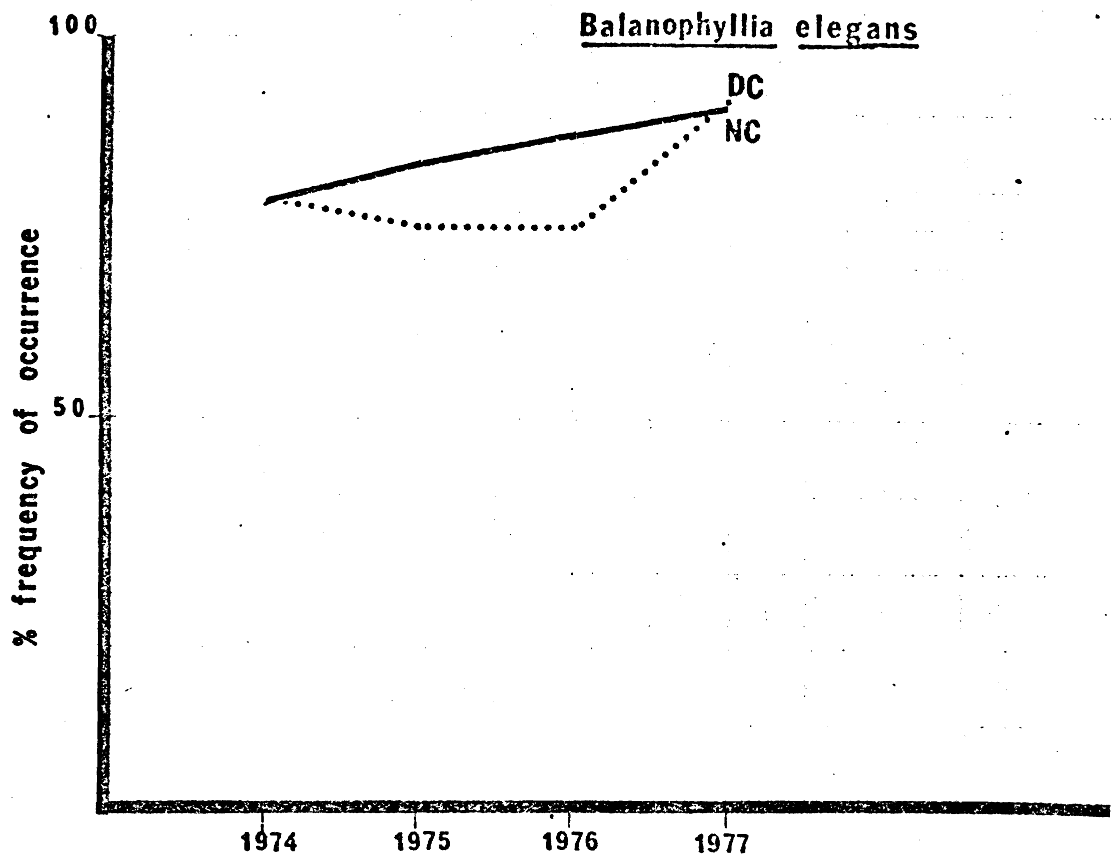


FIGURE 10. Frequency of occurrence of orange cup corals at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. DC-Diablo Cove, NC-North Control.

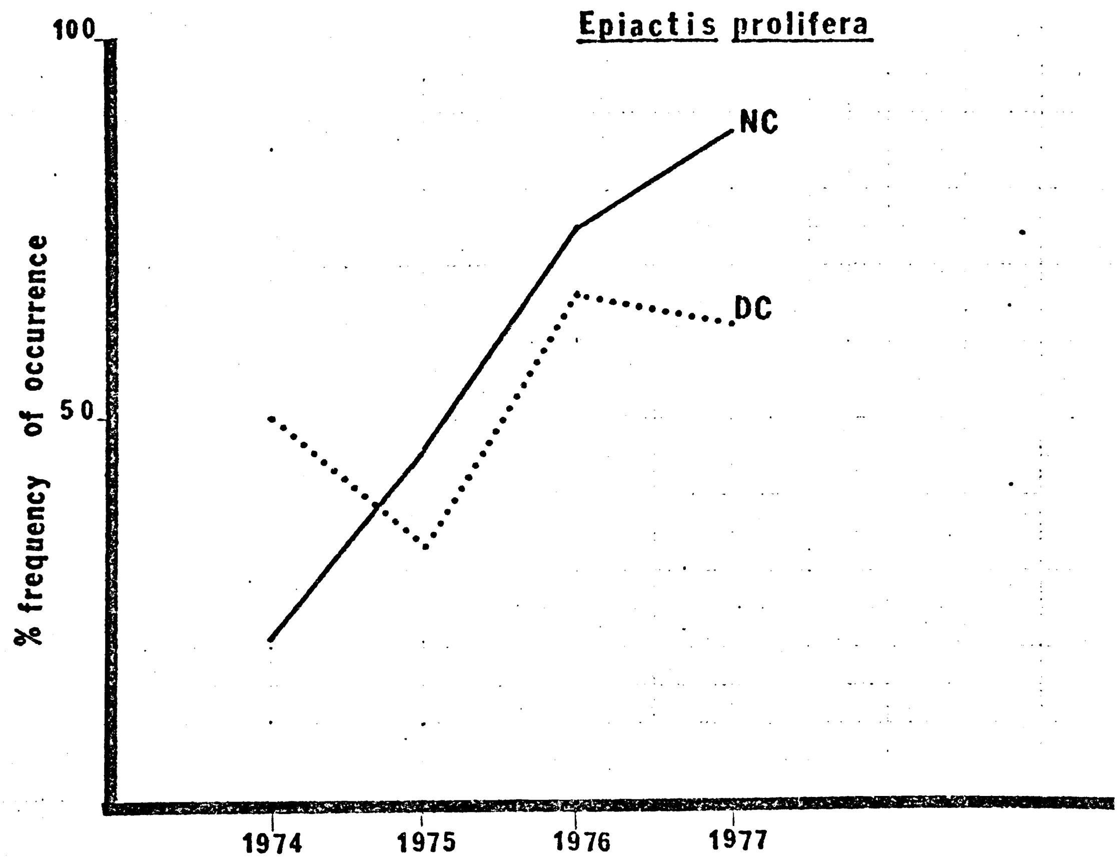


FIGURE 11. Frequency of occurrence of proliferating anemones at all random $30\text{-}m^2$ subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove.

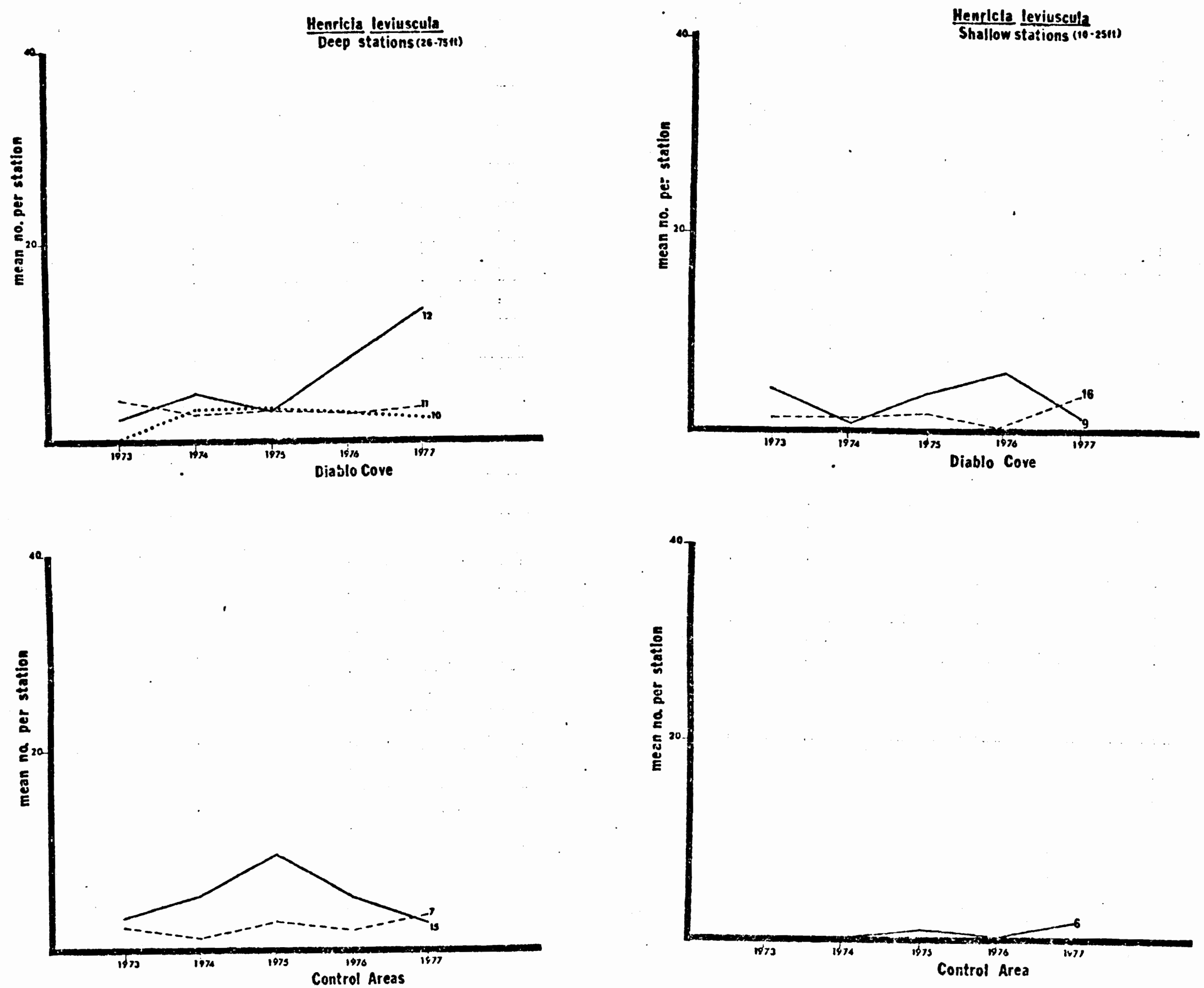


FIGURE 12. Mean counts of red sea stars at permanent subtidal stations, Diablo Canyon Power Plant Site.

stars has consistently increased at North Control random stations since 1974 (Figure 13). There appears to be little or no relationship between depth and abundance of red sea stars that we have observed in Diablo Cove (Table 5).

Orthasterias koehleri: despite year-to-year fluctuations, rainbow sea star populations are about the same at permanent control stations as they were in 1974 (Figure 14). There was an apparent decrease in numbers at North Control random stations (Figure 15).

Patiria miniata: sea bat numbers have varied widely at permanent control stations over the years (Figure 16). At random North Control stations, there has been a small increase in abundance (Figure 17). *Patiria* were significantly more abundant at deeper North Control stations (Table 5).

Pisaster giganteus: giant spined sea stars increased in numbers at permanent stations 6 and 7 but declined at station 15 (Figure 18). Their abundance at North Control random stations has decreased (Figure 19). Giant spined sea stars were significantly more abundant at deeper stations; the r value of the regression for occurrence with depth is 0.73 (Table 5).

Pycnopodia helianthoides: numbers for the sun star have also varied considerably at permanent control stations (Figure 20) at North Control random stations. *Pycnopodia* has declined steadily at all locations since our initial surveys in 1974 (Figure 21).

Strongylocentrotus franciscanus: the decline of giant red sea urchins at permanent control stations and random North Control stations parallels that of Diablo Cove permanent and random stations (Figures 22, 23). Giant red sea urchins were more abundant at deeper stations (Table 5).

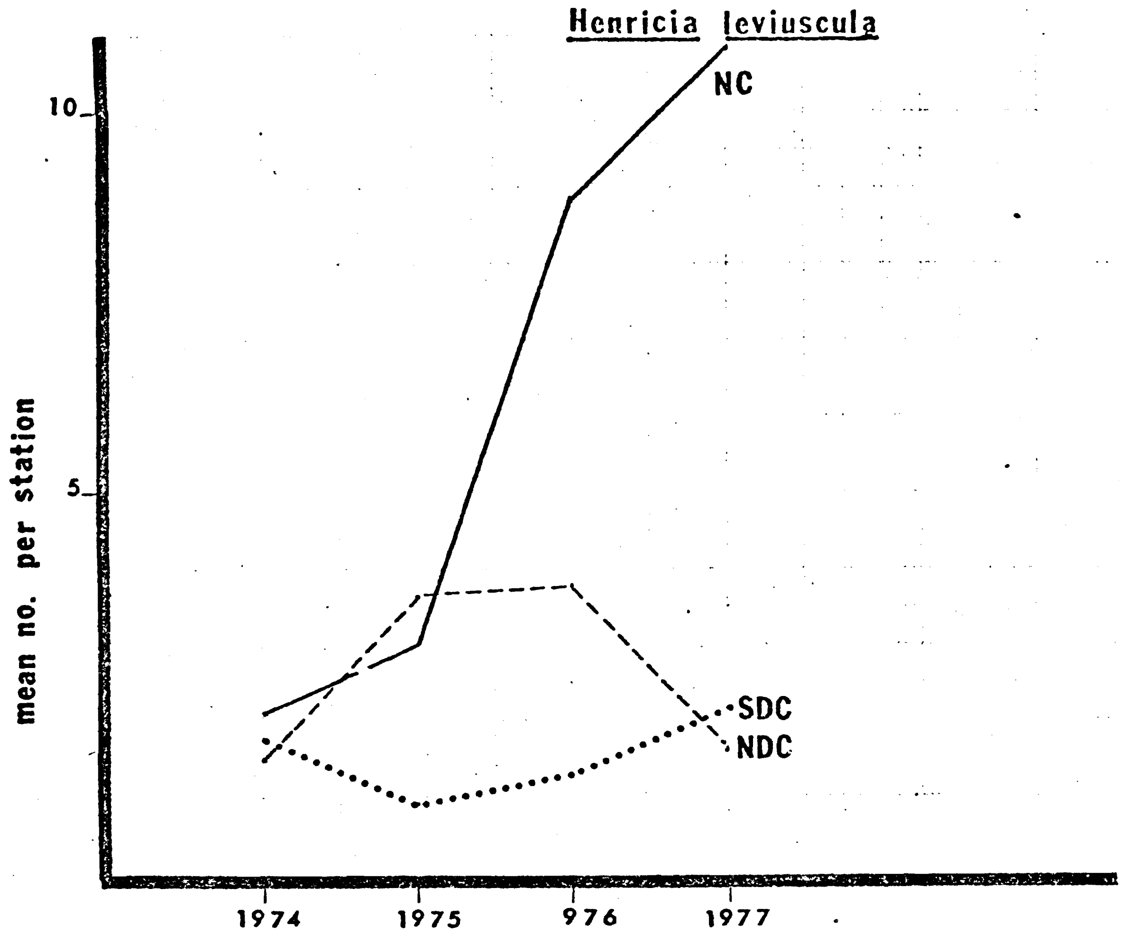


FIGURE 13. Mean counts of red sea stars at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, SDC-South Diablo Cove, NDC-North Diablo Cove.

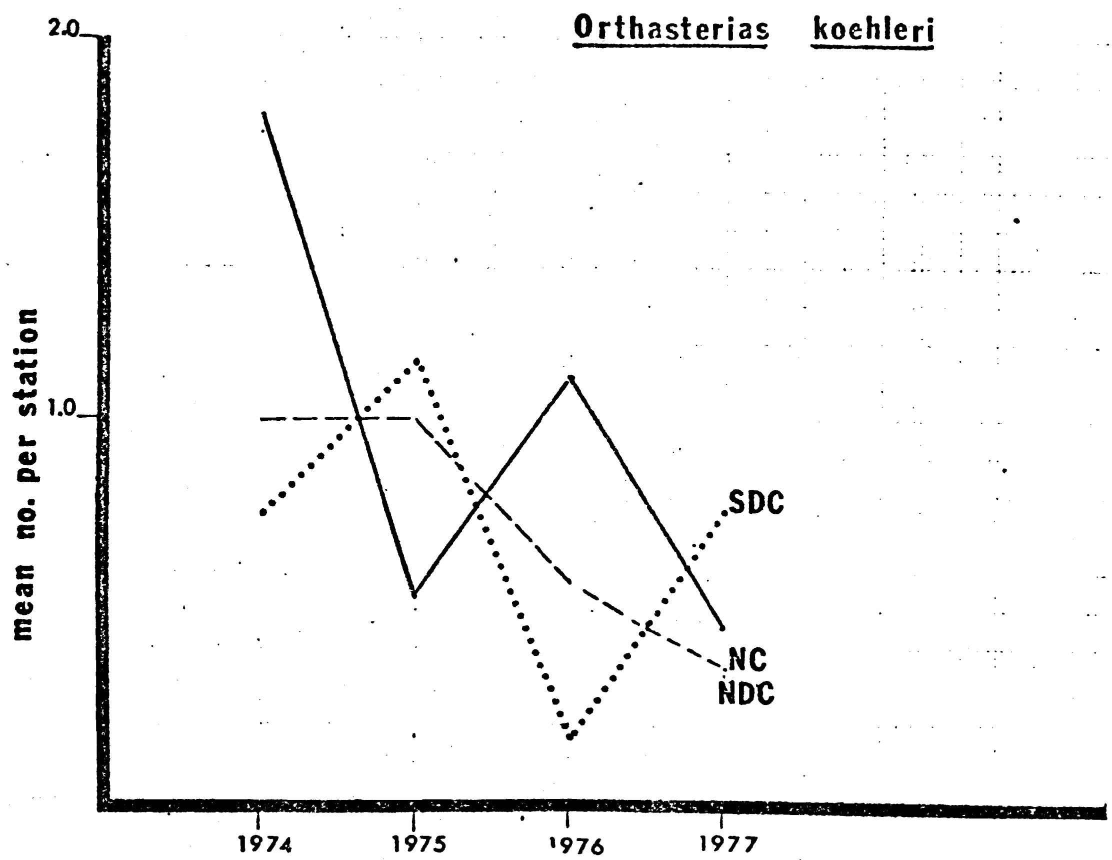


FIGURE 15. Mean counts of rainbow sea stars at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. SDC-South Diablo Cove, NC-North Control, NDC-North Diablo Cove.

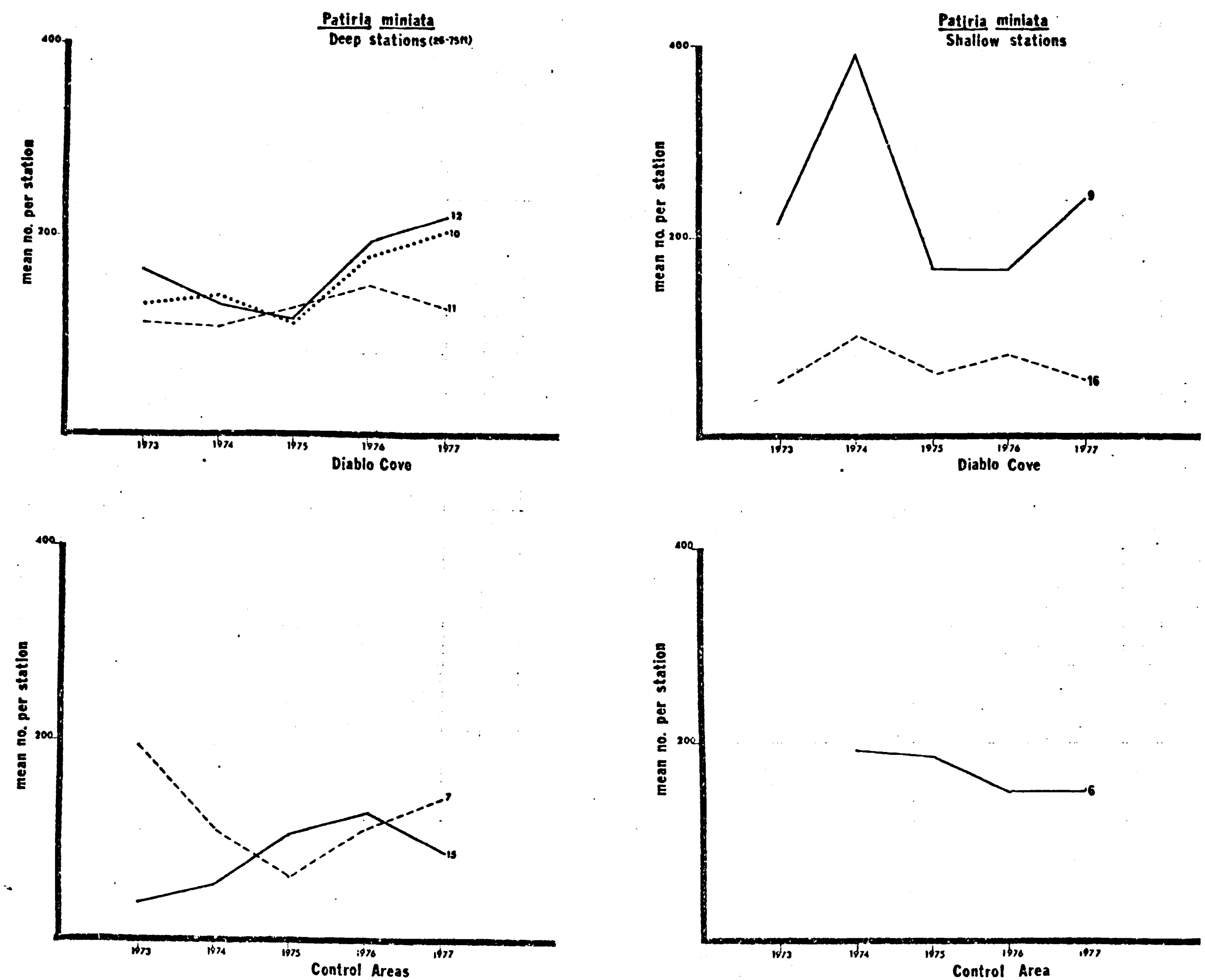


FIGURE 16. Mean count of sea bats at permanent subtidal stations, Diablo Canyon Power Plant Site.

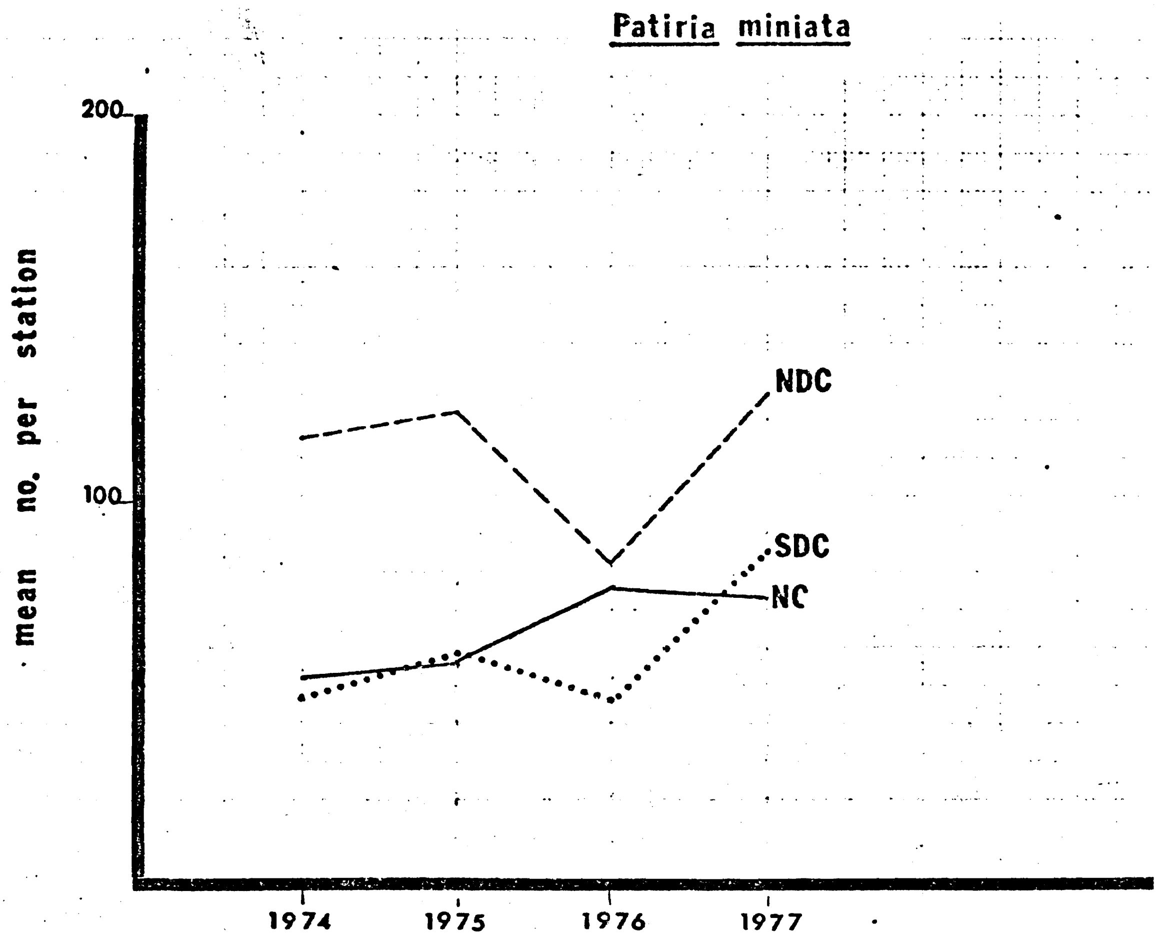


FIGURE 17. Mean counts of sea bats at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NDC-North Diablo Cove, SDC-South Diablo Cove, NC-North Control.

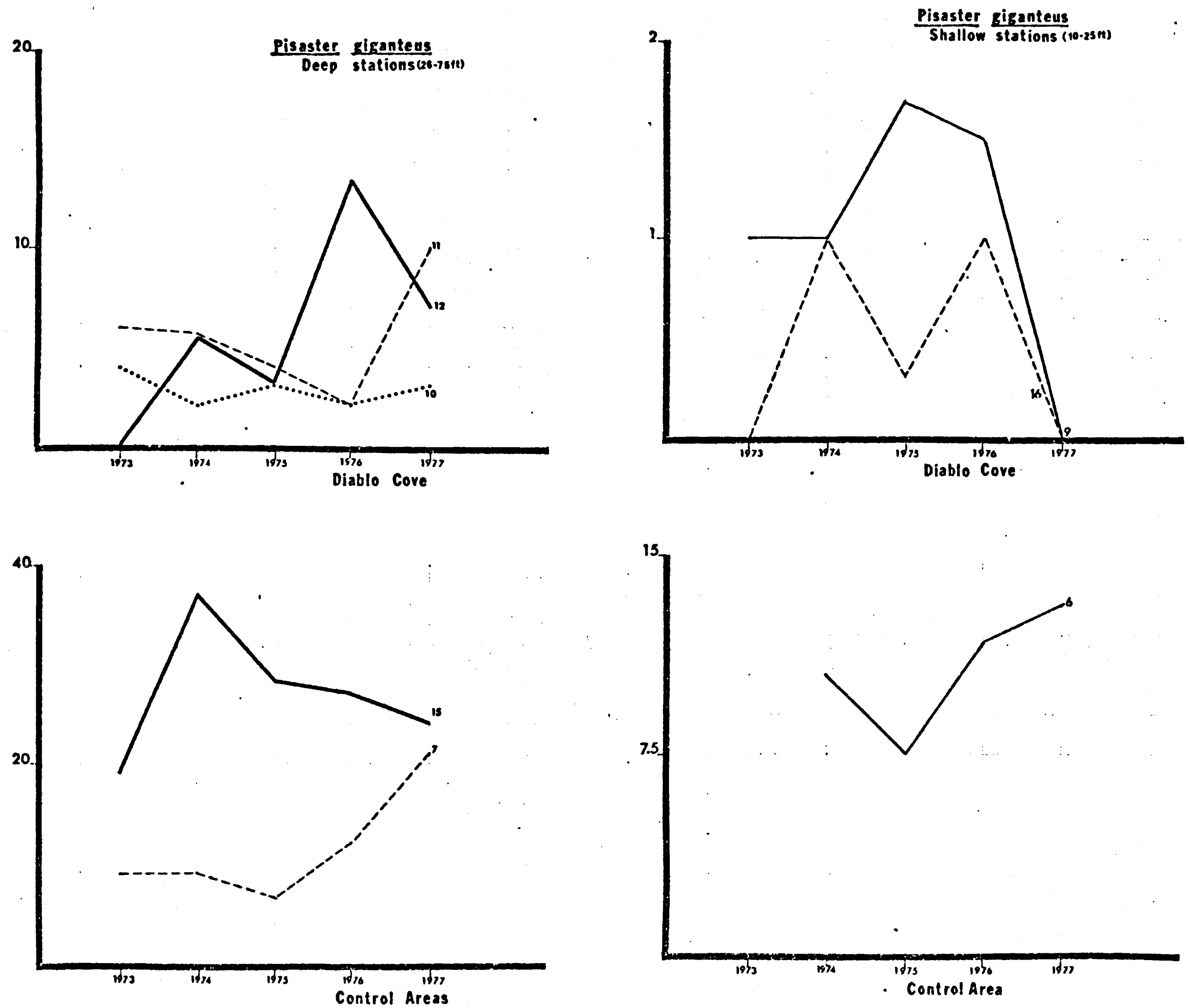


FIGURE 18. Mean counts of giant spined sea stars at permanent subtidal stations, Diablo Canyon Power Plant Site.

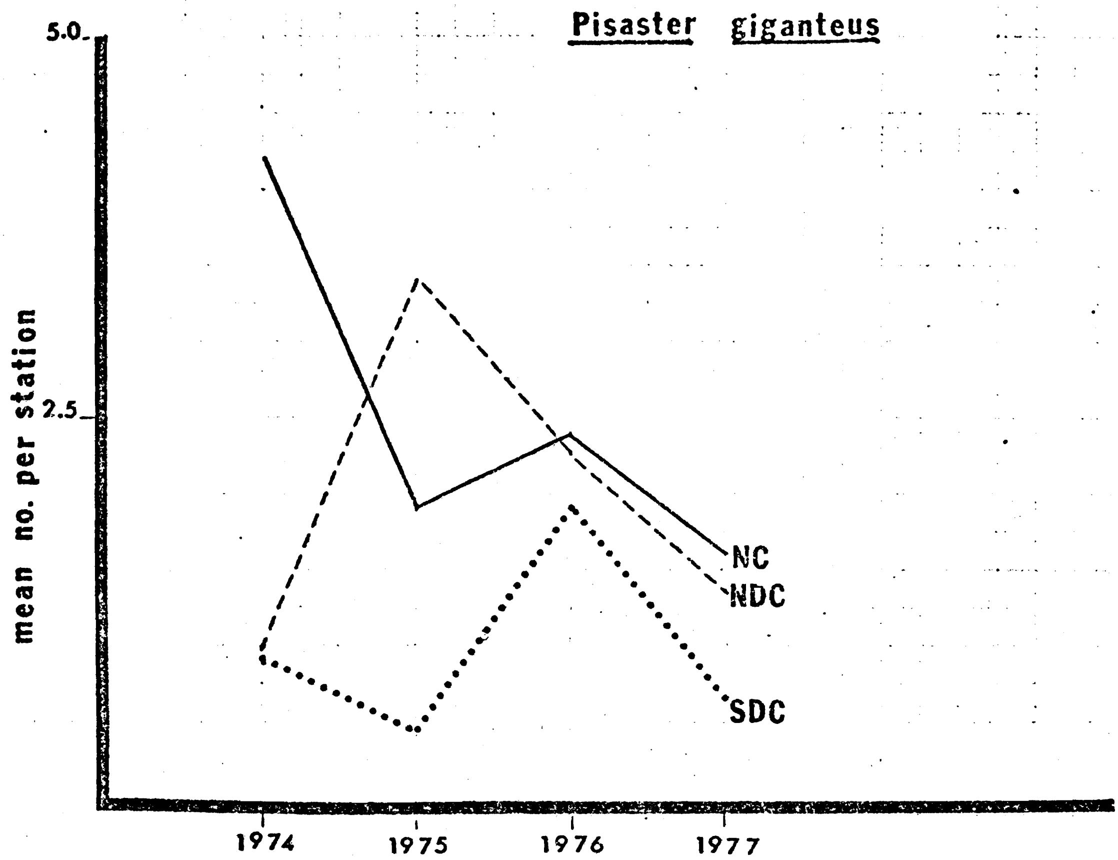


FIGURE 19. Mean counts of giant spined sea stars at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, NDC-North Diablo Cove, SDC-South Diablo Cove.

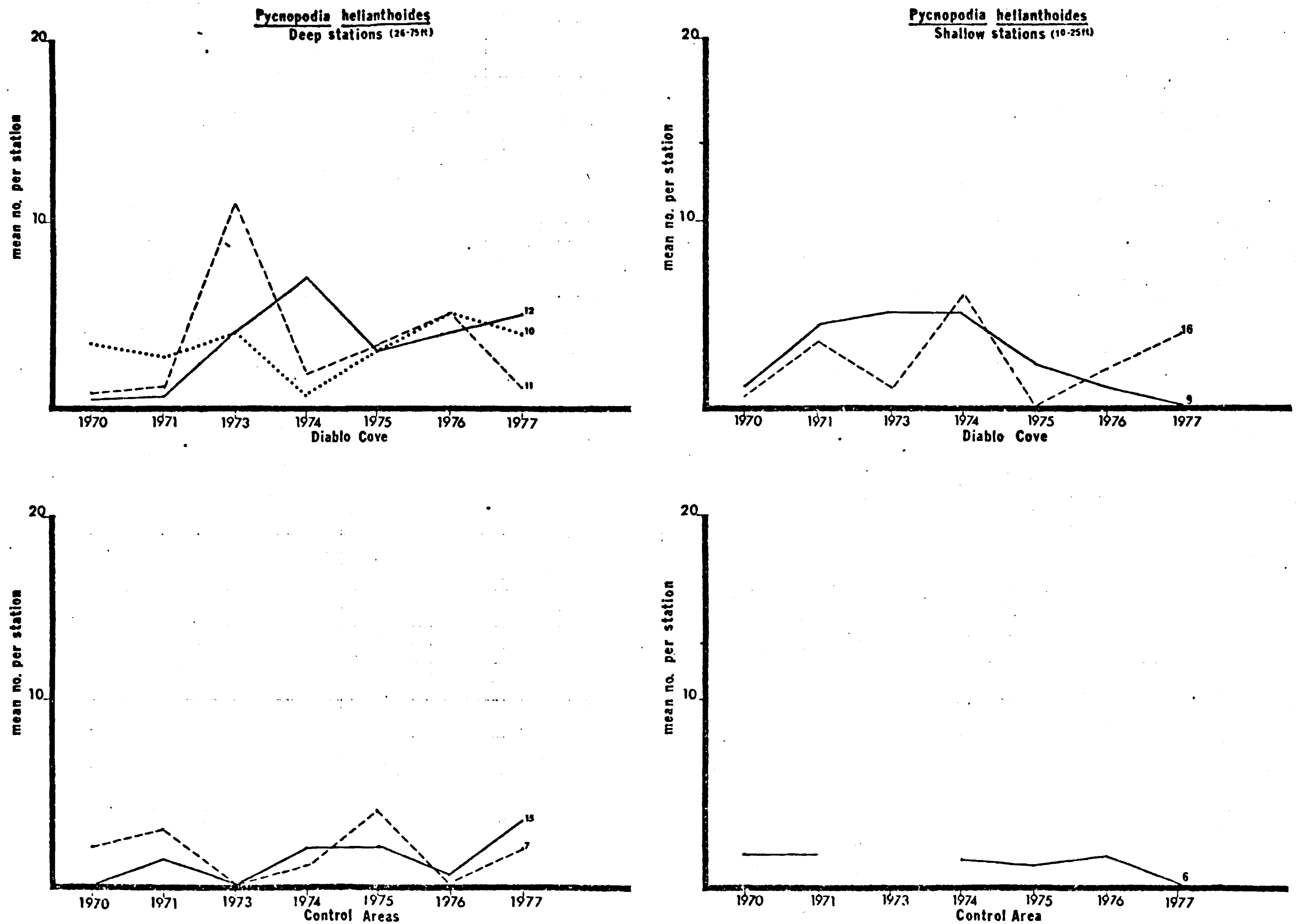


FIGURE 20. Mean counts of sun stars at permanent subtidal stations, Diablo Canyon Power Plant Site.

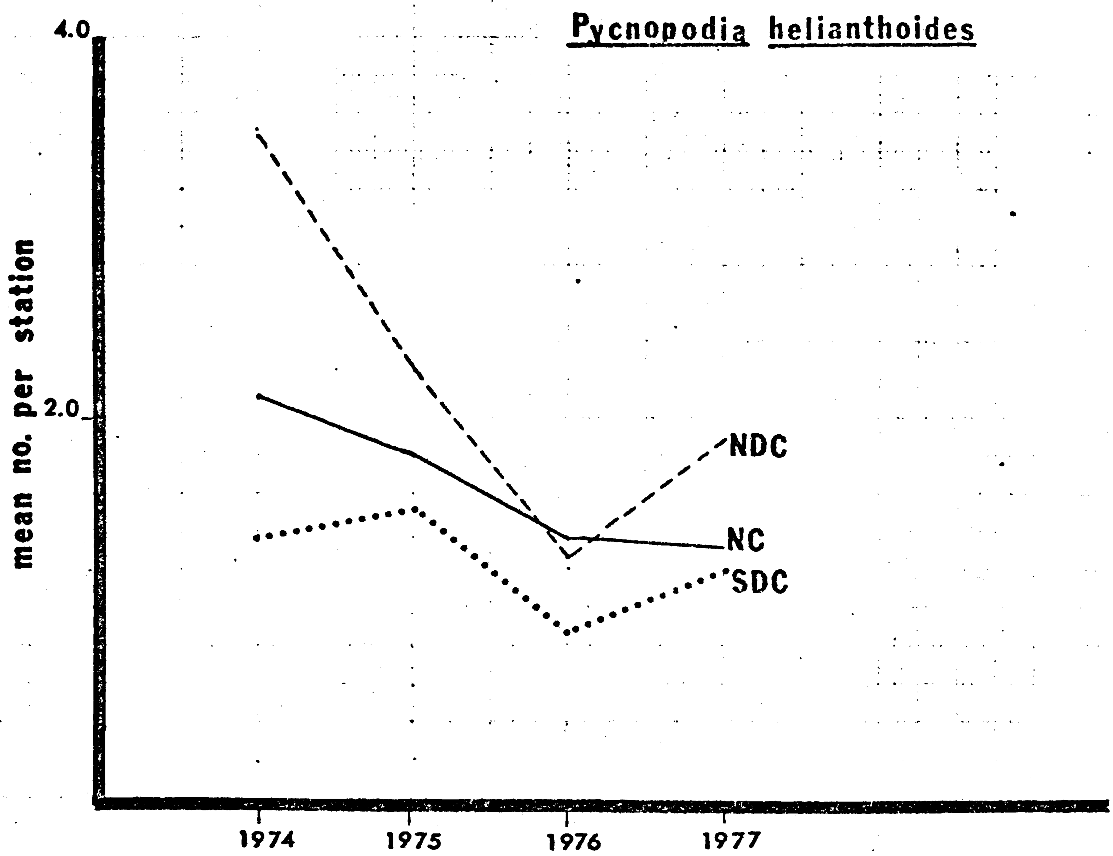


FIGURE 21. Mean counts of sun stars at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NDC-North Diablo Cove, NC-North Control, SDC-South Diablo Cove.

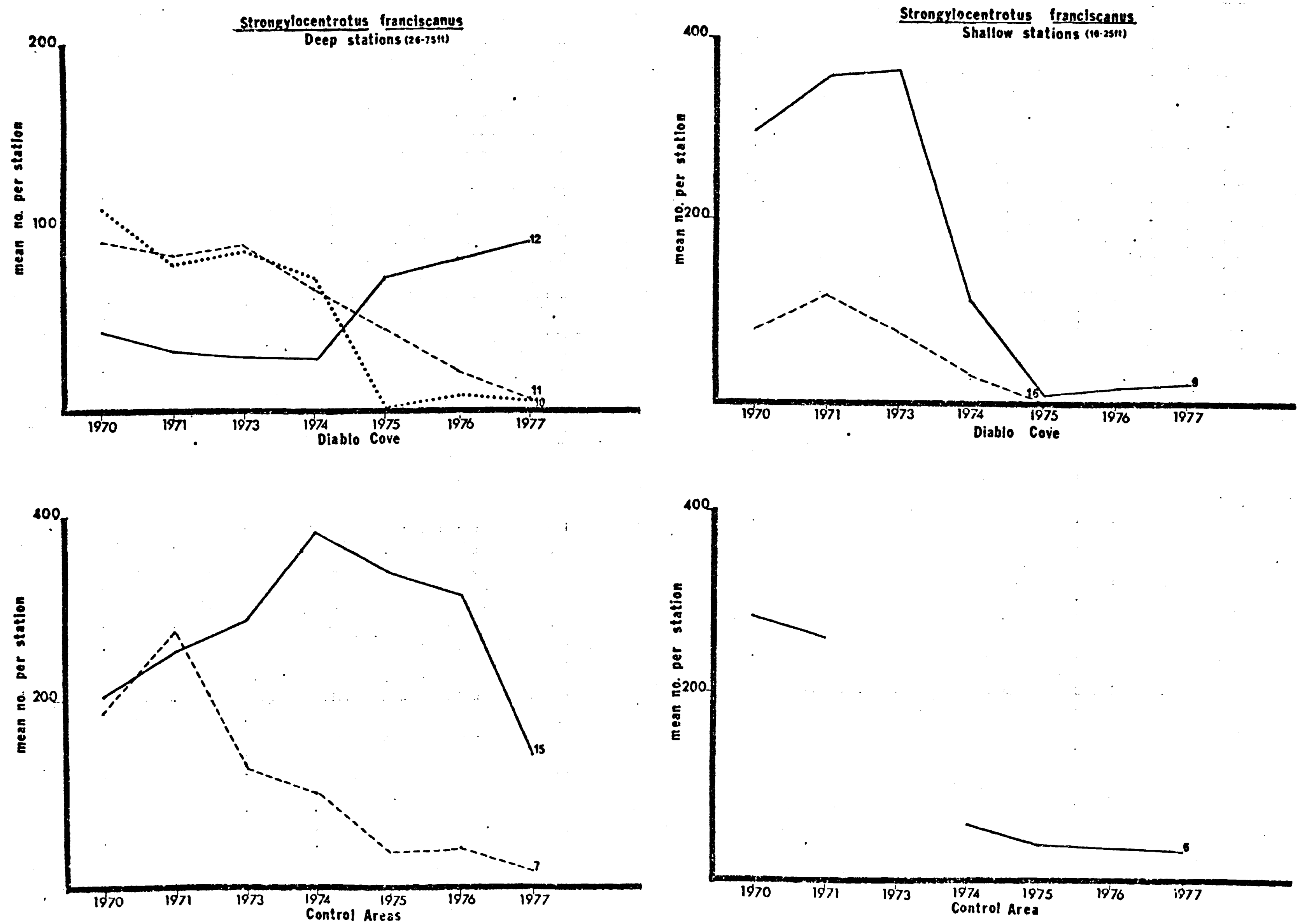


FIGURE 22. Mean counts of giant red sea urchins at permanent subtidal stations, Diablo Canyon Power Plant Site.

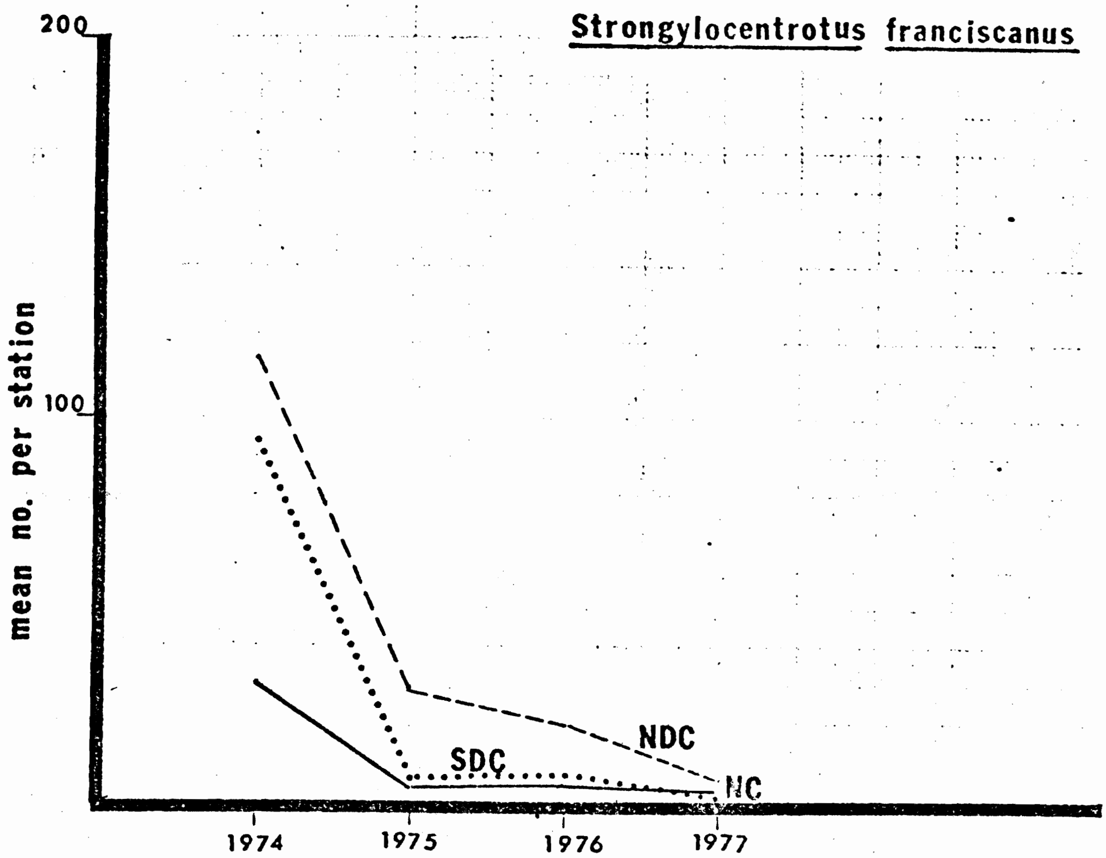


FIGURE 23. Mean counts of giant red sea urchins at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NDC-North Diablo Cove, SDC-South Diablo Cove.

Cancer antennarius: rock crabs increased at permanent control stations 6 and 7 but decreased at station 15 (Figure 24). An apparent slight increase in rock crab density has been observed at North Control random stations since 1974 (Figure 25).

Astraea gibberosa: red turban snail numbers have been quite stable at permanent control stations, but have increased substantially at North Control random stations (Figures 26 and 27).

Doriopsilla albopunctata: *Doriopsilla* increased in abundance at all permanent control stations, and at North Control random stations (Figures 28 and 29). The regression of numbers and depth for *Doriopsilla* produced a low r value of 0.32 (Table 5), indicating no relationship with depth.

Haliotis rufescens: red abalone numbers have declined substantially at permanent control stations. However, the density at North Control random stations apparently has been increasing since 1975 when the sea otter front moved farther to the south (Figures 30 and 31).

Homalopoma luridum: *Homalopoma* are one of the most common snails that we have observed at our random 1/4-m^2 stations. The calculated r value of 0.35 for the relationship of abundance with increasing depth was significant at the 95% level (Table 5).

Tonicella lineata: the frequency of occurrence of the lined chiton appears to have increased over the years at North Control random stations (Figure 32).

Eudistylia polymorpha and *Boltenia villosa*: our divers are seeing *Eudistylia* and *Boltenia* at more random stations than in previous years (Figure 33).

Styela montereyensis: densities of this solitary tunicate have followed the same patterns at random North Control stations as noted in

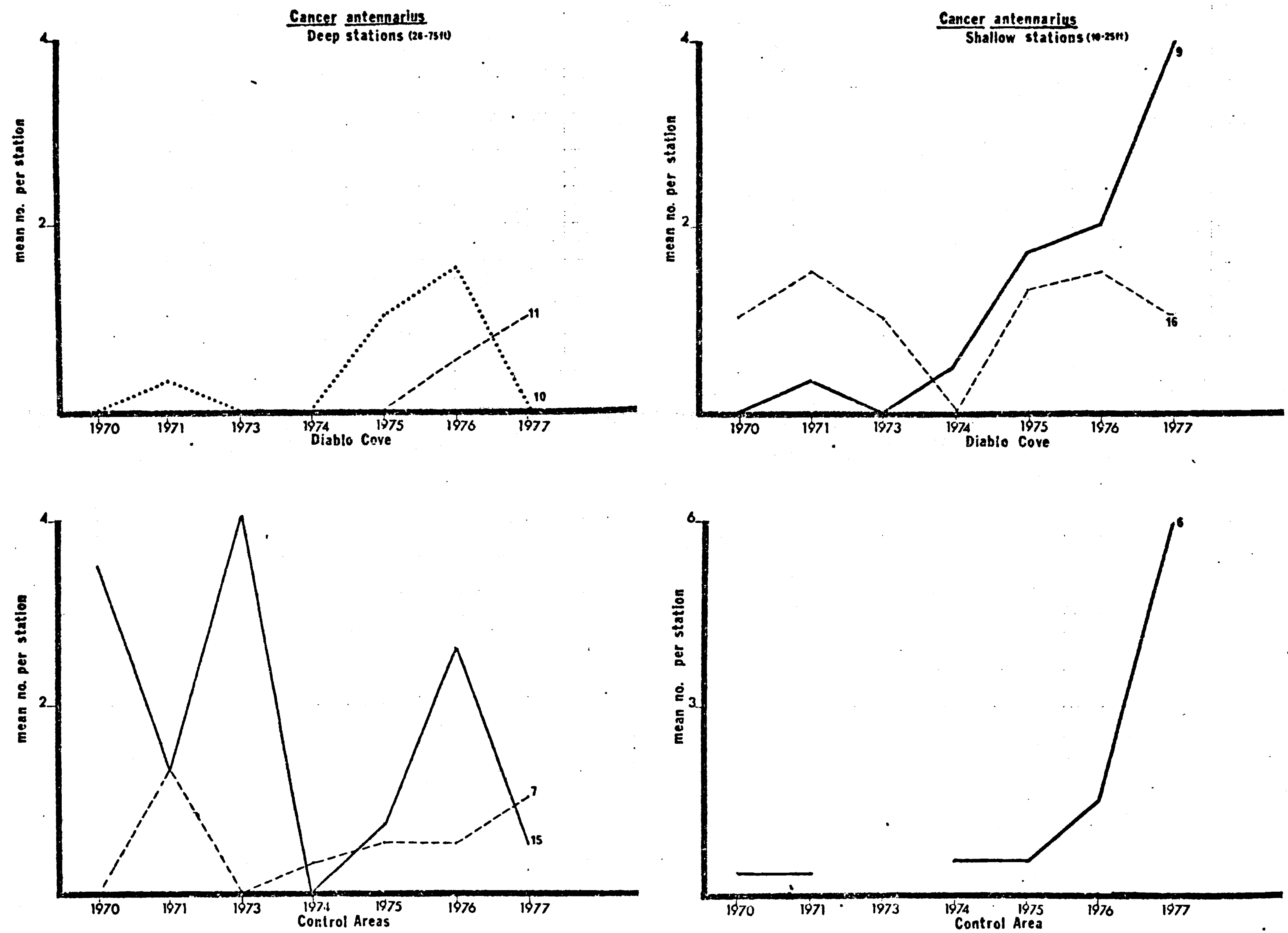


FIGURE 24. Mean counts of rock crabs at permanent subtidal stations, Diablo Canyon Power Plant Site.

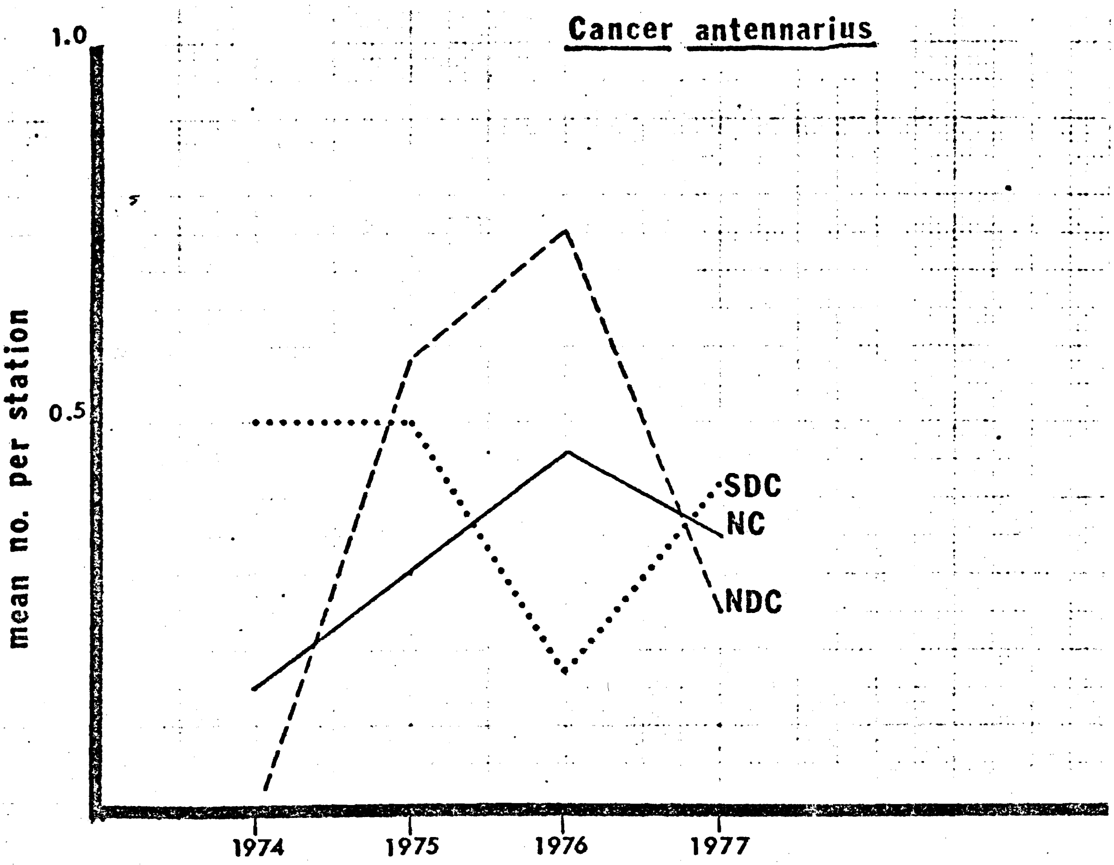


FIGURE 25. Mean counts of rock crabs at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. SDC-South Diablo Cove, NC-North Control, NDC-North Diablo Cove.

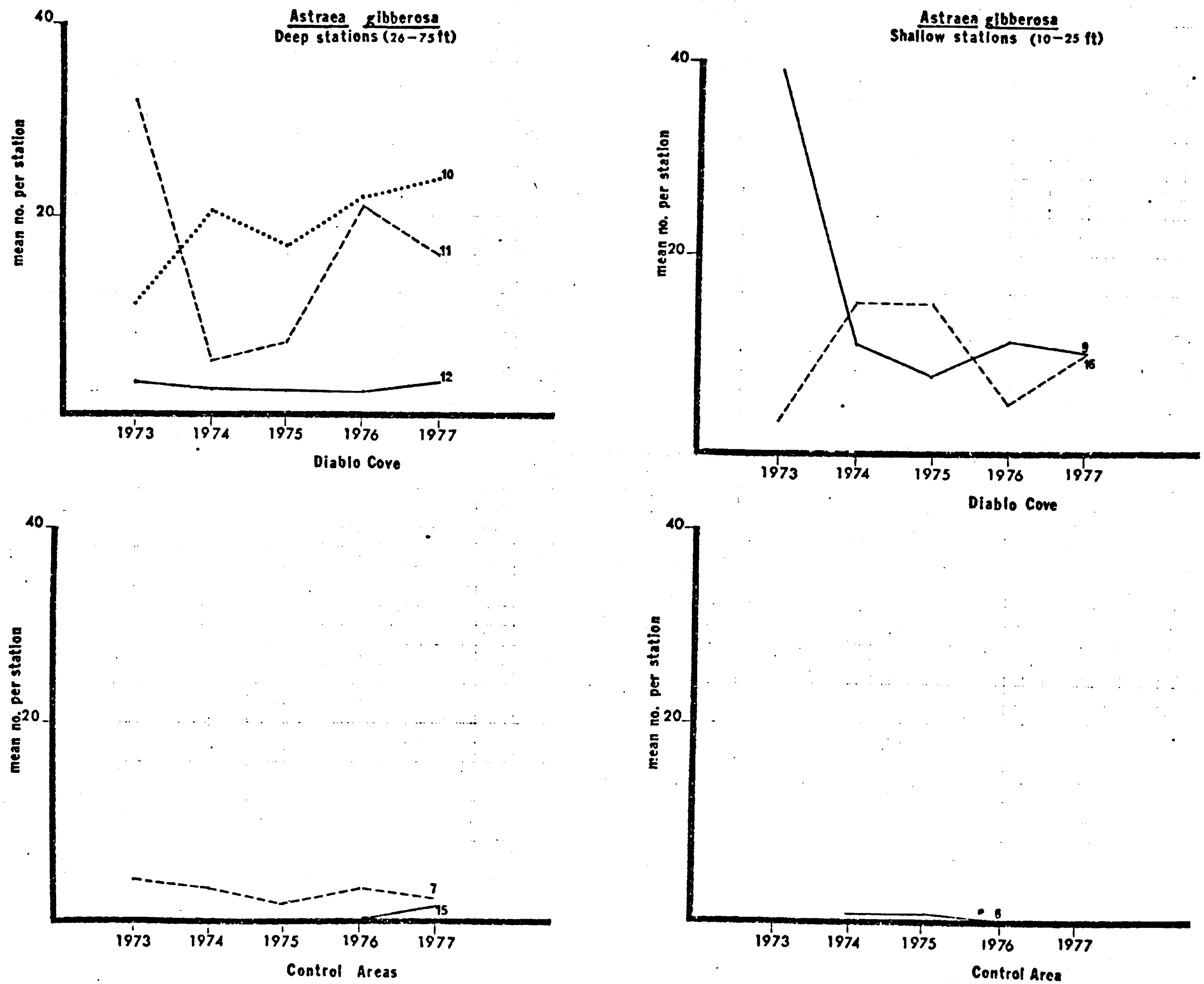


FIGURE 26. Mean counts of red turban snails at permanent subtidal stations, Diablo Canyon Power Plant Site.

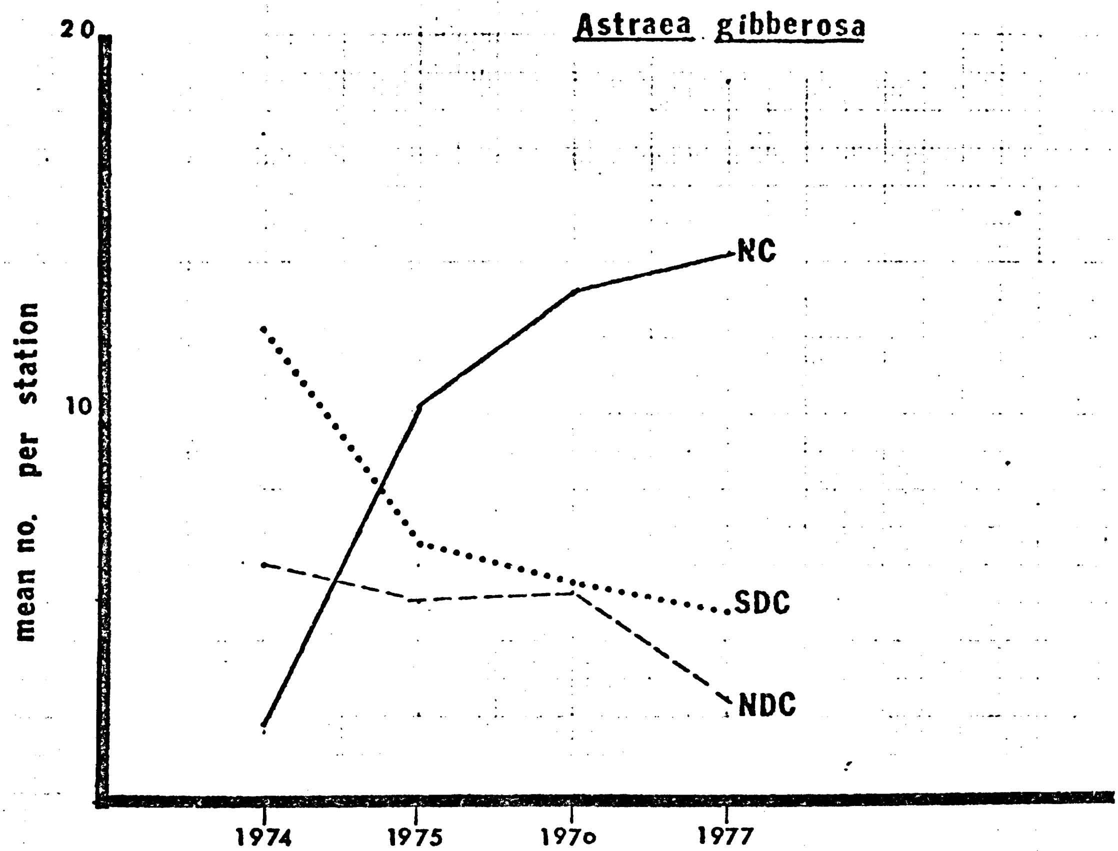


FIGURE 27. Mean counts of red turban snails at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, SDC-South Diablo Cove, NDC-North Diablo Cove.

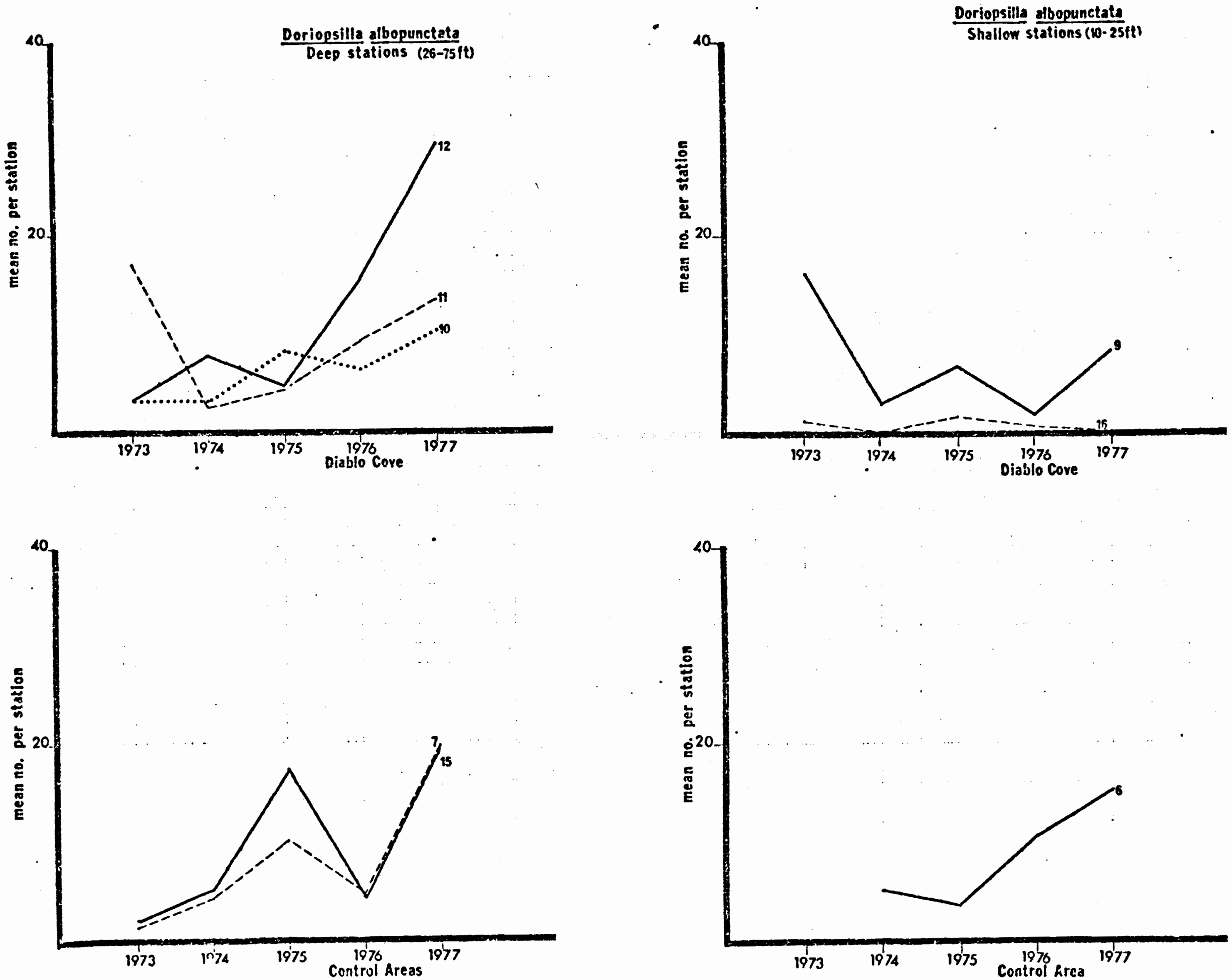


FIGURE 28. Mean counts of white spotted sea lemon at permanent subtidal stations, Diablo Canyon Power Plant Site.

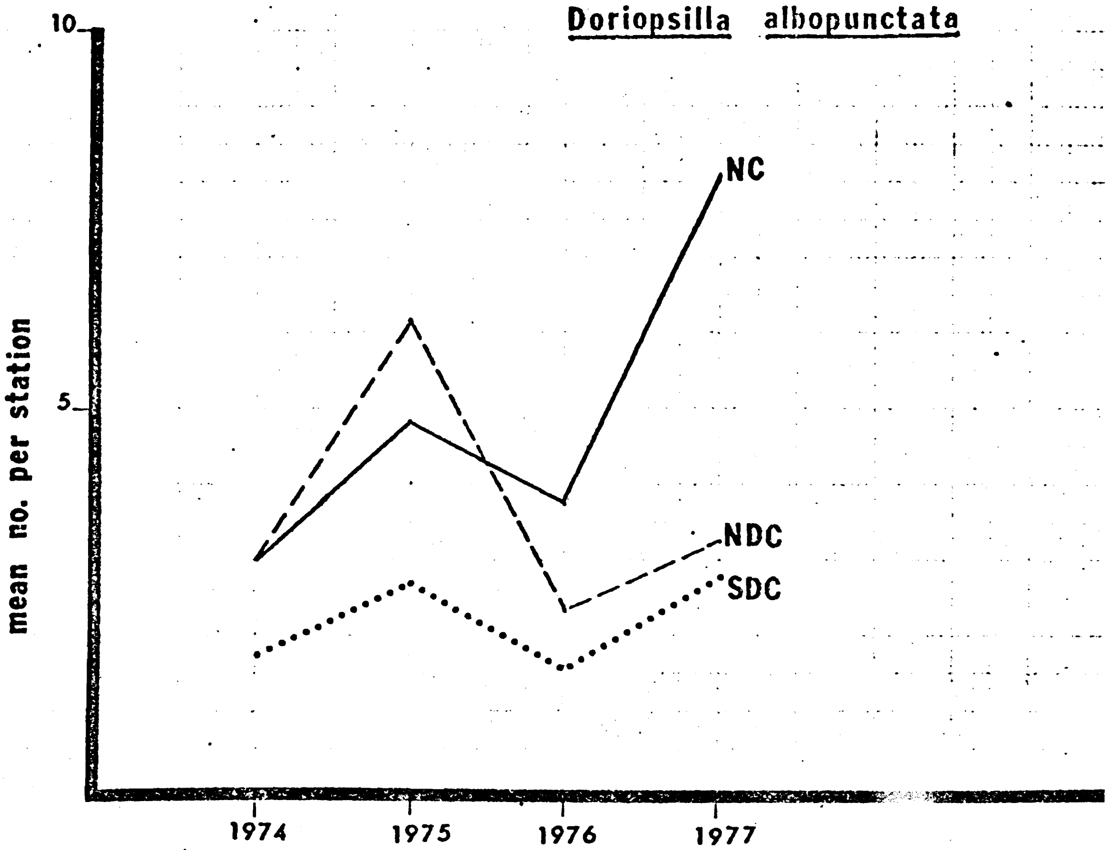


FIGURE 29. Mean counts of white spotted sea lemon at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Contro, NDC-North Diablo Cove, SDC-South Diablo Cove.

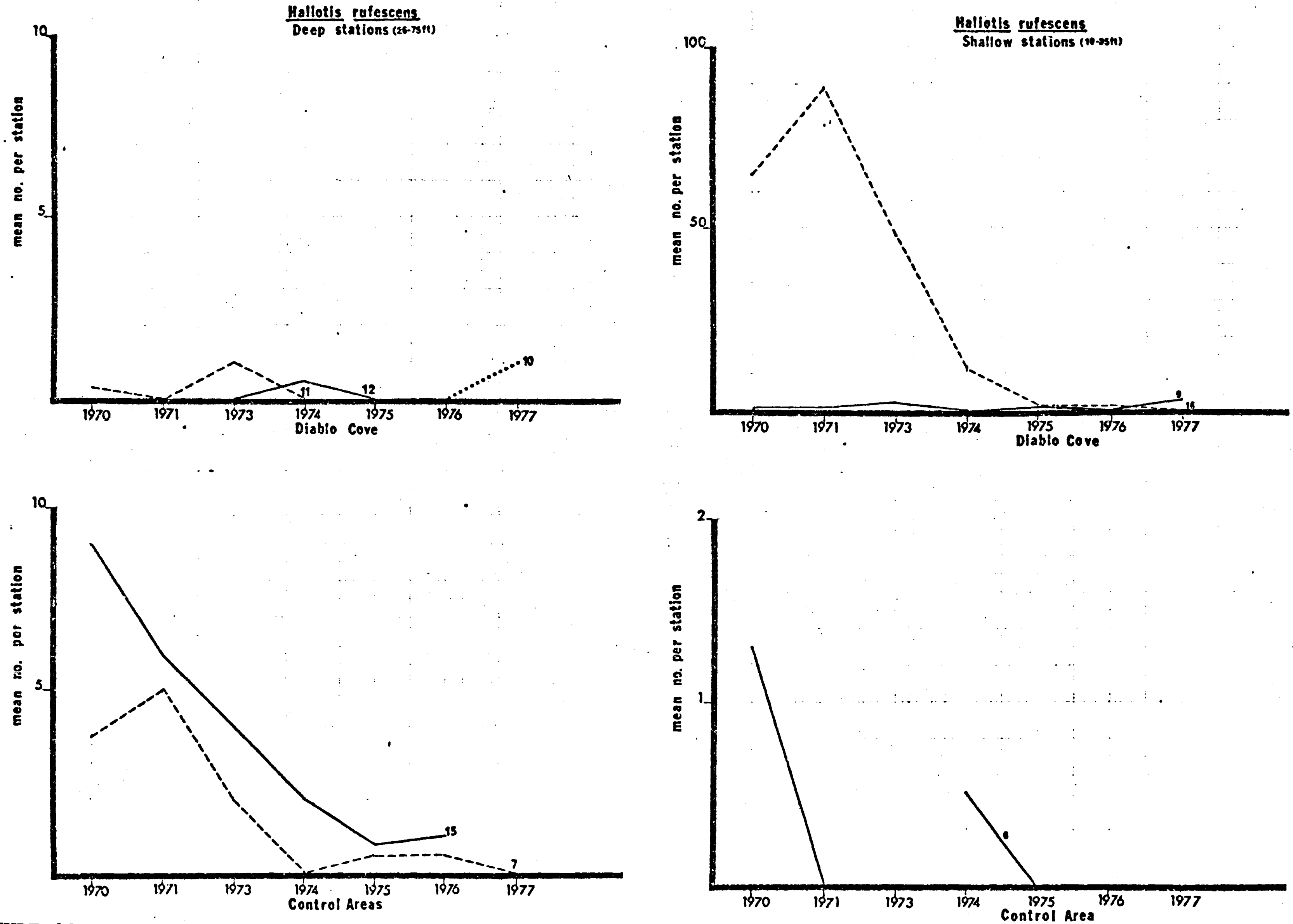


FIGURE 30. Mean counts per station of red abalone at permanent subtidal stations, Diablo Canyon Power Plant Site.

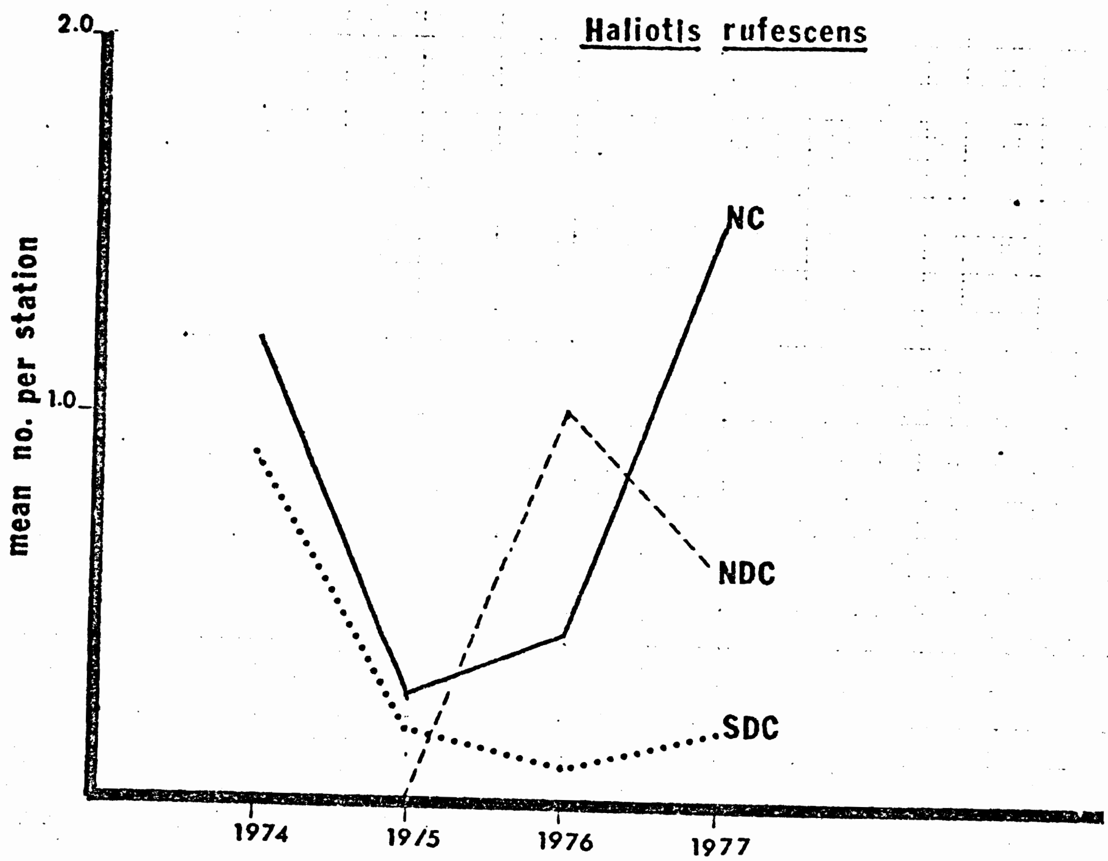


FIGURE 31. Mean counts of red abalone at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, NDC-North Diablo Cove, SDC-South Diablo Cove.

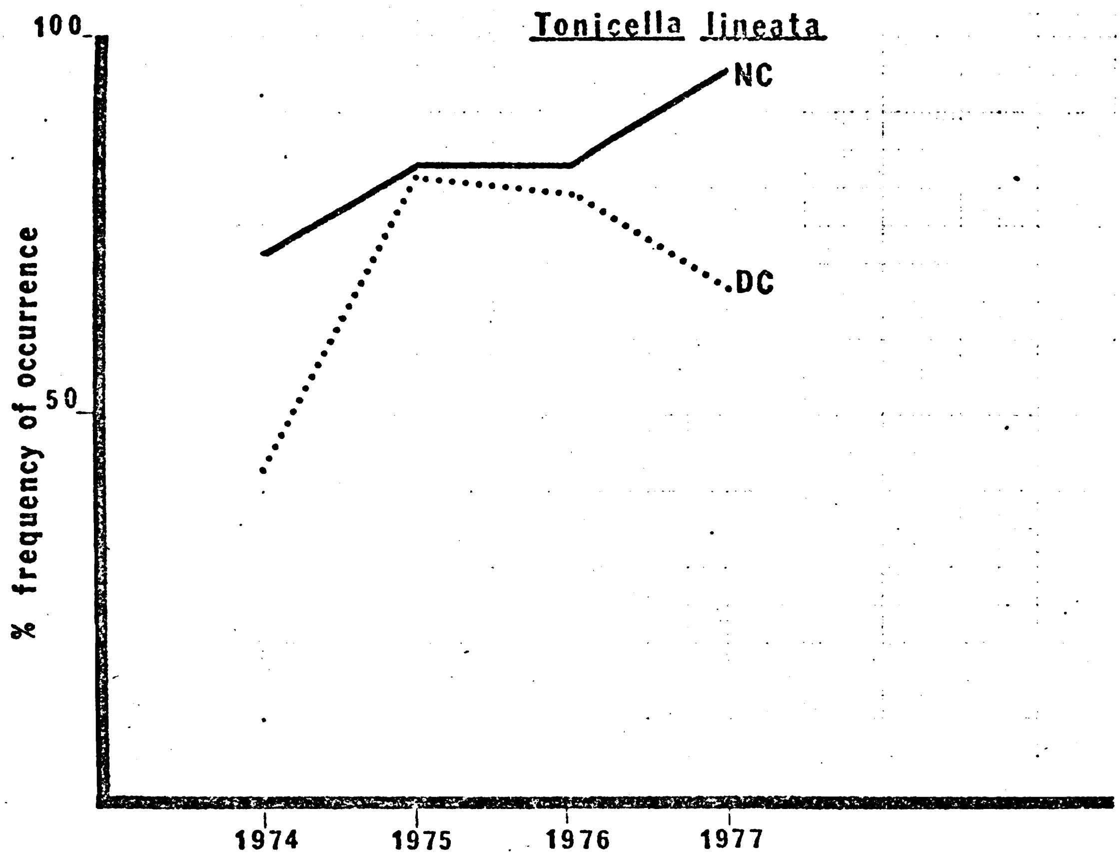


FIGURE 32. Frequency of occurrence of lined chitons at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).

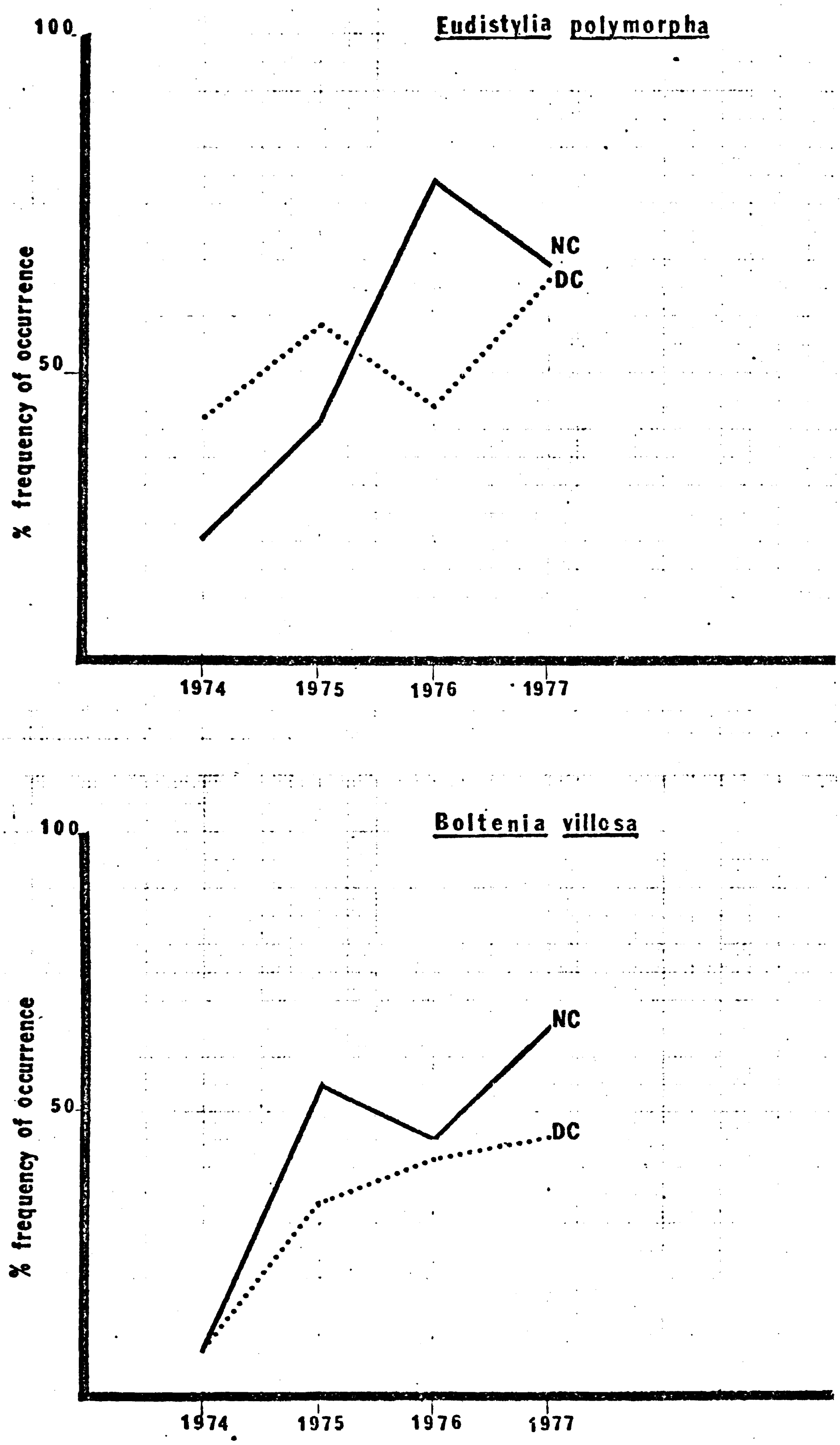


FIGURE 33. Frequency of occurrence of feather duster worms and spiny headed tunicates at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).

Diablo Cove random stations. Generally, the numbers have increased since 1974 (Figure 34).

The regression analysis of numbers of animals and depth was conducted in order to determine if this would reflect significant trends for the animals in question. These abundance/depth regressions then could be compared with similar regressions after the plant goes into operation. Theoretically a significant change in the regression line would indicate a shift of the populations, either inshore or offshore, of a particular species. These population shifts into either deeper or shallower water could then be related to natural causes or plant operations. Even though there were statistically significant trends for some species, we are not convinced that this method of assessing changes will prove viable.

Fish

Results

Since our studies began in 1973, we have observed and identified 40 species of fish representing 16 families at Diablo Cove and control subtidal stations (Gotshall et al. 1974, 1976, 1977). However, only eight species are observed regularly (25% or more of the stations). In this report, we will limit our discussion to those eight species.

Embiotoca lateralis: striped surfperch were observed at 57% of permanent control stations during 1976-77 surveys and at 46% of North Control random stations (Table 6, Figure 35).

Hexagrammos decagrammus: kelp greenling were present during every survey of permanent control stations in 1973-74, but this percentage dropped to about 50% in subsequent years (Table 6). The frequency of occurrence of kelp greenling has declined at random stations also (Figure 35).

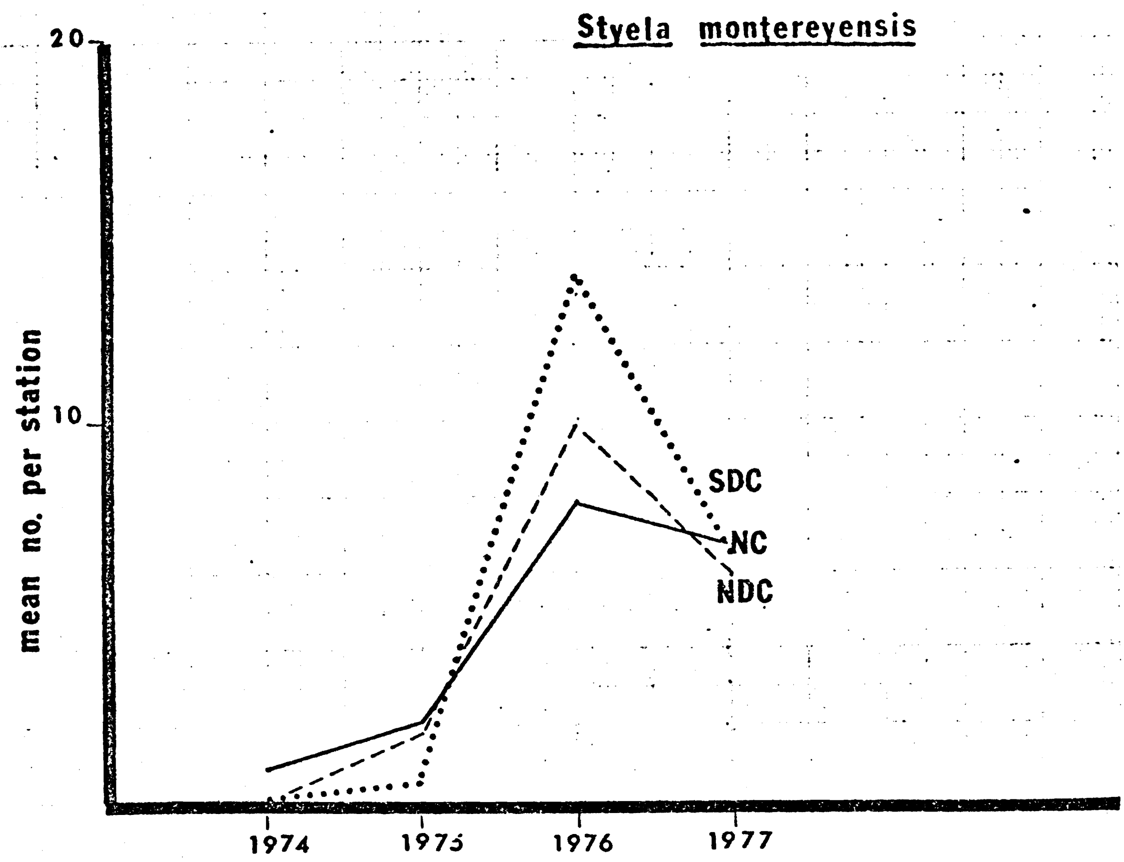


FIGURE 34. Mean counts per station of the monterey solitary tunicate at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. SDC-South Diablo Cove, NC-North Control, NDC-North Diablo Cove.

TABLE 6. Percent Frequency of Occurrence of Eight Species of Fish at Permanent Stations, Diablo Canyon Power Plant Site, July 1973 -- June 1977.

	1973-74		1974-75		1975-76		1976-77	
Species	Diablo Cove	Control	Diablo Cove	Control	Diablo Cove	Control	Diablo Cove	Control
mbiotoca lateralis	28.5	25.0	38.5	87.5	69.2	33.3	60.0	57.1
exagrammos decagrammus	57.1	100.0	30.8	50.0	23.1	66.7	30.0	57.1
phiodon elongatus	14.3	50.0	30.8	37.5	7.7	33.3	30.0	57.1
xylebius pictus	57.1	75.0	76.9	87.5	69.2	55.6	80.0	85.1
corpaenichthys marmoratus	42.8	75.0	46.2	50.0	38.5	44.4	50.0	28.6
ebastes chrysomelas	28.5	0.0	38.5	75.0	30.8	77.8	30.0	71.4
ebastes carnatus	71.4	50.0	46.2	50.0	46.2	33.3	60.0	57.1
ebastes mystinus (adult)	42.8	50.0	38.5	75.0	38.5	66.7	70.0	57.1
ebastes mystinus (juveniles)	57.1	100.0	69.2	100.0	84.6	66.7	40.0	57.1
NUMBER OF SURVEYS	7	4	13	8	14	9	10	7

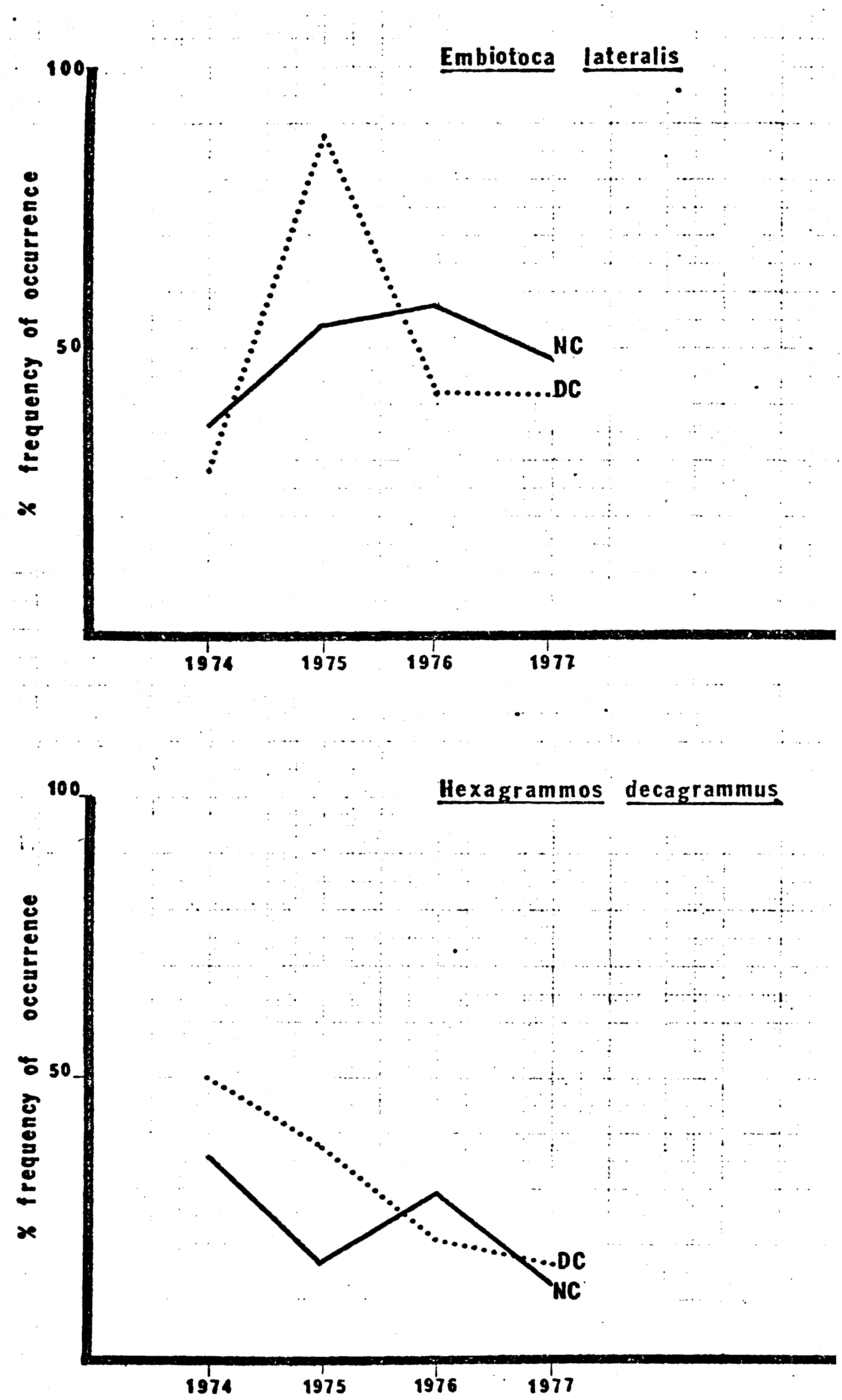


FIGURE 35. Frequency of occurrence of striped surfperch and kelp greenling at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).

Ophiodon elongatus: lingcod occurrence at permanent control stations fluctuated between approximately 33% and 57% with no apparent trend (Table 6). However, there was a definite decline in lingcod observations at random stations (Figure 36).

Oxylebius pictus: painted greenling occurrences at both permanent as well as random control stations has been quite stable (Table 6, Figure 36).

Scorpaenichthys marmoratus: cabezon occurrences have declined at permanent control stations while increasing slightly at North Control random stations (Table 6, Figure 37).

Sebastes chrysomelas: black and yellow rockfish were not observed during any of the permanent control stations in 1973-74 surveys, however, in subsequent years, they were present during about 75% of the surveys (Table 6). Their occurrence at North Control have been relatively stable after a substantial increase between 1974 and 1975 (Figure 37).

Sebastes carnatus: gopher rockfish occurrence has changed only slightly at permanent control stations (Table 6). There has also been little change in frequency of occurrence at random North Control stations since the increase that occurred between 1974 and 1975 (Figure 38).

Sebastes mystinus: juvenile blue rockfish have decreased in frequency of occurrence at permanent control stations while increasing at North Control random stations (Table 6, Figure 38). Conversely, adult blue rockfish occurrences at both permanent and random control stations have shown only slight changes (Figure 39).

The sportfish catch-per-unit-of-effort study undertaken in July 1974 was cancelled in December 1976 due to the high variability of the data. From July through December, we fished at 30 North Control and permanent control stations (Table 7). The total effort amounted to 18 pole hours

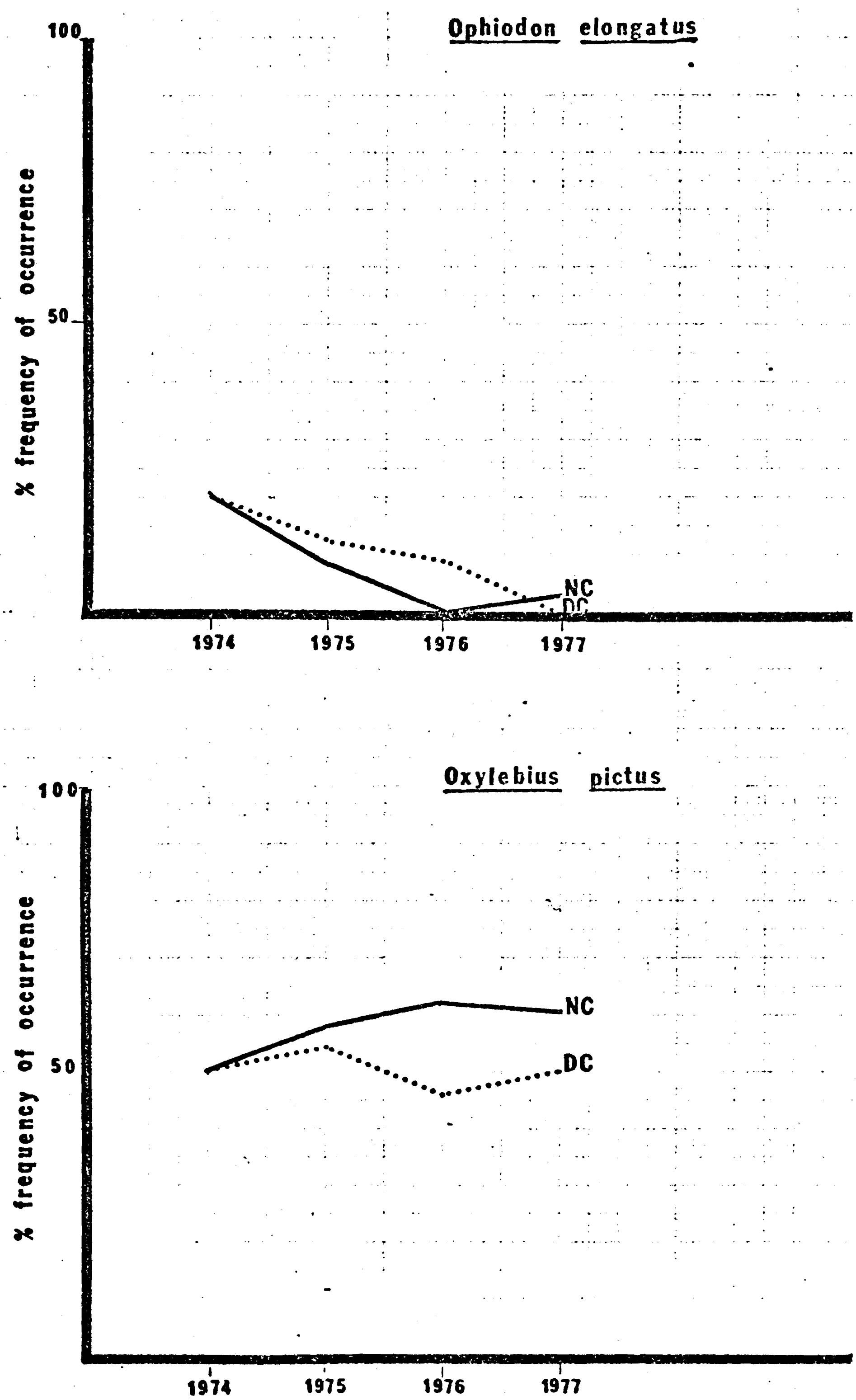


FIGURE 36. Frequency of occurrence of lingcod and painted greenling at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).

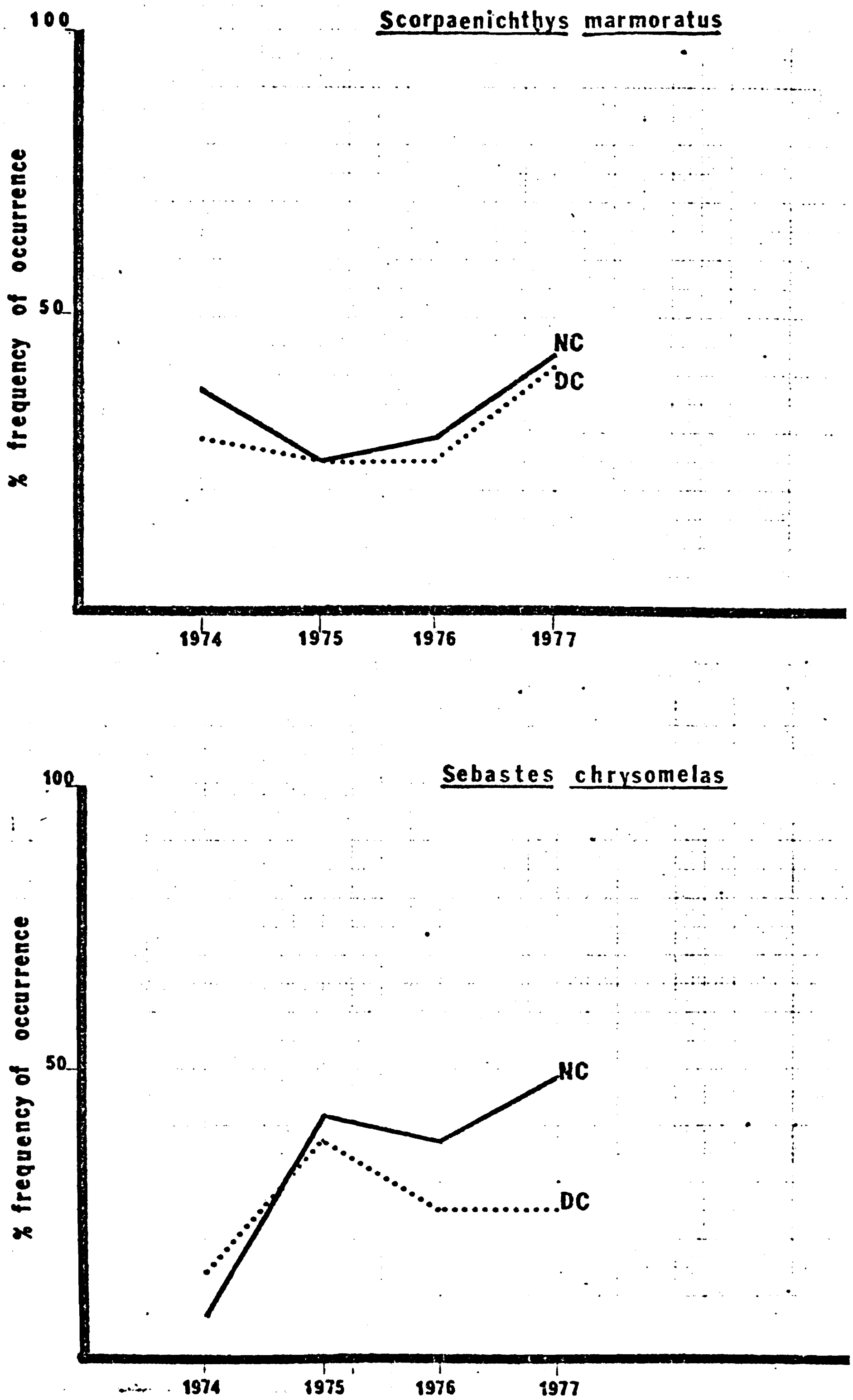
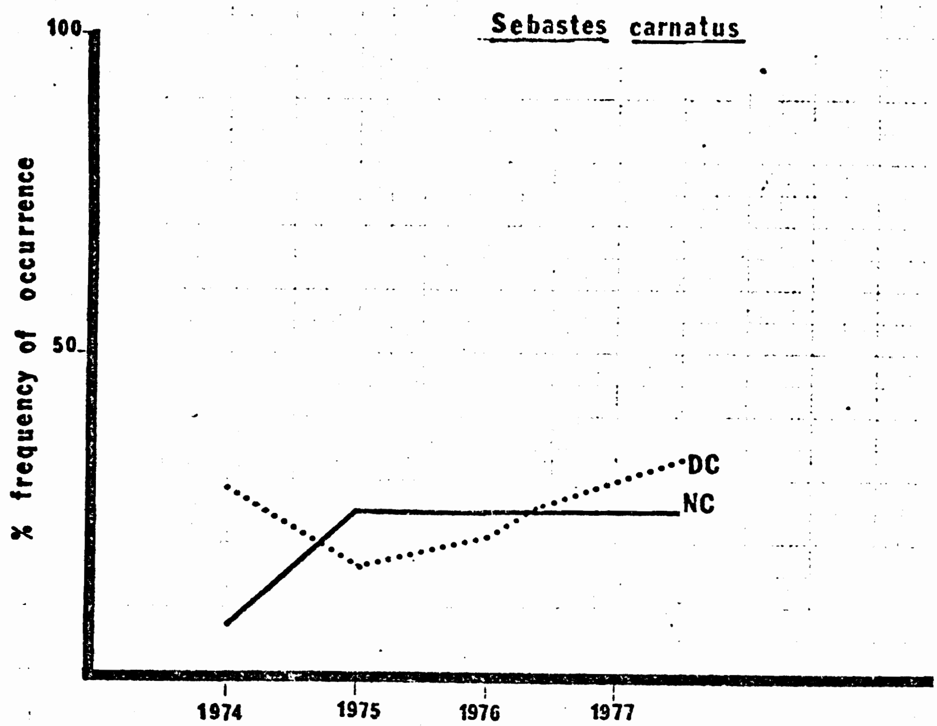


FIGURE 37. Frequency of occurrence of cabezon and black-and-yellow rockfish at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).



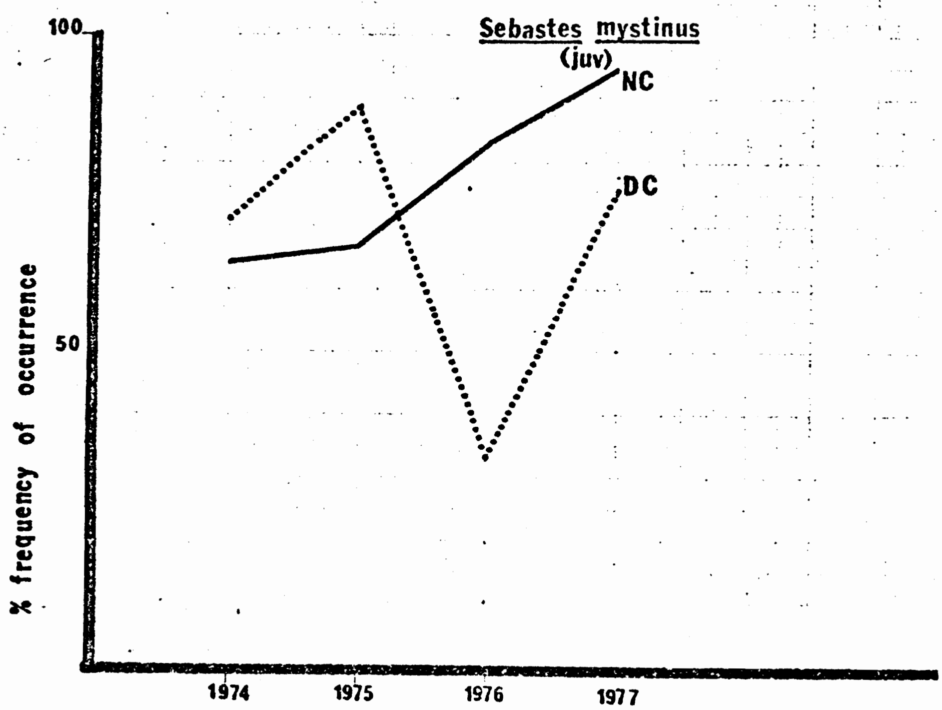


FIGURE 38. Frequency of occurrence of gopher and juvenile blue rockfish at all random 30-m^2 subtidal stations, Diablo Canyon Power Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).

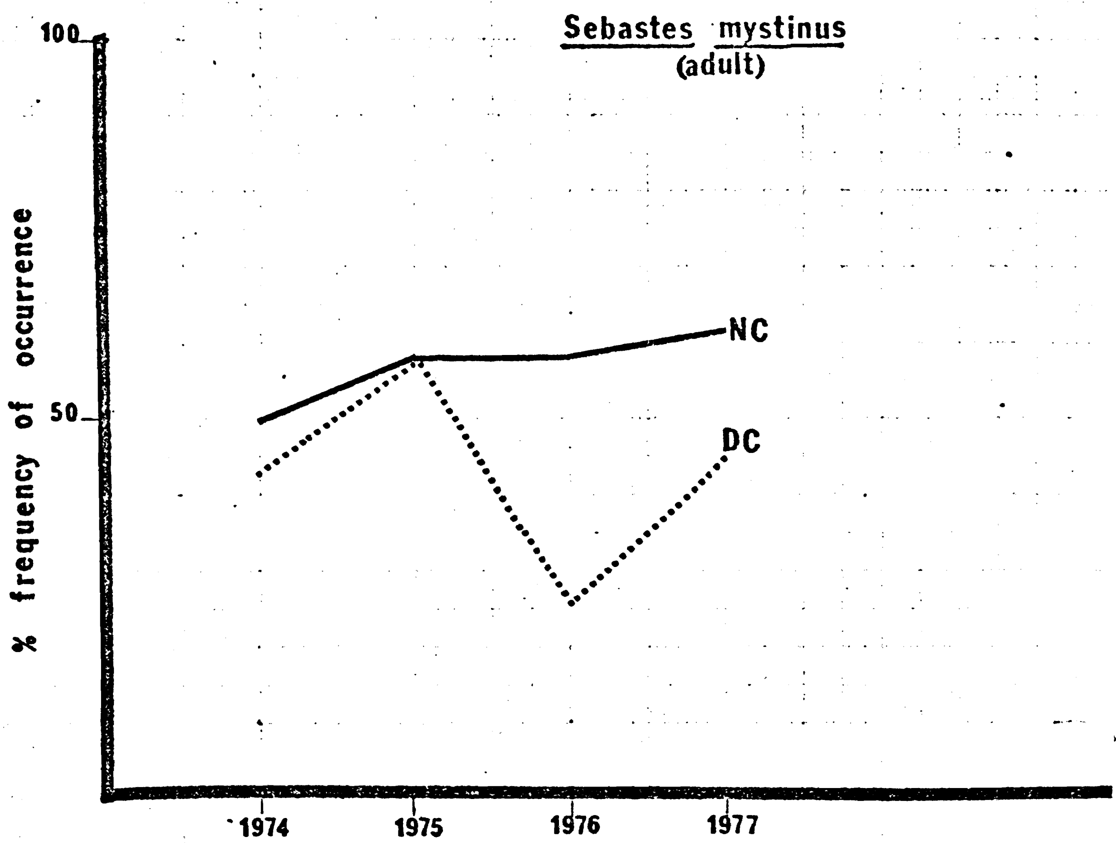


FIGURE 39. Frequency of occurrence of adult blue rockfish at all random 30-m^2 subtidal stations, Diablo Canyon Power Plant Site. NC-North Control, DC-Diablo Cove (includes both North and South Diablo Cove).

TABLE 7. Summary of Sportfish Catch-Per-Unit-of-Effort Data, Diablo Canyon Power Plant Site, July 1974 Through December 1976.

	1974	1975		1976	
	July-Dec.	Jan.-June	July-Dec.	Jan.-June	July-Dec.
DIABLO COVE					
Total Stations	10	10	7	20	34
Depth Range of Stations (ft.)	25-70	20-80	20-70	15-70	10-68
Total Effort (Pole Hours)	9.0	8.0	4.1	14.7	19.8
Total Catch (No. of Fish)	6	5	11	13	19
Mean* Number of Fish Per Hour	0.60	0.90	2.00	0.75	0.91
Standard Deviation	0.84	1.66	3.06	1.02	2.25
CONTROL AREAS					
Total Stations	10	9	25	8	30
Depth Range of Stations (ft.)	10-60	20-60	12-55	20-55	10-55
Total Effort	7.2	15.0	13.5	6.0	18.0
Total Catch	45	52	33	20	21
Mean* Number of Fish Per Hour	5.10	6.18	2.24	3.38	1.19
Standard Deviation	8.61	7.26	3.53	2.26	1.96

*A weighted mean calculated by averaging the calculated number of fish per pole hour from each station.

which resulted in a total catch of 20 fish, 14 of which were blue rockfish (Tables 7 and 8). The mean number of fish per hour was 1.19, (Sd = 1.96). The standard deviation has exceeded the mean during every six-month period since we began the study, except between January and June 1976 (Table 8).

Sea Otters

Results

Previous annual reports have included results of a study by Suzanne Benech, Pacific Gas and Electric consultant. Since her work regularly appears in PG&E reports, it seemed redundant to continue including it herein. The present discussion of sea otter occurrence in the areas near Diablo Canyon is based on 81 observation days spaced irregularly throughout the year.

Otters were sighted on 57 of the 81 observation days (Table 9). The most otters ever counted at any one time occurred February 9, 1977, when 21 were seen in the South Cove area. However, Lion Rock Cove was more consistently inhabited by otters. Of the 300 sightings that occurred in control areas, 268 were in Lion Rock Cove. Sightings on consecutive days do not indicate individual otters; it is probable that the same animals are counted several days in succession.

There appears to be a periodicity to the otters' occurrence in the area. Of 268 sightings in the North Cove, 254 occurred from March through July. From March 2, 1977 to the end of July, otters were sighted in control areas on all but five of the observation days. However, during the remainder of the year, otters were sighted on only six of 29 observation days.

TABLE 8. Number and Catch-Per-Hour of Fishes Caught on Hook and Line at Random and Permanent Subtidal Stations, Diablo Canyon Power Plant Site, July 1, 1976 Through December 1976.

SPECIES	DIABLO COVE Number Caught	DIABLO COVE C/H	NORTH CONTROL* Number Caught	NORTH CONTROL* C/H
Embiotoca lateralis	1	0.05	0	0.00
Scorpaenicthys marmoratus	5	0.25	1	0.06
Sebastes carnatus	3	0.15	5	0.28
Sebastes chrysomelas	4	0.20	0	0.00
Sebastes mystinus	5	0.25	14	0.78
Sebastes serranoides	1	0.05	1	0.06
Totals	19	0.96	20	1.11
Total Hours+	19.75		18.0	

C/H = Catch Per Hour

* Includes North Cove and Fields Cove

+ Hours by Poles Fished

TABLE 9. Sea Otter Sightings Per Day from March Through December 1977 in the North Control Area of the Diablo Canyon Power Plant Site.

	Observation Days	No. of Otters	Otters per Day
March	14	42	3.0
April	13	74	5.7
May	6	41	6.8
June	14	79	5.6
July	5	17	3.4
Aug.	6	10	1.7
Sept.	4	2	0.5
Oct.	3	0	0.0
Nov.	8	1	0.1
Dec.	6	3	0.5

The most commonly observed behavior was rafting. This may be due, in part, to the fact that the observations were usually made in the early afternoon.

Intertidal Activities

Invertebrates

Results

Haliotis cracherodii, black abalone, and *Haliotis rufescens*, red abalone, abundance at random parallel stations remains relatively stable (Table 10). During the 1976-77 Davidson period, the mean numbers of both black and red abalones per m^2 were slightly below those of the previous Davidson. However, black abalone mean per m^2 for the 1977 Upwelling period parallel stations was slightly greater than in 1976 and red abalone density was unchanged. Black abalone abundance at perpendicular stations increased over comparable figures for both the Davidson and Upwelling periods (Table 11) in 1975-76.

Data from the $1/4m^2$ quadrats for algae and invertebrates for the North Control random intertidal stations will not be presented in this report as collation and analysis is under way for the final report.

TABLE 10. Mean Numbers of Abalone from Random Parallel Intertidal Stations (Area = 30x2m). Diablo Canyon Power Plant Site. 1975 - 1976.

	Haliotis cracherodii		*Haliotis rufescens*	
Area and Survey Period	No. of Stations	Mean/m^2	No. of Stations	Mean/m^2
NORTH CONTROL				
Davidson 1975-76	10	0.68	10	0.05
Upwelling 1976	8	0.61	8	0.01
Davidson 1976-77	10	0.40	10	0.02
Upwelling 1977	8	0.72	10	0.01
NORTH DIABLO COVE				
Davidson 1975-76	7	1.28	7	0.16
Upwelling 1976	9	1.14	9	0.13
Davidson 1976-77	9	1.35	9	0.15
Upwelling 1977	9	0.94	9	0.10
SOUTH DIABLO COVE				
Davidson 1975-76	9	0.02	8	0.06
Upwelling 1976	7	0.01	7	0.09
Davidson 1976-77	9	0.04	9	0.06
Upwelling 1977	9	0.03	9	0.05
DIABLO POINT				
Davidson 1975-76	2	0.96	2	0.02
Upwelling 1976	3	1.48	3	0.00

TABLE 11. Mean Number Per m^2 of Black Abalone, *Haliotis cracherodii*, From Perpendicular Intertidal Transects, Diablo Canyon Power Plant Site, 1975 Through 1977.

Study Area/ Survey Period	Abalone/m^2	Number of Stations
North Control		
Davidson 1975-76	0.36	
Upwelling 1976	0.72	
Davidson 1976-77	1.46	9
Upwelling 1977	1.00	9
South Diablo Cove		
Davidson 1975-76	0.27	
Upwelling 1976	0.15	
Davidson 1976-77	0.06	4
Upwelling 1977	0.12	9
North Diablo Cove		
Davidson 1975-76	2.39	
Upwelling 1976	2.91	
Davidson 1976-77	3.41	5
Upwelling 1977	1.90	9

DIABLO COVE

Subtidal Activities

All five permanent stations in Diablo Cove (Figure 2) were surveyed twice during the report period, once in the fall of 1976 and once in the spring of 1977.

Twenty-four random 30-m^2 stations were also surveyed; in addition, 48 - 1/4-m^2 quadrats (12 transects) were surveyed (Tables 2A and 2B).

Algae

Results

Twelve 1/4-m^2 samples of red algae were taken from Diablo Cove random subtidal stations during the 1976 Upwelling period. Of these, eight were shallow ($\leq$25 ft) and four were deep (25-55 ft).

Botryoglossum farlowianum and *Microcladia coulteri*, occurring in 11 (91.7%) of the samples, were the most common algae (Table 3). *Hymenena* spp., present in eight (66.7%) of the samples, was also common. *Gigartina exasperata* and *Iridaea cordata* v. *splendens*, each occurred in five (41.7%) samples. *Callophyllis flabellulata, Neoptilota densa, Opuntiella californica, Prionitis lanceolata* and *Rhodymenia californica* comprised the remainder of the dominant red algae. *Spermothamnion snyderiae, Pterochondria woodyi*, and *Heterosiphonia asymmetria*, not previously found in our collections, were among the 31 species of red algae identified.

The mean dry weight of all Diablo Cove subtidal red algae samples was 124.3 grams (Table 4). Mean dry weight of samples from shallow stations (141.9 g) was greater than that of deep stations (90.4 g); however, deep stations showed greater species diversity.

Discussion

Samples from both Diablo Cove and North Control indicate an increase over previous years' algal abundance. The mean dry weight of red algae from shallow stations in Diablo Cove during the 1976 Upwelling period was 141.9 g, which is an increase over 1975 (61.1 g) and 1974 (53.1 g). The same is true for North Control stations. The 1976 shallow station mean dry weight of 220.8 g is considerably greater than 1975 (166.5 g) and 1974 (148.8 g).

We observed a greater number of species at Diablo Cove deep stations than in previous years, while at North Control stations, the number of all species showed little change. The increase in red algal density and speciation may be a result of the recent years' low rainwater runoff with subsequent improved water transparency and increased light penetration. It is also possible that this is an artifact of reduced foraging by red sea urchins and red abalone, once the major herbivores in this area.

Invertebrates

Results

Leucilla nuttingi: aggregating urn sponges were reported at 71% of the random 30-m^2 stations in 1977, a substantial increase since the 1974 surveys (Figure 5).

Tethya aurantia: *Tethya* abundance at permanent stations has remained fairly stable (Figure 6) with the exception of station 11 where densities of this distinctive sponge have increased steadily since our initial surveys in 1973. Generally, *Tethya* has been more abundant at the deeper stations (i.e., 10, 11 and 12). This evident stability is also reflected in the mean number per station data from random stations (Figure 7). Although the densities have fluctuated more drastically at South Diablo Cove stations than at stations in North Diablo Cove, *Tethya* abundance has increased significantly with depth at random stations; a linear regression plot of data from the 24 stations yielded a correlation coefficient of 0.51 (Table 5).

Anthopleura xanthogrammica: green anemone's density has increased slightly at all of the Diablo Cove permanent stations since 1973 (Figure 8). However, the random station data shows a different pattern; in North Diablo Cove, the mean density per station has fluctuated widely from year to year with the result that the densities recorded in 1977 are almost the same as those recorded in 1973 (Figure 9). In South Diablo Cove, the densities have also fluctuated from year to year; however, the densities have generally increased here. Since all of the permanent stations are located in the middle and in the south portion of Diablo Cove, the South Diablo Cove stations are more comparable to the permanent station data. There appears to be no relationship between *Anthopleura* numbers per station and depth as the linear regression yielded a coefficient of correlation value (r) of 0.16 (Table 5).

Balanophyllia elegans: we did not attempt to quantify the orange cup coral at permanent or random stations until we began surveys of the 1/4-m^2 quadrats in 1975. However, we did record their presence or absence at all stations. The plot of the orange cup corals frequency of occurrence in Diablo shows a fairly stable pattern with a slight increasing trend (Figure 10). *Balanophyllia* was more abundant at deeper stations; the regression analysis of this relationship yielded an r value of 0.52 which is significant at the 95% level (Table 5).

Epiactis prolifera: the proliferating anemone's frequency of occurrence at random 30-m^2 stations has fluctuated from year to year but the trend has been for a slight increase in occurrence (Figure 11). They were more commonly observed at shallow stations but the r value from the regression analysis was only -0.21 (Table 5).

Henricia leviuscula: red sea star observed densities have remained fairly stable at both permanent and random stations in Diablo Cove since we began our surveys (Figures 12 and 13). When the number per station and depth data are plotted, there is a significant relationship at the 95% level; the *r*-value is -0.75 (Table 5).

Orthasterias koehleri: rainbow sea stars are the most brilliantly colored of the larger sea stars found in our study areas. *Orthasterias* numbers have shown considerable fluctuation at permanent stations (Figure 14). This fluctuation may be due to the possibility that these predatory sea stars are highly mobile.

Patiria miniata: sea bat abundance also has varied widely at permanent stations (Figure 16) and at random stations (Figure 17). However, a regression line fitted to the data over the past four years is horizontal. *Patiria* were more abundant at the deeper stations; the calculated *r* value for the regression of this relationship is 0.46 (Table 5).

Pisaster giganteus: the giant spined sea star density has remained relatively stable at permanent stations, except at stations 11 and 12 during 1976 and 1977 (Figure 18). The densities of this large asteroid have also been stable at random stations (Figure 19). Even though they appear to be more abundant at deeper stations, the *r* value from the calculated regression was only 0.28 (Table 5).

Pycnopodia helianthoides: sunflower sea stars' densities have shown wide variations at permanent stations. At random stations, there has been a general decline in abundance (Figures 20 and 21).

Strongylocentrotus franciscanus: densities of giant red sea urchin have declined at all Diablo Cove permanent stations except station 12 since 1974 when sea otters invaded the Cove. Station 12 is located in depths of 21 to 23 m. Evidently, the sea otters have not foraged in that depth range at station 12 (Figure 22). The decline in density is also reflected very strongly in the random station data (Figure 23). Sea otter foraging probably has been the main influence on the abundance/depth relationship, as sea urchin densities have decreased in shallower waters since we began our survey (Table 5).

Cancer antennarius: rock crab numbers have fluctuated widely at permanent stations and random stations in Diablo Cove, (Figures 24 and 25) probably due to their cryptic nature, mobility, and feeding behavior.

Astraea gibberosa: densities of red turban snails have been fairly stable at most of the permanent stations, particularly since 1974 (Figure 26). However, they have declined in abundance at the random stations (Figure 27). A regression of depth and abundance yielded a very low correlation coefficient of -0.16 (Table 5).

Doriopsilla albopunctata: observed abundance of white spotted nudibranchs has remained fairly constant at most permanent stations, except station 12 where there has been a substantial increase (Figure 28). The densities at random stations appear to be similar to those observed during the initial surveys in 1974 (Figure 29). *Doriopsilla* were significantly more abundant at deeper stations; the r value for the calculated regression is 0.58 (Table 5). To some extent, this may be related to observability due to algal cover.

Haliotis rufescens: red abalone numbers have declined substantially at permanent stations in Diablo Cove since the initial counts by Burge and Schultz (1973). This decline is most evident at station 16 (Figure 30). The hypothetical reasons for the declines have been detailed in previous annual reports

(Gotshall et al. 1974, 1976, 1977). Random station data suggests the decline has been more severe in South Diablo Cove (Figure 31).

Tonicella lineata: we have not consistently quantified the lined chiton at permanent or random 30-m^2 stations due to its size and protective coloration which make counts over a large survey area almost impossible. We have, however, noted its presence or absence at all permanent and random 30-m^2 stations. The frequency of occurrence appears to have increased slightly at random stations (Figure 32).

Eudistylia polymorpha: feather duster worms have not been quantified at the permanent stations or random 30-m^2 stations. However, their presence or absence has been recorded. *Eudistylia* appears to have increased in frequency of occurrence since 1974; this increase may be due, in part, to increasing diver awareness and recognition (Figure 33).

Boltenia villosa: spiny headed tunicates also have not been consistently counted at permanent stations or random 30-m^2 stations but observations on their presence or absence indicate an increase in frequency of occurrence (Figure 33). Some of this apparent increase may be due to increased awareness by our divers rather than an actual increase in the population.

Styela montereyensis: the abundance of Monterey stalked tunicates has increased substantially at the random 30-m^2 stations since 1974 (Figure 34). *Styela* were more abundant at the deeper stations; the calculated r value for the regression of density versus depth is 0.57 (Table 5).

Discussion

The increases in densities and/or frequencies of occurrence of many of the discussed invertebrates, as mentioned earlier, may represent an increase in diver awareness of the animal rather than true increases in population size. This is particularly true for the smaller animals, such as *Boltenia* and *Epiactis* and those that tend to be camouflaged or cryptic, such as *Tonicella*. However, the trends discussed for some of the larger and more common animals are possibly due to natural fluctuation or other causes. This group includes the giant red sea urchin, red abalone, *Pycnopodia, Astraea,* rock crabs, and *Patiria*. Several species' populations have remained fairly stable, particularly at random stations, and they may prove to be very valuable indicator species during operational studies. They include: *Pisaster giganteus, Tethya aurantia,* and *Orthasterias koehleri*.

In the final preoperational report now in preparation, we will determine if the changes in densities we have observed are statistically significant. To do this we plan to utilize as many different tests and approaches as possible. It appears that most of the invertebrates do not fit a normal distribution; thus our analyses must include both parametric (utilizing transformation) as well as non-parametric tests.

Fish

Results

Embiotoca lateralis: of the eight species of surfperches (Family Embiotocidae) that we have encountered, the striped surfperch is by far the most ubiquitous. In 1976, they were observed at 60% of the permanent stations in Diablo Cove and 47% of the random stations (Table 6, Figure 35). The frequency of occurrence has increased at permanent stations and decreased at random stations, particularly since 1975. We believe that these changes are due to natural causes and sampling variations.

Hexagrammos decagrammus: three species of greenlings (Family

Hexagrammidae) can be considered important segments of the Diablo Cove fish community. Kelp greenlings are an important segment of the central and northern California rocky shore sport fishery (Miller and Gotshall 1965). The population of kelp greenling in Diablo Cove appears to be on the decline; the frequency of occurrence at permanent stations dropped from 57% during 1973-74 surveys to 30% during 1976-77 surveys (Table 6). At random stations, the decline was even more pronounced (Figure 35).

Ophiodon elongatus: lingcod are one of the most sought-after sportfish in this area of the California coast. Their frequency of occurrence at permanent stations has fluctuated from year to year with no indication of a trend (Table 6). Conversely, at random stations there has been a steady decline in their frequency of occurrence (Figure 36). The catch-per-day of lingcod by partyboat anglers in the area from Morro Bay to Avila has also been declining, particularly since 1975 (Table 12).

Oxylebius pictus: painted greenlings are the smallest members of the greenling family and, because of their small mouths, are rarely caught by sportfishermen. However, they are one of the most common fishes we encounter at our subtidal stations. At permanent stations, painted greenlings have increased in their frequency of occurrence (Table 6). The frequency of occurrence at random stations has been very stable over the years (Figure 36).

Scorpaenichthys marmoratus: the cabezon population has changed little since we began our surveys. The frequency of occurrence of this popular sportfish at both permanent and random stations has shown little fluctuation through 1976; however, in 1977 there was an increase at both types of stations (Table 6, Figure 37).

Sebastes chrysomelas: we have observed ten species of rockfishes in

TABLE 12. Lingcod Catch-Per-Angler-Day by Partyboat Anglers, Diablo Canyon Area (CDF&G Catch Block 615). 1968 - 1977.

Year	Lingcod/ Angler Day
1968	0.53
1969	0.52
1970	0.41
1971	0.60
1972	0.64
1973	0.38
1974	0.38
1975	0.32
1976	0.16
1977	0.09

Diablo Cove and the control areas, but only three species can be considered common. The black and yellow rockfish has been observed at about 30% of the permanent stations and 28% of the random stations since 1973 (Table 6, Figure 37). From our observations, it appears that the population of black and yellow rockfish in Diablo Cove is quite stable.

Sebastes carnatus: based on the permanent and random station observations, the population of gopher rockfish in Diablo Cove has also remained fairly static (Table 6, Figure 38).

Sebastes mystinus: the occurrence of both juvenile and adult blue rockfish has shown fairly wide fluctuations at both permanent and random stations (Table 6, Figures 38, 39). Adult blue rockfish were more frequently observed at permanent stations in 1977 than in 1973, while the converse is true for juveniles. Both adults and juveniles were present at about the same number of random stations in 1977 as they were in 1974 but there were wide variations in 1975 and 1976.

A total of 34 hook-and-line stations were completed in Diablo Cove between July 1 and December 31 (Table 7). The mean catch-per-hour for 19.8 hours of fishing was 0.91 (standard deviation = 2.25). Of the 19 fishes caught, five were blue rockfish and five were cabezon, *Scorpaenichthys marmoratus* (Table 8). The standard deviation has exceeded the mean during every six-month period since we began the study.

Discussion

Accurate quantification of fishes by diver surveys is admittedly very difficult due to their mobility, cryptic behavior, and camouflage ability. We had hoped that the catch-per-unit-of-effort study would strengthen our data base, at least for the sport caught species; however, as indicated in the results for both control and Diablo Cove stations, the variability is much too large to provide for accurate comparisons. Although the divers make estimates of the abundance of each species observed in and around each permanent and random station, we have not subjected these counts to even preliminary analysis. We feel that the most meaningful fish data collected by diver observations are the frequency of occurrence observations, particularly of the adult surfperches, rockfishes, greenlings, and the cabezon. Thus, we believe the declines noted at random stations for lingcod and kelp greenlings are representative of population trends in the entire Diablo Canyon area. This belief is supported in part by the decline in the catches of the partyboat anglers in this area. We have no explanation why this decline of lingcod is not reflected by the control stations.

The fish data from the random 1/4-m^2 stations has not been collated for this report, but the number and frequency of occurrence data of the smaller, more cryptic fishes may be more applicable to statistical analysis than the data from the permanent 60-m^2 and random 30-m^2 stations. During the next year, we will analyze all of the subtidal fish data to determine their quality and to determine if there are any statistically significant trends.

Sea Otters

Results

Sea otters were sighted in Diablo Cove during only four of the 81 observation days in 1977. Fresh evidence of sea otter predation, such as characteristically broken abalone shells and sea urchin tests, was observed during many dives in this area.

Bull Kelp Census in Diablo Cove

Methods

The annual census of bull kelp, *Nereocystis luetkeana*, in Diablo Cove was conducted in October. As in previous censuses, only the plants in the surface canopy, a relatively small percentage of the total number of plants, could be counted. The census was performed from shore by two observers working independently with spotting scopes from two widely separated locations.

Results

The two counts were very close: 11,323 and 11,655. The lower, more conservative count is used here to represent the number of plants in the surface canopy (Figure 40). This count marks a significant decline in what had been a steadily increasing population since the annual census was initiated in 1970 (Table 13).

An interesting aspect of this year's census is the comparison with the 1974 census. These are the only two years where both shore counts and subtidal survey data are available for population estimates. This year's shore count of 11,263 plants is 14% of the 78,920 total population estimate derived from 1976 subtidal surveys. For 1974, the 18,663 shore count is 13% of the total population estimate of 148,200 from subtidal surveys. The closeness of these two percentages of surface-plants-to-total-plants leads us to believe that the 10% figure we used to derive a surface canopy estimate in 1975 of 33,000 plants was fairly close to reality; in fact, it may have been slightly conservative. In any case, 1975 was the banner year for *Nereocystis* in Diablo Cove thus far in our studies. We believe that these changes during the last few years have been due to natural variation.

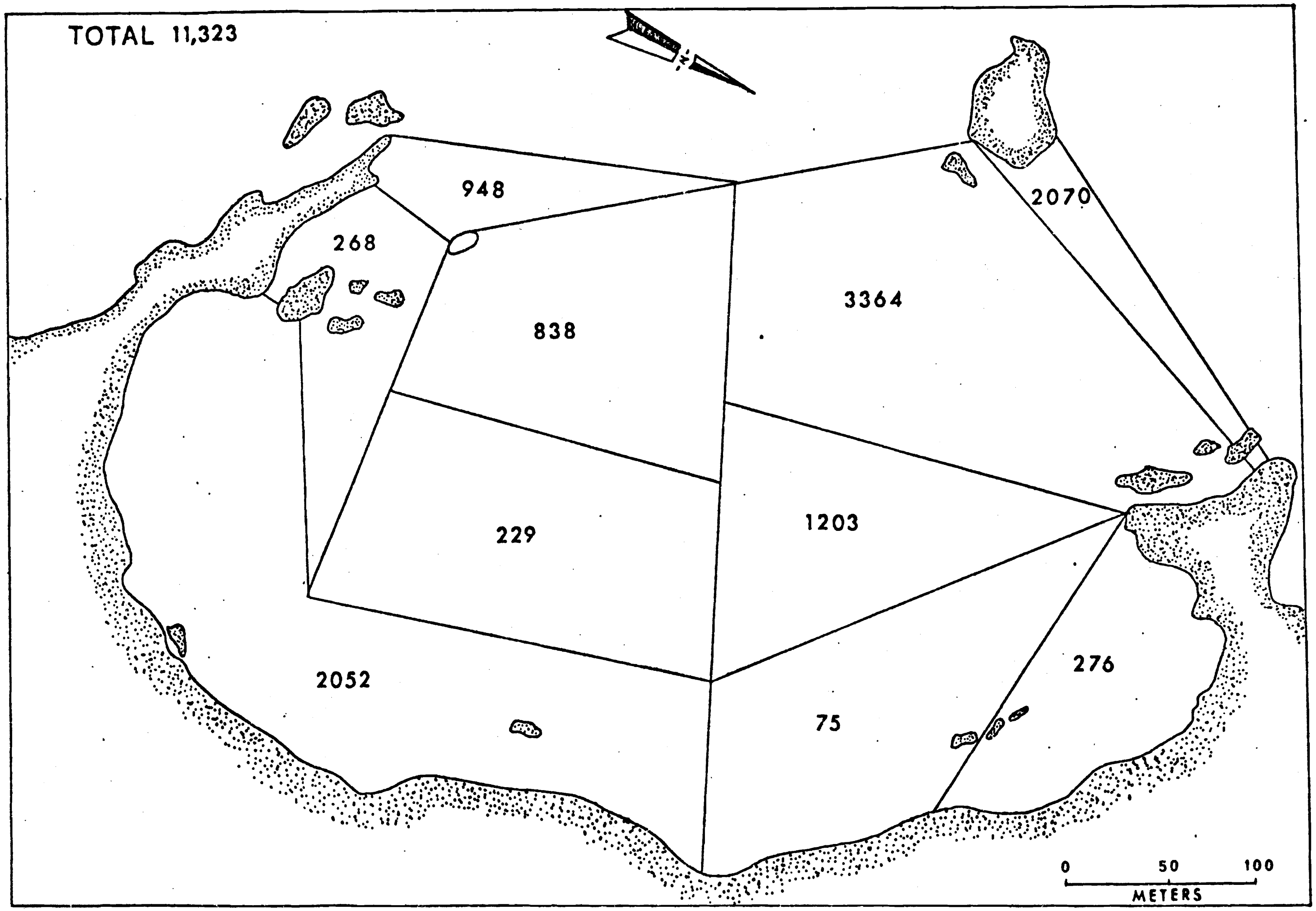


FIGURE 40. Counts of *Nereocystis luetkeana* in Diablo Cove, October 1976, Diablo Canyon Power Plant Site.

TABLE 13. Numbers of Bull Kelp, *Nereocystis luetkeana*, in Diablo Cove From Shore Censuses and Subtidal Surveys. Diablo Canyon Power Plant Site, 1970 to 1976.*

Year	Numbers of *Nereocystis* in Surface Canopy (Shore Census)	Estimated Total Population of *Nereocystis* (from Subtidal Surveys)
1970	3,925	No Surveys
1971	5,154	No Surveys
1973	10,263	No Surveys
1974	18,663	148,200
1975	No Census (Estimate 33,000)	338,000
1976	11,323	78,920

* Neither census nor surveys were performed in 1972.

NORTH DIABLO COVE

Subtidal Activities

Algae

Results

Laminaria dentigera was the most abundant subtidal brown alga in North Diablo Cove random stations (Figure 3). The 1977 mean of 172.3 plants per 30-m^2 station represents a significant increase over the 1976 figure of 109.9. Both *Pterygophora californica* (62.67 plants per 30-m^2) and *Nereocystis luetkeana* (8.50 plants per 30-m^2) are reduced from the 1976 means of 96.3 and 34.5 plants, respectively (Figure 4). Regression analyses of *L. dentigera, N. luetkeana* and *P. californica* data demonstrated some slight relationship between depth and plant density (Table 5).

Intertidal Activities

Algae

Results

Biomass data from two years of sampling in the North Diablo Cove Intertidal (NDCI) have been summarized for this report. The sampling periods considered begin with the Upwelling period of 1975 and proceed through the Davidson period of 1976-77. Generally, the algae in the other three study areas have followed the same trends as in the NDCI.

There are four species of red algae that have occurred with high frequencies and relatively high abundance in our samples. These species are characteristic of the mid- to low-intertidal zones (+0.9 to -0.3 m, MLLW) and we have come to refer to them as 'the big four'. They are: *Gastroclonium coulteri, Gigartina canaliculata, Iridaea* complex (composed of *I. cordata* v. *splendens* and *I. flaccida*), and *Prionitis lanceolata*. With the exception of *Iridaea* complex, these species have been generally stable in their seasonal abundances and, to a lesser extent, in their frequencies of occurrence and percentages of the total biomass they represent (Table 14). The *Iridaea* complex shows a definite seasonality of abundance with the Upwelling (summer) season being the obvious peak.

These four species form the bulk of the total algal biomass in the sampled area (Table 15). Except for the Upwelling season of 1976, they composed over 80% of total measured weight. Other dominant species, (frequencies of occurrence of 25% or greater) represented from 8.4% to 29.8% of the biomass during the various sampling periods. At no time did the "non-dominants" (<25% occurrence) compose more than 7.3% of the biomass. Therefore, the 'big four' plus the ten to 18 species of other dominant algae make up from 92.7 to 98.1% of the total biomass during the various periods.

The seasonality of algal productivity is shown when biomass means, confidence intervals, and ranges are graphed (Figure 41). This shows several aspects of seasonality: 1) there is generally more algae in summer than in the winter; 2) the range in algal weights is much greater in summer than in winter; 3) corresponding to No. 2, confidence intervals about the mean are much more precise (narrower) in the winter: and 4) seasonality of abundance is not a static phenomenon.

Invertebrates

Results

Rather than present cursory, overall results of the past twelve months' sampling as has been the practice in previous reports, population trends of the six dominant invertebrate species in one study area are presented. The study area is NDCI and the six species considered are also generally dominant

TABLE 14. Seasonal Composition of the Four Major Components of 'Soft' Algae. North Diablo Cove Intertidal. Diablo Canyon Power Plant Site, June 1975 Through February 1977.

	Upwelling 1975 (N[1]=36)			Davidson 1975 (N=34)			Upwelling 1975 (N=36)			Davidson 1976 (N=36)		
	$\bar{x}/1/4m^2$ [2]	%B [3]	%f [4]	$\bar{x}/1/4m^2$	%B	%f	$\bar{x}/1/4m^2$	%B	%f	$\bar{x}/1/4m^2$	%B	%f
Gastroclonium coulteri	12.2	14.4	56	6.3	15.1	74	8.5	7.8	39	18.0	30.1	72
Gigartina canaliculata	10.6	12.5	67	9.3	22.4	85	10.2	9.4	69	11.4	19.1	83
Iridaea complex	44.4	52.3	75	11.9	28.6	97	47.9	44.1	92	11.7	19.6	89
Prionitis lanceolata	4.4	5.2	69	3.7	8.9	75	6.1	5.6	89	7.7	13.0	86

(1) N = Sample Size

(2) In Dry Weight Grams

(3) Percentage of Total Average Biomass

(4) Frequency of Occurrence

TABLE 15. Relative Seasonal Composition of 'Soft' Algae Biomass. North Diablo Cove Intertidal. Diablo Canyon Power Plant Site. June 1975 Through February 1977.

	PERCENTAGE OF TOTAL BIOMASS			
	Summer, 1975	Winter, 1975-76	Summer, 1976	Winter, 1976-77
"Big Four"	84.3%	83.9%	66.9%	81.9%
All Other Dominant(1) Algae (Number of Species)	8.4% (10)	13.9% (18)	29.8% (17)	16.2% (16)
Remaining Algae	7.3%	2.2%	3.3%	1.9%

(1) Dominant = Species with $\geq$ 25% Occurrence in Samples

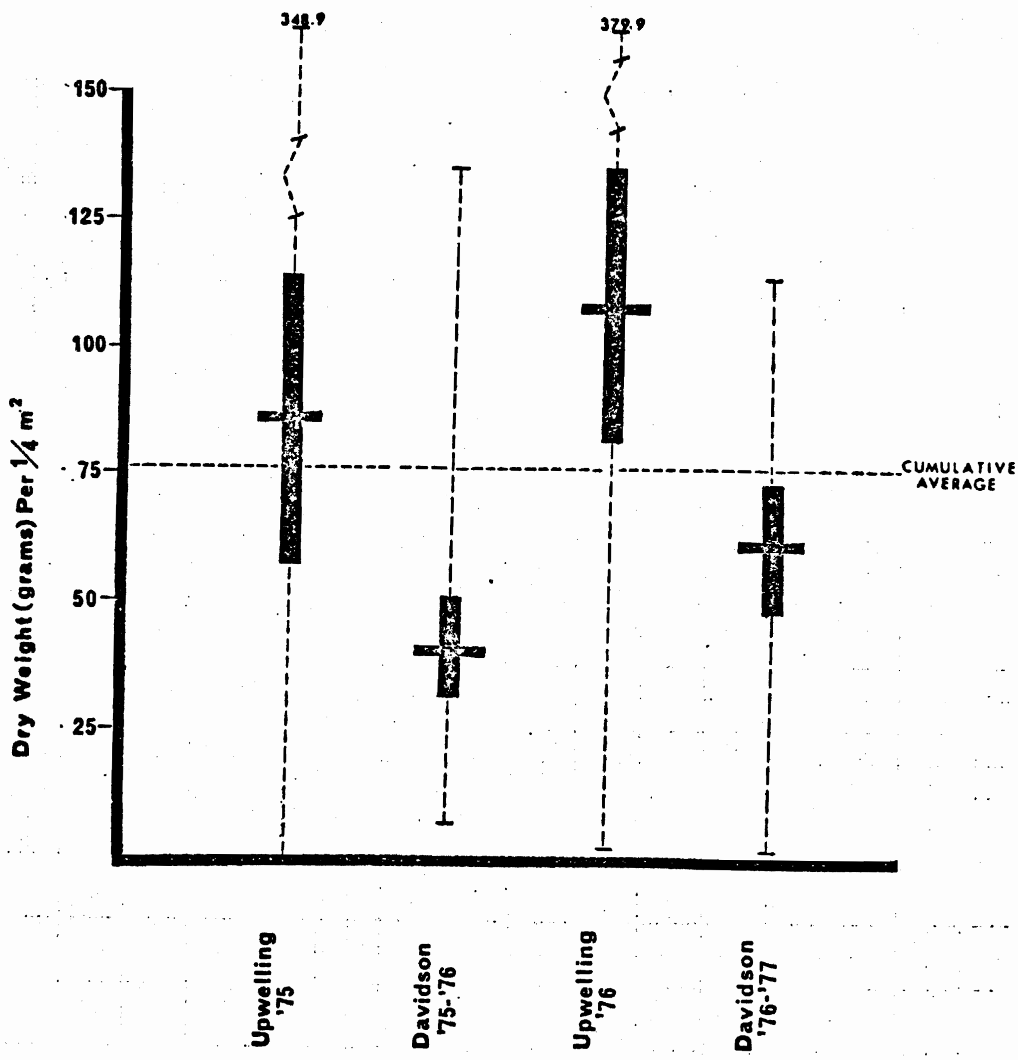


FIGURE 41. Seasonal means (represented by thick horizontal bar), 95% confidence intervals of the means (thick vertical bar) and ranges (dashes) of total biomass of 'soft' algae from North Diablo Cove Intertidal. Diablo Canyon Power Plant Site.

in the other study areas. Data presented cover the sampling seasons beginning with the Davidson period of 1974-75 and extend through the Upwelling period of 1977.

Our first two sampling seasons, Davidson 1973-74 and Upwelling 1974, were incomplete; not all of the stations within each study area were sampled. Beginning with the second Davidson period (1974-75), the sampling routine became standardized and sample sizes within a study area since that time have become equal (with a few minor exceptions).

Of the six species, two are small ($\leq$ 2.5 inches) predatory sea stars, two are herbivorous molluscs, one is a sea anemone, and the last is a mostly herbivorous (possibly somewhat omnivorous) crab.

The sea stars *Henricia leviuscula* and *Leptasterias* spp. appear to have increased somewhat since the study began (Figure 42). Both their abundances and frequencies of occurrence have generally followed positive slopes. During the 1974-75 Davidson period, both species showed average densities (abundance) substantially less than 0.50 animals per 1/4-m^2 and their frequencies of occurrence were less than 20%. Six sampling periods later, in Upwelling 1977, the abundance of *Henricia* had increased to nearly 2.0 animals per 1/4-m^2 and *Leptasterias* had increased to 1.50 per 1/4-m^2; their frequencies were 83% and 75%, respectively.

The two molluscs, *Tegula brunnea*, the brown turban snail, and *Fissurella volcano*, the volcano limpet, have shown inconsistent seasonal trends in both their abundance and frequency figures (Figure 43). However, there appears to be some relationship between abundance and frequency for each species as they generally increase or decrease simulteneously.

The kelp crab, *Pugettia producta*, for the most part found as a juvenile in the intertidal, has remained fairly stable in numbers through the seasons

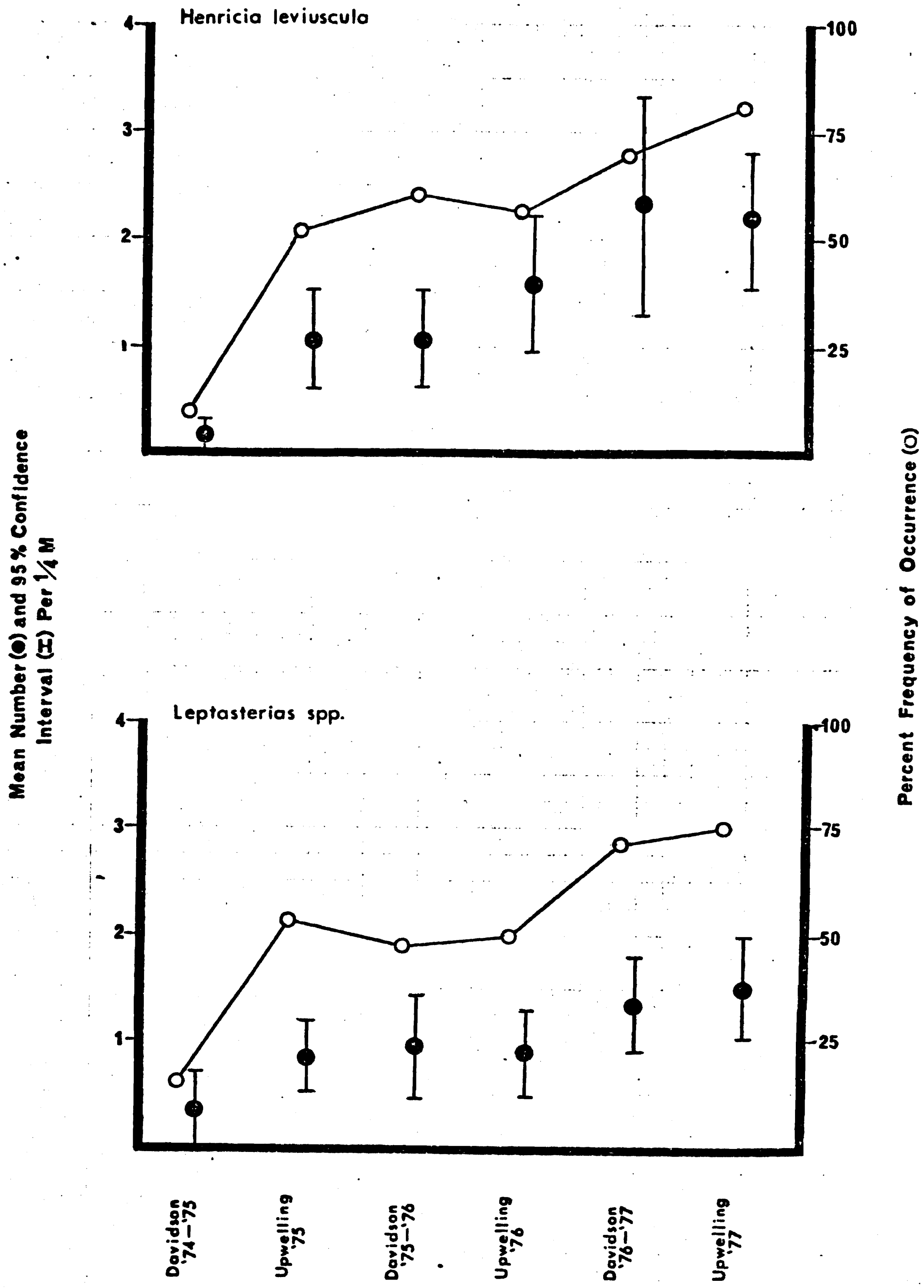


FIGURE 42. Seasonal abundance and frequencies of occurrence of two dominant sea stars from the North Diablo Cove Intertidal. Diablo Canyon Power Plant Site.

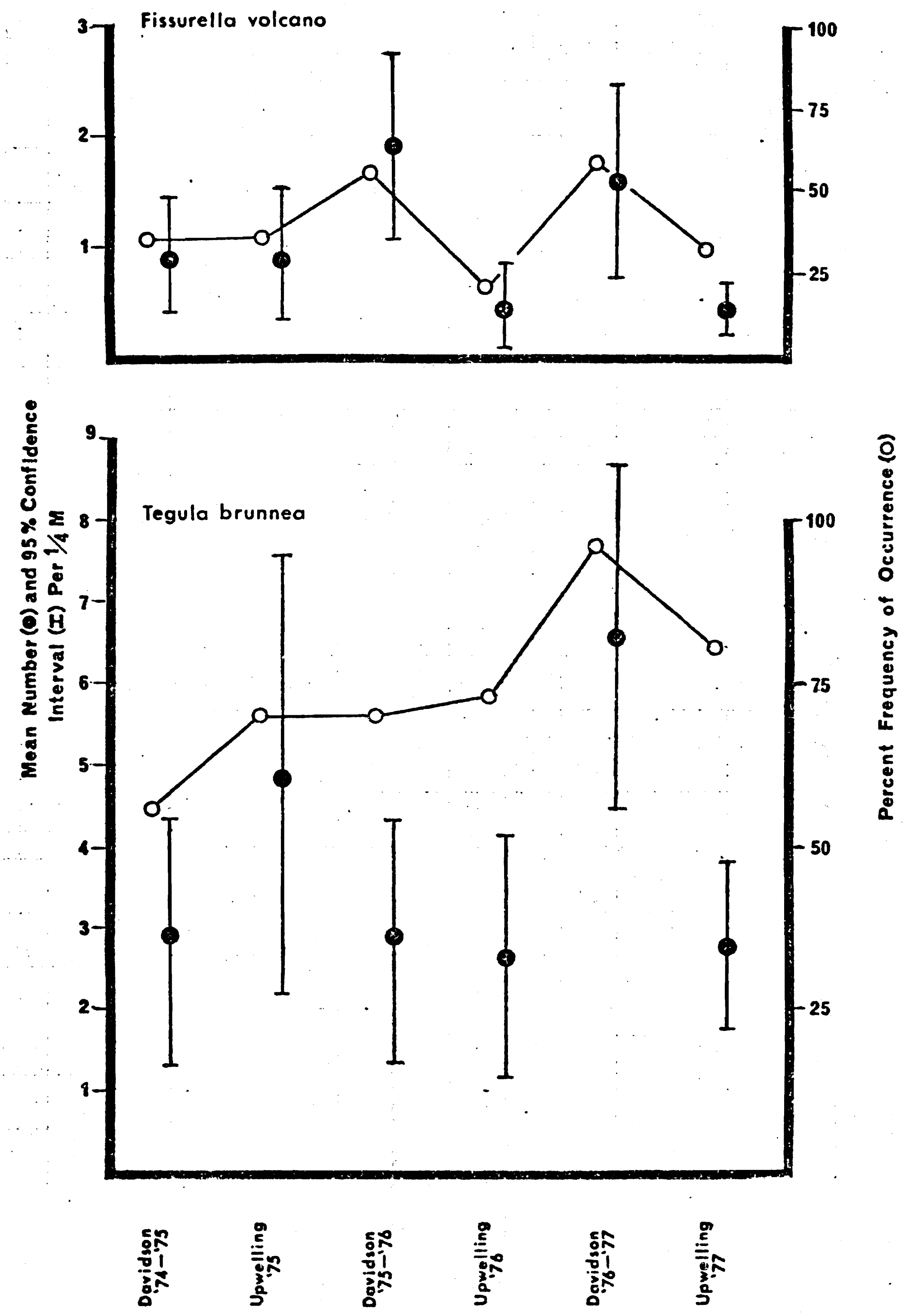


FIGURE 43. Seasonal abundances and frequencies of occurrence of two dominant molluscs from North Diablo Cove Intertidal. Diablo Canyon Power Plant Site.

(Figure 44). It also appears that its frequency is related to its abundance.

Epiactis prolifera, the sea anemone, was also variable in numbers from season to season, but generally demonstrated an increasing trend in abundance (Figure 44).

North Diablo Cove black abalone abundance at parallel 60-m^2 stations during the 1976-77 Davidson was slightly higher than the previous year (Table 10). Red abalone decreased slightly from numbers found during the 1975-76 Davidson. During the 1977 Upwelling period, both black and red abalone numbers at parallel stations were below 1976. Black abalone abundance at perpendicular stations increased during the 1976-77 Davidson period compared to the similar season in 1975-76 (Table 11).

SOUTH DIABLO COVE

Subtidal Activities

Algae

Results

In South Diablo Cove, *Pterygophora californica* was the most numerically abundant subtidal brown alga on random stations (Figure 3). The mean of 197.9 plants recorded in 1977 is lower than the 241.2 recorded in 1976. *Nereocystis luetkeana* was also less common in 1977 (4.5 plants per 30-m^2). *Laminaria dentigera* gained substantially in 1977 with 144.4 plants per station, a nearly three-fold increase over the 50.8 calculated for 1976.

At permanent stations during 1977, *Laminaria* (147.6 plants per station) increased in abundance when compared to 1976 (102.0 per station). *Pterygophora* (164.0 plants per station) maintained levels similar to 1976 (160.5 per station). *Nereocystis* was not observed at Diablo Cove permanent stations in 1977. During the previous year, 7.5 plants were tabulated per station.

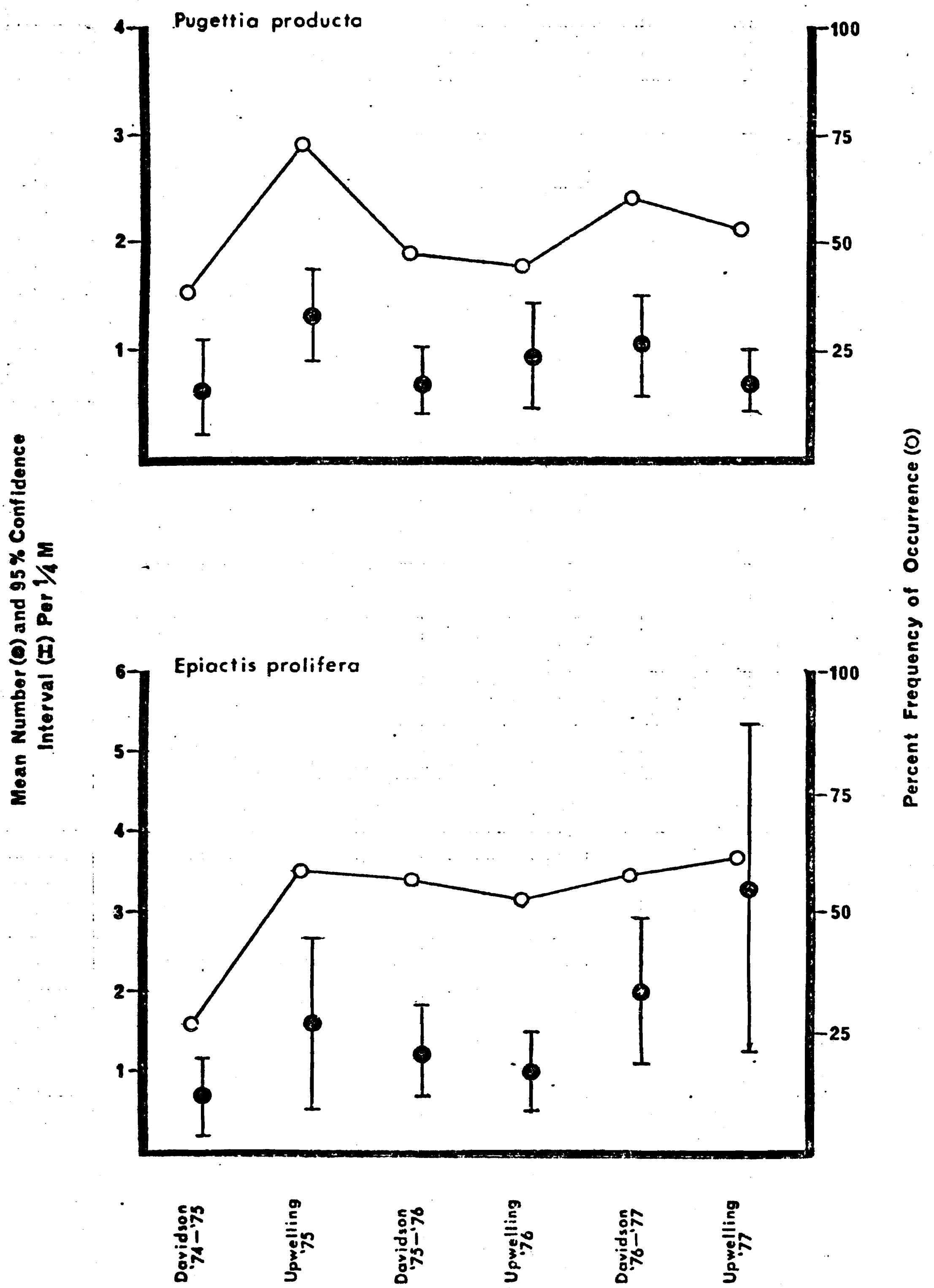


FIGURE 44. Seasonal abundances and frequencies of occurrence of a dominant crab (*Pugettia producta*) and a sea anemone (*Epiactis prolifera*) from North Diablo Cove Intertidal. Diablo Canyon Power Plant Site.

Intertidal Activities

Fish

Results

On December 20, 1976, we drained a tidepool in South Diablo Cove roughly measuring 5 m x 3 m and averaging about 0.4 m in depth. The pool contained many small boulders and exposed rocks. We were not able to collect all of the fish in the pool due to the many inaccessible areas and the fact that we were not able to drain the pool completely. A total of 82 fish were collected representing nine species (Table 16). The most abundant fish was the striped kelpfish, *Gibbonsia metzi*.

We examined 30 of the striped kelpfish stomachs in the laboratory to determine what food items were present. Unidentifiable crustaceans, primarily brachyurans, were the most frequently observed food item (Table 17). Identifiable genera included *Hemigrapsus*, *Pachygrapsus*, and *Pugettia*. Brachyurans were also dominant in eleven striped kelpfish stomachs collected in the North Control Intertidal during 1974 and 1975 (Gotshall et al. 1976).

Sea urchin spines, *Strongylocentrotus* sp., found in the stomachs may have been incidental.

Invertebrates

Results

During the 1976-77 Davidson period, black abalone abundance at parallel stations in South Diablo Cove was slightly higher than recorded the previous year (Table 10). Red abalone abundance at those stations was unchanged from the 1975-76 Davidson. Black abalone abundance at parallel stations during the 1977 Upwelling period was slightly greater than in

TABLE 16. Fishes Collected at Intertidal Station, South Diablo Cove, Diablo Canyon Power Plant Site, December 20, 1976.

SPECIES	Number	Total Length (mm)
Anoplarcus purpurescens	8	44-98
Artedius lateralis	1	---
Chilara taylori	1	81
Clinocottus analis	13	26-73
Gibbonsia metzi	38	54-92
Girella nigricans	2	37-47
Gobiesox maeandricus	1	32
Oligocottus snyderi	12	39-69
Xiphister atropurpureus	6	47-140
Total	82	

TABLE 17. Stomach Contents of Striped Kelpfish, *Gibbonsia metzi*, Collected in Diablo Cove Intertidal, Diablo Canyon Power Plant Site, December 1976.

FOOD ITEM	Number of Items	Percent Freq. of Occurrence	Volume (ml)
Barleeia sp.	12	10.0	0.04
Bryozoa	2	6.7	T
Caridea	7	13.3	0.09
Crepidula sp.	2	6.7	T
Crustacea (mostly brachyurans)	20	76.7	0.63
Gammarid amphipods	33	50.0	0.07
Gastropods	6	20.0	0.11
Grapsid crabs	5	10.0	0.06
Hemigrapsus sp.	3	10.0	0.06
Idotea	1	1.0	0.05
Isopoda	10	30.0	0.11
Megalops	1	3.0	0.04
Pachygrapsus sp.	1	3.0	0.02
Paguridae	15	36.7	0.08
Pelecypoda	3	10.0	0.02
Polychaeta	9	30.0	0.08
Pugettia gracilis	4	10.0	0.36
Strongylocentrotus sp. (spines)	4	13.3	T
Total Stomachs	30		
Number Empty	1		

T = Trace.

1976 while red abalone decreased slightly. Mean counts per m^2 of black abalone at the perpendicular stations were slightly lower during the 1976-77 Davidson and 1977 Upwelling periods than during the same periods the previous year.

DIABLO POINT

Intertidal Activities

Invertebrates

Results

Three Diablo Point parallel stations were sampled during the 1976-77 Davidson period. Both black and red abalones showed an increase in abundance when compared to the 1975-76 Davidson (Table 10).

SUMMARY

1. A total of 818 man-days was spent at the site conducting lab and field studies.

2. Two hundred seventy-two permanent and random intertidal and subtidal stations were surveyed during this report period, an increase of 83 stations over the previous year.

3. Quantitative samples of benthic red algae were taken at 23 random subtidal stations in the North Control area. Twenty-six species were identified and of these, *Botryoglossum farlowianum* was the most abundant alga.

4. Of the stipitate brown algae quantified at the North Control random subtidal stations, the tree kelp, *Pterygophora californica* was numerically most abundant, followed by *Laminaria dentigera.* Bull kelp, *Nereocystis luetkeana*, showed a marked decrease in numbers from the previous year.

5. At the permanent subtidal control stations to the north of Diablo Cove, *Pterygophora californica* was again the most abundant brown alga followed by *Laminaria dentigera.*

6. Trends in abundance and frequency of occurrence of 19 species of the more common invertebrates at the permanent and random North Control subtidal stations are discussed. Regression analyses of numbers at depth has been performed for selected species.

7. Of the 40 species of fish observed in the study areas, eight species have occurred with a frequency of 25% of greater in the North

Control stations. These are the striped surfperch, kelp and painted greenlings, lingcod, cabezon, and three rockfish species; blue, gopher, and black and yellow. The frequency of occurrence of lingcod and kelp greenling have decreased at random stations since the initial 1974 surveys.

8. Because of high variability of data, we cancelled our sportfish catch-per-unit-of-effort study in December 1976.

9. Sea otters were sighted regularly in the control areas. South Cove was the location of the greatest number of otters on any one day, but Lion Rock Cove was more consistently inhabited by them.

10. Numbers of black and red abalones at random intertidal stations remained relatively stable from the previous year.

11. In Diablo Cove, the five permanent stations were surveyed twice during the period and 24 random stations were completed during the summer. Twelve "micro" stations were also surveyed.

12. The dominant red alga, of the 31 species identified from Diablo Cove random subtidal 1/4-m^2 samples, was *Botryoglossum farlowianum*. The mean dry weight (biomass) of Diablo Cove algae samples was about 20% less than the average biomass for the North Control area.

13. In general, red algal abundance and diversity appear to have been increasing since 1974 in both subtidal study areas.

14. Population abundance and frequency of occurrence trends are discussed for 19 species of invertebrates quantified at our permanent and random subtidal stations in Diablo Cove. These are the same 19 species discussed in

the North Control section of this report.

15. The frequencies of occurrences of the eight most common fish at our permanent and random subtidal Diablo Cove stations are discussed. These are the same species discussed in the North Control section. Declines of lingcod and kelp greenling frequency of occurrence at random stations followed the pattern noted at North Control stations.

16. Sea otters were rarely observed in Diablo Cove during the period. They were seen on only 5% of the sighting occasions. However, characteristically broken abalone shells and urchin tests observed on many dives in Diablo Cove served as evidence of a transitory presence of the sea otter.

17. The distribution of subtidal kelp from our random stations within Diablo Cove is discussed in terms of north-south components of the cove. *Laminaria dentigera* is the most abundant of the three major kelp species in North Diablo Cove whereas *Pterygophora californica* is most abundant in the southern portion of Diablo Cove.

18. The annual shore census for *Nereocystis luetkeana* was performed in October 1976. The counts of two independent observers were very close and this year's surface canopy population is set at 11,323 plants. This year marks the first decline in what had been a steadily increasing population since 1970.

19. Biomass of intertidal algae, determined by random sampling of 1/4-m^2 plots, is represented by a summary of two years of data from the North Diablo Cove Intertidal study area. Dominance and seasonality of algal species are discussed.

20. Long-term trends of abundance and distribution of six species of dominant intertidal invertebrates at the North Diablo Cove Intertidal study area are presented and discussed.

21. An intertidal fish collection was made in December 1976 in South Diablo Cove. A total of 82 fish, representing nine species, was collected. Stomachs of the most abundant fish collected, *Gibbonsia metzi*, were examined to determine diet.

22. Numbers of black abalone, *Haliotis cracherodii*, seem to have increased slightly at most of the random intertidal study areas in Diablo Cove.

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APPENDIX I

Summary of Diablo Canyon Power Plant Site Field Studies

Intertidal Surveys		May 3 - 7
	Participants:	Gotshall, Laurent, Wendell, Kelly, Krenn
		June 1 - 4
	Participants:	Gotshall, Laurent, Wendell, Kelly, Krenn
		June 5 - 7, 29 - 30
	Participants:	Laurent, Wendell, Kelly, Krenn
Subtidal Surveys		April 4 - 7
	Participants:	Laurent, Wendell, Kelly
		April 21
	Participants:	Gotshall, Laurent, Wendell
		May 12, 16
	Participants:	Laurent, Wendell, Krenn
		May 31
	Participants:	Gotshall, Wendell, Kelly
		June 4
	Participants:	Gotshall, Laurent, Kelly
		June 13
	Participants:	Gotshall, Wendell, Kelly
		June 16, 27, 30
	Participants:	Wendell, Kelly Krenn

MAN-DAYS SPENT AT DIABLO CANYON POWER PLANT SITE

July 1, 1976 -- June 30, 1977

	July 1, 1976 -- March 31, 1977	April 1 -- June 30, 1976	Totals
Total Man-Days	817	245	1062
Total Man-Days at Site*	612	206	818
Total Stations Surveyed	173	35	208
Travel Time Man-Days	15	5	20
Boat Time (Hours)	61	11	72
Laboratory Time Man-Days+	190	34	224

*Total time spent at Diablo Canyon by all project personnel, includes both field time and laboratory time.

+Time spent at Monterey office by project leader and seasonal aid.

PROJECT PERSONNEL

Daniel W. Gotshall	Senior Marine Biologist, Project Leader
Laurence L. Laurent	Associate Marine Biologist
Fred E. Wendell	Assistant Marine Biologist
Lois E. Sloan	Stenographer
Barbara G. Freeman	Seasonal Aid
Philip R. Taylor	Seasonal Aid
Monica Farris	Seasonal Aid
Kathleen A. Casson	Seasonal Aid
James L. Kelly	Seasonal Aid
Sally J. Krenn	Seasonal Aid