THERMAL EFFECTS MONITORING PROGRAM
1984 ANNUAL REPORT
DIABLO CANYON POWER PLANT

PACIFIC GAS AND ELECTRIC COMPANY

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EXECUTIVE SUMMARY

The results of the Thermal Effects Monitoring Program (TEMP) for the Diablo Canyon Power Plant are summarized and reported for the period January to December 1984. A brief review of activities and data obtained since program inception (1976) is included as background information. The monitoring program currently includes 18 biological and oceanographic study subtasks, two of which (subtidal red abalone survey and subtidal video transects) were initiated in 1984. The status of all subtasks is briefly described and analysis of data from thirteen subtasks is reported. Analyses were made of results from:

- o Intertidal studies, including: band transect sampling of algal and invertebrate populations and random point contact sampling of algal populations

- o Subtidal studies, including: arc quadrant sampling of algal and invertebrate populations, fixed quadrat sampling of invertebrate populations, line contact sampling of algal populations, rock crab trapping and tagging studies, fish observation transects, settling plate sampling of algae and invertebrates, surveys of red abalone populations, video sampling of transects, and bull kelp population estimates

- o Physical oceanographic studies including: in situ temperature and light recordings.

The 1984 biological and physical data summarized in this report provide further documentation and description of long- and short-term trends in the species, communities, and environment of Diablo Cove. Population trends established by these studies will make possible an assessment of the effects of the thermal discharge following commercial operation of the power plant, which is anticipated to occur in mid-1985.

Special emphasis in this report has been placed upon two subjects: evidence in the data for 1984 of continuing biological changes subsequent to the El Nino events of 1982 and 1983, and a description of unusual biological changes in south Diablo Cove during 1984.

The populations of several intertidal species that experienced marked decreases as a result of the severe 1982-83 storms appear to have recovered, for the most part, to levels comparable to those of the years preceding 1982.

In May 1984, absence of normal pigmentation was observed in some algae occurring in a portion of south Diablo Cove. Careful observations and a focused analysis of TEMP data revealed that several major algal species exhibited tissue discoloration and/or loss of tissue. Concomitantly or subsequent to these observations, increases in two algal species populations (for which increases are often associated with community disturbance) were recorded. Through the summer and fall, these abnormal algal conditions subsided, so that by the end of 1984, the area appeared normal and no major long-term effects were anticipated. Review of TEMP temperature and light data and plant discharge data for the first half of 1984 did not provide an explanation for these changes. A review of the plant discharge values during this period indicated that concentrations of waste stream constituents were within the normal range anticipated during plant operations.

1.0 INTRODUCTION

The 1984 Thermal Effects Monitoring Program (TEMP) report is submitted in accordance with Provision D.3 (Compliance with Monitoring and Reporting Program) and D.7(a) of the NPDES Permit (order number 82-24 as amended in March 1983) issued by the California Regional Water Quality Control Board, Central Coast Region (hereafter referred to as the "Board") for the operation of the Diablo Canyon Power Plant. A report summarizing the results of the Thermal Effects Monitoring Program of the cooling water discharge is submitted annually.

Since the power plant did not reach commercial power operation in 1984, there were no significant thermal discharges and hence no thermal effects related to the cooling water discharge to report. This report summarizes the methods and the status of 18 TEMP subtasks (individual sampling and data recording activities) and examines in detail the data for selected species sampled in most subtasks. The majority of these subtasks have been performed routinely (with some modifications to their methods and scope) since 1976 when they were designed and implemented under the 316(a) Demonstration Program.

The TEMP field studies are designed to yield an extensive data base on the spatial distribution of the major populations of marine flora and fauna in Diablo Cove and the surrounding areas that will make possible comparative evaluations of the effects of the thermal discharge on these species. Intertidal and subtidal algal, invertebrate, and fish abundances have been quantitatively monitored at regular sampling intervals since 1976. Fixed sampling is conducted at precisely located sampling stations in Diablo Cove and in reference areas to the north and south of the Cove.

Nearshore marine communities occurring on rocky substrates, such as those at Diablo Cove, are relatively complex in terms of species composition. To assess potential changes in such communities, sampling stations have been positioned at a number of intertidal and subtidal locations within Diablo Cove and the adjoining areas. The species that make up these communities are not only

numerous (see Appendix B), but also represent a wide range of mature sizes, growth forms, mobility, and seasonal changes. Because no one sampling method can adequately measure species occurrence and abundance over this wide range of attributes, 14 biological data-gathering methods are currently employed in this program. To obtain data on the intertidal communities, intertidal band transect (IBT) samples provide counts and area cover estimates of algae and invertebrates, and associated random point contact (RPC) samples provide detailed information on multidimensional aspects of algal associations. These two major intertidal sampling methods are supplemented by intertidal station photography, which documents the visual aspects of the IBT and RPC stations, the intertidal algal scraping (IAS) method, which provides biomass estimates from a limited set of stations, and two methods specifically directed toward populations of the commercially important black abalone (intertidal black abalone tagging and surveying). Eight additional biological sampling methods are employed in the subtidal. Counts and area cover estimates of algae and invertebrates are documented by the subtidal arc quadrant (SAQ) method. These data are supplemented by detailed counts of small and abundant invertebrates from the subtidal fixed quadrat (SFQ) method and by counts of large (so-called canopy) algae from the subtidal line contact (SLC) method. To broaden the perspective of the Diablo Cove communities obtained by these sampling methods, subtidal video transects ranging over much of Diablo Cove provide qualitative information on easily visible species. Three subtidal sampling methods provide information on species of specific interest, including trapping and tagging of the commercially important rock crab, surveys of red abalone populations, and fish transect counts. Settling plates are exposed to potential settling of larvae and algal spores in the subtidal to provide information on the potential of certain species to maintain populations and colonize substrates. From the tops of adjacent cliffs, counts of bull kelp plants that appear at the surface of Diablo Cove are made once each year.

Temperature data are collected at numerous intertidal and subtidal stations in and around Diablo Cove to document the primary parameter that could potentially affect the species and communities studied. Supplemental information on

terrestrial and subtidal incident solar light and waves and tides is also recorded at a limited number of stations.

Taken together, this wide range of data-gathering activities provides an extensive data base which will make possible comprehensive assessment of any potential thermal effects of the Diablo Canyon Power Plant discharge on the communities of the receiving water body.

This 1984 annual report is the ninth in the series of progress reports to the Board required under 316(a) and/or thermal effects monitoring program (TEMP) guidelines. The series includes reports dated December 1976 (Kaiser Engineers 1976), October 1977, May 1978, February 1979, November 1979, August 1980, January 1983, and January 1984 (PGandE 1977, 1978, 1979, 1980, 1983, and 1984). In addition to these progress reports, three special reports directly pertaining to the DCPP thermal discharge have been submitted to the Board under the titles of "Assessment of Alternatives to the Existing Cooling Water System," "Thermal Discharge Assessment Report," and "Compendium of Thermal Effects Laboratory Studies" (PGandE 1982a, 1982b, and 1982c).

2.0 MONITORING PROGRAM RESULTS

Results of the 1984 field sampling studies are presented in this section. In addition to reporting the completion status for all 18 sampling subtasks (two of which, subtidal red abalone survey and subtidal video transects, are reported here for the first time), this section also includes analyses of the data for selected species from all biological sampling subtasks, with the exception of the algal scraping and black abalone tagging and surveying subtasks. No black abalone tagging or surveying activities were conducted in 1984. Data from the algal scraping surveys are still in process. Representative analyses of the temperature and light data are also included in this section. This year's level of analysis extends that presented in the 1983 Annual Report (PGandE 1984) and includes analyses of the two new subtasks.

A number of inactive stations were sampled in 1984 to provide a comparison with previously collected data prior to significant thermal discharges from the power plant. The data were not analyzed for this report, but have been archived and will be available for future analyses if the need arises. Seven inactive intertidal stations were sampled in June: 3, 4, and 5 (north of Diablo Cove); 13 (Diablo Point, at the south side of Diablo Cove); and 16, 17, and 18 (just south of Diablo Cove). Five inactive subtidal stations (all in Diablo Cove) were sampled in July and August: 5-25, 6-11, 7-10, 8-15, 11-10, and 11-15.

From the inception in 1976 of the TEMP study (originally known as the 316(a) Demonstration Program) to the end of 1984, 53 intertidal and 46 subtidal biological surveys have been conducted, resulting in the accumulation of a large biological data base. In the intertidal, approximately 17,200 quadrats have been sampled for algae and approximately 9,520 quadrats for invertebrates. In the subtidal, approximately 1,530 arc quadrants have been sampled for both algae and invertebrates. Approximately 450 subtidal fish transects have been sampled in the same period. Several other subtasks have produced additional data on various algal and invertebrate species. During the course of the study, approximately 1,168 species of algae, invertebrates, and fish have been identified in the samples collected (see Appendix B). In support of the biological

sampling effort, temperature data have been collected since 1976, and data on light, waves, and tides have been recorded in recent years.

The present progress report provides an overview of this large data base by focusing upon analyses of a limited number of algal, invertebrate, and fish species selected because of their abundance or resource management importance. To provide a perspective on natural changes in the populations of these species, summary data are presented for the period 1976 through 1984.

The analyses are organized by sampling task in the following sections:

Intertidal Band Transects (IBT)
Intertidal Random Point Contact Quadrats (RPC)
Intertidal Algal Scrapings
Intertidal Black Abalone Tagging
Intertidal Black Abalone Survey
Intertidal Station Photography
Subtidal Arc Quadrant (SAQ)
Subtidal Fixed Quadrat (SFQ)
Subtidal Line Contact (SLC)
Subtidal Crab Trapping and Tagging
Subtidal Fish Observations
Subtidal Settling Plates
Subtidal Red Abalone Survey
Subtidal Video Transects
Bull Kelp Population Estimates
Temperature Measurement
Light Measurement
Wave/Tide Measurement

2.1 INTERTIDAL BAND TRANSECT (IBT)

Six intertidal band transect (IBT) surveys were completed in 1984 (TABLES 2-1, 2-2, 2-3). Details of the IBT sampling methods and locations are presented in Appendix A (Section A.1). Five algal species (Endocladia muricata, Gastroclonium coulteri, Gigartina canaliculata, G. papillata, and Iridaea flaccida) and five invertebrate species (Anthopleura elegantissima, Haliotis cracherodii, Collisella scabra, Pagurus spp., and Tegula funebralis) that are dominant or otherwise important were selected for analysis. For each species

TABLE 2-1

SUMMARY OF COMPLETED TEMP INTERTIDAL SAMPLING: +1 FT (MLLW) TRANSECTS

Survey	Date	Algae: Band Transect No. Stations	Algae: Band Transect No. Quadrats	Algae: Point Contact No. Stations	Algae: Point Contact No. Quadrats	Algae: Algal Scraping No. Stations	Algae: Algal Scraping No. Quadrats	Invertebrates: Std. Inverts. Count No. Stations	Invertebrates: Std. Inverts. Count No. Quadrats	Invertebrates: "Precise" Count No. Stations	Invertebrates: "Precise" Count No. Quadrats	Invertebrates: "Tegula" No. Stations	Invertebrates: "Tegula" No. Quadrats
01	April 1976	15	450	16	48	15	45	15	375	0	0	15	75
02	June 1976	15	450	16	48	15	45	15	375	0	0	15	75
03	August 1976	15	225	16	48	15	45	15	150	15	75	15	75
04	October 1976	15	225	16	48	15	45	15	150	15	75	15	75
05	December 1976	15	225	16	48	15	45	15	150	15	75	15	75
06	February 1977	15	225	16	48	15	45	15	150	15	75	15	75
07	May 1977	15	225	16	48	15	45	15	150	15	75	15	75
08	June 1977	7	105	8	24	7	21	7	70	7	35	7	35
09	July 1977	7	105	8	24	7	21	7	70	7	35	7	35
10	November 1977	7	105	8	24	7	21	7	70	7	35	7	35
11	December 1977	7[a]	105	7[a]	21	0	0	7	70	0	0	7	35
12	February 1978	7	104	7	21	0	0	7	70	1	5	7	34
13	April 1978	9	135	10	30	0	0	9	90	1	5	9	45
14	June 1978	9	135	10	30	0	0	9	90	1	5	9	45
15	August 1978	9	135	10	30	0	0	9	90	1	5	9	45
16	October 1978	9	129	10	28	0	0	9	86	1	5	9	43
17	December 1978	9	135	10	30	0	0	9	90	1	5	9	45
18	February 1979	9	135	10	28	0	0	9	90	1	5	9	45
19	April 1979	9	135	10	30	0	0	9	90	1	5	9	45
20	June 1979	9	135	10	30	0	0	9	90	1	5	9	45
21	August 1979	9	135	10	30	b		9	90	1	5	9	45
22	October 1979	8	105	9	27			7	65	1	5	8	40
23	December 1979	9	135	10	30			9	90	1	5	9	45
24	February 1980	5	66	6	16			5	42	1	5	5	24
25	April 1980	9	90	10	30			9	45	1	5	9	45
26	June 1980	9	90	10	30			9	45	1	5	9	45
27	August 1980	9	90	10	30			9	45	1	5	9	45
28	October 1980	9	90	9	27			9	45	1	5	9	45
29	December 1980	9	90	10	30			9	45	1	5	9	45
30	February 1981	9	90	10	30			9	45	1	5	9	45

a Two stations outside of work plan were sampled.

b New subtask, see TABLE 2-11.

TABLE 2-1

SUMMARY OF COMPLETED TEMP INTERTIDAL SAMPLING: +1 FT (MLLW) TRANSECTS (CONTINUED)

		Algae						Invertebrates					
		Band Transect		Point Contact		Algal Scraping		Std. Inverts. Count		"Precise" Count		"Tegula"	
Survey	Date	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats
31	April 1981	9	90	9	27	b		9	45	1	5	9	45
32	June 1981	9	90	10	30			9	45	1	5	9	45
33	August 1981	9	90	10	30			9	45	1	5	9	45
34	October 1981	9	90	10	30			9	45	1	5	9	45
35	December 1981	9	90	10	30			9	45	1	5	9	45
36	February 1982	9	90	10	30			9	45	1	5	9	45
37	April 1982	11	110	12	36			11	55	1	5	11	55
38	June 1982	11	110	12	36			11	55	1	5	11	55
39	August 1982	11	110	12	36			11	55	1	5	11	55
40	October 1982	6	60	11	32			6	30	1	5	6	30
41	December 1982	9	90	9	27			9	45	1	5	9	45
42	February 1983	8	79	9	25			8	40	1	5	8	39
43[c]	April 1983	8	80	12	34			8	40	1	5	8	40
44	June 1983	12	120	12	34			12	60	1	5	12	60
45	August 1983	12	120	12	33			12	60	1	5	12	60
46	October 1983	7	68	10	27			7	35	1	5	7	33
47	December 1983	10	100	9	26			10	50	1	5	10	50
48	February 1984	10	100	9	27			10	50	1	5	10	50
49	April 1984	10	100	10	30			10	50	1	5	10	50
50	June 1984	15	150	15	45			15	75	1	5	15	75
51	August 1984	12	120	12	36			12	60	1	5	12	60
52	October 1984	12	120	12	36			12	60	1	5	12	60
53	December 1984	10	100	9	27			10	50	1	5	10	50

[b] New subtask, see TABLE 2-11.

[c] One quadrat on the 7+1 transect was replaced in Survey 43.

TABLE 2-2

SUMMARY OF COMPLETED TEMP INTERTIDAL SAMPLING: +3 FT (MLLW) TRANSECTS

Survey	Date	Algae						Invertebrates					
		Band Transect		Point Contact		Algal Scraping		Std. Inverts. Count		"Precise" Count		"Tegula"	
		No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats
01	April 1976	19	570	21	61	18	54	19	480	0	0	18	90
02	June 1976	19	570	21	61	18	54	19	480	0	0	18	90
03	August 1976	19	285	21	61	18	54	19	195	18	90	18	90
04	October 1976	19	285	21	61	18	54	19	195	18	90	18	90
05	December 1976	19	285	21	61	18	54	19	195	18	90	18	90
06	February 1977	19	285	21	61	18	54	19	195	18	90	18	90
07	May 1977	19	285	21	61	18	54	19	195	18	90	18	90
08	June 1977	0	0	4	12	0	0	0	0	0	0	0	0
09	July 1977	9	135	9	27	0	0	9	90	9	45	9	45
10	November 1977	0	0	4	12	0	0	0	0	0	0	0	0
11	December 1977	7[a]	105	7[a]	19	0	0	7	75	0	0	6	30
12	February 1978	7	105	8	22	0	0	7	75	1	5	6	30
13	April 1978	10	150	10	28	0	0	10	105	1	5	9	45
14	June 1978	10	150	10	28	0	0	10	105	1	5	9	45
15	August 1978	10	150	10	28	0	0	10	105	1	5	9	45
16	October 1978	10	150	10	28	0	0	10	105	1	5	9	45
17	December 1978	10	150	10	28	0	0	10	105	1	5	9	45
18	February 1979	10	150	10	28	0	0	10	105	1	5	9	45
19	April 1979	10	150	10	28	0	0	10	105	1	5	9	45
20	June 1979	10	150	10	28	0	0	10	105	1	5	9	45
21	August 1979	10	150	10	28	b		10	105	1	5	9	45
22	October 1979	10	140	10	28			9	95	1	5	9	45
23	December 1979	10	150	10	28			10	105	1	5	9	45
24	February 1980	7	105	7	19			7	75	1	5	6	30
25	April 1980	10	100	10	28			10	55	1	5	9	45
26	June 1980	10	100	10	28			10	55	1	5	9	45
27	August 1980	10	100	10	28			10	55	1	5	9	45
28	October 1980	10	100	10	28			10	55	1	5	9	45
29	December 1980	10	100	10	28			10	55	1	5	9	45
30	February 1981	10	100	10	28			10	55	1	5	9	45

[a] Two stations outside of work plan were sampled.

[b] New subtask, see TABLE 2-11.

TABLE 2-2

SUMMARY OF COMPLETED TEMP INTERTIDAL SAMPLING: +3 FT (MLLW) TRANSECTS
(CONTINUED)

Survey	Date	Algae						Invertebrates					
		Band Transect		Point Contact		Algal Scraping		Std. Inverts. Count		"Precise" Count		"Tegula"	
		No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats	No. Stations	No. Quadrats
31	April 1981	10	100	10	28	b		10	55	1	5	9	45
32	June 1981	10	100	10	28			10	55	1	5	9	45
33	August 1981	10	100	10	28			10	55	1	5	9	45
34	October 1981	10	100	10	28			10	55	1	5	9	45
35	December 1981	10	100	10	28			10	55	1	5	9	45
36	February 1982	10	100	10	28			10	55	1	5	9	45
37	April 1982	14	140	14	40			14	75	1	5	13	65
38	June 1982	14	140	14	40			14	75	1	5	13	65
39	August 1982	14	140	14	40			14	75	1	5	13	65
40	October 1982	11	110	11	31			11	60	1	5	10	50
41	December 1982	10	100	10	28			10	55	1	5	9	45
42	February 1983	9	90	9	24			9	50	1	5	8	40
43[c]	April 1983	14	140	14	39			14	75	1	5	13	65
44	June 1983	15	150	14	39			15	80	1	5	14	70
45	August 1983	15	150	14	39			15	80	1	5	14	70
46	October 1983	12	120	12	33			12	65	1	5	11	55
47	December 1983	13	130	12	33			13	70	1	5	12	60
48	February 1984	10	100	10	24			10	55	1	5	9	45
49	April 1984	13	130	12	34			13	70	1	5	12	60
50	June 1984	20	200	20	57			20	105	1	5	19	95
51	August 1984	15	150	14	39			15	80	1	5	14	70
52	October 1984	15	150	14	39			15	80	1	5	14	70
53	December 1984	11	110	10	27			11	60	1	5	10	50

[b] New subtask, see TABLE 2-11.

[c] Three quadrats on the 7+3 transect were replaced in Survey 43.

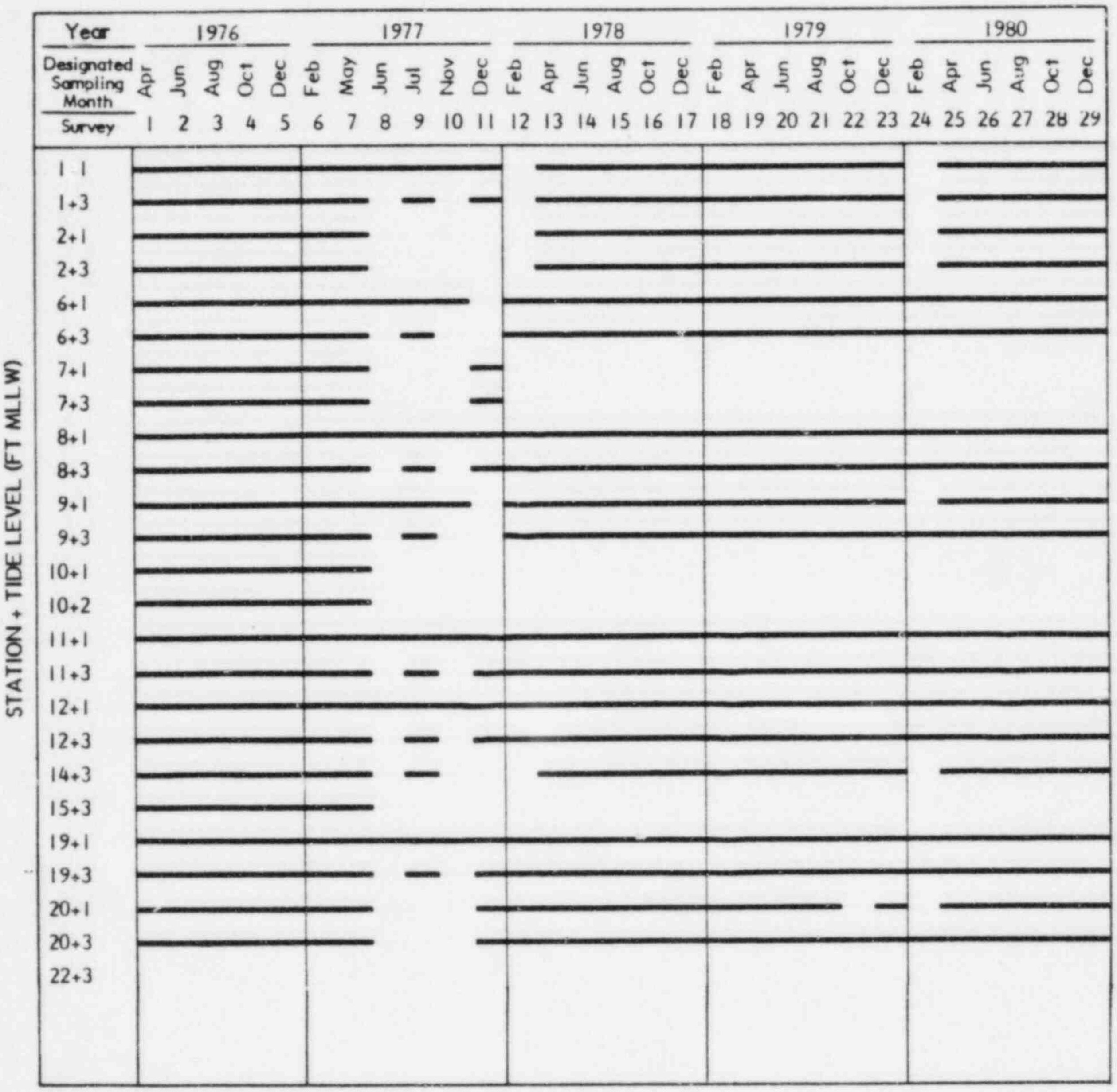
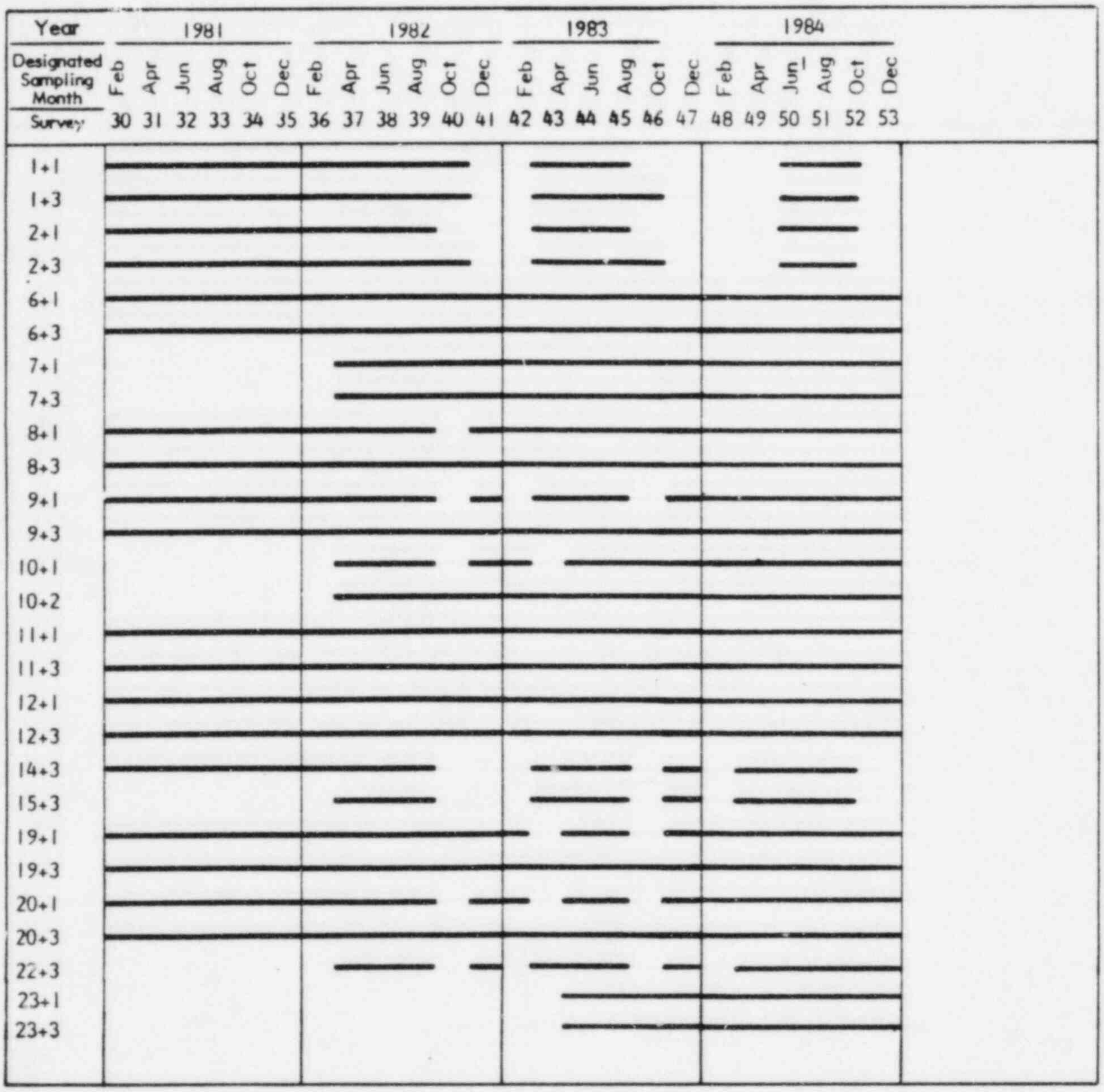


TABLE 2-3

COMPLETION SCHEDULE OF IBT SAMPLING
BY SURVEY, DATE, ACTIVE STATION AND LEVEL



[1] Samples also collected at Stations 3, 4, 5, 13, 16, 17 and 18

TABLE 2-3

COMPLETION SCHEDULE OF IBT SAMPLING
BY SURVEY, DATE, ACTIVE STATION AND LEVEL
(CONTINUED)

the mean abundance (percentage cover for the algae, number per 1 m^2 for the invertebrates) was calculated from the ten quadrat samples for the +1 and +3 ft transects for each survey for selected Diablo Cove stations. In this report, the results include data from April 1976 to December 1984.

2.1.1 ALGAE

This section includes analysis of the data collected on five algal species within ten 1 m^2 quadrats on each band transect. These species are Endocladia muricata, Gastroclonium coulteri, Gigartina canaliculata, G. papillata, and Iridaea flaccida. New data analyzed in this report include survey results from October 1983 to December 1984 for the five algal species. Together with the results presented in last year's report, these results provide a continuous record from April 1976 to December 1984.

Visual observations indicate that Endocladia muricata, Gastroclonium coulteri, Gigartina canaliculata, G. papillata, and Iridaea flaccida remain among the most abundant algal species within most TEMP study sites. For these species, data from Stations 8, 9, 11, 12, and 14 were analyzed for seasonal variations during the period April 1976 to December 1984 (Surveys 1 to 53). Survey data have been summarized using mean percentage cover values. These values have been calculated from untransformed visually estimated percentage cover data obtained from ten 1 m^2 quadrats per band transect. The results are organized on a species-by-species basis and are presented below. Percentage cover measurements obtained using the random point contact method within fixed 0.25 m^2 quadrats are presented for these same species in Section 2.2 of this report.

2.1.1.1 ENDOCLADIA MURICATA

Endocladia muricata is the most common alga in upper intertidal habitats in central California (Abbott and Hollenberg 1976) including Diablo Cove and vicinity. This low (4-8 cm tall) densely shrubby alga forms clumps or mats on the tops and vertical faces of rocks.

Mean percentage cover data for this species within the +1 and +3 ft Diablo Cove transects are presented in FIGURES 2-1 and 2-2, respectively. Because of its high intertidal distribution, this species was nearly lacking in most +1 ft transects. This was also true for the wave exposed Station 14+3. Seasonal peak abundances in the +3 ft transects at Stations 8, 9, and 12 generally occurred in the February to June period each year. Station 12 was completely buried under fragmented rock after the severe 1982-1983 winter storms. Consequently, the abundance of E. muricata at Station 12+3 declined. Since the time of the 1982-1983 winter storms, continued substrata movement has hindered successful E. muricata recruitment and growth at Station 12. Similar storm effects were evident for this species at Station 8+3. However, during 1984 E. muricata abundances at Station 8+3 show a gradual trend of recovery. A drop in percentage cover also occurred at Station 11+3 during the time of the 1982-1983 winter storms. Abundances at this station have increased slightly since then.

2.1.1.2 GASTROCLONIUM COULTERI

Literature on Gastroclonium coulteri was reviewed and presented in an earlier report (PGandE 1979). This moderately large, shrubby red alga grows up to 25 cm or more in length. The often densely clumped branches arise from a thick, mat-like stolon system which can trap and stabilize sand. In the intertidal region of Diablo Cove and vicinity, G. coulteri is most abundant in the mid to lower zones (Burge and Schultz 1973, LCMR 1978, PGandE 1978).

Within Diablo Cove mean percentage cover values for this species never exceeded 30 percent in the +1 ft transects (FIGURE 2-3) nor 15 percent in the +3 ft transects (FIGURE 2-4). Variations in abundance within transects through time do not exhibit consistent seasonal patterns. Winter 1982-1983 storm effects were evident at Stations 8+1, 11+1, and 12+1. Abundances at Station 8+1 declined as a result of sand scour on the low relief bench-rock portion of this station, and recovery has been slow probably because of continued sand abrasion or lack of sufficient surviving plant material to create measurable increases in cover by plant regrowth. A sharp decline occurred at Station 11+1, probably as a

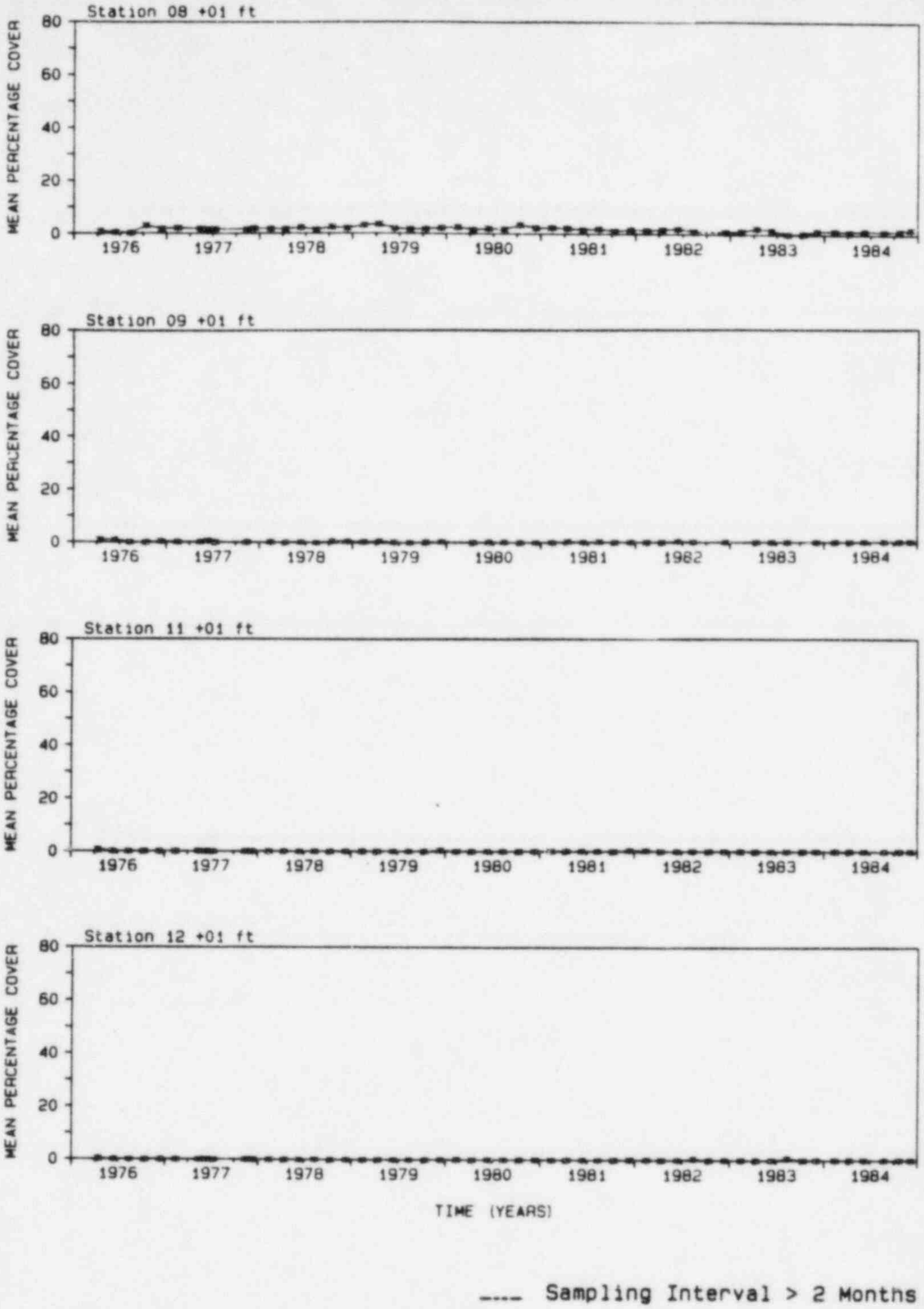


FIGURE 2-1

ABUNDANCE VERSUS TIME FOR ENDOCLADIA MURICATA AT +1 FT MLLW (IBT METHOD)

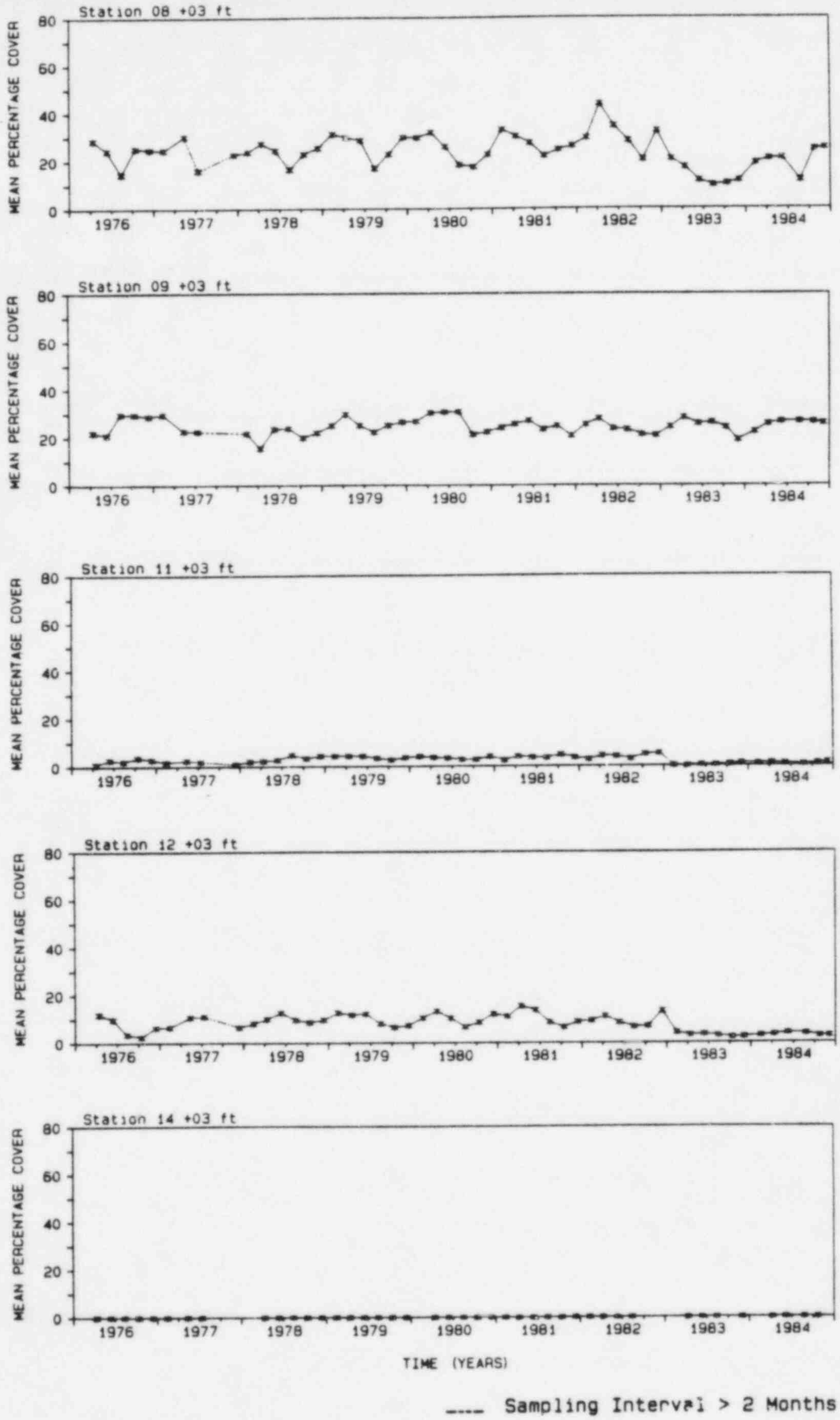


FIGURE 2-2

ABUNDANCE VERSUS TIME FOR *ENDOCLADIA MURICATA* AT +3 FT MLLW (IBT METHOD)

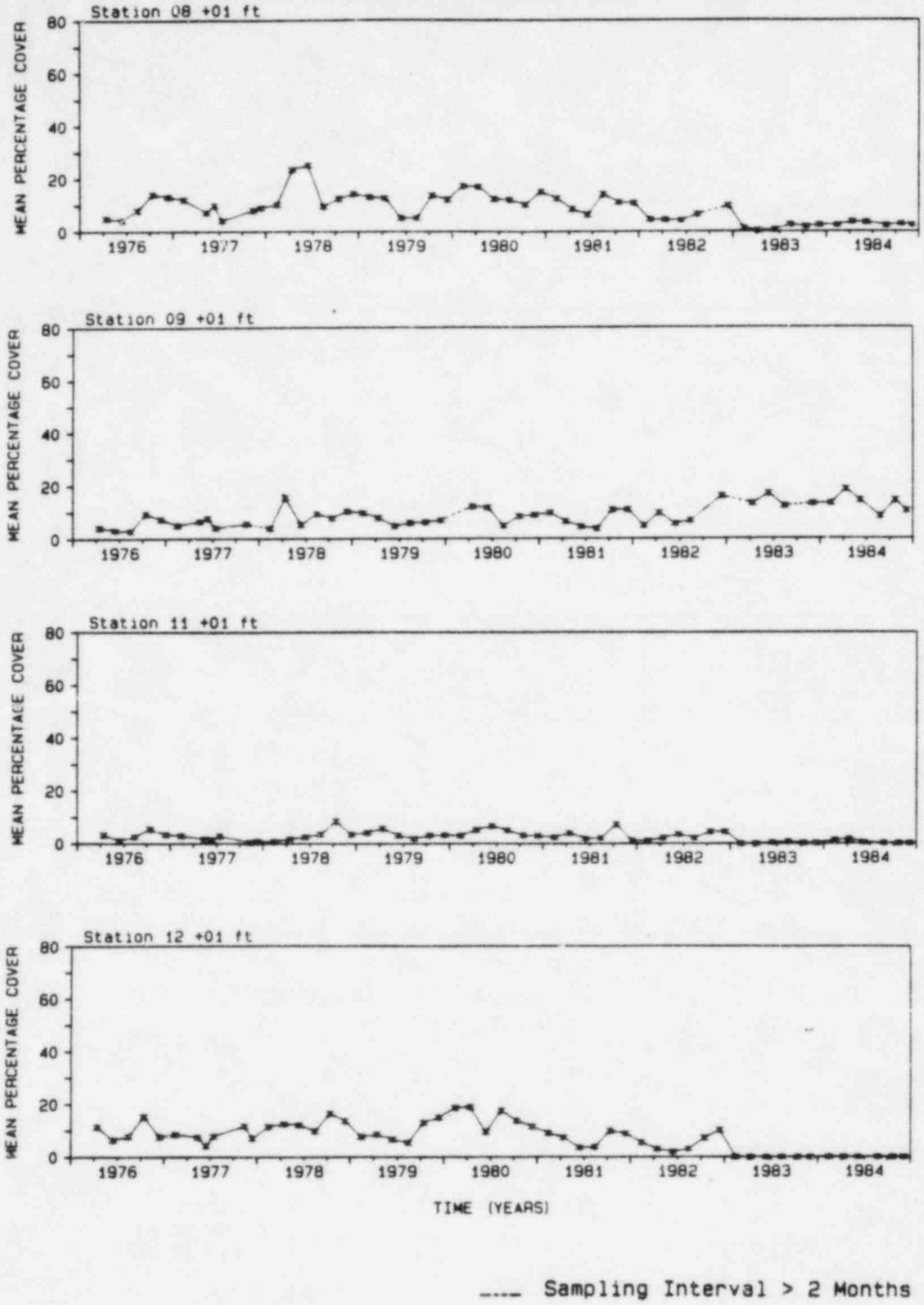


FIGURE 2-3

ABUNDANCE VERSUS TIME FOR GASTROCLONIUM COULTERI AT +1 FT MLLW (IBT METHOD)

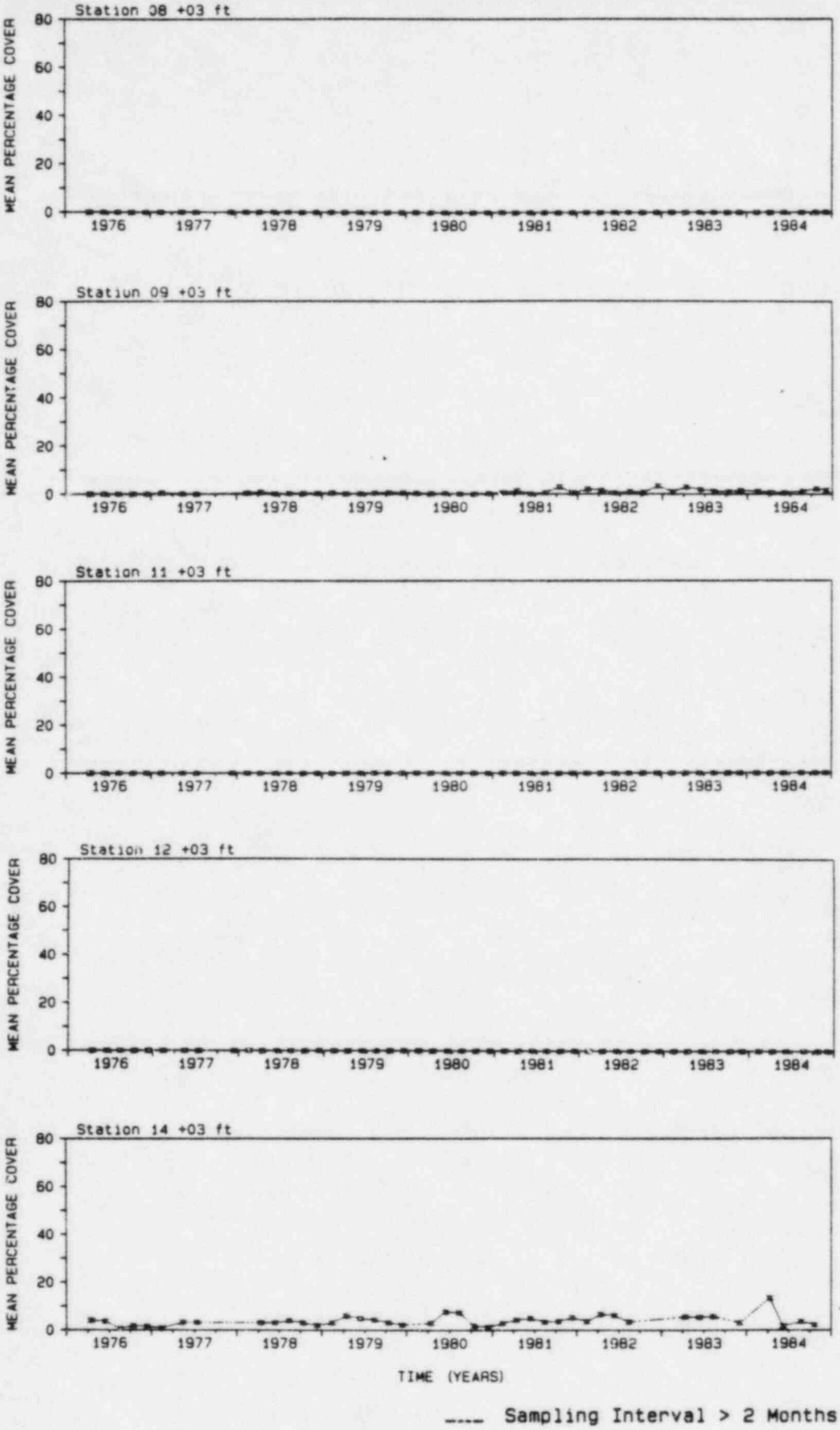


FIGURE 2-4

ABUNDANCE VERSUS TIME FOR *GASTROCLONIUM COULTERI* AT +3 FT MLLW (IBT METHOD)

result of sand abrasion. Abundances declined at Station 12+1 as a result of cobble burial. Periodic cobble movement at Station 12+1 has hindered G. coulteri from becoming re-established. 1982-1983 storm damage to G. coulteri was not evident at Station 9+1. This station is higher in substrate relief and has less sand. Plants here are thus less susceptible to continual sand scouring effects compared to plants growing on low relief bench-rock areas such as the upcoast portion of Station 8+1.

2.1.1.3 GIGARTINA CANALICULATA

A review of the literature on Gigartina canaliculata was presented in a previous report (PGandE 1979). This species consists of narrow branches arranged in a "Christmas tree-like" pattern. Abbott and Hollenberg (1976) state that the erect branches of G. canaliculata are annual, being produced by perennial basal branches. The life history is quite different from that of G. papillata (see the following section) in that the generations of G. canaliculata are identical in morphology. G. canaliculata is generally found only in low intertidal habitats. G. papillata has a wider vertical range and can be found in both low and high intertidal zones.

Mean percentage cover values for G. canaliculata within the +1 and +3 ft Diablo Cove transects are provided in FIGURES 2-5 and 2-6, respectively. Like many other algal species, the abundance of G. canaliculata is usually greater during the spring to fall periods. This is evident primarily in the +1 ft transects, where cover is generally greater than 10 percent (FIGURE 2-5). Winter 1982-1983 storm effects were observed for this species primarily at Station 12+1, which became buried under cobble (fragmented rock). Recovery has probably been hindered due to periodic cobble movement.

2.1.1.4 GIGARTINA PAPILLATA

The life history and general ecology of Gigartina papillata was presented in a previous report (PGandE 1979). The gametophytic plants of this species appear as short (15 cm tall), irregularly shaped blades. The alternate tetrasporophyte

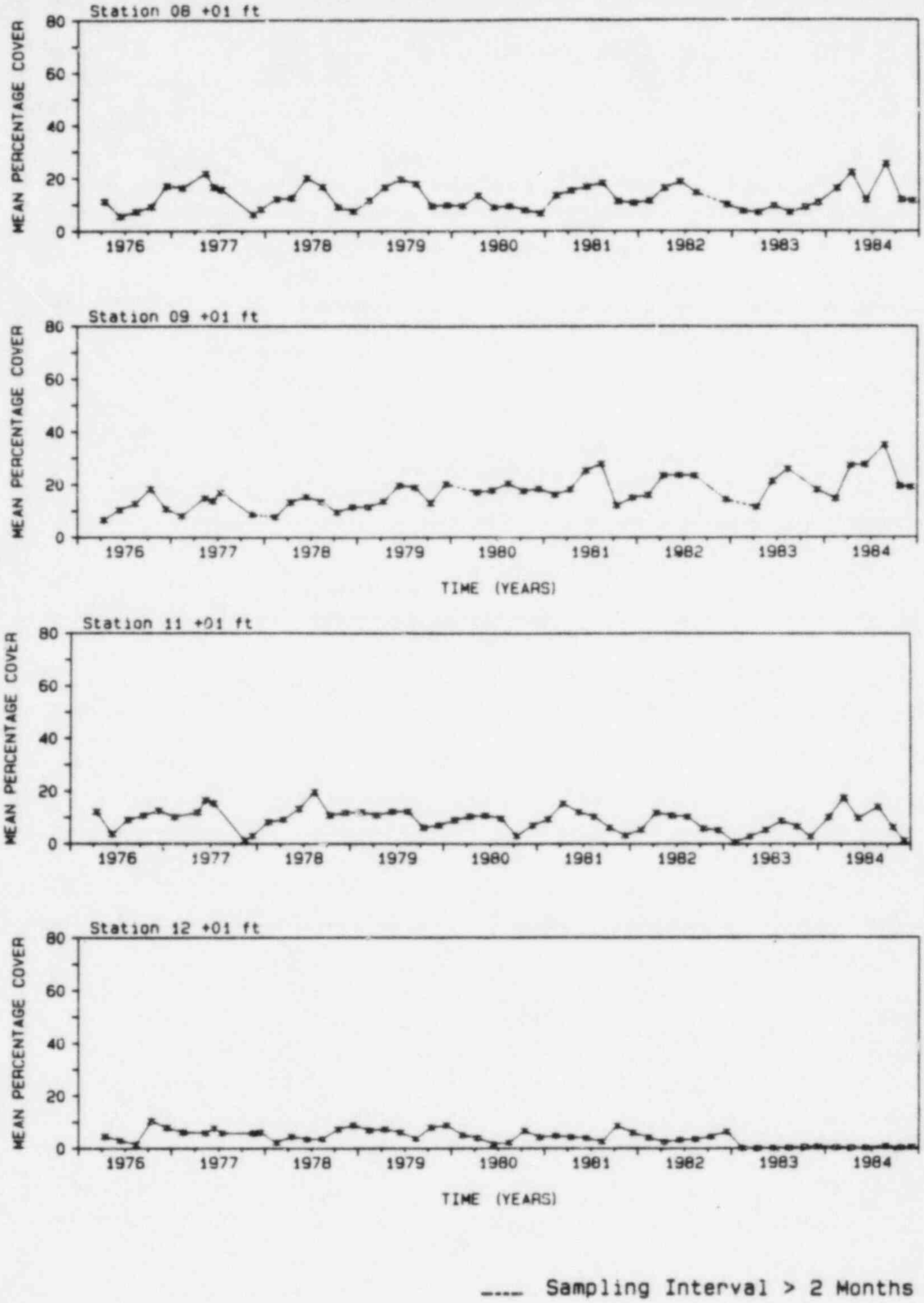


FIGURE 2-5

ABUNDANCE VERSUS TIME FOR GIGARTINA CANALICULATA AT +1 FT MLLW (IBT METHOD)

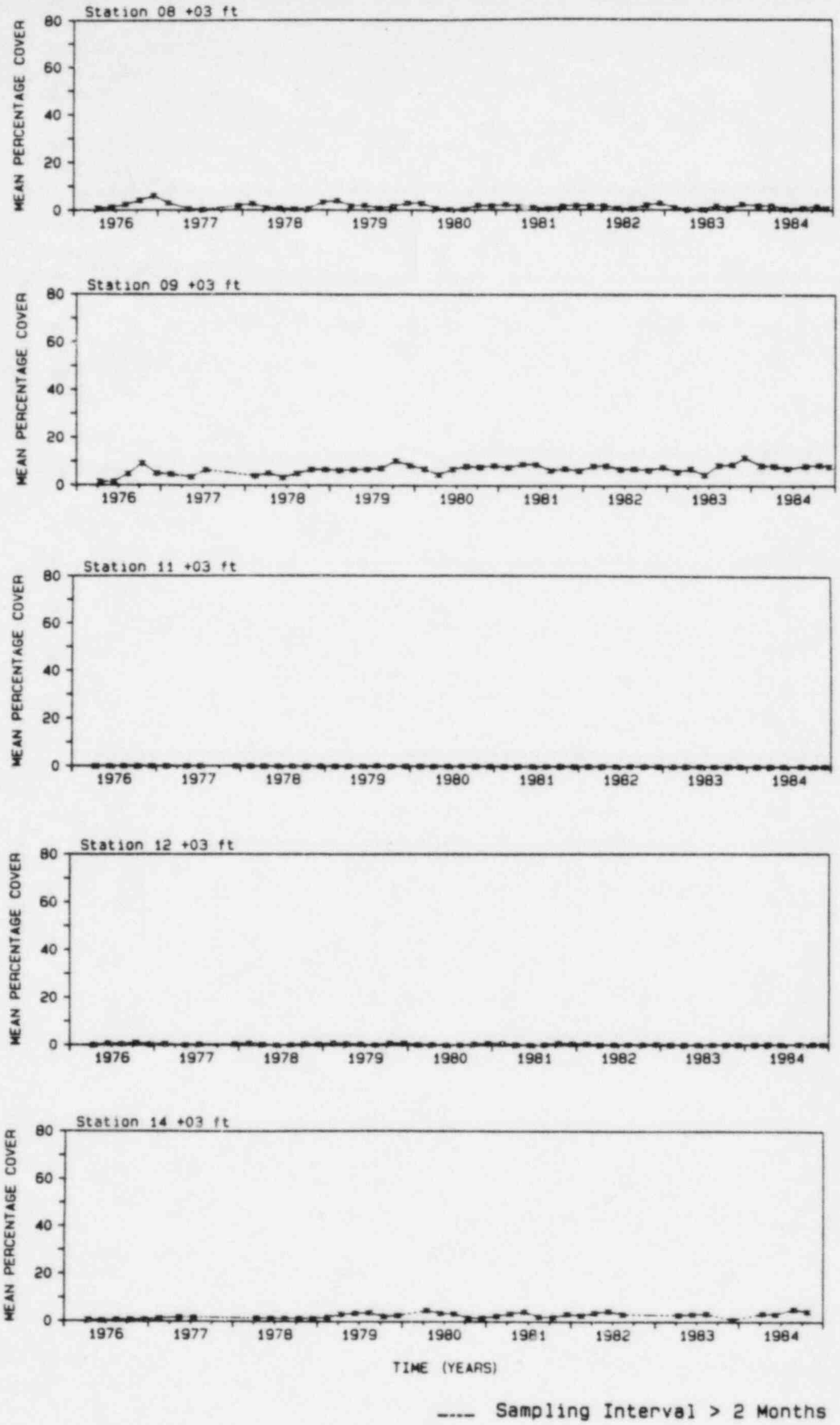


FIGURE 2-6

ABUNDANCE VERSUS TIME FOR GIGARTINA CANALICULATA AT +3 FT MLLW (IBT METHOD)

generation has been described as a crustose plant formerly placed in the genus Petrocelis. Seasonal abundances of only the erect blade form (gametophyte generation) plants of G. papillata are presented and discussed in this section.

Mean percentage cover values within the Diablo Cove +1 and +3 ft transects are plotted in FIGURES 2-7 and 2-8, respectively. At each station this species was generally more abundant in the +3 ft transects. Annual cycles with peaks during the summer months were evident in most transects. Gigartina papillata at Station 14+3 occurred in only a few quadrats and in sparse abundance. Consequently, there were no obvious seasonal changes in cover for this species at this transect. The 1982-1983 winter storm damage (cobble inundation) at Station 12 dramatically reduced G. papillata cover in both the +1 and +3 ft transects. Abundance at Stations 11+1, 12+1, 11+3 and 12+3 decreased in 1983 compared with earlier samples, which was attributed to the storms in 1983. In 1984, abundances recovered to "normal" levels at Stations 11+1, 12+1 and 11+3. Although some recovery was evident at Station 12+3 in 1984, peak abundance remained below the pre-1983 levels.

2.1.1.5 IRIDAEA FLACCIDA

A review of the literature and synopsis of pertinent knowledge on Iridaea flaccida was presented in a previous report (PGandE 1979). Plants of this red algal species consist of a perennial crustose holdfast from which several blades grow each year to as much as one meter in length. It is one of the most conspicuous and common blade-like red algae in the central California mid-intertidal zone (Abbott and Hollenberg 1976). Cover data for I. flaccida reflect almost entirely the abundance of the blades because the crustose holdfasts occupy relatively little area.

Mean percentage cover values are plotted for the Diablo Cove +1 and +3 ft transects in FIGURES 2-9 and 2-10, respectively. Excluding Station 14, which lacks a +1 ft transect, this species is always more abundant at the +1 than at the +3 ft transect. In general, seasonal abundances in all transects were greatest during the summer periods. The magnitude of change between seasons in most

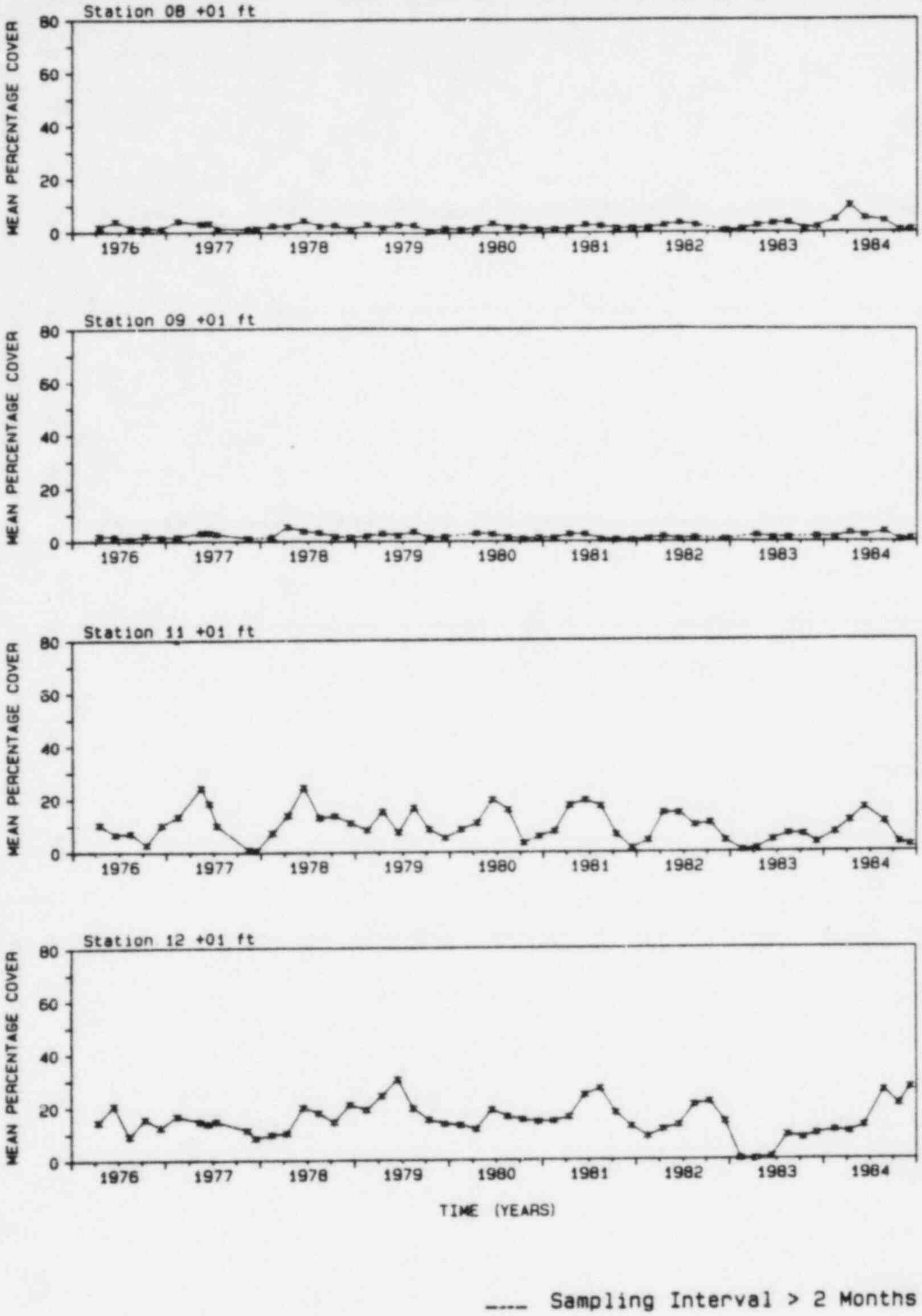


FIGURE 2-7

ABUNDANCE VERSUS TIME FOR *GIGARTINA PAPILLATA* AT +1 FT MLLW (IBT METHOD)

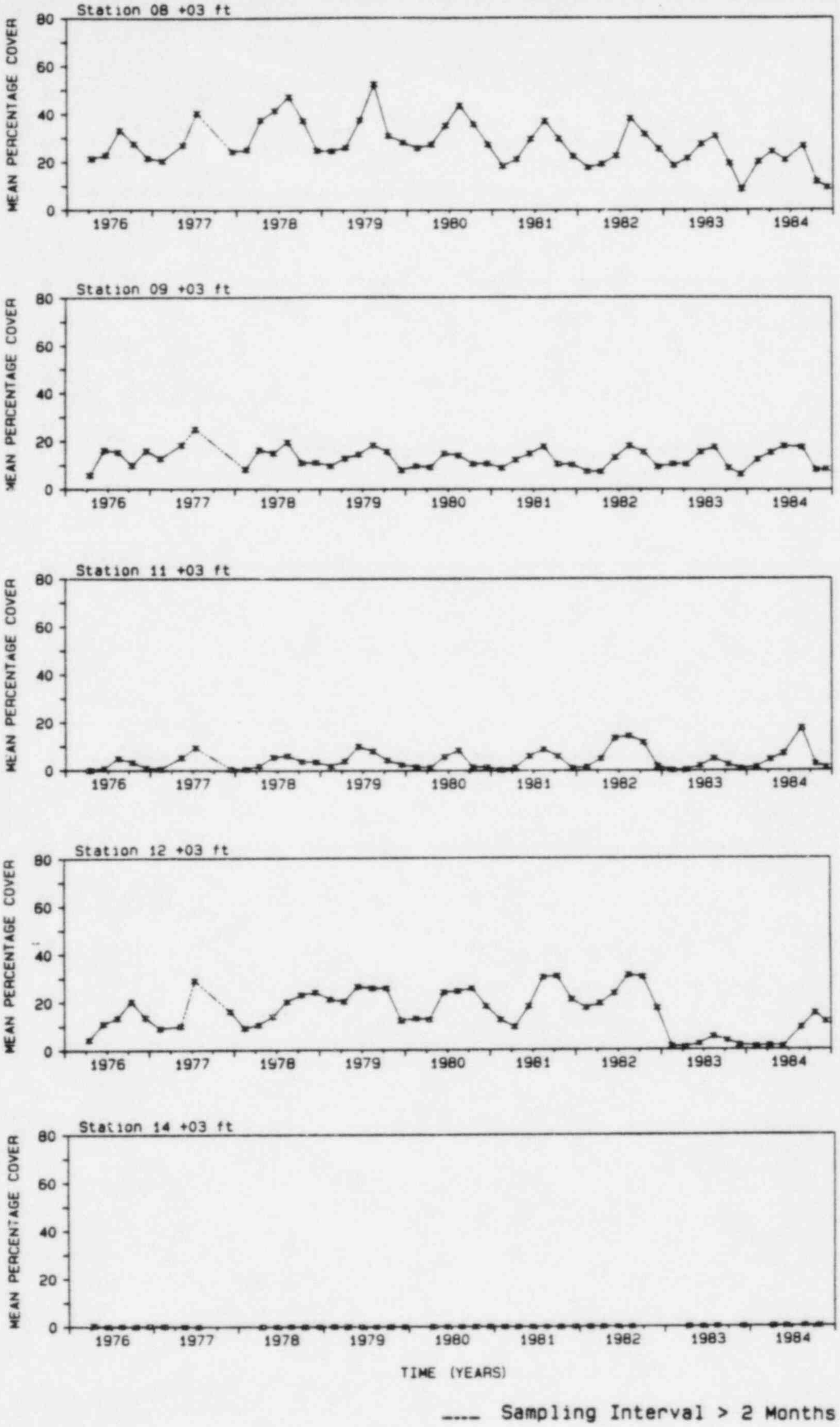


FIGURE 2-8

ABUNDANCE VERSUS TIME FOR GIGARTINA PAPILLATA AT +3 FT MLLW (IBT METHOD)

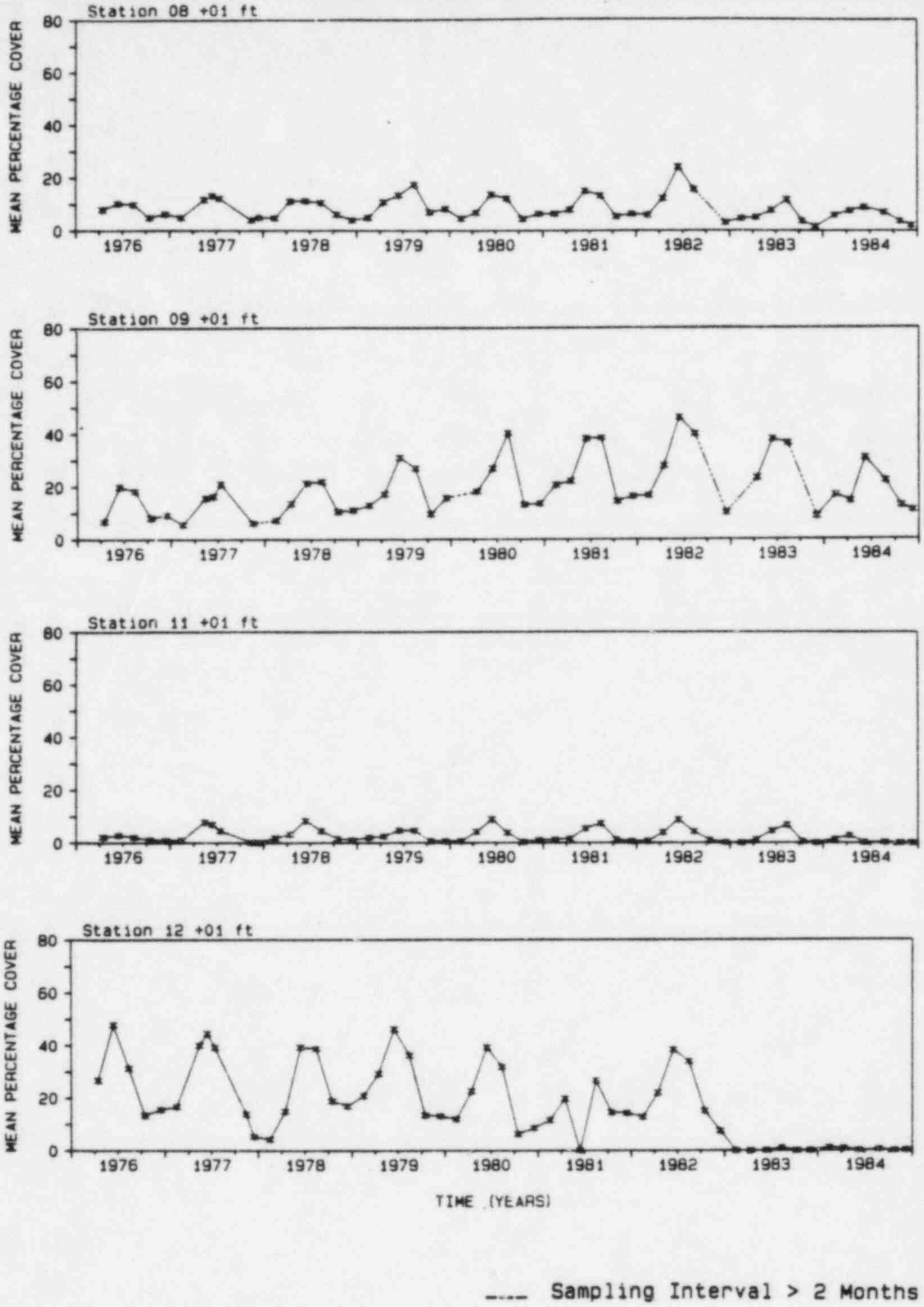


FIGURE 2-9

ABUNDANCE VERSUS TIME FOR *IRIDAEA FLACCIDA* AT +1 FT MLLW (IBT METHOD)

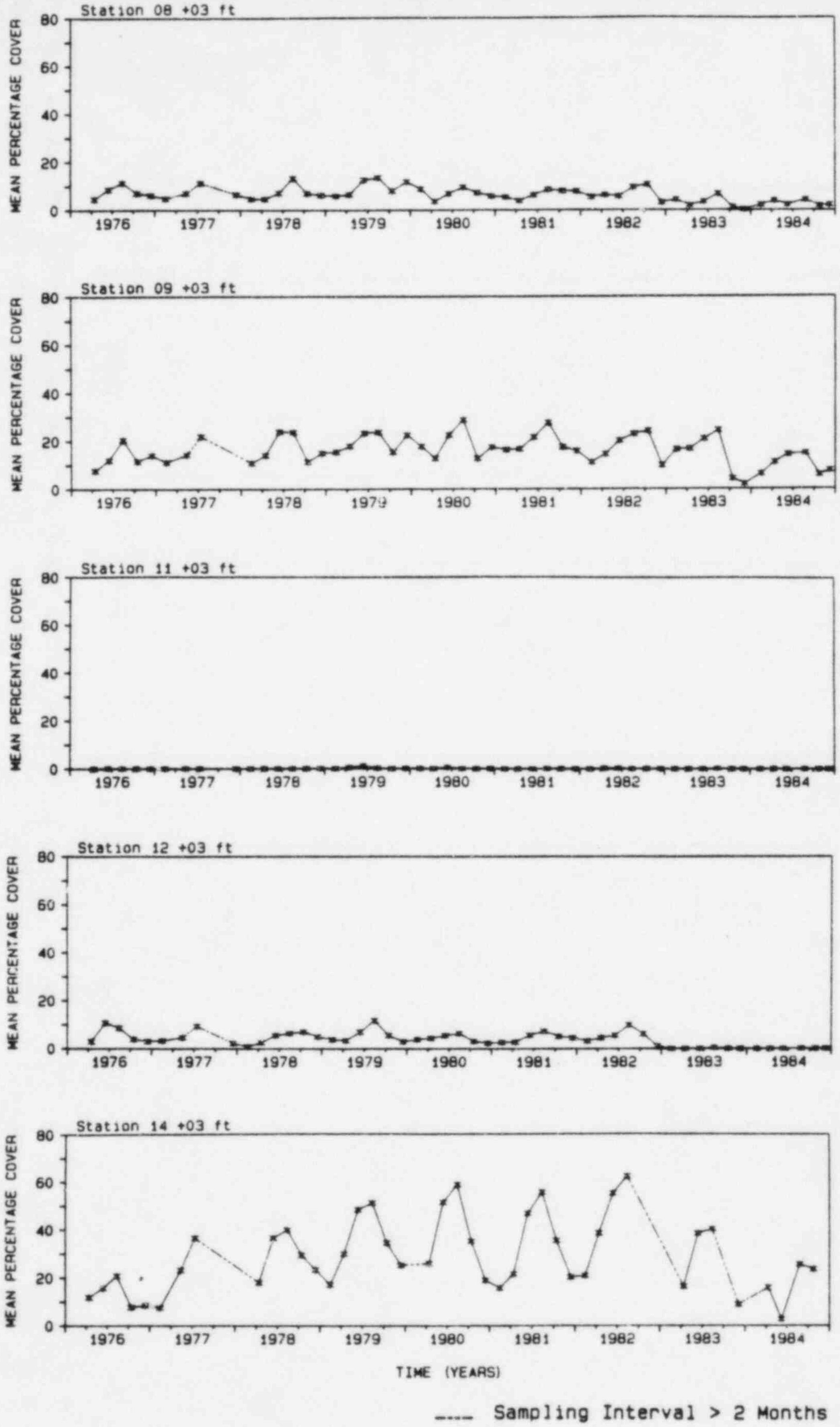


FIGURE 2-10

ABUNDANCE VERSUS TIME FOR IRIDAEA FLACCIDA AT +3 FT MLLW (IBT METHOD)

transects has been quite large. The maximum summer percentage cover values are usually two to three times greater than the minimum winter percentage cover values. At Station 11+3 the abundance of Iridaea flaccida has been sparse since 1976, and thus large seasonal changes in cover were not evident. Like other algal species discussed above, the abundance of I. flaccida at Station 12 was noticeably reduced when cobbles covered the area during the 1982-1983 winter storms. Subsequent recovery has likely been hindered by periodic cobble movement. Seasonal abundance patterns for this species in all other transects were not appreciably altered by the 1982-1983 winter storms. At Station 14+3 I. flaccida cover during the 1984 summer period was the lowest recorded since 1976. This trend is unusual in that the summer period has historically been the time of greatest I. flaccida cover.

2.1.2 INVERTEBRATES

This section includes analysis of the data collected on five invertebrate species within either five or ten 1 m^2 quadrats (depending on the species) on each band transect. These species are Anthopleura elegantissima, Haliotis cracherodii, Collisella scabra, Pagurus spp., and Tegula funebralis. For each species the mean abundance (mean number per 1 m^2) is plotted for those transects sampled from April 1976 to December 1984.

2.1.2.1 ANTHOPLEURA ELEGANTISSIMA

Anthopleura elegantissima, the aggregating sea anemone, is distributed in the middle intertidal zones from Alaska to Baja California, Mexico (Morris et al. 1980). A. elegantissima occurs in the intertidal zone as two distinct growth forms, aggregating and solitary individuals. Aggregating individuals are usually small and occur in dense groups of up to several thousand individuals per 1 m^2. The large solitary Anthopleura can attain a maximum width across the tentacular crown of 25 cm. A review of the biology of Anthopleura was presented in PGandE (1979).

FIGURES 2-11 and 2-12 summarize the mean abundance of A. elegantissima in the five "Tegula quadrats" at each of the Diablo Cove stations from August 1976 to December 1984. There are generally more A. elegantissima at the +3 than at the +1 ft level for all surveys combined (TABLE 2-4). The anemones at Stations 8+3, 11+1, 11+3, and 12+3 are the aggregating form, whereas those at Stations 8+1, 9+1, 12+1, and 14+3 are solitary individuals.

In 1983, abundance decreased at Stations 11+3 and 12+3. The decreases may have been due to storm effects. In 1984, abundance increased at Station 11+3, although it remained below the levels of the 1979-1982 period. Abundance at Station 12+3 remained low compared to the 1976-82 period.

Stations 8+3, 11+3, and 12+3 generally exhibited lower abundances of anemones during summer months. Large fluctuations between surveys were seen in the number of individuals at Station 11+3, which may be covered by sand during some surveys and uncovered on others.

2.1.2.2 HALIOTIS CRACHERODII

Black abalone, Haliotis cracherodii, typically inhabit the rocky intertidal and subtidal regions to a depth of 3 m (20 ft) from Oregon to Baja California, Mexico. In the intertidal they are usually found along ledges and in crevices; in favorable habitats they are commonly found clustered together. In and around Diablo Cove, black abalone was observed to be one of the most numerous and conspicuous of the intertidal invertebrates (Burge and Schultz 1973, Gotshall et al. 1974, North et al. 1975). In 1970-71 Burge and Schultz (1973) recorded a mean black abalone density in north Diablo Cove of 2.7 individuals/m^2 based on observations along two intertidal transects.

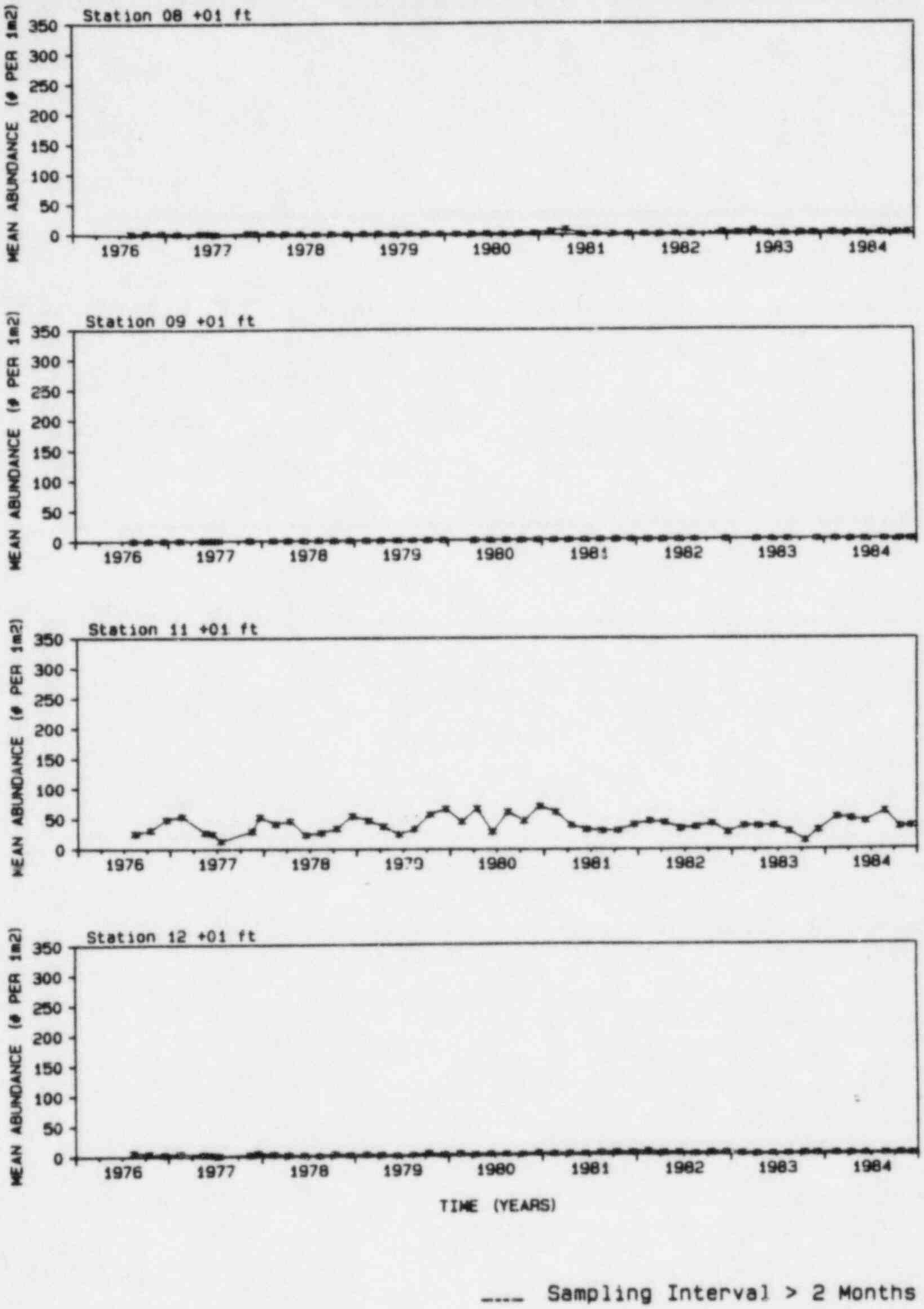


FIGURE 2-11

ABUNDANCE VERSUS TIME FOR ANTHOPLEURA ELEGANTISSIMA AT +1 FT MLLW (IBT METHOD)

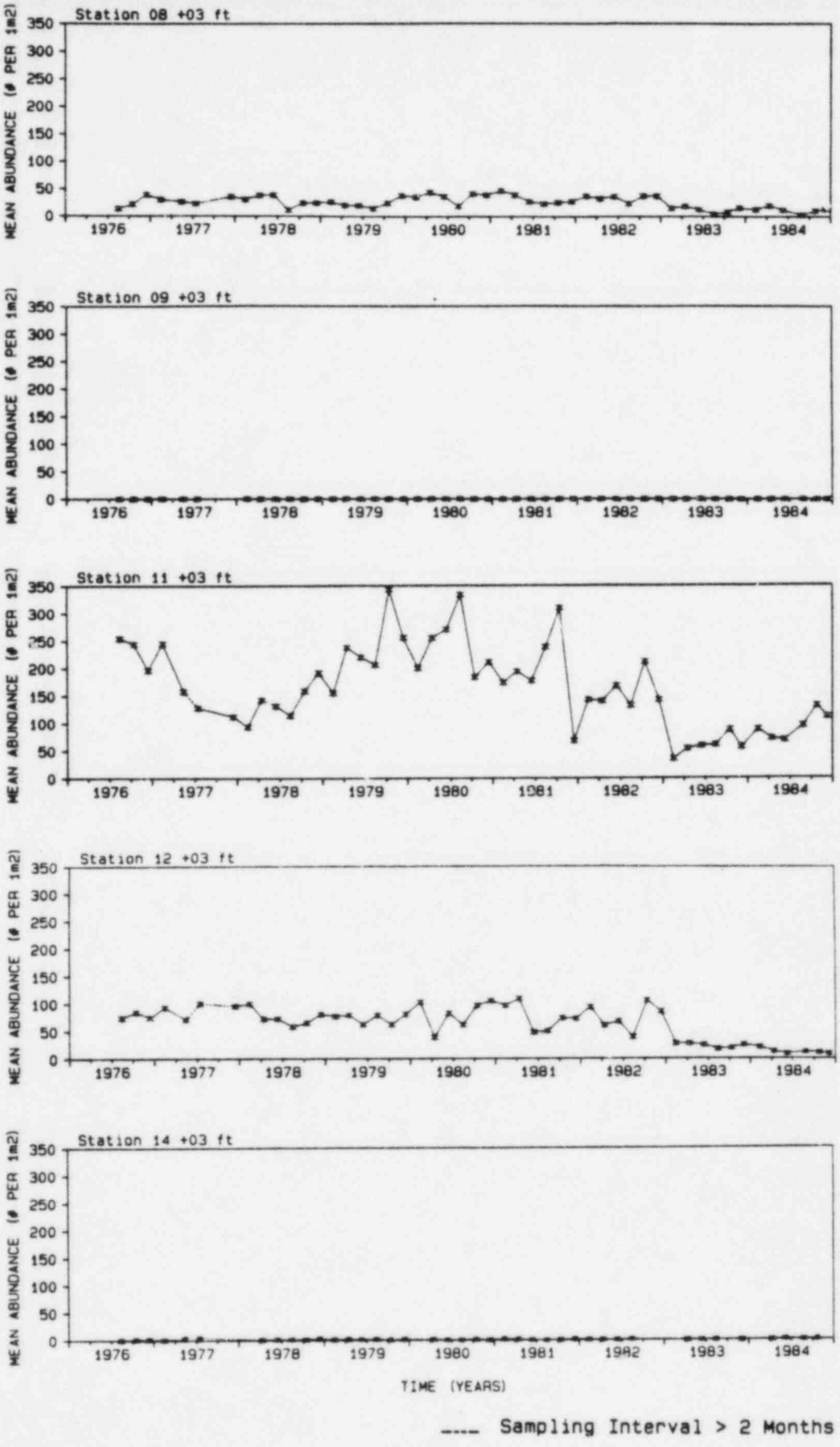


FIGURE 2-12

ABUNDANCE VERSUS TIME FOR ANTHOPLEURA ELEGANTISSIMA AT +3 FT MLLW (IBT METHOD)

TABLE 2-4

MEAN ABUNDANCE OF
ANTHOPLEURA ELEGANTISSIMA
IN THE IBT "TEGULA QUADRATS" FOR THE
DIABLO COVE INTERTIDAL STATIONS FROM
AUGUST 1976 TO DECEMBER 1984

Station Level +1	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	2.6	0.4	50
09	0.0	0.0	46
11	40.7	3.7	51
12	2.3	0.3	51
Station Level +3	**Mean Abundance[1] (number/m^2)**	**2 Std Errors**	**Number of Surveys (N)**
08	25.5	3.2	49
09	0.1	0.1	48
11	164.2	21.4	49
12	63.1	8.6	49
14	1.4	0.3	40

[1] Mean of survey means for each station.

More detailed information on the biology of black abalone in the Diablo Canyon study area was presented in PGandE (1979).

FIGURES 2-13 and 2-14 summarize the mean abundance of Haliotis at the five Diablo Cove study stations. Abalone were counted in all 10 quadrats of the band transects, not just in the five "Tegula quadrats" as were the other four invertebrate species.

As shown in TABLE 2-5, the range of mean abundances of black abalone is from a minimum of no abalone ever observed at Station 11+3 to a maximum of 5.8 abalone/m^2 during December, 1979 at Station 9+3. This table also shows that stations in south Diablo Cove have a very low mean abundance of abalone compared to stations in north Diablo Cove. Mean abundance for Haliotis at Station 14+3 lies between these two extremes.

The abundances of black abalone at the Diablo Cove intertidal stations have not changed significantly from those presented in last year's report. However, many abalone were observed either dead or with badly damaged shells in the intertidal areas of Diablo Cove immediately following the worst of the 1982-1983 winter storms.

2.1.2.3 COLLISELLA SCABRA

Collisella scabra, commonly known as the ribbed or rough limpet, occurs from Oregon to Baja California, Mexico. They are found in the upper rocky intertidal and splash zones, and prefer horizontal surfaces and gentle slopes. Maximum length is 35 mm (McLean 1978), and the largest individuals at Bodega Head, California, have been estimated to be 11 years old (Morris et al. 1980). This limpet feeds by grazing on thin films of algae and diatoms during high tide, and then returns to a specific "home site," where it remains during low tide.

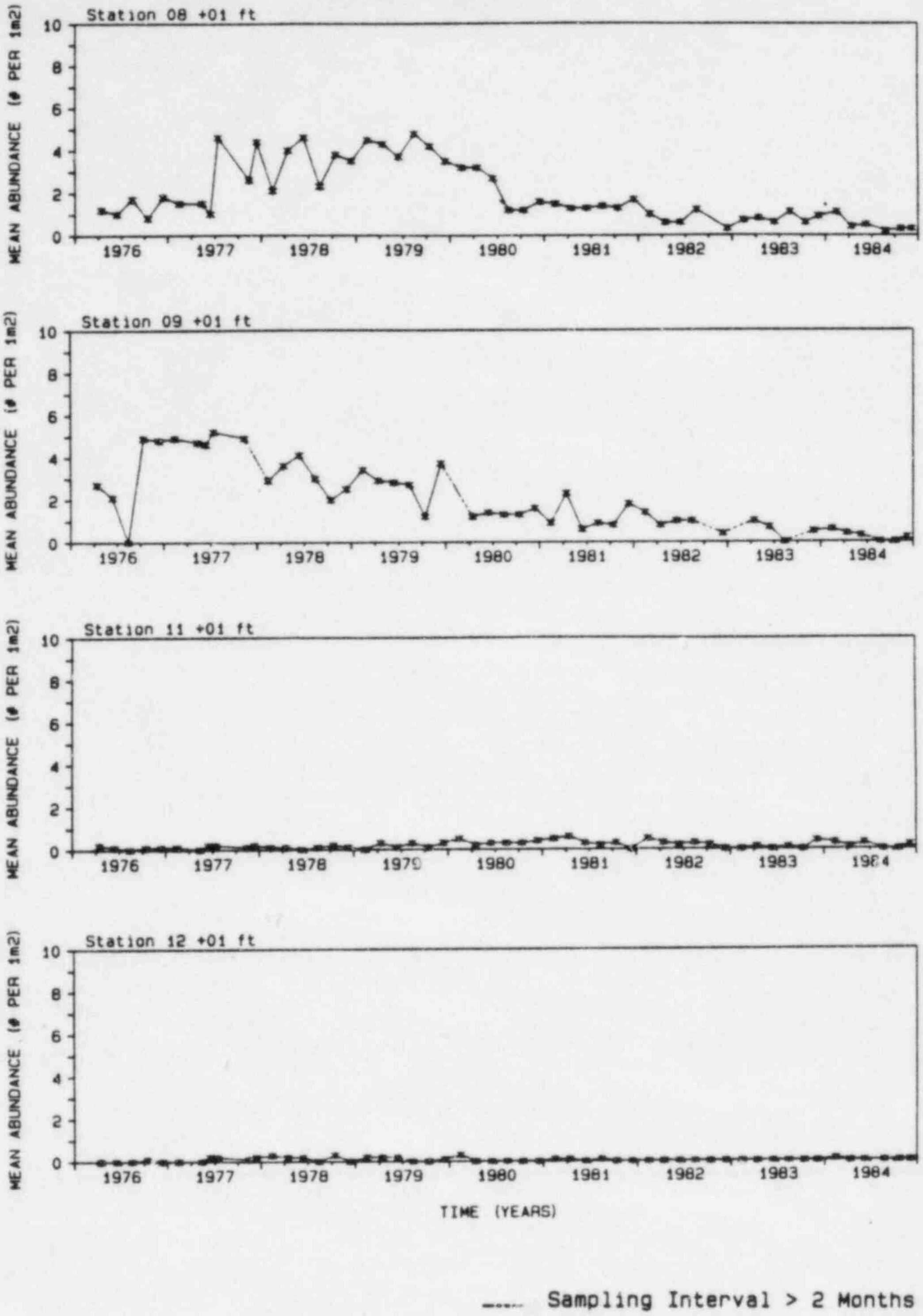


FIGURE 2-13

ABUNDANCE VERSUS TIME FOR HALIOTIS CRACHERODII
AT +1 FT MLLW (IBT METHOD)

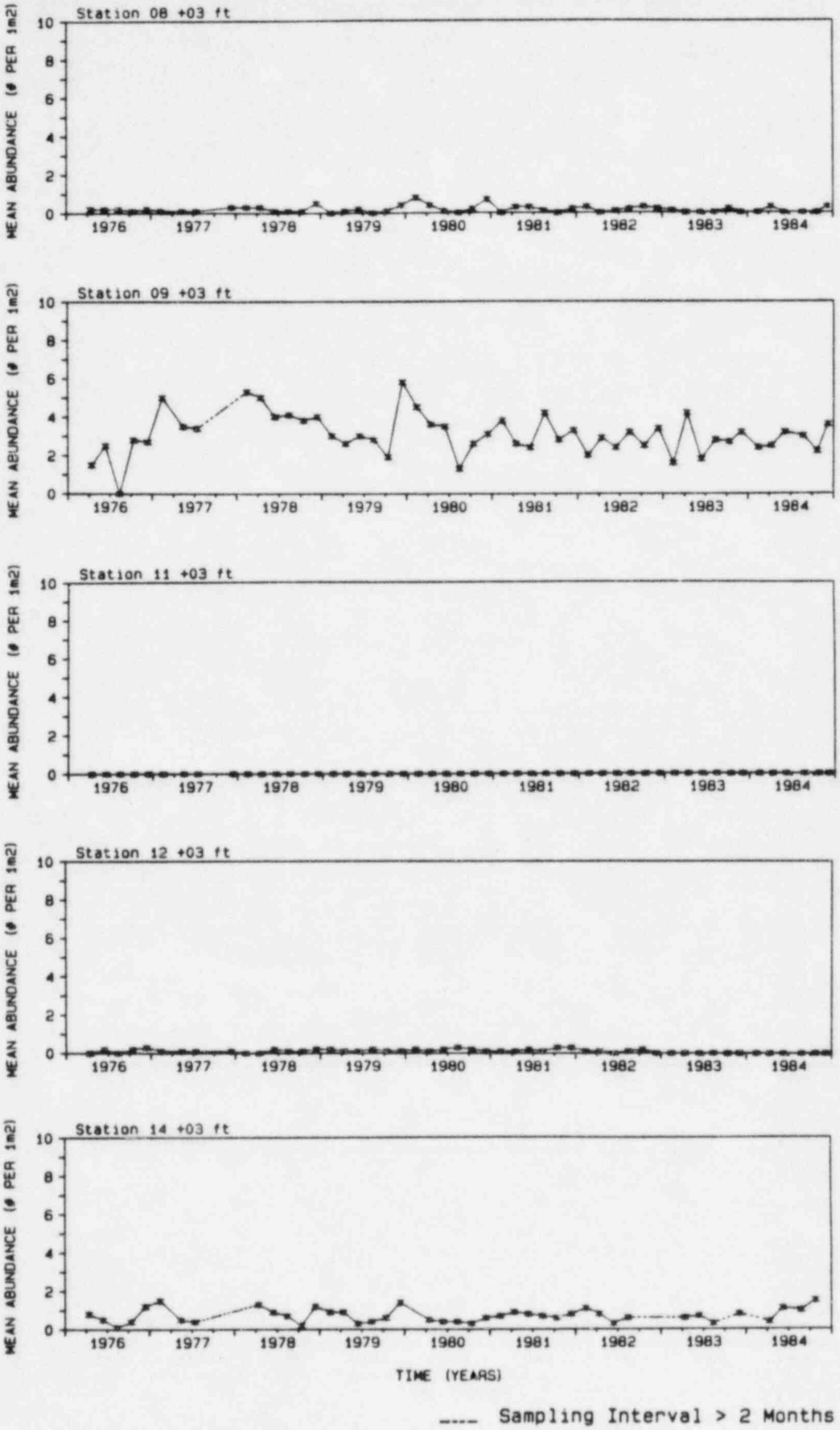


FIGURE 2-14

ABUNDANCE VERSUS TIME FOR *HALIOTIS CRACHERODII* AT +3 FT MLLW (IBT METHOD)

TABLE 2-5

MEAN ABUNDANCE OF
HALIOTIS CRACHERODII
IN THE IBT QUADRATS FOR THE
DIABLO COVE INTERTIDAL STATIONS FROM
MAY 1976 TO DECEMBER 1984

Station Level +1	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	1.9	0.4	52
09	2.0	0.5	48
11	0.2	0.1	53
12	0.1	0.1	53

Station Level +3	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	0.2	0.1	51
09	3.1	0.3	50
11	0.0	0.0	51
12	0.1	0.1	51
14	0.7	0.1	42

[1] Mean of survey means for each station.

FIGURES 2-15 and 2-16 summarize the mean abundance of C. scabra in the five "Tegula quadrats" at the five Diablo Cove stations from 1976 to 1983. There was a greater abundance of C. scabra at +3 ft than at +1 ft, except at Station 14+3 which had only a few individuals per m^2. TABLE 2-6 presents the mean number of C. scabra per m^2 in the "Tegula quadrats" for all surveys combined.

The differences in abundance of C. scabra between the two levels reflect the preference of these limpets for rocks in the upper intertidal zone.

The 1982-1983 winter storms generally reduced the abundances of C. scabra at Stations 8+3, 11+3, 12+3, and 12+1, probably as a result of burial of one or more "Tegula quadrats" by sand or rock rubble. The numbers of C. scabra reached a peak in 1984 on Stations 12+1, 8+3, and 9+3. At other stations, abundances were comparable to 1976-1982 levels.

2.1.2.4 PAGURUS SPP.

Three species of Pagurus comprise the common intertidal hermit crab populations in the Diablo Cove study areas. Pagurus samuelis, probably the most common and abundant species, ranges from Vancouver Island, Canada, to Baja California, Mexico. Within this range P. samuelis is usually found in the middle intertidal zones. Pagurus hirsutiusculus, with a range from northern Japan through Alaska into southern California, generally lives in lower intertidal zones than P. samuelis, but the populations overlap. The third common hermit crab species is P. granosimanus, found in tide pools and more protected areas of the lower middle to low intertidal and subtidal areas from Alaska to Baja California, Mexico.

Although adults of these three species are not too difficult to identify to species in the field, the juveniles are very difficult to separate taxonomically. Because juvenile hermit crabs are ubiquitous in the intertidal zone, no attempt has been made to separate the species, and all three species are recorded as "Pagurus spp."

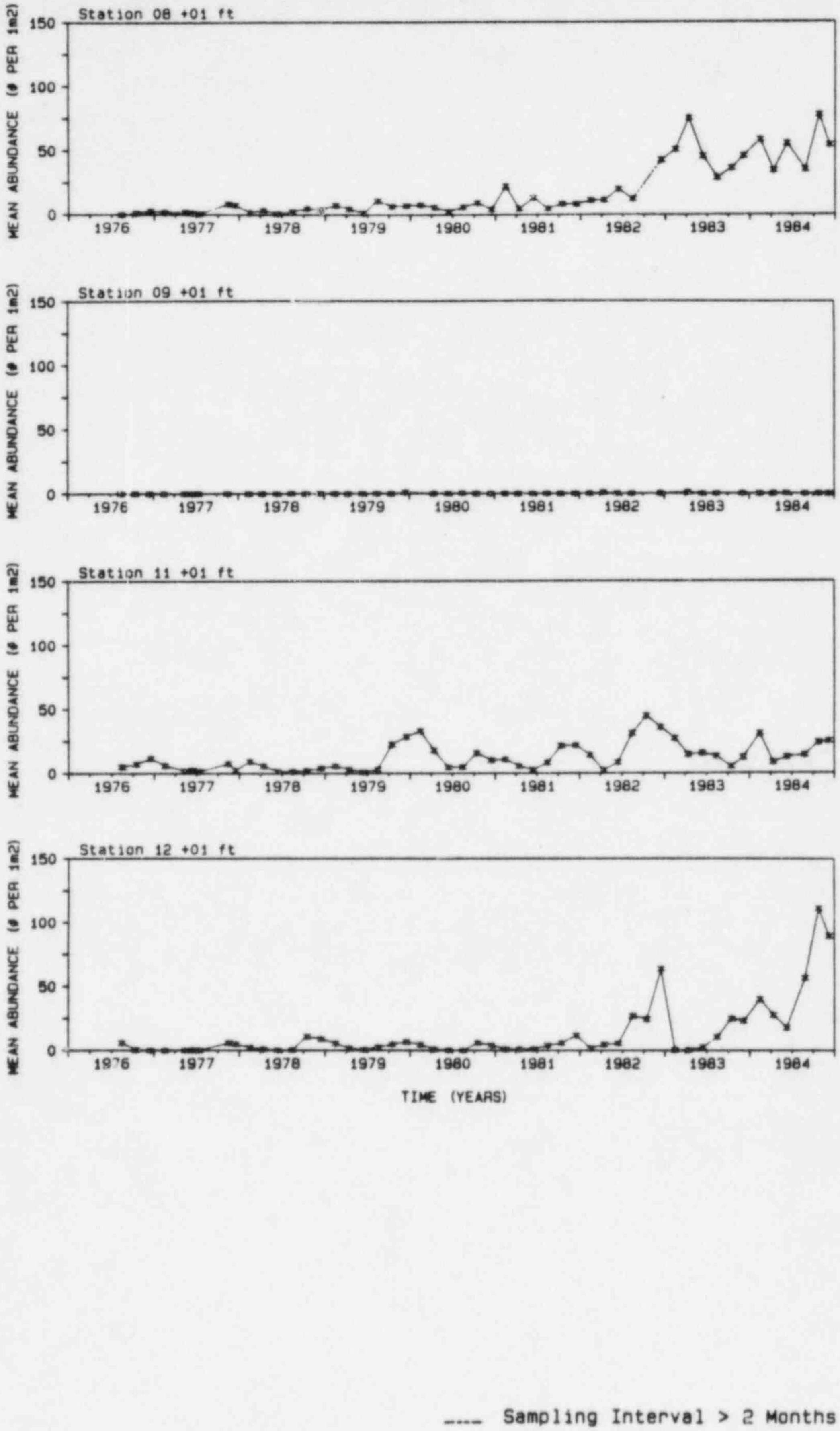


FIGURE 2-15

ABUNDANCE VERSUS TIME FOR COLLISELLA SCABRA AT +1 FT MLLW (IBT METHOD)

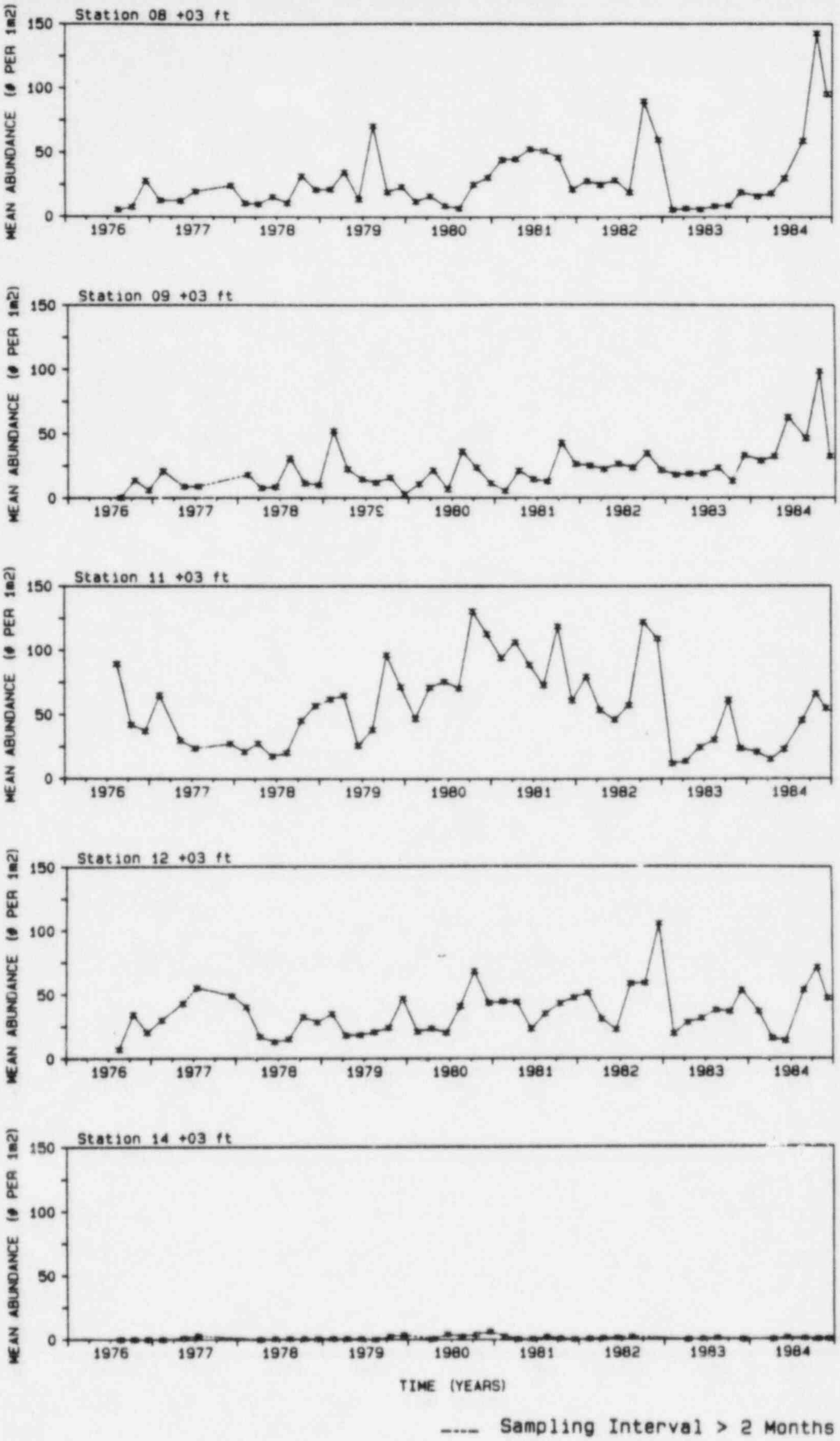


FIGURE 2-16

ABUNDANCE VERSUS TIME FOR COLLISELLA SCABRA AT +3 FT MLLW (IBT METHOD)

TABLE 2-6

MEAN ABUNDANCE OF
COLLISELLA SCABRA
IN THE IBT "TEGULA QUADRATS" FOR THE
DIABLO COVE INTERTIDAL STATIONS FROM
AUGUST 1976 TO DECEMBER 1984

Station Level +1	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	17.5	5.8	50
09	0.1	0.1	46
11	12.5	2.9	51
12	12.5	6.2	51

Station Level +3	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	28.9	7.5	49
09	22.4	4.8	48
11	56.6	9.0	49
12	36.1	5.1	49
14	1.2	0.4	40

[1] Mean of station means for each survey.

FIGURES 2-17 and 2-18 summarize the mean abundance of hermit crabs in the five "Tegula quadrats" at the Diablo Cove stations from 1977 to 1984. TABLE 2-7 presents the mean number of Pagurus per square meter for all surveys combined.

On the average, the abundance of Pagurus at the +1 ft stations is greater than at the +3 ft stations. Pagurus appear to be most abundant in fall and winter surveys at Stations 11 and 12 (FIGURES 2-17 and 2-18).

The abundances of Pagurus spp. during the 1984 surveys have changed little from previously sampled abundances in Diablo Cove (PGandE 1983).

2.1.2.5 TEGULA FUNEBRALIS

The black turban snail, Tegula funebralis, occurs from Vancouver Island, Canada to central Baja California, Mexico (Morris et al. 1980). Within this range, T. funebralis occurs in the intertidal zone with its greatest population densities generally between the +1 and +5 ft tidal levels. These snails are primarily herbivorous and feed on microscopic algal films, attached fleshy algae and drift algae.

Within the Diablo Canyon study areas, the black turban snail is the most ubiquitous and abundant animal encountered in the intertidal. The abundance of T. funebralis as mean number of individuals per m^2 in the "Tegula quadrats" for the four +1 ft and five +3 ft stations in Diablo Cove and Diablo Point are shown in FIGURES 2-19 and 2-20. There are generally more T. funebralis at +3 than at +1 ft, with the exception of Station 14+3 (Diablo Point) which, despite its elevation, exhibits the lowest mean number of Tegula of all transects considered in this analysis. TABLE 2-8 presents the mean number of T. funebralis per m^2 for all surveys at each station.

One noticeable feature of FIGURES 2-19 and 2-20 is the large fluctuations in the mean abundances of Tegula over the study period. The mean abundances of turban snails at +1 ft at all Diablo Cove stations show seasonal trends with

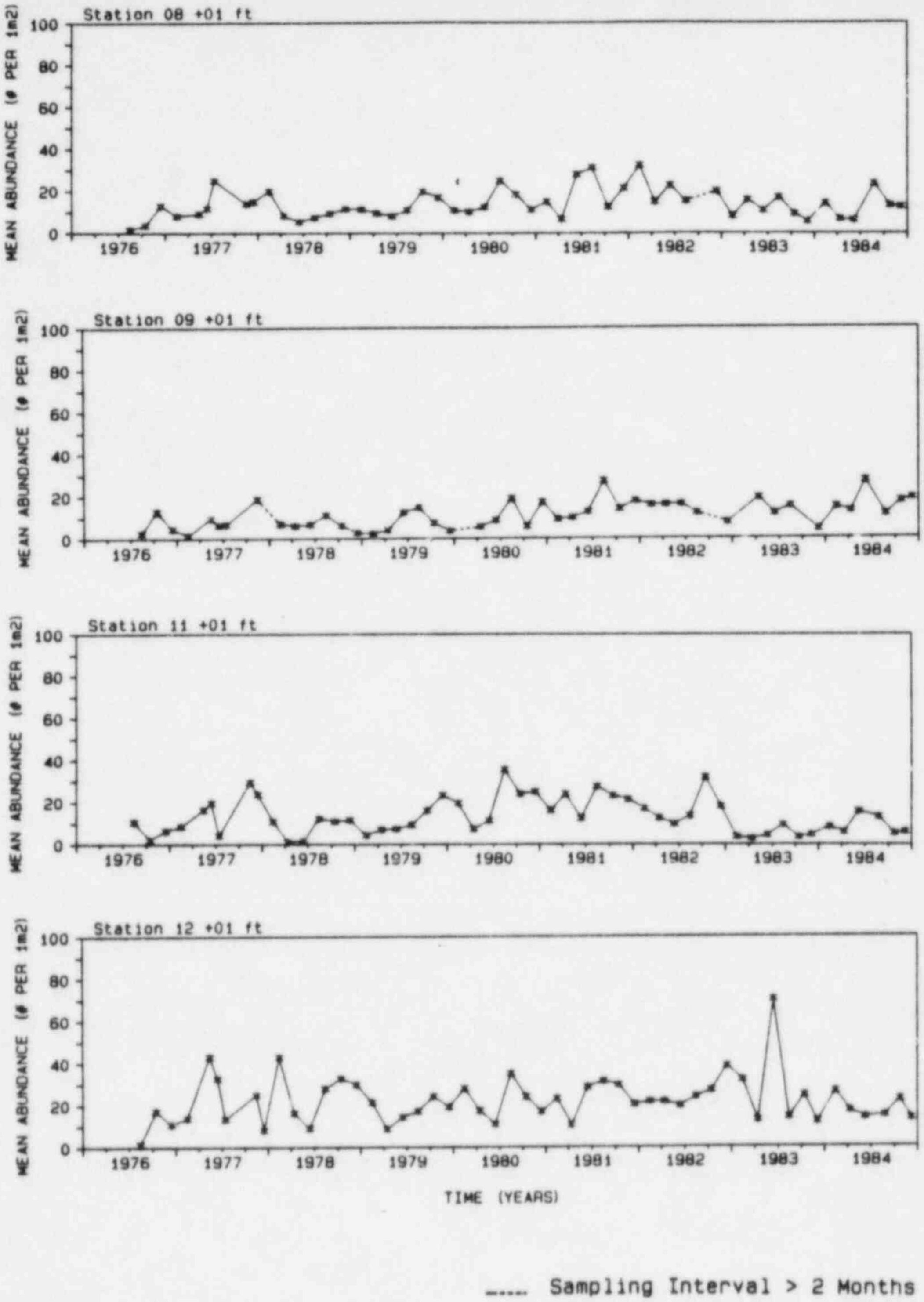


FIGURE 2-17

ABUNDANCE VERSUS TIME FOR <u>PAGURUS</u> SPP.
AT +1 FT MLLW (IBT METHOD)

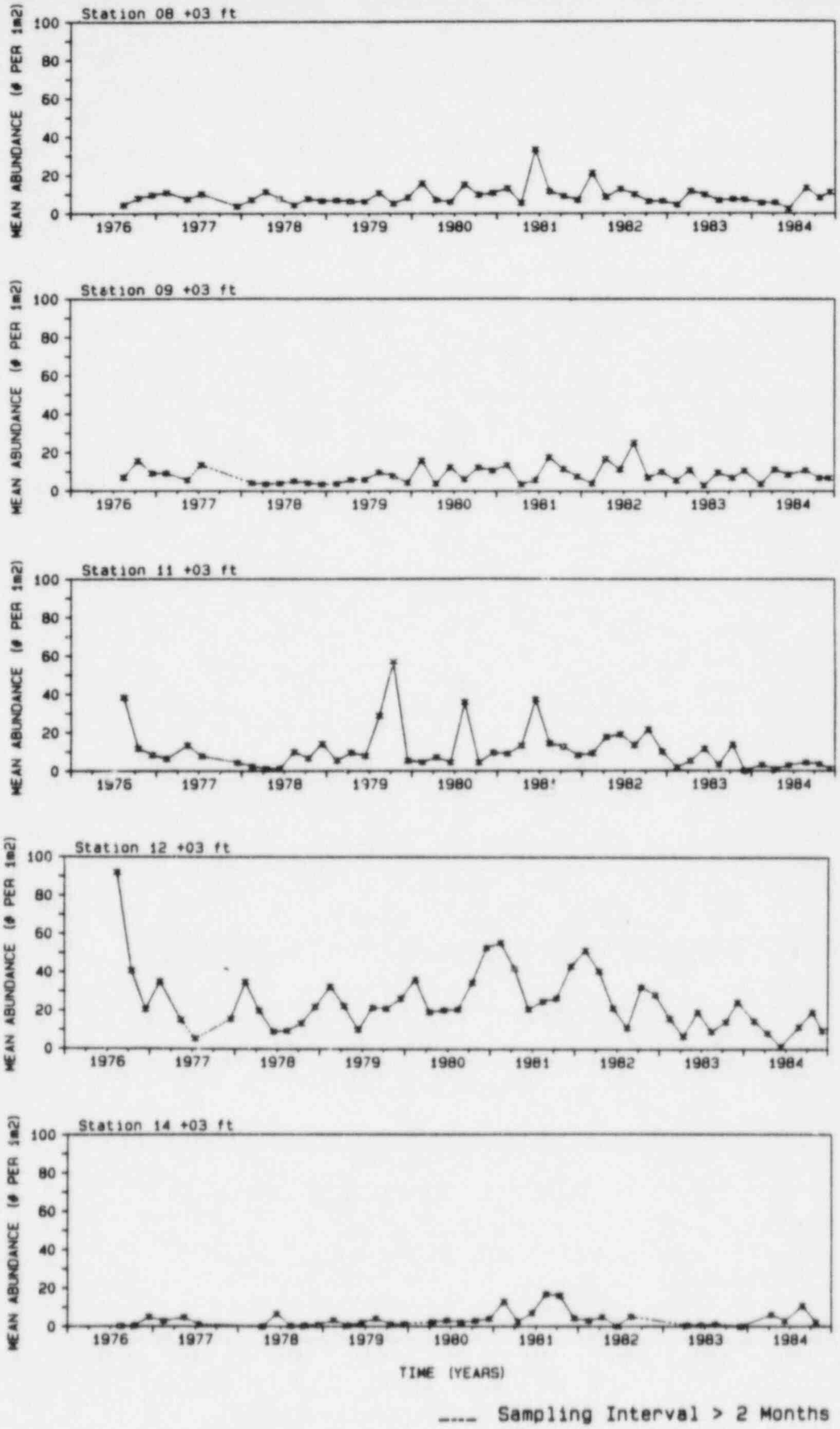


FIGURE 2-18

ABUNDANCE VERSUS TIME FOR *PAGURUS* SPP.
AT +3 FT MLLW (IBT METHOD)

TABLE 2-7

MEAN ABUNDANCE OF
PAGURUS SPP.
IN THE IBT "TEGULA QUADRATS" FOR THE
DIABLO COVE INTERTIDAL STATIONS FROM
AUGUST 1976 TO DECEMBER 1984

Station Level +1	Mean Abundance[1] (number/m²)	2 Std Errors	Number of Surveys (N)
08	13.8	1.9	50
09	11.2	1.8	46
11	13.2	2.4	51
12	22.3	3.1	51
Station Level +3	**Mean Abundance[1] (number/m²)**	**2 Std Errors**	**Number of Surveys (N)**
08	9.1	1.4	49
09	8.7	1.3	48
11	11.1	3.2	49
12	24.7	4.5	49
14	3.7	1.3	40

[1] Mean of station means for each survey.

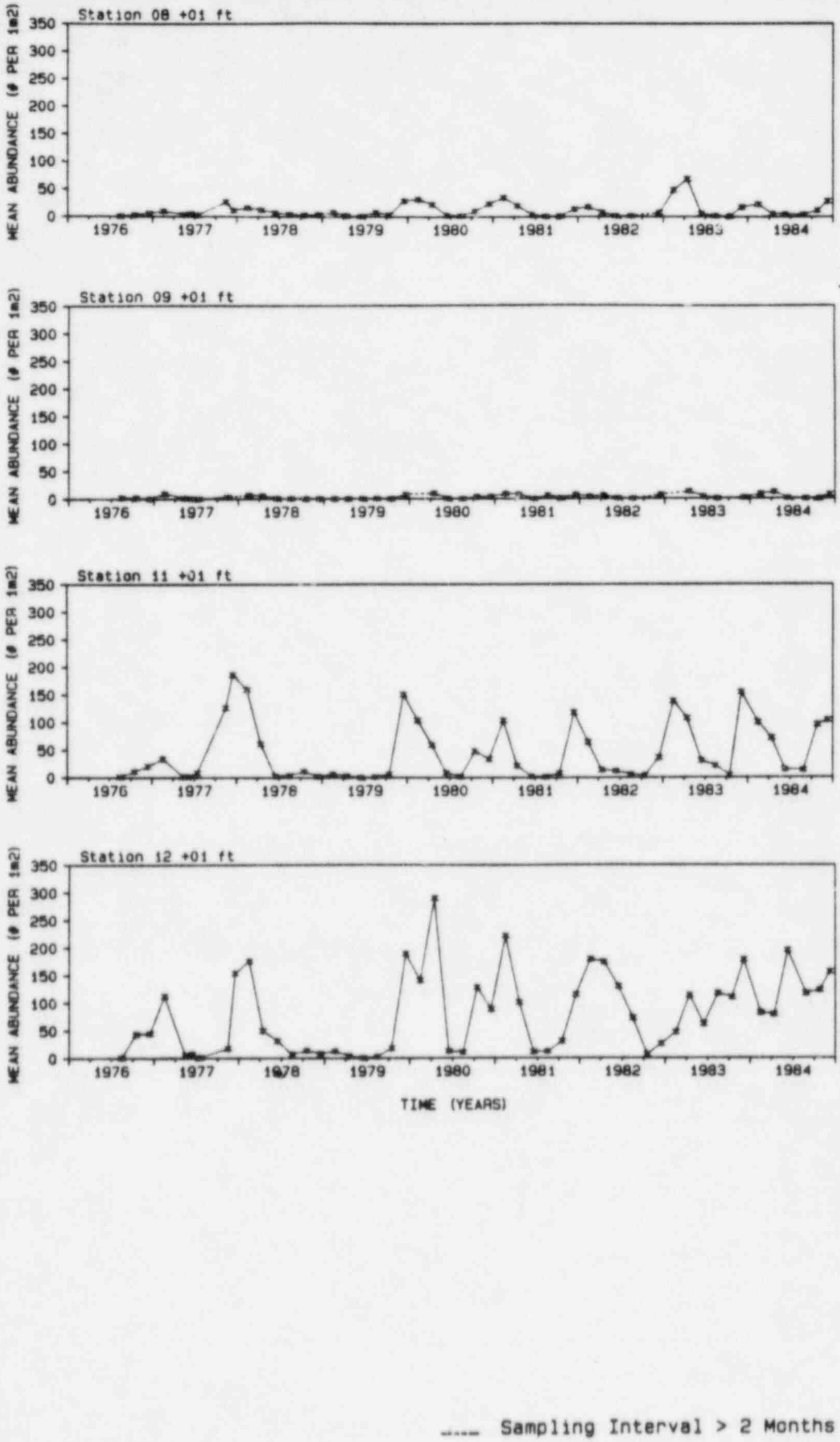


FIGURE 2-19

ABUNDANCE VERSUS TIME FOR TEGULA FUNEBRALIS
AT +1 FT MLLW (IBT METHOD)

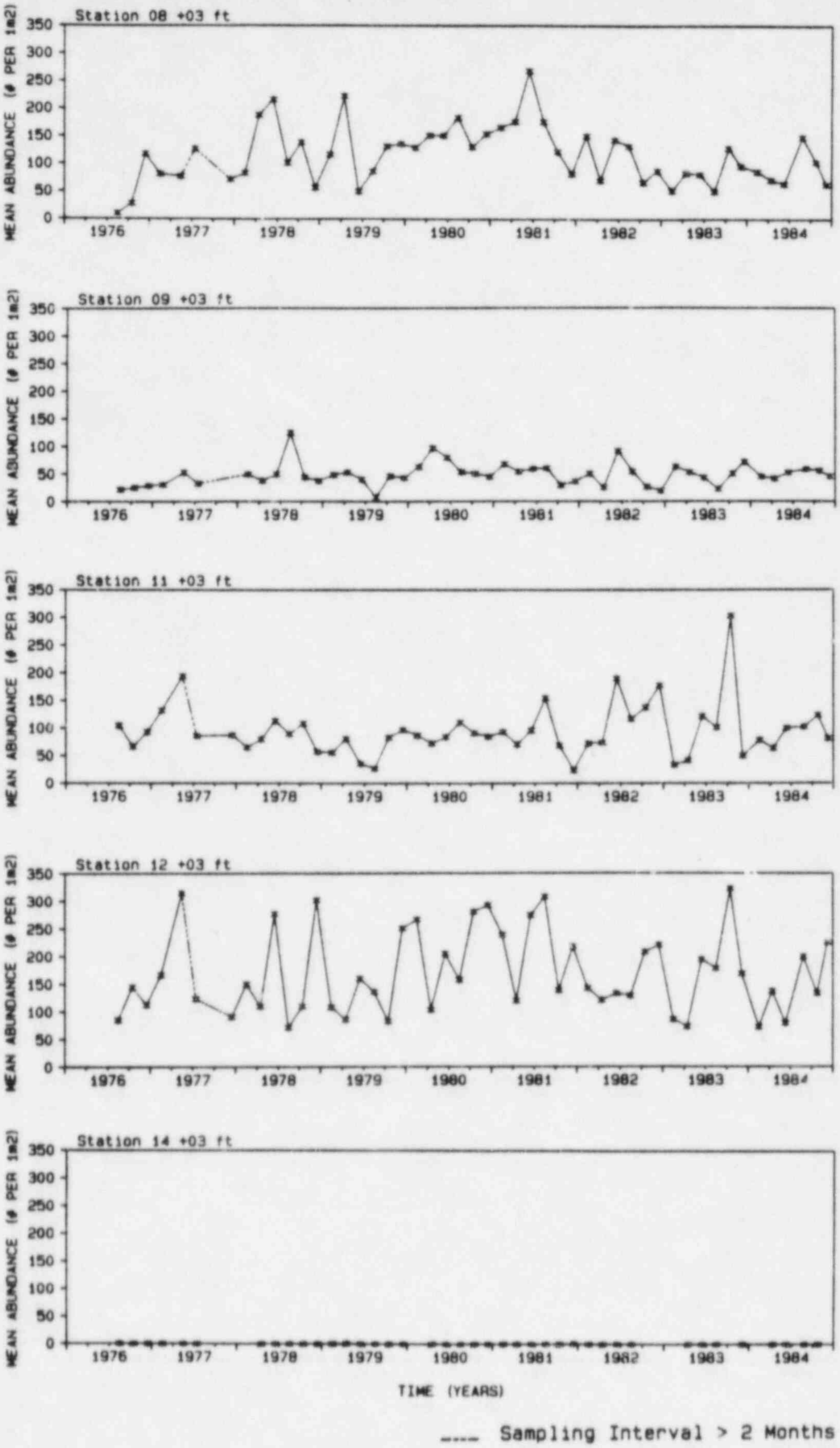


FIGURE 2-20

ABUNDANCE VERSUS TIME FOR <u>TEGULA FUNEBRALIS</u>
AT + 3 FT MLLW (IBT METHOD)

TABLE 2-8

MEAN ABUNDANCE OF
TEGULA FUNEBRALIS
IN THE IBT "TEGULA QUADRATS" FOR THE
DIABLO COVE INTERTIDAL STATIONS FROM
AUGUST 1976 TO DECEMBER 1984

Station Level +1	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	11.9	3.7	50
09	3.4	1.1	46
11	45.3	14.6	51
12	79.1	19.8	51

Station Level +3	Mean Abundance[1] (number/m^2)	2 Std Errors	Number of Surveys (N)
08	114.3	14.8	49
09	48.6	5.9	48
11	95.9	14.0	49
12	169.4	21.0	49
14	0.1	0.1	40

[1] Mean of station means for each survey.

highest abundances in the winter surveys and lowest abundances, very nearly zero in most cases, in the summer surveys. At +3 ft transects in Diablo Cove there is no definite seasonal cycle.

The high degree of wave exposure is probably a significant factor in explaining the almost complete absence of T. funebralis at Diablo Point and the relatively lower numbers of snails at the stations in north Diablo Cove (more wave action) than those in south Diablo Cove (semi-protected). Microhabitat is undoubtedly important as a factor contributing to variability in the mean abundance figures of Tegula; certain quadrats (i.e., locations) provide better shelter to Tegula than other quadrats.

The abundances of T. funebralis during the 1984 intertidal surveys appear to be comparable to those of previous years.

2.2 INTERTIDAL RANDOM POINT CONTACT (RPC) QUADRAT

Six intertidal random point contact quadrat surveys were completed in 1984 (see TABLES 2-9 and 2-10). Details of the IPC sampling methods and locations are presented in Appendix A (Section A.2). In the following sections, the Diablo Cove station quadrat data (percentage contact) for five algal species are presented, documenting changes in species abundance from 1976 to 1984. IPC quadrat 12+1B was buried under cobble during the 1982-83 storms and was thus not sampled in 1983. Sampling was resumed in 1984 after the quadrat became uncovered.

2.2.1 ALGAE

This section includes percentage cover values obtained by using the random point contact method within fixed 0.25 m^2 quadrats for five algal species (Endocladia muricata, Gastroclonium coulteri, Gigartina canaliculata, G. papillata, and Iridaea flaccida). These data are complimentary to visually estimated percentage cover data obtained within band transects (Section 2.1 in this report). Random point contact data for these species have been presented in earlier reports (PGandE 1980, 1984) which included data collected from April 1976 to August 1979 and from April 1976 to October 1983, respectively.

In this section individual quadrat data from Stations 8, 9, 11, 12, and 14 are presented for the five species for the period April 1976 to December 1984. The results are organized on a species-by-species basis below.

2.2.1.1 ENDOCLADIA MURICATA

Percentage cover values obtained using the random point contact method for Endocladia muricata are presented in FIGURES 2-21 (+1 ft) and 2-22 (+3 ft). This species is found primarily in high intertidal habitats, and consequently its abundance within Diablo Cove (Stations 8,9,11,12,) has been greater at the higher elevation (+3 ft). At the wave exposed Station 14 area, which is located on the south headland of Diablo Cove, Endocladia occurs higher in elevation (about +4 ft

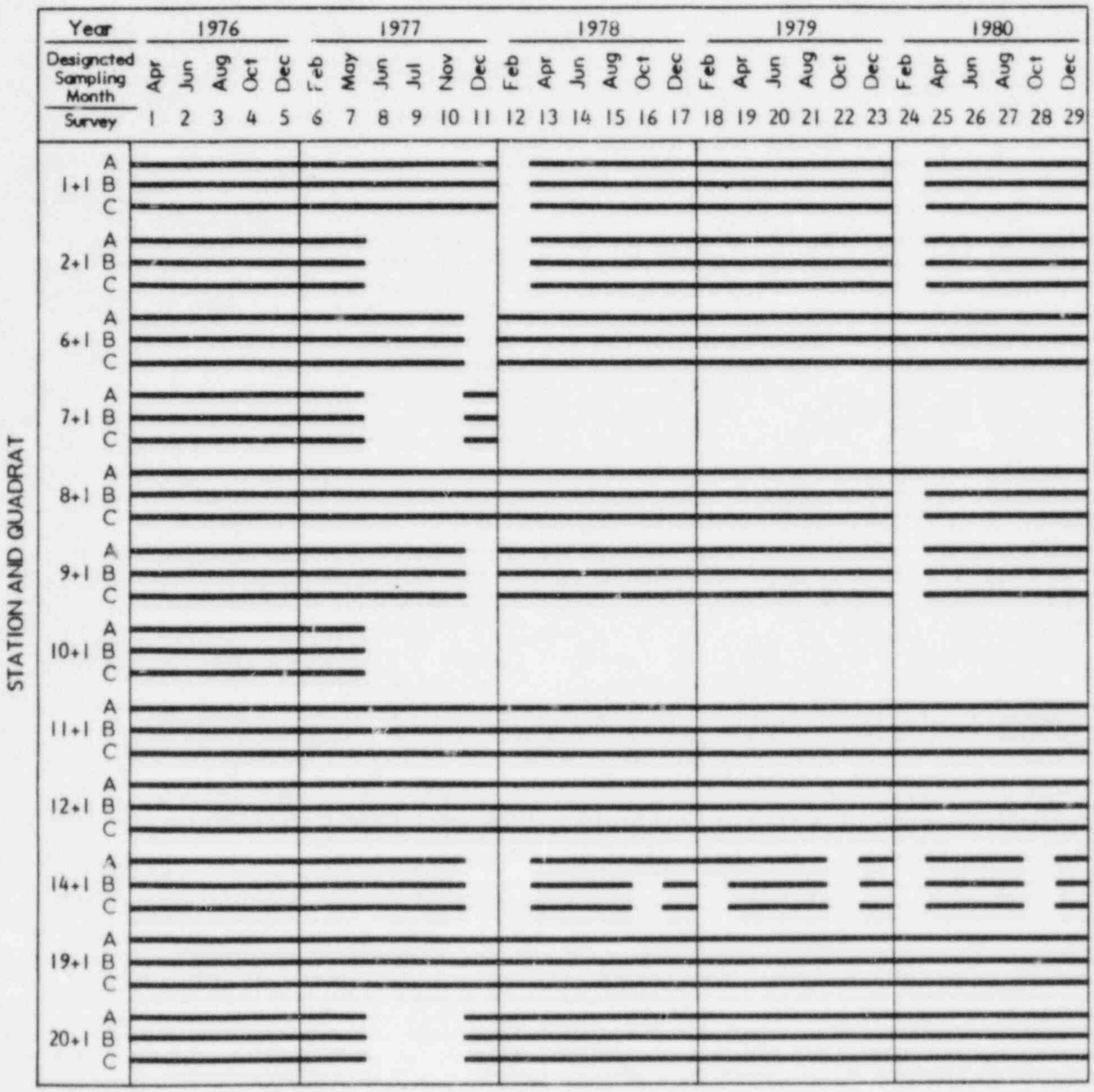


TABLE 2-9

COMPLETION SCHEDULE OF RANDOM POINT CONTACT +1 FT (MLLW) ACTIVE QUADRAT SAMPLING BY SURVEY, DATE, STATION, AND QUADRAT

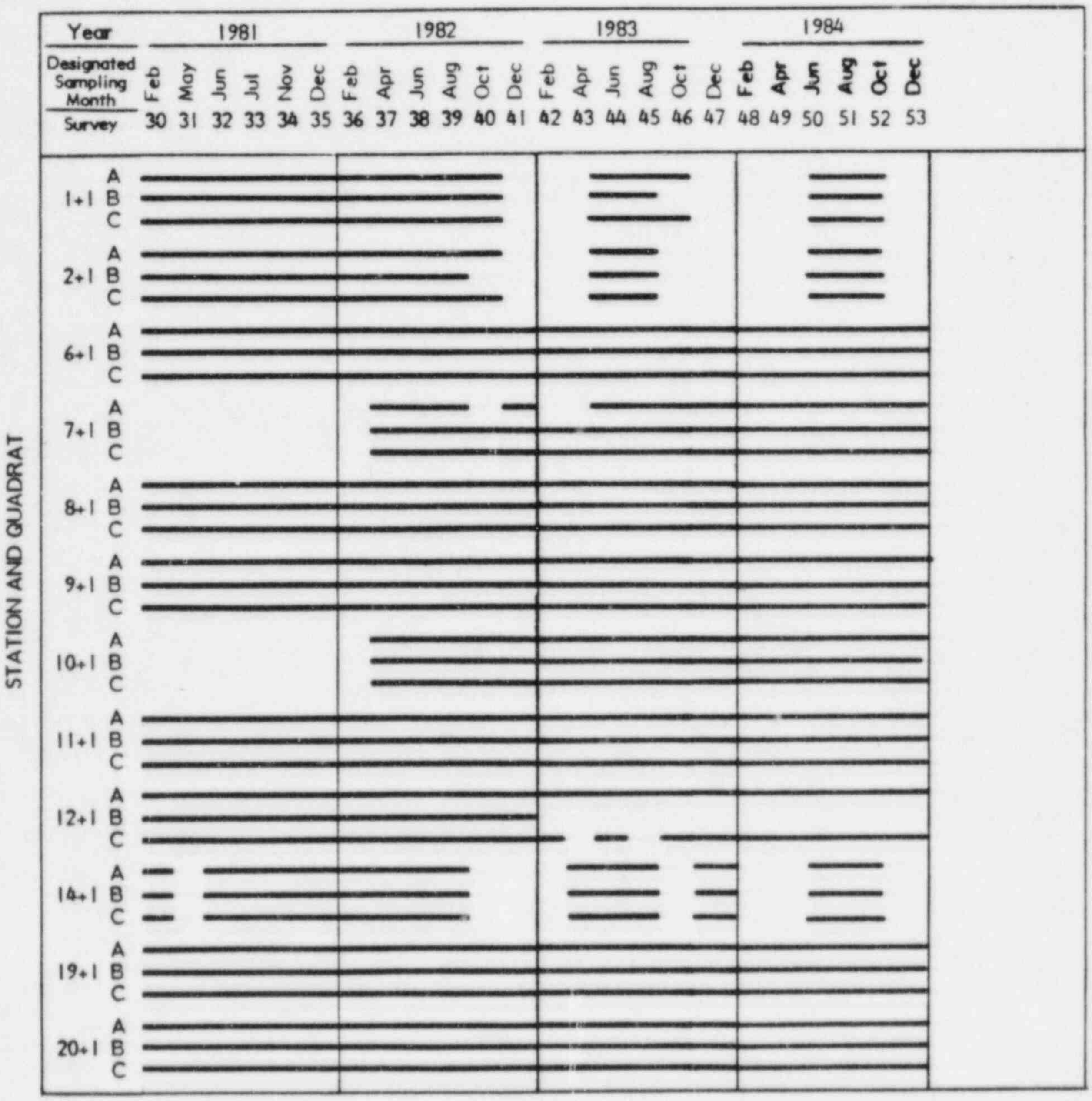


TABLE 2-9

COMPLETION SCHEDULE OF RANDOM POINT CONTACT
+1 FT (MLLW) ACTIVE QUADRAT SAMPLING BY
SURVEY, DATE, STATION, AND QUADRAT
(CONTINUED)

TABLE 2-10

COMPLETION SCHEDULE OF RANDOM POINT CONTACT +3 FT (MLLW) ACTIVE QUADRAT SAMPLING BY SURVEY, DATE, STATION, AND QUADRAT

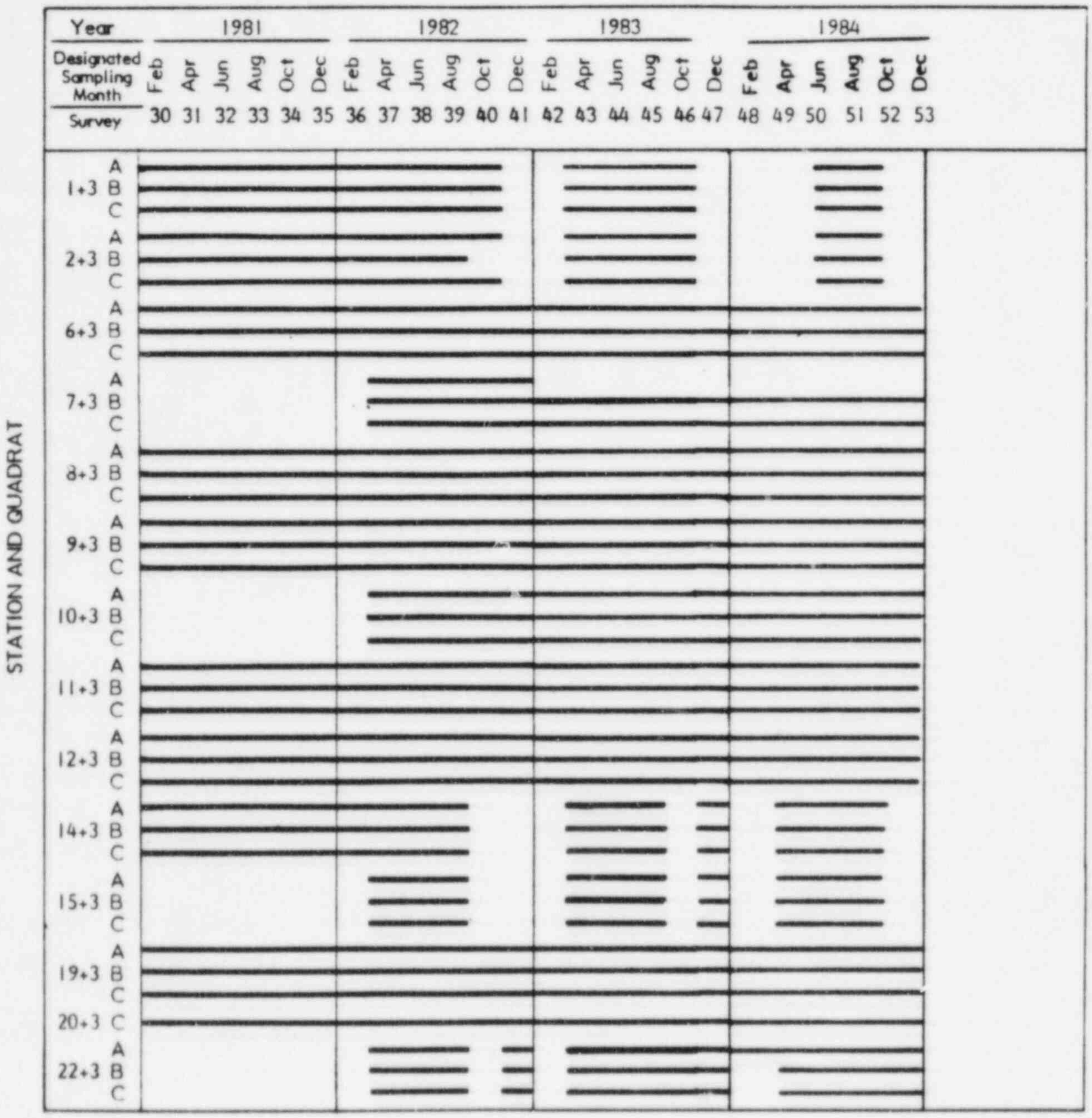


TABLE 2-10

COMPLETION SCHEDULE OF RANDOM POINT CONTACT +3 FT (MLLW) ACTIVE QUADRAT SAMPLING BY SURVEY, DATE, STATION, AND QUADRAT (CONTINUED)

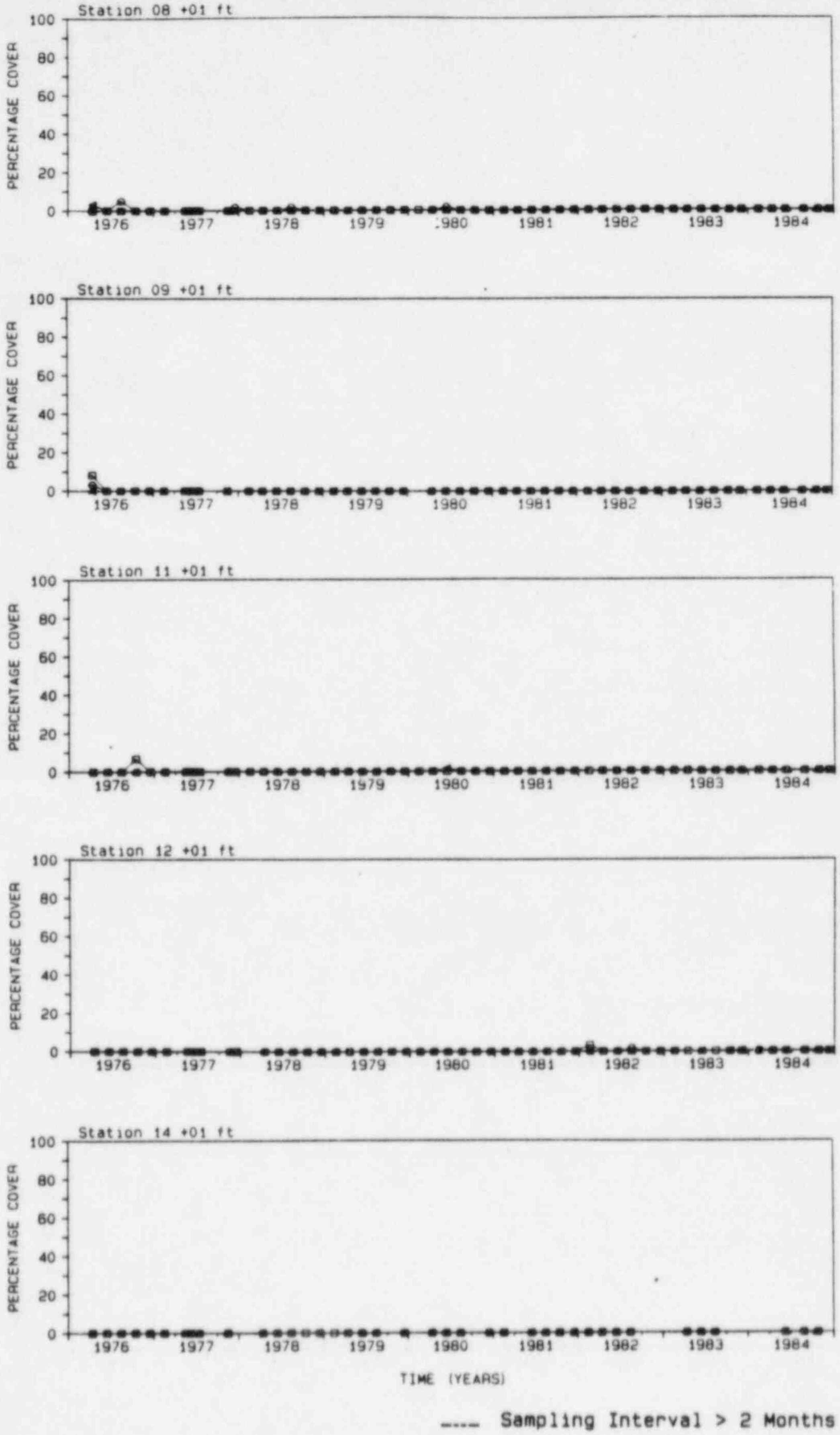


FIGURE 2-21

Overprinting of above symbols appear to be different symbols

ABUNDANCE VERSUS TIME FOR <u>ENDOCLADIA MURICATA</u> AT +1 FT MLLW (IPC METHOD)

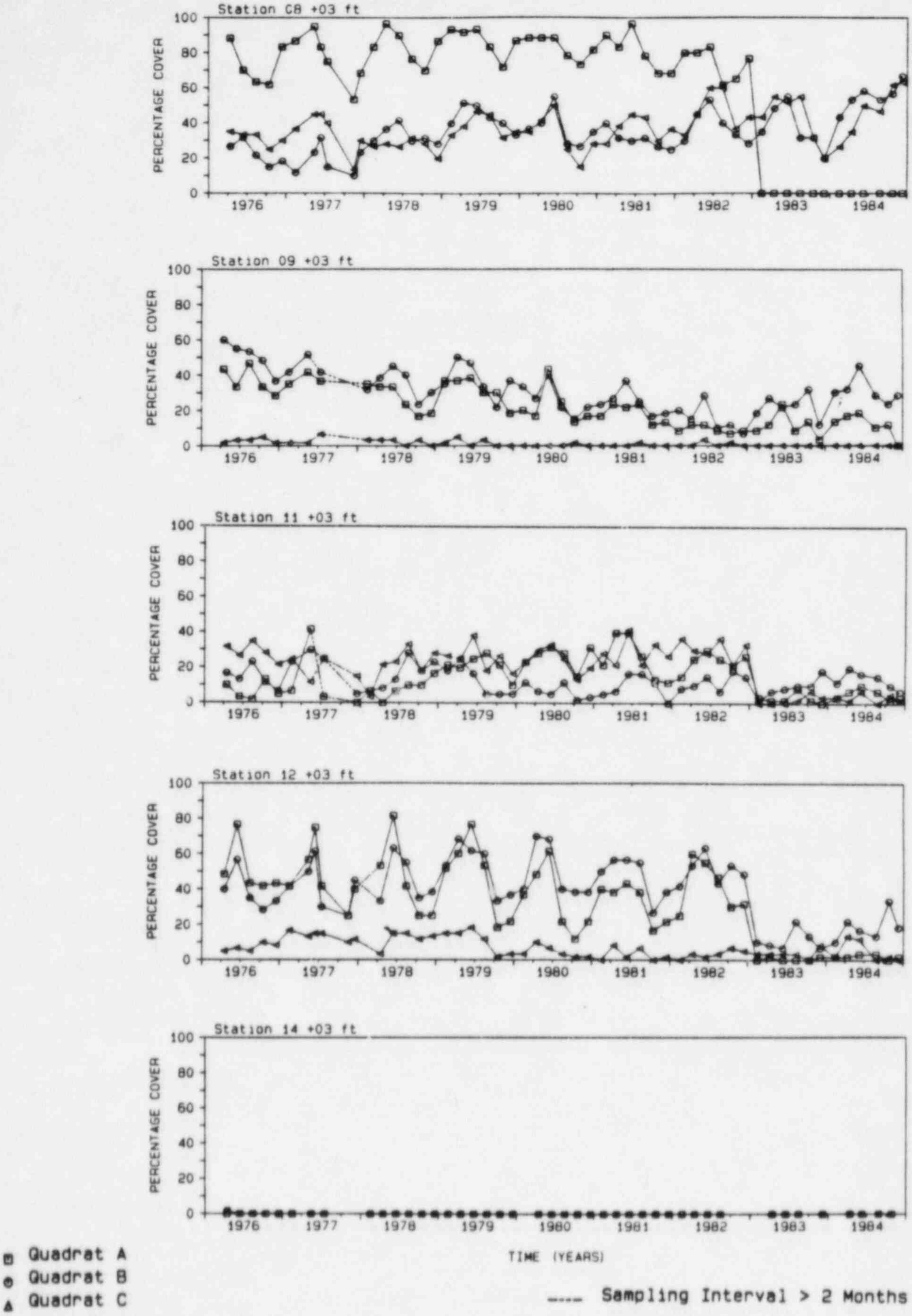


FIGURE 2-22

ABUNDANCE VERSUS TIME FOR ENDOCLADIA MURICATA AT +3 FT MLLW (IPC METHOD)

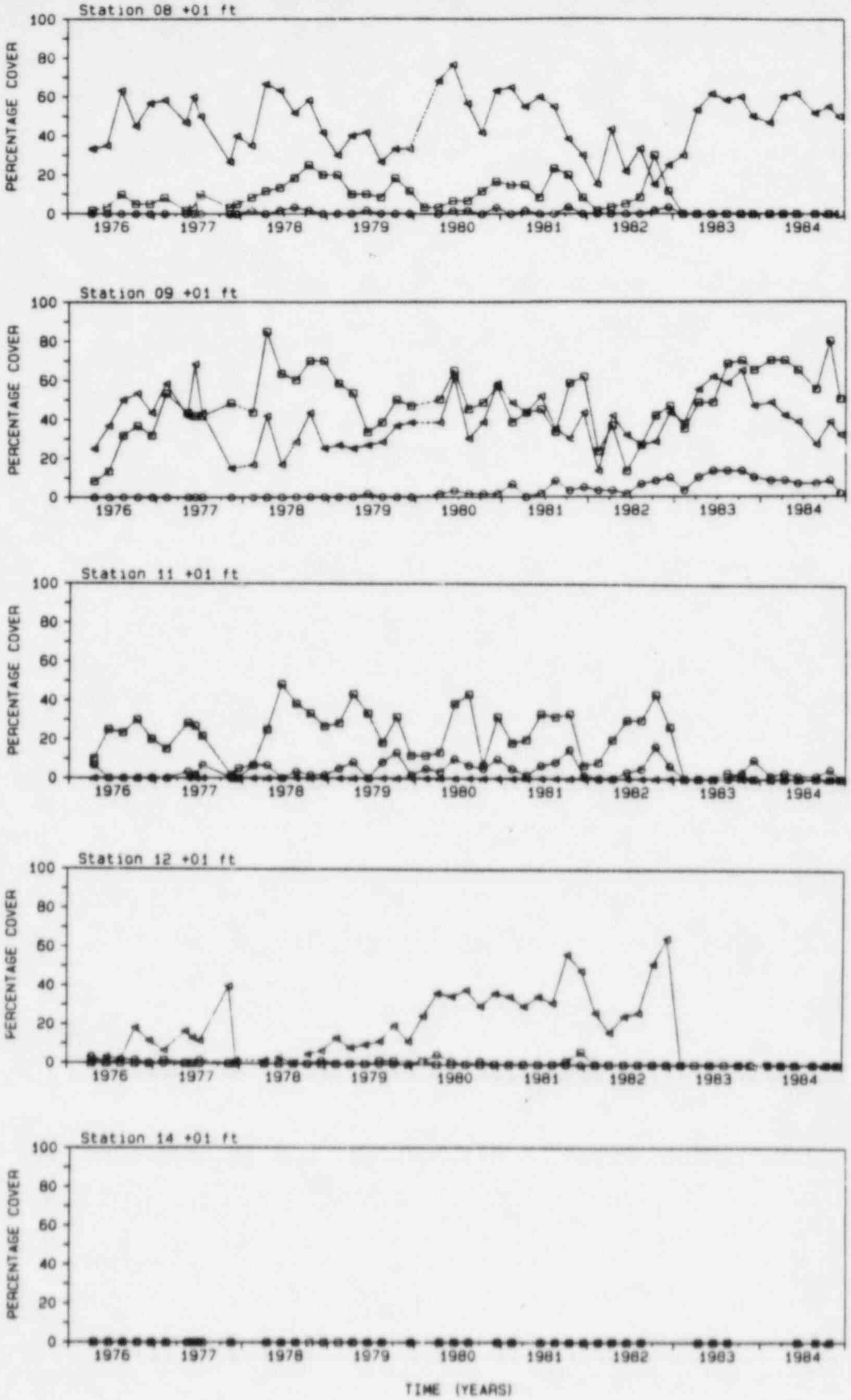
Overprinting of above symbols appear to be different symbols

MLLW) and is generally not found at +3 ft. Trends in nearly all +3 ft quadrats in Diablo Cove indicate that this species is most abundant during the spring and summer (April to June) months. The effects of the 1982-1983 winter storms varied among quadrats, but some recovery of Endocladia coverage is noticeable in the affected quadrats, except quadrat 8+3A, which was completely buried under sand.

2.2.1.2 GASTROCLONIUM COULTERI

Percentage cover values obtained using the random point contact method are presented for Gastroclonium coulteri in FIGURES 2-23 (+1 ft) and 2-24 (+3 ft). This species is found more commonly in lower elevation habitats, and consequently abundances are greatest at +1 ft, except at the wave-exposed Station 14. Greatest percentage cover values have generally occurred during the spring to fall periods, but have not necessarily been consistent from year to year in any of the quadrats. After the 1982-1983 winter through 1984, several quadrats (8+1A, 11+1A, and 12+1C) which during previous years had substantial amounts of Gastroclonium, had percentage cover values of less than one percent. The decreases can be attributed to 1982-1983 winter storm damage. Quadrat 12+1C became intermittently covered with cobble. In the other quadrats (8+1A and 11+1A) decreases in Gastroclonium can be attributed to sand scour. Gastroclonium commonly traps sand among its rhizomatous holdfast. High water motion causes the trapped sand to abrade these plants. Lack of recovery in 1984 is due in part to insufficient amounts of remaining plant material for regrowth.

However, other factors may have contributed to lack of recovery: (1) an insufficient amount of spores and growth of new plants and/or (2) competition for space and light (in some cases Ulva spp. and Porphyra spp. quickly colonized and grew in quadrats disturbed by storms). Though herbivore grazing can prevent or limit algal establishment, no appreciable numbers of grazing invertebrates have been present in these quadrats since the studies began.



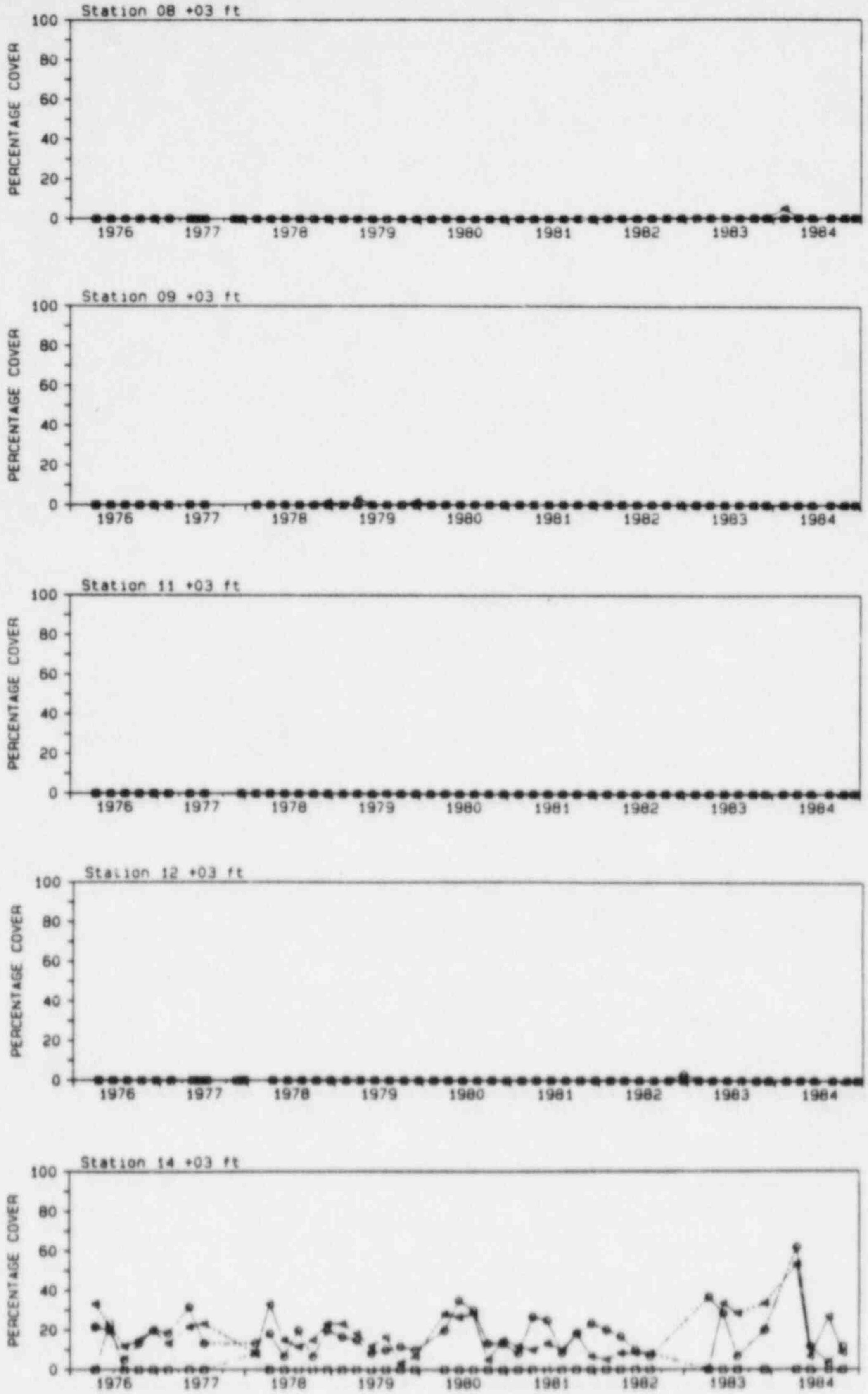
▫ Quadrat A
◦ Quadrat B
▴ Quadrat C

---- Sampling Interval > 2 Months

Overprinting of above symbols appear to be different symbols

FIGURE 2-23

ABUNDANCE VERSUS TIME FOR GASTROCLONIUM COULTERI AT +1 FT MLLW (IPC METHOD)



Quadrat A
Quadrat B
Quadrat C

---- Sampling Interval > 2 Months

FIGURE 2-24

ABUNDANCE VERSUS TIME FOR GASTROCLONIUM COULTERI AT +3 FT MLLW (IPC METHOD)

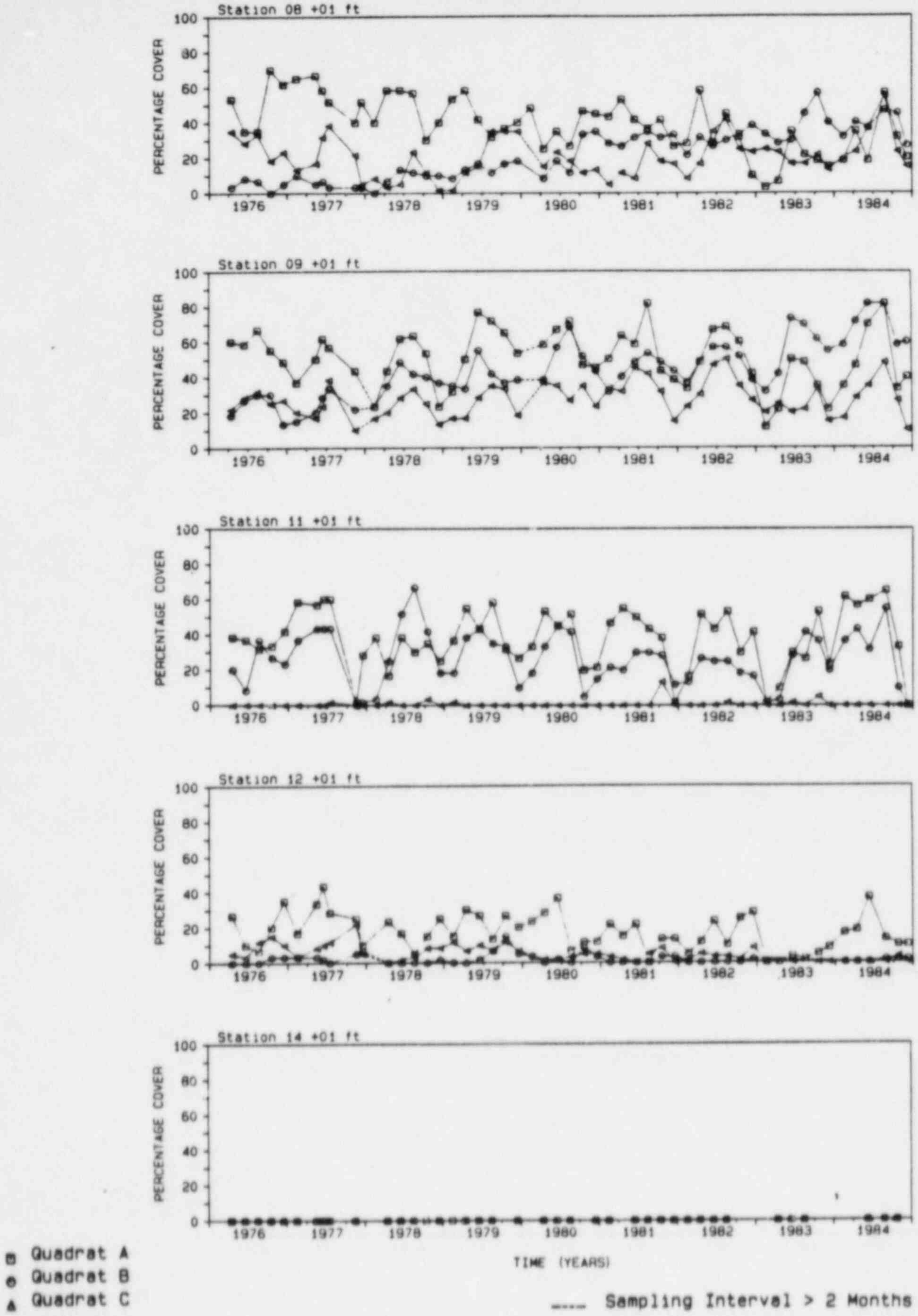
Overprinting of above symbols appear to be different symbols

2.2.1.3 GIGARTINA CANALICULATA

Percentage cover values obtained using the random point contact method are presented for Gigartina canaliculata in FIGURES 2-25 (+1 ft) and 2-26 (+3 ft). Gigartina canaliculata is found mainly at lower elevations, and consequently it has been more abundant at the +1 than the +3 ft level. An exception to this is at the wave-exposed Station 14, where the intertidal ranges of algae extend to higher elevations on the shore due to wave run up. Gigartina canaliculata abundances at the +3 ft transect of this location have been similar to those found at the +1 ft level of other, more protected stations. Spring-summer increases in percentage cover have been consistent from year to year at most +1 ft quadrats at Stations 9 and 11 and +3 ft quadrats at Station 14. This pattern is not as evident in the other quadrats. The winter 1982-1983 storms which, relative to other years, appreciably lowered the abundance of other species such as Gastroclonium coulteri and G. papillata, in several quadrats did not affect G. canaliculata to the same degree. The lack of noticeable storm effects on G. canaliculata may result from its thallus form (low-lying branches), which is perhaps structurally better able to withstand wave forces. Thus, the abundances of this species in 1984 are comparable to those of previous years.

2.2.1.4 GIGARTINA PAPILLATA

Percentage cover values obtained using the random point contact method are presented for Gigartina papillata in FIGURES 2-27 (+1 ft) and 2-28 (+3 ft). In north Diablo Cove (stations 8 and 9) the cover values of G. papillata have been generally greater at +3 ft. In the south Diablo Cove (stations 11 and 12) the abundance of this species has been more similar among the high and low elevations. This is due to the wave-protected nature of south Diablo Cove. Algae commonly found in mid-to-high tidal ranges along wave-exposed shores are able to colonize and grow in lower elevation habitats in protected areas. Gigartina papillata at the heavily wave-exposed Station 14 area occurs mostly above 3 ft, and consequently its values within the Station 14 sample sites were never greater than one percent. In other station quadrats where G. papillata was sufficiently abundant, seasonal trends indicate that this species is most common



Overprinting of above symbols appear to be different symbols

FIGURE 2-25

ABUNDANCE VERSUS TIME FOR GIGARTINA CANALICULATA AT +1 FT MLLW (IPC METHOD)

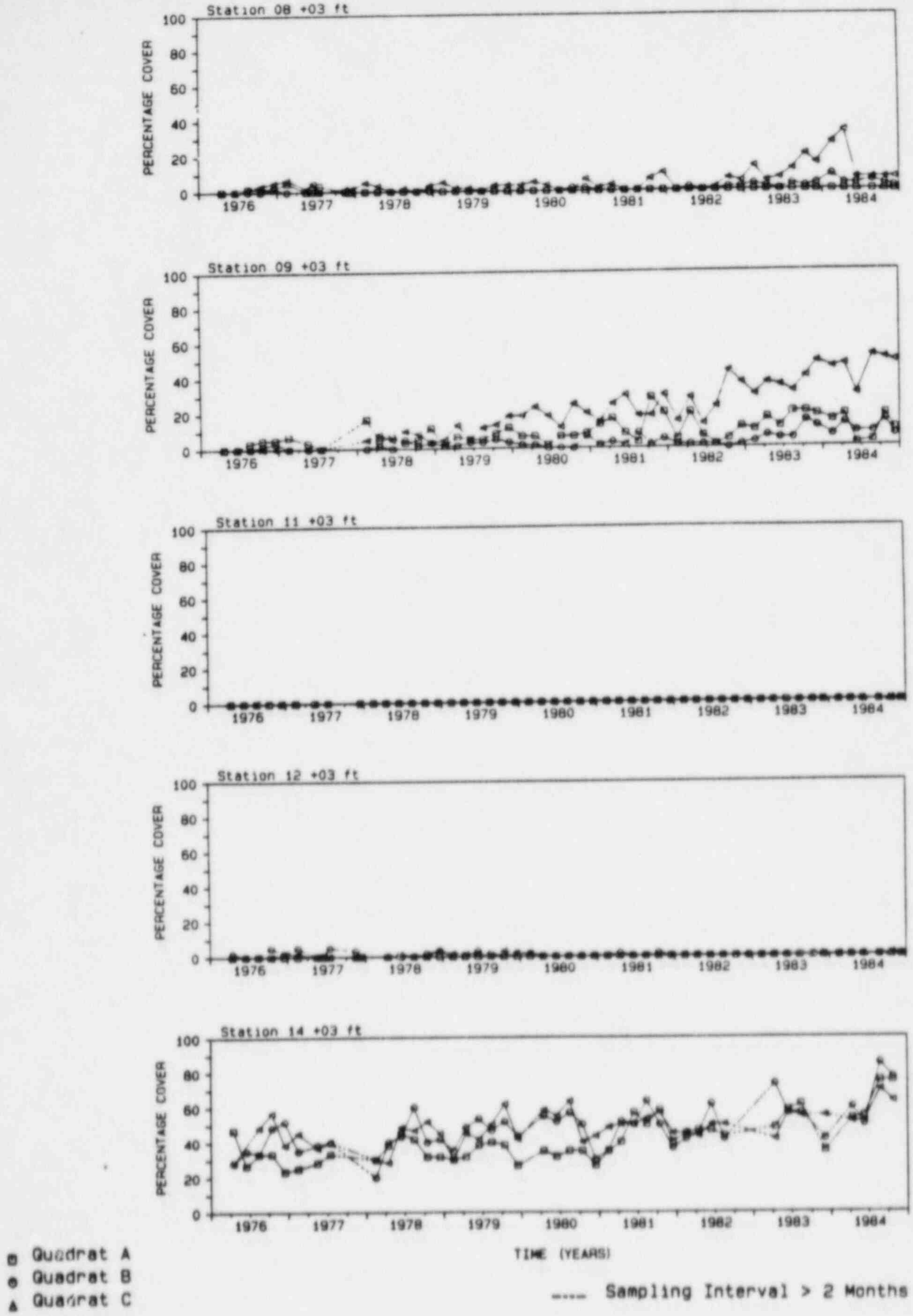
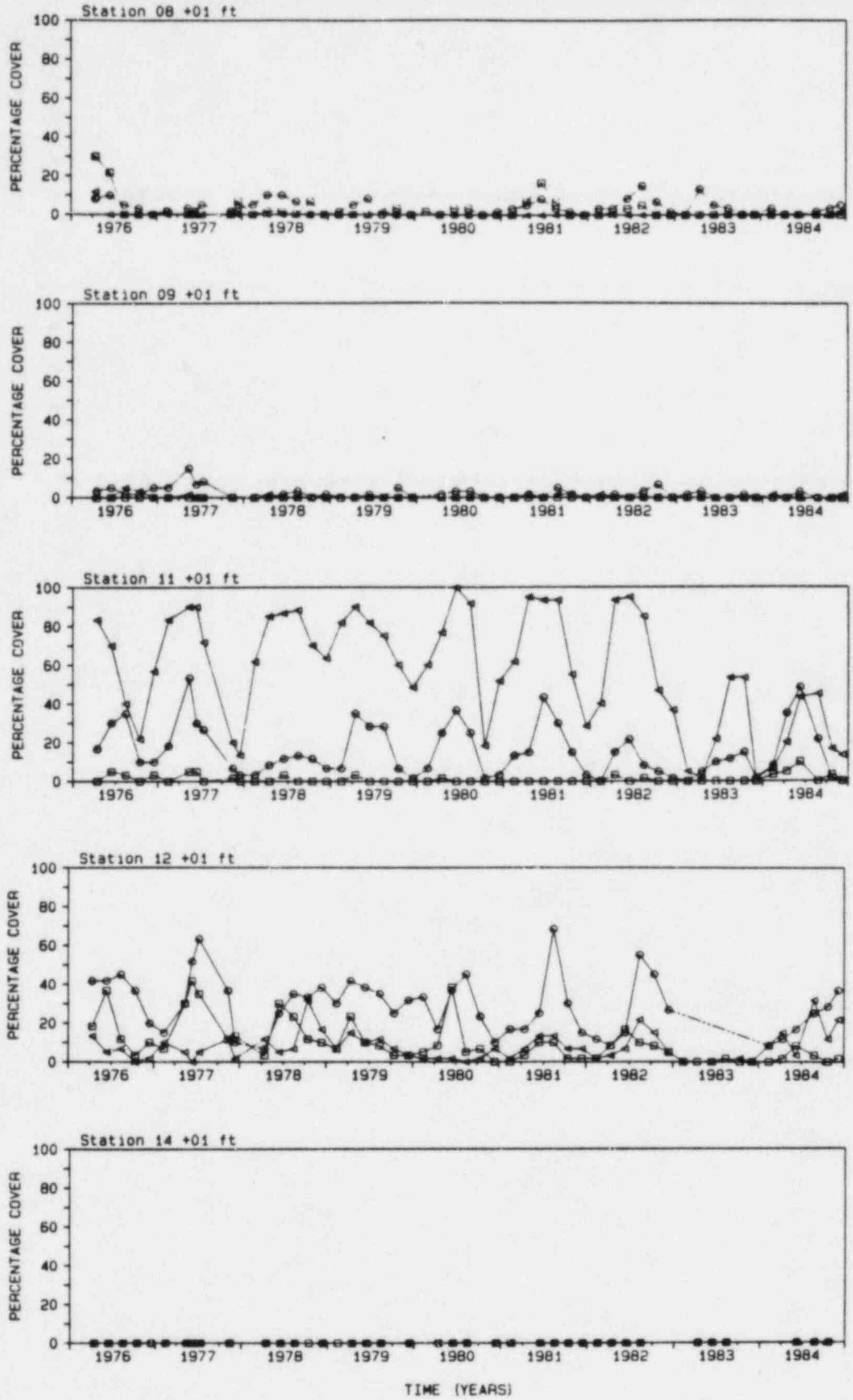


FIGURE 2-26

Overprinting of above symbols appear to be different symbols

ABUNDANCE VERSUS TIME FOR GIGARTINA CANALICULATA AT +3 FT MLLW (IPC METHOD)



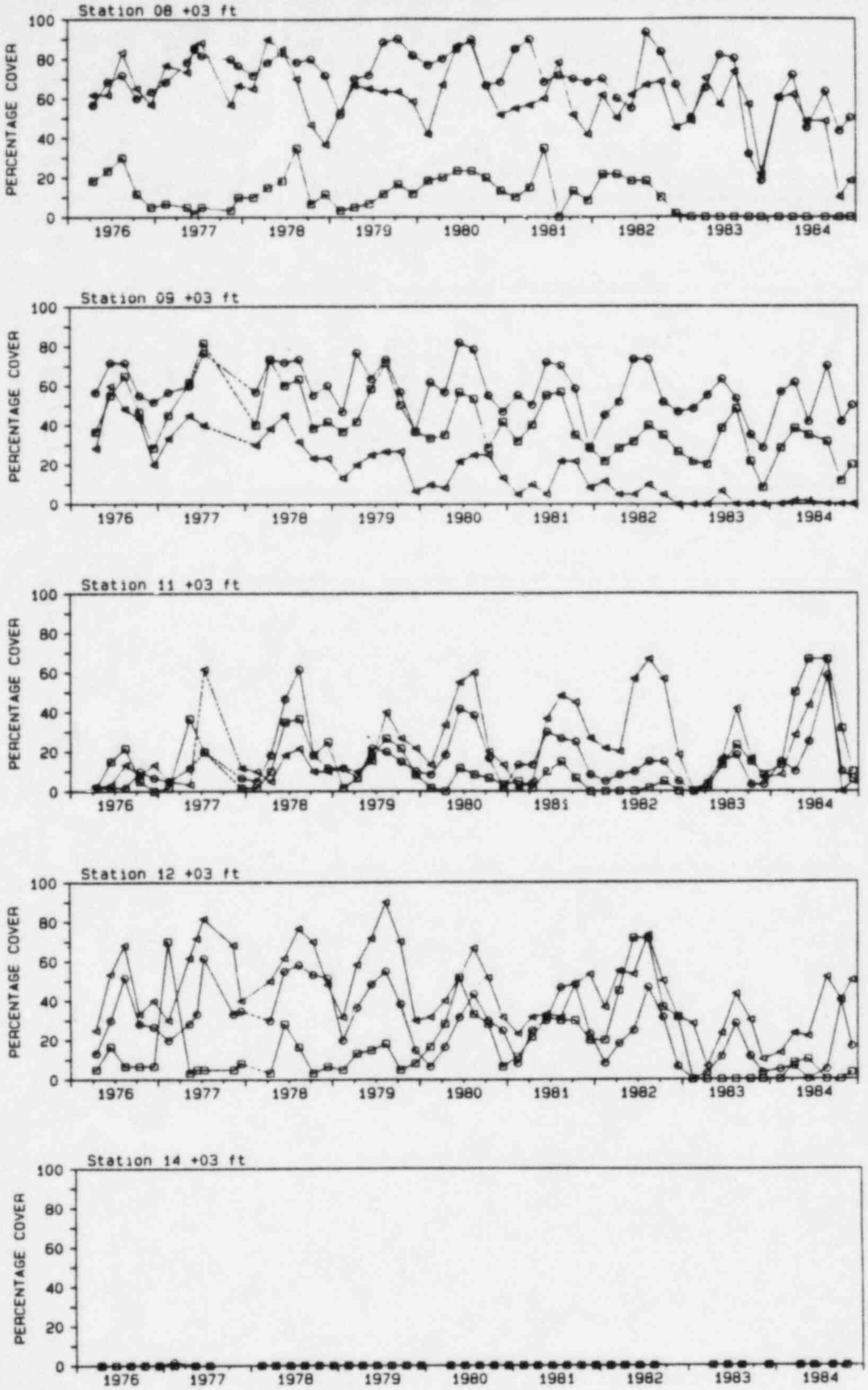
▫ Quadrat A
◦ Quadrat B
▵ Quadrat C

---- Sampling Interval > 2 Months

FIGURE 2-27

Overprinting of above symbols appear to be different symbols

ABUNDANCE VERSUS TIME FOR GIGARTINA PAPILLATA AT +1 FT MLLW (IPC METHOD)



▣ Quadrat A
⊙ Quadrat B
▲ Quadrat C

---- Sampling Interval > 2 Months

Overprinting of above symbols appear to be different symbols

FIGURE 2-28

ABUNDANCE VERSUS TIME FOR GIGARTINA PAPILLATA AT +3 FT MLLW (IPC METHOD)

during the spring to fall period. The scouring effects of the winter storms of 1982-1983 appreciably lowered G. papillata abundances, which in turn affected the typical spring-fall increase for this species in some quadrats, 8+3A, 12+1A, B, and C, 12+3A) in 1983. Quadrats 12+1B and C and 8+3A were intermittently buried under cobble and sand during 1983. Although quadrat 12+1B was never sampled in 1983, G. papillata in this quadrat can be considered to have been absent during this period. In 1984, cobbles were removed from quadrats 12+1B and C and G. papillata abundance recovered somewhat, as in quadrat 12+3A. In quadrat 8+3A, which still experienced sand inundation in 1984, G. papillata abundance remained less than one percent cover. Of the stations affected by the 1982-83 storms, Stations 12+1 and 11+3 remain somewhat below levels of the 1976-1981 period, while the other stations have recovered to comparable levels in 1984.

2.2.1.5 IRIDAEA FLACCIDA

Percentage cover values obtained using the random point contact method are presented for Iridaea flaccida in FIGURES 2-29 (+1 ft) and 2-30 (+3 ft), respectively. I. flaccida abundance in many of the intertidal random point contact quadrats has been greater in the spring to fall months in most years from 1976 to 1984. This is especially so in quadrat 12+1B and C and, excluding 1984, all three quadrats at 14+3. This seasonal pattern is not as evident in some quadrats (8+3C, 12+3C). The severe winter storms of 1982-1983 did not noticeably alter the seasonal pattern or cover of I. flaccida in most quadrats. Two exceptions were quadrats 12+1B and C, which were buried under fragmented rock during 1983. In 1984 these quadrats became uncovered and were subsequently sampled. Some recovery of I. flaccida abundance is evident in quadrat 12+1C.

In June 1984 all three quadrats at Station 14+3 were unusually low in I. flaccida abundance for the time of year. By August I. flaccida cover increased to abundance levels more similar to abundances noted during previous summer periods.

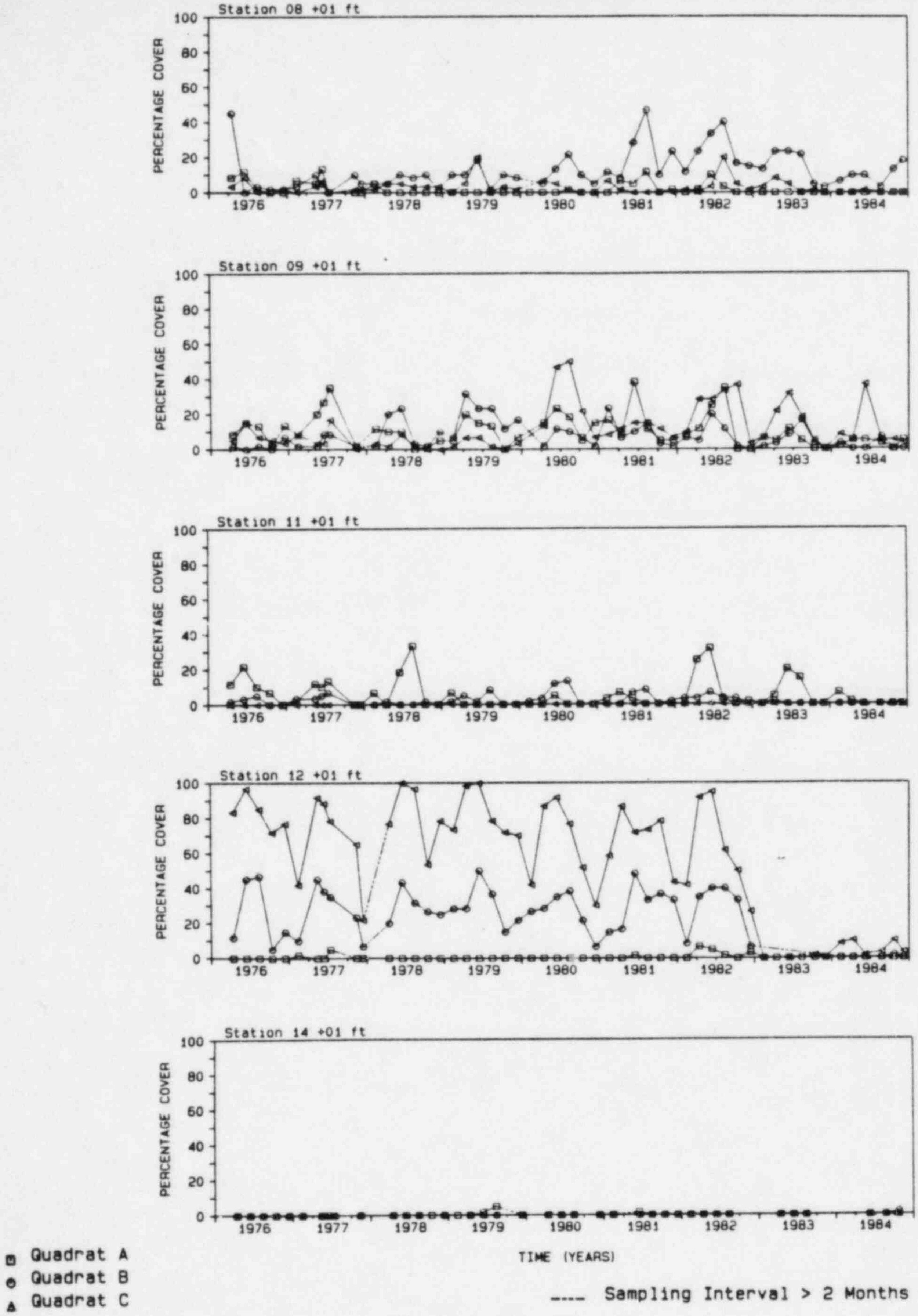
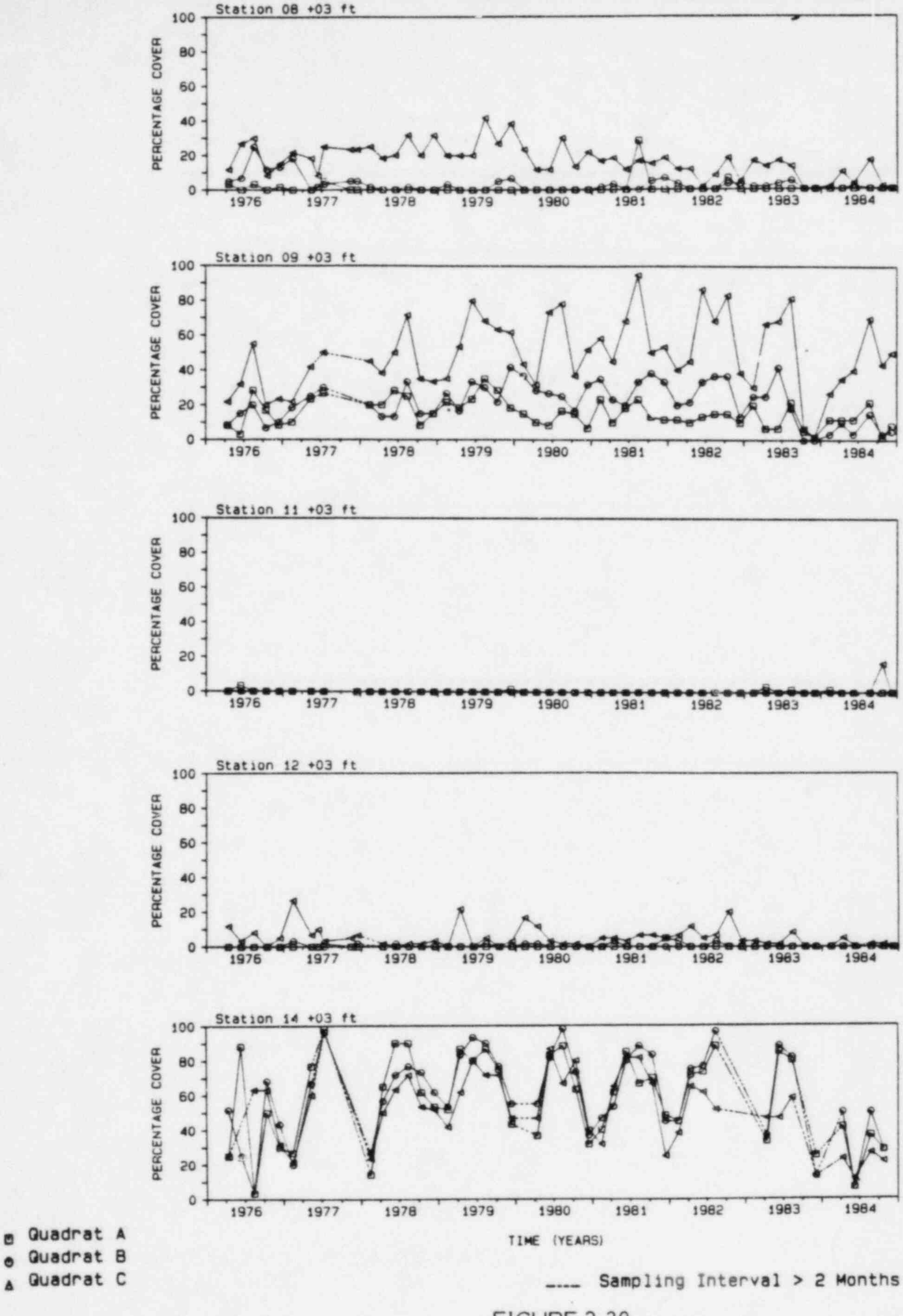


FIGURE 2-29

ABUNDANCE VERSUS TIME FOR *IRIDAEA FLACCIDA* AT +1 FT MLLW (IPC METHOD)

Overprinting of above symbols appear to be different symbols



Overprinting of above symbols appear to be different symbols

FIGURE 2-30

ABUNDANCE VERSUS TIME FOR IRIDAEA FLACCIDA AT +3 FT MLLW (IPC METHOD)

2.3 INTERTIDAL ALGAL SCRAPINGS

The objective of the algal scraping subtask is to provide algal biomass information for comparison between pre-operational and operational power plant phases. Two algal scraping surveys were conducted in 1984 (TABLE 2-11). Details of the intertidal algal scraping methods and locations are presented in Appendix A (Section A.3). Data from these surveys are still in the process of being summarized, and thus a discussion of algal scraping biomass results is deferred.

2.4 INTERTIDAL BLACK ABALONE TAGGING

Nineteen intertidal black abalone (Haliotis cracherodii) tagging surveys were completed through 1982 (see TABLE 2-12). Details of the intertidal black abalone tagging methods and locations are presented in Appendix A (Section A.4). Analysis of the data collected thus far have sufficiently defined the field growth rates and mortality rates of black abalone to meet the original objectives of this subtask. Therefore, no surveys were conducted in 1983 and 1984.

TABLE 2-11

SUMMARY OF COMPLETED INTERTIDAL
ALGAL SCRAPING PROGRAM
(+ 2 FT MLLW)

Survey and Date			Station*			
			1	2	3	4
1	August	1979	X	X	X	X
2	November	1979	X	--	--	--
2	December	1979	--	X	X	X
3	January	1980	X	--	--	--
3	March	1980	--	X	X	X
4	May	1980	X	--	--	--
4	June	1980	--	X	X	X
5	August	1980	X	X	X	X
6	January	1981	X	X	--	X
6	February	1981	--	--	X	--
7	June	1981	X	X	X	**
8	December	1981	--	X	X	**
8	February	1982	X	--	--	**
9	June	1982	X	X	X	**
10	January	1983	X	X	X	**
11	July	1983	X	X	X	**
12	January	1984	X	X	X	**
13	July	1984	X	X	X	X

* 25 scrapes were taken at each station marked "X"; for locations, see FIGURE A-1 in Appendix A.

** Station 4 deleted from program.

TABLE 2-12

SUMMARY OF COMPLETED INTERTIDAL BLACK ABALONE TAGGING SURVEYS

Number in parentheses ( ) is the number of abalone stations sampled

Date	Survey	Number of Abalone Tagged	Number of Abalone Recaptured
11/78	1	442 (4)	--
1/79	2	--	140 (4)
4/79	3	--	115 (4)
5/79	4	142 (4)	62 (1)
6/79	5	209 (4)	170 (4)
7/79	5	14 (1)	169 (3)
9/79	6	113 (4)	136 (4)
1/80	7	168 (4)	212 (4)
3/80	8	73 (2)	157 (2)
5/80	9	--	276 (4)
7/80	10	134 (4)	118 (4)
11/80	11	66 (3)	137 (3)
2/81	12	139 (4)	180 (4)
5/81	13	111 (4)	222 (4)
7/81	14	29 (3)	151 (3)
8/81	15	29 (1)	112 (1)
11/81	16	--	86 (1)
1/82	17	--	174 (4)
4/82	18	68 (3)	129 (3)
5/82	19	--	18 (1)
*			

* No surveys were conducted in 1983 and 1984.

2.5 INTERTIDAL BLACK ABALONE SURVEY

A discussion on habitat preferences, life history, and some aspects of the ecology of black abalone (Haliotis cracherodii) was presented in a previous report (PGandE 1979). Black abalone are most abundant in intertidal habitats with numerous rock crevices and large boulders for protection, and most animals have been observed in north Diablo Cove where this type of substrate predominates. Details of the intertidal black abalone survey methods and locations are presented in Appendix A (Section A.5). In the 1983 survey, maximum densities of black abalone have been found in the headland area of north Diablo Cove. The least productive cove area has been the relatively flat benchrock terrace and cobble beach southeast of the discharge structure. No black abalone survey was undertaken in 1984.

2.6 INTERTIDAL STATION PHOTOGRAPHY

Intertidal station photography was completed in the six surveys conducted in 1984 (see TABLES 2-1 and 2-2). Details of intertidal station photography methods and locations are presented in Appendix A (Section A.6).

2.7 SUBTIDAL ARC QUADRANT (SAQ)

Six subtidal surveys were completed from January through November 1984 (TABLE 2-13). Details of the subtidal arc quadrant methods and locations are presented in Appendix A, (Section A.7). In the following sections data are presented showing the distribution and abundance of four algal and nine invertebrate taxa from Survey 1 (May 1976) through Survey 46 (November 1984).

The TEMP subtidal stations to be considered in this report are only those located within Diablo Cove (see FIGURE A-1 and Map A in pocket):

North Diablo Cove	Central Diablo Cove	South Diablo Cove
8-10	13-32	10-10
9-10		12-10
9-15		10-15
		12-15

The digits to the left of the hyphen in the station designation refer to the location of the station and the digits to the right of the hyphen indicate the approximate depth of the station in feet below MLLW.

2.7.1 ALGAE

This section includes seasonal abundance descriptions for four brown algal species counted in the TEMP Diablo Cove subtidal stations. The species are Cystoseira osmundacea, Laminaria dentigera, Nereocystis luetkeana, and Pterygophora californica. These brown algae are commonly referred to as kelp and are of considerable importance as a habitat and food source for various fish and invertebrates. When they occur in high numbers their blades form canopies which shade the bottom and regulate the composition and abundance of understory algae. Abundance data for these species during the first year sampling

TABLE 2-13

SUMMARY OF COMPLETED SUBTIDAL TEMP SAMPLING

Survey and Date	No. of Stations Sampled	No. of $7 m^2$ Arc Quadrants Sampled (SLC)	No. of $7 m^2$ arc Quadrants Sampled (SAQ)	No. of ¼ m^2 Quadrats Sampled (SFQ)	No. of Algal Scrapings Taken	No. of ¼ m^2 Quadrat Photos	Fish Observations No. Stations (2 repl.)
01 May-Aug 1976	32	--	128	128	93	--	14
02 Sept-Dec 1976	28	112	112	115	84	116	13, 1 (1 repl.) - (1 station w/1 replicate)
03 Jan-April 1977	28	112	112	115	84	12	14
04 May-Aug 1977	17	68	68	69	51	2	14
05 Sept-Dec 1977	3	12	12	12	9	0	13
06 Feb-Mar 1978	5	20	20	21	0	--	2
07 April-May 1976	9	36	36	37	0	0	6
08 June-July 1978	9	36	36	37	0	0	4 (2 repl.), 2 (1 repl.)
09 Aug-Sept 1978	9	36	36	37	0	0	6
10 Oct-Nov 1978	6	24	24	25	0	10	6
11 Dec-Jan 1978-79	4	16	16	17	0	0	0
12 Feb-Mar 1979	8	32	32	32	0	0	6
13 April-May 1979	9	36	36	36	0	0	6
14 June-July 1979	5	20	20	20	0	0	6
15 Aug-Sept 1979	9	36	36	36	0	0	6
16 Oct-Nov 1979	9	36	36	36	0	0	6
17 Dec-Jan 1979-80	7	28	28	28	0	0	6
18 Feb-Mar 1980	5	20	20	20	0	0	0
19 April-May 1980	9	36	36	36	0	0	6
20 June-July 1980	4	16	16	16	0	0	0
21 Aug-Sept 1980	8	32	32	32	0	0	0
22 Oct-Nov 1980	5	20	20	20	0	0	6
23 Dec-Jan 1980-81	2	8	8	8	0	0	6
24 Feb-Mar 1981	1	4	4	4	0	0	0
25 April-May 1981	9	36	36	36	0	0	6
26 June-July 1981	9	36	36	36	0	0	0
27 Aug-Sept 1981	0	0	0	0	0	0	6 (1 repl.)
28 Oct-Nov 1981	7	28	28	28	0	0	0
29 Dec-Jan 1981-82	4	16	16	16	0	0	6
30 Feb-Mar 1982	7	28	28	28	0	0	6
31 April-May 1982	10	40	40	40	0	0	6
32 June-July 1982	10	40	40	40	0	0	0
33 Aug-Sept 1982	7	28	28	28	0	0	0
34 Oct-Nov 1982	2	8	8	8	0	0	2 (2 repl.), 4 (1 repl.)
35 Dec-Jan 1982-83	2	8	8	8	0	0	0
36 Feb-Mar 1983	0	0	0	0	0	0	0
37 Apr-May 1983	10	40	40	40	0	0	9 (1 repl.)
38 Jun-Jul 1983	10	40	40	40	0	0	11 (1 repl.)
39 Aug-Sep 1983	10	40	40	40	0	0	11

TABLE 2-13

SUMMARY OF COMPLETED SUBTIDAL TEMP SAMPLING
(CONTINUED)

Survey and Date	No. of Stations Sampled	No. of $7 m^2$ Arc Quadrants Sampled (SLC)	No. of $7 m^2$ arc Quadrants Sampled (SAQ)	No. of $¼ m^2$ Quadrats Sampled (SFQ)	No. of Algal Scrapings Taken	No. of $¼ m^2$ Quadrat Photos	Fish Observations No. Stations (2 repl.)
40 Oct-Nov 1983	4	16	16	16	0	0	0
41 Dec-Jan 1983-84	10	40	40	40	0	0	6 (2 repl.), 10 (1 repl.)
42 Feb-Mar 1984	4	16	16	16	0	0	0
43 Apr-May 1984	8	32	32	32	0	0	8(1 repl.)
44 Jun-Jul 1984	14	56	56	56	0	0	0
45 Aug-Sept 1984	12	48	48	48	0	0	3(2 repl), 11 (1 repl.)
46 Oct-Nov 1984	4	16	16	16	0	0	8 (1 repl.)

period (1976-1977) were presented earlier in LCMR (1978) and PGandE (1979) and then updated to include the period 1976 to 1983 in PGandE (1984). The field data for these four algal species are counts of plants greater than 20 cm long. All plants in each of the four arc quadrants (each arc quadrant encompasses 7 m^2) are counted. The four arc quadrant counts have been averaged in this report to give the mean number of plants (N=4) per 7 m^2. The following sections discuss the analysis conducted on data collected from 1976 through 1984.

2.7.1.1 CYSTOSEIRA OSMUNDACEA

Cystoseira osmundacea is a summer surface canopy-forming kelp plant. During the winter, individuals of this species appear as a rosette of branches about 0.5 m long. As spring approaches these branches produce fronds which elongate and float on the surface to form a canopy. This canopy persists through the summer and is later removed by fall-winter storms, leaving the basal portion to overwinter and begin frond production again the next spring. Surface canopy-forming C. osmundacea plants are normally attached in water less than 10 m deep. Plants growing in deeper water usually do not produce floating fronds, presumably due to reduced light. Data obtained at the Diablo Cove stations are presented in FIGURE 2-31.

In general, Cystoseira osmundacea has been less abundant than Pterygophora californica and Laminaria dentigera (see Sections 2.7.1.4 and 2.7.1.2, respectively), but more abundant than Nereocystis luetkeana (see Section 2.7.1.3). C. osmundacea has generally been more common in the shallow (-10 to -15 ft depth) Diablo Cove stations. At Station 13-32 (32 ft sample depth) only one C. osmundacea plant was found on one sampling occasion. Recruitment occurs for this species, as with many other algae, mostly during the spring and summer months. Accordingly, abundances have been greatest during these periods. However, the numbers of recruiting C. osmundacea individuals have generally been low and thus seasonal abundance variations for this species have not been as large in magnitude as those seen for P. californica and L. dentigera. Variations in C. osmundacea abundances in all the Diablo Cove TEMP stations during 1984

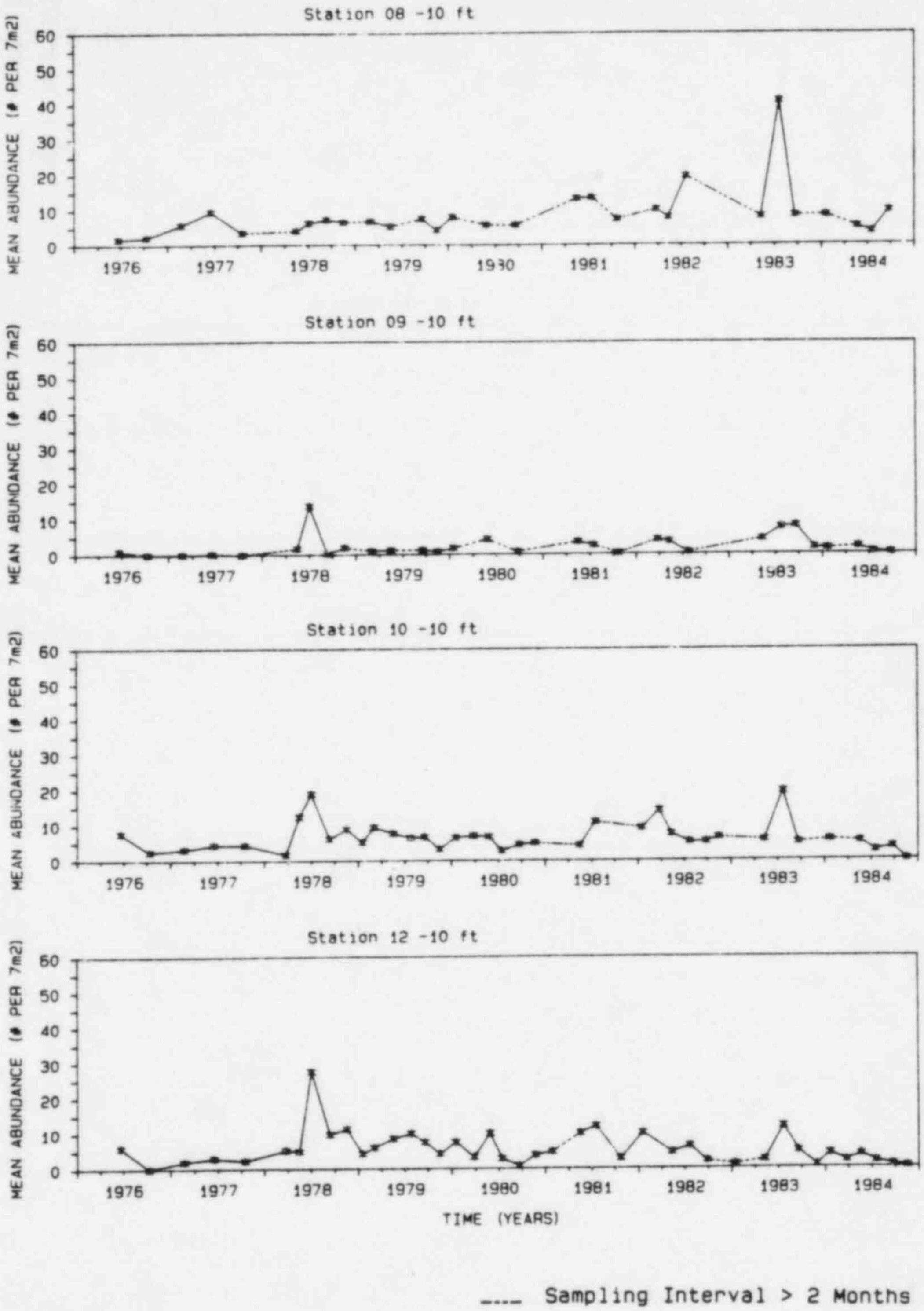


FIGURE 2-31

ABUNDANCE VERSUS TIME FOR SUBTIDAL
<u>CYSTOSEIRA OSMUNDACEA</u> IN DIABLO COVE
(SAQ METHOD)

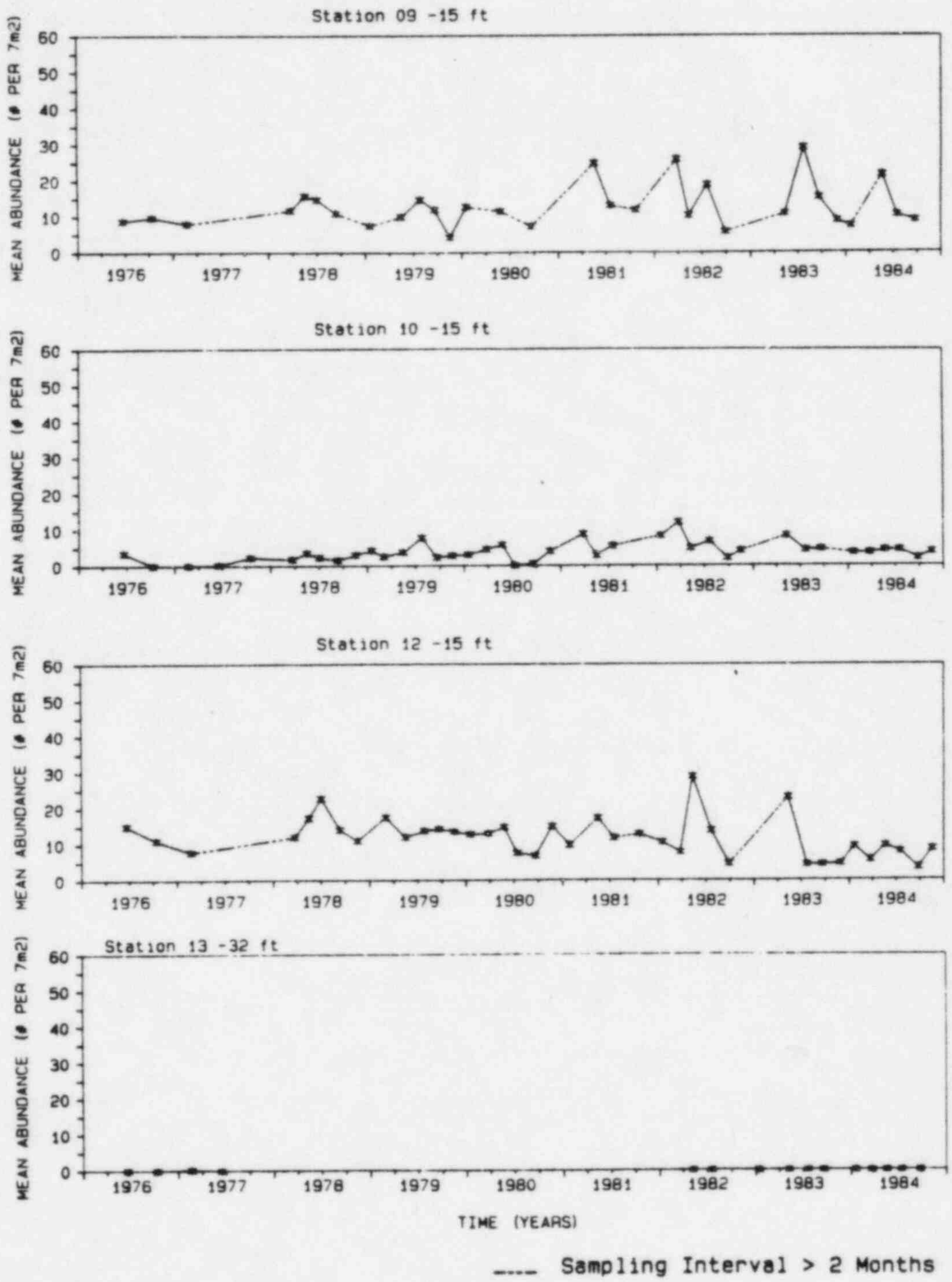


FIGURE 2-31 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL
CYSTOSEIRA OSMUNDACEA IN DIABLO COVE
(SAQ METHOD)

have been similar to seasonal abundance variations observed during previous years.

2.7.1.2 LAMINARIA DENTIGERA

Laminaria dentigera, like Pterygophora californica (see Section 2.7.1.4), is a perennial tree-like kelp plant extending roughly one meter off the bottom. Its life history and general ecology have been presented in an earlier report (PGandE 1979). Individuals of this species are counted in the stations, and density data are presented in FIGURE 2-32.

Laminaria dentigera has generally been less abundant than Pterygophora californica. However, the abundances of L. dentigera have been more uniform among the Diablo Cove stations. Consequently, L. dentigera has been only slightly less abundant than P. californica in the north Diablo Cove stations (8-10, 9-10, 9-15). But in the south Diablo Cove stations (10-10, 10-15, 12-10, 12-15, 13-32), P. californica has been roughly twice as numerous as L. dentigera. Recruitment for L. dentigera, as for most other kelps, occurs more often during the spring-summer months. Thus, within the TEMP stations there has been considerable seasonal variation in L. dentigera plant densities. Aside from occasional large within-year fluctuations, year-to- year changes in overall abundance indicate that this species has not declined to the extent seen for P. californica in some stations. Stipes of L. dentigera are more pliable than P. californica stipes, and thus L. dentigera is less susceptible to breakage and loss during storms. This may be why L. dentigera abundances at some stations have remained relatively stable while P. californica abundances have declined.

2.7.1.3 NEREOCYSTIS LUETKEANA

Nereocystis luetkeana (bull kelp) density estimates are provided by two methods: (1) counts made underwater within TEMP fixed stations, and (2) counts of surface canopy-forming plants from cliff-top vantage points. Density data obtained by the former method (counts within Diablo Cove subtidal TEMP stations) are

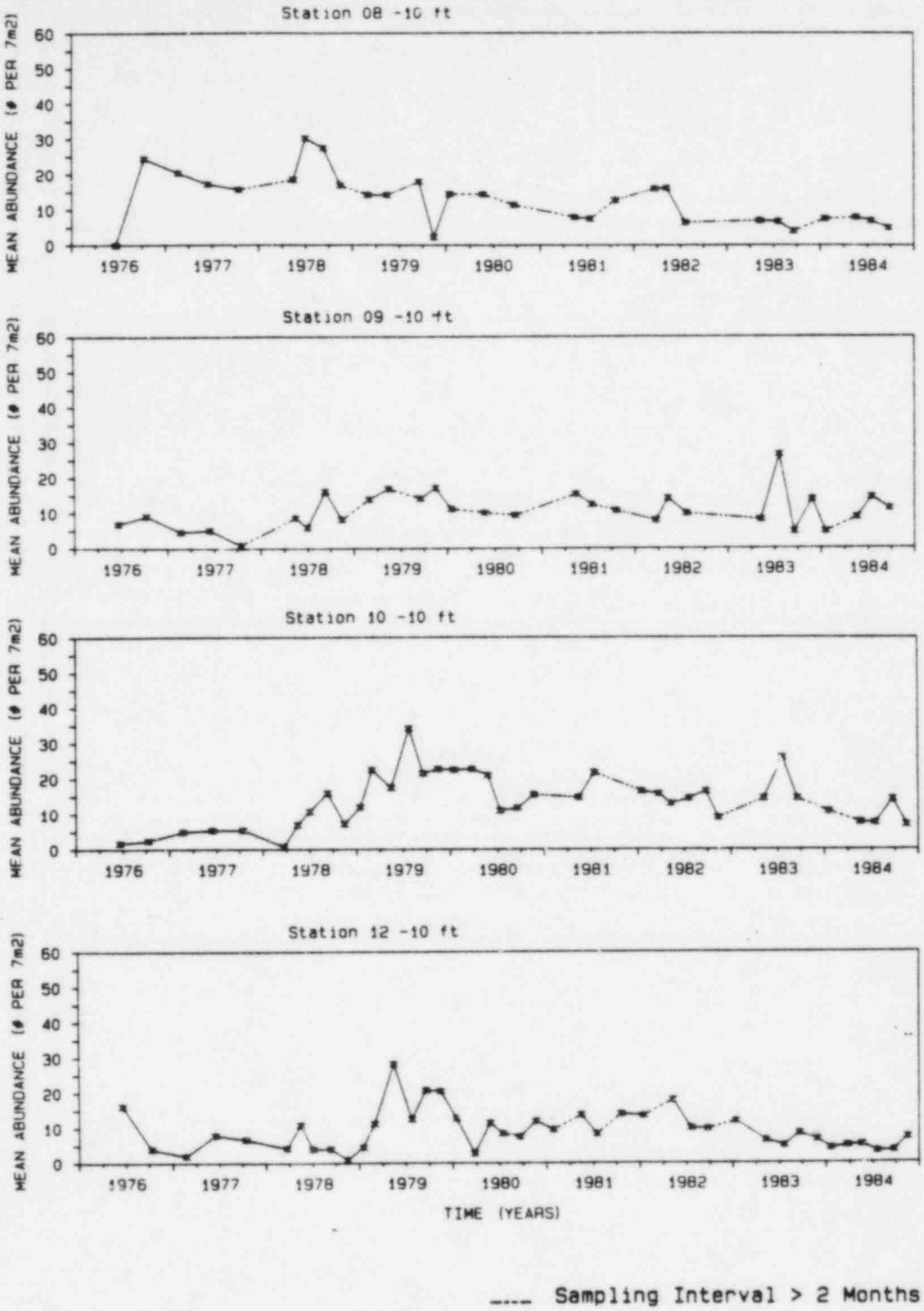


FIGURE 2-32

ABUNDANCE VERSUS TIME FOR SUBTIDAL LAMINARIA DENTIGERA IN DIABLO COVER (SAQ METHOD)

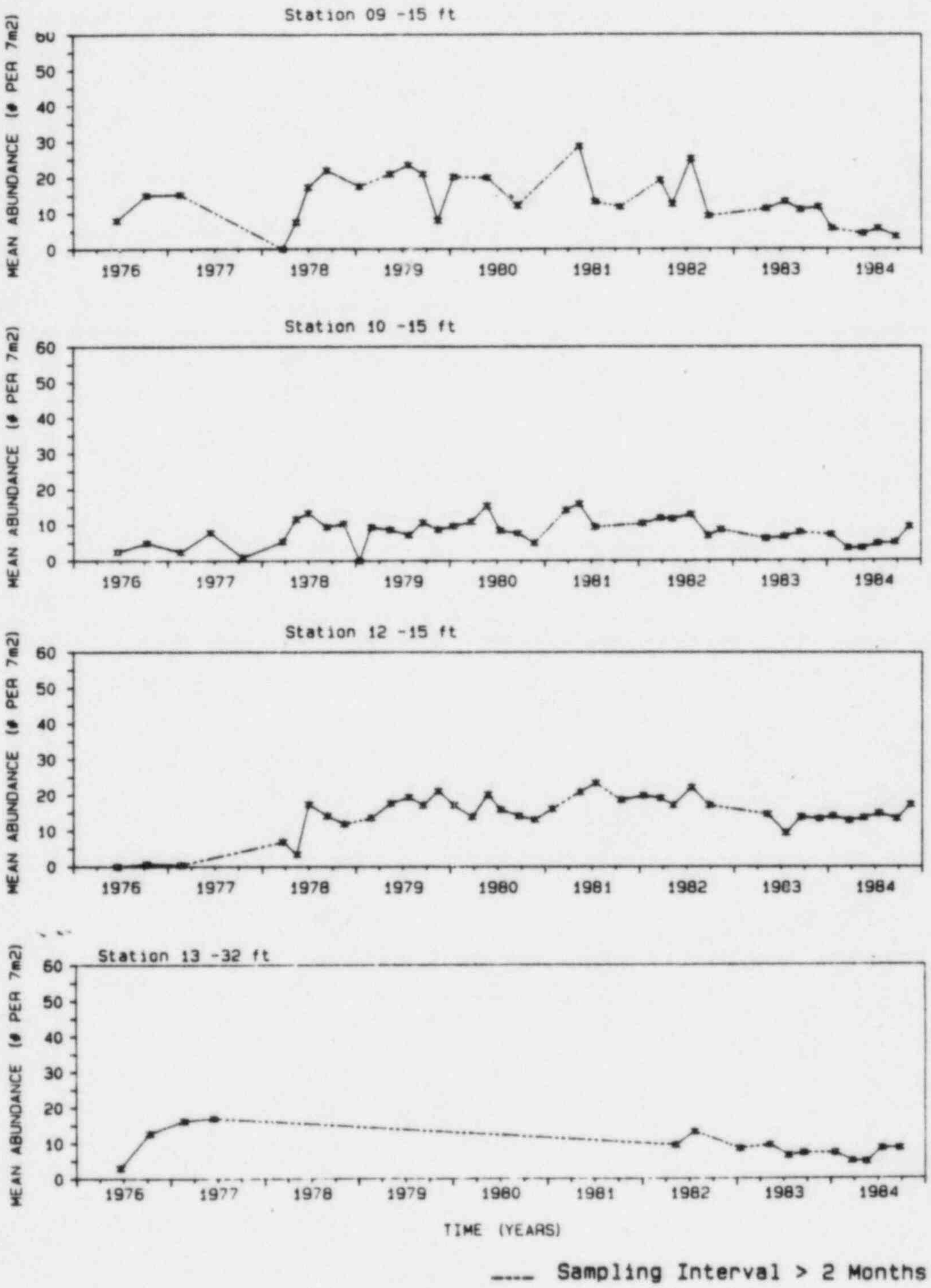


FIGURE 2-32 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL *LAMINARIA DENTIGERA* IN DIABLO COVER (SAQ METHOD)

discussed in this section. Cliff-top counts are presented and discussed later in this report (see Section 2.15).

The life history and other pertinent information for Nereocystis luetkeana was presented in PGandE (1979 and 1982). The large macroscopic sporophyte generation alternates with a microscopic gametophyte phase on an annual cycle. Seasonal abundance trends in the Diablo Cove stations show this cycle (FIGURE 2-33). Plants are most common during the spring to fall periods and are almost always absent during the winter seasons. In addition, due to its annual turnover cycle, there can be large differences in abundance between years and between stations. The abundances of Nereocystis at Stations 10-15, 12-15, and 13-32 were very low from 1976 to the present. Stations 8-10, 9-10, 10-10, 12-10 and 9-15 had variable abundances from 1976 until about 1981. Since then, abundances on these stations have also been very low. The low densities of this species at these stations are probably attributable to lack of suitable substrate (i.e., available hard surfaces have been buried by large amounts of sand), a low frequency of substrate turnover, and/or lack of sufficient light caused by shadowing Pterygophora californica canopies (see Section 2.7.1.4).

2.7.1.4 PTERYGOPHORA CALIFORNICA

Pterygophora californica is a perennial tree-like kelp plant extending roughly one meter off the bottom. Its life history and general ecology were presented earlier by PGandE (1979). Abundance values from 1976 to 1984 are presented in FIGURE 2-3 .

The abundance of this species has generally been greater in south (10-10, 10-15, 12-10, 12-15, 13-32) than in north (8-10, 9-10, 9-15) Diablo Cove Stations. Recruitment of Pterygophora normally occurs during the spring and summer months and can create large differences in seasonal abundance. At Station 9-10 there was a substantial increase (recruitment) during the summer of 1983. This increase was facilitated by the previous winter storms which opened up fresh substrate for colonization. The increase in Pterygophora plants at this time was the largest observed for this station since the beginning of this study in 1976.

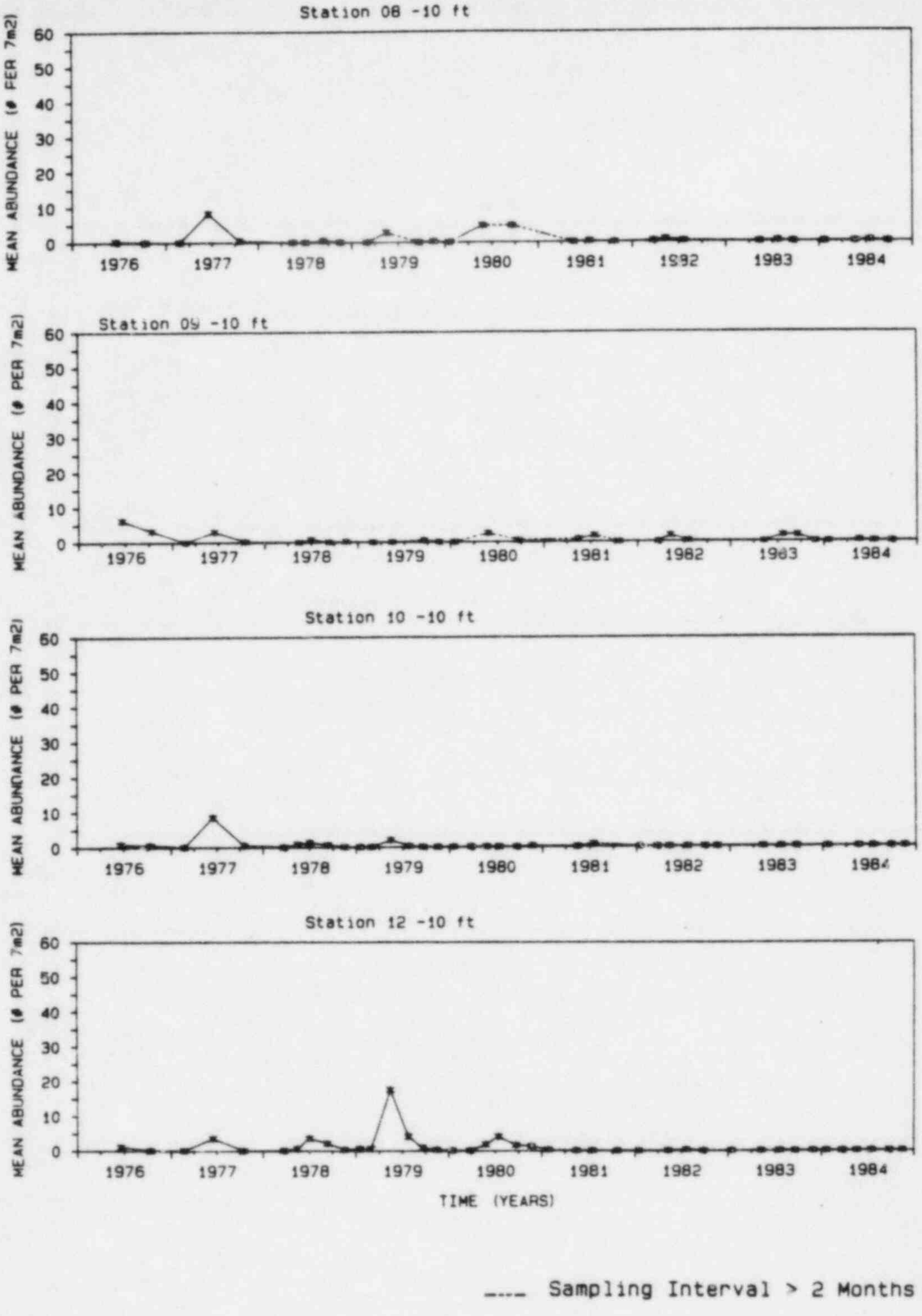


FIGURE 2-33

ABUNDANCE VERSUS TIME FOR SUBTIDAL NEREOCYSTIS LUETKEANA IN DIABLO COVE (SAQ METHOD)

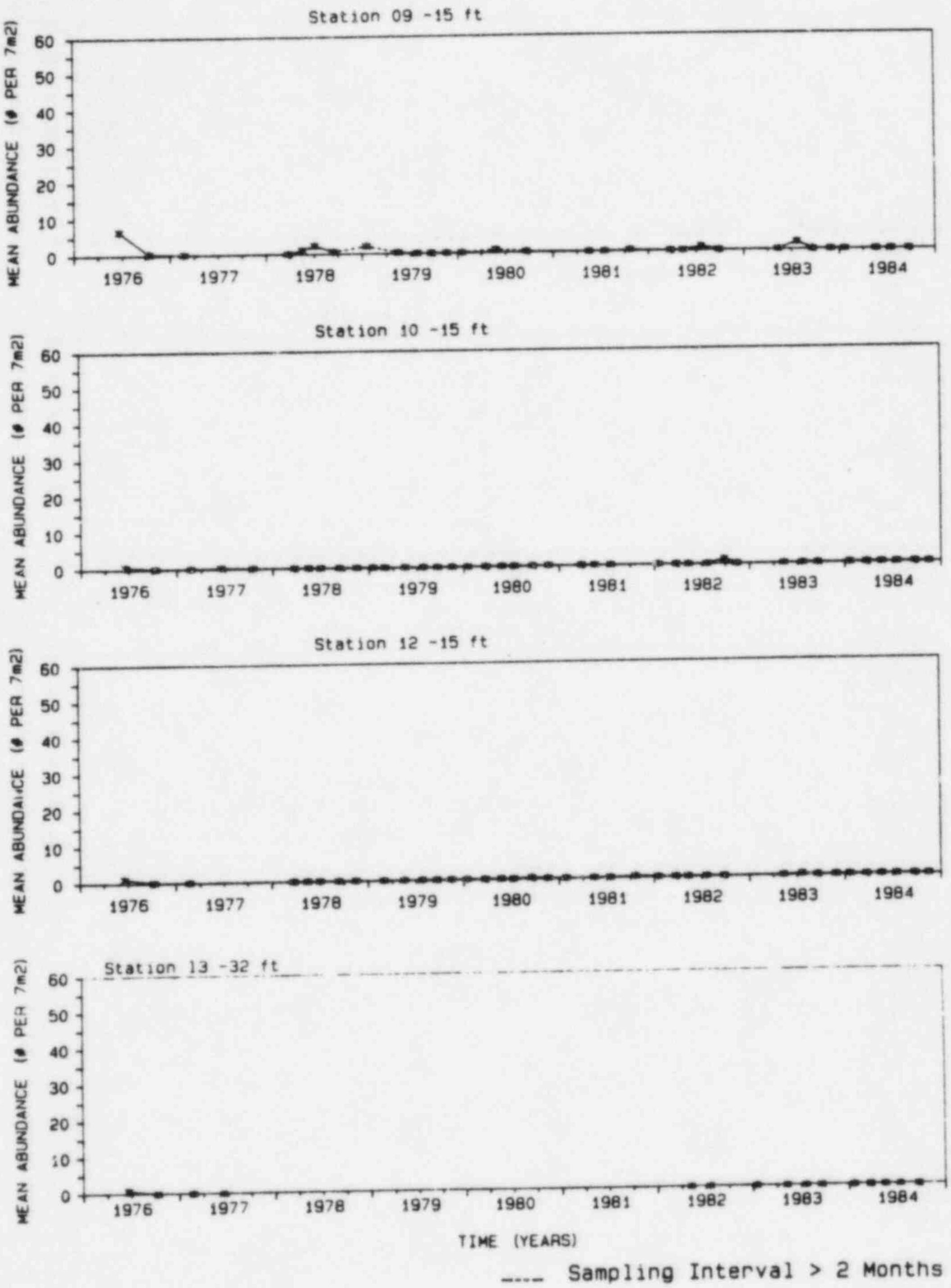


FIGURE 2-33 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL *NEREOCYSTIS LUETKEANA* IN DIABLO COVE (SAQ METHOD)

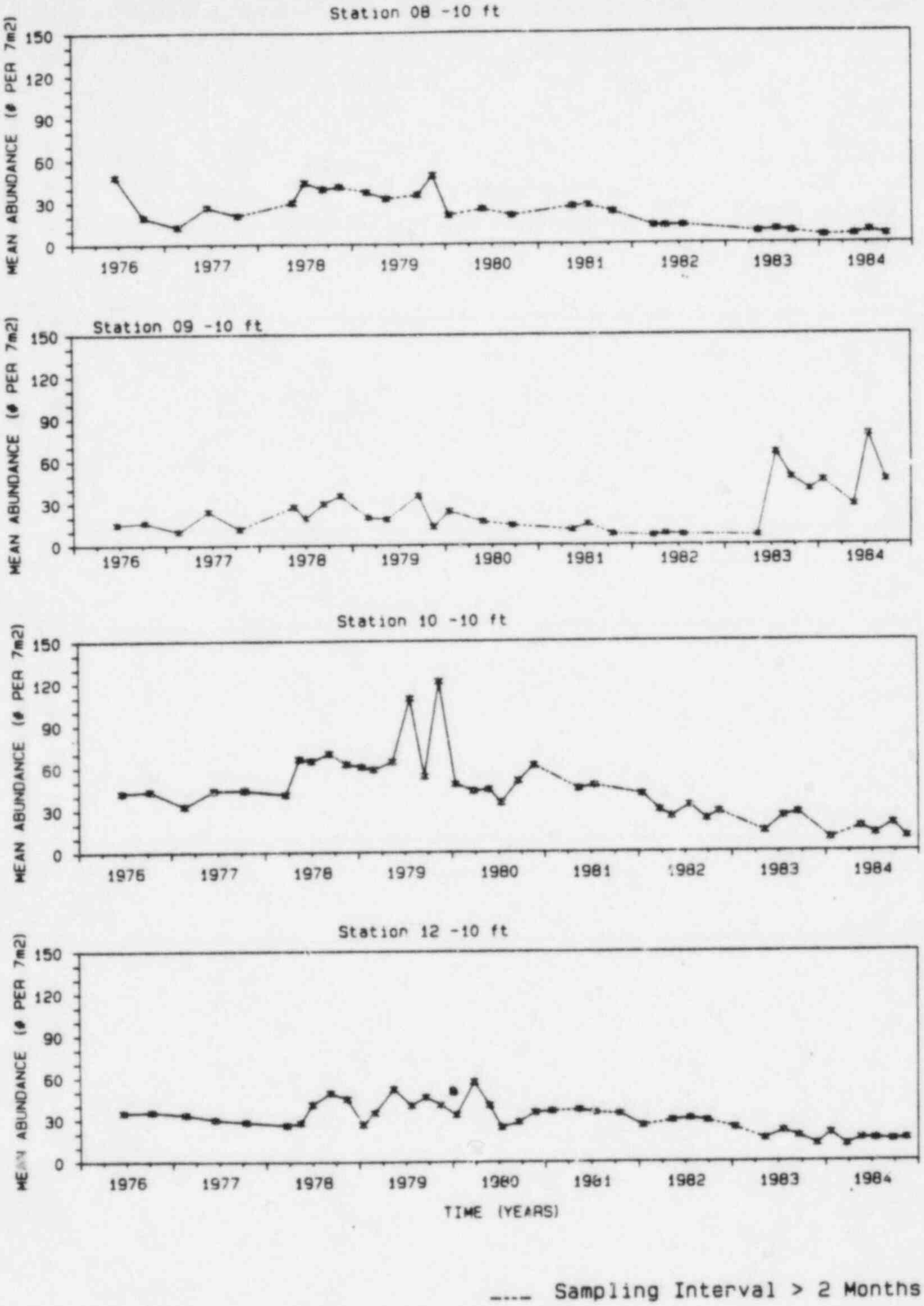


FIGURE 2-34

ABUNDANCE VERSUS TIME FOR SUBTIDAL PTERYGOPHORA CALIFORNICA IN DIABLO COVE (SAQ METHOD)

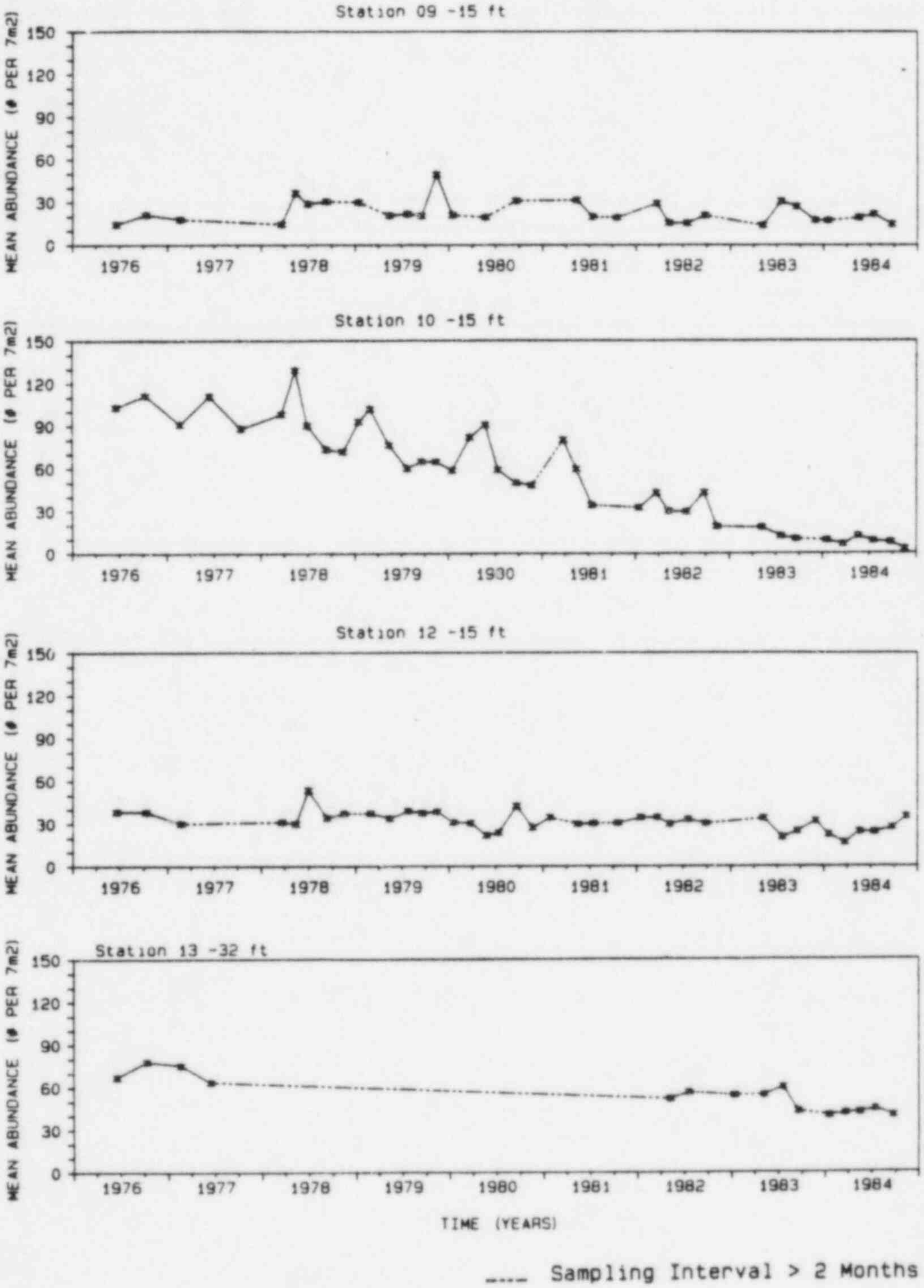


FIGURE 2-34 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL PTERYGOPHORA CALIFORNICA IN DIABLO COVE (SAQ METHOD)

Despite large variations in Pterygophora recruitment and mortality, this species has always been a conspicuous alga at all TEMP subtidal stations. Long-term (year-to-year) abundance trends for this species at Stations 9-15 and 12-15 appear to be quite stable. Gradual long-term decreases are apparent at Stations 8-10, 10-10, 12-10, and 13-32. At Station 10-15 there has been a dramatic and steady decline in Pterygophora densities over the course of this study. Station 10-15 was originally occupied by adult Pterygophora plants dominating stable substrata areas. Densities (greater than 100 plants/ 7 m^2) were so great that the blades of these plants formed nearly a continuous canopy over the station. The abundance of understory algae was sparse because of the shading effect of the thick canopy. Pterygophora recruitment occurred each spring-summer, but the young plants were confined to unstable substrate areas which were not under the direct shading influence of the adult canopy. Consequently, these juvenile plants were probably short-lived due to their attachment on unstable substrate (rocks small enough to be moved by water movement). As the adult plants gradually senesced or were broken by storms, the shading effect of the canopy was reduced, which increased opportunities for new plants to colonize the stable substrata. However, instead of Pterygophora, other species (primarily Botryoglossum farlowianum, see Section 2.9.1.1. in this report) became more abundant.

Storms are a principal factor structuring nearshore subtidal communities in central California (Foster 1982). At Station 10-15 the gradual reduction of Pterygophora was likely the result of ineffective recruitment concurrent with repeated winter storms removing more and more adult plants. Although storms can override grazing effects (Cowen et al. 1982), increased grazing pressures by abundant species such as Tegula brunnea (Section 2.7.2.9 in this report) could have influenced the decrease in the number of Pterygophora plants at Station 10-15. However, juvenile Pterygophora plants have commonly been observed during the spring months; furthermore, the abundances of other algal species such as Laminaria dentigera (a closely related kelp species susceptible to grazing) have remained relatively stable at this station (FIGURE 2-32). Therefore, storm breakage and natural senescence were probably the chief factors which lowered the abundance of Pterygophora at Station 10-15. The fact that L. dentigera does not appear to be similarly affected by storms may be attributed to its more

elastic stipe being less prone to breakage compared to the more rigid stipe of Pterygophora.

2.7.2 INVERTEBRATES

This section contains descriptions of the abundance of nine taxa of macroinvertebrates sampled by the SAQ method: the anemone Anthopleura elegantissima; the sea stars Patiria miniata, Pisaster ochraceus, and Pycnopodia helianthoides; the sea urchins Strongylocentrotus franciscanus and S. purpuratus; the gastropods Astraea gibberosa, Haliotis rufescens, and Tegula brunnea; and the crab Pugettia producta. Data collected consist of counts of individual organisms present at a station. Descriptions of the general biology and thermal ecology of all but two of these species were presented in PGandE (1979).

Data for three invertebrate taxa in this section have been combined with those of their congeners to increase the data base for the genera. Data for Haliotis rufescens, the red abalone, were combined with those for the flat abalone, Haliotis walallensis. Pisaster ochraceus data were combined with data for P. brevispinus and P. giganteus because these latter taxa are generally subtidal species. Strongylocentrotus franciscanus and S. purpuratus were combined as a single taxon.

For each species, the total counts of individuals in each arc quadrant were averaged to yield a mean (N=4) abundance per arc quadrant (7 m^2) for each station sampled. An exception to this is the data for Tegula brunnea, which, because of its high abundance, was subsampled within one-third (2.33 m^2) of each arc quadrant. An overview of these species' abundances as the average number of individuals on each station for all surveys sampled is presented in TABLE 2-14. This table shows the relative distribution of these organisms among the subtidal stations in Diablo Cove.

TABLE 2-14

MEAN NUMBER OF INDIVIDUALS PER 28 $M^2 \pm 2$ S.E. FOR SELECTED INVERTEBRATE SPECIES AT DIABLO COVE SUBTIDAL STATIONS (SAQ METHOD)

Station/ Level	Number of Surveys (N)	*Anthopleura elegantissima*	*Astraea gibberosa*	*Haliotis* spp.	*Tegula brunnea**	*Strongylo-centrotus* spp.	*Pycnopodia helianthoides*	*Pisaster* spp.	*Patiria miniata*	*Pugettia producta*
8-10	29	2.1 ± 1.0	1.6 ± 1.1	2.3 ± 1.1	130.8 ± 35.8	0	1.7 ± 0.5	0.5 ± 0.3	6.9 ± 2.7	1.2 ± 0.8
9-10	30	2.7 ± 1.1	0.8 ± 0.4	1.1 ± 0.7	64.6 ± 10.4	0.1 ± 0.1	1.4 ± 0.5	0.5 ± 0.3	11.1 ± 4.4	0.5 ± 0.3
10-10	38	9.6 ± 2.1	4.1 ± 1.5	0.2 ± 0.2	94.3 ± 19.1	0.1 ± 0.1	1.5 ± 0.4	0.5 ± 0.3	24.2 ± 4.5	1.2 ± 0.7
12-10	41	4.4 ± 1.0	3.7 ± 1.4	0.1 ± 0.1	75.0 ± 15.6	0	1.5 ± 0.5	0.5 ± 0.3	11.6 ± 2.7	1.1 ± 0.5
9-15	30	8.7 ± 1.9	2.8 ± 1.1	0.3 ± 0.3	105.6 ± 19.5	0.1 ± 0.1	1.8 ± 0.7	1.1 ± 0.6	30.8 ± 6.2	0.7 ± 0.4
10-15	40	26.0 ± 4.1	9.8 ± 3.2	0	93.6 ± 14.4	0.1 ± 0.1	2.6 ± 0.8	1.2 ± 0.5	52.0 ± 8.0	0.4 ± 0.3
12-15	38	9.6 ± 1.7	5.6 ± 1.5	0	60.5 ± 12.0	0.1 ± 0.1	1.3 ± 0.3	0.6 ± 0.3	41.1 ± 7.3	0.8 ± 0.5
13-32	15	14.2 ± 3.9	6.7 ± 1.9	0	46.0 ± 21.7	0.1 ± 0.1	1.7 ± 1.2	4.6 ± 1.5	52.4 ± 16.5	0.1 ± 0.1

* Number per 9.33 m^2.

2.7.2.1 ANTHOPLEURA ELEGANTISSIMA

Anthopleura elegantissima is commonly called the aggregating sea anemone because in the intertidal region it frequently forms aggregations of up to several thousand individuals. Subtidally, Anthopleura is found as large, solitary individuals in cracks and crevices and under ledges in rocky areas or in the sand at the base of a rock shelf or boulder. The variation in abundance of Anthopleura seen at a given station through time may be largely due to the difficulty of sampling these animals when, after being disturbed, they contract into inconspicuous sand-covered bumps on a rock.

FIGURE 2-35 shows the abundance of Anthopleura over time for the subtidal stations in Diablo Cove. These anemones occur at all stations in numbers that range from an average of 2 to over 25 individuals per station per survey sampled (TABLE 2-14). This table shows Anthopleura to be more abundant on the stations in south Diablo Cove than on those in the northern part of the Cove. Anthopleura are also shown to be more abundant on the deeper stations than on the shallower ones. Abundances in 1984 were comparable to those of the 1976-1983 period.

2.7.2.2 ASTRAEA GIBBEROSA

Astraea gibberosa, the red turban (or top) snail is fairly common in the Diablo Cove subtidal stations. This species seems to prefer areas with thick mats of articulated coralline algae. Turban snails are probably exclusively herbivorous and have been observed to eat both drift and attached algae. Although no studies on the size distribution of Astraea in the Diablo Canyon area have been done, they appear to have a distinct bi-modal size distribution: the smaller size class is centered at approximately 25-35 mm shell diameter (1-1.5 in.) and the larger class is centered at 60 mm and larger (2.5-3 in.).

The abundance of Astraea through time is shown in FIGURE 2-36 for the Diablo Cove subtidal stations. They occur in numbers ranging from an average of 1 to 10 individuals per station per sample (TABLE 2-14). Astraea appears to be more

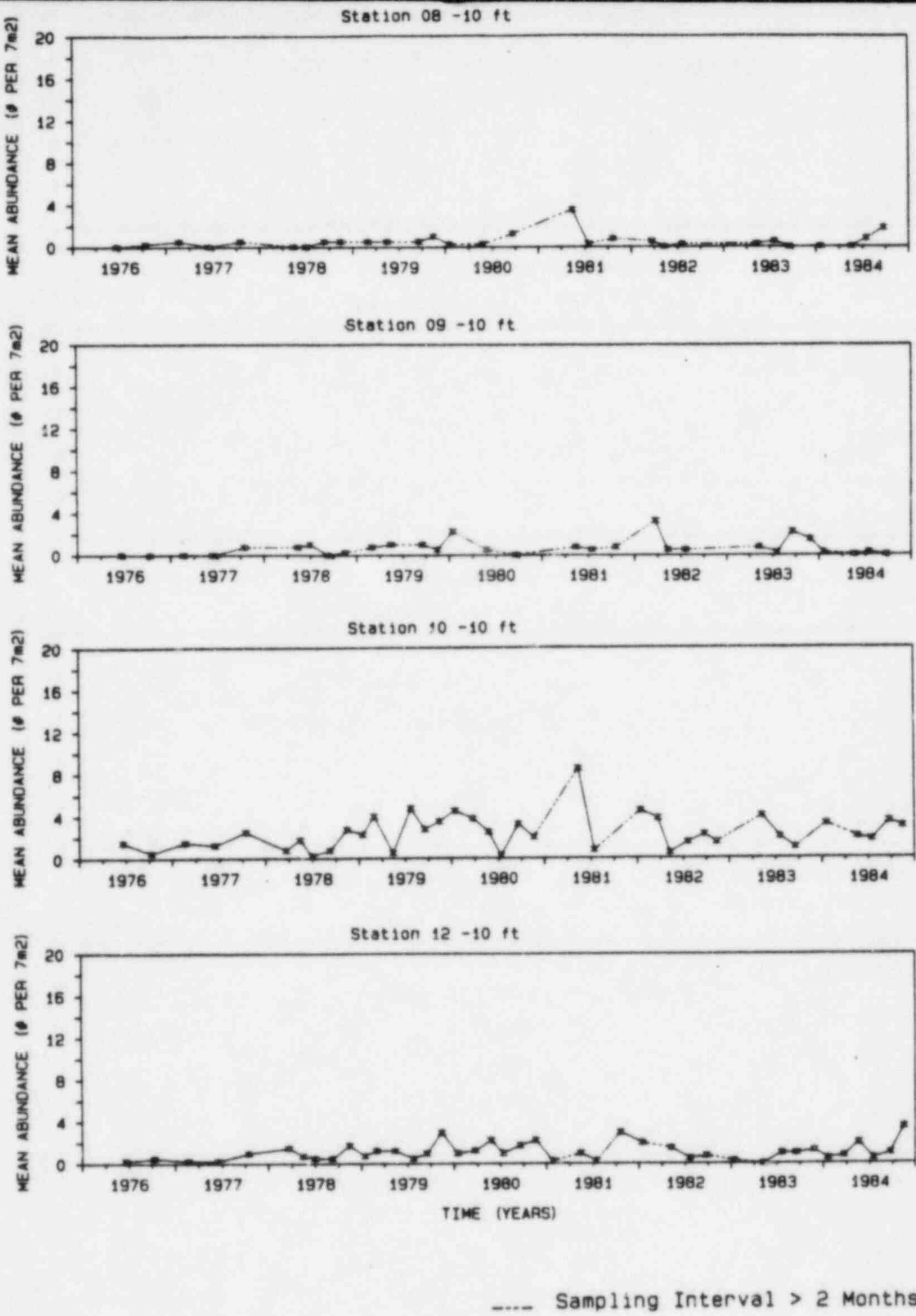


FIGURE 2-35

ABUNDANCE VERSUS TIME FOR SUBTIDAL ANTHOPLEURA ELEGANTISSIMA IN DIABLO COVE (SAQ METHOD)

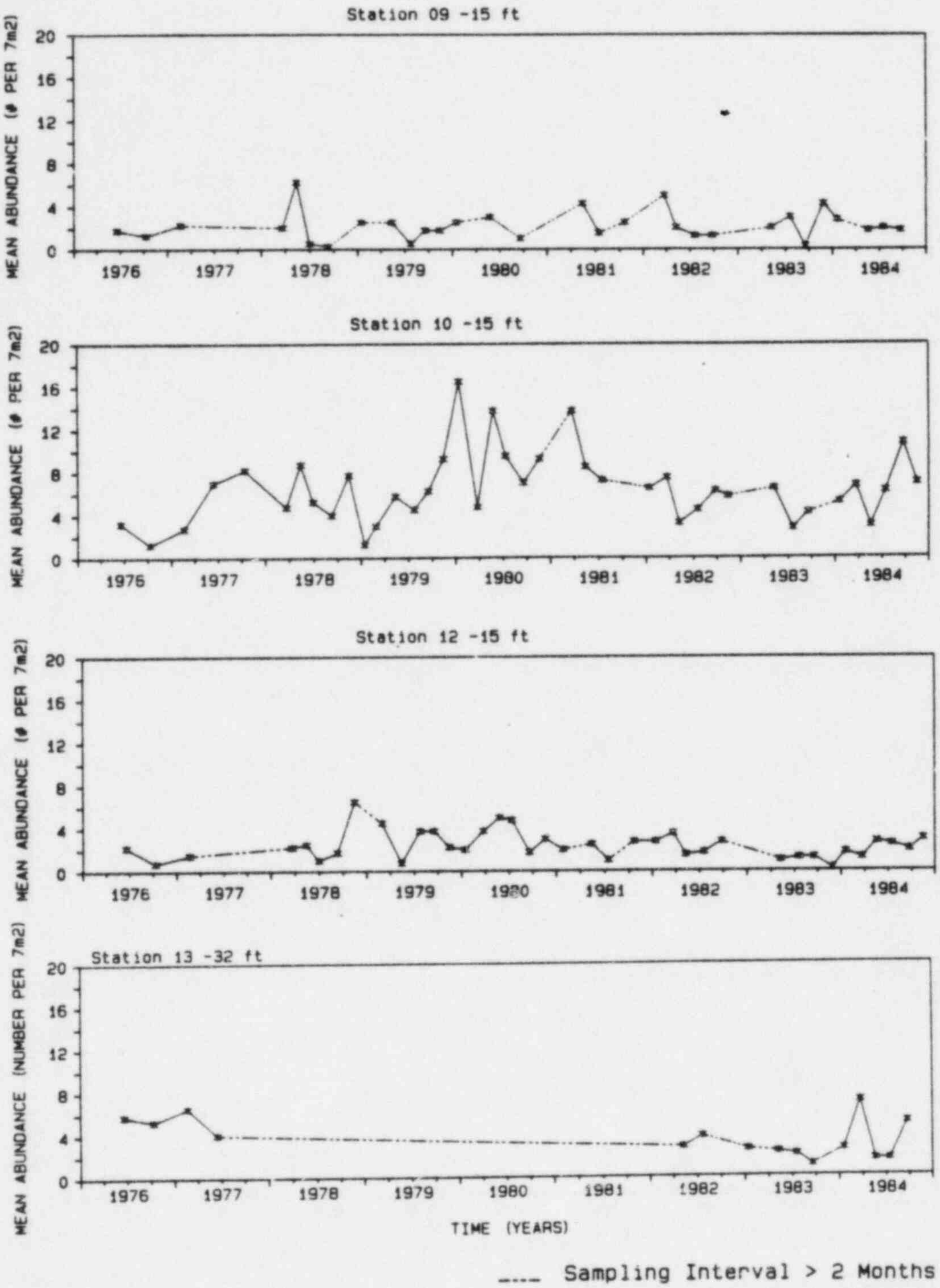
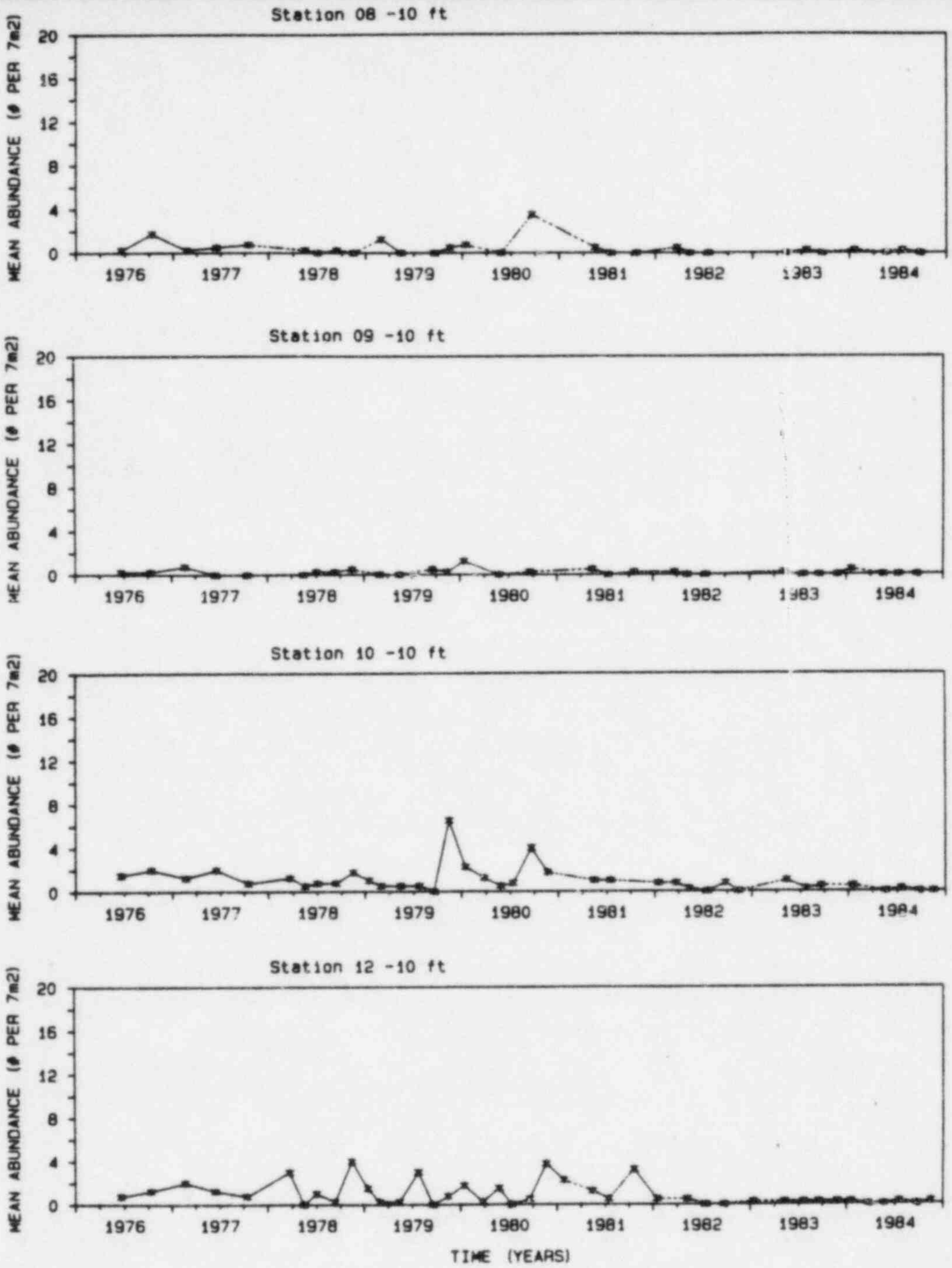


FIGURE 2-35 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL ANTHOPLEURA ELEGANTISSIMA IN DIABLO COVE (SAQ METHOD)



---- Sampling Interval > 2 Months

FIGURE 2-36

ABUNDANCE VERSUS TIME FOR SUBTIDAL ASTRAEA GIBBEROSA IN DIABLO COVE (SAQ METHOD)

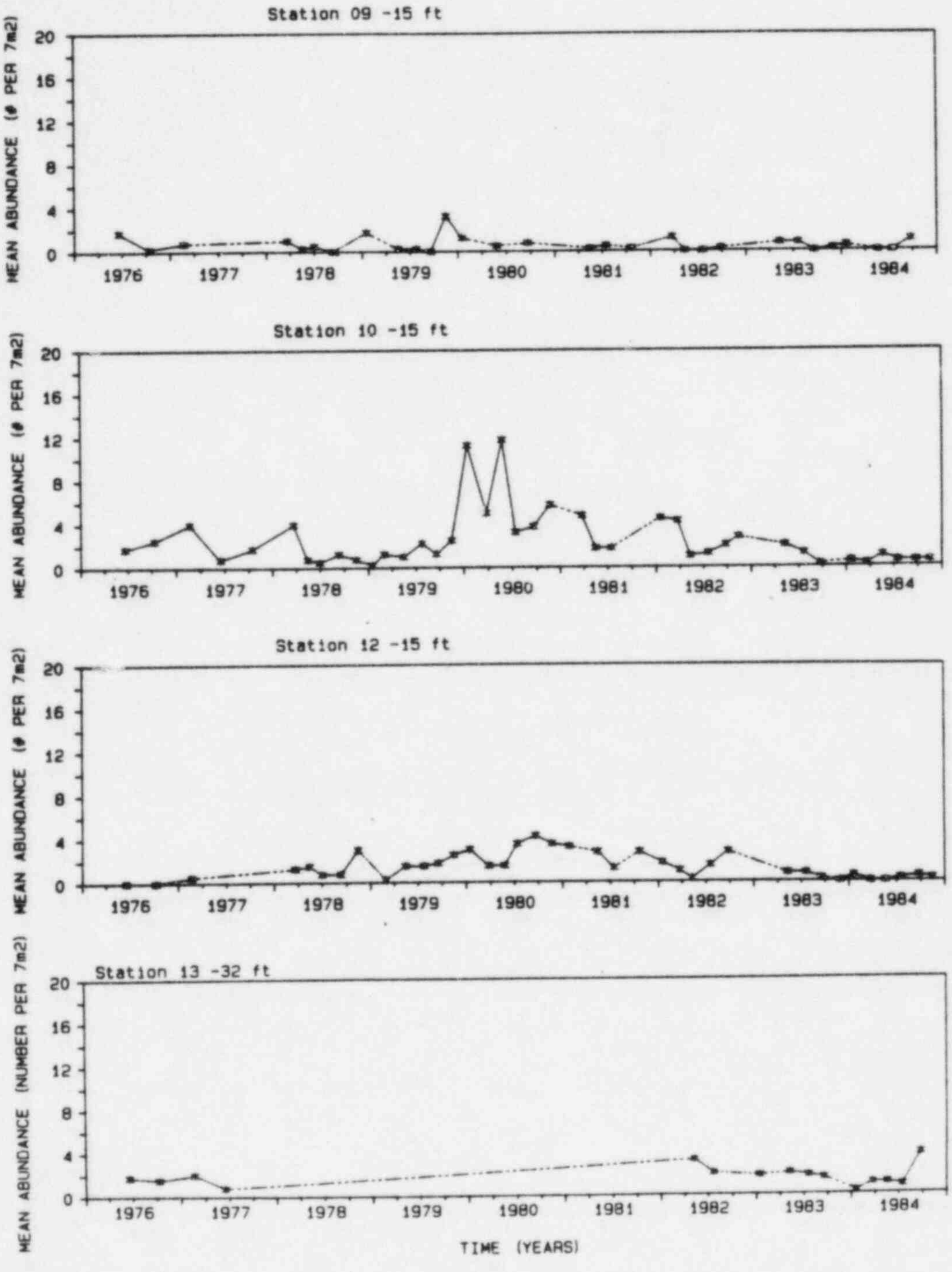


FIGURE 2-36 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL *ASTRAEA GIBBEROSA* IN DIABLO COVE (SAQ METHOD)

abundant on the stations in south Diablo Cove (Stations 10 and 12) than on those in north Diablo Cove (Stations 8 and 9) and slightly more abundant at the -15 ft stations than at the -10 ft stations. Abundances of this species have been lower from 1982 through 1984, compared with the 1976-1981 period. An exception is evident at Station 13-32, where in 1984 abundance was the highest recorded for that station during the study period.

2.7.2.3 HALIOTIS RUFESCENS AND H. WALALLENSIS

Red abalone, Haliotis rufescens, and the flat abalone H. walallensis are both present in Diablo Cove, although only two flat abalone have been recorded from the TEMP subtidal stations since May 1976. Burge and Schultz (1973) described the shallow (0 to 6 m) depths along most of the inside perimeter of Diablo Co:e as excellent abalone habitat, with a large population of H. rufescens and densities in some areas of 1.29 abalone/1 m^2. The entire subtidal community structure, including abalone abundance, changed dramatically a few years after the Burge and Schultz (1973) study with the arrival in the Diablo Cove area of the southern sea otter.

As seen in FIGURE 2-37 and TABLE 2-14, Haliotis are neither common nor abundant in the TEMP subtidal stations in Diablo Cove. North Diablo Cove Stations 8 and 9 show the greatest abundance of abalone through time. At Station 8-10, Haliotis abundance declined steadily with time. No Haliotis have been observed on Stations 10-15 or 12-15 in south Diablo Cove or on Station 13-32 in the center of the Cove. The low levels in 1984 are comparable to the 1976-1983 period.

2.7.2.4 PATIRIA MINIATA

Bat stars, Patiria miniata, are a conspicuous macroinvertebrate in the SAQ samples. They are omnivorous scavengers, not predators as are most asteroids, and are seldom seen actively moving about. Patiria are commonly found on sediments or cobbles and are easily dislodged from the substrate.

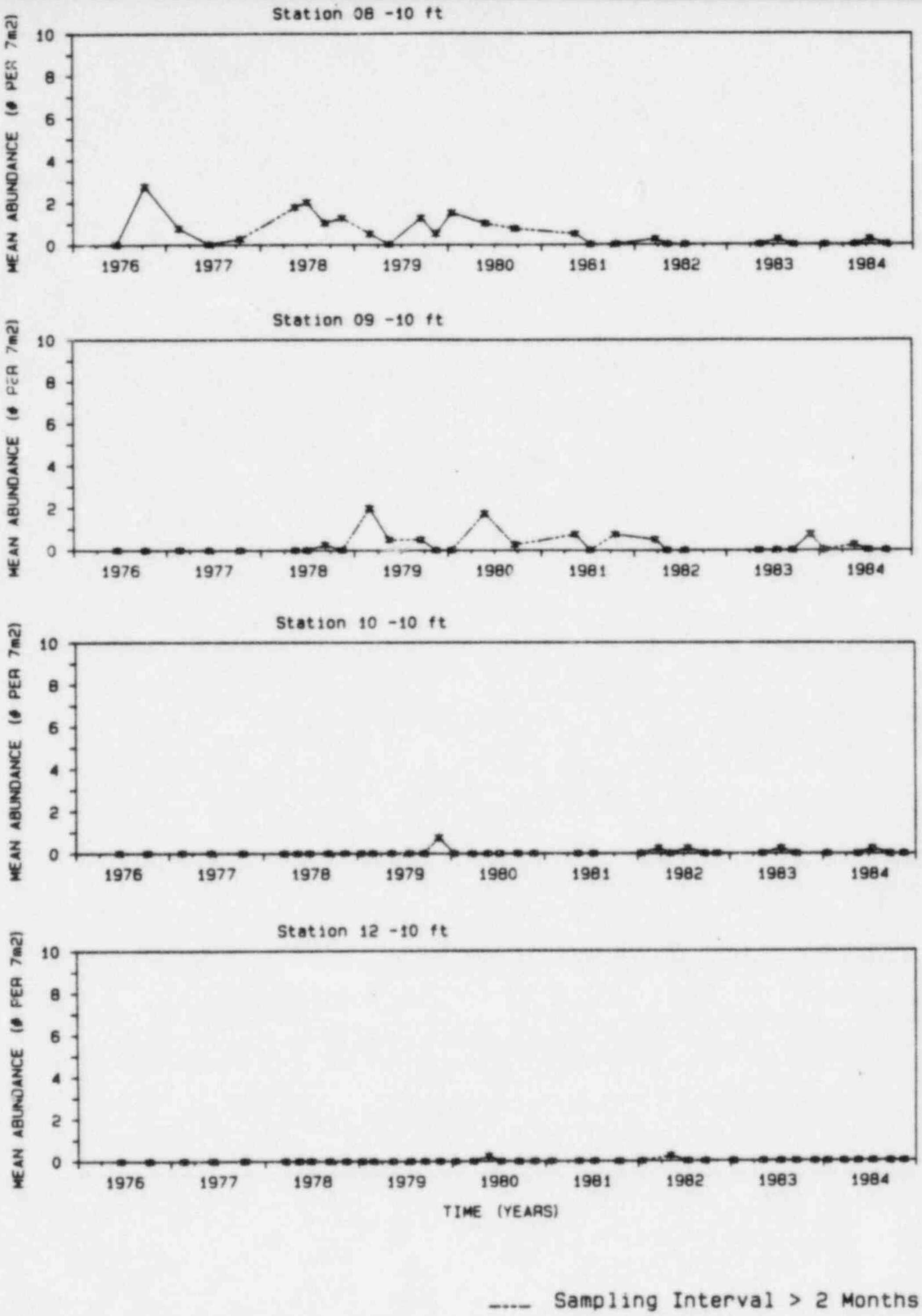


FIGURE 2-37

ABUNDANCE VERSUS TIME FOR SUBTIDAL HALIOTIS RUFESCENS AND H. WALALLENSIS IN DIABLO COVE (SAQ METHOD)

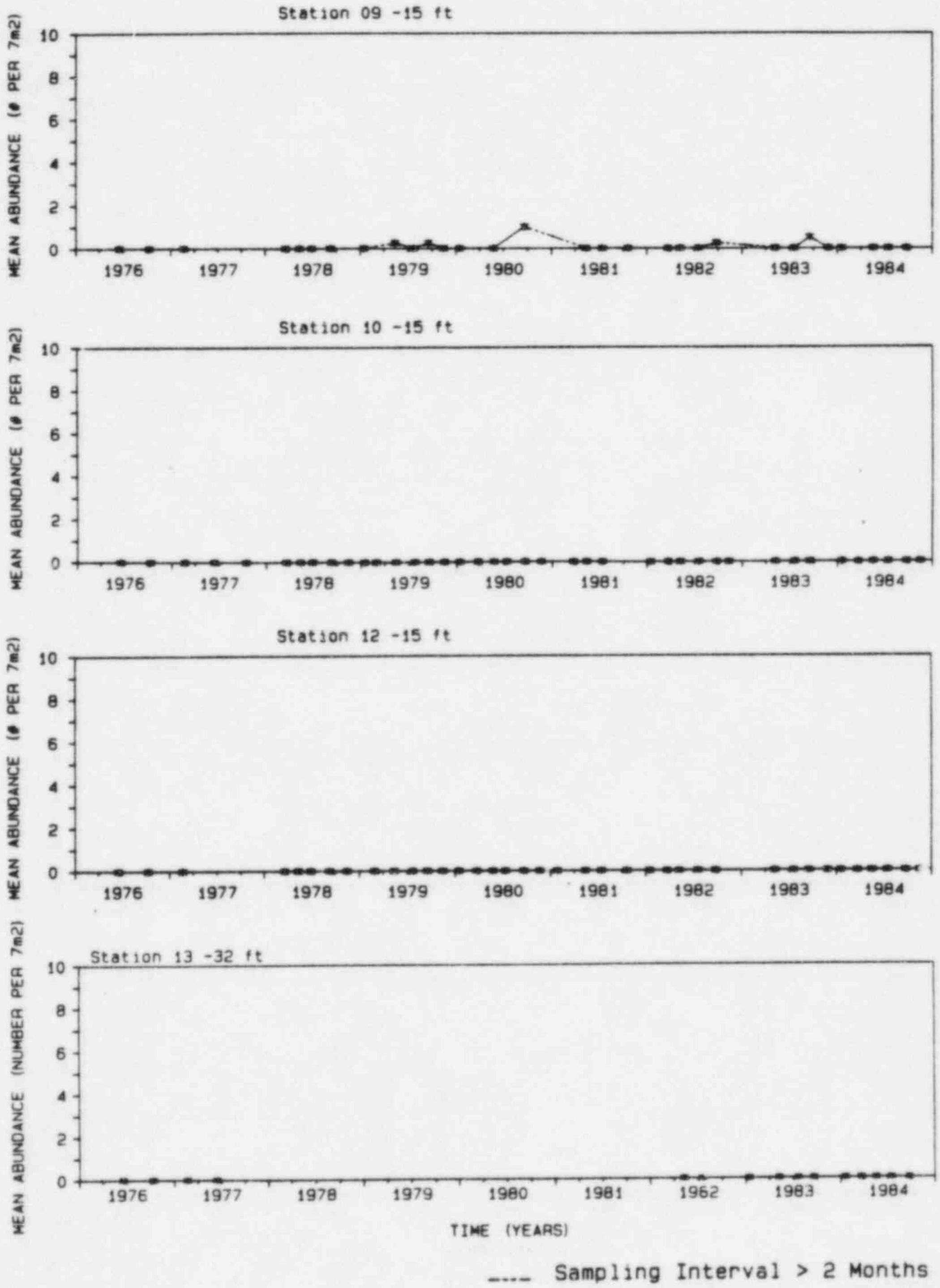


FIGURE 2-37 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL HALIOTIS RUFESCENS AND H. WALALLENSIS IN DIABLO COVE (SAQ METHOD)

The abundance of Patiria through time is shown in FIGURE 2-38 for the subtidal stations in Diablo Cove. Patiria is more abundant on the stations in the southern half of Diablo Cove than on those in the northern half, and their abundance increases with increasing depth (see also TABLE 2-14). Their distribution is probably strongly influenced by water turbulence, as indicated by the fact that the animals are more common in areas with lower turbulence. Over the study period, Patiria have been present in numbers ranging from an average of about 7 to 50 individuals per station per survey (TABLE 2-14). Most of the stations exhibited a sharp decline in Patiria abundance to the lowest levels recorded in the second half of 1983. The storms of 1982-83 were probably the cause of this decrease in that the water movement most likely dislodged many animals in the surf zone. The lower abundances of these species continued to be recorded in 1984.

2.7.2.5 PISASTER OCHRACEUS, P. GIGANTEUS, AND P. BREVISPINUS

These three species of Pisaster occur intermittently on the Diablo Cove subtidal stations. As an active predator on mussels and barnacles, P. ochraceus, the ochre sea star, is a common and important member of the rocky shore intertidal communities. It is generally replaced in the shallow subtidal areas of Diablo Cove by P. brevispinus, also an active predator on molluscs. Pisaster giganteus are most abundant in the deeper subtidal areas.

FIGURE 2-39 shows that the abundance of Pisaster on the subtidal stations is low, generally averaging one or two sea stars per station when present. On Station 13-32, Pisaster was present in significantly higher numbers with an average of about 5 sea stars per station for each of the 15 surveys (TABLE 2-14). Pisaster was present in slightly more than 50 per cent of the surveys sampled at Stations 8 and 9 and in less than 50 percent of the surveys sampled at Stations 10 and 12, with the exception of Station 10-15 where Pisaster was present in most of the 40 surveys for which that station was sampled. Abundances of these species in 1984 are comparable to those of the 1976-1983 period.

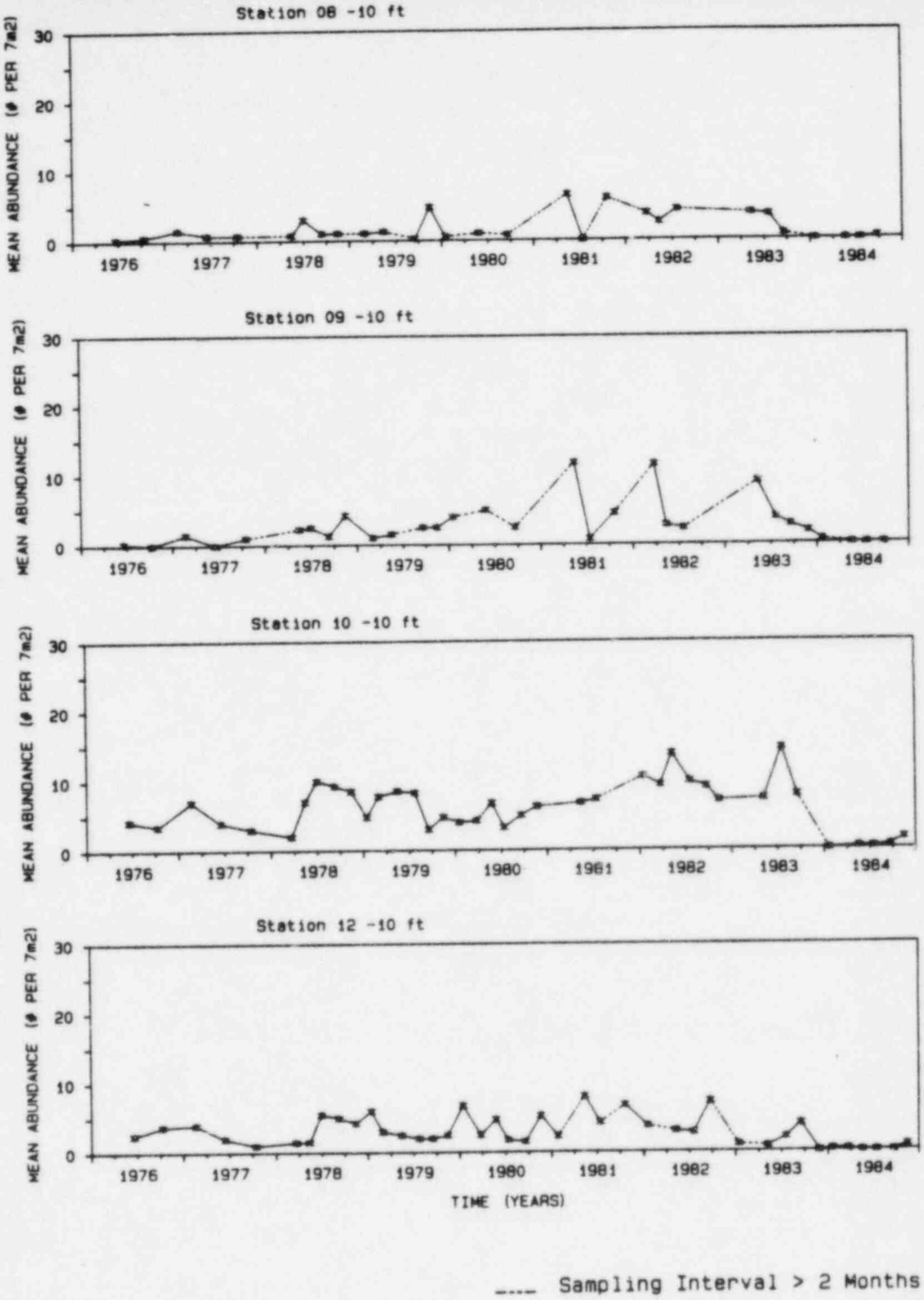


FIGURE 2-38

ABUNDANCE VERSUS TIME FOR SUBTIDAL <u>PATIRIA MINIATA</u> IN DIABLO COVE (SAQ METHOD)

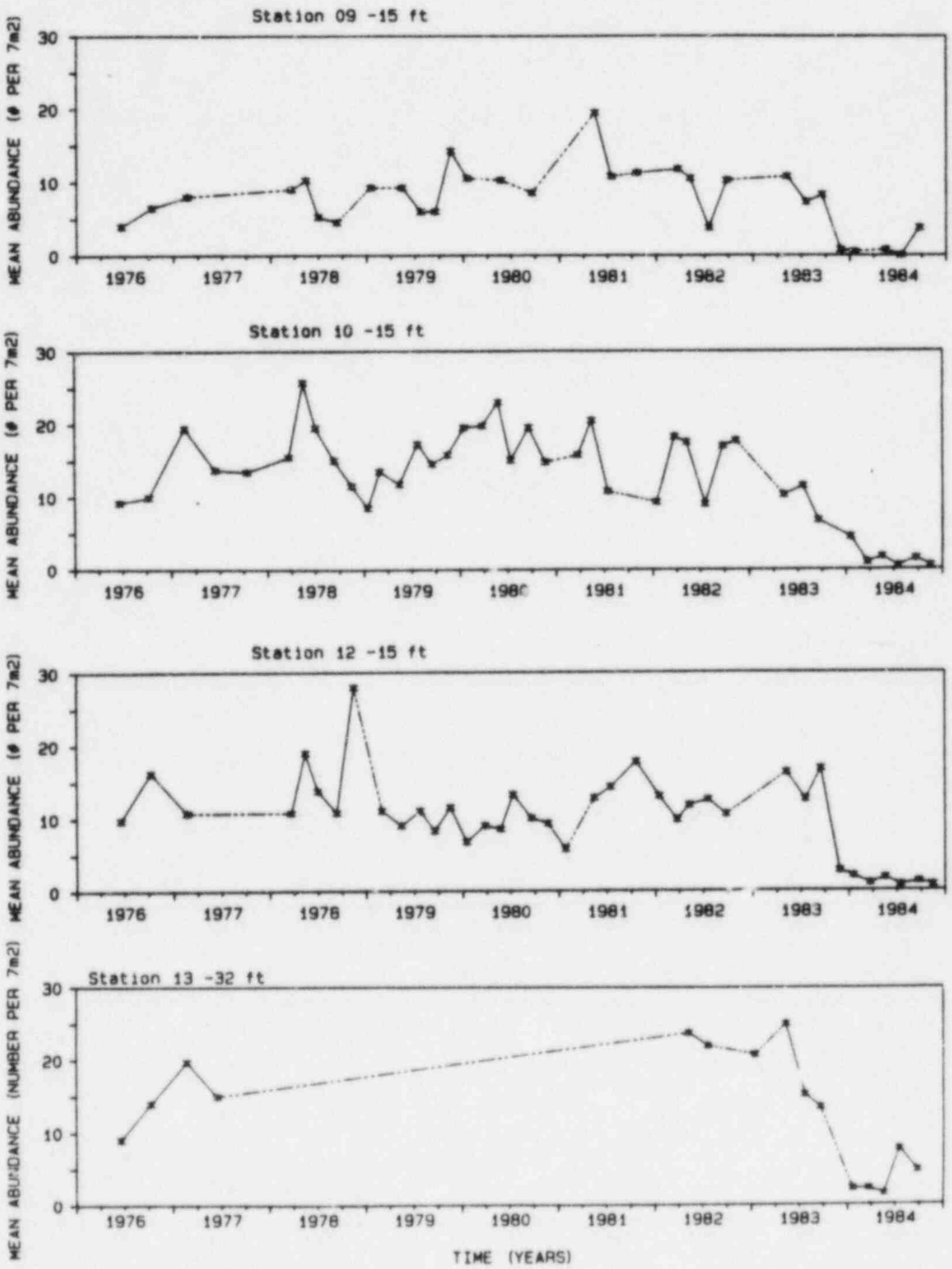


FIGURE 2-38 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL *PATIRIA MINIATA* IN DIABLO COVE (SAQ METHOD)

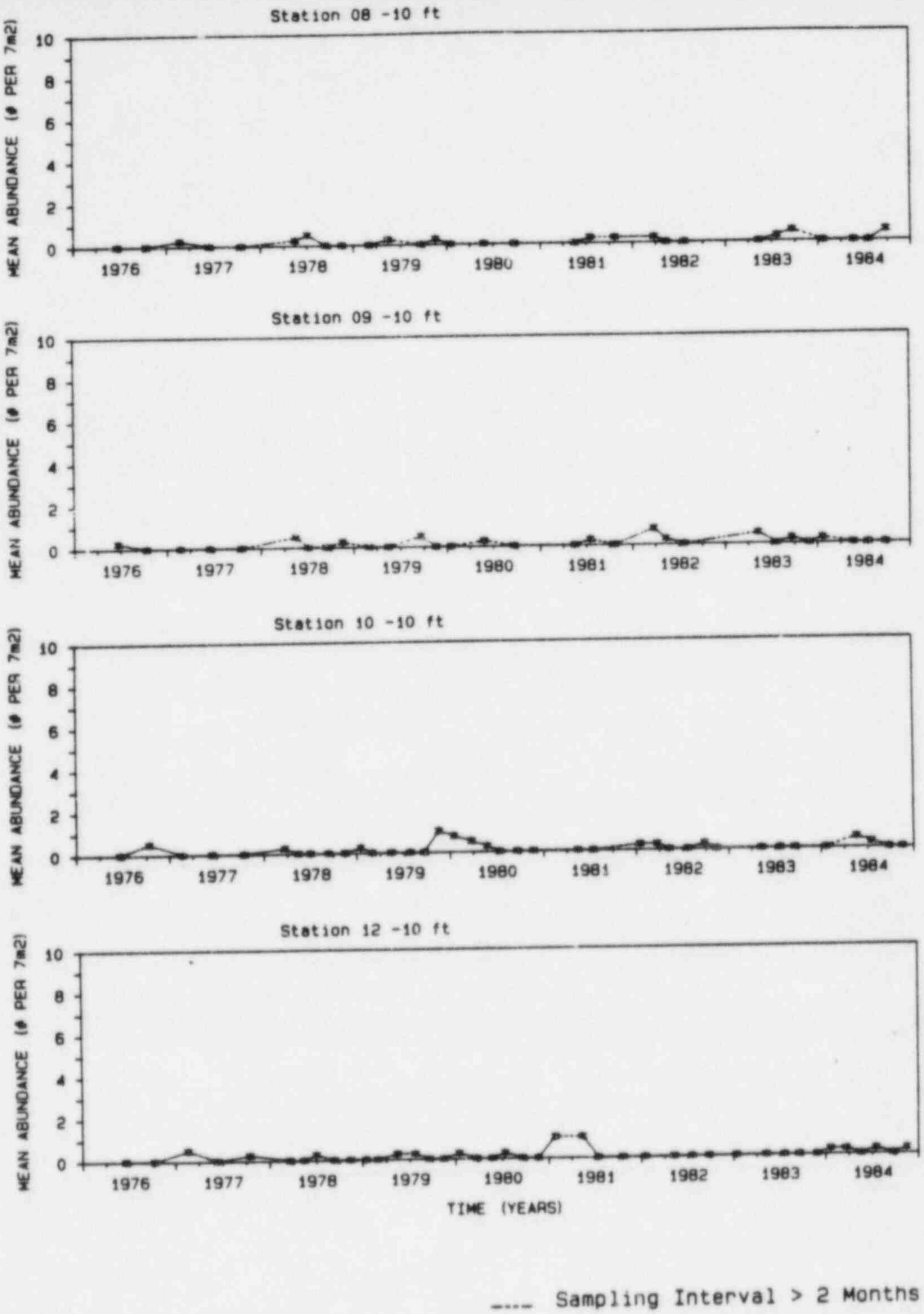


FIGURE 2-39

ABUNDANCE VERSUS TIME FOR SUBTIDAL PISASTER OCHRACEUS, P. GIGANTEUS, AND P. BREVISPINUS IN DIABLO COVE (SAQ METHOD)

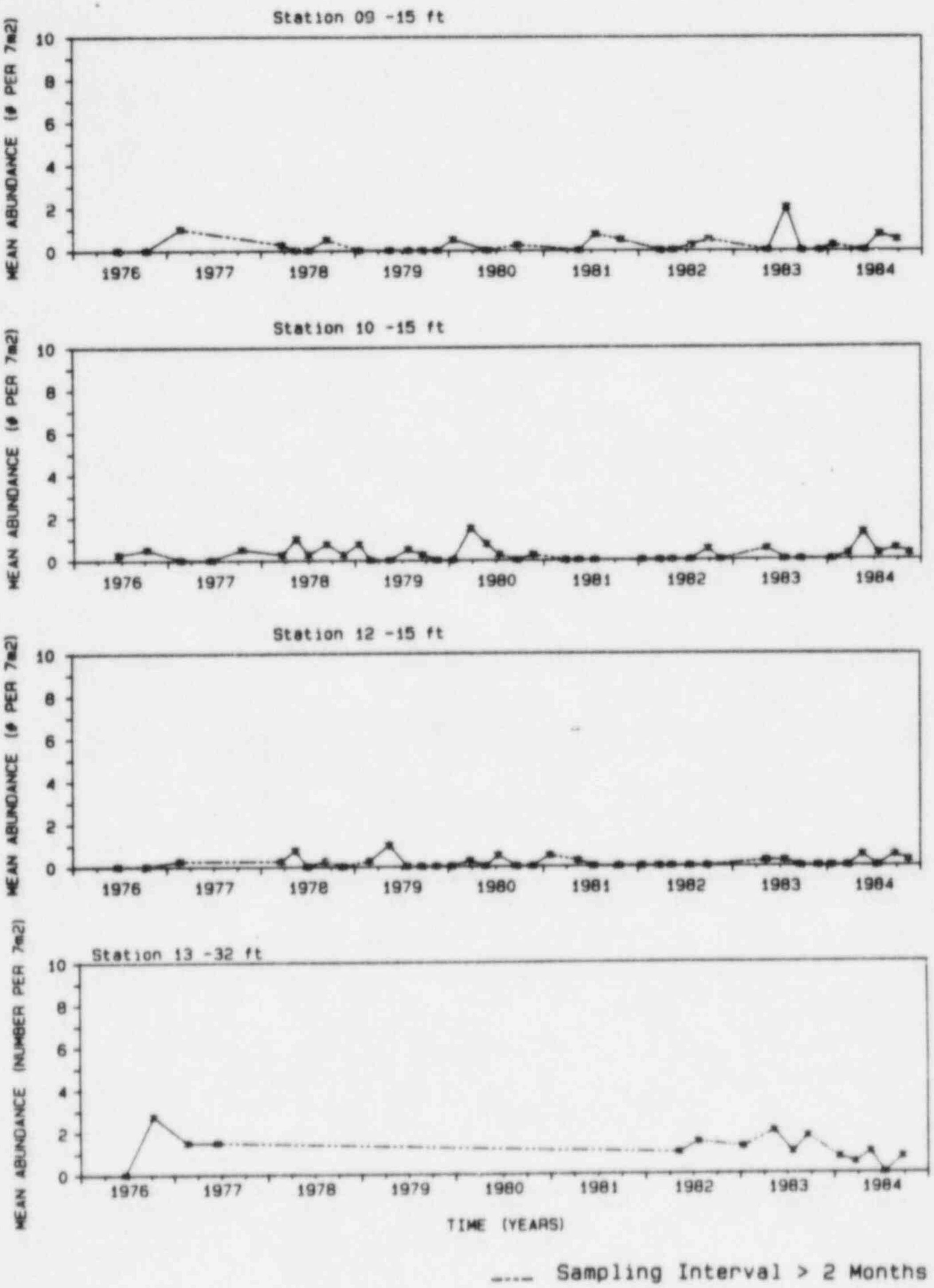


FIGURE 2-39 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL *PISASTER OCHRACEUS*, *P. GIGANTEUS*, AND *P. BREVISPINUS* IN DIABLO COVE (SAQ METHOD)

2.7.2.6 PUGETTIA PRODUCTA AND P. RICHII

Pugettia producta is a member of the spider crab family, but is commonly called the kelp crab. Large adults are generally found in the canopy of the brown algae Cystoseira and Pterygophora. Juvenile P. producta are distributed throughout the intertidal and shallow subtidal areas, usually in the understory algae. Pugettia richii, the decorator crab, is common subtidally in the understory algae, particularly the articulated corallines. Both species are herbivorous and are important forage items for various fishes found in the study area (Quast 1968, PGandE 1979).

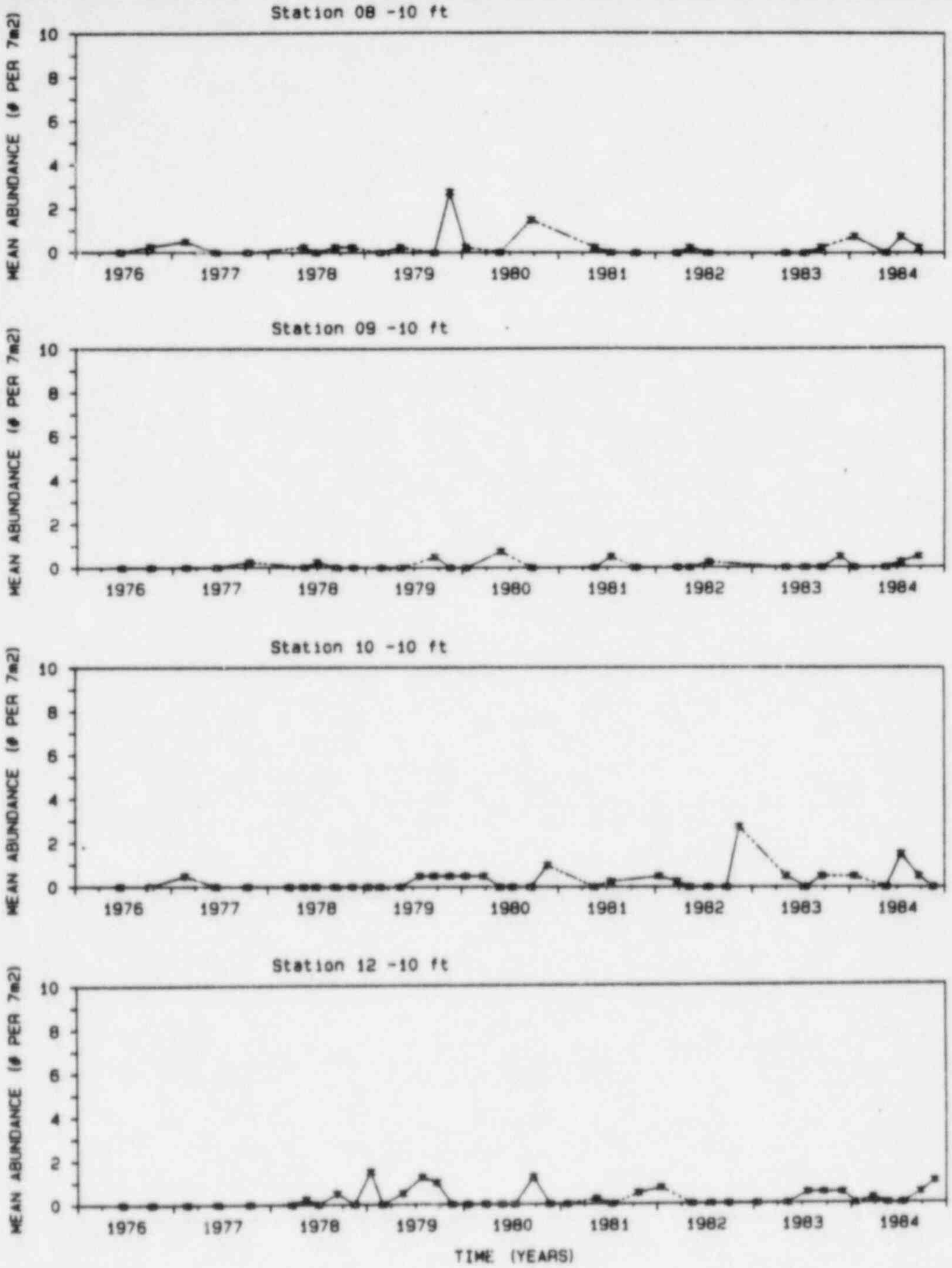
The graphs in FIGURE 2-40 show the abundances of Pugettia for each Diablo Cove subtidal station through time. In general, the abundances of Pugettia are low and its occurrence on the subtidal stations is sporadic. These crabs appear to prefer shallower subtidal areas; no Pugettia have been found on Station 13-32.

The data for Station 12-15 indicate that a peak abundance was recorded in 1984. Abundances at other stations are comparable to the 1976-1983 period.

2.7.2.7 PYCNOPODIA HELIANTHOIDES

Pycnopodia helianthoides, commonly called the sunflower star, is a large, fast-moving, active predator on sea urchins, bivalves, chitons, gastropods, other sea stars, sea cucumbers, and crabs (Morris et al. 1980). Proximity to or contact with Pycnopodia initiates an escape response in many of its prey species, including abalone (Montgomery 1967). They are very conspicuous when present on a station and are not easily overlooked by divers.

As seen in FIGURE 2-41, Pycnopodia was present in 70-80 percent of the surveys at each station. The average number of Pycnopodia present on a station was between 1 and 2; Station 10-15 in south Diablo Cove had a slightly higher abundance than the other stations (TABLE 2-14). These sea stars do not appear to show a preference for a particular area or depth within Diablo Cove, although at Station 13-32 they were present in only about 50 percent of the surveys



---- Sampling Interval > 2 Months

FIGURE 2-40

ABUNDANCE VERSUS TIME FOR SUBTIDAL PUGETTIA PRODUCTA IN DIABLO COVE (SAQ METHOD)

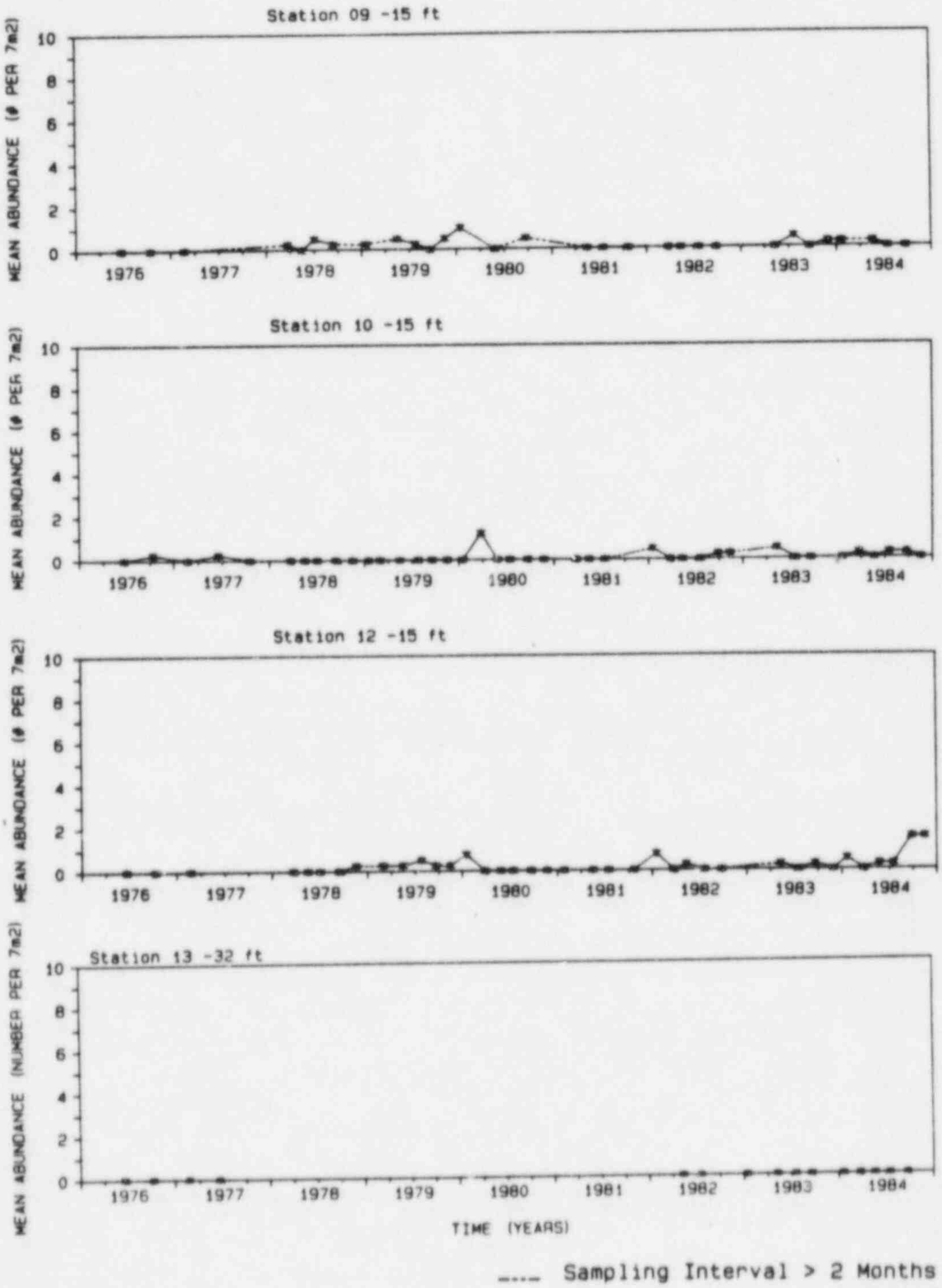


FIGURE 2-40 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL *PUGETTIA PRODUCTA* IN DIABLO COVE (SAQ METHOD)

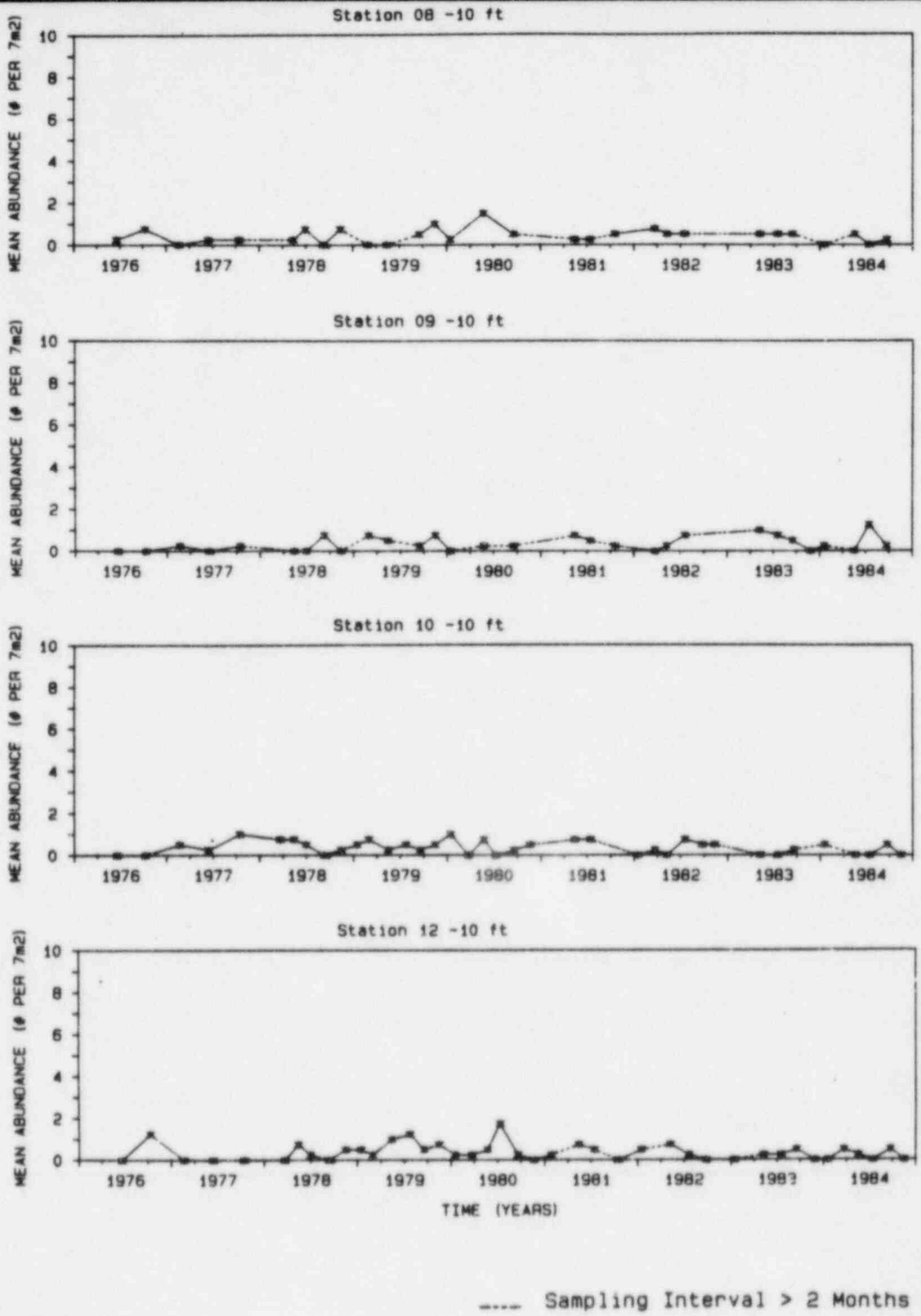


FIGURE 2-41

ABUNDANCE VERSUS TIME FOR SUBTIDAL PYCNOPODIA HELIANTHOIDES IN DIABLO COVE (SAQ METHOD)

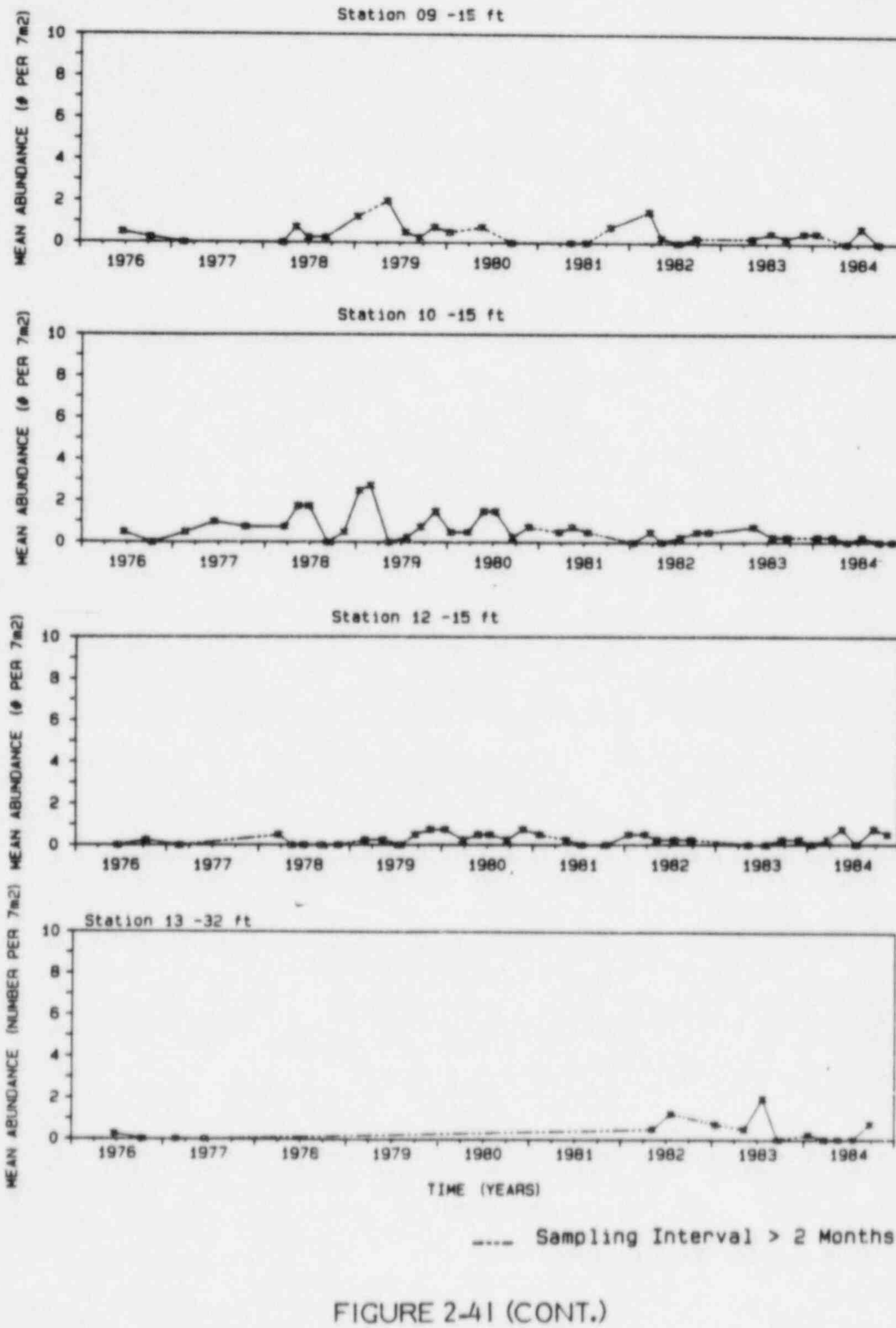


FIGURE 2-41 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL PYCNOPODIA HELIANTHOIDES IN DIABLO COVE (SAQ METHOD)

sampled. The data for Station 9-10 reveal a peak abundance in 1984 for that station. The values for all other stations appear comparable to those of the 1976-1983 period.

2.7.2.8 STRONGYLOCENTROTUS FRANCISCANUS AND S. PURPURATUS

Both the red sea urchin, Strongylocentrotus franciscanus, and the purple urchin, S. purpuratus, occur in the Diablo Cove subtidal stations. Strongylocentrotus displays two basic types of feeding behavior depending upon the prevailing environmental conditions: (1) feeding predominantly on drift algae, especially brown algae, and (2) grazing on attached microscopic and macroscopic algae. In areas where Strongylocentrotus is abundant, it may play a significant role in determining the species composition and relative abundance of the associated algae.

Prior to 1974, Strongylocentrotus densities in Diablo Cove reached 105/1 m^2 in areas described by North (1971) as "barren areas," because of the almost complete lack of algae (Benech and Colson 1976). The densities of both species of urchins were reduced drastically due to foraging activities by the southern sea otter which arrived in Diablo Cove in 1974. As indicated in TABLE 2-14 and FIGURE 2-42, a total of less than 20 Strongylocentrotus were counted on all subtidal stations in Diablo Cove during all subtidal surveys since May 1976.

2.7.2.9 TEGULA BRUNNEA

Brown turban snails, Tegula brunnea, are ubiquitous throughout the Diablo Canyon subtidal areas and the most abundant invertebrate species sampled by the SAQ method in the Diablo Canyon TEMP subtidal stations. The majority of adult Tegula are found off the bottom, in the fronds and stipes of the large brown algae Pterygophora, Laminaria, and Cystoseira. Juveniles are generally associated with understory algae, particularly the fleshy red algae. These snails are probably exclusively herbivorous with a marked food preference for the brown algae (Morris et al. 1980, PGandE 1979).

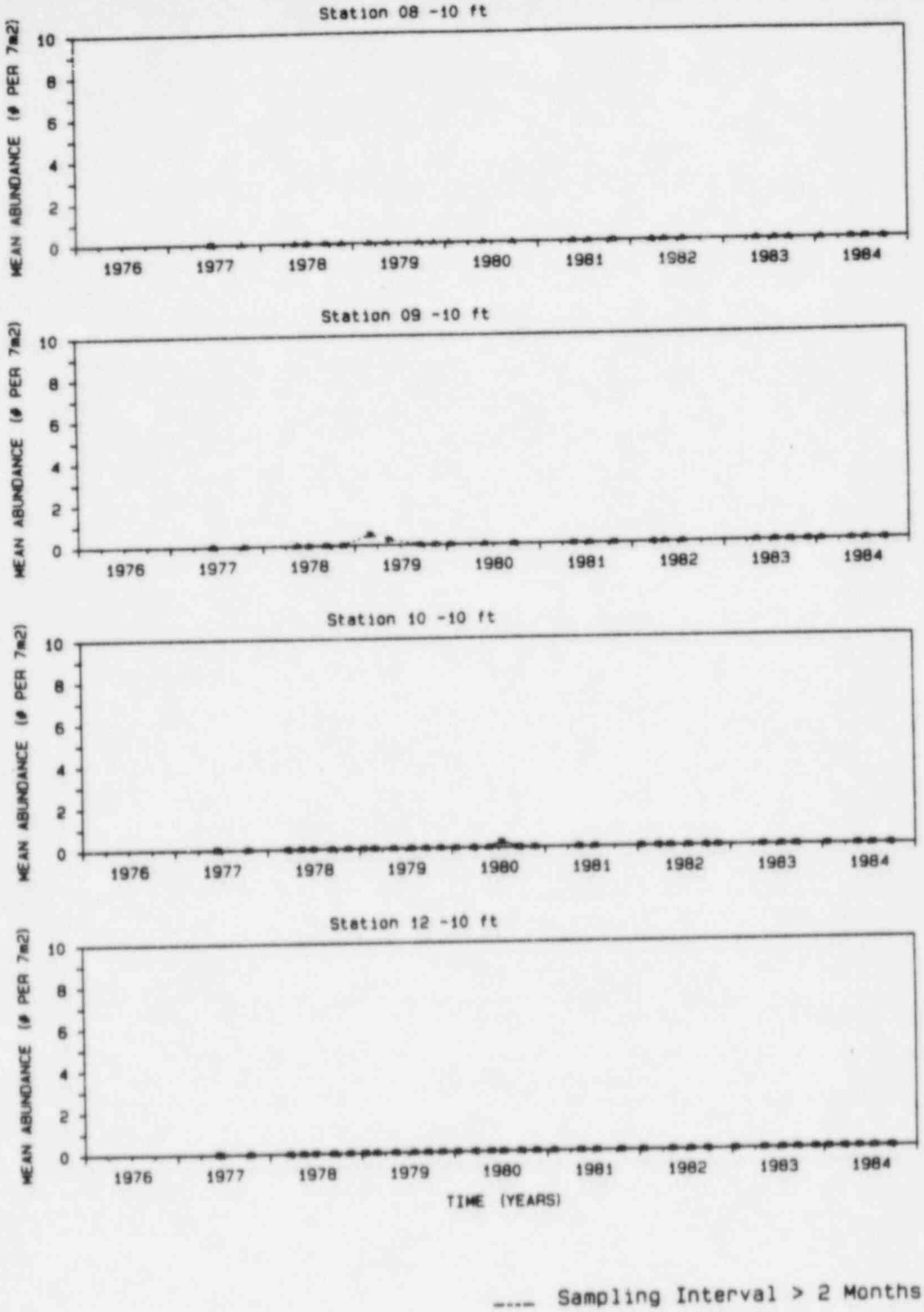


FIGURE 2-42

ABUNDANCE VERSUS TIME FOR SUBTIDAL STRONGYLOCENTROTUS PURPURATUS AND S. FRANCISCANUS (SAQ METHOD)

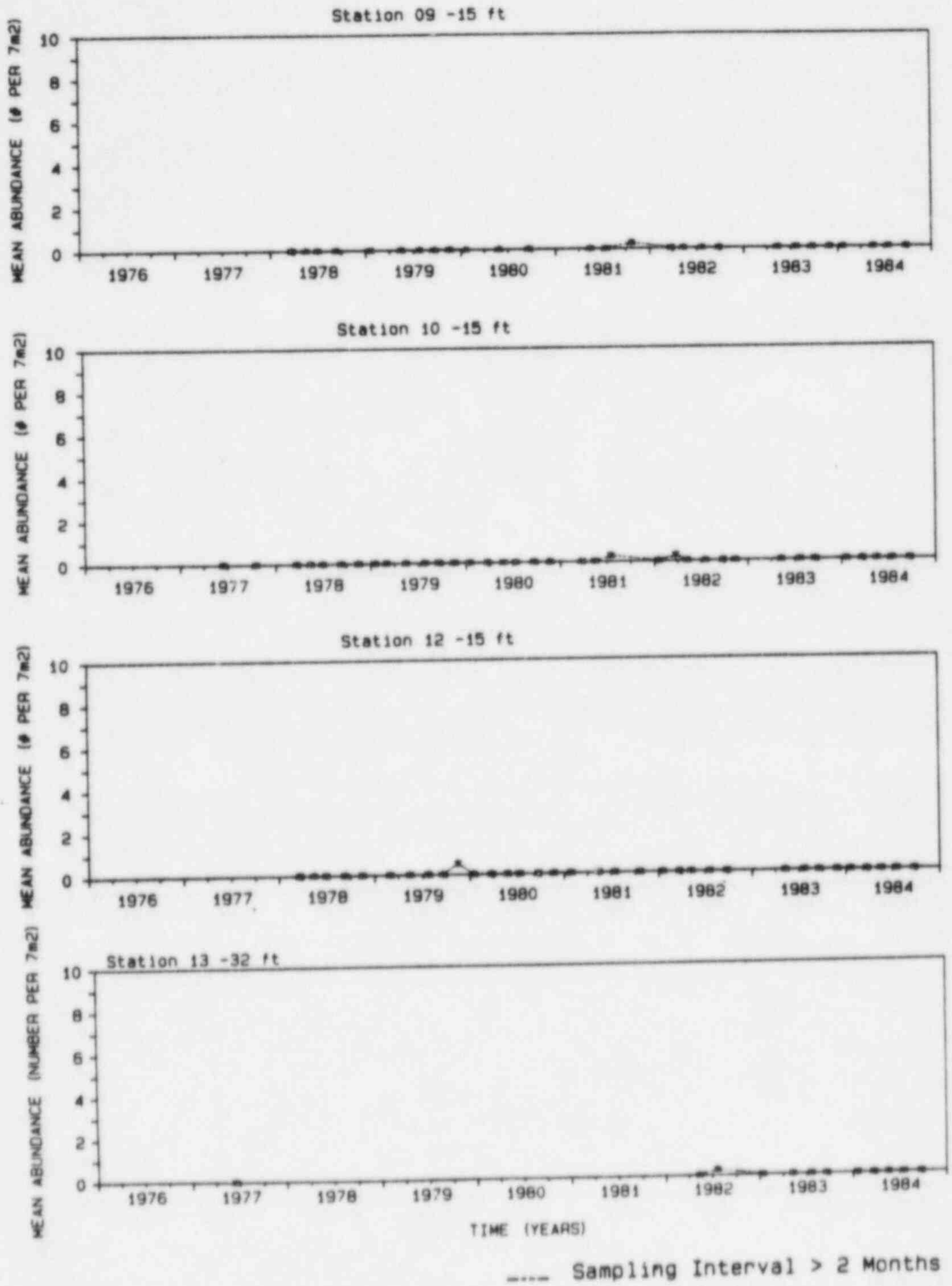


FIGURE 2-42 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL STRONGYLOCENTROTUS PURPURATUS AND S. FRANCISCANUS (SAQ METHOD)

Because of their high abundance on the subtidal stations, which makes accurate counting difficult and time-consuming, Tegula brunnea is subsampled, that is, only those individuals in the first one-third of each arc quadrant are counted (sample area = 2.33 m^2; total area sampled per station = 9.3 m^2). As shown in FIGURE 2-43, T. brunnea is abundant at all subtidal stations in Diablo Cove. From TABLE 2-14, the mean number of Tegula per 9.33 square meter subsample at each station per survey ranged from nearly 50 to over 130 individuals. It appears to be about equally abundant in both the north and south Diablo Cove stations as well as at both the 10 and 15 ft depths. The abundance of Tegula brunnea generally drops sharply at depths over 20-25 ft, as is indicated by their low abundance at Station 13-32.

In general, the abundances of this species are comparable to those of the 1976-1983 period. An exception is evident at Station 8-10, where a marked peak was recorded in late 1983 to early 1984 for that station.

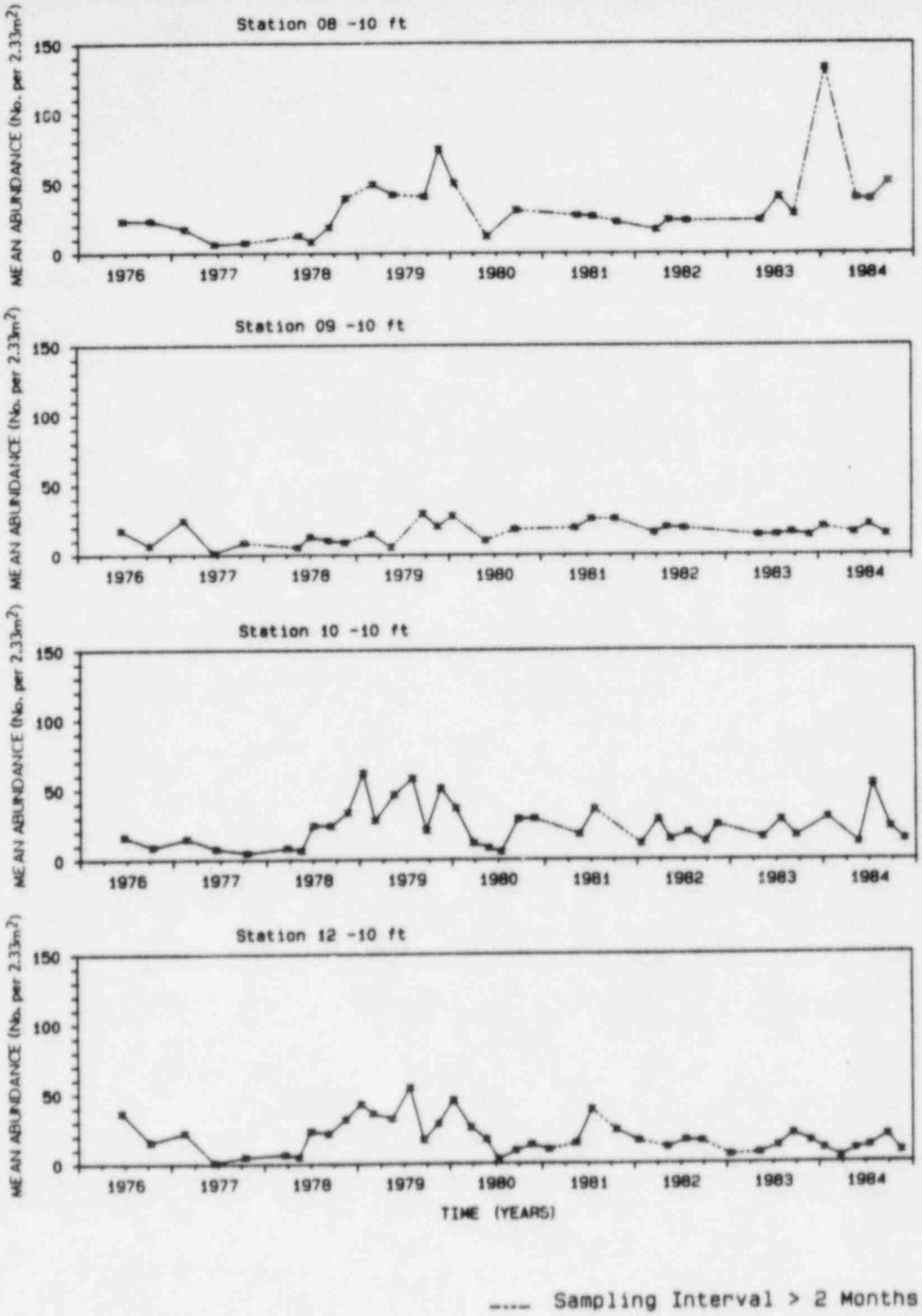


FIGURE 2-43

ABUNDANCE VERSUS TIME FOR SUBTIDAL TEGULA BRUNNEA IN DIABLO COVE (SAQ METHOD)

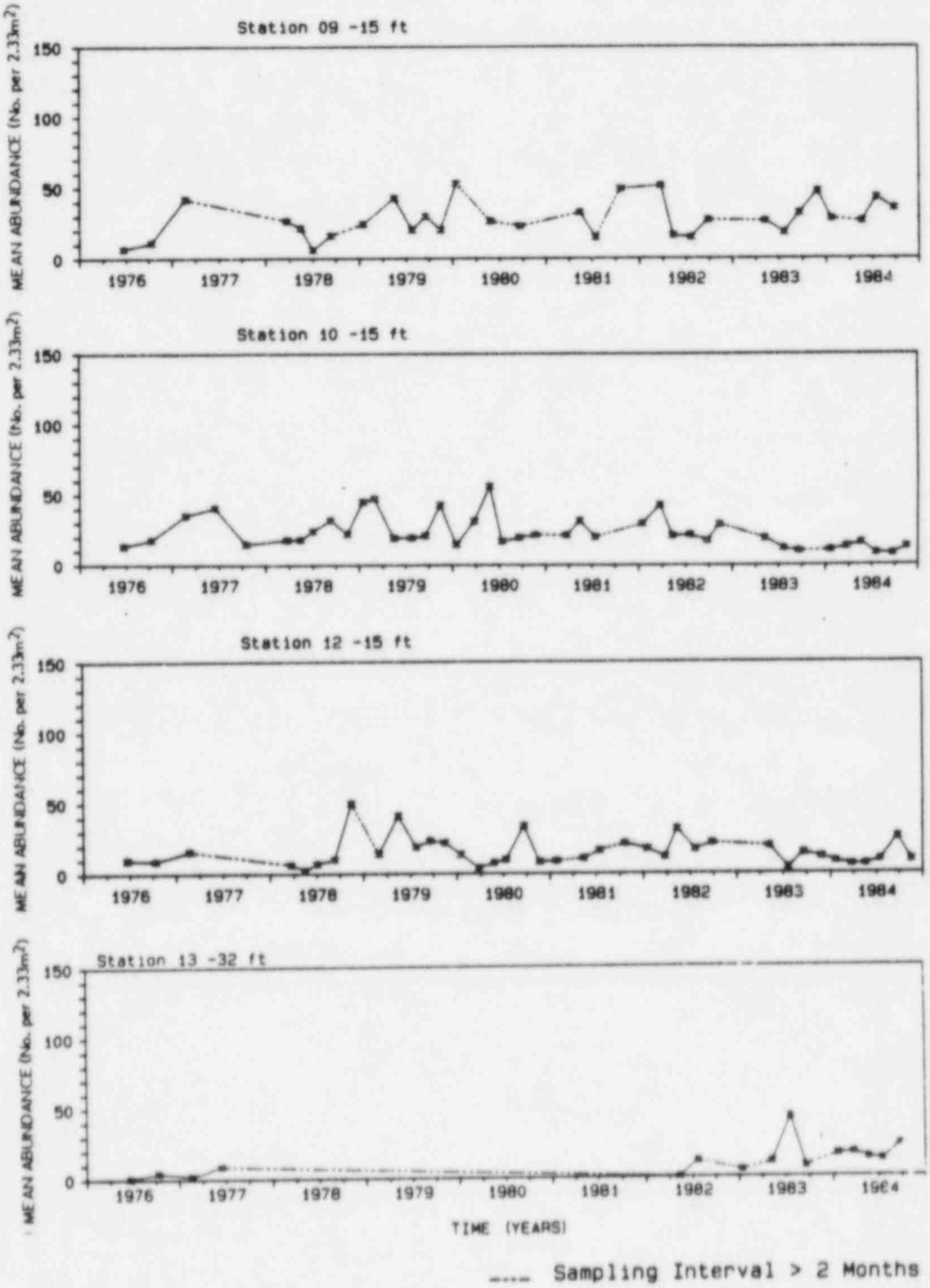


FIGURE 2-43 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL TEGULA BRUNNEA IN DIABLO COVE (SAQ METHOD)

2.8 SUBTIDAL FIXED QUADRAT (SFQ)

Forty-six subtidal surveys were completed from May 1976 to November 1984 (see TABLE 2-13). Details of the subtidal fixed quadrat sampling methods and locations are presented in Appendix A (Section A.8).

In the following sections, data are presented showing the abundance over 46 surveys of seven invertebrate taxa sampled by the SFQ method. Only data collected from TEMP subtidal stations located within Diablo Cove are included in this report.

2.8.1 INVERTEBRATES

This section contains a description of the abundance in the TEMP subtidal stations of seven invertebrate taxa sampled by the SFQ method: Anthopleura elegantissima, Tegula brunnea and Pugettia producta (abundances of these species as sampled by the SAQ method were discussed above in Sections 2.7.2.1, 2.7.2.9, and 2.7.2.6.) and the hermit crabs, Pagurus spp., the gastropods Acmaea mitra and Mitrella spp., and the habitat-forming colonial/social tunicates.

For six of the seven species, counts of all individuals within each of the four fixed quadrats (0.25 m^2 each) were made. For colonial/social tunicates, estimates of area cover in square inches (1 $in.^2$ = 6.45 cm^2) were made in the quadrats. These data were then converted to square centimeters and averaged to obtain a mean (N=4) number of square centimeters cover per 0.25 m^2 for each station.

2.8.1.1 ACMAEA MITRA

Acmaea mitra, commonly referred to as the white-cap or dunce-cap limpet, is found from the low intertidal to the shallow subtidal. Acmaea mitra breeds in the winter and spawns when the sea temperature is at or near minimum (Morris et al. 1980). Ricketts et al. (1968) state that individuals of this species are usually solitary. In Diablo Cove, A. mitra are not uncommon. Adults seem to

prefer the relatively unstable boulder and cobble habitat while juveniles are found on coralline crust covered rocks.

FIGURE 2-44 presents the mean abundance of A. mitra from the SFQ method. This species has occurred at all stations in Diablo Cove; during most surveys the maximum abundance occurs at Station 10-15 (TABLE 2-15). The number of individuals varies both within and between years at all stations. The data indicate a slight increase in the number of individuals at Station 10-15 during fall surveys. In 1984, the abundance of A. mitra reached the highest levels recorded during the study on several stations.

2.8.1.2 ANTHOPLEURA ELEGANTISSIMA

A brief description of Anthopleura elegantissima was given in Section 2.7.2.1 above. FIGURE 2-45 shows the mean abundance through time for the TEMP subtidal stations in Diablo Cove. As explained earlier, these data are not appropriate for defining the distribution of Anthopleura. They are, however, similar to a marking or tagging study for Anthopleura if the data are examined on a quadrat by quadrat basis for each station. At Station 12-15, for example, a single A. elegantissima has been recorded in fixed quadrat 2 for all but seven of the 38 surveys. This station has been sampled since May 1976. Therefore, it appears that Anthopleura can live at least eight years and will remain in essentially the same location for that length of time.

2.8.1.3 COLONIAL/SOCIAL TUNICATES

The colonial/social tunicate sampling category includes at least five genera (Aplidium, Archidistoma, Distaplia, Ritterella and Didemnum) and at least fifteen species of colonial tunicates and four species of social tunicates in the Diablo Canyon study area. Tunicates are encrusting, filter-feeding animals that are generally more abundant on vertical surfaces and underhangs than on horizontal surfaces. The colonial tunicates have their individual zooids embedded in a common tunic material, while the zooids of the social tunicates are generally separated from each other, being only connected at their base. It is sometimes

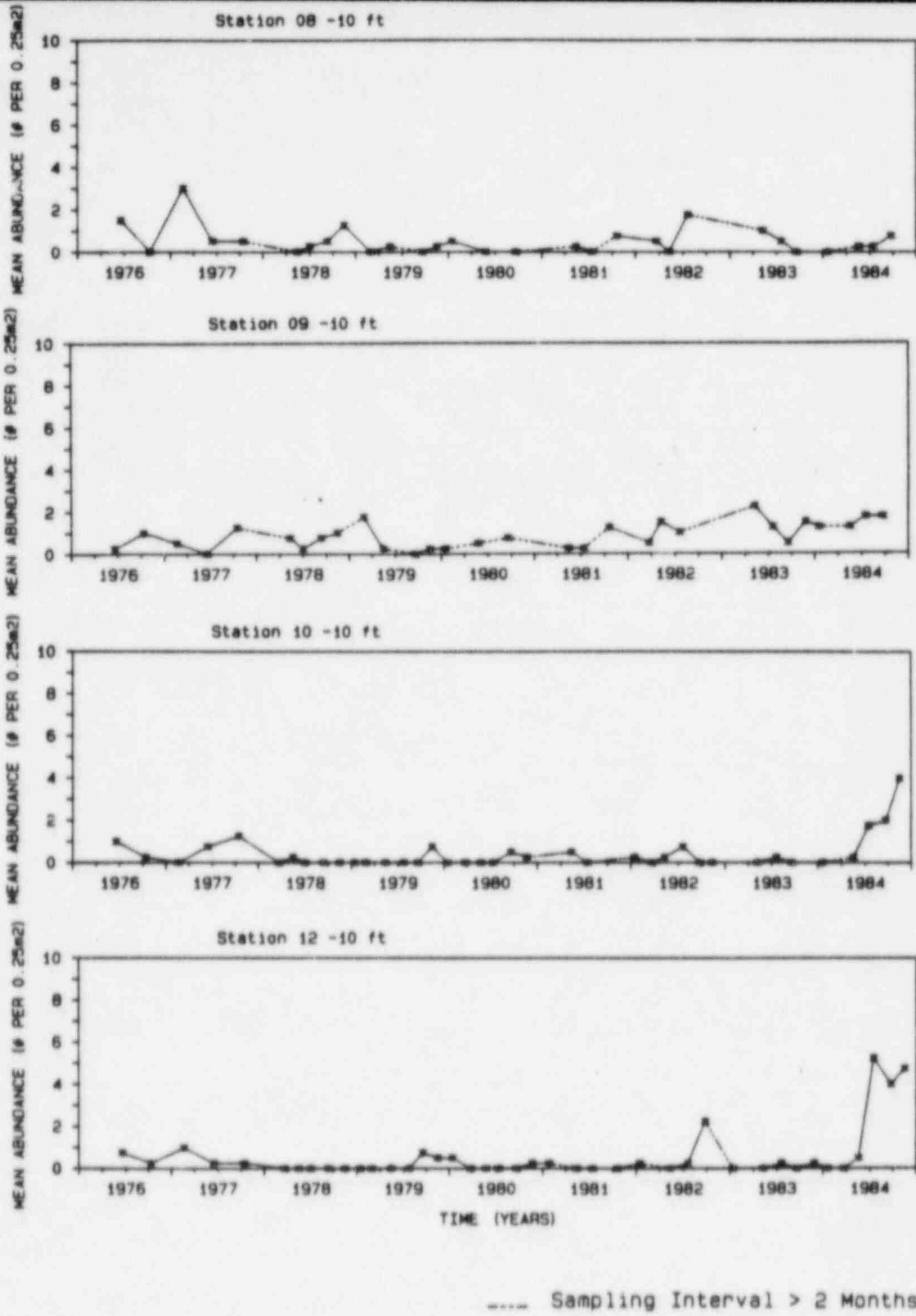


FIGURE 2-44

ABUNDANCE VERSUS TIME FOR SUBTIDAL ACMAEA MITRA IN DIABLO COVE (SFQ METHOD)

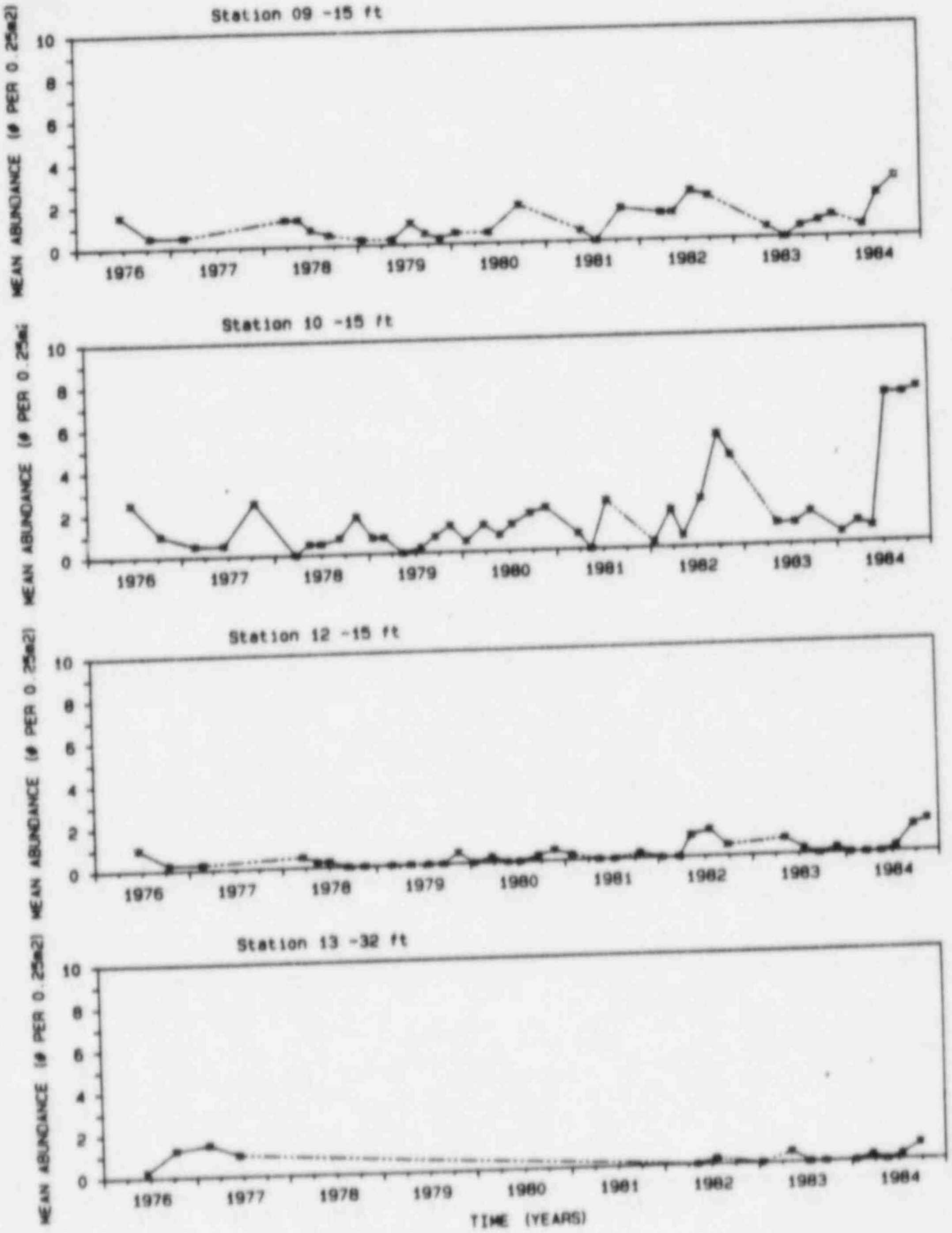


FIGURE 2-44 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL <u>ACMAEA MITRA</u> IN DIABLO COVE (SFQ METHOD)

TABLE 2-15

MEAN NUMBER OF INDIVIDUALS PER 0.25 m^2 ± 2 S.E. FOR SELECTED INVERTEBRATE SPECIES AT DIABLO COVE SUBTIDAL STATIONS FROM MARCH 1976 TO DECEMBER 1984.

Station/ Level	Number of Surveys (N)	Anthopleura Elegantissima	Pagurus spp.	Pugettia spp.	Acmaea mitra	Mitrella spp.	Tegula brunnea	C/S* tunicates
8-10	29	0	10.9 ± 2.2	1.6 ± 0.5	0.4 ± 0.2	7.9 ± 1.9	3.2 ± 0.6	1.0 ± 0.2
9-10	30	0	7.1 ± 1.9	1.3 ± 0.6	0.9 ± 0.2	6.5 ± 1.8	4.5 ± 1.1	1.0 ± 0.3
10-10	38	0.2 ± 0.1	8.5 ± 2.4	0.4 ± 0.2	0.4 ± 0.2	2.5 ± 0.9	2.4 ± 0.7	1.2 ± 0.4
12-10	41	0.1 ± 0.1	9.9 ± 2.4	1.5 ± 0.5	0.6 ± 0.4	2.8 ± 0.6	4.1 ± 1.0	1.9 ± 0.3
9-15	30	0.2 ± 0.1	6.7 ± 1.7	1.3 ± 0.4	0.9 ± 0.3	1.6 ± 0.5	4.4 ± 0.9	1.5 ± 0.3
10-15	40	0.5 ± 0.1	5.9 ± 1.2	0.7 ± 0.2	1.7 ± 0.6	0.6 ± 0.2	3.4 ± 0.6	2.3 ± 0.3
12-15	38	0.3 ± 0.1	10.6 ± 2.1	0.9 ± 0.3	0.3 ± 0.1	3.6 ± 0.7	1.3 ± 0.4	1.0 ± 0.2
13-32	15	0.6 ± 0.2	1.9 ± 1.0	0.3 ± 0.2	0.4 ± 0.3	0	0.9 ± 0.4	1.8 ± 0.9

* Values are $in.^2$ per 0.25 m^2.

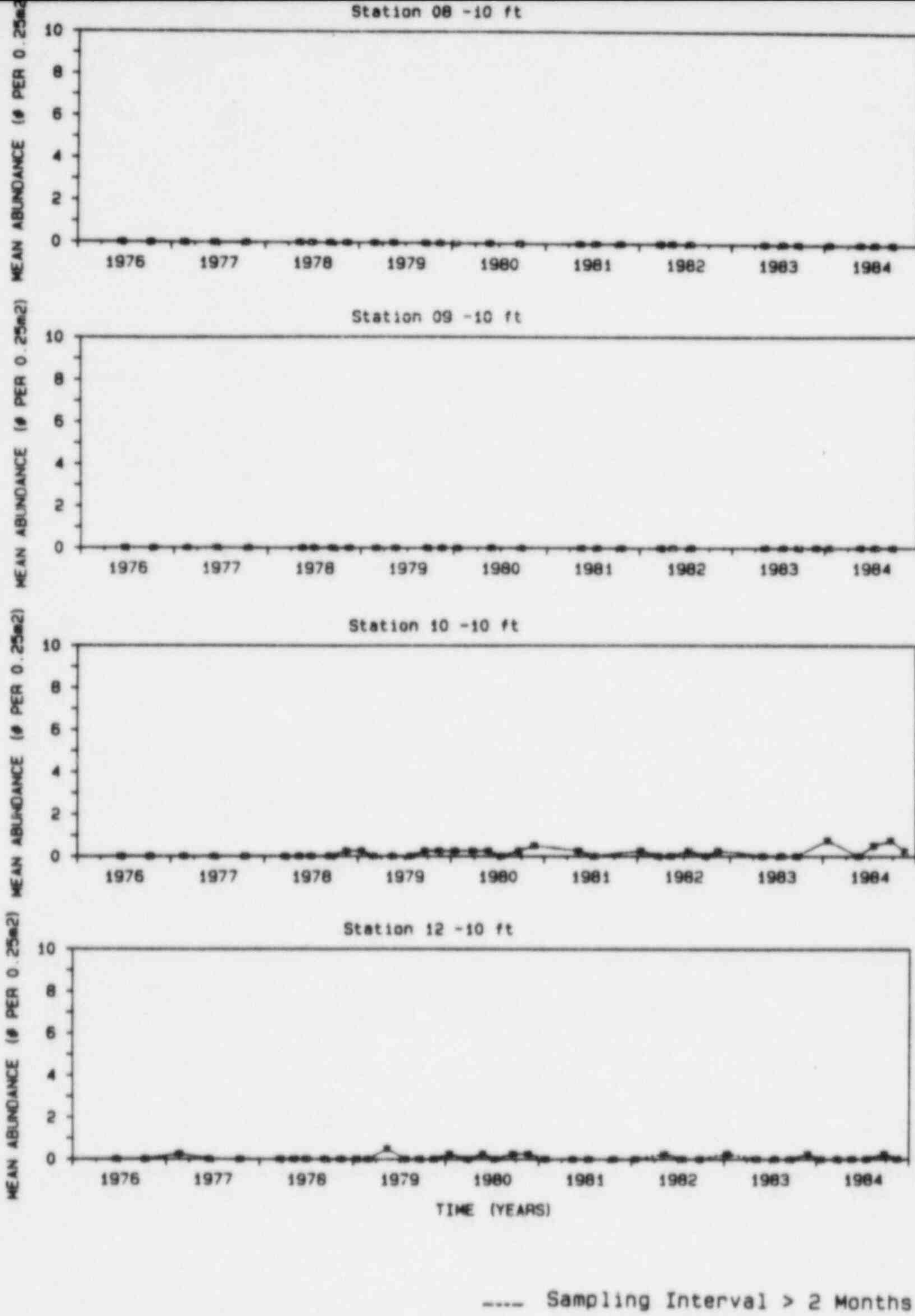
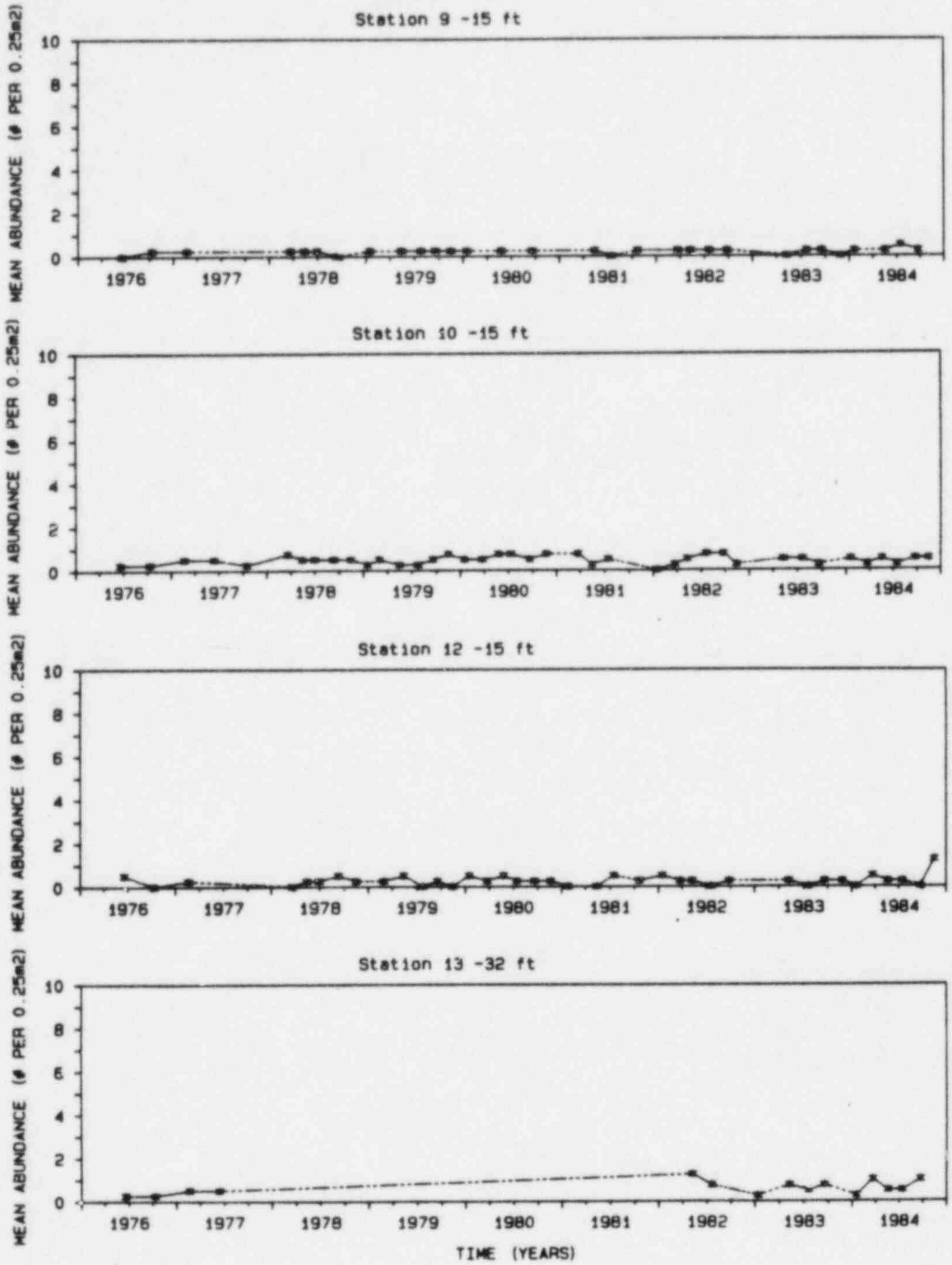


FIGURE 2-45

ABUNDANCE VERSUS TIME FOR SUBTIDAL ANTHOPLEURA ELEGANTISSIMA IN DIABLO COVE (SFQ METHOD)



---- Sampling Interval > 2 Months

FIGURE 2-45 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL ANTHOPLEURA ELEGANTISSIMA IN DIABLO COVE (SFQ METHOD)

difficult to distinguish these two categories of tunicates in the field, so they have been recorded as one entity. The individual zooids undergo asexual reproduction (budding) and are not very long lived, but the colony as a whole can live up to one or two years and even longer for some species.

The mean abundance, as number of square centimeters per 0.25 m^2 of colonial/social tunicates is presented in FIGURE 2-46. This "taxon" was observed during almost every survey at all the stations. No one station consistently had the maximum area covered throughout the study period. After Survey 17 (December, 1979 - January, 1980), the mean area covered by colonial/social tunicates at Station 9-15 decreased and has remained relatively low. There was generally more area covered at Stations 10-10 and 12-10 (south Diablo Cove) than at 8-10 and 9-10 (north Diablo Cove) throughout all of the surveys (TABLE 2-15). Abundances in 1984 were comparable in general to those of the 1976-1983 period except at Station 9-10, where that station's peak abundance was recorded, and at Station 10-15, where the lowest abundance for that station was recorded.

2.8.1.4 MITRELLA SPP.

Diablo Cove is within the geographical distribution ranges of three species of *Mitrella*: *M. aurantiaca*, *M. tuberosa* and *M. carinata*. The majority of the individuals found in the study area are *M. carinata*, commonly referred to as the carinate dove shell. *Mitrella* is abundant on subtidal kelp holdfasts and appears to be a microcarnivore and detritus feeder. When feeding on algal blades, it probably eats the attached (epiphytic) material and not the algae itself. Dove shell is probably an important forage item for certain fish and the shells of dead individuals are used by small *Pagurus* spp.

FIGURE 2-47 presents the subtidal fixed quadrat data for *Mitrella* spp. at all of the Diablo Cove stations. In 1984, abundances of this species were quite comparable to those of the 1976-1983 period. At each of the stations, there is variation both within and between years. The north Diablo Cove Stations 8-10 and 9-10 generally had the greatest abundance of *Mitrella* (TABLE 2-15); their abundance appears to decrease with increasing depth. No *Mitrella* have been

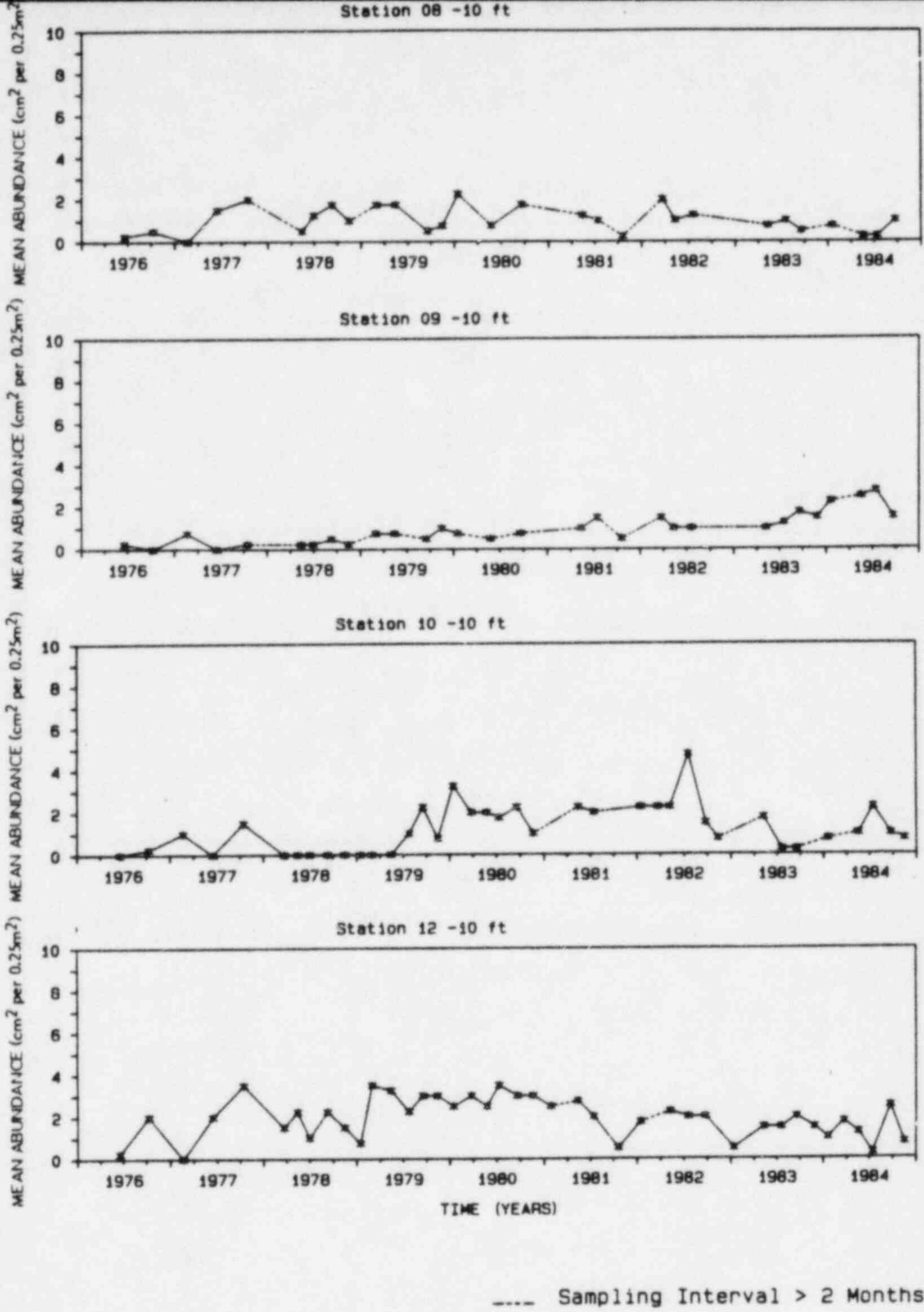


FIGURE 2-46

ABUNDANCE VERSUS TIME FOR SUBTIDAL COLONIAL/SOCIAL TUNICATES IN DIABLO COVE (SFQ METHOD)

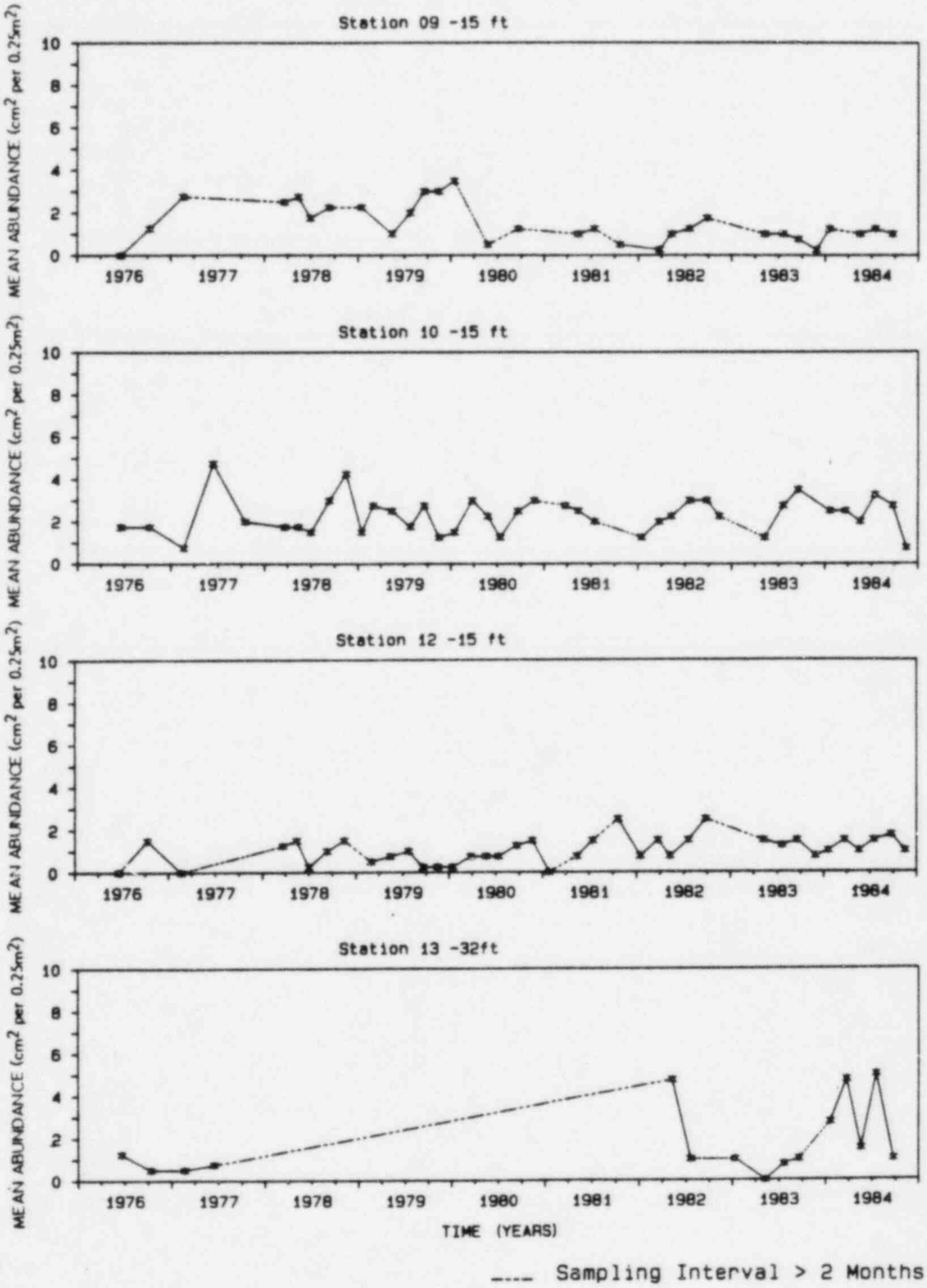


FIGURE 2-46 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL COLONIAL/SOCIAL TUNICATES IN DIABLO COVE (SFQ METHOD)

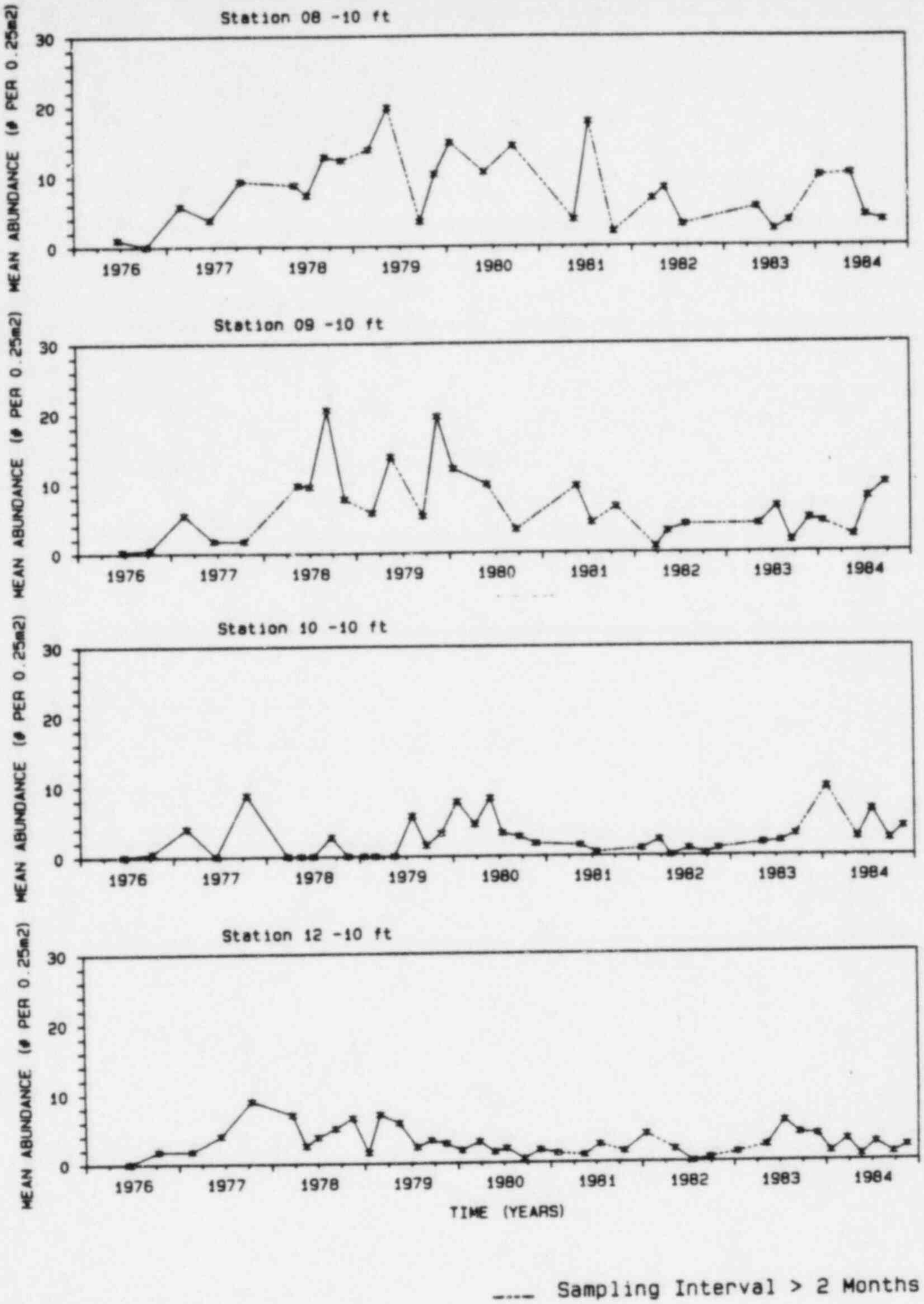
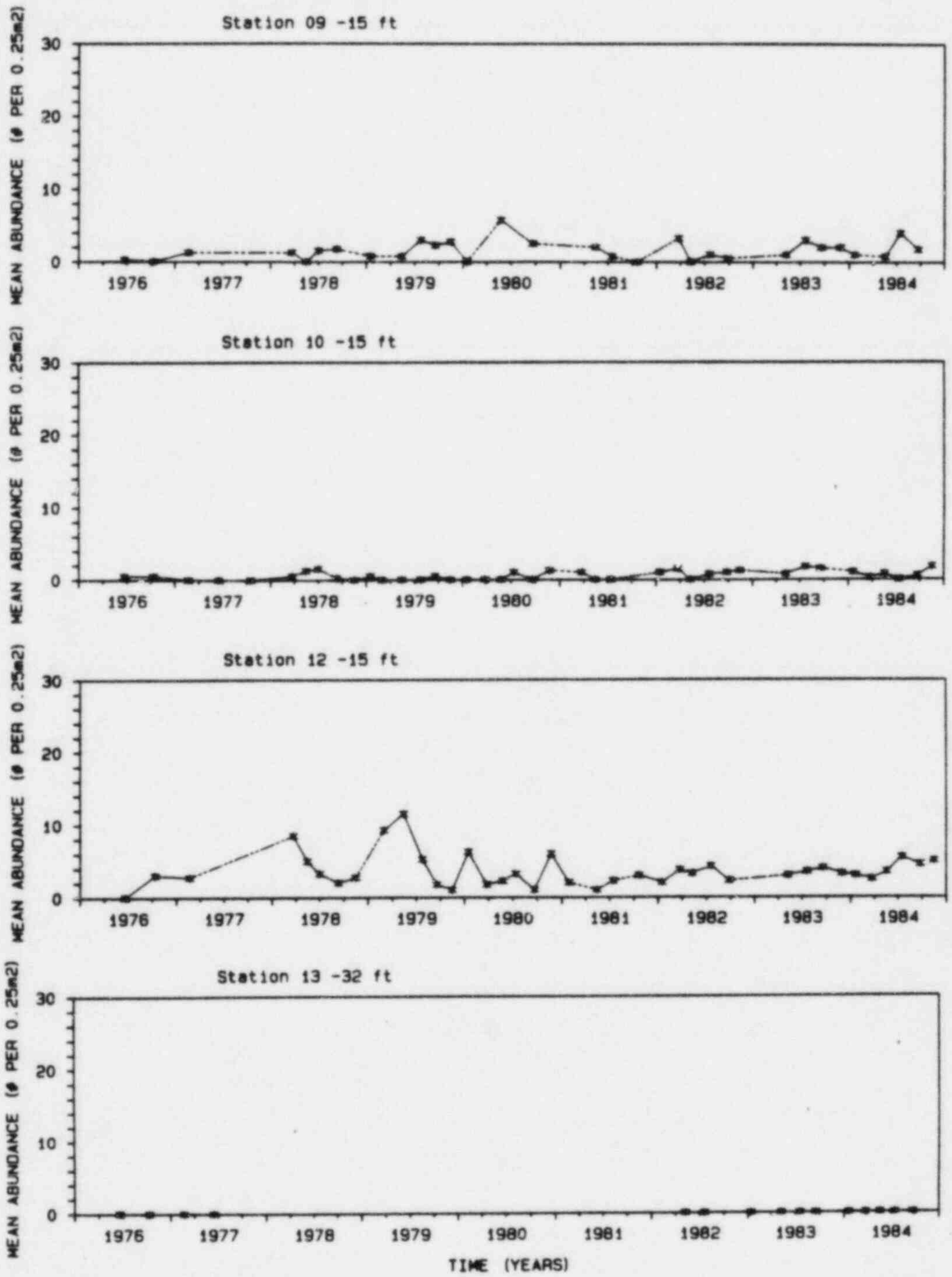


FIGURE 2-47

ABUNDANCE VERSUS TIME FOR SUBTIDAL MITRELLA SPP. IN DIABLO COVE (SFQ METHOD)



---- Sampling Interval > 2 Months

FIGURE 2-47 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL MITRELLA SPP.
IN DIABLO COVE (SFQ METHOD)

recorded in the fixed quadrats at Station 13-32. The variation in the abundance of this taxon in any one quadrat through time appears to be directly influenced by algal abundance. As the algal abundance decreases, the abundance of Mitrella decreases.

2.8.1.5 PAGURUS SPP.

Three species of Pagurus spp. are found in the Diablo Cove study areas: Pagurus samuelis, P. hirsutiusculus, and P. granosimanus. Adults and juveniles of all three species occur from the intertidal to at least the shallow subtidal zone. Two species of subtidal hermit crabs may also be included in the Pagurus spp. categories: Isocheles pilosus and Pagurus bakeri.

Pagurus spp. are scavengers on plant and dead animal matter. They have been observed to pick tentacles off tube worms and the tube feet off of sea urchins and may kill a snail for its shell (Ricketts et al. 1968). Hermit crabs are an important item in the diet of the pile surfperch, Damalichthys vacca (Morris et al. 1980), a common fish in the Diablo Cove study areas, and other fish species as well.

The mean abundances through time of Pagurus spp. are presented in FIGURE 2-48. In 1984, the abundances of this species were comparable to those of the 1976-1983 period, with the exception of Station 13-32, where that station's peak abundance was recorded in early 1984. The SFQ method samples many more small Pagurus individuals than is practical to sample by the SAQ method. At each station there is considerable variation. No one station consistently had more individuals throughout all of the surveys. Overall, the abundance of Pagurus was lowest at Station 13-32 (see TABLE 2-15).

2.8.1.6 PUGETTIA PRODUCTA AND P. RICHII

The spider crabs Pugettia producta and P. richii were briefly described in Section 2.7.2.6 above. Pugettia appear to be more abundant based on the SFQ data when compared with the SAQ data (Section 2.7.2.6). The SFQ method records juvenile

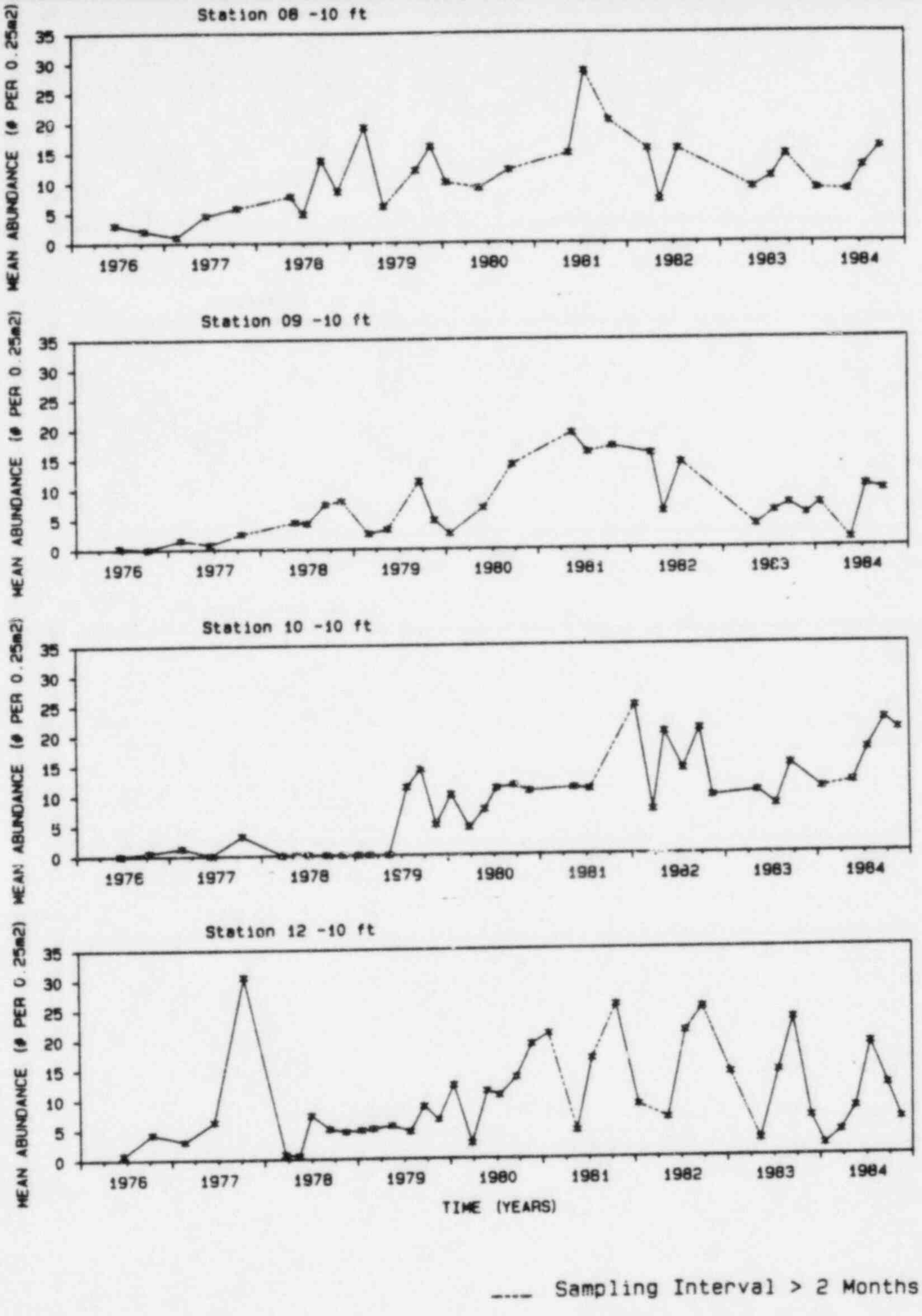


FIGURE 2-48

ABUNDANCE VERSUS TIME FOR SUBTIDAL PAGURUS SPP. IN DIABLO COVE (SFQ METHOD)

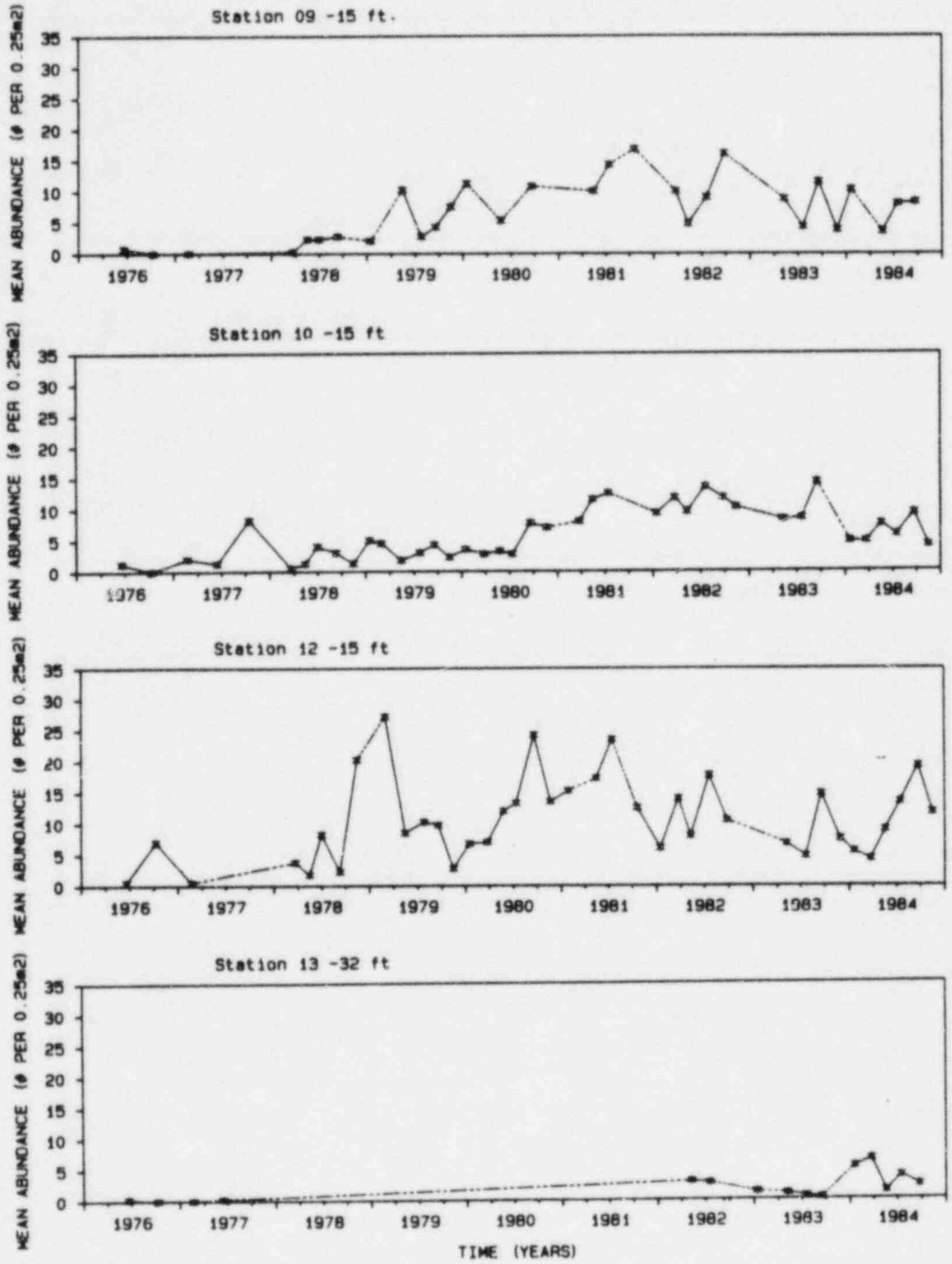


FIGURE 2-48 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL PAGURUS SPP.
IN DIABLO COVE (SFQ METHOD)

spider crabs, which are generally more abundant than the large adults. Though adult P. richii are common in Diablo Cove, they are often cryptic and covered with a layer of sand.

The SFQ data for the mean number of Pugettia at all the Diablo Cove stations through time is presented in FIGURE 2-49. The 1984 abundances of these species are comparable to those of the 1976-1983 period. The numbers of Pugettia vary considerably at all stations. The highest abundances of these species occurred on most stations from 1979 to 1983. Averaged over the entire study period, abundance was low, usually less than two Pugettia per 0.25 m^2 quadrat (TABLE 2-15). The greatest mean number of Pugettia, seven individuals per quadrat, was found during Survey 17 (December, 1979 - January, 1980) at Station 9-10. No one station consistently had more individuals than any of the other stations. The lowest abundance of Pugettia was recorded at Station 13-32.

2.8.1.7 TEGULA BRUNNEA

Brown turban snails, Tegula brunnea, were described in Section 2.7.2.9. Variation in the abundance of Tegula in the fixed quadrats at a given station is partially a result of the different habitats included in each fixed quadrat, T. brunnea numbers being quite high in those quadrats containing large Pterygophora or Cystoseira plants. Densities calculated from SFQ data for Tegula are greater than the densities calculated from the SAQ sampling method, due to the fact that juveniles in the understory algae are sampled by the SFQ method and not generally by the SAQ method.

FIGURE 2-50 presents the SFQ data of the mean abundance of Tegula brunnea at all the Diablo Cove stations through time. The 1984 data are generally comparable to those of the 1976-1983 period, except that peak abundances occurred in 1984 at Stations 8-10, 9-10, and 10-10. Individuals of this species were found at all stations during most all of the surveys. No one station consistently had more individuals than the other stations during all of the surveys. At each station the number of Tegula brunnea varied considerably. These data indicate that there are slightly more T. brunnea in the north Diablo

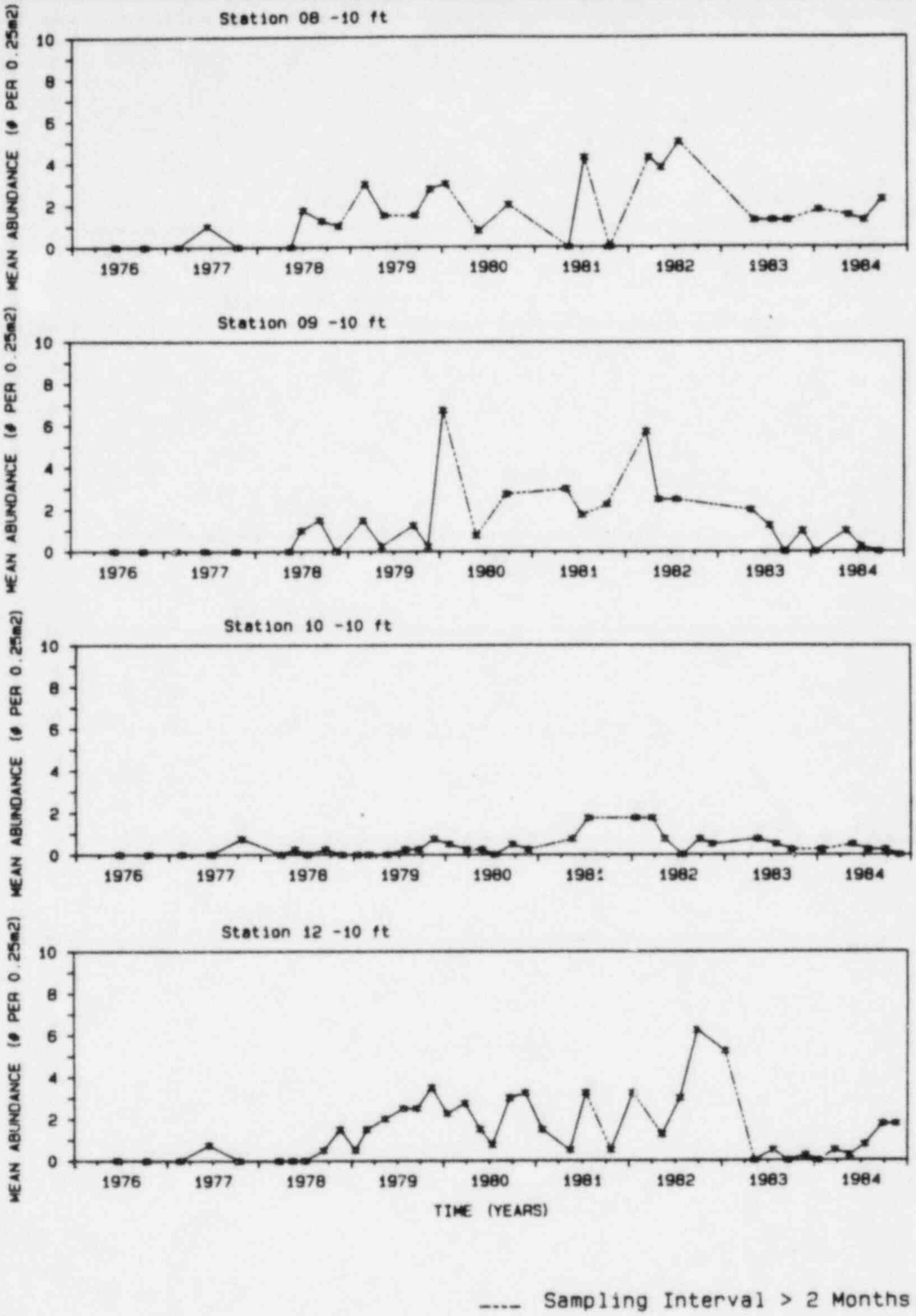


FIGURE 2-49

ABUNDANCE VERSUS TIME FOR SUBTIDAL PUGETTIA PRODUCTA AND P. RICHII IN DIABLO COVE (SFQ METHOD)

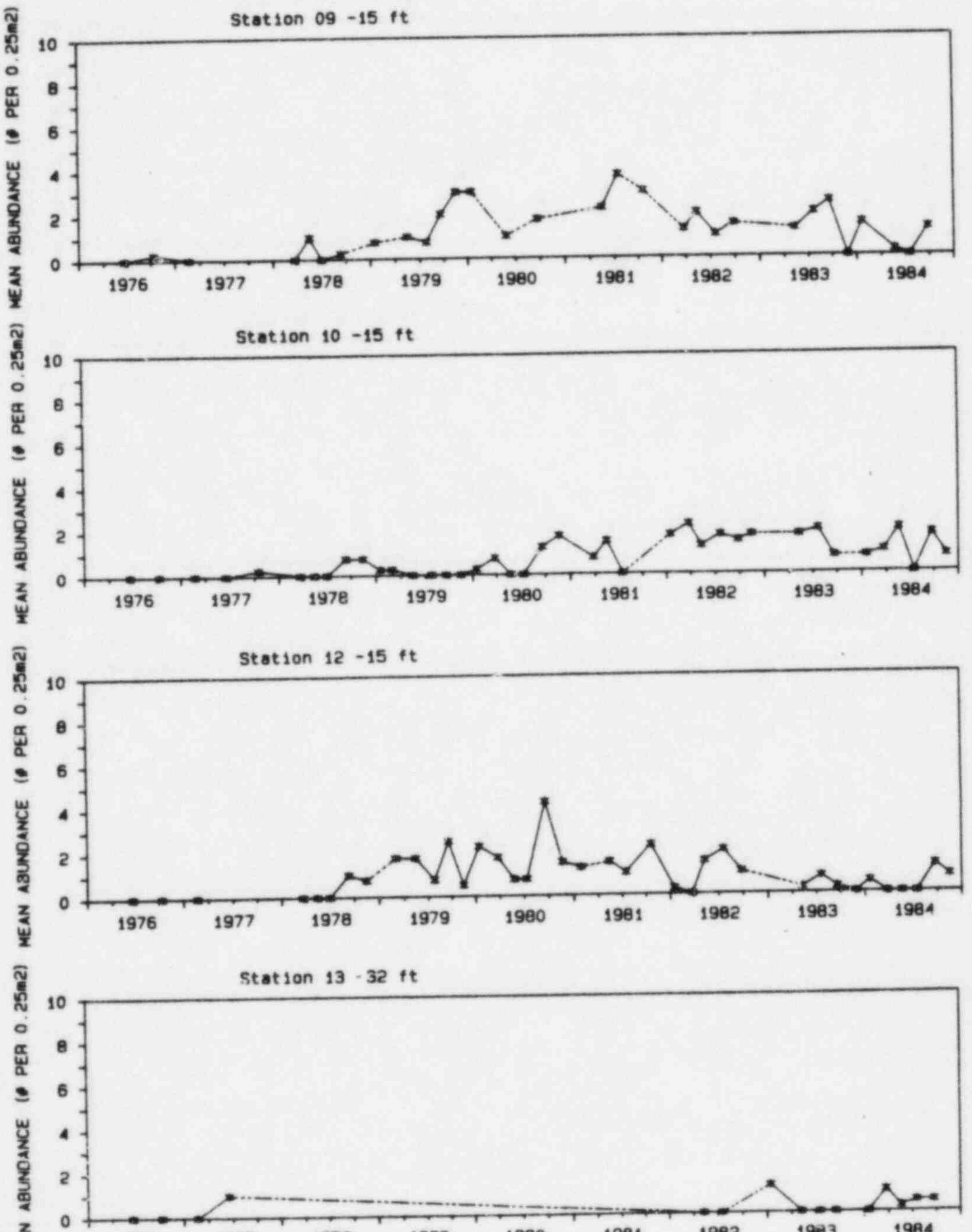


FIGURE 2-49 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL PUGETTIA PRODUCTA AND P. RICHII IN DIABLO COVE (SFQ METHOD)

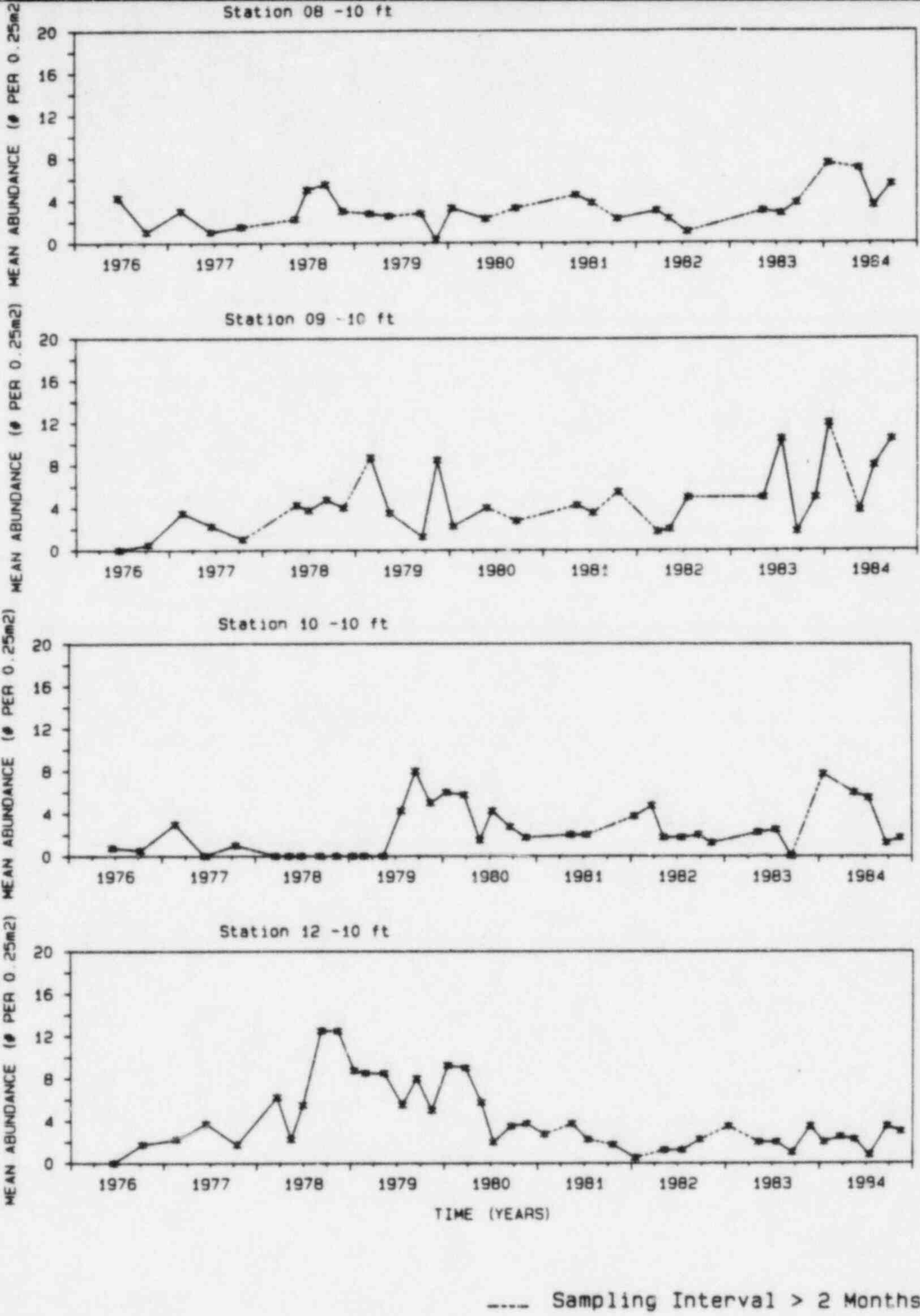


FIGURE 2-50

ABUNDANCE VERSUS TIME FOR SUBTIDAL TEGULA BRUNNEA IN DIABLO COVE (SFQ METHOD)

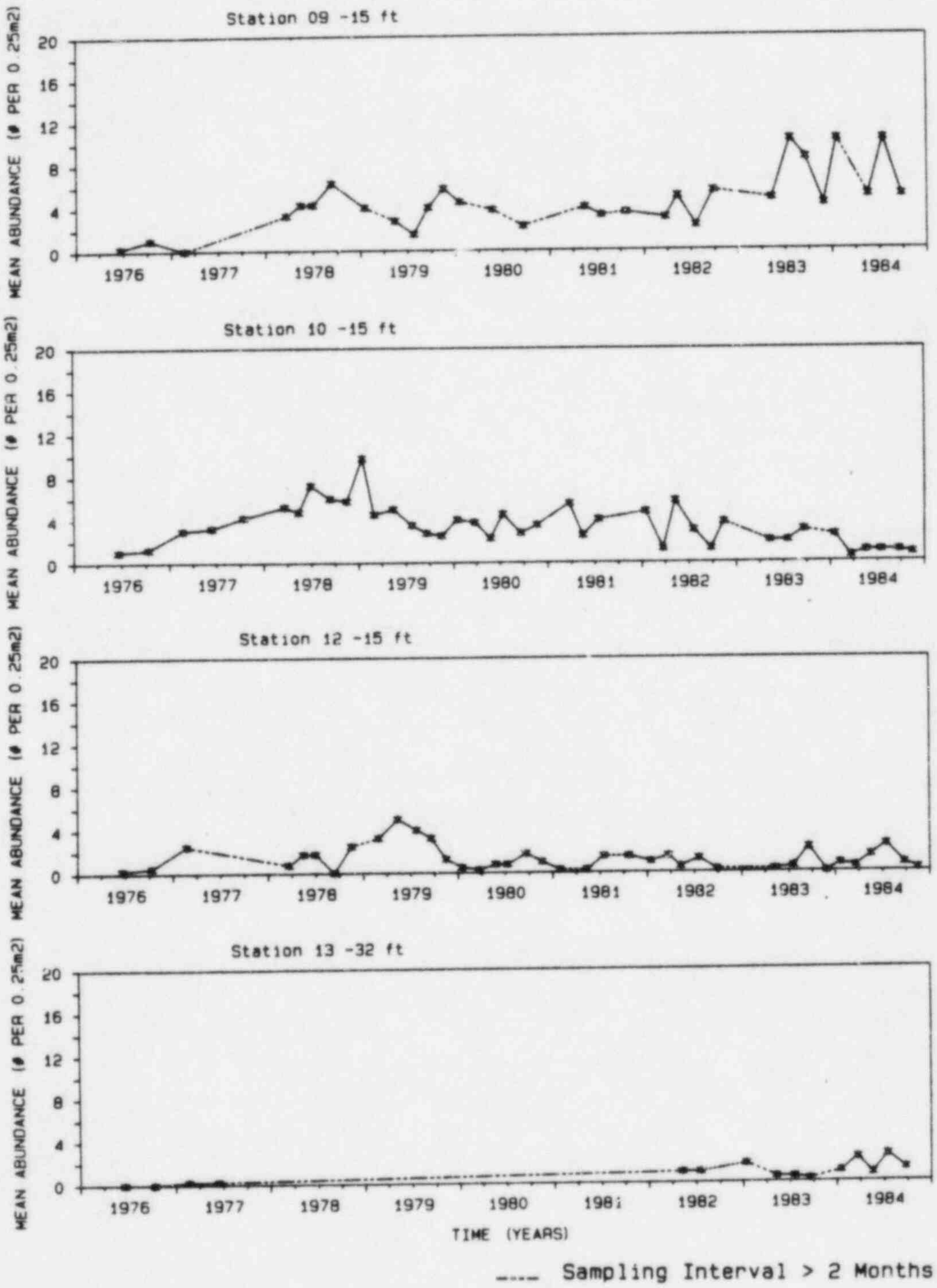


FIGURE 2-50 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL TEGULA BRUNNEA IN DIABLO COVE (SFQ METHOD)

Cove than in the south Diablo Cove. These results are in agreement with those of the SAQ method (see TABLE 2-14).

2.9 SUBTIDAL LINE CONTACT (SLC)

A total of 45 subtidal line contact surveys have been completed over the period 1976 to 1984 (TABLE 2-13). Details of the methods and locations of subtidal line contact sampling are presented in Appendix A (Section A.9).

2.9.1 ALGAE

The following sections present percentage cover data for the foliose red alga Botryoglossum farlowianum and the articulated coralline algae complex consisting of Calliarthron spp., Bossiella spp., and Serraticardia spp. ("CBS complex"). B. farlowianum and the CBS complex have been reported to be among the most abundant algal taxa in most TEMP subtidal study sites (LCMR 1978, PGandE 1979). Abundance descriptions in these reports were based on data collected within the first two and one-half years of this program. Seasonal abundances presented in PGandE (1984) for these taxa were based on the study period September 1976 to September 1983. The sampling period considered for this report is September 1976 to December 1984.

Data collected are the number of points at which a species occurs within each of the four arc quadrants (total points sampled = 50). When divided by 50, the values for each species are considered to represent percentage cover values. The four values on each station were averaged to obtain the mean values presented.

2.9.1.1 BOTRYOGLOSSUM FARLOWIANUM

Botryoglossum farlowianum is a perennial foliose red alga that occurs primarily epiphytically on articulated coralline algae (Calliarthron spp. and Bossiella spp., see Section 2.9.1.2). It is one of the most abundant seaweeds in shallow subtidal Diablo Cove habitats (PGandE 1979). Hymenena spp., a closely related and similar appearing species, is occasionally found mixed in clumps of B. farlowianum, and the data for this species are combined with those for B. farlowianum in this report.

Percentage cover measurements for B. farlowianum (plus Hymenena spp.) in the Diablo Cove stations from 1976 to 1984 are presented in FIGURE 2-51. The data from 1984 are generally consonant with those of the 1976-1983 period. On a year-to-year basis, this species' abundance has been relatively stable at all stations. Variations within the year show a tendency for higher abundances during the summer months. An overall long-term gradual increase in cover is noticeable at Stations 10-10 and 10-15. This may be attributed to a simultaneous decrease in Pterygophora californica (FIGURE 2-34), whose subsurface canopies can limit, by shading, the abundance of understory algae.

Since articulated coralline algae provide a substrate for attachment of B. farlowianum, the abundance of B. farlowianum in shallow water has been generally greater in areas where there is more articulated coralline algae. Hence, in the past, B. farlowianum has been slightly more abundant in north (8-10, 9-10, 9-15) than in south (10-10, 10-15, 12-10, 12-15, 13-32) Diablo Cove stations. However, over recent years the abundance of B. farlowianum at Stations 10-10 and 10-15 has increased (probably as a result of diminishing Pterygophora canopies) and now approaches the abundance at the north Diablo Cove stations.

2.9.1.2 CALLIARTHRON, BOSSIELLA, AND SERRATICARDIA SPP. (CBS-COMPLEX)

Calliarthron spp., Bossiella spp. and Serraticardia spp. (commonly described as articulated coralline algae) are recorded as one sampled category ("CBS complex"), due to their similarities in morphology and growth habits. Based on percentage cover, these three genera combined were found to be one of the most common taxa in most TEMP subtidal fixed stations (PGandE 1979). For this report, the CBS complex does not include Bossiella californica ssp. schmittii. This plant is readily distinguishable from other members of the genus Bossiella. Also, for the TEMP subtidal stations it has been found only at Station 13-32, and there in small quantity. Abundances of the CBS complex from 1976 to 1984 at all Diablo Cove TEMP stations are shown in FIGURE 2-52. A number of stations

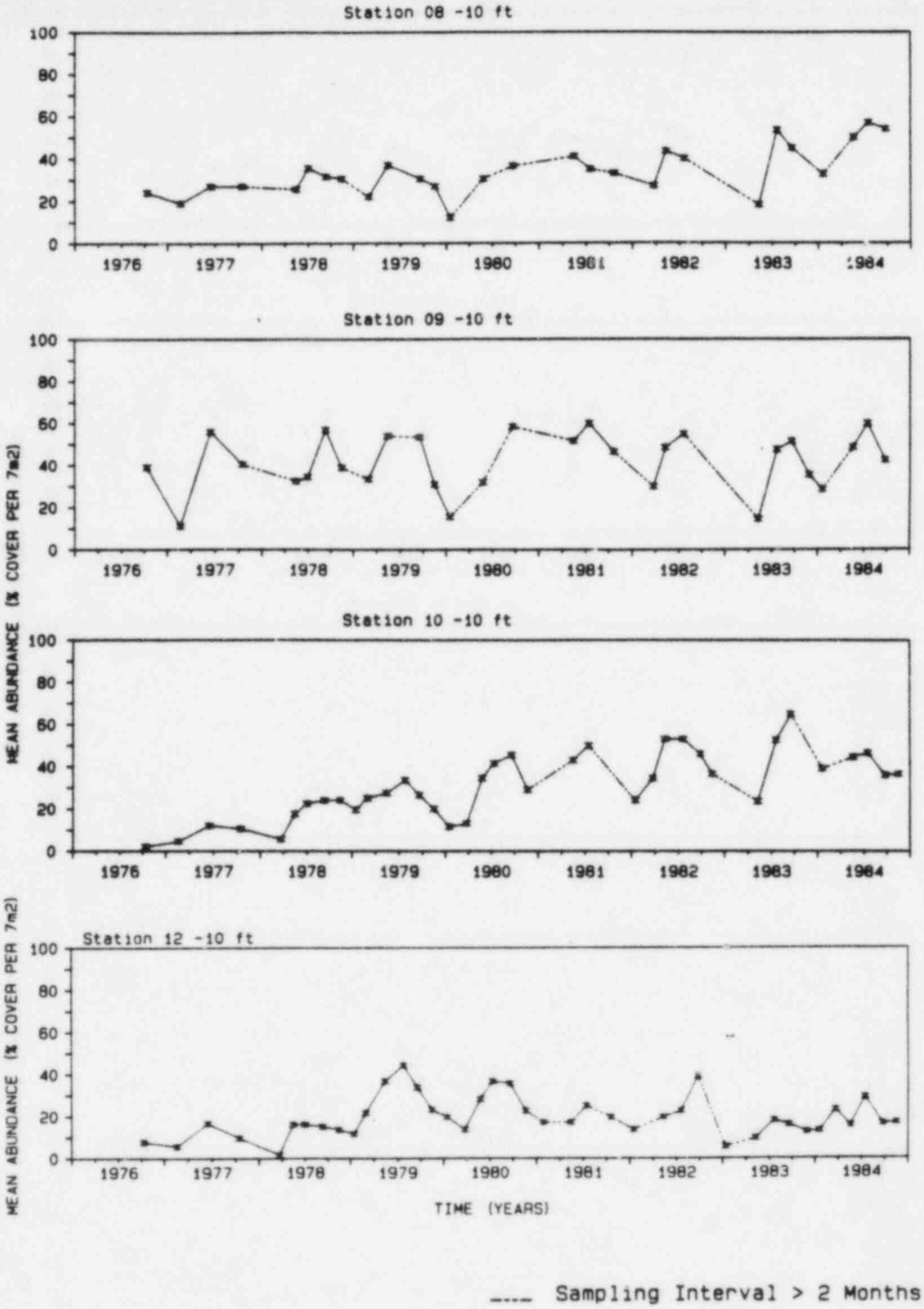


FIGURE 2-51

ABUNDANCE VERSUS TIME FOR SUBTIDAL BOTRYOGLOSSUM FARLOWIANUM IN DIABLO COVE (SLC METHOD)

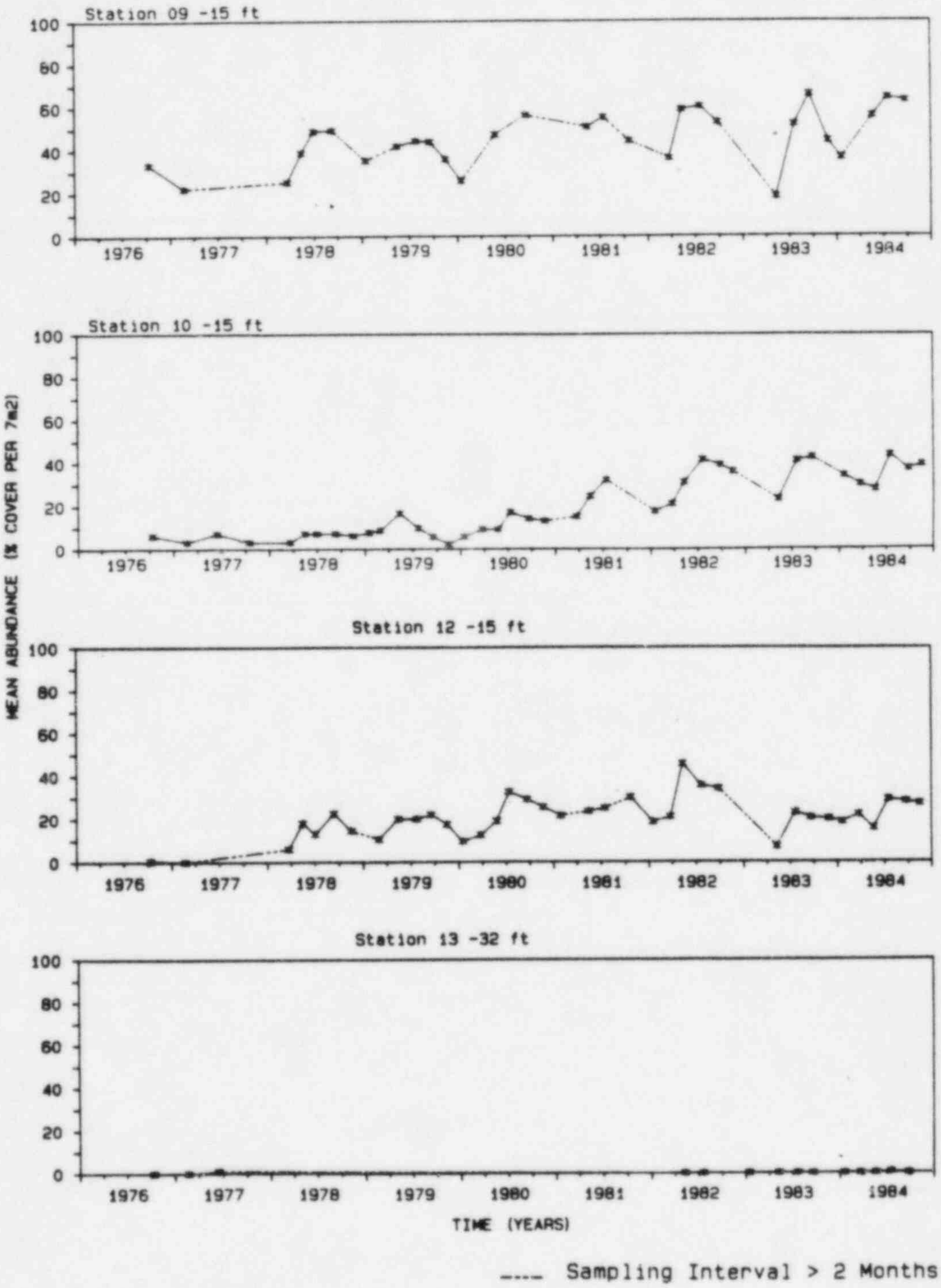


FIGURE 2-51 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL BOTRYOGLOSSUM FARLOWIANUM IN DIABLO COVE (SLC METHOD)

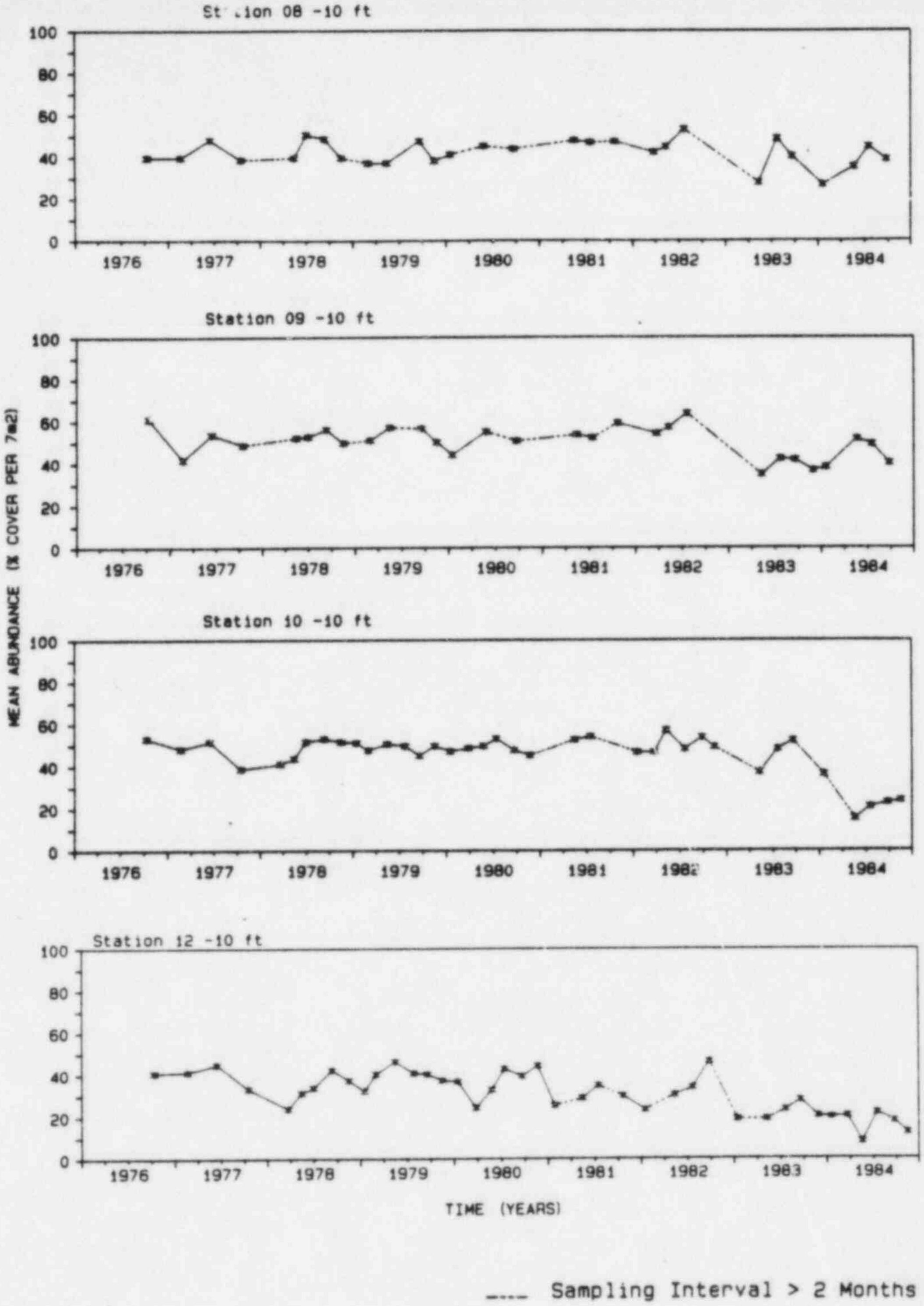


FIGURE 2-52

ABUNDANCE VERSUS TIME FOR SUBTIDAL ARTICULATED CORALLINES (C.B.S. COMPLEX) IN DIABLO COVE (SLC METHOD)

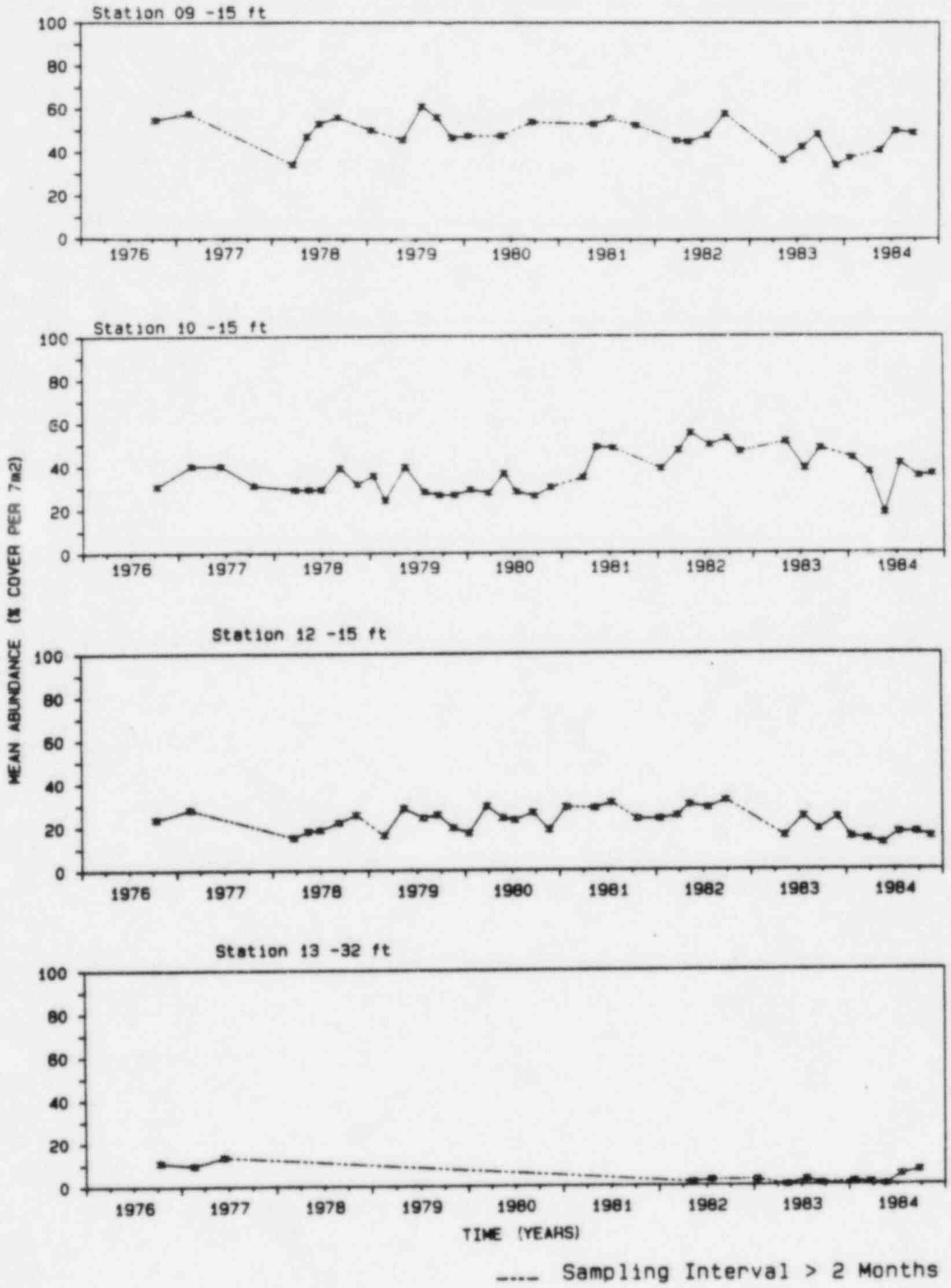


FIGURE 2-52 (CONT.)
ABUNDANCE VERSUS TIME FOR SUBTIDAL
ARTICULATED CORALLINES (C.B.S. COMPLEX)
IN DIABLO COVE (SLC METHOD)

(10-10, 12-10, 12-15) exhibited a decrease in 1983 and relatively low levels have continued in 1984. Abundance increased slightly at Station 13-32 in 1984.

2.9.2 SUBSTRATES

The abundance of various types of substrates (rock, cobble, sand) within TEMP Diablo Cove subtidal stations was presented in PGandE (1979). The data described in this earlier report were from the first years sampling period (1976-1977). In PGandE (1984) seasonal changes in sand cover were presented for the period 1976 to 1983 and are updated in this report to include 1984. Sand cover is of biological interest since it relates to storm disturbance effects as well as providing information on substrate suitability/non-suitability and availability within the TEMP stations.

2.9.2.1 SAND

One of the principal community structuring forces in central California subtidal habitats is high water turbulence (and associated sand motion). Seasonal data on sand cover in the Diablo Cove TEMP subtidal stations are presented in FIGURE 2-53. Although these data do not provide direct indications of disturbance or sand movement (i.e., a station with constant values of sand cover does not imply absence of transport), it does provide information on the amount of non-suitable substrate for algal and invertebrate attachment. Sand transport is revealed by cover measurements only when sand cover changes appreciably through time. Stations 12-10 and 12-15 provide examples where large amounts of sand have been deposited and removed: sand cover has generally been higher during winter and lower during summer periods. Excluding Station 10-15, sand cover has been higher in south Diablo Cove (10-10, 12-10, 12-15, 13-32) than in north Diablo Cove (8-10, 9-10, 9-15) stations.

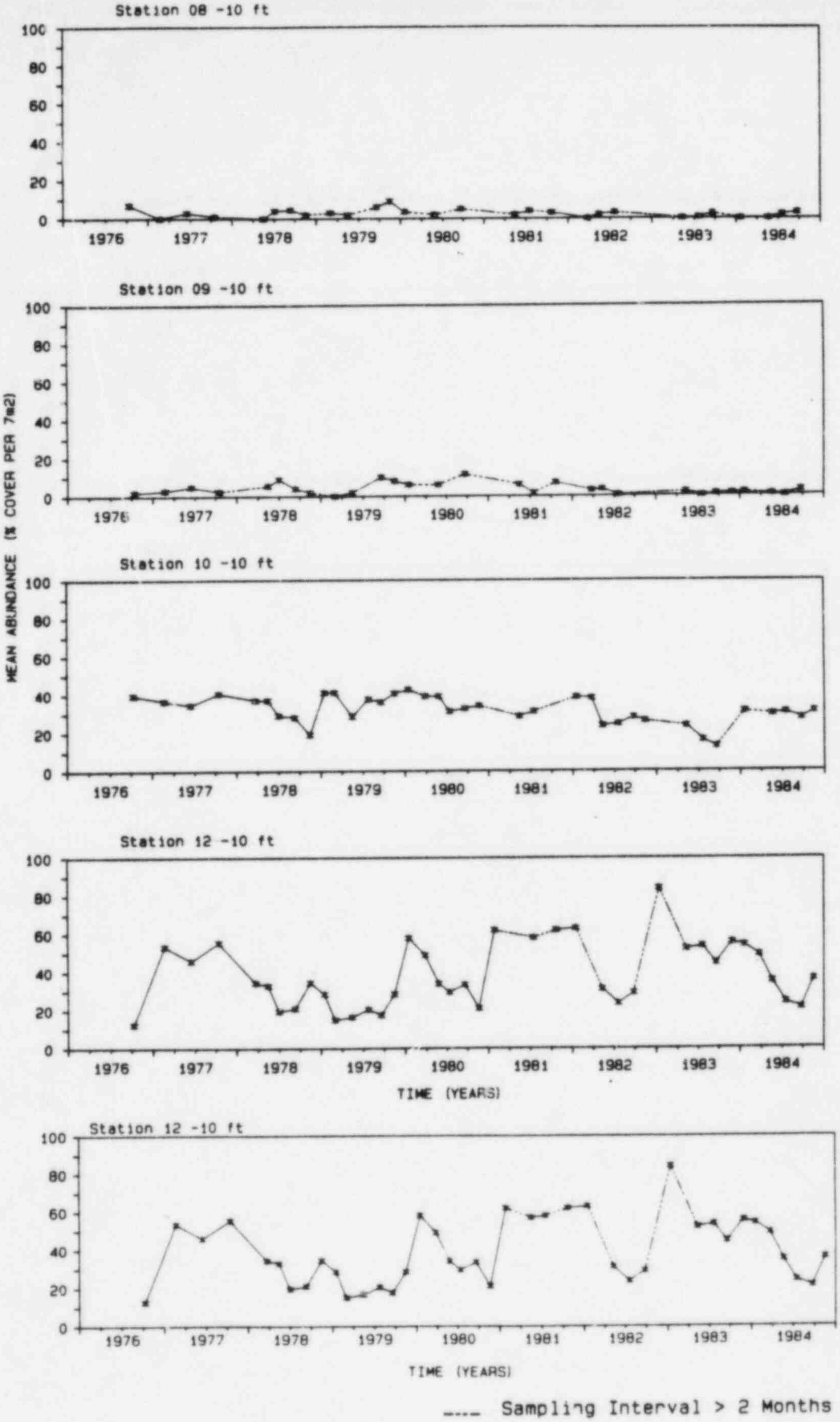


FIGURE 2-53

ABUNDANCE VERSUS TIME FOR SUBTIDAL SAND IN DIABLO COVE (SLC METHOD)

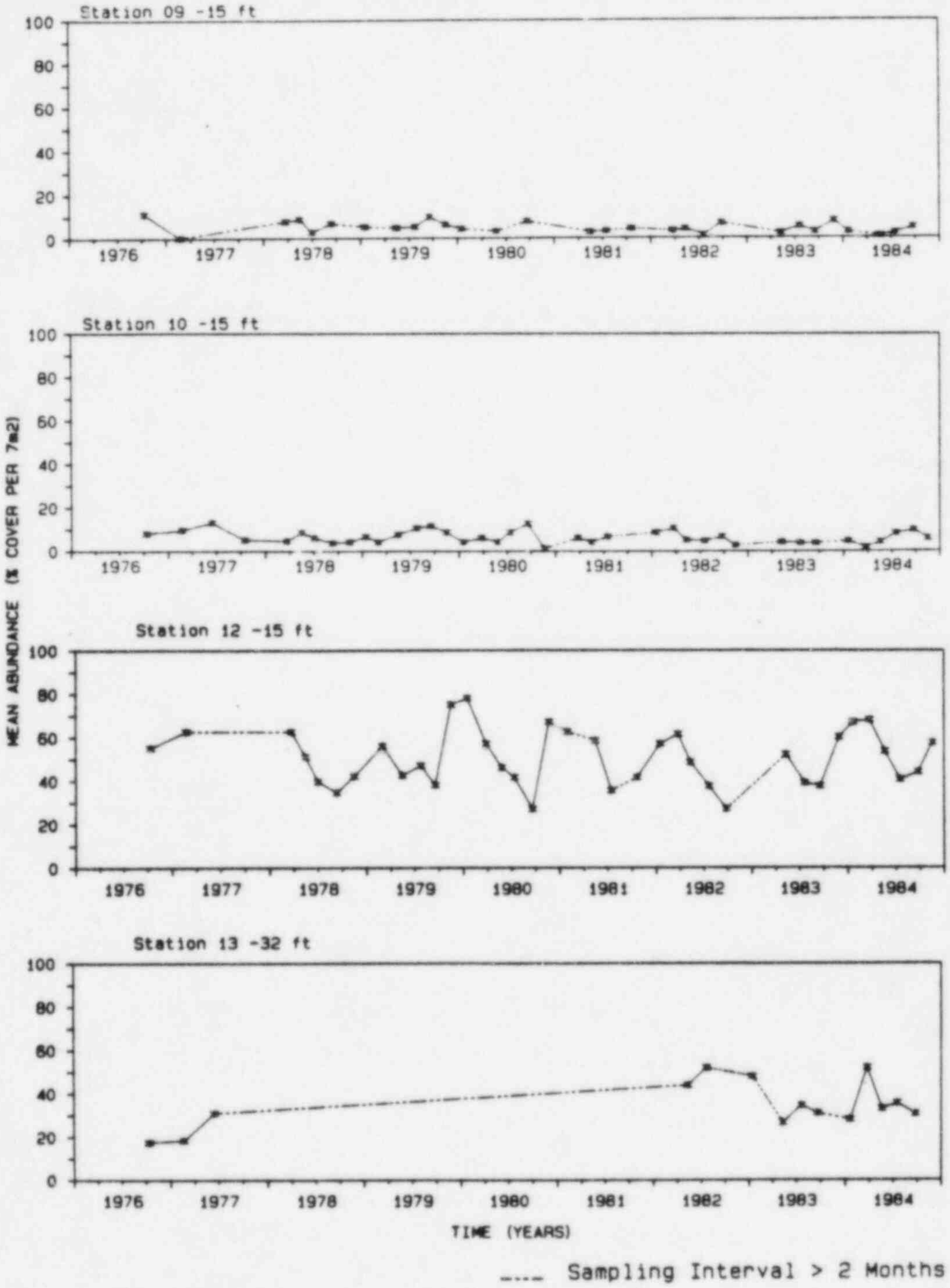


FIGURE 2-53 (CONT.)

ABUNDANCE VERSUS TIME FOR SUBTIDAL SAND
IN DIABLO COVE (SLC METHOD)

2.10 SUBTIDAL CRAB TRAPPING AND TAGGING

During 1984, six subtidal crab trapping surveys were conducted, with a range of 69 to 72 trap sets deployed during each survey over a 6-day period (see TABLE 2-16). Set locations and depths and crab trapping methods are presented in Appendix A (Section A.10). Total numbers of Cancer antennarius trapped, bimonthly catch per unit effort (i.e., number of crabs trapped per 24-hr trap set), and the associated dispersion statistics are presented in TABLE 2-16. FIGURE 2-54 illustrates changes in CPUE from August 1976 to December 1984. In 1984, the greatest CPUE was recorded during the October survey, as has been the case in nearly all previous years. This cyclic trend probably reflects the inshore migration of females during the fall mating season. A detailed discussion of catch trends, ecology, and life history of C. antennarius can be found in the TEMP 1982 Annual Report (PGandE 1983).

TABLE 2-16

SUMMARY STATISTICS FOR CRAB TRAPPING SUBTASK
SURVEY 46 (MARCH - DECEMBER 1984)

Survey	Date	Total No. Crabs	Percent Males	N (No. trap Sets)	CPUE*		
					Mean	Upper 95% ci	Lower 95% ci**
41	03-84	149	57.0	70	2.13	2.74	1.52
42	04-84	159	70.4	71	2.25	2.88	1.62
43	06-84	103	74.8	71	1.45	1.87	1.03
44	08-84	284	59.1	72	3.94	4.90	2.98
45	10-84	415	46.0	72	5.76	7.42	4.10
46	12-84	193	62.9	69	2.81	5.25	0.37

* Number of crabs trapped per 24-hr trap set.

* ci = confidence interval.

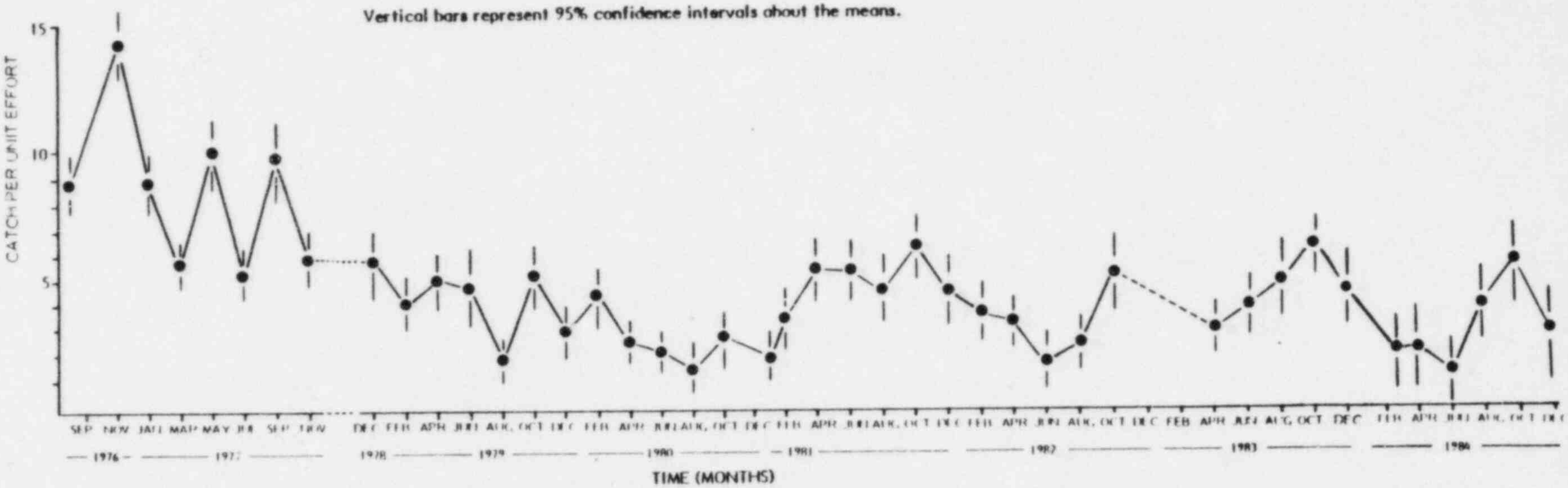


FIGURE 2-54

BIMONTHLY SUBTIDAL CANCER ANTENNARIUS
CATCH PER UNIT EFFORT (CPUE) FROM
AUGUST 1976 TO DECEMBER 1984

CPUE defined as the mean number trapped per 24 hr trap set.

2.11 SUBTIDAL FISH OBSERVATIONS

Subtidal fish observation surveys have been conducted since August 1976. Details of the methods and sampling locations used for subtidal fish observations are presented in Appendix A (Section A.11). The survey dates and number of transects occupied in 1984 are presented in TABLE 2-13.

Prior to 1983, six fish transect stations were actively sampled (Stations 6, 7, 8, 10, 13, and 14 (see Appendix A, FIGURE A-5). The general physical features of these transects were described by PGandE (1983, p. 3-69). Beginning with Survey 35 in January 1983, five additional stations (4, 5, 9, 11, and 12) were reactivated for sampling, resulting in a total of eleven active fish transect stations. (Note, however, that not all transects may be sampled in every survey because of adverse sea conditions.) Of the eleven stations, five (4, 5, 6, 8, and 12) are oriented parallel to the shoreline or follow depth contours, and six (7, 9, 10, 11, 13, and 14) are oriented perpendicularly to the shoreline or across depth contours.

The physical features of the five reactivated stations are briefly described below. Station 4 follows the 25 ft isobath from subtidal Station 5-25 on a compass bearing of 270 degrees. A small stand of kelp, Macrocystis pyrifera, is located 30 m inshore and 40 m upcoast of this transect. The bottom is outcropping rock and large boulders with Laminaria and foliose red algae. Shallow caves and ledges are present throughout this area. Station 5 in north Diablo Cove extends from subtidal Station 8-10 along the 10 ft isobath to subtidal Station 7-10. The transect crosses rock ledges and Phyllospadix beds. The relief is moderate (less than 2 m). Station 9 originates at subtidal Station 11-15 in south Diablo Cove and traverses 50 m of rock outcropping and a major sand channel. Boulders are common along this transect. Station 11 is located near the center of Diablo Cove, downcoast from the main channel. Depths range from 32 ft at the origin (subtidal Station 13-32), to 47 ft at the terminus. The transect runs parallel to rock ledges which support dense Pterygophora stands. Station 12, located in South Cove, follows the 10 ft depth contour from subtidal Station 20-10 (a benthic station not sampled for algae and invertebrates at this

time). High relief boulders with coralline crusts and articulated coralline algae are common in the area.

Ten species of fish were selected for detailed analysis on the basis of their overall abundance. A brief summary of the composition, total abundance, and overall rank of each species in 1984 is presented.

During the 1984 surveys, 8,088 fish comprising 48 taxa (20 of which were observed fewer than 6 times) were observed in Diablo Cove and South Cove (TABLE 2-17). Ten species comprised about 92 percent of the total young and adult fish observed in the 46 transect samples obtained in 1984: senorita (63 percent), black-and-yellow rockfish (8 percent), olive rockfish (6 percent), blue rockfish (4 percent), painted greenling (3 percent), striped surf-perch (2 percent), black surfperch (2 percent), topsmelt (2 percent), and blacksmith (2 percent).

Juveniles of seventeen taxa made up 17 percent of the total fish observed, with juvenile black-and-yellow rockfish comprising 34 percent of all juvenile fish, followed in abundance by juvenile olive rockfish (33 percent) and juvenile senorita (17 percent).

Adult fish numbered 6,719 and represented 44 taxa. The five most abundant adult taxa were senorita (72 percent), painted greenling (4 percent), blue rockfish (3 percent), striped surfperch (3 percent), and black-and-yellow rockfish (3 percent).

Of all individuals counted, 66 percent were observed on the benthic portion of the transects (within 1 m of the bottom). With the exception of Stations 4 and 11, similar mid-water and benthic distribution ratios occurred at all stations. The most abundant taxa seen on the benthic portion of transects, for all surveys combined in 1984, were senoritas (61 percent), black-and-yellow rockfish (9 percent), olive rockfish (5 percent), and painted greenling (4 percent). The most abundant fishes in the mid-water were senoritas (66 percent), olive rockfish (7 percent), black-and-yellow rockfish (6 percent), and topsmelt (6 percent).

TABLE 2-17

SUMMARY OF ABUNDANCE AND SPECIES COMPOSITION OF YOUNG AND ADULT FISHES IN DIABLO COVE AND SOUTH COVE FROM FEBRUARY 1984 TO NOVEMBER 1984

Species	Total Number Observed	Percentage Composition	Total Number Adults	Percentage Adult Composition	Total Number Juveniles	Percentage Juvenile Composition
Oxyjulis californica (senorita)	5,084	63	4,852	72	232	17
Sebastes chrysomelas (black-and-yellow rockfish)	642	8	180	3	462*	34
Sebastes serranoides (olive rockfish)	474	6	23	**	451*	33
Sebastes mystinus (blue rockfish)	336	4	224	3	112*	8
Oxylebius pictus (painted greenling)	268	3	268	4	-	-
Embiotoca lateralis (striped surfperch)	196	2	175	3	21	1
Embiotoca jacksoni (black surfperch)	157	2	128	2	29	2
Atherinidae unid (topsmelt)	150	2	150	2	-	-
Chromis punctipinnis (blacksmith)	121	2	120	2	1	**
Cymatogaster aggregata (shiner surfperch)	90	1	90	1	-	-
Damalichthys vacca (pile surfperch)	83	1	72	1	11	1
Scorpaenichthys marmoratus (cabezon)	55	1	55	1	-	-
Sebastes rastrelliger (grass rockfish)	51	1	50	1	1*	**
Gibbonsia spp. (kelpfish)	49	1	49	1	-	-
Cottidae unid. (sculpin)	41	1	41	1	-	-

-- Continued on next page --

* Juveniles of this species may have been recorded as "Sebastes spp."
** Value less than 0.5 percent.

TABLE 2-17

SUMMARY OF ABUNDANCE AND SPECIES COMPOSITION OF YOUNG AND ADULT FISHES IN DIABLO COVE AND SOUTH COVE FROM FEBRUARY 1984 TO NOVEMBER 1984. (CONTINUED)

Species	Total Number Observed	Percentage Composition	Total Number Adults	Percentage Adult Composition	Total Number Juveniles	Percentage Juvenile Composition
-- Continued from previous page --						
Citharichthys spp. (sanddab)	39	*	39	1	-	-
Sebastes atrovirons (kelp rockfish)	32	*	25	*	7*	**
Hexagrammos decagrammus (kelp greenling)	29	*	29	*	-	-
Orthonopias triacis (snubnose sculpin)	25	*	25	*	-	-
Artedius spp. (sculpin)	24	*	24	*	-	-
Sebastes paucispinis (bocaccio)	22	*	-	-	22*	2
Sebastes carnatus (gopher rockfish)	20	*	19	*	1*	**
Cebidichthys violaceus (monkeyface eel)	12	*	12	*	-	-
Heterostichus rostratus (giant kelpfish)	9	*	4	*	5	**
Sebastes caurinus (copper rockfish)	9	*	8	*	1*	**
Hypsurus caryi (rainbow surfperch)	9	*	9	*	-	-
Sebastes spp. (rockfish)	8	*	-	-	8	1
Coryphopterus nicholsii (blackeye goby)	7	*	7	*	-	-
Other taxa (total of 20 species) (less than 5 individuals counted during sampling period)	46		41		5	
Totals	8,088		6,719		1,369	

* Juveniles of this species may have been recorded as "Sebastes spp."

** Value less than 0.5 percent.

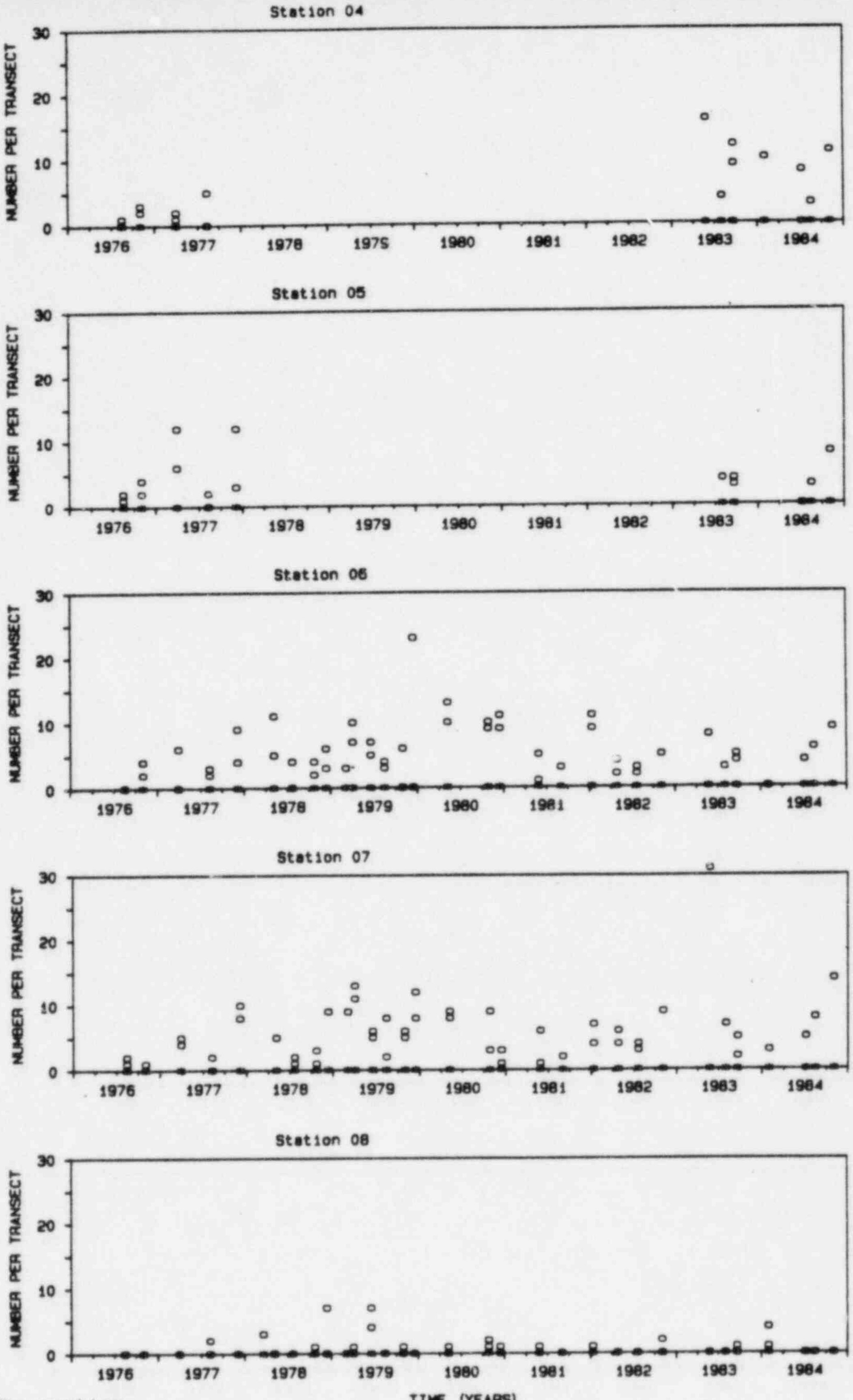
The following species were selected for detailed abundance summaries:

- o black-and-yellow rockfish (Sebastes chrysomelas)
- o black surfperch (Embiotoca jacksoni)
- o blue rockfish (Sebastes mystinus)
- o cabezon (Scorpaenichthys marmoratus)
- o grass rockfish (Sebastes rastrelliger)
- o olive rockfish (Sebastes serranoides)
- o painted greenling (Oxylebius pictus)
- o senorita (Oxyjulis californica)
- o striped surfperch (Embiotoca lateralis)
- o kelp bass (Paralabrax clathratus)

Summaries of the available life history information on all of the above species was presented in the 1982 annual report (PGandE 1983), with the exception of the kelp bass. Aside from these species, which are commonly recurring taxa, certain other species have been observed in high abundance only at certain periods. For example, during 1979 and 1981, bocaccio appeared in large numbers but have not been observed on the transects since that time.

2.11.1 BLACK-AND-YELLOW ROCKFISH

Black-and-yellow rockfish, Sebastes chrysomelas, was the second most abundant species in 1984, totaling 642 adults and juveniles. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-55. This species comprised 34 percent of all juvenile fish and 3 percent of all adult fish encountered. All adult black-and-yellow rockfish were observed on or near the bottom, whereas only 65 percent of the juveniles were encountered on the benthic portion of the transects. In 1984, adults were observed on all stations except Station 11, which is deeper than the preferred depth range of these fish. More adults were seen in spring and fall than in



* Midwater Observation
o Benthic Observation

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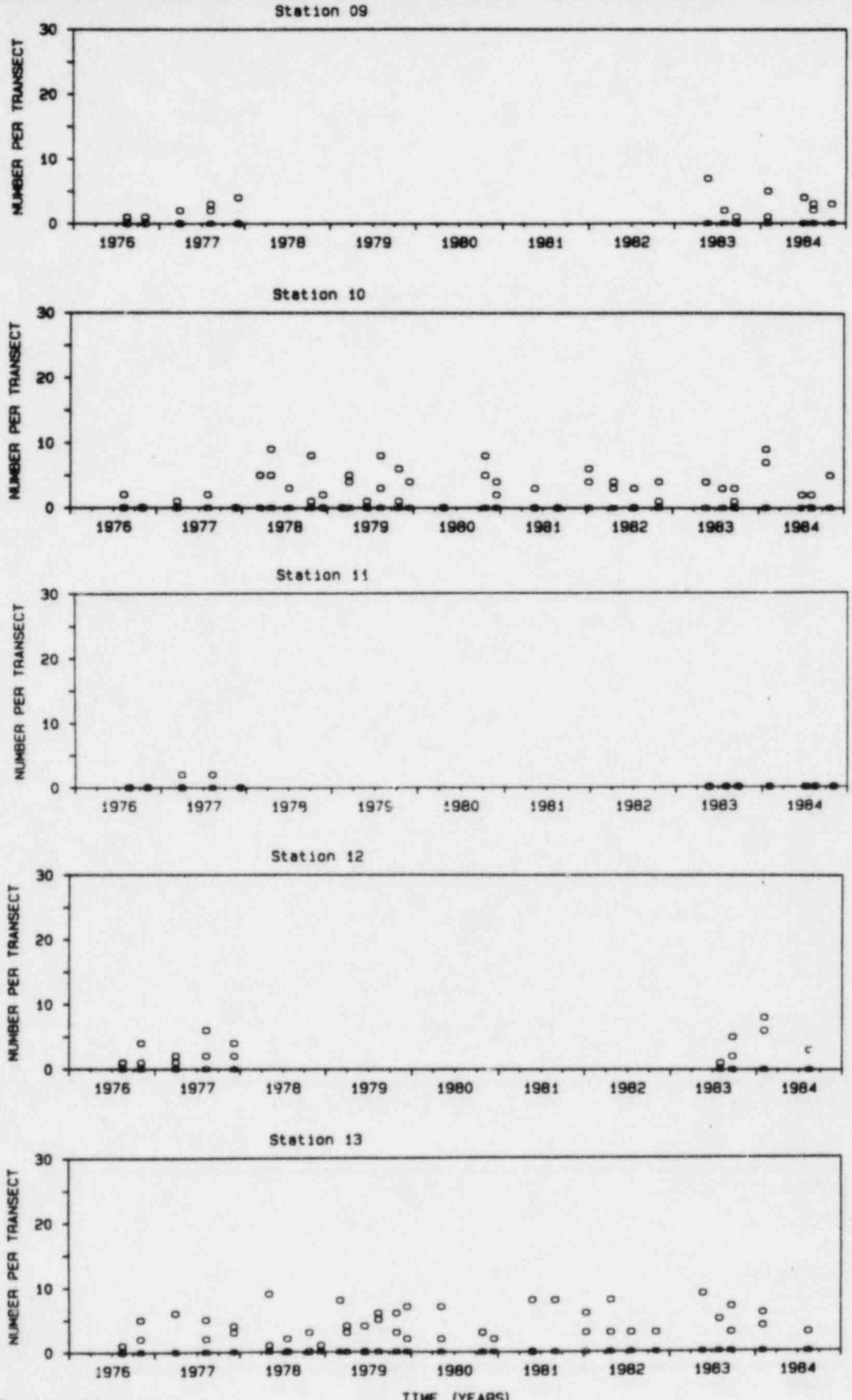
FIGURE 2-55

NUMBER OF ADULT BLACK-AND-YELLOW ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

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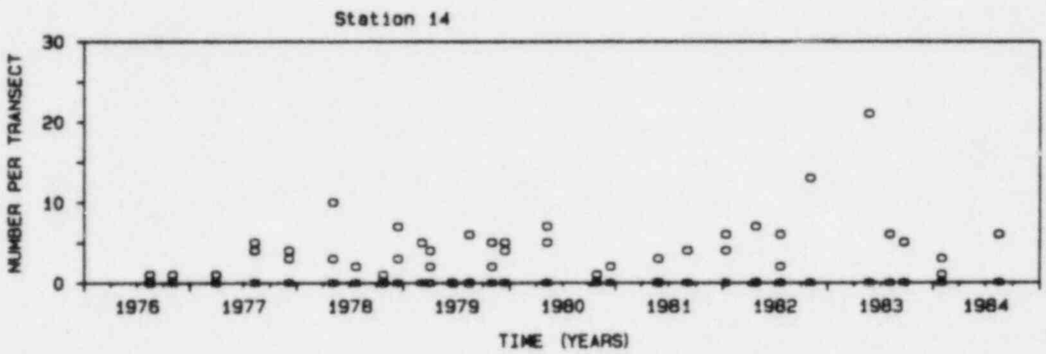
FIGURE 2-55 (CONT.)

NUMBER OF ADULT BLACK-AND-YELLOW ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-55 (CONT.)

NUMBER OF ADULT BLACK-AND-YELLOW ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

summer. Black-and-yellow rockfish were the most abundant juveniles of the rockfish family in 1984.

2.11.2 BLACK SURFPERCH

Black surfperch, Embiotoca jacksoni, was the seventh most abundant species in 1984, accounting for 2 percent of the fish counted. The numbers of adult fish observed on the transects from 1976-1984 are presented graphically in FIGURE 2-56. All but two of the 128 adults were observed on the benthic portion of the transects. This species was observed on all stations, but was most abundant at Station 4.

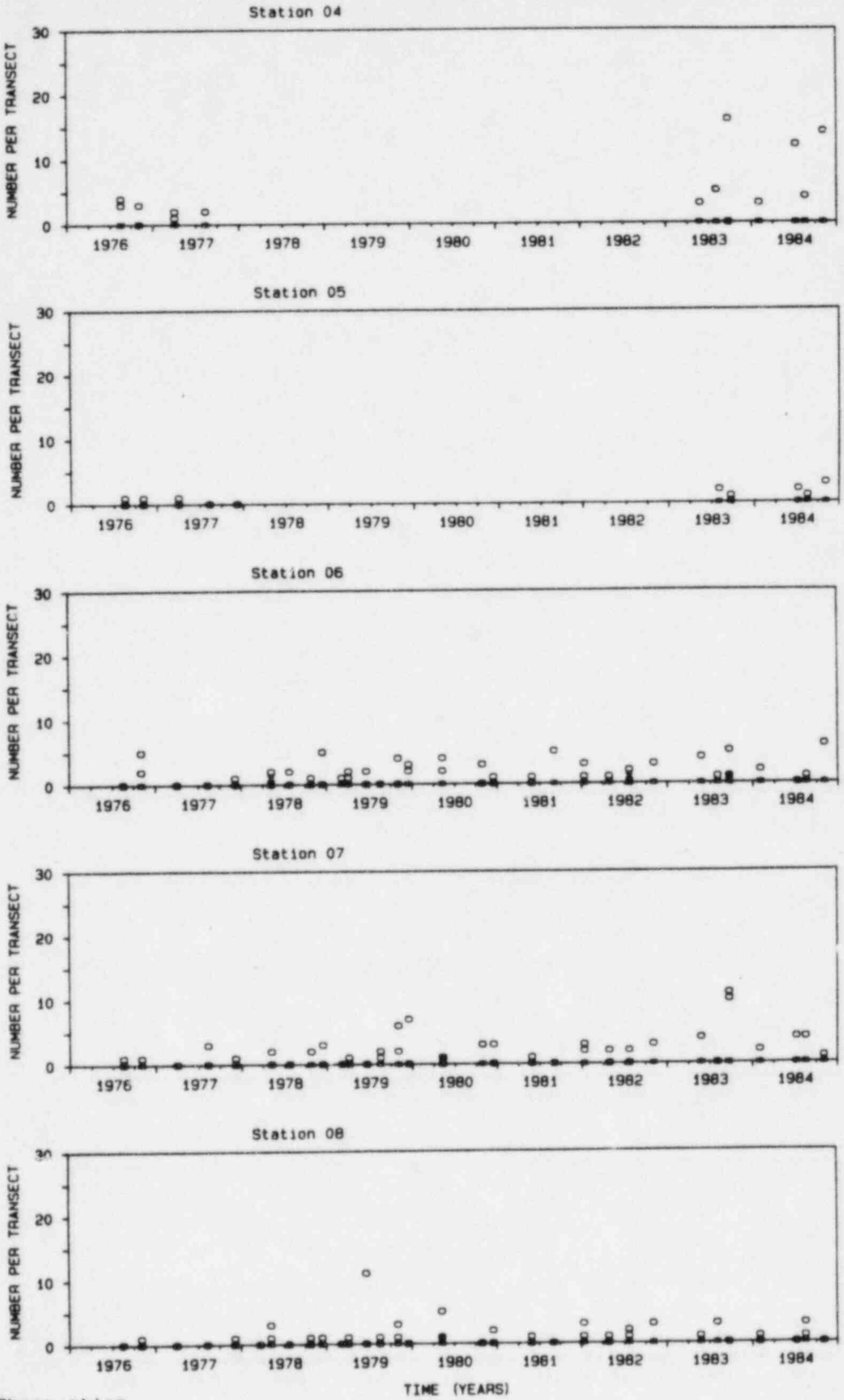
2.11.3 BLUE ROCKFISH

Blue rockfish, Sebastes mystinus, was the fourth most abundant species in 1984, accounting for 4 percent of the fish counted. The adults accounted for 3 percent of all adult fish observed on the transects. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-57. Over one third of these fish (43 percent) were observed in the benthic portion of the transects. Only one juvenile was counted during 1983 compared with 112 counted in 1984.

Seven percent of blue rockfish were observed in spring, 39 percent in summer, and 41 percent in fall. In the fall, the deep-water Stations 4 and 11 in central Diablo Cove had the highest numbers of blue rockfish for the year (FIGURE 2-57).

2.11.4 CABEZON

Cabezon, Scorpaenichthys marmoratus, was the twelfth most abundant species in 1984, accounting for 1 percent of the fish observed. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-58. No juveniles or egg masses were observed along the transects. Cabezon were observed at all stations and were most abundant at Station 4.



* Midwater Observation
o Benthic Observation
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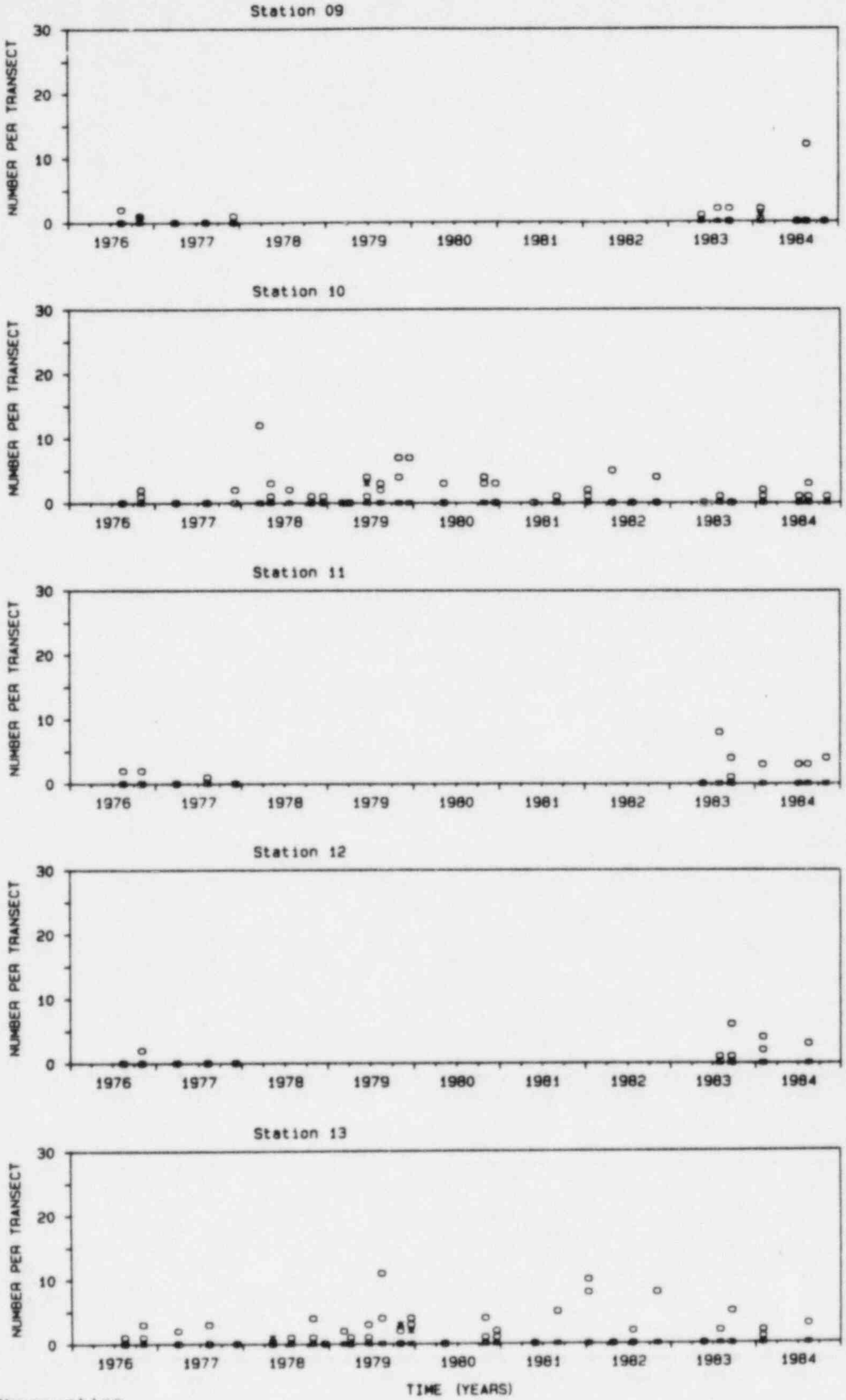
FIGURE 2-56

NUMBER OF ADULT BLACK SURFPERCH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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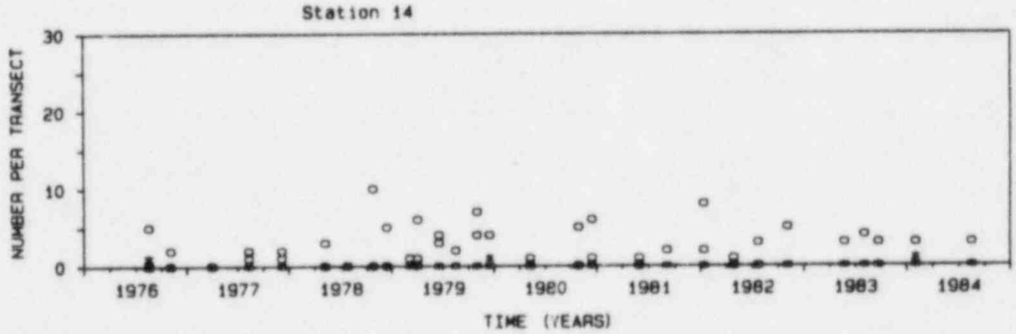
FIGURE 2-56 (CONT.)

NUMBER OF ADULT BLACK SURFPERCH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

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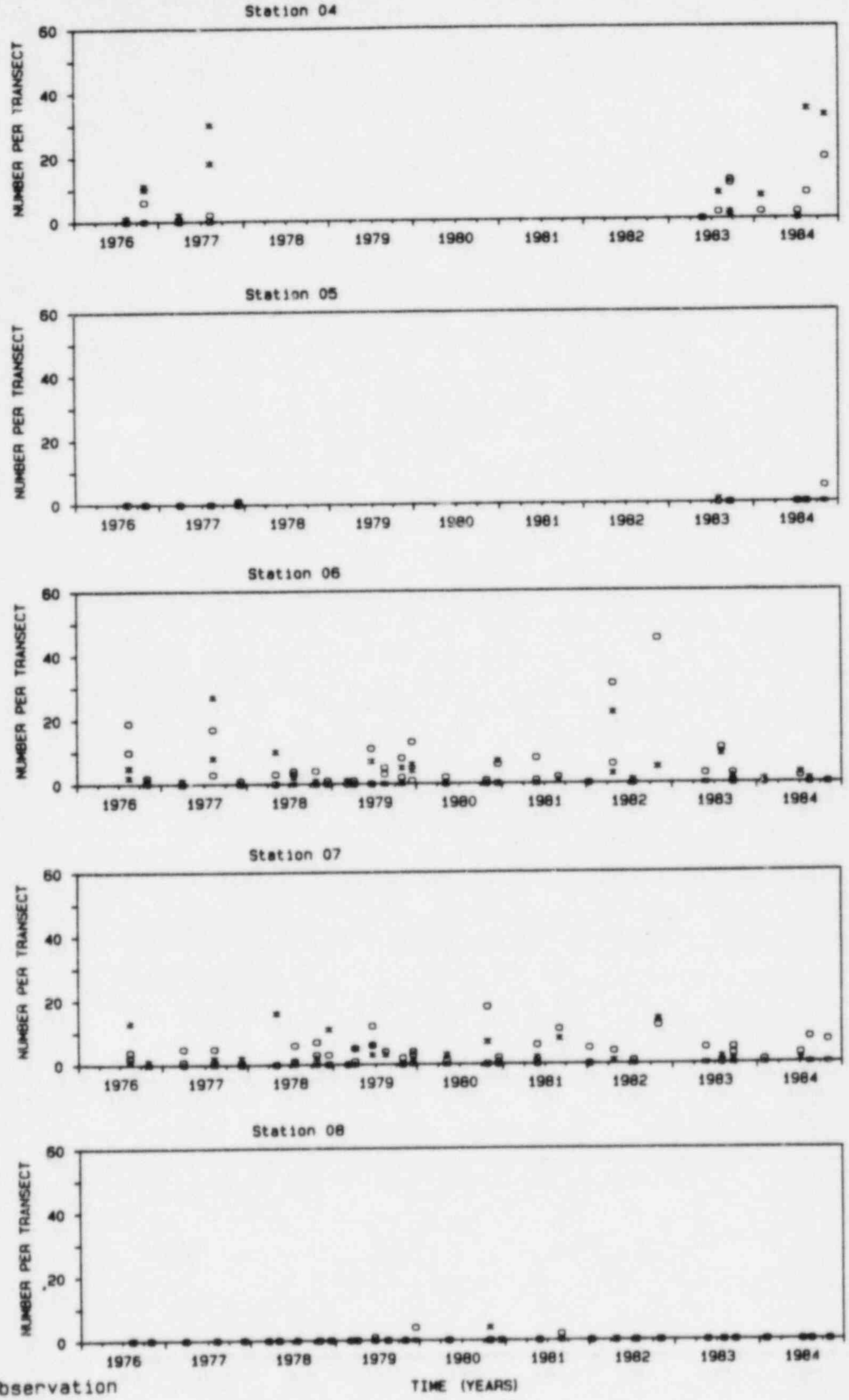
FIGURE 2-56 (CONT.)

NUMBER OF ADULT BLACK SURFPERCH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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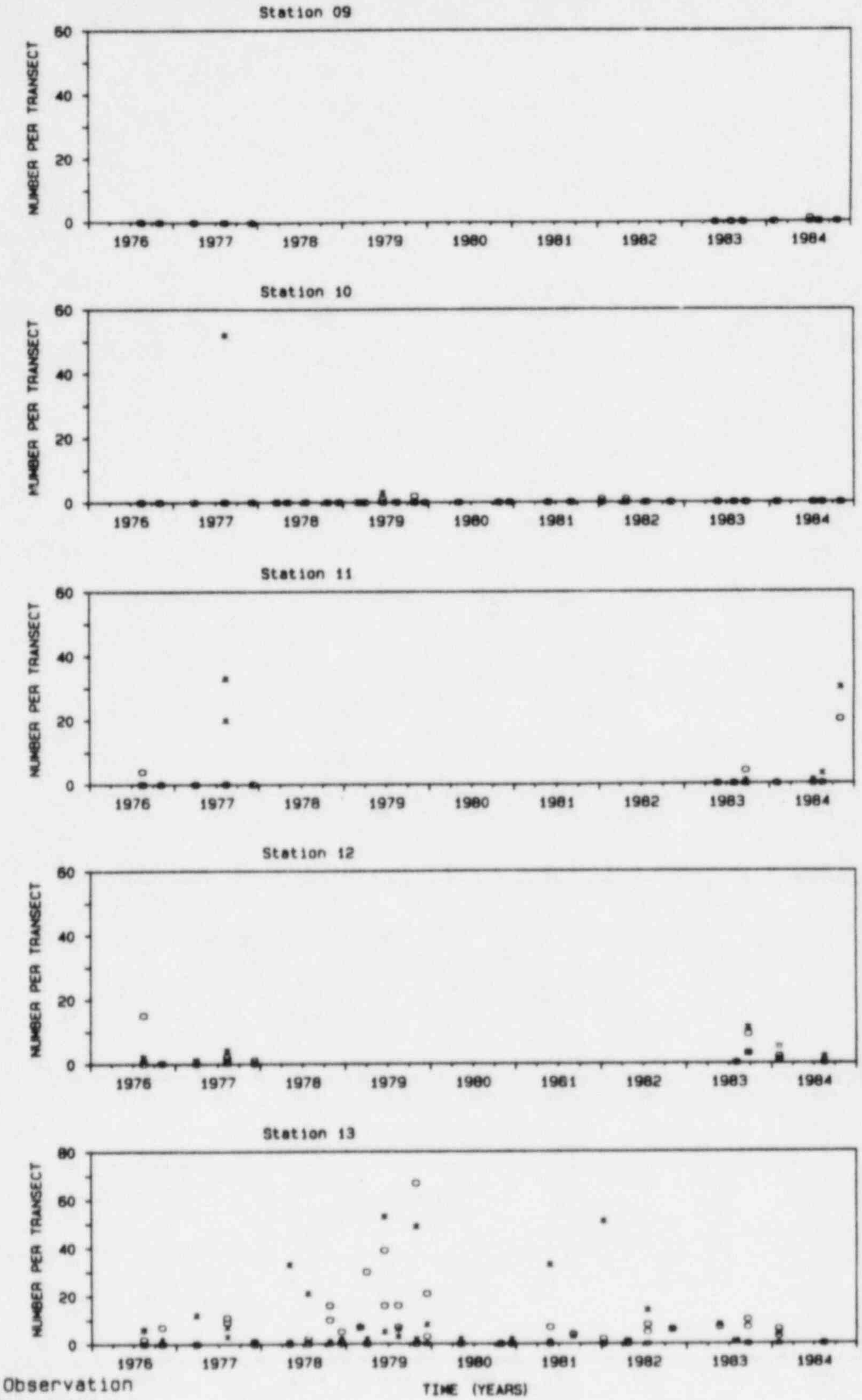
FIGURE 2-57

NUMBER OF ADULT BLUE ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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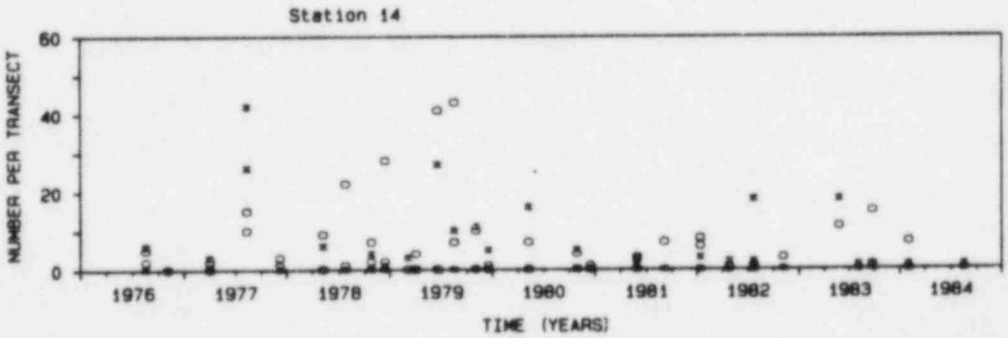
FIGURE 2-57 (CONT.)

NUMBER OF ADULT BLUE ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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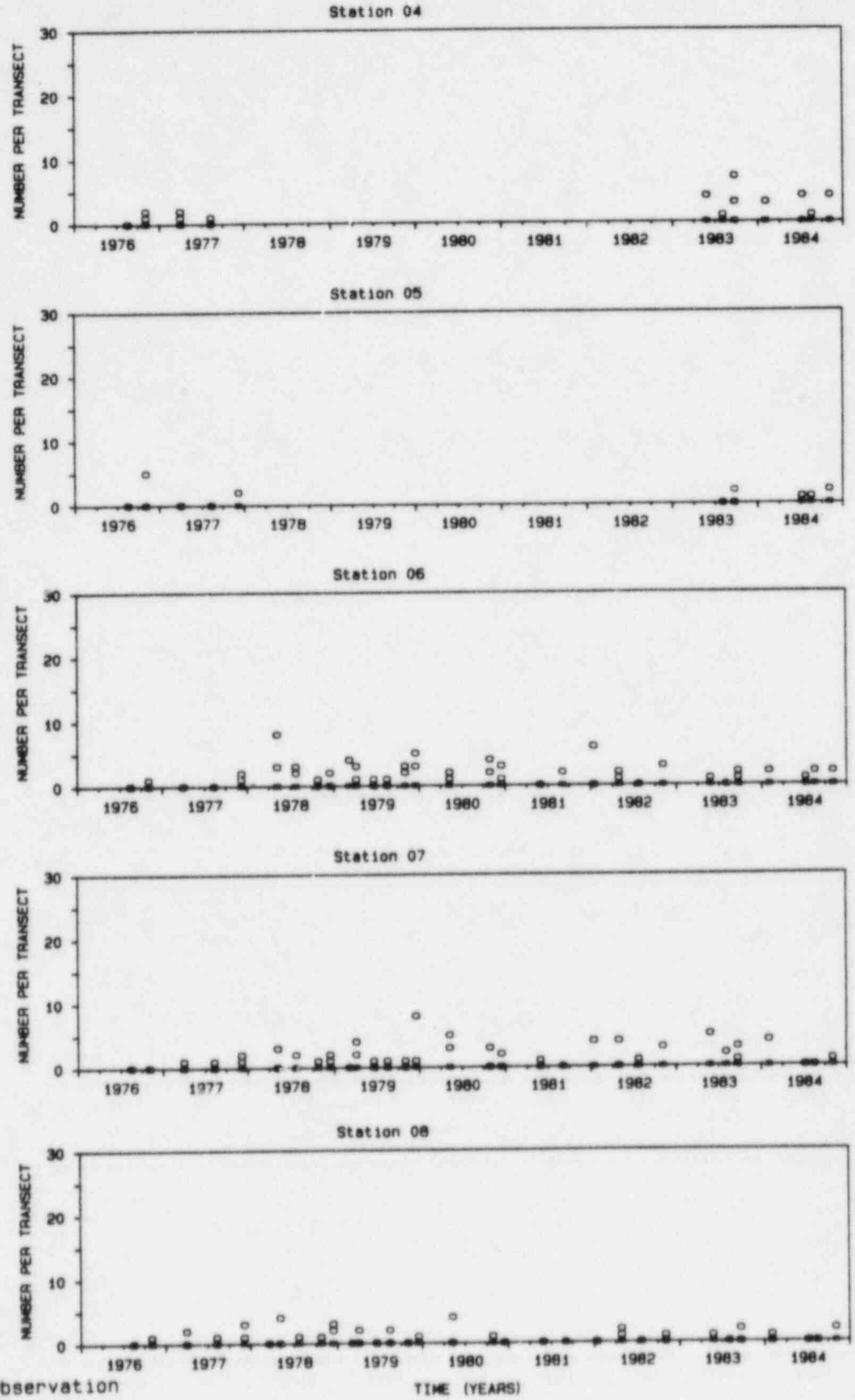
FIGURE 2-57 (CONT.)

NUMBER OF ADULT BLUE ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

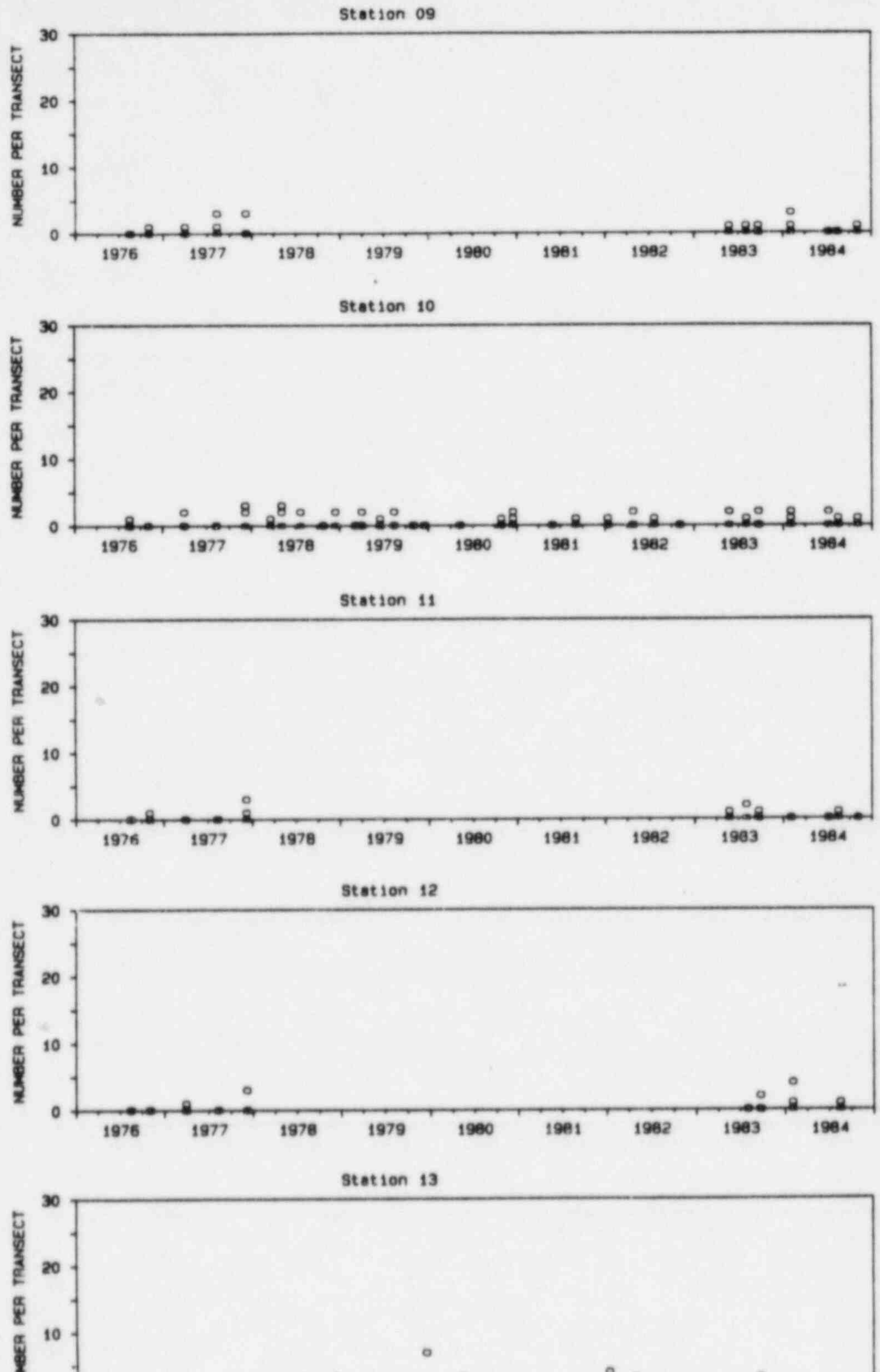


* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-58

NUMBER OF ADULT CABEZON OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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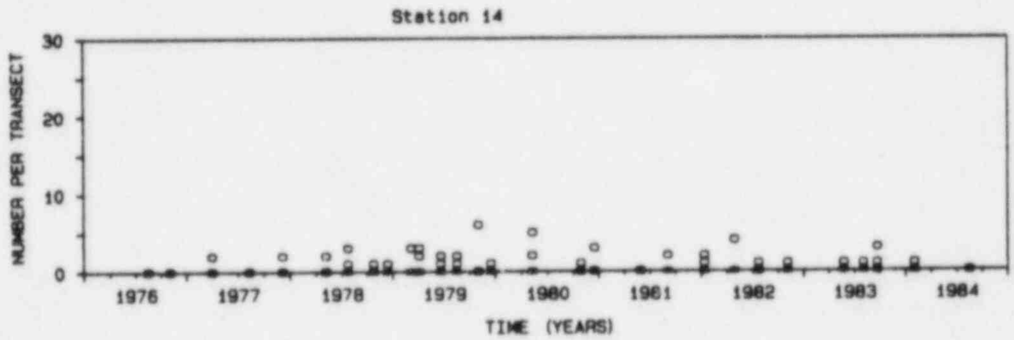
FIGURE 2-58 (CONT.)

NUMBER OF ADULT CABEZON OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-58 (CONT.)

NUMBER OF ADULT CABEZON OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

2.11.5 GRASS ROCKFISH

Grass rockfish, Sebastes rastrelliger, was the thirteenth most abundant species in 1984. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-59. Most juveniles of this species were probably recorded as Sebastes spp. because rockfish juveniles are impossible to distinguish. The 50 adults seen were distributed among all stations except Stations 11 and 13 in South Cove. All adults were observed on the benthic portions of the transects.

2.11.6 OLIVE ROCKFISH

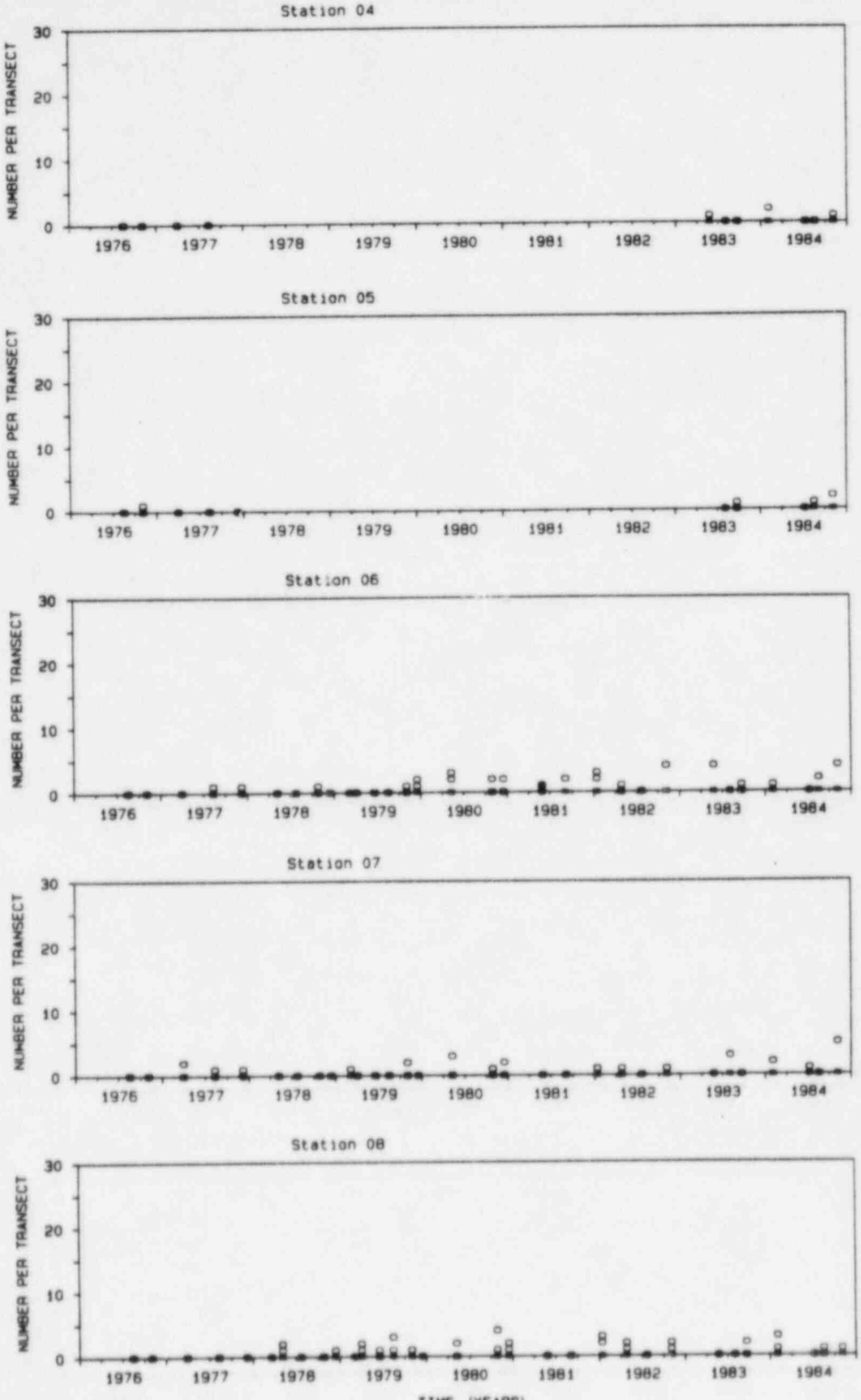
Olive rockfish, Sebastes serranoides, was the third most abundant species in 1984. Only one juvenile was seen in 1983 compared to the 451 counted in 1984. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-60. Of the 23 adult fish seen, fifteen were observed on the benthic portion of the transects and eight were observed in the midwater portion (FIGURE 2-60). More olive rockfish were observed in the summer than the spring, 59 percent versus 29.5 percent, respectively.

2.11.7 PAINTED GREENLING

Painted greenling, Oxylebius pictus, was the fifth most abundant species in 1984. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-61. This species was least abundant at Station 8 and most abundant at Station 4.

2.11.8 SENORITA

Senorita, Oxyjulis californica, is a ubiquitous species in the Diablo Cove area. It occurs throughout the year and has been the most abundant species since 1976. In 1984 senorita was once again the most abundant species in all three categories (63 percent of total fish, 72 percent of adults, and 17 percent of juveniles). The numbers of adult fish counted on the transects from 1976-1984 are presented



* Midwater Observation
o Benthic Observation

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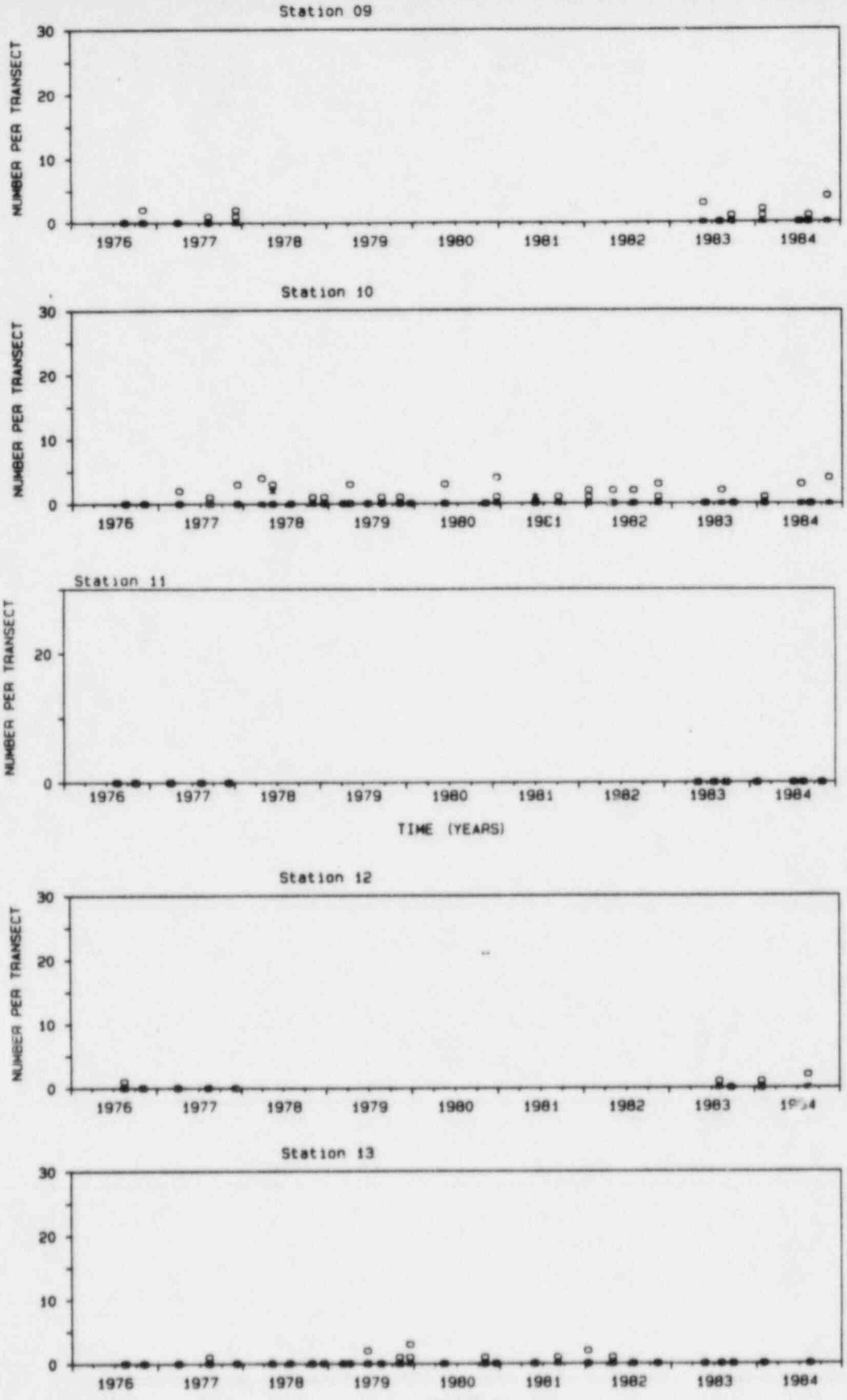
FIGURE 2-59

NUMBER OF ADULT GRASS ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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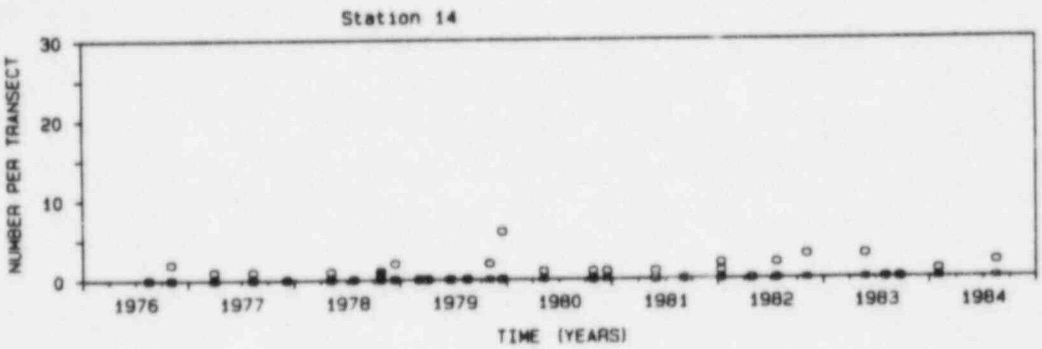
FIGURE 2-59 (CONT.)

NUMBER OF ADULT GRASS ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

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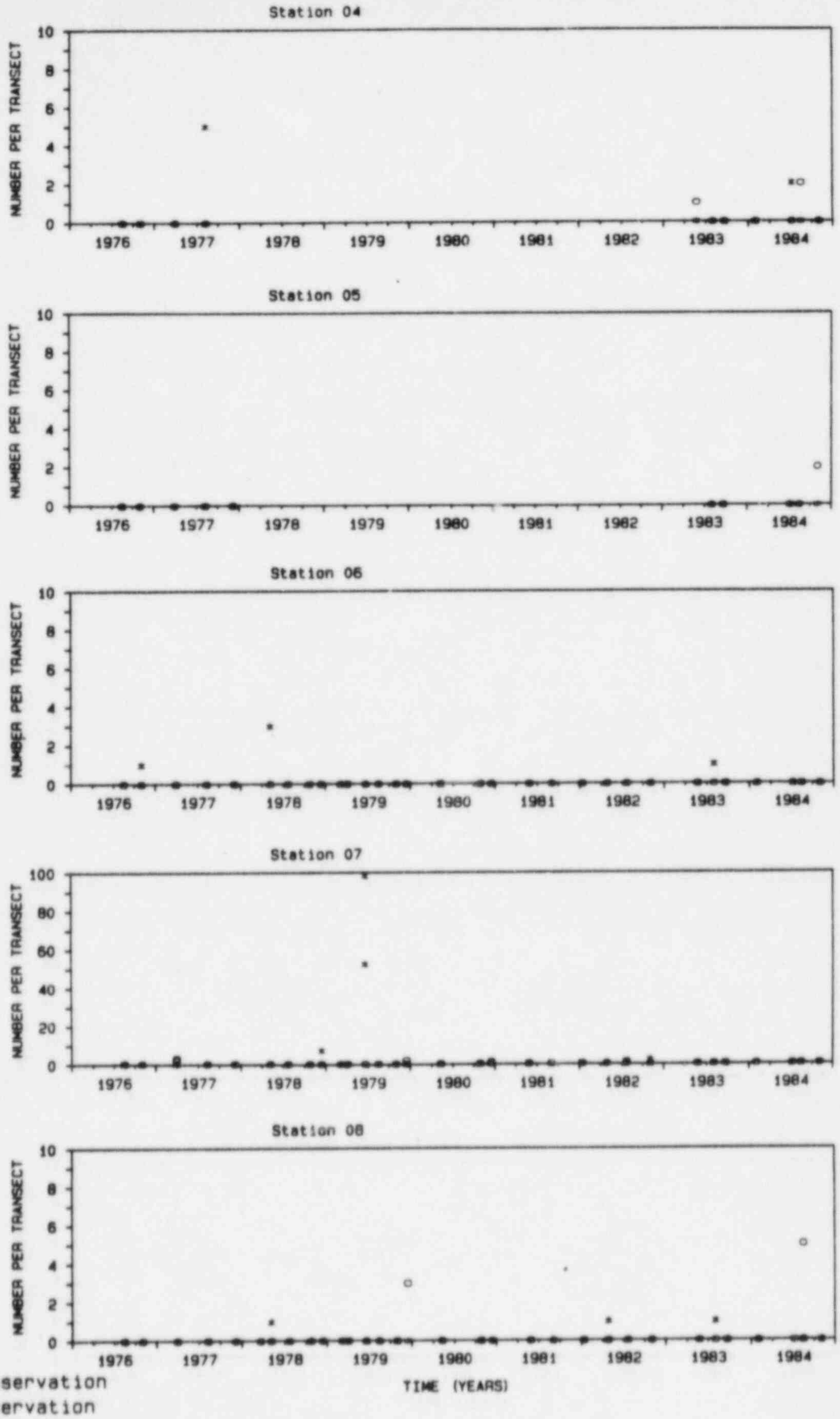
FIGURE 2-59 (CONT.)

NUMBER OF ADULT GRASS ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

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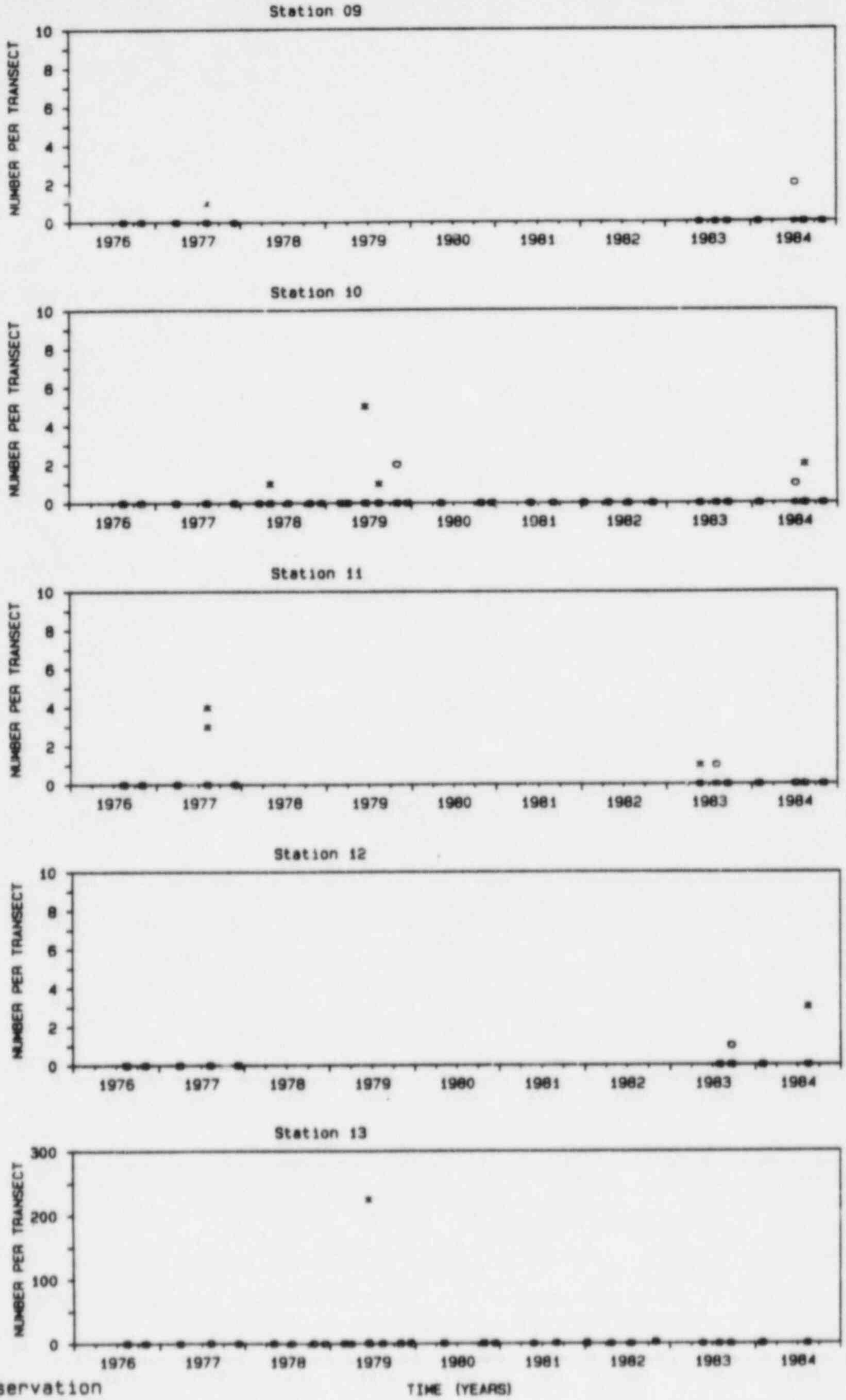
FIGURE 2-60

NUMBER OF ADULT OLIVE ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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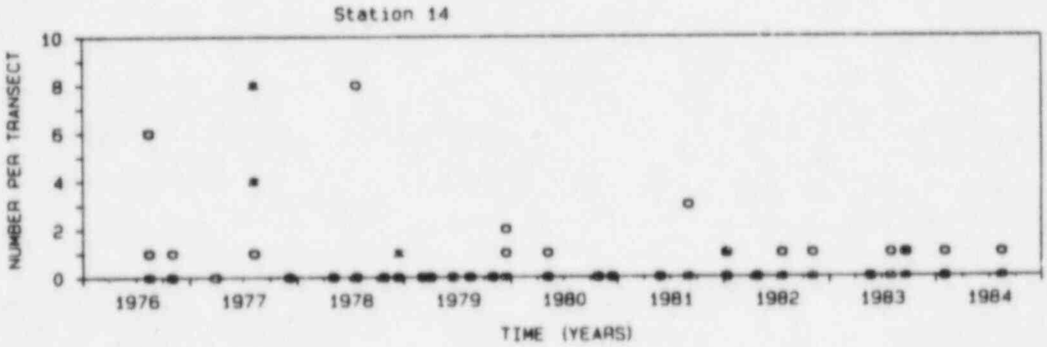
FIGURE 2-60 (CONT.)

NUMBER OF ADULT OLIVE ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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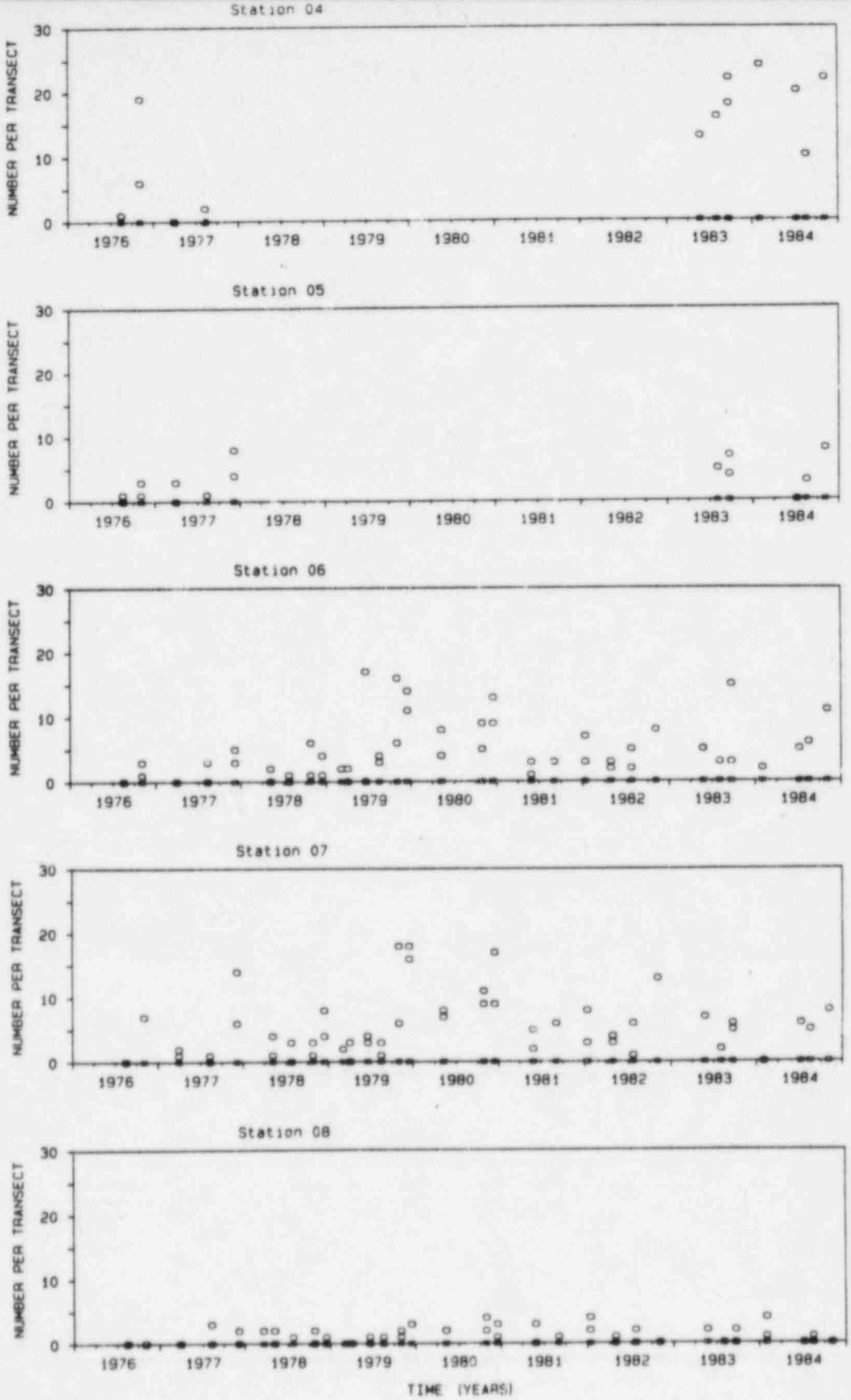
FIGURE 2-60 (CONT.)

NUMBER OF ADULT OLIVE ROCKFISH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

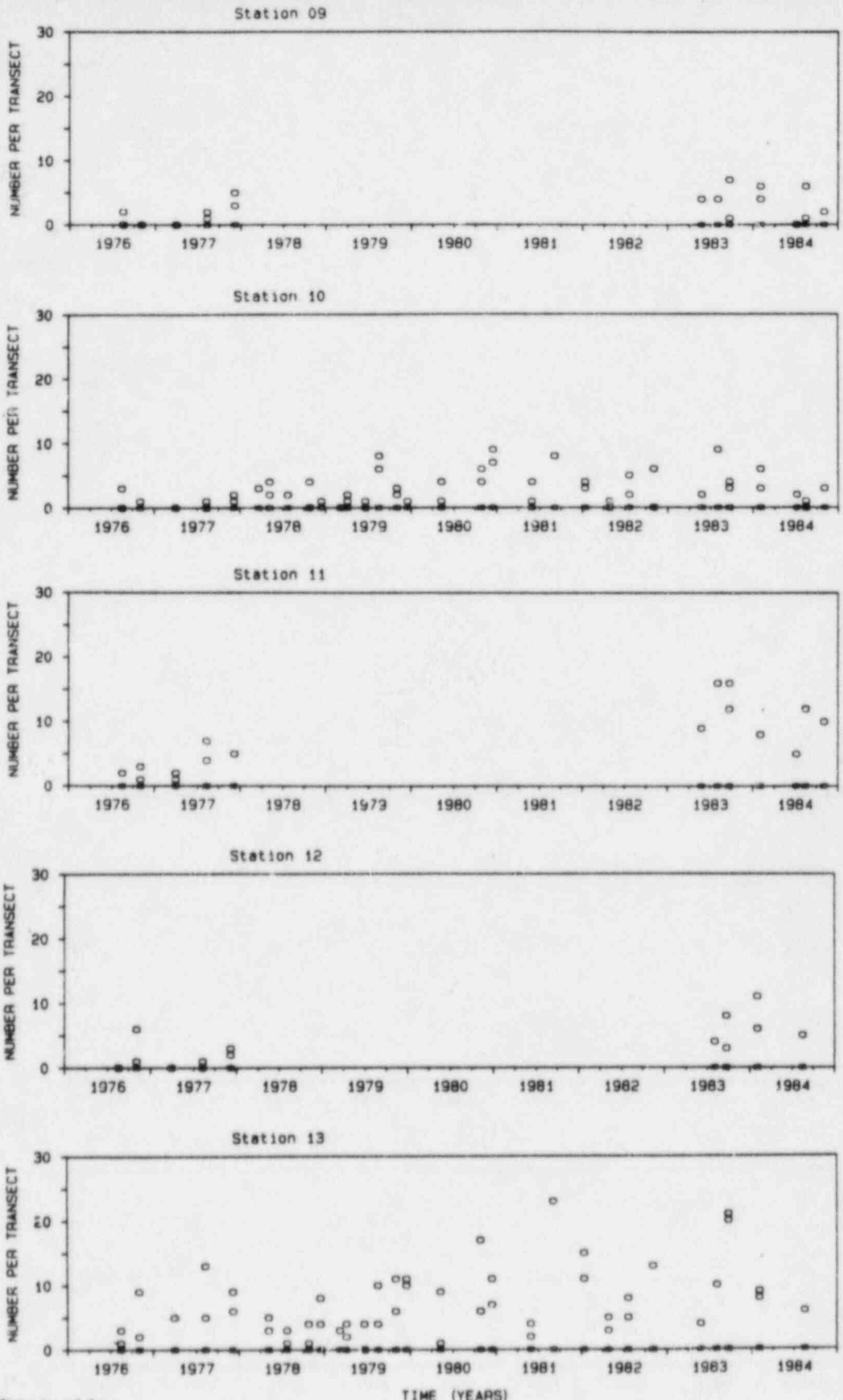


* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-61

NUMBER OF ADULT PAINTED GREENLING OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

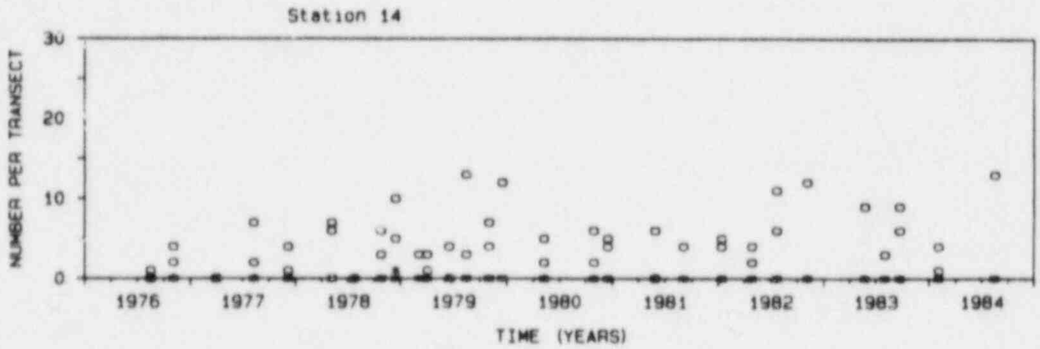


* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-61 (CONT.)

NUMBER OF ADULT PAINTED GREENLING OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-61 (CONT.)

NUMBER OF ADULT PAINTED GREENLING OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

graphically in FIGURE 2-62. The majority of adults and juveniles were observed on the benthic portion of the transects (65 percent of adults and 66 percent of juveniles). Adults were most abundant during winter and least abundant in the spring. The juveniles were abundant during the fall.

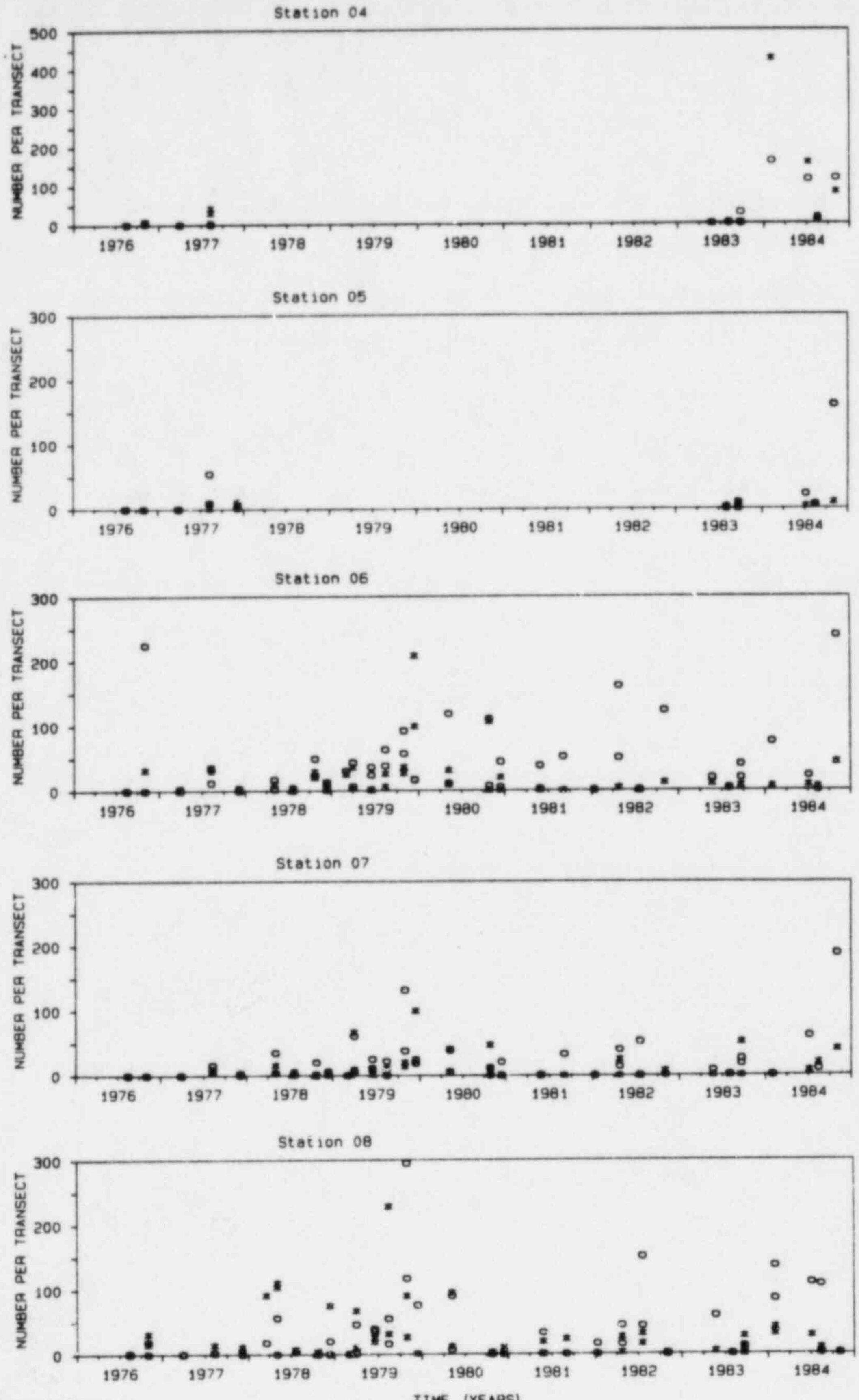
2.11.9 STRIPED SURFPERCH

Striped surfperch, Embiotoca lateralis, continued to be the most numerous Embiotocid observed thus far. This surfperch was the sixth most abundant species in 1984 (196 total fish, 2 percent). It ranked fourth among adult taxa. The numbers of adult fish counted on the transects from 1976-1984 are presented graphically in FIGURE 2-63. All but seventeen of the 158 adults were observed on the benthic portion of the transects. Adults were recorded at all stations, being most abundant at Station 12 and least abundant at Station 11.

2.11.10 KELP BASS

Kelp bass, Paralabrax clathratus, range from Magdalena Bay, Baja California, Mexico, to the Columbia River. These bass live among seaweeds and rocks. Juveniles are observed in shallower depths than adults. In southern California they are not reported to migrate extensively (Limbaugh 1955). Spawning occurs from early May through August and the eggs are pelagic. The young are common in inshore seaweeds and eelgrass of bays. First-year fish are reported to be 1 to 2 inches long, and second-year fish 4 inches long. Maturation is at 8 inches at an age of 2 years. Their food includes squid, smaller fish, and crustaceans.

During 1983 the kelp bass was the second most abundant fish encountered on the transects (FIGURE 2-64). Although they were not recorded on the transects in 1984, they were observed to be abundant in areas adjacent to the transects, including the shallow water (less than 2 m depth) Phyllospadix zone along south Diablo Cove, deeper offshore reefs at 10 m depth, and inside the breakwater of the intake Cove.



* Midwater Observation
o Benthic Observation
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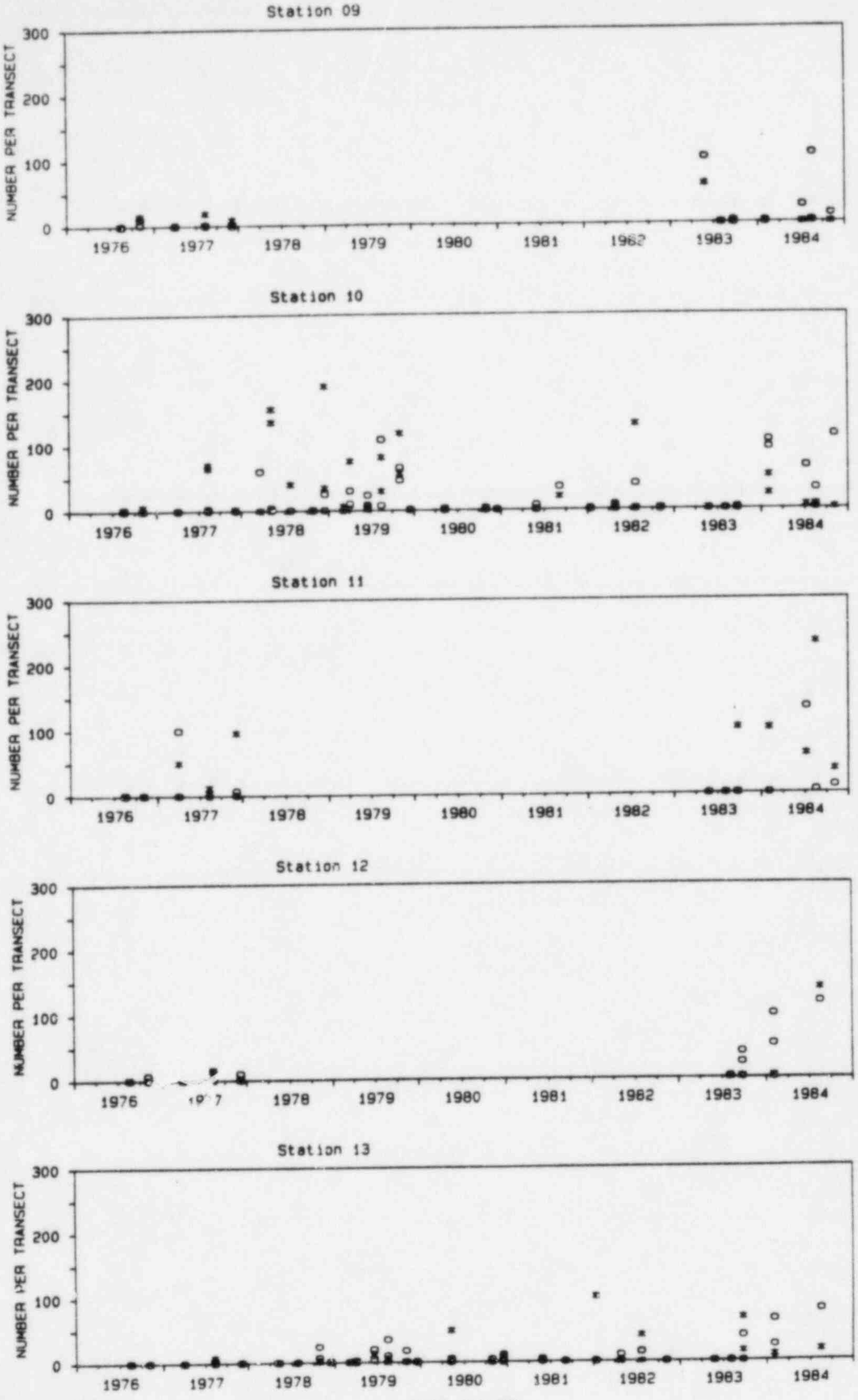
FIGURE 2-62

NUMBER OF ADULT SENORITA OBSERVED IN
50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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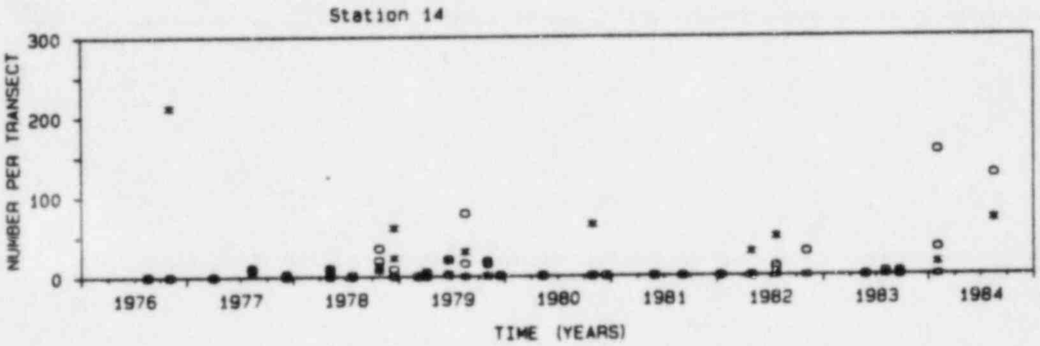
FIGURE 2-62 (CONT.)

NUMBER OF ADULT SENORITA OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation

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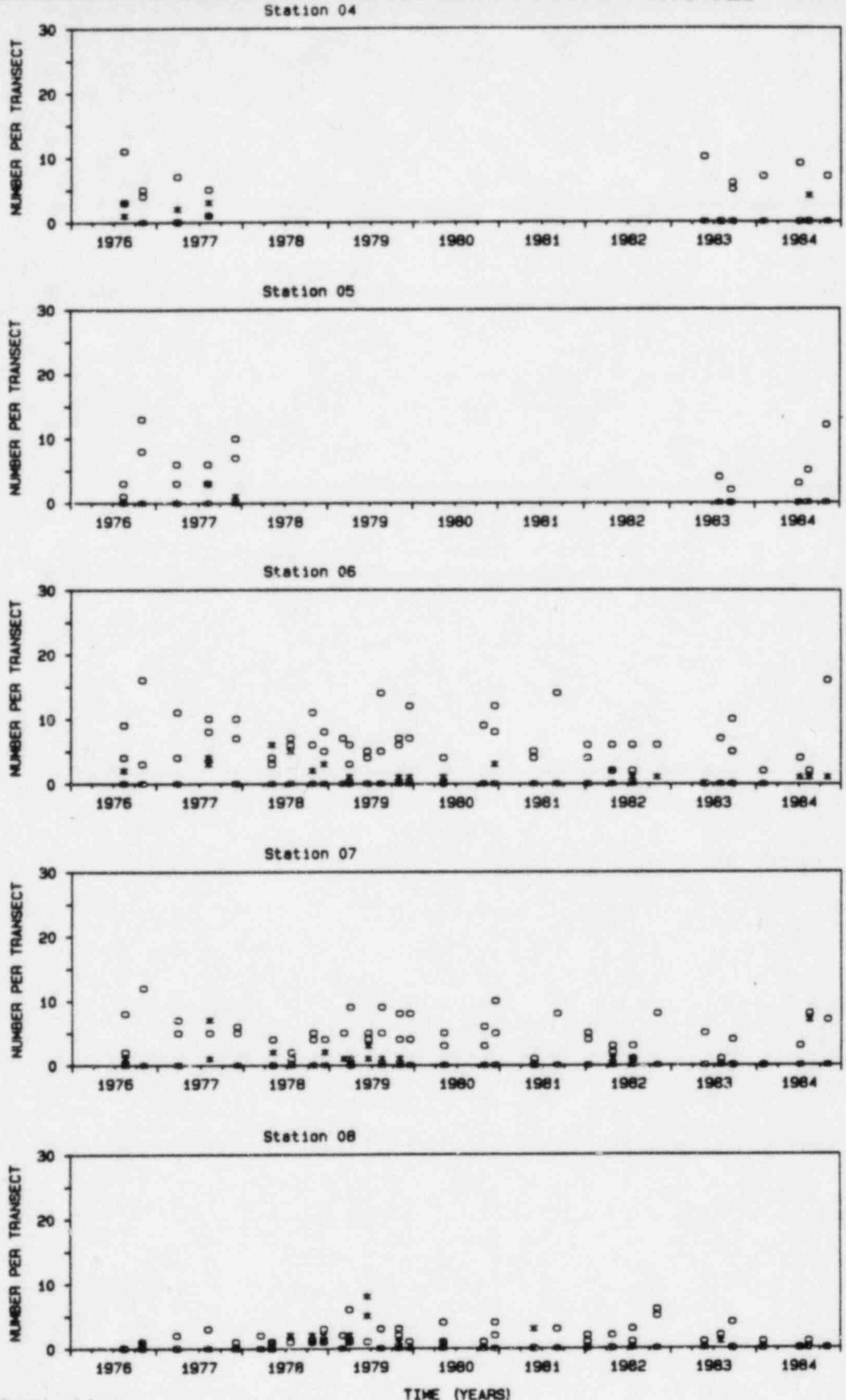
FIGURE 2-62 (CONT.)

NUMBER OF ADULT SENORITA OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
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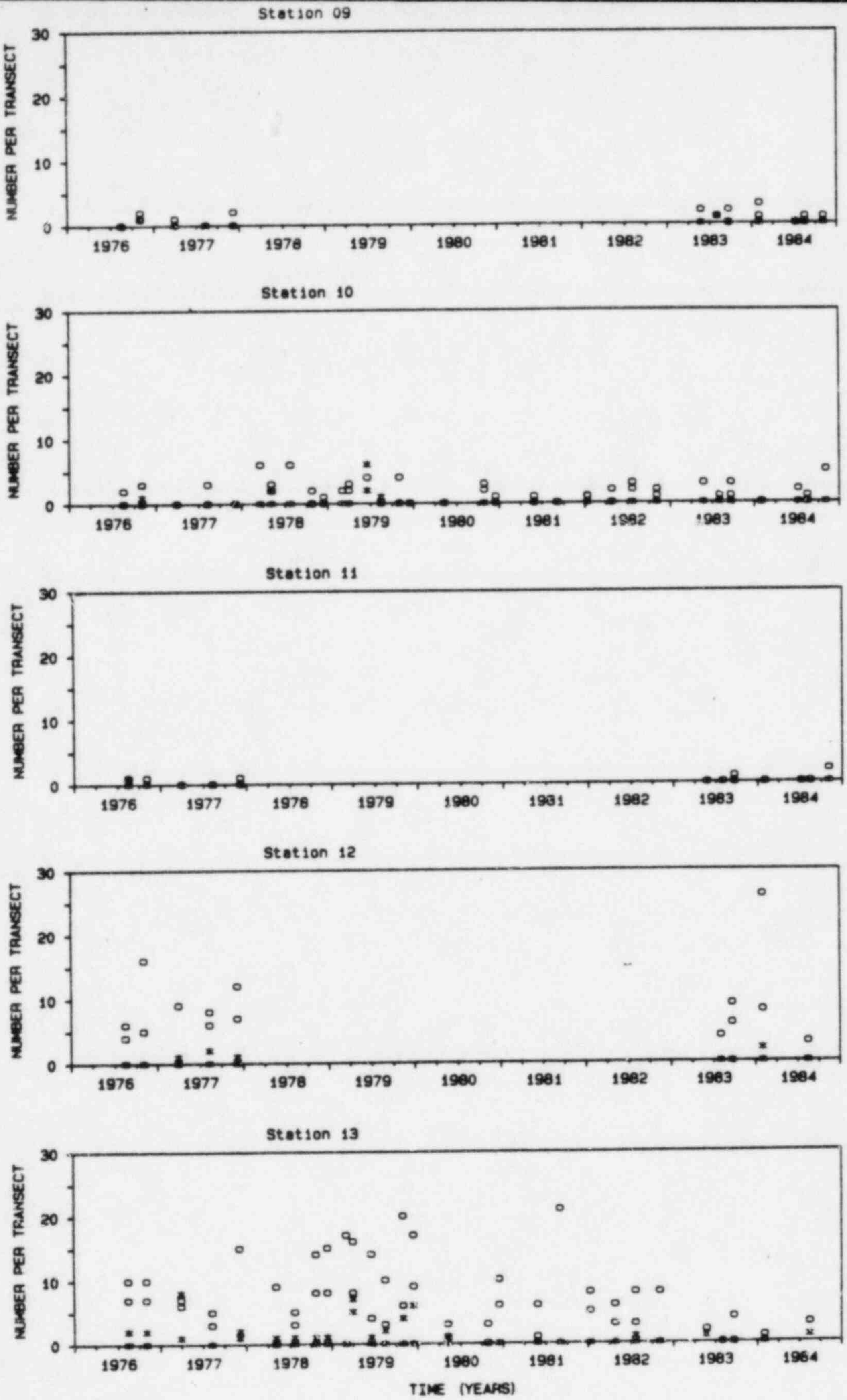
FIGURE 2-63

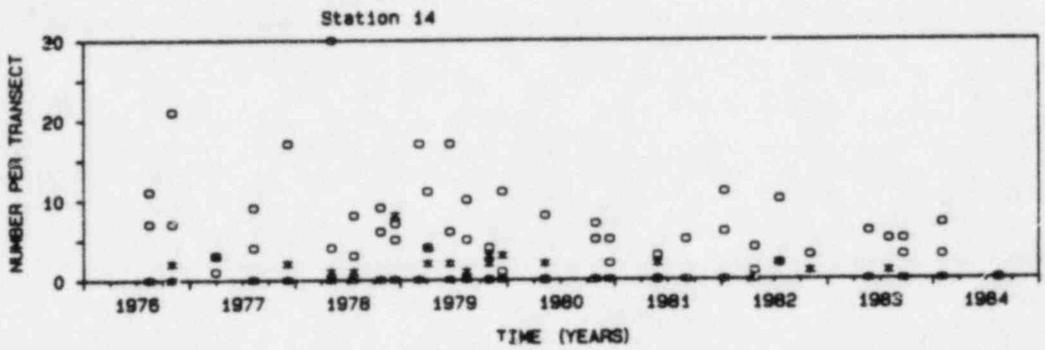
NUMBER OF ADULT STRIPED SURFPERCH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
Overprinting of above symbols appear to be different symbols

FIGURE 2-63 (CONT.)

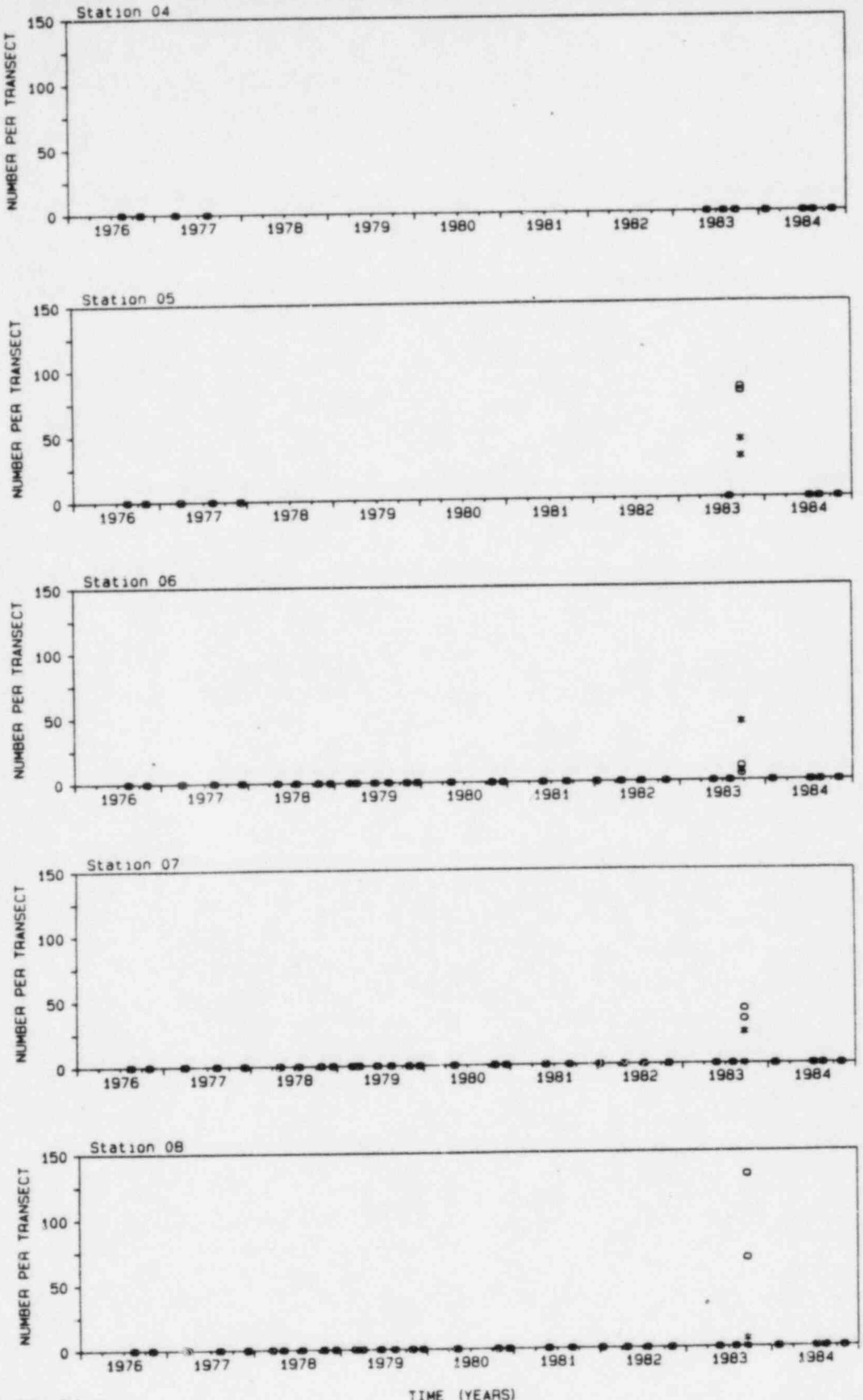
NUMBER OF ADULT STRIPED SURFPERCH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
Overprinting of above symbols appear to be different symbols

FIGURE 2-63 (CONT.)

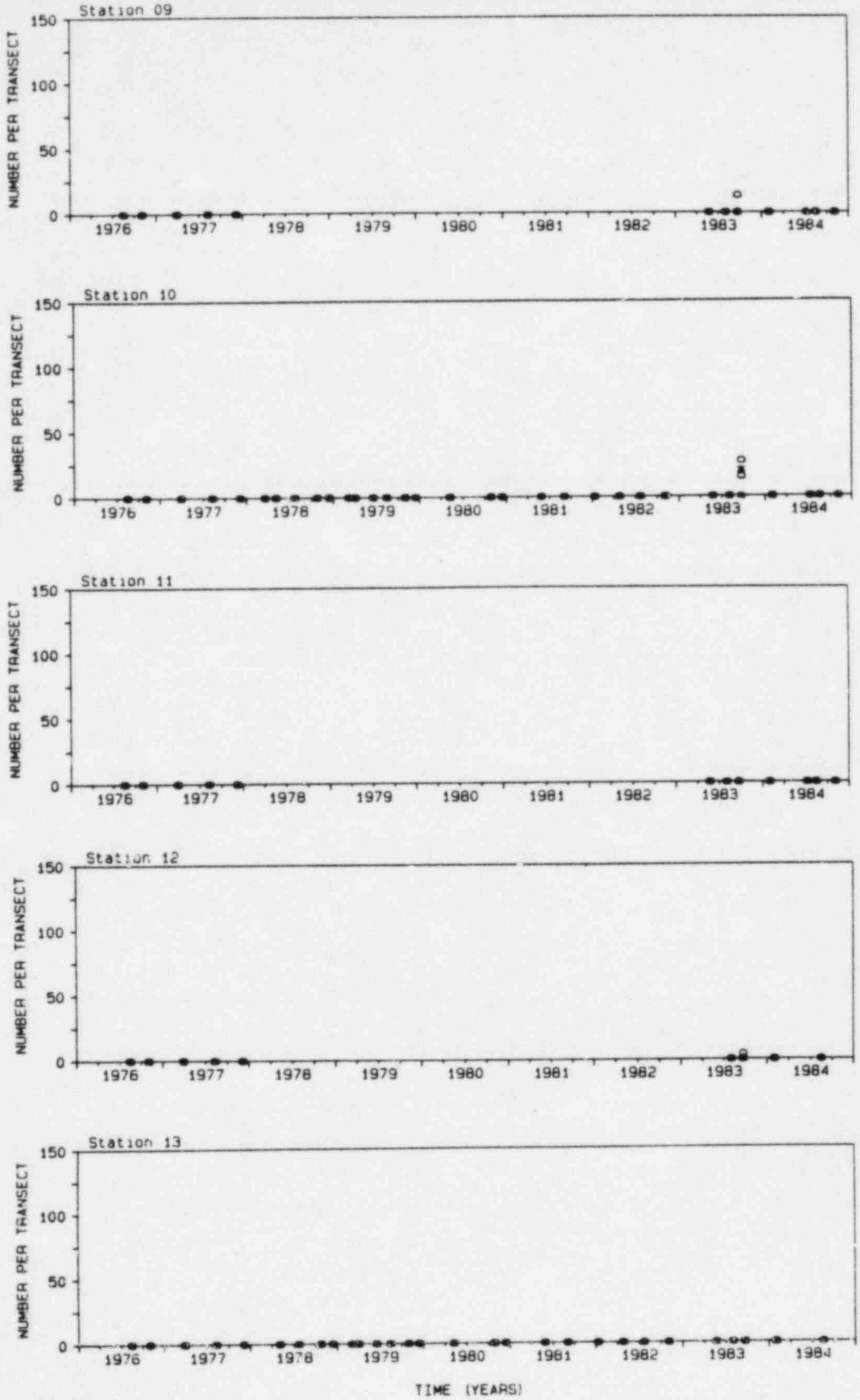
NUMBER OF ADULT STRIPED SURFPERCH OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS



* Midwater Observation
o Benthic Observation
Overprinting of above symbols appear to be different symbols

FIGURE 2-64

NUMBER OF KELP BASS OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSECT SURVEYS

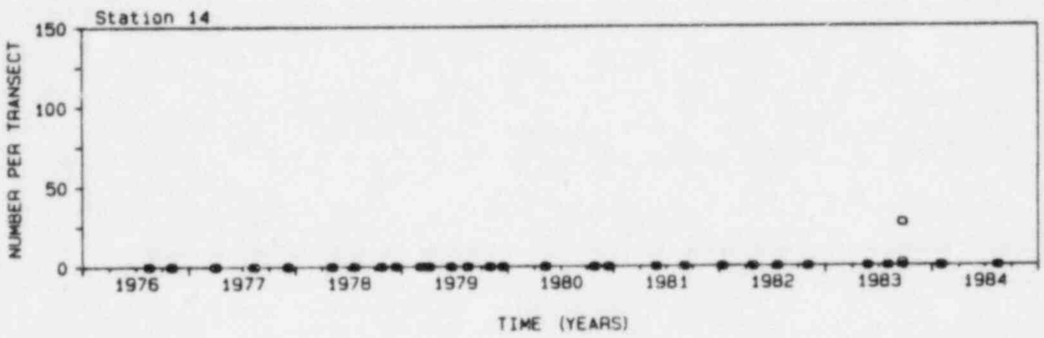


* Midwater Observation
o Benthic Observation

Overprinting of above symbols appear to be different symbols

FIGURE 2-64 (CONT.)

NUMBER OF KELP BASS OBSERVED IN 50 X 4 M SUBTIDAL BAND TRANSSECT SURVEYS



* Midwater Observation
o Benthic Observation
Overprinting of above symbols appear to be different symbols

FIGURE 2-64 (CONT.)

NUMBER OF KELP BASS OBSERVED IN
50 X 4 M SUBTIDAL BAND TRANSSECT SURVEYS

The presence of kelp bass coincided with the El Nino conditions of 1983. Other southern California species that occurred with kelp bass were rock wrasse, half moon, and blacksmith. In addition, numerous immature sheepshead were present in the area. Kelp bass were previously observed in the study areas at Diablo Canyon only during the warm water period in 1976 (on stations not included in this report because they are not currently being sampled). Young fish have also been reported in Morro Bay in the past several years. The unusual current conditions in 1982-1983 could have carried the pelagic eggs of this species into the area. However, many 10-12 inch adults (4 plus year class) have been observed, which may suggest that this fish is more migratory than reported in past studies.

2.12 SUBTIDAL SETTLING PLATES

This section presents settling plate data from the short-term plates (2-month exposure) for Surveys 1-51 (July 1976 to December 1984) and from the long-term (4- to 12-month exposure) plates for Surveys 1 to 43 (July 1976 to July 1983). Data on spatial and temporal variation were analyzed for species richness (all methods combined) and dry-weight biomass. Settlement patterns of five taxa over time on the short-term plates at all six stations are also reported. Settlement patterns on the long-term plates will be considered in a future report.

TABLE 2-18 lists the dates of plate installation and retrieval, and the number of stations sampled within each survey. The 94 algal taxa and 68 invertebrate taxa (including Ascidiacea, which are chordates) identified on the settling plates are listed in TABLE 2-19. Of the algal taxa, 73 percent were red algae, 16 percent brown algae, and 9 percent green algae. The predominant invertebrate groups were bryozoans (28 percent), cnidarians (16 percent), annelids (15 percent), and protozoans (13 percent). Forty-one algal taxa and 37 invertebrate taxa were recorded from the short-term plates (2-month exposure). On the long-term plates, nearly double the number of taxa was identified: 78 algal and 66 invertebrate taxa.

2.12.1 SPECIES RICHNESS

FIGURE 2-65 presents the total number of algal and invertebrate taxa encountered on the short-term plates at the six stations in the Diablo Cove area. The number of attached taxa varied both within years and between years. No one station consistently had more taxa than the other stations. Greater numbers of attached algae were recorded during the spring-summer period. In many years, the number of attached invertebrates increased in the summer-fall period. This seasonal increase in larval settlement is in accordance with findings in studies at Woods Hole, Massachusetts (Osman 1977), and San Francisco Bay, California (Ehrler and Lyke 1980).

TABLE 2-18

SUBTIDAL SETTLING PLATE COLLECTION DATES

Date		Survey Number	Study Year	Number of Stations Sampled	Plates Removed/ Installed Per Station
July	1976	1	1	14	6*
September	1976	2	1	14	1
November	1976	3	1	14	2
January	1977	4	1	14	2
March	1977	5	1	14	2
May	1977	6	1	14	2
July	1977	7	1/2	14	6
September	1977	8	2	10	1
November	1977	9	2	10	2
January	1978	10	2	6	2
March	1978	11	2	6	2
May	1978	12	2	6	2
July	1978	13	2/3	6	6
September	1978	14	3	6	1
November	1978	15	3	6	2
January	1979	16	3	6	2
March	1979	17	3	6	2
May	1979	18	3	6	2
July	1979	19	3/4	6	6
September	1979	20	4	6	1
November	1979	21	4	6	2
January	1980	22	4	6	2
March	1980	23	4	6	2
May	1980	24	4	6	2
July	1980	25	4/5	6	6
September	1980	26	5	6	1
November	1980	27	5	6	2
January	1981	28	5	6	2
March	1981	29	5	6	2
May	1981	30	5	6	2

* Installation only.

TABLE 2-18

SUBTIDAL SETTLING PLATE COLLECTION DATES
(CONTINUED)

Date		Survey Number	Study Year	Number of Stations Sampled	Plates Removed/ Installed Per Station
July	1981	31	5/6	6	6
September	1981	32	6	6	1
November	1981	33	6	6	2
January	1982	34	6	6	2
March	1982	35	6	6	2
May	1982	36	6	6	2
July	1982	37	6/7	6	6
September	1982	38	7	6	1
November	1982	39	7	6	2
January	1983	40	7	6	2
March	1983	41	7	6	2
May	1983	42	7	6	2
July	1983	43	7/8	6	6
September	1983	44	8	6	1
November	1983	45	8	6	2
January	1984	46	8	6	2
March	1984	47	8	6	2
May	1984	48	8	6	2
July	1984	49	8/9	6	6
September	1984	50	9	6	1
November	1984	51	9	6	2

TABLE 2-19

TAXA ENCOUNTERED ON SUBTIDAL SETTLING PLATES,
JULY 1976 - DECEMBER 1984

(Random point contact, quadrat and
edge/margin methods combined)

ALGAE

Chlorophyta

Bryopsis corticulans
Cladophorales
Enteromorpha linza
Enteromorpha spp.
green filaments, unid.
Halicystis ovalis
Spongomorpha spp.
Spongomorpha spp/Cladophora spp
Ulva spp.

Phaeophyta

Brown filaments, unid.
Colpomenia spp./Soranthera spp.
Cystoseira osmundacea
Desmarestia ligulata
Dictyoneurum californicum
Ectocarpales
Egregia menziesii
Giffordia granulosa
Halorhipis winstonii
Haplogloia andersonii
Laminaria dentigera
Laminariales (juvenile)
Nereocystis luetkeana
Phaeophyta (juvenile)
Pterygophora californica

Rhodophyta

Antithamnion defectum
Antithamnion spp.
Antithamnionella pacifica
Asterocolax gardneri
Botryoglossum farlowianum
Branchioglossum undulatum
Calliarthron spp./Bossiella spp./Serraticardia spp. (CBS)
Callithamnion spp./Pleonosporium spp.
Callophyllis firma
Callophyllis flabellulata
Callophyllis pinnata
Callophyllis spp.
Callophyllis violacea
Corallina officinalis
Corallina spp.
Corallina spp./CBS (juvenile)
Corallina vancouveriensis
Coralline crust
Cryptopleura spp.
Cryptopleura violacea
Delesseriaceae (juvenile)
Erythrophyllum delesserioides

Rhodophyta (Cont.)

Gastroclonium coulteri
Gelidium coulteri
Gelidium spp.
Gigartina exasperata/G. corymbifera
Gigartina harveyana
Gigartina leptorhynchos
Gigartina spp.
Halymenia spp./Schizymenia spp.
Herposiphonia verticillata
Hymenena flabelligera
Hymenena spp.
Iridaea cordata
Iridaea heterocarpa
Janczewskia gardneri
Laurencia spectablis
Membranoptera multiramosa
Membranoptera weeksiae
Membranoptera spp.
Microcladia borealis
Microcladia coulteri
Neoagardhiella gaudichaudii
Neoptilota densa
Non-coralline crust
Phycodrys setchellii
Phycodrys spp.
Platythamnion pectinatum
Platythamnion spp.
Pleonosporium squarrulosum
Polyneura latissima
Polysiphonia spp.
Porphyra occidentalis
Porphyra spp.
Prionitis spp.
Prostrate red filaments
Pseudogloiophloea confusa
Pterochondria woodii
Pterocladia caloglossoides
Pterosiphonia dendroidea
Red algal turf 01 (straight or branched filaments)
Red algal turf 02 (feather-like)
Rhodoglossum roseum
Rhodophyta (juvenile)
Rhodymenia callophyllidoides
Rhodymenia spp.
Rhodoptilum plumosum
Tiffaniella snyderiae

Bacillariophyta

Diatom chains, unid.
Licmophora spp.

TABLE 2-19
(CONTINUED)

TAXA ENCOUNTERED ON SUBTIDAL SETTLING PLATES,
JULY 1976 - DECEMBER 1984

(Random point contact, quadrat and edge/margin methods combined)

INVERTEBRATA

Protozoa

Folliculina spp.
Foraminifera, unid.
Gromia oviformis
Quinqueloculina spp.
Protozoan, unid.
Radiolarian, unid.
Rosalina spp.
Spirillina spp.
Zoothamnium spp.

Porifera

Encrusting sponge, unid.
Leucandra heathi
Leucosolenia spp.

Cnidaria

Abietinaria spp./Sertularella spp./Sertularia spp. (ASS)
Aglaophenia struthionides
Anthozoan, unid.
Balanophyllia elegans
Epiactis prolifera
Eudendrium californicum
Haliclystus auricula
Hydroid, unid.
Obelia spp.
Sertularella spp.
Syncoryne spp.

Annelida

Hydroides pacificus
Janua spp.
Paradexiospira vitrea
Phragmatopoma californica
Pileolaria spp.
Protolaeospira spp.
Salmacina tribranchiata
Serpulidae, unid.
Spirobranchus spinosus
Spirorbidae, unid.

Crustacea

Balanus crenatus
Balanus spp.
Balanus spp./Tetraclita squamosa
Balanus tintinnabulum
Barnacle scar
Gammaridean tube, unid.
Tetraclita squamosa

Mollusca

Dendropoma lituella
Macoma spp.
Pelecypoda, unid.
Pododesmus cepio

Ectoprocta/Entoprocta

Aetea anguinac
Alcyonidium polyoum
Barentsia spp.
Caulibugula ciliata
Cauloramphus spiniferum
Costazia robertsoniae
Crisia spp.
Encrusting bryozoan, unid.
Erect bryozoan, unid.
Eurystomella bilabiata
Filicrisia spp.
Flustrellidra spp.
Hippodiplosia spp.
Hippothoa hyalina
Lichenopora spp./Tubulipora spp.
Microporella californica
Microporella cribrosa
Microporella spp.
Rhynchozoon spp.
Tricellaria spp.

CHORDATA (Tunicata)

Colonial/Social tunicate
Metandrocarpa taylori
Solitary tunicate, unid.
(Tri)Didemnum spp.

MISCELLANEOUS CATEGORIES

Egg case, unid.
Bare plate
"Diatom film"

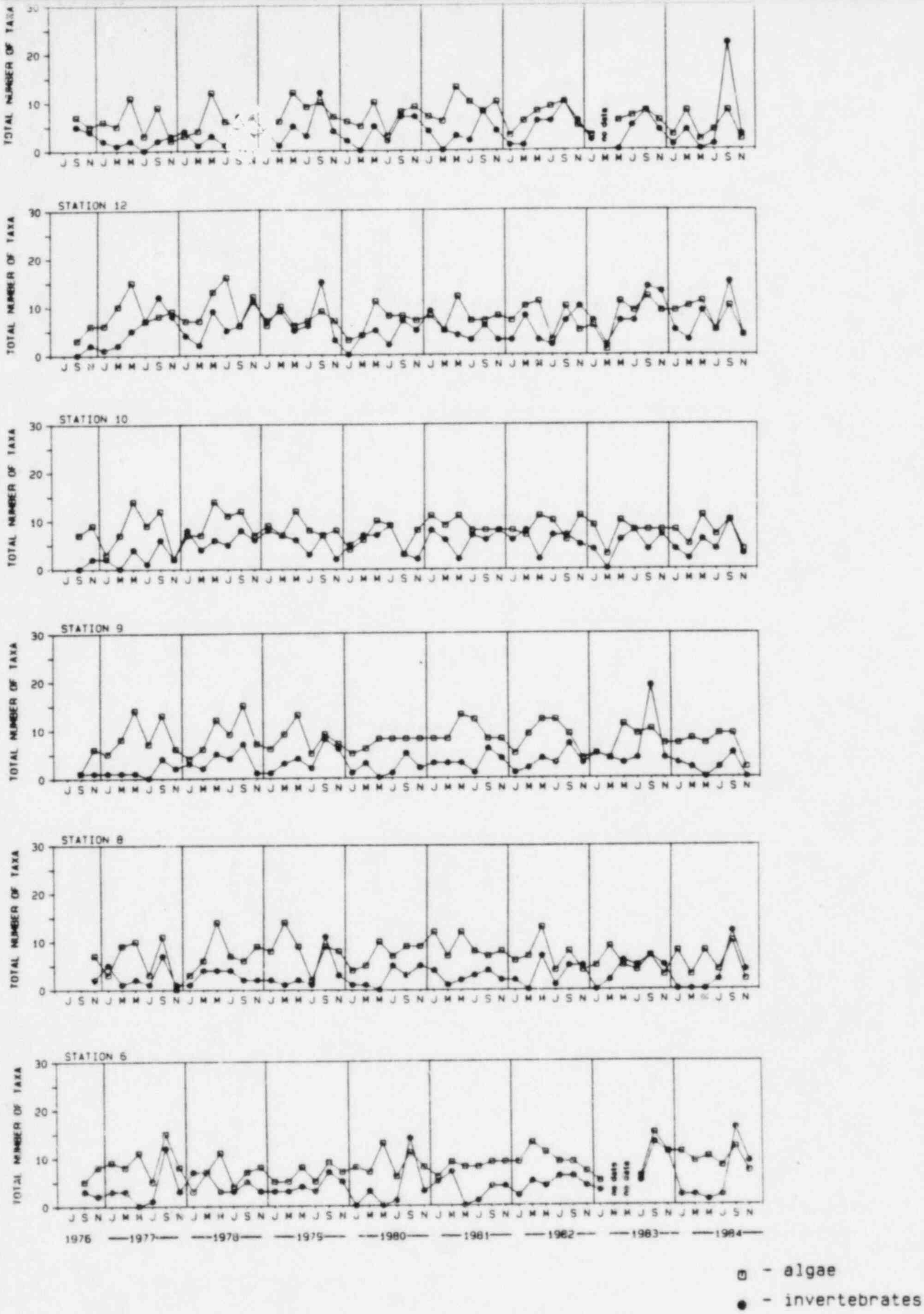


FIGURE 2-65

NUMBERS OF ALGAL AND INVERTEBRATE TAXA COLONIZING SUBTIDAL SETTLING PLATES AFTER 2-MONTH SUBMERGENCE

E-85-04

The long-term plates revealed that, as submergence time increased, there was an increase in the number of colonizing algal and invertebrate species (FIGURE 2-66). This trend is consistent with the results of other marine colonization studies (Saito et al. 1976, Grigg and Maragos 1974, Fager 1971). In some cases the number of taxa, especially the algal species, reached a peak on the 8 and 10 month plates and then dropped slightly on the 12 month plates. The decrease may indicate that the maximum number of taxa is reached after 8 to 10 months' exposure in Diablo Cove. In this case, the total number of attached taxa on plates of the same size exposed for longer periods of time would be expected to fluctuate about this mean value. These are similar to Osman's (1977) findings in his Atlantic Coast settling plate study.

2.12.2 BIOMASS

Maximum dry-weight biomass on the short-term plates was obtained from late spring to early fall (FIGURE 2-67). The amount of biomass varied throughout the year as well as between years. No one station consistently had the greatest amount of biomass. The seasonality in biomass was directly related to seasonal algal and invertebrate attachment. The greatest biomass was found on the September 1977 plate from Station 6, which yielded almost 19 gm of material. Maximum weights at most of the other stations also occurred during this survey. This peak of biomass was primarily attributable to the presence of large numbers of attached barnacles.

Typically, dry-weight biomass increased with increasing exposure of the long-term plates at each station (FIGURE 2-68). It can also be seen that the amount of accumulated biomass varies between the different years. As on the short-term plates, maximum amounts of biomass were generally observed at Station 6, where nearly continuous wave surge and currents provide favorable conditions for growth of barnacles and bryozoans. In this case, the weights recorded were directly related to the dominant barnacles and bryozoans present on the plates. These two species are much heavier per unit area than are any of the algae. In some instances, the weights on the 12-month plates were less than those on the 10-month plates. Boyd (1972), working at Bodega Harbor, California, found that there was not always a continual increase in biomass as the community develops,

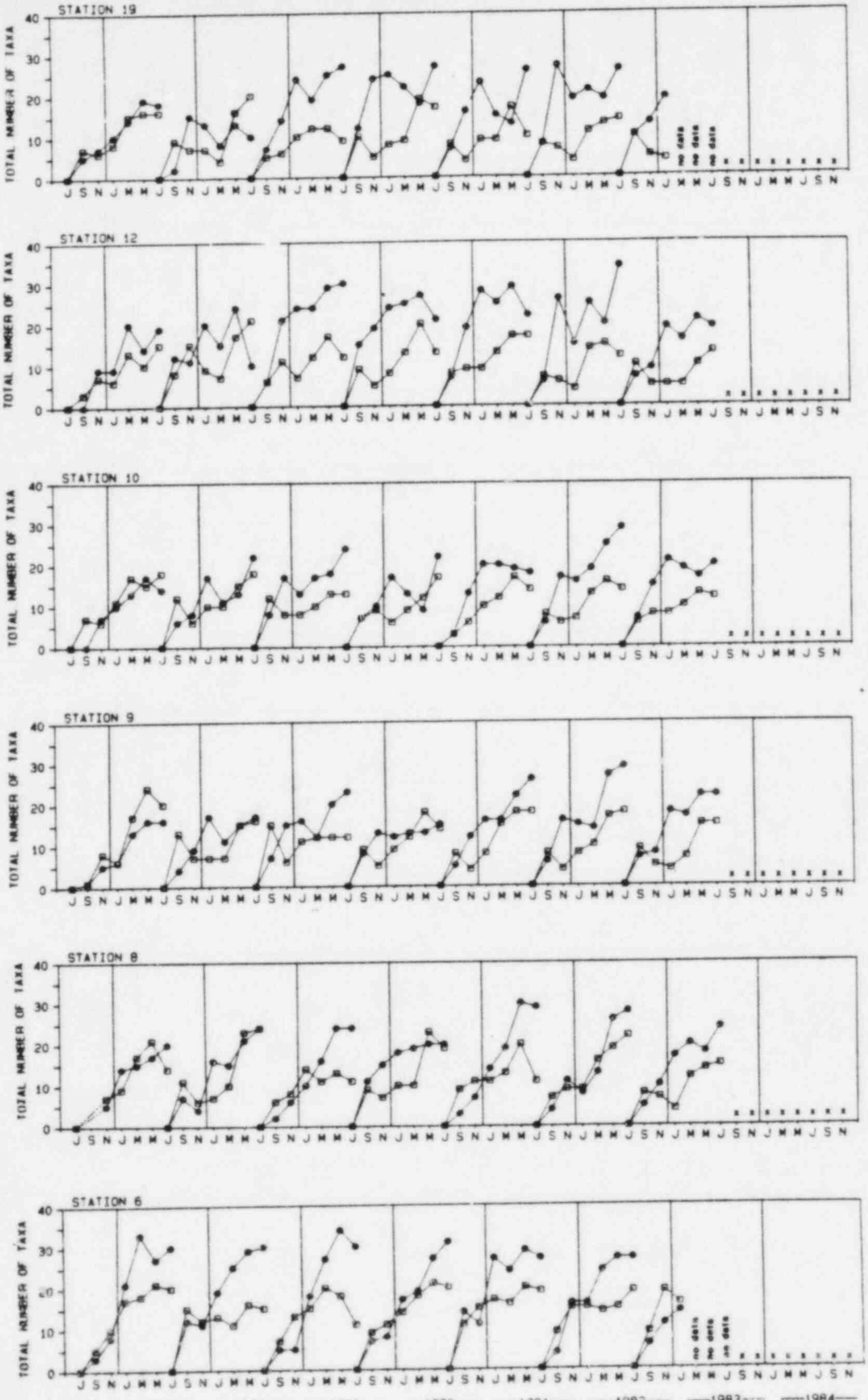


FIGURE 2-66

NUMBERS OF ALGAL AND INVERTEBRATE TAXA COLONIZING SUBTIDAL SETTLING PLATES AFTER INCREASING PERIODS OF SUBMERGENCE (2-12 MONTHS)

E-85-04

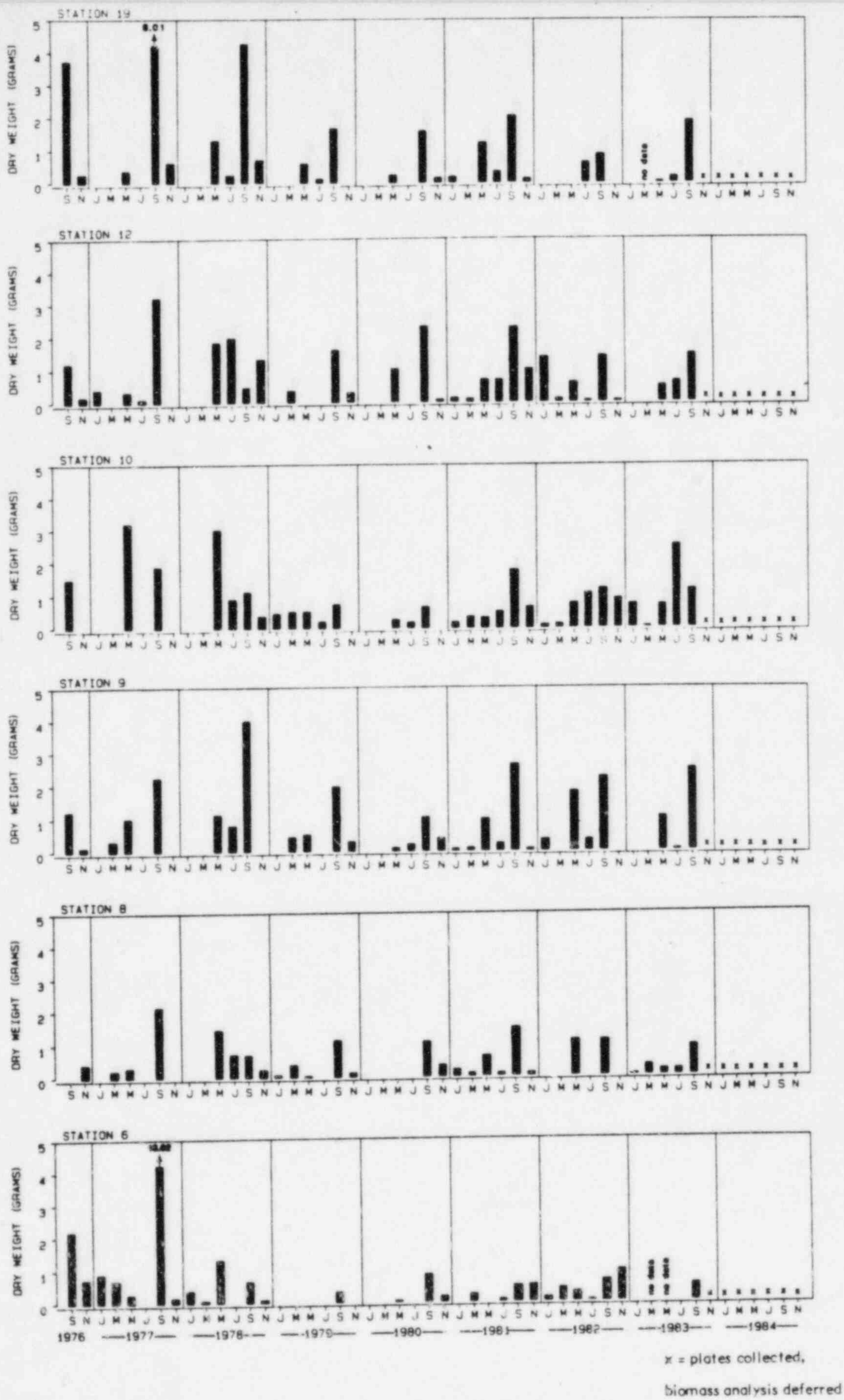
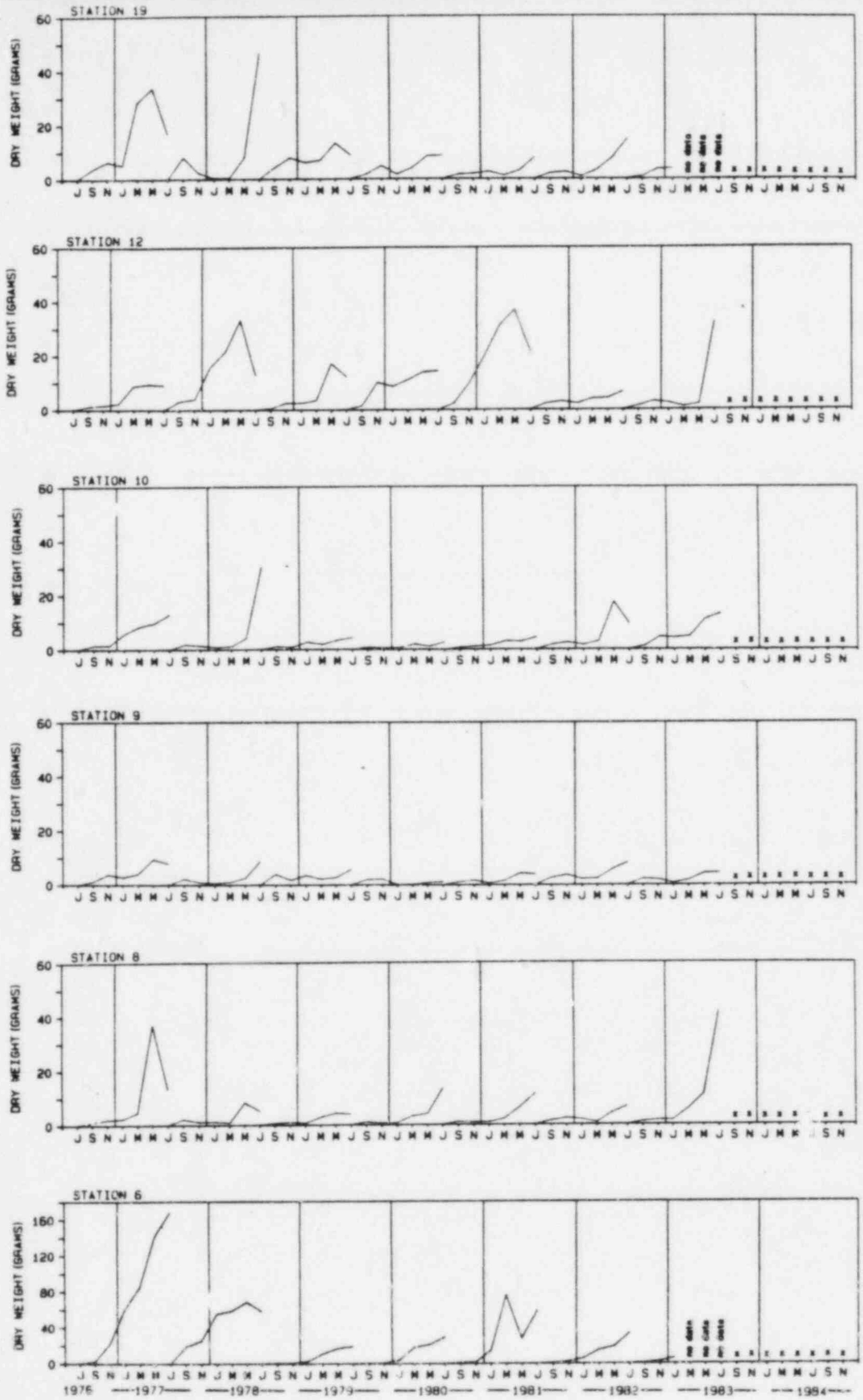


FIGURE 2-67

DRY-WEIGHT BIOMASS ON SUBTIDAL SETTLING PLATES
AFTER 2-MONTH SUBMERGENCE

E-85-04



X = plates collected,

biomass analysis deferred

FIGURE 2-68

DRY-WEIGHT BIOMASS ON SUBTIDAL SETTLING PLATES
AFTER INCREASING PERIODS OF SUBMERGENCE (2-12 MONTHS)

E-85-04

because total biomass depends on the plate's history of biological interactions. It is possible that such interactions (intra- and interspecific competition for space, and predation) have caused biomass to decrease on some of the 12-month plates.

2.12.3 PERCENTAGE COVER

Percentage cover data were recorded from the short-term plutes using the random point contact sampling method (see Appendix A, Section A.12). Data for five taxa (Ulva spp., Enteromorpha spp., coralline crust, juvenile Laminariales, and diatom chains) were tabulated and are presented below.

The percentage cover data of Ulva spp. are shown in FIGURE 2-69. No one station consistently had the greatest cover of Ulva throughout all of the surveys. Generally, Station 6 had the least cover of this taxon. Ulva settled during the entire year, but maximum abundance was usually recorded on the late summer and fall plates. During most years, there was 50-60 percent cover of Ulva on the plates submerged from July to September at all stations except Station 6.

FIGURE 2-70 presents the percentage cover data of Enteromorpha spp. This taxon was very seasonal in its settlement, usually attaching to the plates that were submerged during summer and fall. The occurrence of settlement was not consistent from year to year. No one station consistently had the greatest abundance of this taxon during all of the sampling periods. Enteromorpha spp. was found only once at Station 6.

The percentage cover data of coralline crust are presented in FIGURE 2-71. This taxon was generally present throughout the year, with maximum abundance during the winter and spring. There was year-to-year variation seen at all six stations. No one station consistently had the greatest cover during all of the surveys. Usually Station 6 had the lowest cover of coralline crust.

FIGURE 2-72 presents the percentage cover data of juvenile Laminariales. These juvenile plants primarily consisted of individuals of Laminaria dentigera and Pterygophora californica. The juveniles of these species are identical in

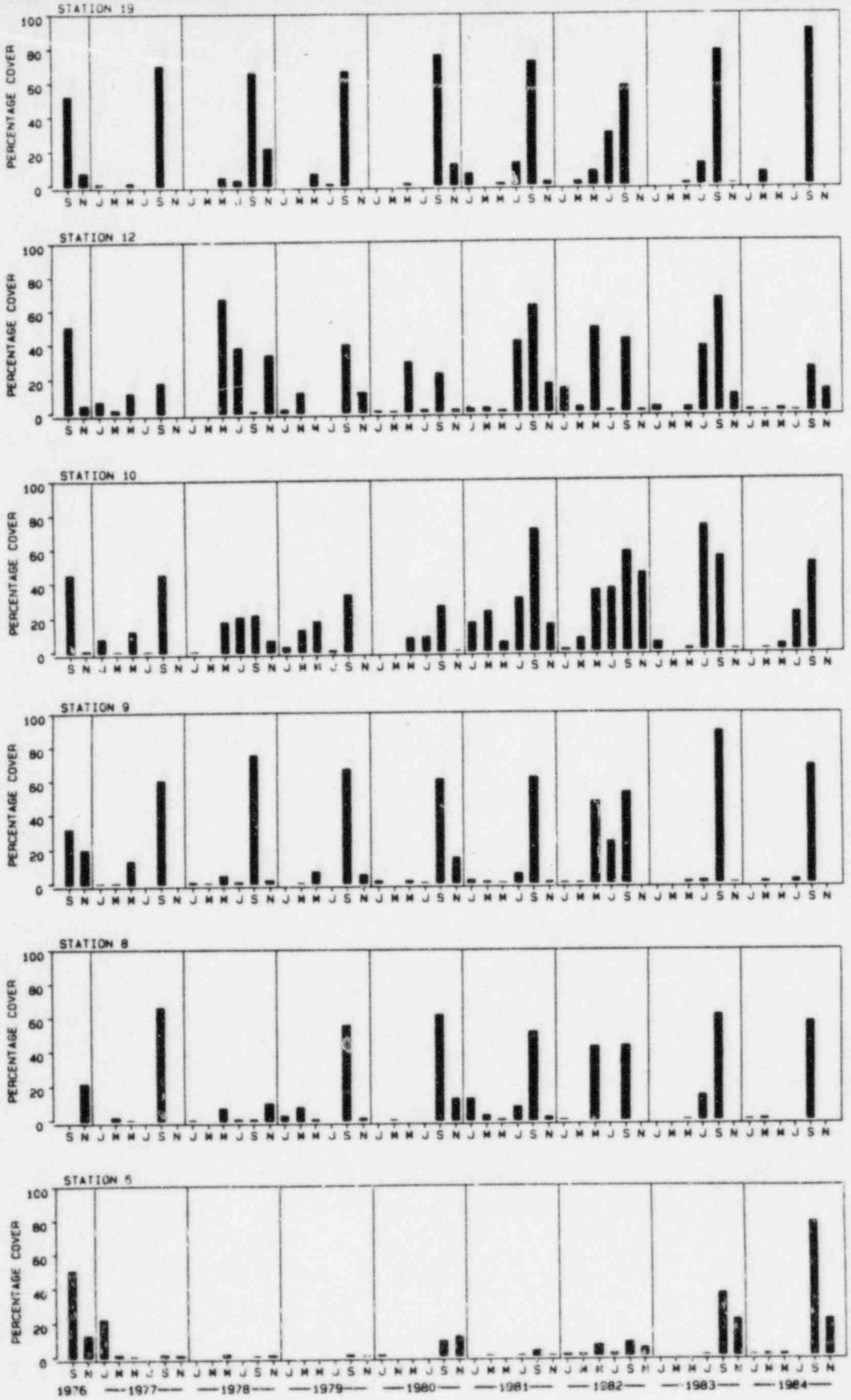


FIGURE 2-69

PERCENTAGE COVER OF ULVA SPP. FROM THE RANDOM POINT CONTACT SAMPLING METHOD ON THE SHORT-TERM (2-MONTH SUBMERGENCE) SUBTIDAL SETTLING PLATES

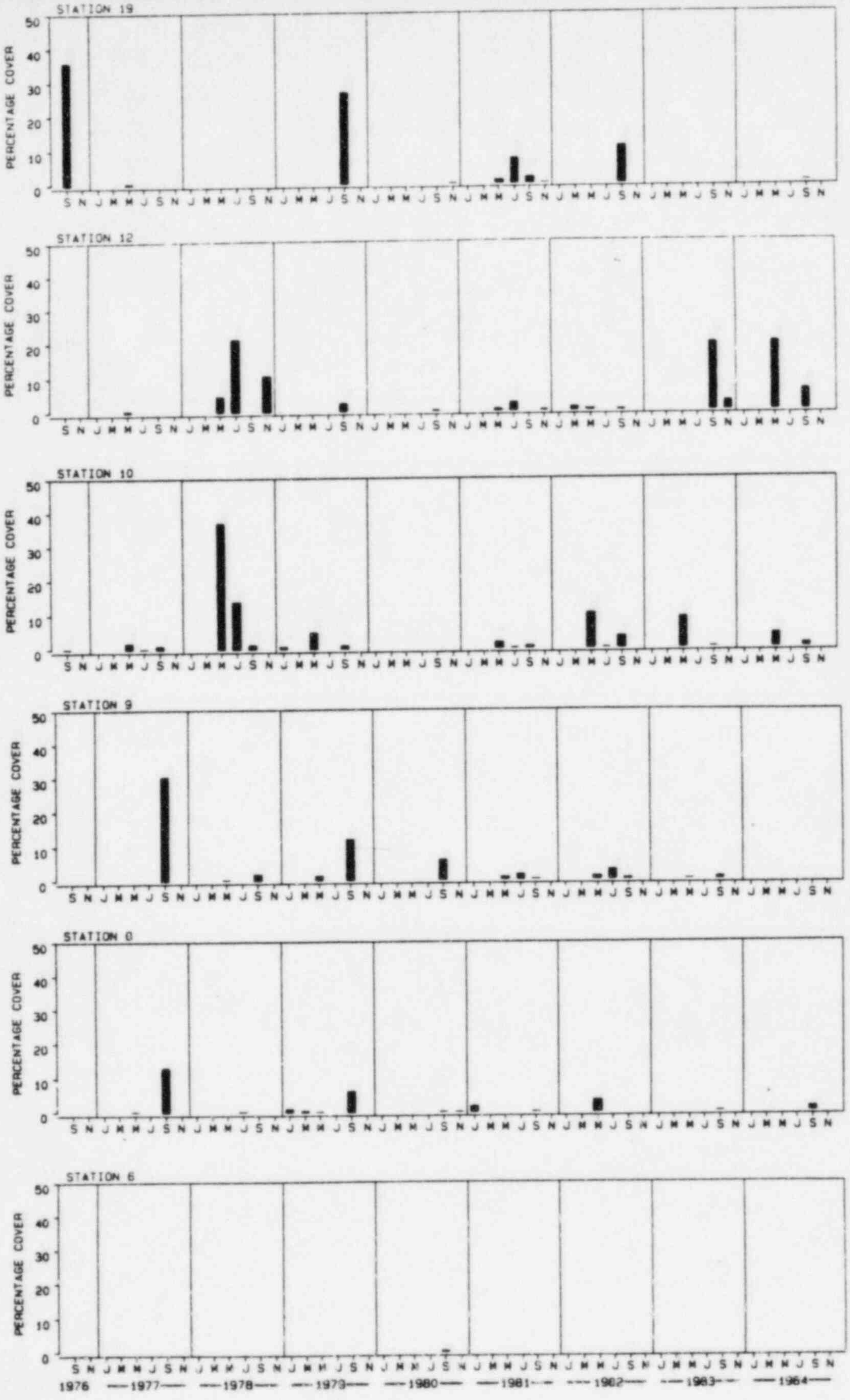


FIGURE 2-70

PERCENTAGE COVER OF ENTEROMORPHA SPP. FROM THE RANDOM POINT CONTACT SAMPLING METHOD ON THE SHORT-TERM (2-MONTH SUBMERGENCE) SUBTIDAL SETTLING PLATES

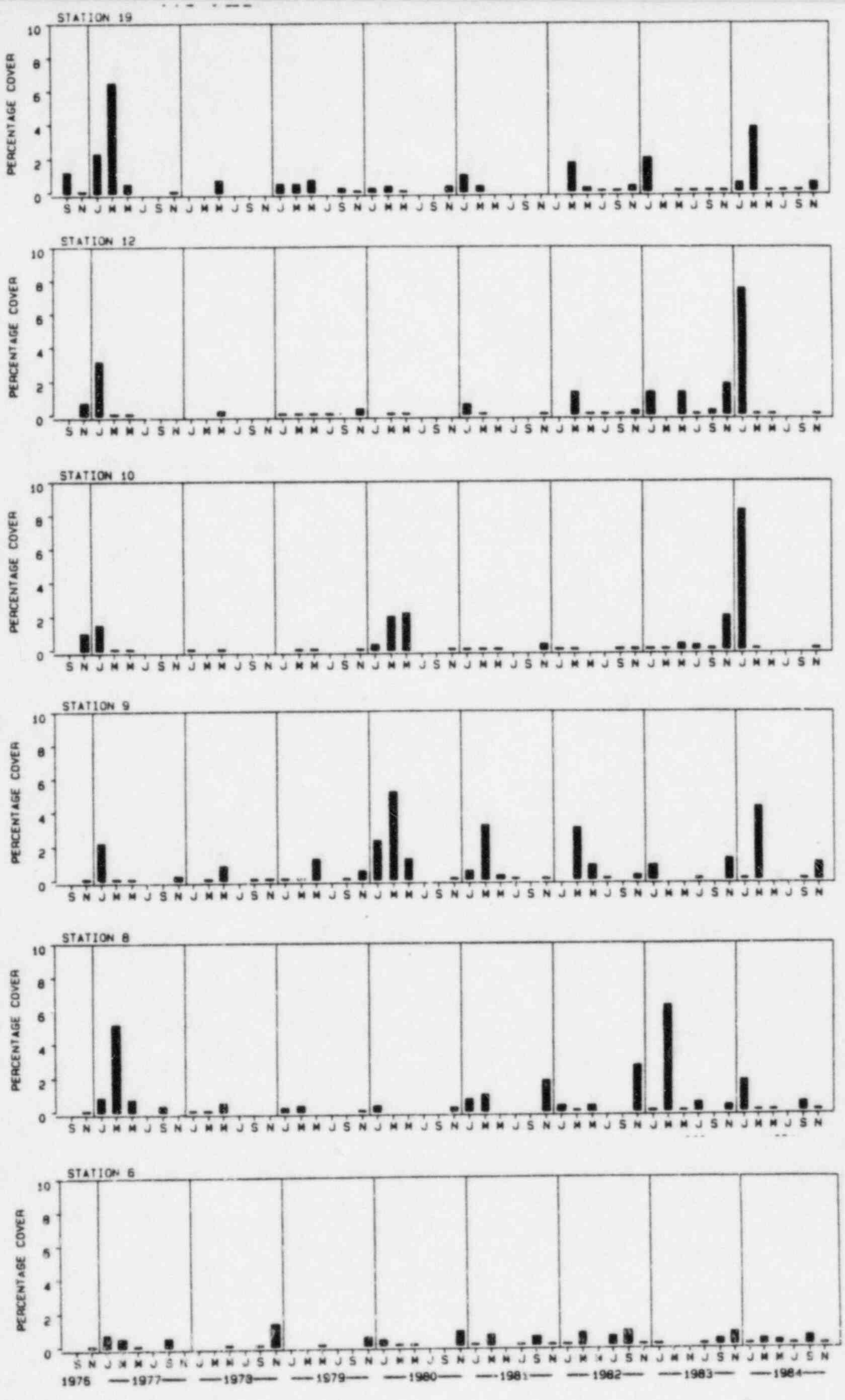


FIGURE 2-71

PERCENTAGE COVER OF CORALLINE CRUST FROM THE RANDOM POINT CONTACT SAMPLING METHOD ON THE SHORT-TERM (2-MONTH SUBMERGENCE) SUBTIDAL SETTLING PLATES

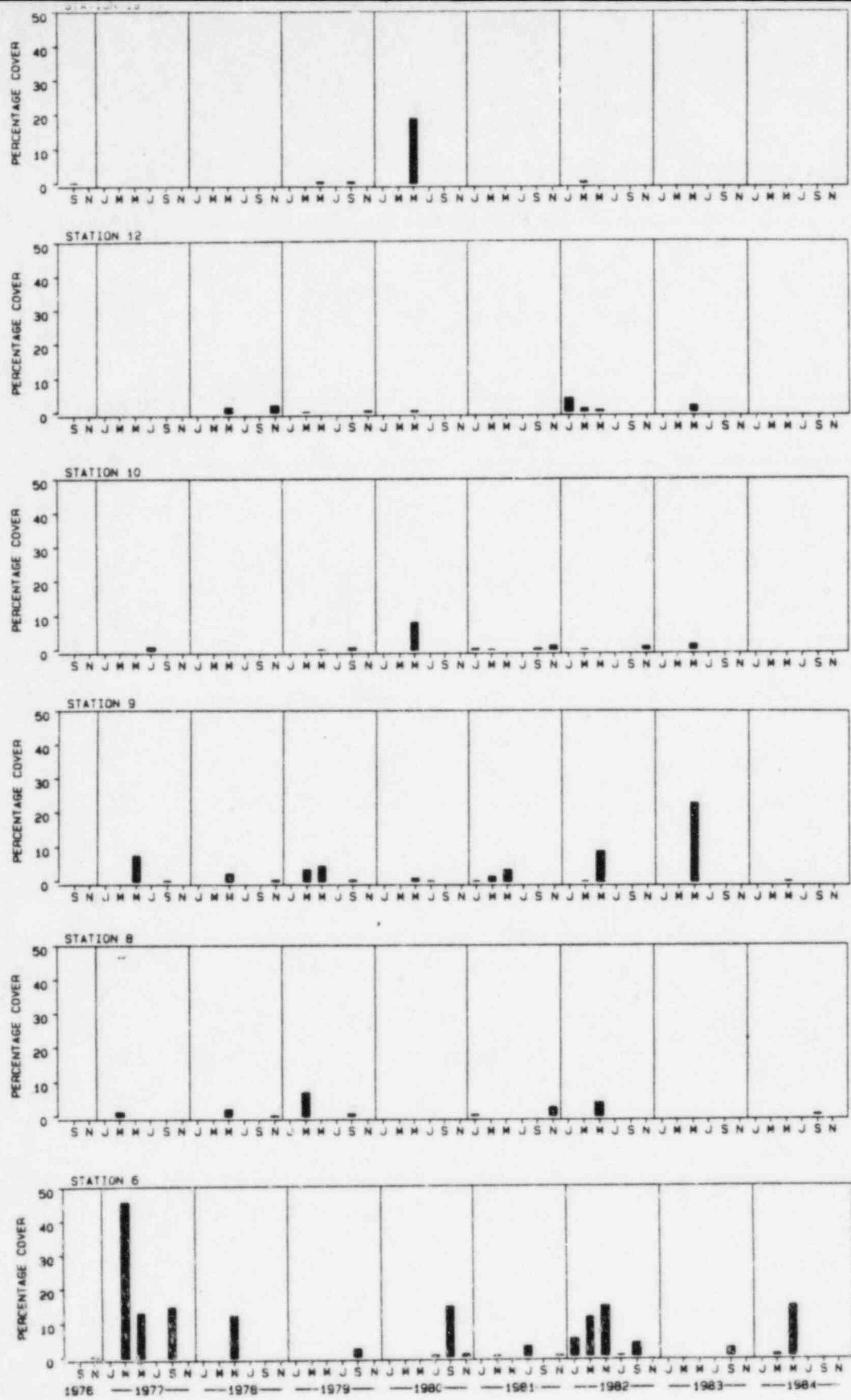


FIGURE 2-72

PERCENTAGE COVER OF LAMINARIALES FROM THE RANDOM POINT CONTACT SAMPLING METHOD ON THE SHORT-TERM (2-MONTH SUBMERGENCE) SUBTIDAL SETTLING PLATES

E-85-04

appearance. The greatest percentage cover of juvenile Laminariales was recorded during both the spring and the fall. Station 6 generally had a greater abundance of juvenile Laminariales than any of the other stations. There was significant year-to-year variation in the occurrence of this taxa at all of the stations.

The percentage cover data of diatom chains are shown in FIGURE 2-73. This taxon was recorded at all of the stations, but its occurrence was very sporadic, and its abundance was generally very low. It was usually recorded on the spring and summer plates. The greatest cover of diatom chains occurred on the plates submerged from November 1981 to January 1982 at Station 12, and those submerged from March to May 1984 at Stations 10 and 12.

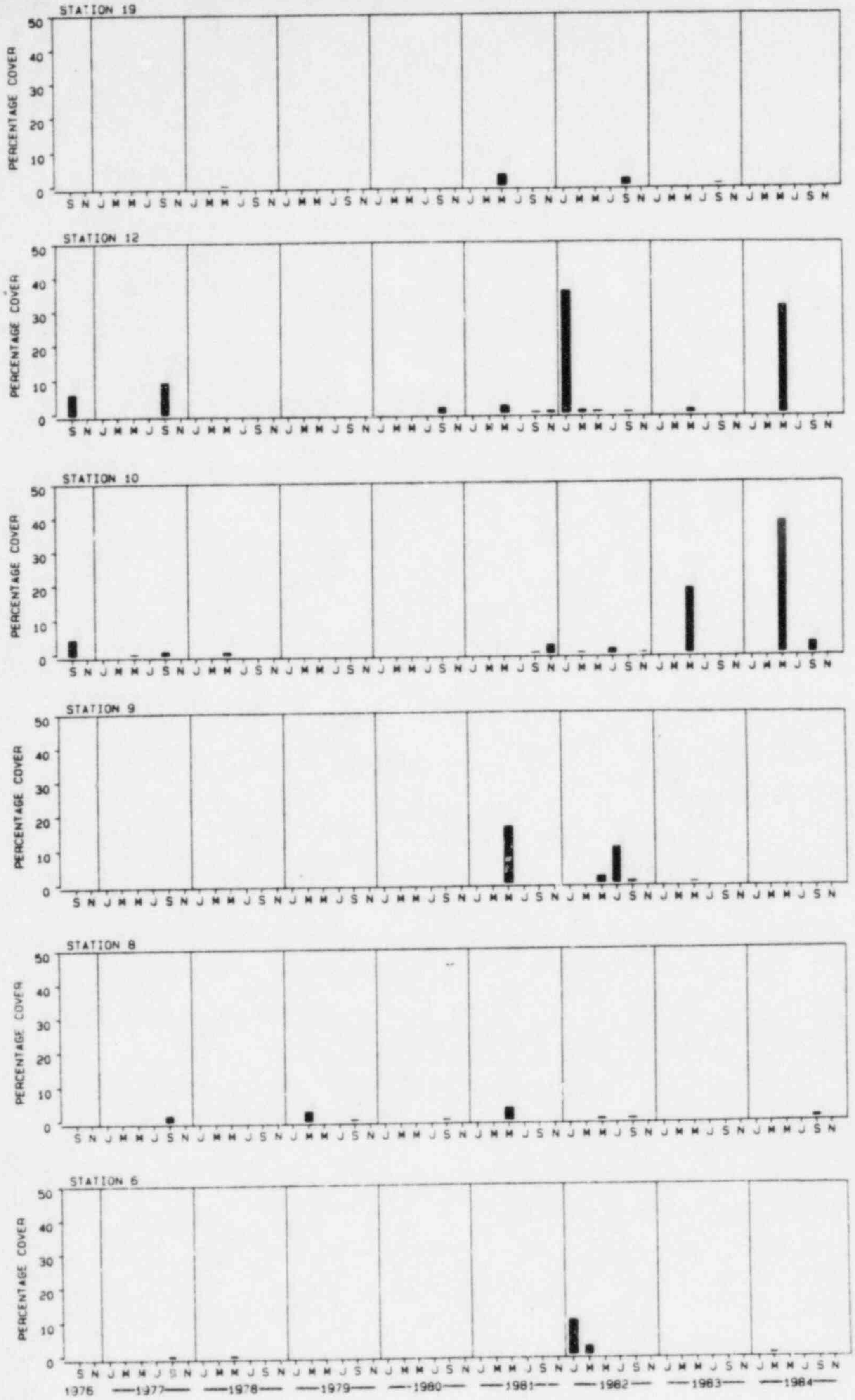


FIGURE 2-73

PERCENTAGE COVER OF DIATOM CHAINS FROM THE RANDOM POINT CONTACT SAMPLING METHOD ON THE SHORT-TERM (2-MONTH SUBMERGENCE) SUBTIDAL SETTLING PLATES

E-85-04

2.13 SUBTIDAL RED ABALONE SURVEY

During 1984, a new TEMP sampling subtask was initiated to provide information on the abundance and distribution of subtidal red abalone (Haliotis rufescens) populations in Diablo Cove. The subtidal arc quadrants (see Section 2.7.2.3) provide some information regarding the abundance of red abalone in Diablo Cove. However, the fixed stations sampled are in locations that may not provide a representative sample of the Diablo Cove population. Furthermore, not being randomly located, they cannot provide a statistical estimate of the entire Diablo Cove red abalone population. Red abalone is an important commercial and sport fishing species. It can have a major influence (by grazing) on algal communities, and historically it has been an abundant species in Diablo Cove (see below). For these reasons, earlier surveys were conducted by the California Department of Fish and Game (CDFandG) but were discontinued in 1982. This TEMP surveying subtask was designed to complement the earlier surveys and to provide definitive estimates of red abalone populations in Diablo Cove.

2.13.1 PREVIOUS DIABLO COVE RED ABALONE STUDIES

The first published reports of the subtidal biota of Diablo Cove indicated that red abalone were abundant (North 1966). In 1969, CDFandG began a two-year biological study of Diablo Cove with special focus on abalone and bony fish. Eleven permanent (fixed) subtidal stations (5 located inside Diablo Cove and 6 located outside), each 30 m long and 2 m wide (60 m^2 in total area) were sampled in 1970 and 1971. The report on these data (Burge and Schultz 1973) showed that red abalone were common and abundant in the shallow regions (0 to -20 ft MLLW) of Diablo Cove. Anticipating a significant impact on the subtidal biological community of Diablo Cove by the foraging of southward migrating sea otter, some of the 11 permanent subtidal stations of the 1969-1971 study were sampled in 1973, 1974, and 1975. CDFandG initiated a second program to sample randomly located 30 m^2 subtidal stations inside and outside Diablo Cove. This second sampling program was stratified into shallow (-2.1 to -7.6 m MLLW) and deep (-7.9 to -18.3 m MLLW) areas and into north and south sections. In 1979, selection of random stations was limited to areas -7.6 m in depth or shallower.

The red abalone data from the permanent CDF and G subtidal stations in Diablo Cove show two general features: 1) they were abundant at the shallow stations and rare at the deeper ones and 2) on the permanent stations they showed a decline in numbers after 1974 surveys. The change is probably related to the arrival of the sea otter, which was first observed in Diablo Cove about 1974. Based on the data from more than 150 random 30 m^2 stations sampled inside Diablo Cove from 1974 to 1982, red abalone appeared to be scarce and slightly more abundant in shallower areas of the cove. According to data recently presented in Gotshall et al. (1984), red abalone abundance in the Cove may be increasing and they may be becoming more abundant in the deeper areas than at any time since 1969.

2.13.2 TEMP RED ABALONE SURVEY OBJECTIVES

The data previously collected provide little insight into the pattern of distribution of subtidal abalone within Diablo Cove. The objective of the TEMP survey is to determine the distribution, abundance, and approximate size structure of the subtidal red abalone population within Diablo Cove. The details of the sample design and methods are presented in Appendix A (see Section A.13).

2.13.3 RESULTS AND DISCUSSION

Twenty-eight randomly selected 30 m^2 samples of subtidal substrate were surveyed in Diablo Cove in 1984 (see FIGURE 2-74). Of the 28 sample sites, 13 were located in north Diablo Cove and 15 were located in south Diablo Cove. Twenty-one samples (75 percent) were located at depths less than 20 feet. Of these, 11 occurred in north Diablo Cove and 10 occurred in south Diablo Cove. Seven of the 28 samples (25 percent) were located at depths greater than 20 feet. Only two of these samples were located in north Diablo Cove. Four additional loci were proposed for sampling but were not sampled: one shallow sample in south Diablo Cove and three deep samples in north Diablo Cove. Without these samples, the deeper areas of Diablo Cove, particularly the northern half, may be under-represented. TABLE 2-20 presents the number of abalone in each of the three size categories present in each of the samples. The

E-85-04

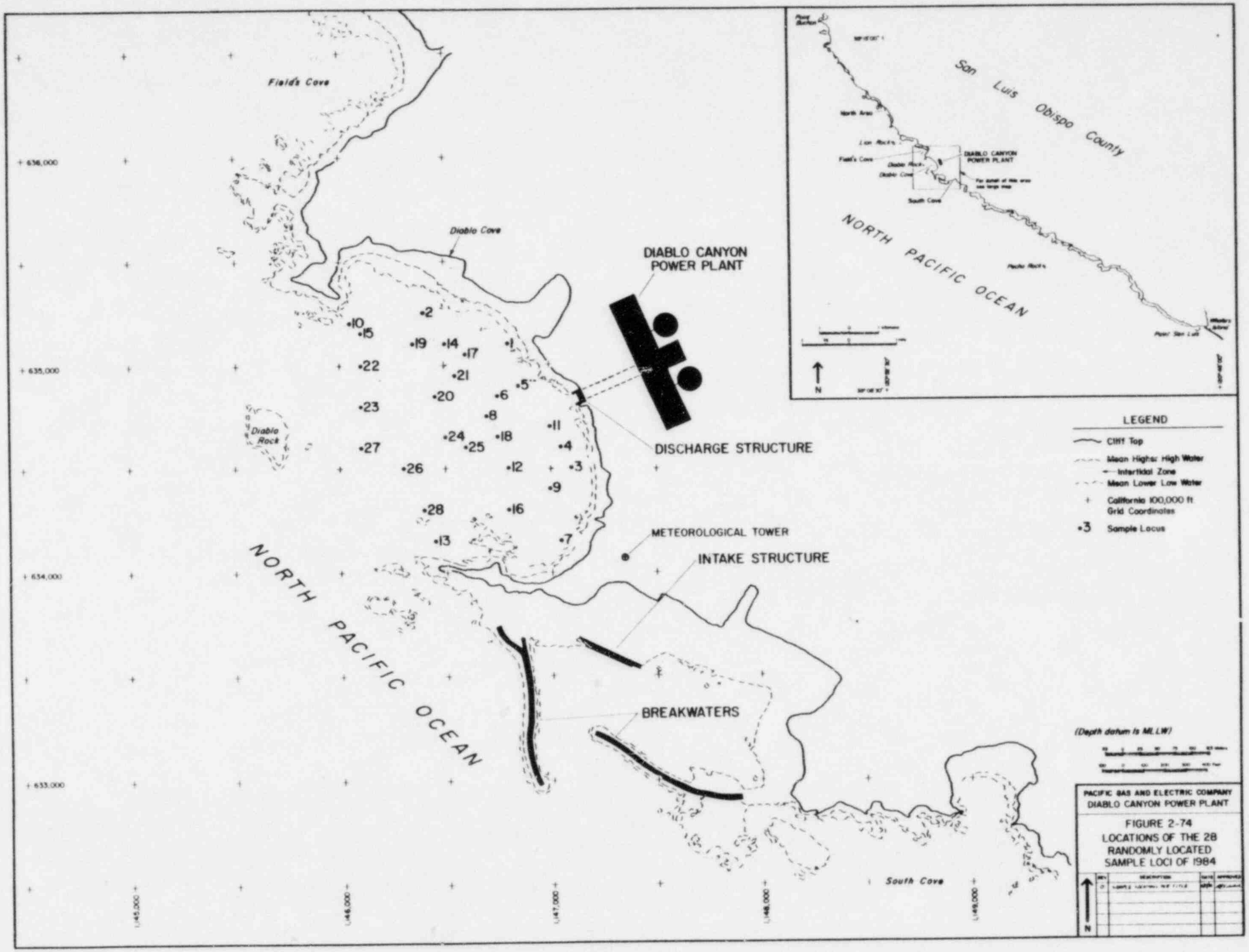


FIGURE 2-74
LOCATIONS OF THE 28 RANDOMLY LOCATED SAMPLE LOCI OF 1984

TABLE 2-20

DATA FROM THE 1984 SUBTIDAL RED ABALONE SURVEY

Sample Number	Area	Depth (Ft.)	No. Abalone / 30 m^2 Small[1]	Medium[2]	Large[3]	Total
1	NDC	2.5		1		1
2	NDC	3.0		5	1	6
3	SDC	3.0				0
4	SDC	5.0	1	5	2	8
5	NDC	6.0	1	2	2	5
6	NDC	6.0		1	1	2
7	SDC	7.1				0
8	SDC	7.6		8	3	11
9	SDC	8.1		4		4
10	NDC	8.2		9	1	10
11	SDC	9.0	1	3	1	5
12	SDC	9.1	1	3	1	5
13	SDC	11.0	6	8	2	16
14	NDC	11.4	1	10	12	23
15	NDC	11.4		4		4
16	SDC	12.0			1	1
17	SDC	12.5	1	6		7
18	NDC	12.5	1	4		5
19	NDC	15.0		2	1	3
20	NDC	18.3		15	3	18
21	NDC	18.3		9	3	12
22	NDC	24.5				0
23	NDC	25.4				0
24	SDC	26.9	1	3		4
25	SDC	28.7				0
26	SDC	38.7				0
27	SDC	38.8				0
28	SDC	45.3				0
TOTAL			14	102	34	150
Mean No. Abalone / 30m^2			0.5	3.6	1.2	5.3

1 Small =< 2 in.

2 Medium = 2 to 7 in.

3 Large = >7 in.

range was from zero to 23 red abalone per sample, with a total of 149 for all 28 samples and a mean of 5.3 abalone per 30 m^2 sample. Sixty-one abalone, or 41 percent of the total, were found in the sample sites in south Diablo Cove, and 88 (59 percent) were found in the north Diablo Cove samples. No abalone were found in two of the 21 samples located at depths less than 20 feet. Abalone were observed in only one of the 7 samples located at depths greater than 20 feet. Only four abalone, or 2.7 percent of the total, were found at a depths of 20 feet or greater. The majority (97.3 percent) were at depths less than 20 feet. The densities of red abalone in Diablo Cove stratified by depth are:

Depths	Area (m^2)	Abalone	Total Mean No./m^2	S.D.	N
<20 ft	630	145	0.23	0.21	21
>20 ft	210	4	0.02	0.05	7
All Depths	840	149	0.18	0.20	28

One hundred and two of the red abalone in the samples (68.5 percent) were 2-7 in. and 33 (22.1 percent) were greater than 7 in. The smallest size class of red abalone (less than 2 in.) had 14 individuals (9.4 percent of the total). Theoretically, juvenile red abalone should be much more abundant than the larger individuals. The disparity in the 1984 data probably reflects, among other factors, the difficulty in detecting very small abalone (1 inch or less in shell length) in a 30 m^2 area. Juveniles may be more accurately sampled by using randomly located 1/4 m^2 quadrats. Using a bathymetric chart of Diablo Cove marked off into a grid of equally sized areas (similar to FIGURE A-7, see Appendix A), the total subtidal area within Diablo Cove was estimated to be 200,000 m^2. Of this area, approximately 144,000 m^2 (72 percent of the total) occurs at depths less than 20 feet and is divided essentially evenly between the north and south portions (FIGURE A-7, see Appendix A). The remaining 28 percent of Diablo Cove, 56,000 m^2, occurs at depths between 20 and 50 feet. The total area sampled for red abalone was 840 m^2 or 0.4 percent. Estimates of the

total numbers of red abalone of all size classes based upon the 1984 survey data are as follows:

Depths (ft)	Mean No. Abalone per m^2	S.D.	Estimated Total Area (m^2)	Estimated Total No. Abalone
<20	0.23	0.20	144,000	33,143 ± 28,000
>20	0.02	0.05	56,000	1,065 ± 2,800

From the 1984 survey results, an estimate of the total population of red abalone in Diablo Cove is 34,208 ± 30,800.

2.14 SUBTIDAL VIDEOTAPE TRANSECTS

During 1984, a second new TEMP sampling subtask was initiated to provide information on the general occurrence and distribution of subtidal communities in Diablo Cove. The technique involved use of an underwater video system on 100 m long transects. Details of the sampling design and methods are included in Appendix A (see Section A.14). The objective of this sampling task is to provide a very general overview of the presence, abundance, and condition of the major subtidal species that are visible when viewing the bottom from above. These observations, which provide information on extensive areas in Diablo Cove, are intended to complement the highly detailed and quantitative data collected on the fixed stations. The occurrence of certain species may be obscured where tall, leafy algae predominate. Therefore, the results of these surveys cannot be quantified and must be carefully interpreted before conclusions regarding apparently major differences can be drawn.

One subtidal videotape survey was conducted in August 1984. This survey took place when annual algal growth was near its maximum, and surface canopy-forming species such as Nereocystis luetkeana and Cystoseira osmundacea were well developed. Physical conditions during the videotape survey were favorable both above and below the surface (TABLE 2-21). Underwater visibility ranged between approximately 7-10 m, and wave surge was gentle. Such conditions were necessary to obtain good quality videotapes. The actual positioning of the twenty-one 100 m transects differed from the originally intended positions (FIGURE 2-75, TABLE 2-21), due mainly to the deployment boat being pushed off course by the power plant discharge plume. Two of the transects were intentionally set off course to avoid rock pinnacles near the surface.

Each videotransect was analyzed qualitatively, and observations were recorded on substrate, bathymetry, algal canopy cover, and understory algal communities (TABLE 2-22) and species presence (TABLE 2-23). Canopy-forming phaeophytes were present on all transects, and a generalized map was constructed which indicates areas with high densities of Pterygophora californica, Laminaria dentigera, Nereocystis luetkeana, and Cystoseira osmundacea (FIGURE 2-76).

TABLE 2-21

PHYSICAL DATA FROM THE 1984
SUBTIDAL VIDEO TRANSECTS

Transect Designation	Date	Time (PST)	Water Temp.(C)	California Coordinates: Origin Northings	Origin Eastings	Terminus Northings	Terminus Eastings
SD-01	10 AUG	0920	13.9	634,606	1,146,792	634,807	1,146,555
SD-02	10 AUG	0914	14.0	634,325	1,146,971	634,603	1,146,793
SD-03	10 AUG	1226	14.6	634,511	1,146,713	634,665	1,146,420
SD-04	10 AUG	1218	15.0	634,194	1,146,858	634,495	1,146,723
SD-05	10 AUG	1500	15.0	634,532	1,146,377	634,406	1,146,455
SD-06	11 AUG	1009	15.0	634,314	1,146,476	634,549	1,146,283
SD-07	11 AUG	0820	14.9	634,254	1,146,243	634,441	1,146,029
CD-01	10 AUG	1030	14.4	634,869	1,146,596	635,089	1,146,373
CD-02	10 AUG	1347	15.4	634,679	1,146,420	634,968.	1,146,355
CD-03	10 AUG	1428	15.0	634,823	1,146,227	634,545	1,146,390
CD-04	11 AUG	1028	15.4	634,525	1,146,249	634,762	1,146,027
CD-05	11 AUG	0843	14.5	634,454	1,146,040	634,691	1,145,848
CD-06	11 AUG	0935	15.0	634,514	1,145,920	634,341	1,145,693
ND-01	10 AUG	1058	14.5	635,100	1,146,400	635,347	1,145,234
ND-02	10 AUG	1355	15.4	634,958	1,146,352	635,212	1,146,139
ND-03	10 AUG	1420	15.0	635,095	1,146,051	634,824	1,146,216
ND-04	11 AUG	1100	15.0	634,764	1,146,045	634,998	1,145,857
ND-05	11 AUG	1109	15.2	634,987	1,145,855	635,208	1,145,649
ND-06	11 AUG	0904	14.6	634,698	1,14[illegible],846	634,964	1,145,740
ND-07	11 AUG	0912	14.6	634,946	1,145,725	635,184	1,145,530
WJN-01	11 AUG	0950	14.7	634,525	1,146,362	634,633	1,146,651

Physical conditions on survey days:
wave surge: light;
underwater visibility: 7-10 m;
cloud cover: none;
surface foam: patchy.

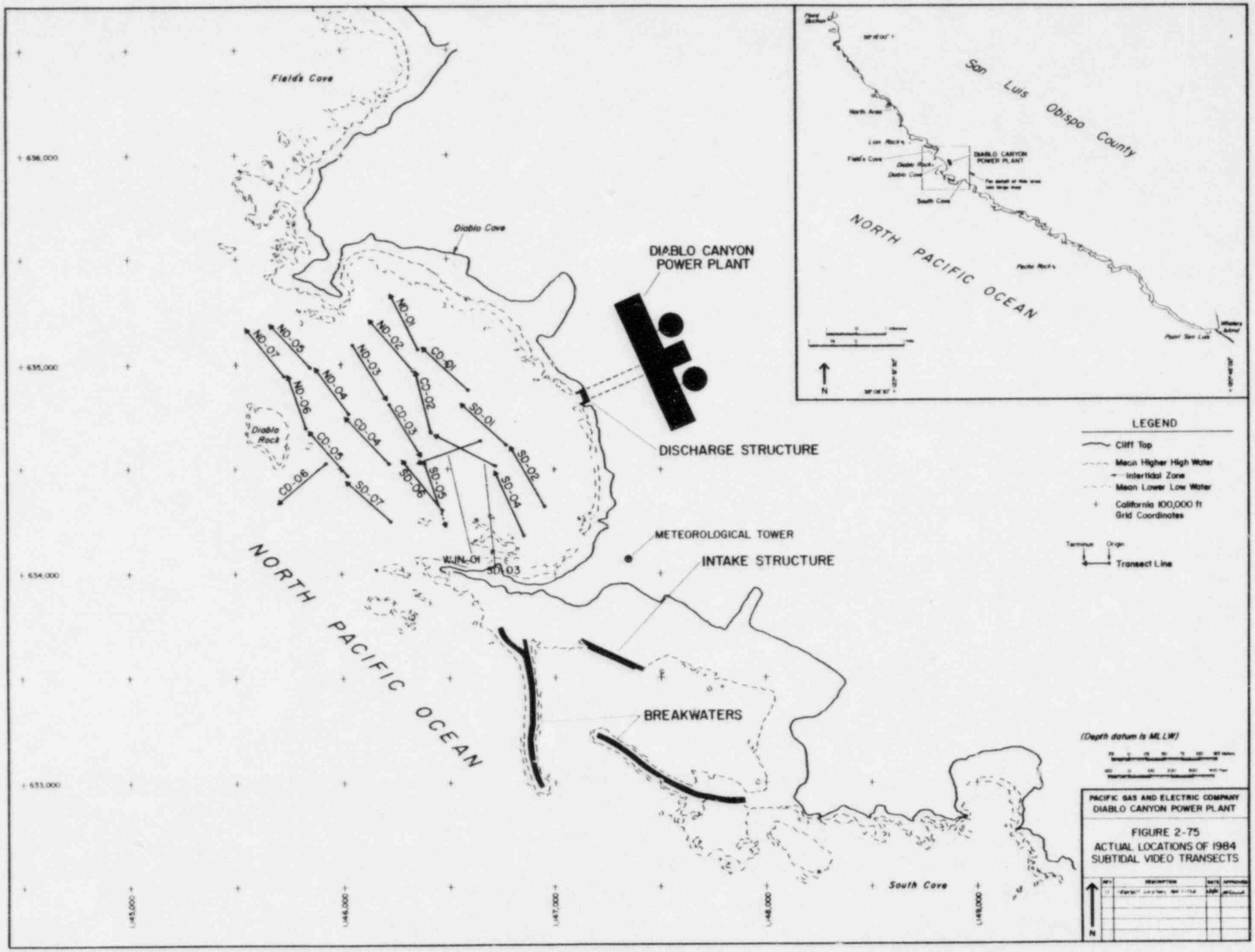


FIGURE 2-75
ACTUAL LOCATIONS OF 1984 SUBTIDAL VIDEO TRANSECTS

TABLE 2-22

BATHYMETRY, SUBSTRATA, CANOPY, AND UNDERSTORY DATA FROM THE 1984 SUBTIDAL VIDEO TRANSECTS

SOUTH DIABLO COVE TRANSECTS

Transect No.	Depth Range (ft. -MLLW)	Substrate/ Bathymetry	Canopy Forming Algal Species	Understory Algal Species	Additional Observations
SD-01	15 - 25	high relief w/ crevices and no sand channels, pinnacles to 2 - 3 m in height	dense Ptery. along entire tx. Lam. not common, some bare stipes	Botryo., Gig. e/c mainly on open rocks, Ulva common	tx crossed outfall plume (no heat), discharge flow forces bending of stipes
SD-02	10 - 15	low relief rock ridges and medium boulder, sand channels present up to 10 m wide	Ptery. in light/mod. density, bare stipes common on last 40 m of tx	Botryo., Gig. e/c, CBS on open rocks, Desmar. lig. present in sand channels	few Cystoseira: those present in poor condition and covered with Ulva epiphytes
SD-03	15 - 30	mod relief b/r shelf and boulder to 1 m, sand present in small patches	Ptery. up to 2 m tall Lam. common: some bare stipes colonized with Ulva	CBS predominant w/ less Botryo. than tx SD-02	foam cover on surface results in signif. drop in illumination
SD-04	10 - 20	extensive sand channel w/ low relief boulder and b/r outcrop.	Ptery. in mod density 1 m tall: bare stipes covered w/ Ulva, no Cystoseira	dense coverage CBS w/ Botryo., Desmar., Gig. e/c	Cysto. in poor condition, covered w/ epiphytes
SD-05	15 - 35	low relief b/r low/mod boulder w/ sand patches	dense Ptery. canopy w/ plants up to 2 m at 30-35 ft depths	understory sparse, CBS and unid. fleshy red algae patchy on rocks	west end of tx begins at Endeco OS station
SD-06	20 - 35	high relief pinnacles w/ large boulder and b/r in channel, sand patches occasional	Ptery. abundant, mainly 1 - 2 m height, Lam. abundant on tops of pinnacles	CBS and I. cord. dominant but understory sparse beneath dense Ptery. canopy	tx changes from high relief at east end to less relief in channel
SD-07	20 - 40	high relief pinnacles, sand patches occasional	Ptery. in mod. density w/ longer stipes in deeper channel	probably sparse due to Ptery. canopy cover, poor sample due to low light levels	similar to tx SD-06 camera lens appeared slightly fogged
WJN-01	15 - 30	b/r relief mod/high at inshore end, changing to cobble/boulder at terminus, occas. sand	Ptery. very abundant w/ Lam. present low density, plants increase height in deeper areas	CBS w/ Botryo. and Gig. e/c	crosses depth contour in area directly offshore discharge

Abbreviations used in annotated observations
- b/r = benchrock substrate
- tx = transect
- CBS = Calliarthron spp./Bossiella spp./Serraticardia spp.
- Botryo. = Botryoglossum farlowianum
- Cysto. = Cystoseira osmundacea
- Desmar. lig. = Desmarestia ligulata
- Dictyo. = Dictyoneurum californicum
- Gig. e/c = Gigartina exasperata/corymbifera
- I. cord. = Iridaea cordata
- Lam. = Laminaria dentigera
- Nereo. = Nereocystis luetkeana
- Ptery. = Pterygophora californica

TABLE 2-22

BATHYMETRY, SUBSTRATA, CANOPY, AND UNDERSTORY DATA FROM THE 1984 SUBTIDAL VIDEO TRANSECTS (CONTINUED)

CENTRAL DIABLO COVE TRANSECTS

Transect No.	Depth Range (ft. -MLLW)	Substrate/ Bathymetry	Canopy Forming Algal Species	Understory Algal Species	Additional Observations
CD-01	20 - 25	moderate relief, b/r outcrops, sand patches occasional between mod. boulder and b/r	Cysto. very dense and reaching surface, Ptery. less dense than on tx SD-02	Botryo., CBS present on open rocks, Dictyo. present	Cysto. major surface canopy former, no Nereocystis
CD-02	15 - 30	moderate relief b/r outcrops, some sand patches	Ptery. and Lam. forming dense canopy to 2 m above substrate, Cystoseira @ west end	CBS sparse beneath dense Ptery. canopy, Gig. e/c, Botryo. dense cover west end	Nereo. absent, discharge plume can pass above tx
CD-03	20 - 35	moderate relief b/r and boulder/cobble, some sand patches beneath canopy	Ptery. dense w/ plants to 2 m, Cysto. canopy reaching surface	very sparse beneath dense Ptery. canopy, incomplete sampling	white encrust. bryoz. conspicuous on Ptery. blades, discharge plume above tx
CD-04	25 - 35	low/mod relief boulder and cobble w/ sand patches, sand channels @ west end	Ptery. canopy dense and over 1 m in height, Lam. more abundant @ west end	prob. sparse CBS and fleshy reds beneath dense canopy, poor lighting for sample	path of discharge plume potentially above tx
CD-05	20 - 40	extensive sand areas w/ medium boulder, some high relief pinnacle to 4 m	Ptery. and Lam. both in moderate density on emergent b/r	Some CBS w/ fleshy reds, generally sparse beneath mixed phaeophyte canopy	Ptery. taller stipes in deeper channel
CD-06	40 - 60	mod. relief b/r with some overhanging rock shelves, low relief w/ sand patches offshore	Ptery. in mod. density, stipe lengths ranging from 0.5 to 1.5 m estimated height	sparse CBS and unid. fleshy reds, dim illumination for accurate sampling	light levels very low in deeper water

TABLE 2-22

BATHYMETRY, SUBSTRATA, CANOPY, AND
UNDERSTORY DATA FROM THE 1984 SUBTIDAL VIDEO TRANSECTS
(CONTINUED)

NORTH DIABLO COVE TRANSECTS

Transect NO.	Depth Range (ft. -MLLW)	Substrate/ Bathymetry	Canopy Forming Algal Species	Understory Algal Species	Additional Observations
ND-01	10 - 20	low/mod relief b/r, medium boulders and some sand patches	Cysto. canopy dense on last half tx, Pteryg. mostly 1 m height, Egregia present	Gig. e/c, Botryo very dense over entire tx	lower relief than tx SD-01 and CD-01, Phyllo. spp. common
ND-02	10 - 20	low/mod. relief b/r and boulder/cobble, sand patches present	Cysto. abundant forming thick surface canopy, Ptery. and Lam. present to 1 m in height	Botryo., Gig. e/c abundant on CBS, Dictyo. on tops of rock outcrops	no bare Lam. or Ptery stipes observed
ND-03	10 - 25	mod./high pinnacles, medium boulder with occassional sand between outcrops	Cysto. abundant forming thick surface canopy, Ptery. and Lam. present in medium density	appearing sparse but incomplete data due to sampling method	Lam., Ptery. cover dominant over tx
ND-04	20 - 25	low boulder w/ sand channels, some b/r ridges w/ mod. relief	Cysto. abundant forming surface canopy, Lam. abundant @ west end tx, shorter Ptery. on rocks	low density CBS and fleshy reds mostly inconspicuous due to canopy cover	water clarity good, Lam. dominant canopy former
ND-05	20 - 30	b/r pinnacles up to 4 m, sand patches present	Cysto. and Nereo. both common surface canopy formers, Lam. very abundant	dense Gig. e/c and fleshy reds, I. cord. and Dictyo. at end of transect	water clarity good, Nereo. most abundant on this tx
ND-06	15 - 25	moderate relief b/r outcrops, some boulder/ cobble substrate	Cysto. abundant forming surface canopy, Lam. abundant @ west end tx	Botryo., juvenile Lam. and Ptery. common	water clarity good, extensive Cysto.
ND-07	15 - 25	moderate relief b/r, boulder with occas. sand patches	Lam. dominant canopy 0.5-1.0 m above bottom, extensive Cystoseira surface canopy	Mixed CBS, Botryo., Gig. e/c, Dictyoneurum abundant on tops of pinnacles	water clarity good, Lam. to Ptery. ratio approx. 4:1

TABLE 2-23

TAXA OBSERVED ON THE 1984 SUBTIDAL VIDEO TRANSECTS
(AUGUST 10-11, 1984)

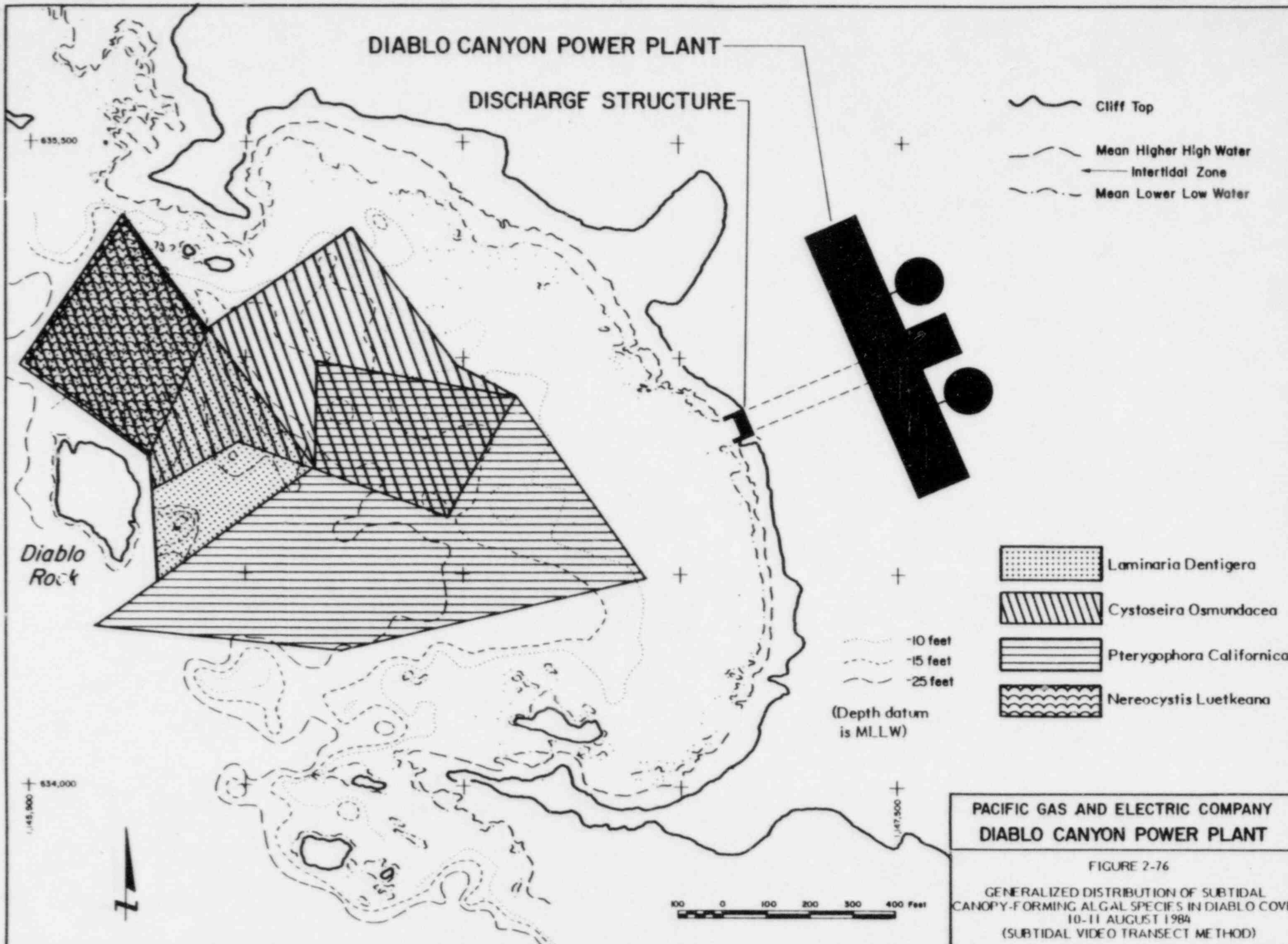
ALGAL TAXA	SD-01	SD-02	SD-03	SD-04	SD-05	SD-06	SD-07	CD-01	CD-02	CD-03	CD-04	CD-05	CD-06	ND-01	ND-02	ND-03	ND-04	ND-05	ND-06	ND-07	WJN-01
Botryoglossum farlowianum	X	X	X	X	X			X	X					X	X	X		X	X	X	X
Calliarthron spp./ Bossiella spp./ Serraticardia spp.	X	X	X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X
Coilodesme californica															X		X	X	X	X	
Cryptopleura violacea								X	X					X	X	X					
Cystoseira osmundacea		X	X	X		X		X	X	X		X		X	X	X	X	X	X	X	X
Desmarestia ligulata	X	X	X	X	X																X
diatom chains				X																	
Dictyoneurum californicum			X					X						X	X	X		X		X	
Egregia menziesii														X							
Erythrophyllum delesserioides									X											X	
Gigartina exasperata/ G. corymbifera	X	X	X	X		X	X	X	X	X		X		X	X			X	X	X	X
Iridaea cordata		X				X		X	X		X	X		X	X			X		X	
Laminaria dentigera	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
L. dentigera (bare stipe)		X										X								X	
Laminariales unid. (bare stipe)		X	X	X					X												
Laminariales unid. (juvenile)					X																
Microcladia coulteri	X			X				X	X					X	X					X	X
Nereocystis luetkeana			X		X	X	X			X	X	X	X			X	X	X	X	X	
Phyllospadix spp.														X	X						
Porphyra nereocystis																			X	X	
Pterygophora californica	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
P. californica (bare stipe)	X	X		X				X													
Ulva spp.	X	X	X	X	X				X	X			X								X

FISH TAXA	SD-01	SD-02	SD-03	SD-04	SD-05	SD-06	SD-07	CD-01	CD-02	CD-03	CD-04	CD-05	CD-06	ND-01	ND-02	ND-03	ND-04	ND-05	ND-06	ND-07	WJN-01
Brachyisticus frenatus																			X		
Citharichthys stigmaeus											X										
Damalichthys vacca										X								X			
Embiotoca jacksoni														X			X				
E. lateralis									X	X					X	X					
Embiotoca spp.				X																	
Oxyjulis californica				X	X	X			X	X	X	X	X		X	X			X		
Oxylebius pictus																					X
Sebastes atrovirens																		X			
S. mystinus			X		X		X		X				X	X			X	X	X	X	X
S. rastrelliger														X							
S. serranoides/S. flavidus (juv)					X					X					X	X	X		X		X
Sebastes spp. (juvenile)												X						X			

TABLE 2-23

TAXA OBSERVED ON THE 1984 SUBTIDAL VIDEO TRANSECTS
(AUGUST 10-11, 1984)
(CONTINUED)

INVERTEBRATE TAXA	SD-01	SD-02	SD-03	SD-04	SD-05	SD-06	SD-07	CD-01	CD-02	CD-03	CD-04	CD-05	CD-06	ND-01	ND-02	ND-03	ND-04	ND-05	ND-06	ND-07	WJN-01
Anthopleura elegantissima					X																
bryozoan unid. (white encrusting)						X				X	X	X	X				X	X		X	
Patiria miniata					X																
Pisaster spp.													X								
Pycnopodia helianthoides										X											
Tegula spp.		X				X		X	X	X	X	X	X	X		X	X				X



PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON POWER PLANT

FIGURE 2-76

GENERALIZED DISTRIBUTION OF SUBTIDAL CANOPY-FORMING ALGAL SPECIES IN DIABLO COVE 10-11 AUGUST 1984 (SUBTIDAL VIDEO TRANSECT METHOD)

Laminaria dentigera and N. luetkeana were most common in the northwest channel area of Diablo Cove, where wave surge is greatest. Cystoseira osmundacea was most common in areas of north and central Diablo Cove shallower than approximately 25 ft depths. Although P. californica was generally present at all depths throughout the cove, it was most common in the central transects at depths from 20 to 50 feet.

For all other taxa observed, only presence data were recorded while reviewing the videotapes (TABLE 2-23). With the present videotape method, a total of 42 taxa were positively identified from reviewing the tapes (TABLE 2-23). These include species which are very abundant habitat-formers and are structurally important in the composition of the Diablo Cove subtidal biological community.

The videotape transect survey provided documentation on the spatial distribution and occurrence of certain dominant algal taxa and an overview of the major habitat types within Diablo Cove. These data will be used for qualitative comparisons with future videotape surveys in Diablo Cove using the same methods.

2.15 BULL KELP POPULATION ESTIMATES

The bull kelp, Nereocystis luetkeana, is a fast-growing annual kelp plant. Its life history and other pertinent information were presented earlier by PGandE (1979, 1982b). Most juvenile sporophytes first appear in spring and reach the surface to form a canopy in summer-fall. In winter most plants senesce and are removed by storm wave activity. Bull kelp ranges from Alaska to San Luis Obispo County, California (Abbott and Hollenberg 1976). This species as well as other species with southern ranges ending near Point Conception is believed to be limited at this southern extent by the warmer water temperatures south of Point Conception.

Bull kelp density data from the TEMP Diablo Cove fixed subtidal stations (arc quadrant sampling) have been presented earlier in this report (Section 2.7.1.3). Population estimates for the entire Diablo Cove area are presented and discussed here. Diablo Cove population estimates are obtained by averaging the total number of plants counted by four observers from permanent cliff-top vantage points. Counts are obtained annually each fall. For details of the method see Appendix A, Section A.15 of this report. Although counting plants from shore-based stations does not consider smaller subsurface plants, the fall timing of each census coincides with the time most plants are sufficiently large to be on the surface and before they have been removed by winter storms. One problem with this sampling technique is that accurate counts are difficult to make when densities are high. Counting individuals becomes difficult when dense beds cause plants to visually obscure one another. However, this method provides easily obtained abundance estimates useful for evaluating year-to-year relative changes and provides maps showing the distribution of bull kelp patches in Diablo Cove.

The year-to-year changes in the number of bull kelp plants within Diablo Cove from 1970 to 1984 are presented in FIGURE 2-77. These counts coincide with the fall season each year. Cursory observations indicate that during the winter periods nearly all of Diablo Cove is devoid of surface bull kelp. Thus, the

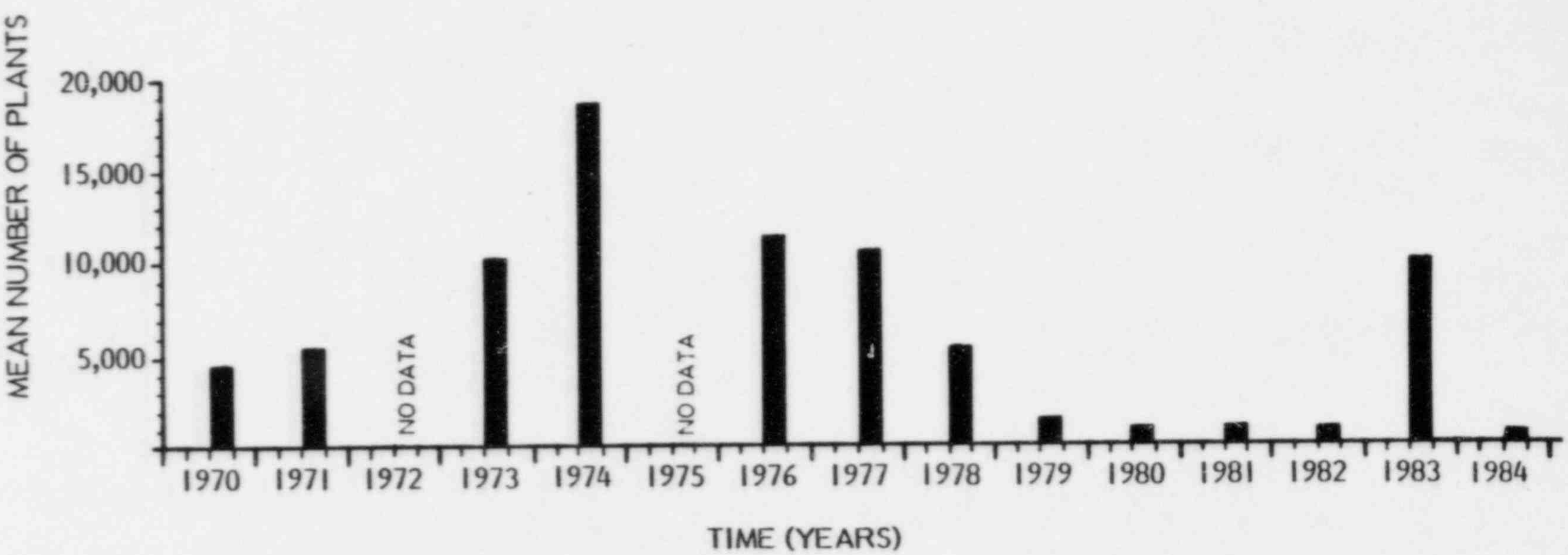


FIGURE 2-77

NUMBER OF NEREOCYSTIS LUETKEANA INDIVIDUALS
OBSERVED IN DIABLO COVE FROM CLIFFTOP
VANTAGE POINTS, FALL 1970-1984

abundance pattern of bull kelp appears to vary in an annual cycle, with winter minimums alternating with fall peaks.

Aside from short-term (within the year) changes in the nearshore conditions of Diablo Cove that may influence the abundance of bull kelp, a number of longer-term processes have occurred during the study period that may have had a strong influence on the trends depicted in FIGURE 2-77. In 1970 and 1971, bull kelp densities were moderate (about 5,000 surface plants in Diablo Cove). At this time there were high densities of sea urchins in Diablo Cove that grazed on bull kelp and its competing algal species. When the sea otter (Enhydra lutris) migrated into the Diablo Canyon coastline region in 1972-73 (Burge and Schultz 1973), they consumed large numbers of sea urchins, which "released" the bull kelp population from intense grazing pressure. As a result, from 1973 to 1974 there was a marked increase in bull kelp densities.

Subsequently, from 1976 to 1979, the density of bull kelp decreased markedly and remained at a low level (about 1,000 plants in Diablo Cove). The decrease may have resulted from competition of other algal species with bull kelp. These species were also "released" when the sea urchin grazing pressure was removed. In 1983 bull kelp abundances rose markedly to nearly 10,000 plants. This marked increase may have resulted from the detrimental effects of the late 1982-early 1983 winter storms on bull kelp competitors and substrate disturbance in nearshore areas. The loss of canopy and resultant increase in light levels may have allowed existing bull kelp gametophytes to become reproductive and young bull kelp sporophytes to survive and grow in late 1982 and early 1983, resulting in high densities. Although the population of bull kelp in 1983 was large, the condition of the mature plants deteriorated later in the year. El Nino (warm water) oceanographic conditions occurred early in the spring and persisted through the summer of 1983, elevating water temperatures above 18 C along the Diablo Canyon coast (PGandE 1984). Canopy-forming plants at this time showed premature signs of senescence. Plants appeared yellow rather than brown, and blades were disintegrating. Fertile sori, which normally appear during the late summer/early fall, never fully developed on most plants. These field observations are consistent with thermal tolerance laboratory findings which indicate

that water temperatures near 18 C are detrimental to bull kelp juvenile sporophytes (PGandE 1982b). During the fall of 1984, bull kelp abundance returned to a level comparable with that of the 1980-1982 period.

During the bull kelp observation of 1977, a small canopy (probably one plant) of Macrocystis pyrifera (giant kelp) was observed in the lee of Diablo Rock (Gotschall et al. 1984). In 1978 several more plants of this species were observed there and in the north channel of the cove. No quantitative data have been collected on this species. TEMP personnel have continued to observe these plants, which have remained in essentially the same areas and with about the same amount of canopy since the initial sightings. In 1984, the total surface area occupied by both clumps was visually estimated to be approximately 120 m^2.

2.16 IN SITU TEMPERATURE MEASUREMENT

Subtidal and intertidal temperature data have been collected at Diablo Canyon from July 1976 to December 1984. The purpose of these measurements is twofold: to develop a baseline assessment of temperature regimes in the vicinity of Diablo Cove prior to power plant operation, and to provide an interpretive data base to supplement marine biological investigations at subtidal and intertidal sampling locations. Temperature measurement instruments and sampling methods are described in Appendix A (see SECTION A.16).

During 1984, temperature data were collected from twelve intertidal stations (TABLE A-1, see Appendix A) and fifteen subtidal stations (TABLE A-2, see Appendix A). The temperature data base spans an eight-year period during which time the major portion of the data was obtained at six subtidal and four intertidal locations in Diablo Cove. Temperature measurements were also recorded at a number of additional subtidal and intertidal stations. Some data from 1983, which were obtained too late to include in last year's report, are reported here to provide a continuous temperature record.

This report presents a summary of subtidal and intertidal water temperature data collected in north and south Diablo Cove from January 1983 to December 1984 (see location map, FIGURE A-9 and Map B, in pocket). Temperature data from subtidal locations in north Diablo Cove are also presented in order to illustrate long-term seasonal trends in water temperature.

2.16.1 SUBTIDAL TEMPERATURES

Water temperatures within Diablo Cove are influenced by both large-scale coastal oceanographic phenomena and local coastal topography. The most important large-scale oceanographic phenomena in California coastal regions are visualized as three current "seasons" during the year: upwelling, oceanic, and Davidson. During the spring and early summer, upwelling results from the combined effects of prevailing north-northwesterly winds and Coriolis forces. Nearshore surface waters are moved offshore and replaced by colder, nutrient-

laden bottom waters. However, localized upwelling may occur at any time of the year in the lee of headlands such as Point Buchon, north of Diablo Cove. When prevailing winds subside during summer months, upwelling ceases and the oceanic season ensues. During this period water temperatures are influenced by the cool southerly flow of the California current. In late summer or early fall, the northward-flowing Davidson current develops inshore of the California current, creating a warming trend along the coast. The effect of the "El Nino" of 1982-1983 on this pattern was to replace spring and early summer upwelling with a warm northward-flowing current. During "El Nino" periods warm waters persist from spring through late fall.

A portion of the 1984 subtidal temperature data records was analyzed and is summarized in three forms: a long-term temperature record covering the entire program period (FIGURE 2-78), monthly mean, maximum, and minimum water temperatures in 1984 (FIGURE 2-79), and frequency distributions of temperatures in 1984 (FIGURES 2-80 to 2-82). The influence of the large-scale coastal oceanographic "seasons" described above is evident in the long-term temperature record of our nearshore recording instruments as shown in FIGURE 2-78. This graph was produced from a composite data base constructed by assembling available data from several north Diablo Cove locations to provide the most continuous record possible. The El Nino events of 1982-83 are first evident by higher than normal temperatures over longer periods during the second half of 1982. In 1983, the "normal" spring upwelling period appears to have been truncated and was followed in the second half of the year by even higher temperatures than those of 1982. These mean weekly temperatures were higher than any recorded since 1976. In 1984, the upwelling period began earlier than in 1983 and maximum temperatures were lower than those of 1983, but were still higher than the 1977-1981 period.

Monthly means, minima, and maxima for north and south Diablo Cove (composite data from Stations 7-10 and 9-10 and Stations 10-10 and 12-10, respectively) are presented in FIGURE 2-79. Relative frequency distributions for temperatures in south Diablo Cove (composite data from Stations 10-10 and 12-10) for the same period are presented in FIGURES 2-80 to 2-82. Coldest annual temperatures in

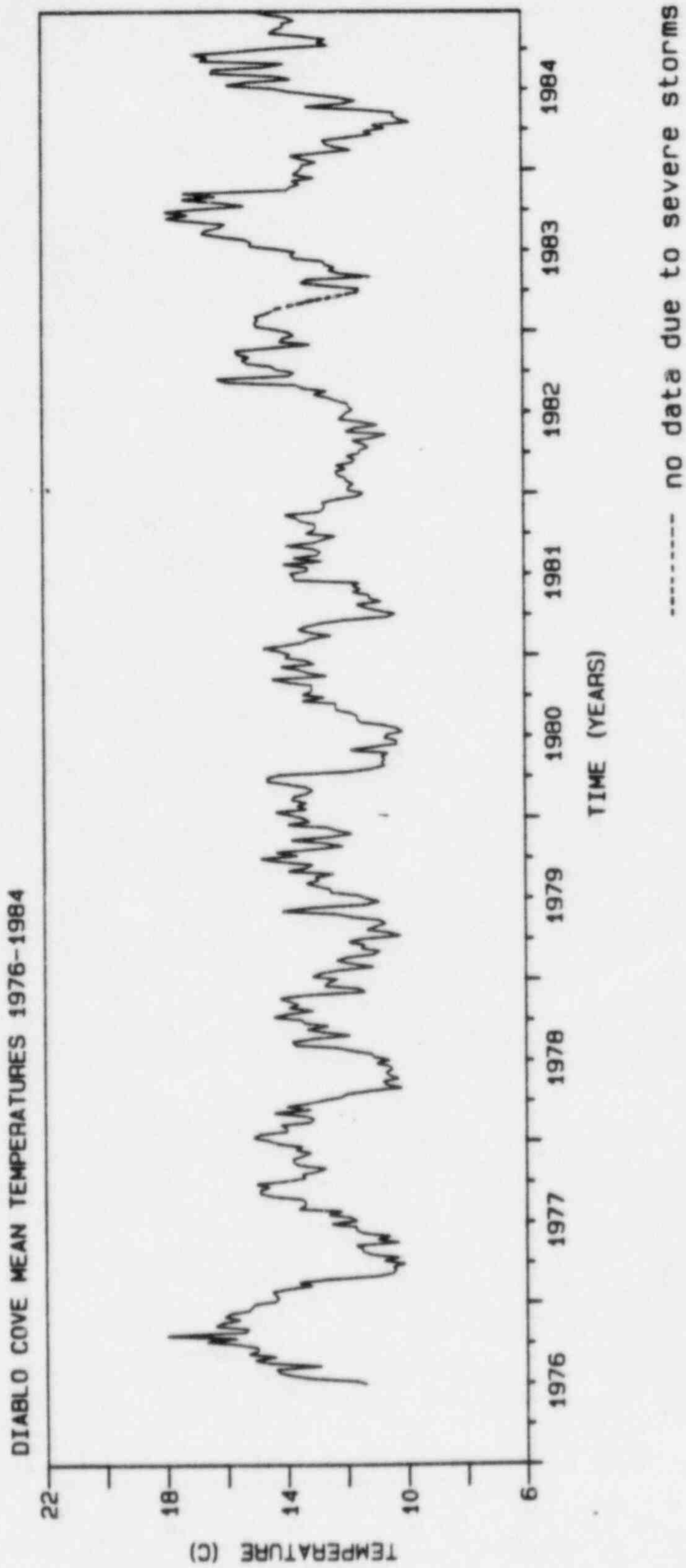


FIGURE 2-78

SUBTIDAL WEEKLY MEAN TEMPERATURES IN NORTH DIABLO COVE FROM JULY 1976 TO DECEMBER 1984

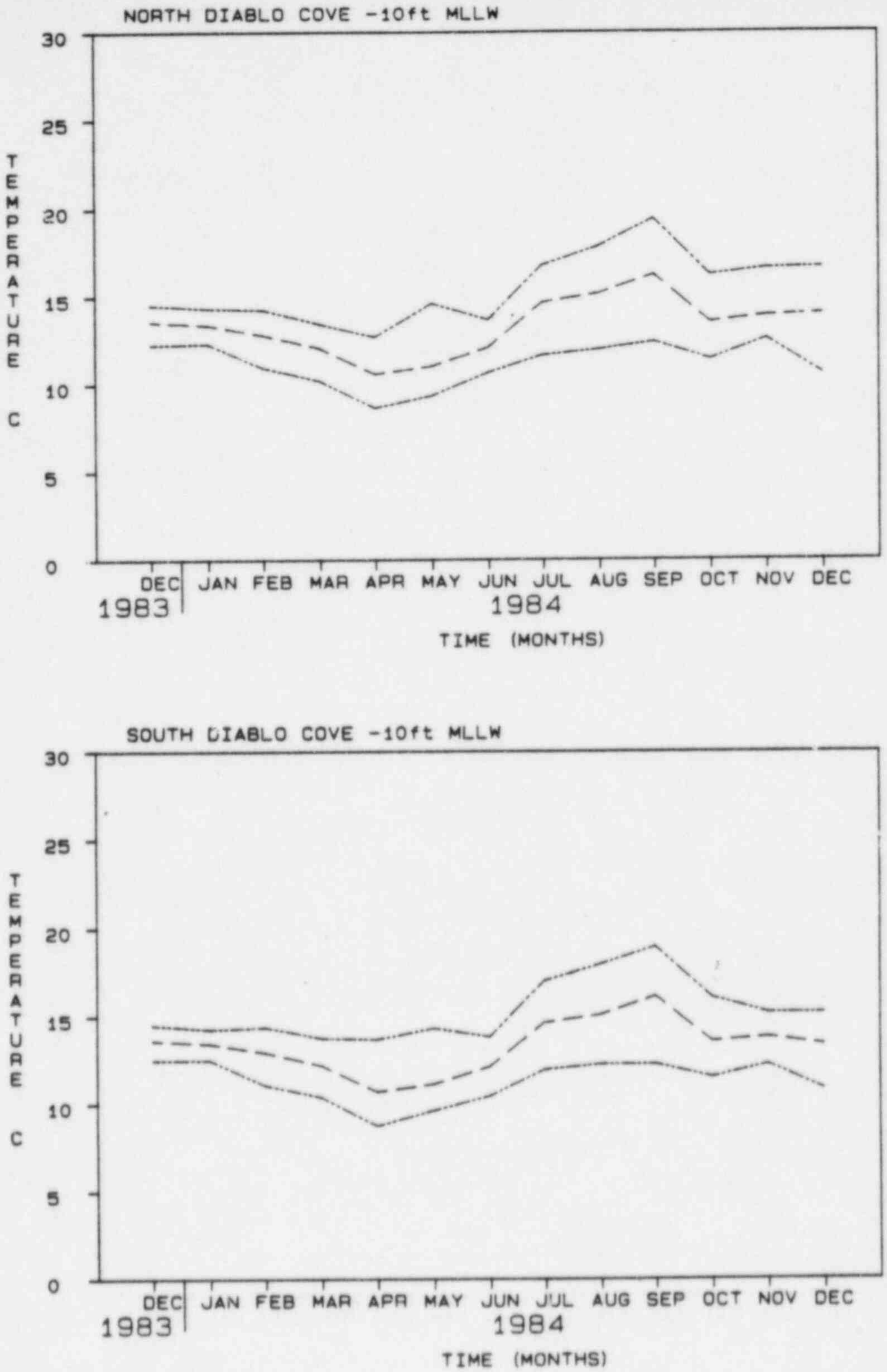


FIGURE 2-79

MONTHLY MEAN, MAXIMUM, AND MINIMUM
WATER TEMPERATURES AT SUBTIDAL (-10 FT MLLW)
NORTH AND SOUTH DIABLO COVE IN 1983 AND 1984

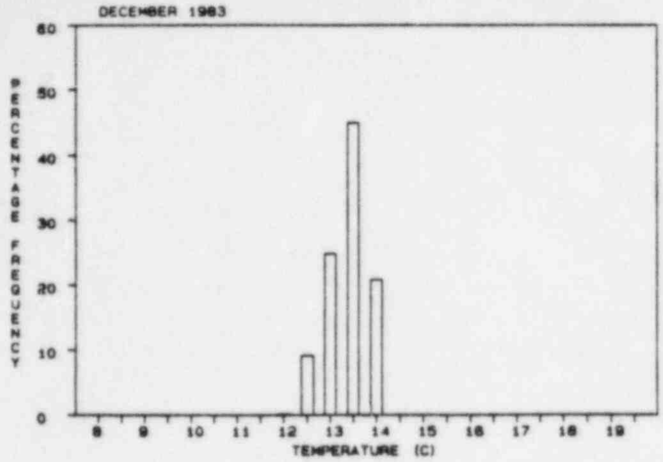


FIGURE 2-80

PERCENTAGE FREQUENCY OF TEMPERATURES IN
SOUTH DIABLO COVE IN DECEMBER 1983

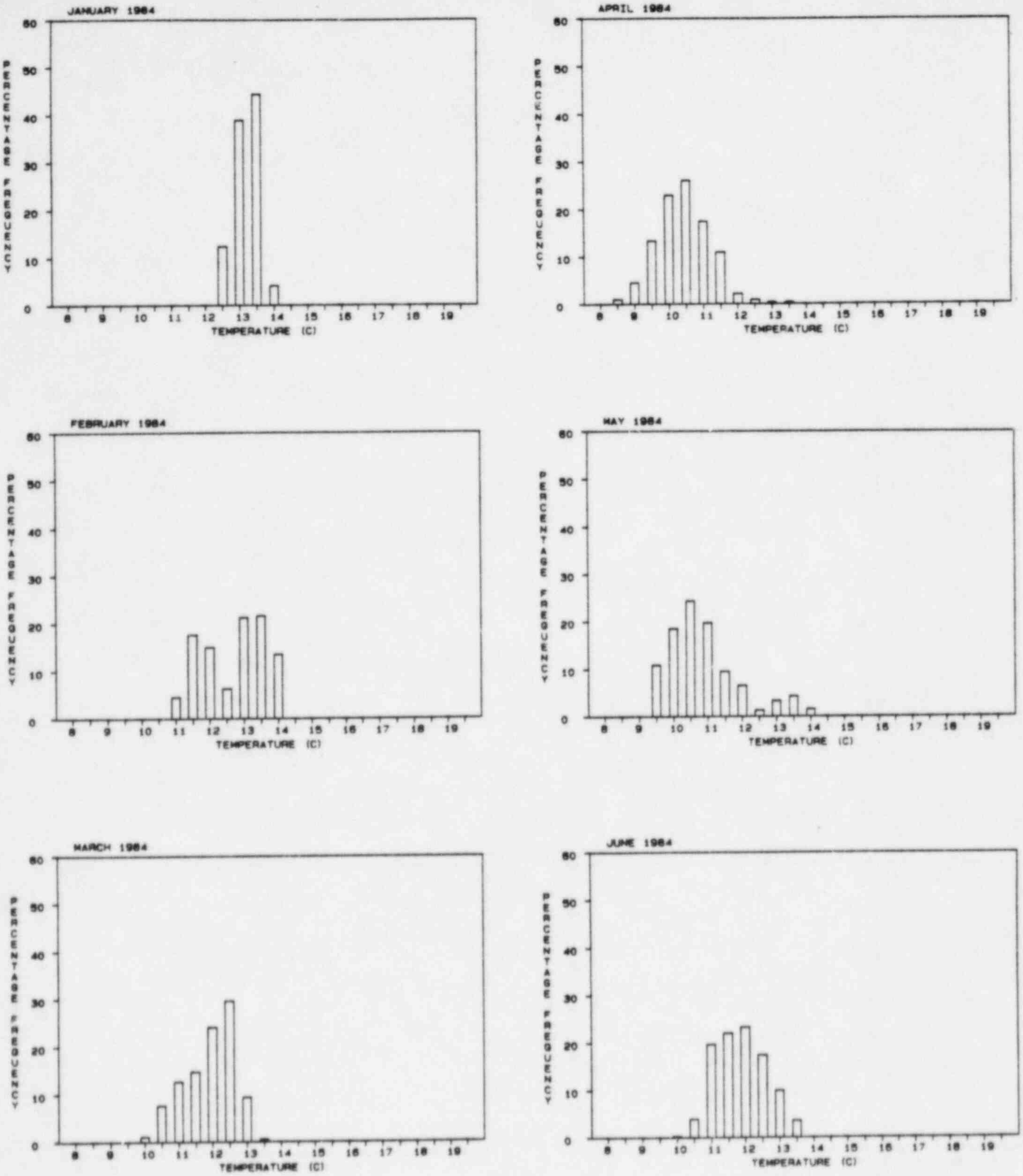


FIGURE 2-81

PERCENTAGE FREQUENCY OF TEMPERATURES IN SOUTH DIABLO COVE FOR THE FIRST HALF OF 1984

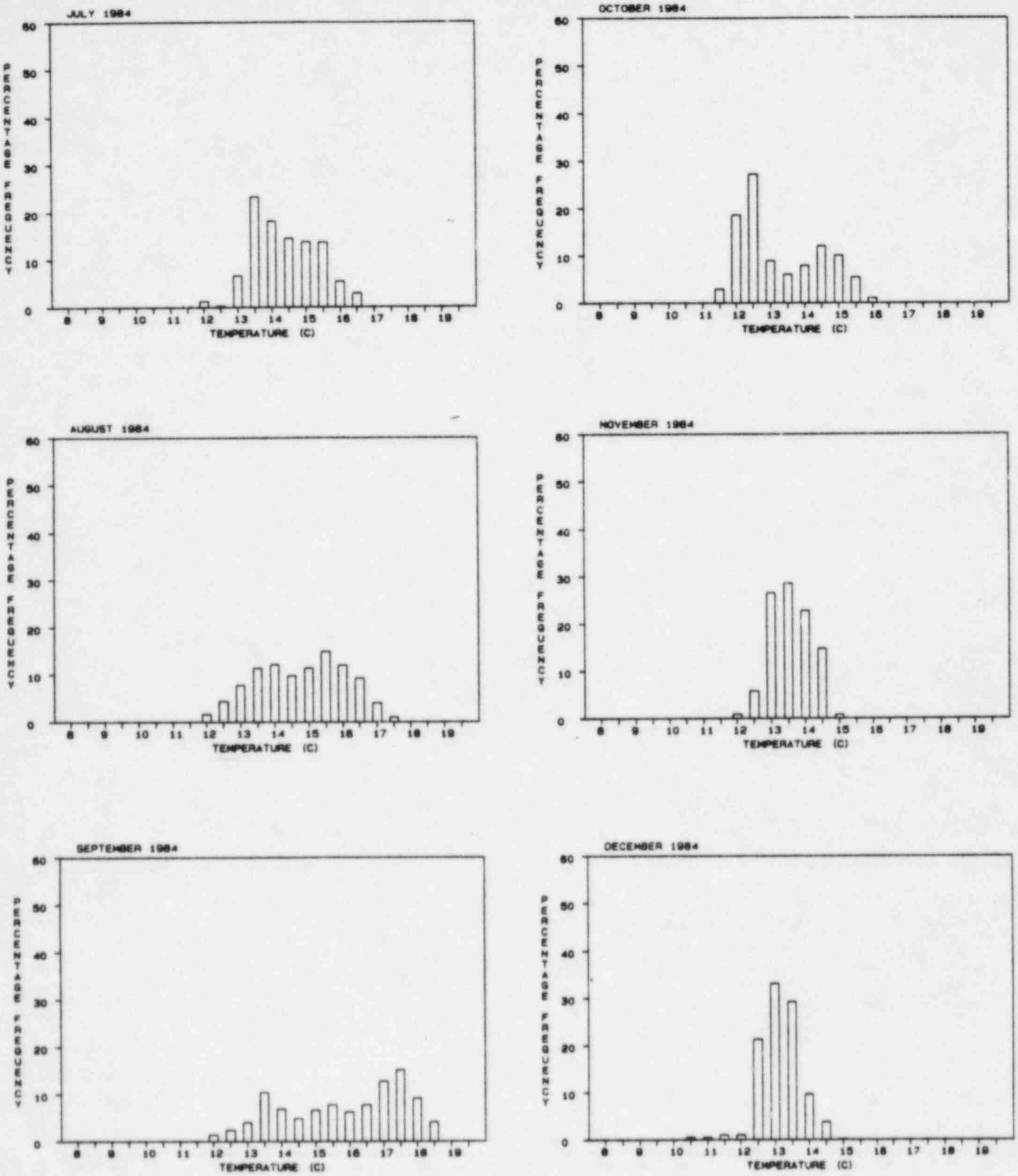


FIGURE 2-82

PERCENTAGE FREQUENCY OF TEMPERATURES IN SOUTH DIABLO COVE FOR THE SECOND HALF OF 1984

both areas occurred during the period March through June, with minima as low as 8.6 C. In contrast to the "El Nino" years of 1982 and 1983, spring temperatures for 1984 did drop to their normal low of 10 C. Warming trends began in July 1984, with the maximum temperatures occurring in September at all stations. The maximum temperature recorded was 19.3 C at Station 7-10. Temperatures in north and south Diablo Cove did not differ greatly throughout the year. This is in contrast to past years when south Diablo Cove temperatures were higher. Relative frequency distributions for Station 12-10 show that the greatest temperature ranges occur during the late summer and early fall.

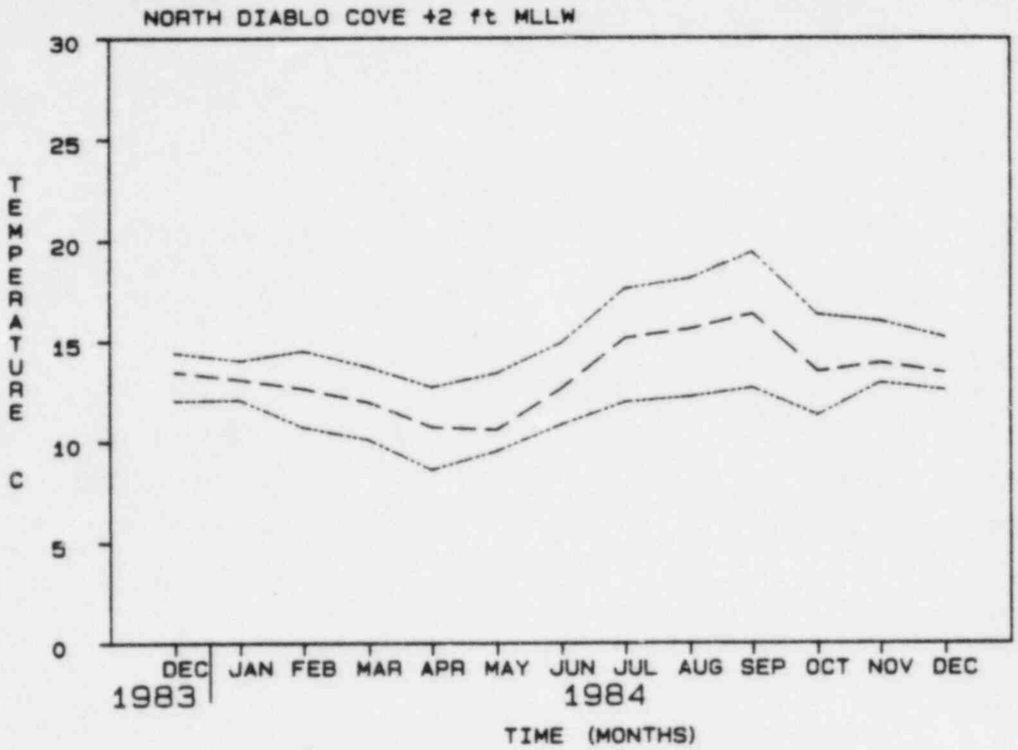
2.16.2 INTERTIDAL TEMPERATURES

Intertidal temperatures are reported in 1984 only from periods during which the recorders were submerged. These periods were defined by using the tide data recorded by the TDR-2 tide recorder located at Station 9-10. Tide and temperature data are traced for the period reported, and only temperatures collected when the tide level was +2.5 feet MLLW or greater are used in this presentation. Temperature data from north Diablo Cove (composite of Stations 8+2 and 9+2) and South Diablo Cove (Station 12+2) were used to produce the graphs in FIGURE 2-83).

Monthly means, minima, and maxima for water temperatures from January through October 1984 in north and south Diablo Cove are presented in FIGURE 2-83. The same general pattern in annual temperature fluctuations described for subtidal stations occurred at the intertidal localities. However, due to periodic exposure to air, intertidal areas are subject to wider variations in temperature.

2.17 IN SITU LIGHT MEASUREMENT

Radiant solar energy in the visible light spectrum (400-700 nm) is necessary for algal photosynthesis and primary production. This photosynthetically active radiation (PAR) impinging on Diablo Cove was measured in units of microein-



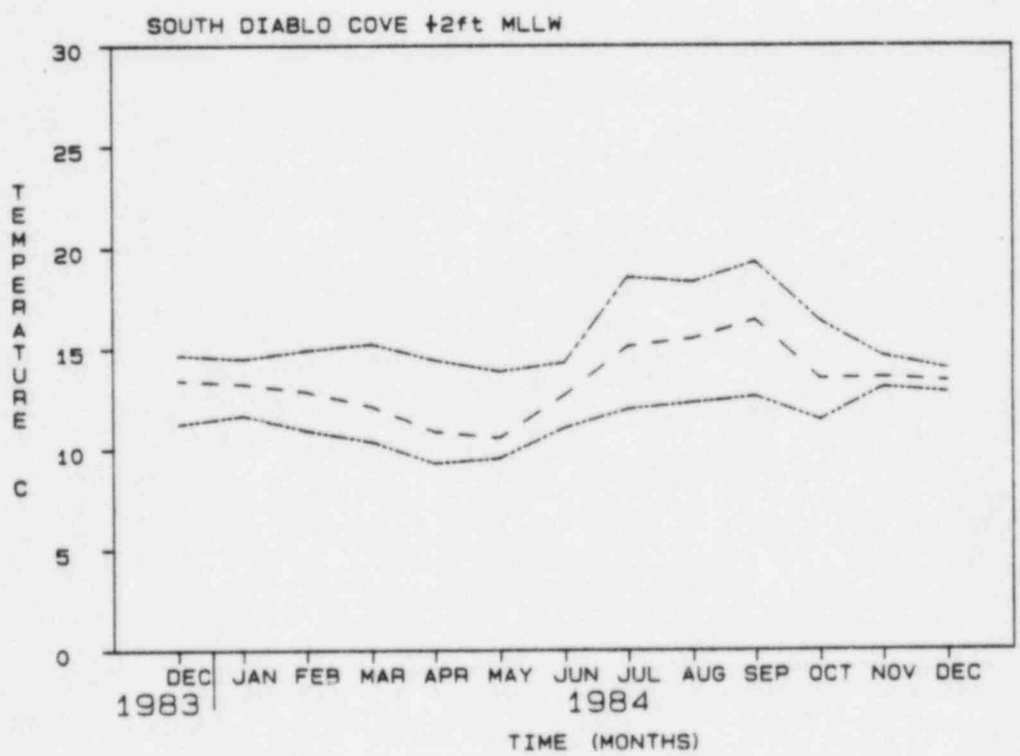


FIGURE 2-83

MONTHLY MEAN, MAXIMUM, AND MINIMUM WATER TEMPERATURES AT INTERTIDAL (+2 FT MLLW) NORTH AND SOUTH DIABLO COVE

steins/m^2/sec (hereafter referred to as "microeinsteins") continuously from 1981 through 1984 at two permanent subtidal locations (-10 ft MLLW) in north and south Diablo Cove and one permanent terrestrial location (approximately 70 ft MLLW) (see Appendix A, FIGURE A-9, and Map B in pocket). In addition, solar energy was measured at the terrestrial station. The purpose of these measurements was to develop a baseline assessment of PAR within Diablo Cove and to provide an interpretive data base to supplement both laboratory algal growth experiments and field biological investigations. Light measurement instruments and sampling methods are described in Appendix A (see Section A.17).

2.17.1 SURFACE LIGHT

Measurements of PAR at the terrestrial monitoring site were used to approximate solar irradiance values at the surface of Diablo Cove. Mean daily irradiance curves for December 1983 and the first and second halves of 1984 are presented in FIGURES 2-84 to 2-86, respectively. Maximum values (2000 microeinsteins) of full sun plus sky PAR occurred in June of 1984, with an approximate day length of 16 hours. The month with lowest PAR was December, with maximum values below 1000 microeinsteins and an approximate day length of 10 hours.

2.17.2 UNDERWATER LIGHT

Several factors influence the amount of submarine illumination underwater, including:

- Light attenuation due to surface reflection
- Transient illumination peaks due to surface refraction
- Light extinction resulting from dissolved and suspended particulates, and the seawater medium itself
- Shading from algal canopy cover.

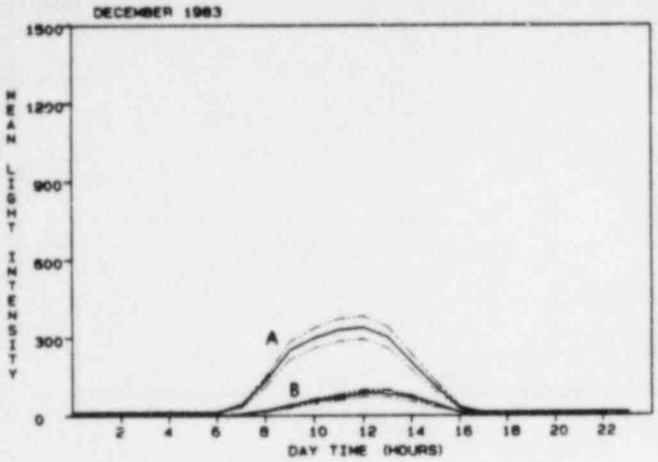


FIGURE 2-84

MONTHLY MEAN SURFACE (A) AND UNDERWATER (B) LIGHT VALUES VERSUS TIME OF DAY AT DIABLO COVE FOR DECEMBER 1983

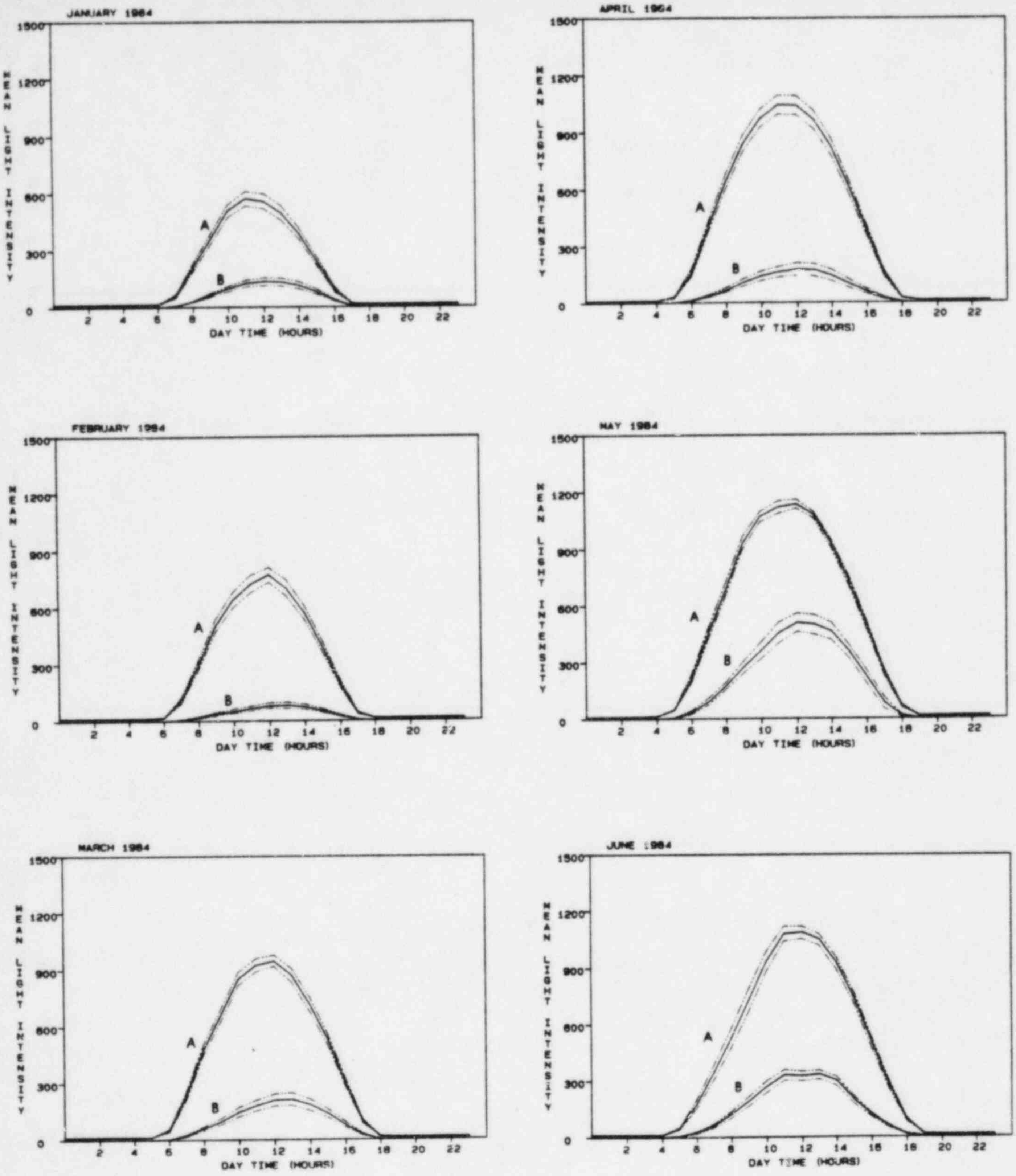


FIGURE 2-85

MONTHLY MEAN SURFACE (A) AND UNDERWATER (B)
LIGHT VALUES VERSUS TIME OF DAY AT DIABLO
COVE FOR THE FIRST HALF OF 1984

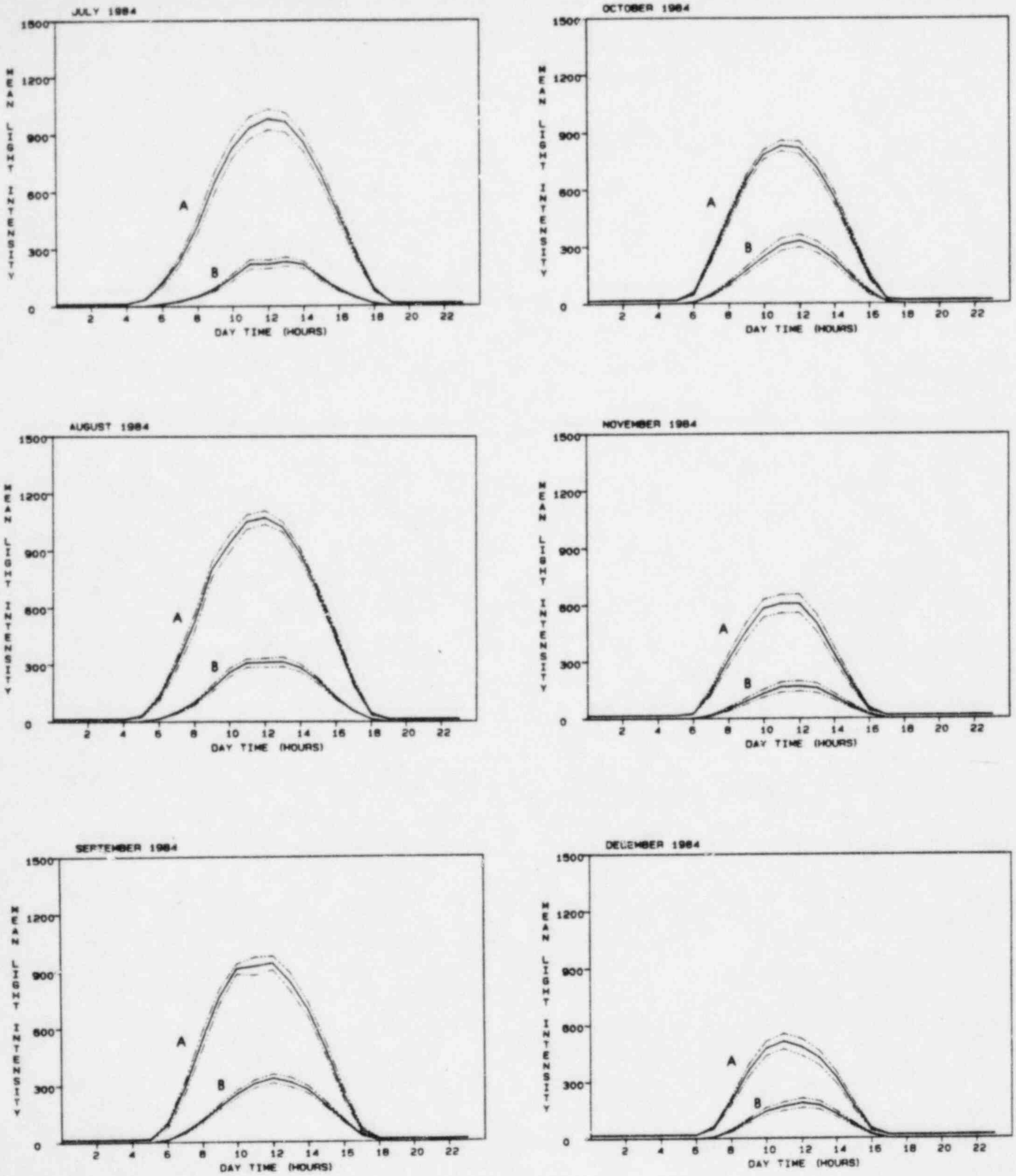


FIGURE 2-86

MONTHLY MEAN SURFACE (A) AND UNDERWATER (B) LIGHT VALUES VERSUS TIME OF DAY AT DIABLO COVE FOR THE SECOND HALF OF 1984

Underwater PAR values at -10 ft MLLW in north Diablo Cove (Station 7-10) are presented as mean daily irradiance (microeinsteins/m^2/sec) curves for December 1983 and the first and second halves of 1984 (FIGURES 2-84 to 2-86, respectively). Highest daily underwater PAR values always occur between 1100 and 1300 hours (24-hour time), when the angle of solar incidence on surface waters is greatest, thus minimizing reflection. These hours of maximum illumination had greatest underwater PAR values during spring months for the following reasons: (1) increasing day length and angle of solar incidence; (2) absence of nearshore turbulence from winter storms that causes light attenuation by suspended particulates; (3) minimal algal canopy cover.

Greatest mean underwater PAR values exceeded 500 microeinsteins in spring months of 1984. With decreasing day length in fall and early winter and with algal canopy cover reaching maximum densities, submarine illumination falls to its lowest monthly mean values in those months. Water clarity in areas offshore from Diablo Cove usually improves during fall months when calm sea conditions prevail. Although fewer suspended particulates are present in fall, the combination of decreasing day length and increased algal canopy cover still results in the reduction in submarine illumination seen in the figures.

2.18 IN SITU WAVE/TIDE MEASUREMENT

Ocean surface tidal data have been collected at Diablo Canyon continuously from 1981 through the present at subtidal Station 9-10 in Diablo Cove (-10 ft MLLW), and since 1983 at Station 32-32 (-32ft MLLW) at the plant's intake structure (see Appendix A, FIGURE A-9). The purpose of these measurements is to develop a data base of tidal conditions within the study area and to provide a means of distinguishing intertidal air versus water temperatures.

The 1984 tide data from Station 9-10 were used to identify periods of air temperature recording by the intertidal temperature recorders. Because the purpose of this study is to assess changes in water temperatures, the air temperature data were deleted from the data base to produce the values presented in FIGURE 2-83.

3.0 GENERAL OBSERVATIONS

This section reports on several field observations of a general nature which were recorded in conjunction with the specific observations of the systematic sampling tasks reported in the Section 2 results. Comments on unusual circumstances or events noted in the appearance or patterns in the Diablo Cove marine communities are also presented in this section. Included in these additional observations are events or patterns which are either not evident in the analyzed data, are based on additional supplemental sampling, or are evident but scattered over several data sets which must be integrated for a complete picture. For 1984, this section includes follow-up comments on 1983 El Nino-associated events (storm damage and high seawater temperatures) and a report on diver observations of an increase in the proportion of unpigmented algae in Diablo Cove.

3.1 EL NINO EFFECTS IN 1984

Changes in the substrate and communities of the Diablo Cove area as a result of elevated ocean water temperatures and winter storms of 1983 were previously described (PGandE 1984, see Section 4). Similar effects were reported for the giant kelp beds in southern California (Tegner 1984). Although the two events occurred at different times in 1983 and were reported separately, it now appears likely that both of the events were related to El Nino effects, and they are therefore discussed together in this report. Maximum 1984 seawater temperatures in Diablo Cove remained higher than those of the 1977-1982 period, although they were lower than in 1983 (see FIGURE 2-78). These results are in agreement with preliminary results reported for early 1984 by McGowan (1984), but are in contrast with the statement by Gunn (1984) that 1984 was a "normal" year in the Santa Barbara Channel (125 miles south of Diablo Cove). It may be that El Nino effects are expressed differently in the two areas. Alternatively, data prior to 1983 might have provided Gunn with a more definitive characterization of "normal" oceanographic conditions in the Santa Barbara Channel than the two points (spring periods of 1983 and 1984) that he used in his analysis.

Biological changes in 1983 attributed to high seawater temperatures included bull kelp senescence, subtidal and intertidal Gigartina bleaching, and presence of fish species normally found only south of Point Conception (PGandE 1984). In 1984, bull kelp abundance in Diablo Cove was reported to be substantially lower than in 1983. The reduced 1984 adult bull kelp densities may be attributable to a coastwide reduction in spore production from the 1983 population. The oceanographic conditions associated with El Nino (temperature, nutrients, currents, etc.) may have influenced the 1983 spore production or recruitment process. These results are presented in Section 2.15 of this report. No other biological effects potentially related to El Nino-induced changes were observed in 1984.

Biological effects of the 1983 storms were evident mostly in the intertidal area (PGandE 1984). A major aspect was the movement of substrate, which resulted in short- and long-term deposition of sand and cobbles on areas colonized by marine communities, or the direct abrasive action of loose material during the storms causing scouring and loss of populations. Many of the storm-related effects on the intertidal communities observed in 1983 continued to be evident in 1984, including abnormally low abundances of Endocladia muricata, Gastroclonium coulteri, Gigartina canaliculata, G. papillata, Iridaea flaccida, and Anthopleura elegantissima on certain intertidal stations (particularly Station 12 in south Diablo Cove). However, some indications of recovery (increasing abundance) were evident at some locations for Endocladia muricata and Gigartina papillata.

3.2 OBSERVATIONS ON BIOLOGICAL CHANGES IN SOUTH DIABLO COVE

On May 16, 1984, during TEMP routine monitoring dives in south Diablo Cove, TEMP personnel observed an absence of normal plant pigmentation among certain algal species to a degree which had not been observed in any of their previous underwater surveys. Whitened tissue or "bleaching" is present normally only in small amounts among the Cove's subtidal algal populations. However, the quick and widespread appearance of a number of unpigmented plants during the spring growth season suggested the occurrence of a brief and unusual event in the Diablo Cove area. The observable effects were limited to four out of the 20

to 25 species of marine algae commonly found in the Cove. The observed biological changes also appeared to be confined to the southern Diablo Cove portions of the affected species' populations.

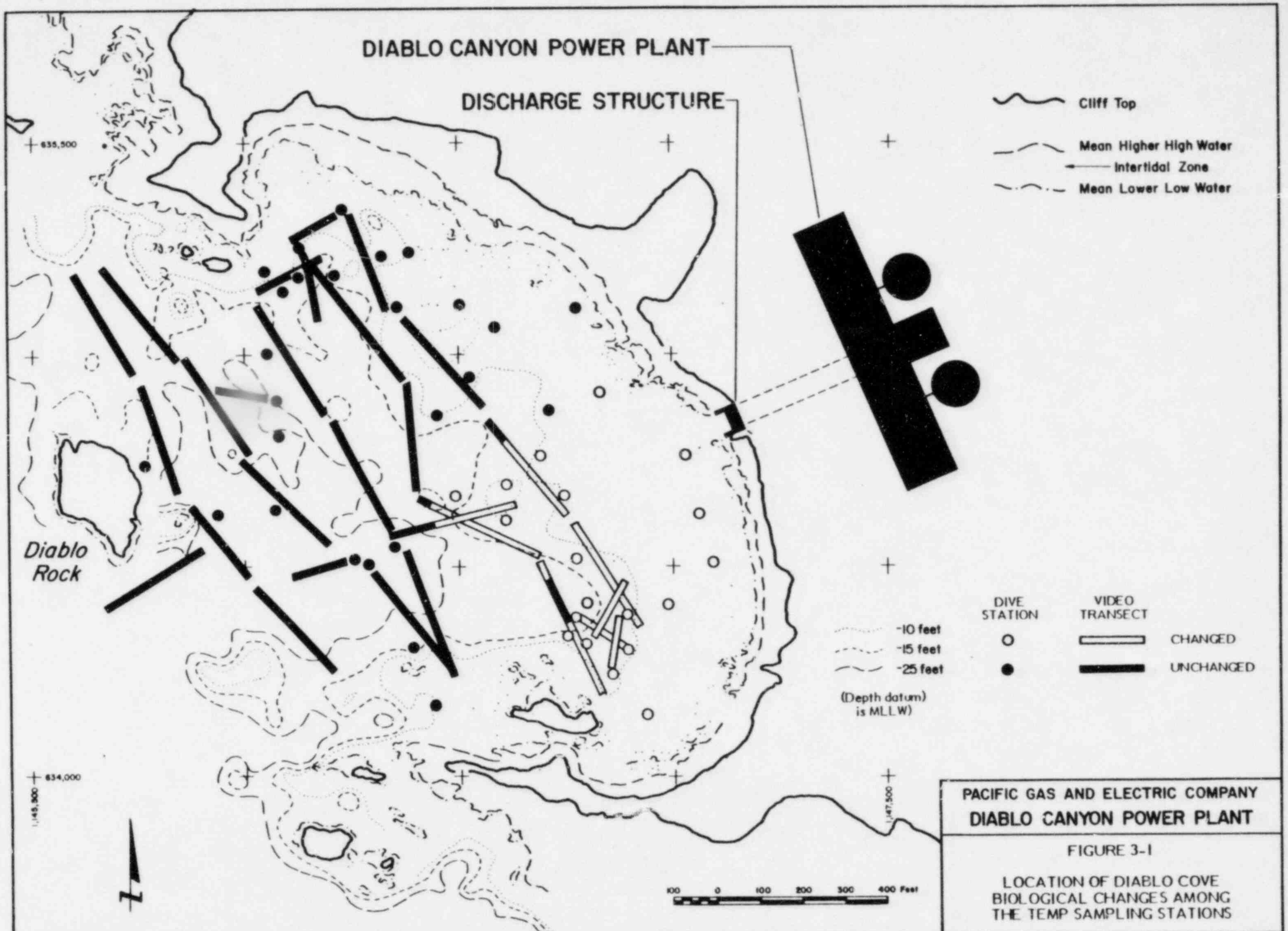
To document the extent and nature of the changes, special studies were added to the normal field monitoring tasks that included careful examination of: species conditions around the sampling stations during routine sampling, data collected on the species affected in samples from the study areas, settling plate data, and special reconnaissance dives in surrounding areas not normally sampled. These results were also examined to assess the significance of the changes to the subtidal community structure of the area. The results of these supplemental analyses are presented below.

3.2.1 AREA AFFECTED AND TIMING OF OBSERVATIONS.

The biological changes in the south Diablo Cove populations which were observed initially included a greater than normal amount of white branches among the normally pink articulated coralline algae, an early senescent (end of growing season) appearance of Botryoglossum farlowianum plants, premature stipe (frond) loss of Cystoseira osmundacea, and an increase in benthic diatom populations. The abundant populations of benthic diatoms were found covering the algal species mentioned above as well as other algal species in the area.

The results of additional reconnaissance dives in north and south Diablo Cove revealed that the algal changes were unique to the southern portion of Diablo Cove (see FIGURE 3-1). This area encompasses the routine TEMP subtidal monitoring stations 10-10, 10-15, 12-10, and 12-15. Within the south Cove area, the affected algal plants were found commonly in depths shallower than 20 ft. No changes were observed at depths greater than 20 ft in the south Diablo Cove area, nor were unusual changes found at any depth in the north Diablo Cove area. The biota of these deeper areas and north Diablo Cove appeared quite normal.

In reviewing field activity logs of the TEMP personnel, it was determined that April 5 was the last date of underwater observations in south Diablo Cove prior



PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON POWER PLANT

FIGURE 3-1

LOCATION OF DIABLO COVE BIOLOGICAL CHANGES AMONG THE TEMP SAMPLING STATIONS

to May 16. Station 10-15, a south Diablo Cove site, was sampled on the April 5 survey date. At that time, the algal populations appeared normal. It is therefore surmised that the environmental condition related to the observed algal changes ocurred during the period of April 5 and May 16. However, there is also the possibility that a condition could have occurred prior to April 5 which produced a lag between the environmental change and the visible appearance of physiological change in the algal plants.

3.2.2 AFFECTED SPECIES

A chronological summary of subtidal algal observations in the affected area is presented in FIGURE 3-2. There were no apparent changes in either the invertebrate or fish populations of the area. Nearly all algal species were covered by an unusually abundant layer of diatoms. In addition, the articulated coralline algae, Botryoglossum farlowianum, Cystoseira osmundacea, and Ulva spp. exhibited other growth or population changes which are described in detail below.

In May, an increase in the number of white branches (fronds) was noted among the normally pink colored fronds of the articulated coralline algae CBS complex, consisting of Calliarthron, Bossiella, and Serraticardia. A frond lacking pink pigmentation generally indicates an absence of photosynthetic tissue in that portion of the plant. The increased number of unpigmented fronds was observed to occur along the upper two thirds of the plants' fronds, including the principal growing region. The data on these algae collected with the subtidal line contact method are presented in Section 2.9.1.2 of this report (see FIGURE 2-52). However, the data in that presentation include both pigmented and unpigmented plants. Field observations in May recorded that between 25-60 percent of the sampled CBS population was unpigmented among the four sampling stations located in the area of algal changes. During the same period, unpigmented fronds in the north Diablo Cove CBS populations were not measurably abundant. Blades of Botryoglossum farlowianum were observed in May to be prematurely senescent in the affected area, whereas in other Diablo Cove areas, plants appeared in a normal growth condition for the season. Review of the data on

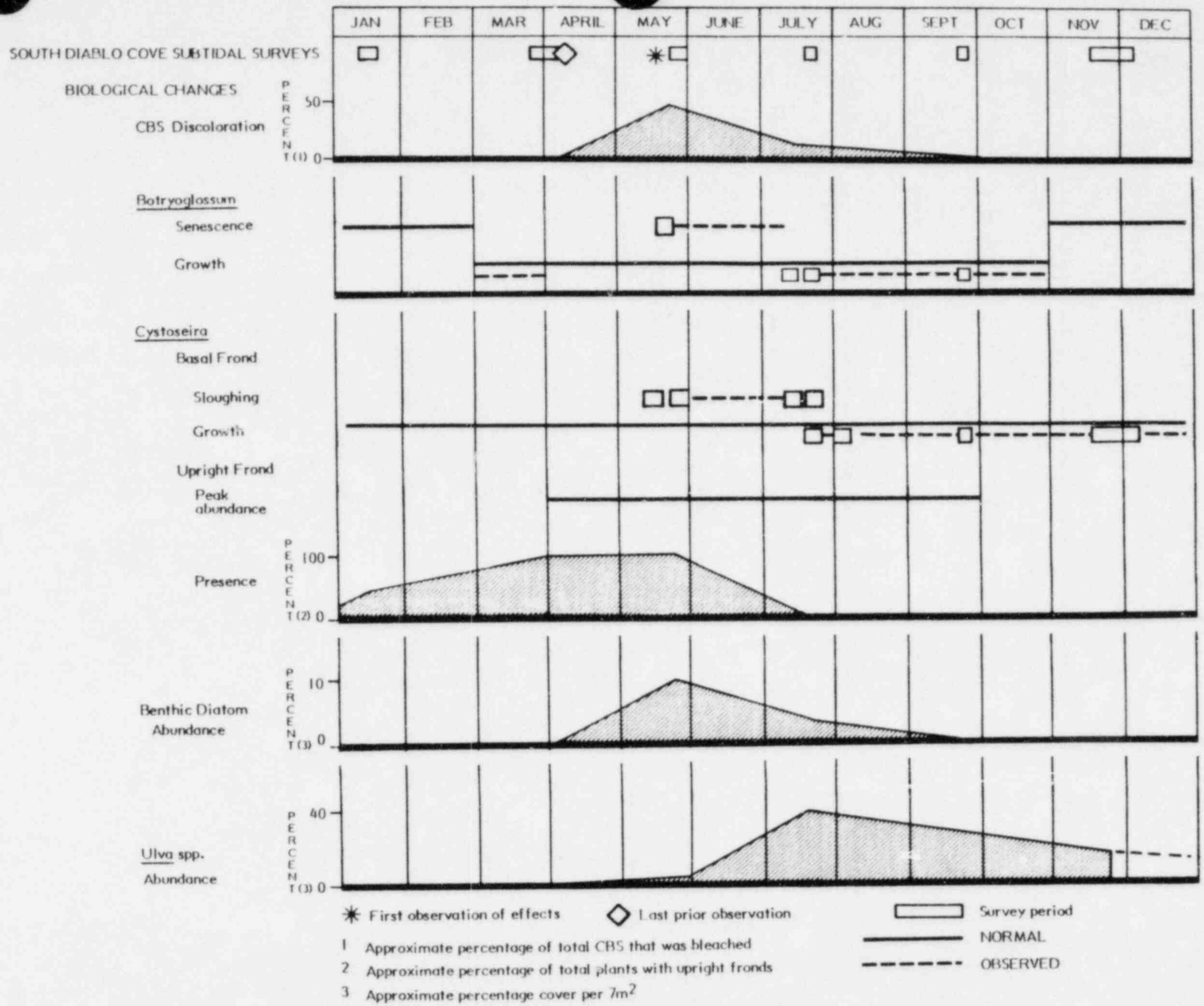


FIGURE 3-2

CHRONOLOGY OF 1984 EVENTS RELATED TO BIOLOGICAL CHANGES IN SOUTH DIABLO COVE
(Source of percentage data from SAQ and SLC South Diablo Cove)

percentage cover did not reveal a quantitative change in the Botryoglossum populations during this period.

Cystoseira osmundacea exhibits a seasonal cyc of growth in which long fronds are produced from perennial basal portions in the spring and summer (see Section 2.7.1.1, FIGURE 2-31). These fronds, which when mature constitute a significant amount of biomass, disintegrate during the winter. The environmental condition associated with the observed algal changes occurred during the initial portion of the fronds' spring growth period. In May, both the upright fronds and basal portions exhibited tissue loss. The upright fronds lacked gas bladders which normally develop along the terminal 50-100 cm of the frond. The absence of these flotation structures left the fronds deeply submerged rather than supported at the surface, as found in plants with normally developed gas bladders.

Ulva spp. is an algal species that is indicative of disturbed habitat conditions. In a weedlike manner, Ulva populations quickly colonize unoccupied substrate that is made available from physical effects such as storms or biological effects such as grazing. Following the initial colonization, the Ulva populations frequently become conspicuously abundant. Prior to May 1984, Ulva abundance in Diablo Cove had been relatively low, never exceeding more than 10 percent of the total algal cover measured in the subtidal arc quadrant samples. In July, the Ulva percent cover values increased to between 20 to 70 percent among the south Diablo Cove subtidal arc quadrant samples. No changes in the Ulva percent cover values were detected among the arc quadrant samples from the north Diablo Cove stations during the same survey period.

Benthic diatoms are normally ubiquitous in nearshore marine communities. Their populations are, however, typically inconspicuous. Substantial increases in diatom growth which result in visible populations are often associated with disturbance, similar to Ulva spp. In May 1984, the diatom populations in south Diablo Cove exhibited an increase in abundance ranging from 5 to 20 percent of the algal cover in the subtidal arc quadrant samples. In previous samples from these south Diablo Cove stations and from samples at the north Diablo Cove stations during the May survey, diatoms were sparsely distributed and generally

undetectable. These field-level observations were also confirmed by laboratory evidence from the subtidal settling plate data. Review of the settling plate results revealed that the highest abundance of diatoms ever measured in the TEMP samples occurred at Station 10 in May, 1984 (FIGURE 2-73).

3.2.3 SUBSEQUENT OBSERVATIONS

The proportion of white branches in the CBS coralline algae began to decrease in May, until by November unpigmented fronds were observed during field surveys only in their normally sparse occurrence. New frond tissue growth was observed in the Botryoglossum populations by mid-summer. The loss of upright fronds continued to occur among Cystoseira plants in south Diablo Cove, so that by July all but a few erect fronds were absent from all the plants in the affected area. Tissue loss also continued to occur from the basal portion of the fronds. However, by August new tissue growth was evident in the basal fronds. During this time, the abundance of Ulva spp. and benthic diatom populations rapidly declined and had returned to its normal levels by the end of 1984.

The in situ water temperature and light monitoring data base was examined for unusual patterns associated with a period surrounding and during April 1984. The data from north and south Diablo Cove stations were graphically compared for the period of February to May 1984. There were no obvious differences between the two areas. Transmitted light values recorded in situ at a depth of -10 ft (MLLW) tended to be higher in south Diablo Cove than in north Diablo Cove.

No persistent difference was found between north and south Diablo Cove water temperatures from in situ recorders located at a depth of -10 ft (MLLW). Power plant wastewater release records and main circulating pump logs were examined for any unusual patterns or operating conditions. There was no evidence in the available data to suggest a causal relationship between a power plant discharge condition and the biological changes observed in the Cove. In mid-April, there were several large-volume wastewater releases which occurred when the main circulating water pumps were not in service. However, a similar operating condition has occurred previously without any evidence of biological changes in

the Cove. A review of the power plant discharge values during this period indicated that concentrations of waste stream constituents were within the normal range anticipated during plant operations.

3.2.4 DISCUSSION

A change which occurred in the marine environment of south Diablo Cove during the spring of 1984 was detected both in the results of underwater biological surveys and in the laboratory analysis of results from the subtidal settling plate samples. Biological changes were observed in the growth and abundance of several species of algae. Based on the rapid biological response of the affected algal species, the conditions associated with environmental changes in the Cove appear to have been limited in time and space to a single event in April, 1984, affecting only the south portion of Diablo Cove. The event produced a biological response in the populations of at least three dominant algal species. The environmental change and its associated primary biological changes subsequently induced an unusual increase in the populations of two other algal species.

Observations of the area and affected species continued throughout the remainder of 1984. Results from the final subtidal surveys of 1984 indicate an absence of any permanent change in the affected species' populations or their associated communities. One of the affected species, Cystoseira osmundacea, is a pseudo-annual species which loses its upright portion each year but retains the basal fronds. Since it is not normally present during the late winter and early spring months, observations on its abundance and distribution during the 1985 spring and summer growth season will be required to fully assess the long-term results of the 1984 changes in Diablo Cove.

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APPENDIX A

MONITORING PROGRAM METHODS

APPENDIX A

MONITORING PROGRAM METHODS

Brief descriptions of the methods employed in gathering biological and physical data for TEMP are included in this appendix. For purposes of clarity, the methods have been broken down into 18 subtasks, each of which is described separately.

A.1 INTERTIDAL BAND TRANSECT (IBT)

The abundance of algae and invertebrates is monitored bimonthly at fixed intertidal stations at two levels (approximately +1 and +3 ft MLLW) within fixed 30 m x 1 m bands (TABLE A-1, FIGURES A-1, A-2; see also Map A in pocket). Currently, 10 fixed horizontal 1 m^2 quadrats per station level are sampled for conspicuous species. Five of these quadrats ("_Tegula_ quadrats") are more intensively sampled for all macroinvertebrates.

The quadrats are clipped to a transect line strung along the station level. Abundance estimates of algae and encrusting invertebrates are obtained by dividing each quadrat into 16 blocks, each of which can be subdivided into nine smaller blocks. Percentage cover estimates are obtained by recording the number of squares (either 1/16 or 1/144) occupied by a particular taxon. The "_Tegula_ quadrats" are searched from all angles of view, and all macroinvertebrate taxa observed are counted and recorded.

A.2 INTERTIDAL RANDOM POINT CONTACT (RPC) QUADRAT

A random point contact method is used to measure percentage frequency of occurrence as an index of percentage area covered by dominant intertidal algae. Algal area cover is monitored at bimonthly intervals within fixed horizontal 0.25 m^2 quadrats located approximately in the middle and at either end of the fixed 30 m x 1 m band transects (FIGURES A-1 and A-2). The area within the quadrat is sampled by reference to a coordinate grid system defined by markings on the quadrat sides and a cross bar which slides across them, with a total of 400 potential cross points. For each bimonthly survey, an independent set of 60 randomly generated sampling cross points is produced. At each sampling cross

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	INTERTIDAL BAND TRANSECT (IBT)	RANDOM POINT CONTACT QUADRATS (RPC)	ALGAL SCRAPING (AS) STATION (APPROXIMATE LOCATION)	STATION PHOTOGRAPHY	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER
1	+3	641, 286.56N 1, 141, 551.08 E	●	●		●		
1	+1	641, 111.13 N 1, 141, 776.62 E	●	●		●		
2	+3	640, 883. N 1, 141, 843.37 E	●	●		●		
2	+2	641, 073.07 N 1, 141, 762.57 E			●		○	
2	+1	641, 010.79 N 1, 141, 800.04 E	●	●		●		
3	+3	640, 561.92 N 1, 141, 986.35 E	○	○		○		
3	+2	640, 598.83 N 1, 141, 964.80 E					○	
3	+1	640, 528.23 N 1, 141, 963.43 E	○	○		○		
4	+3	636, 208.64 N 1, 146, 101.17 E	○	○		○		
4	+2	636,225.90N 1,146,097.29E					○	
4	+1	636,280.92N 1,146,103.88E	○	○		○		
5	+3	636, 176.50 N 1, 146, 025.12 E	○	○		○		
5	+2	636,173.93N 1,146,001.34E					○	

TABLE A-1

INTERTIDAL DATA COLLECTION STATION LOCATIONS, STATUS AND TYPES OF DATA COLLECTED

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	INTERTIDAL BAND TRANSECT (IBT)	RANDOM POINT CONTACT QUADRATS (RPC)	ALGAL SCRAPING (AS) STATION (APPROXIMATE LOCATION)	STATION PHOTOGRAPHY	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER
5	+1	636, 153.01 N 1,145,920.06E	○	○		○		
6	+3	636, 060.93 N 1, 145, 920.06 E	●	●		●		
6	+2	636,071.08N 1,145,934.61E					●	
6	+1	636, 087.87 N 1, 145, 905.54 E	●	●		●		
7	+3	635, 387.13 N 1, 146, 039.83 E	●	●		●		
7	+2	635, 383.74 N 1, 146, 053.23 E						● [1]
7	+1	635, 375.21 N 1, 146, 060.72 E	●	●		●		
8	+3	635, 482.24 N 1, 146, 217.47 E	●	●		●		
8	+2	635, 471.44 N 1, 146, 203.19 E			●		●	
8	+1	635, 446.99 N 1, 146, 207.34 E	●	●		●		
9	+3	635, 433.89 N 1, 146, 313.76 E	●	●		●		
9	+2	635, 431.16 N 1, 146, 303.16 E					●	
9	+1	635, 414.24 N 1, 146, 328.81 E	●	●		●		
10	+1.7	634, 519.05 N 1, 147, 169.43 E	●	●		●		

1 ENDECO DATA COLLECTED UP TO MAY 23, 1984

TABLE A-1

INTERTIDAL DATA COLLECTION STATION LOCATIONS, STATUS AND TYPES OF DATA COLLECTED (CONTINUED)

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	INTERTIDAL BAND TRANSECT (IBT)	RANDOM POINT CONTACT QUADRATS (RPC)	ALGAL SCRAPING STATION (AS) (APPROXIMATE LOCATION)	STATION PHOTOGRAPHY	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER
10	+2	634, 536.58 N 1, 147, 175.99 E			●		●	● [1]
10	+1	634, 516.10 N 1, 147, 162.28 E	●	●		●		
11	+3	634, 184.75 N 1, 147, 106.09 E	●	●		●		
11	+2	634, 164.00 N 1, 147, 086.22 E					●	
11	+1	634, 176.41 N 1, 147, 066.92 E	●	●		●		
12	+3	634, 043.94 N 1, 146, 882.96 E	●	●		●		
12	+2	634.054.14N 1,146,864.86E			○		●	
12	+1	634, 066.48 N 1, 146, 981.80 E	●	●		●		
13	+3	634, 040.37 N 1, 146, 371.45 E		○		○		
13	+2	634, 046.82 N 1, 146, 361.57 E					●	
14	+3	634,011.11N 1,146,349.79E	●	●		●		
14	+1	634,011.70N 1,146,332.60E		●		●		
15	+3	633, 956.52 N 1, 146, 406.01 E	●	●		●		
15	+2	633,979.20N 1,146,397.96E					●	

1 ENDECO DATA COLLECTED UP TO APRIL 9, 1984

TABLE A-1

INTERTIDAL DATA COLLECTION STATION LOCATIONS, STATUS AND TYPES OF DATA COLLECTED (CONTINUED)

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	INTERTIDAL BAND TRANSECT (IBT)	RANDOM POINT CONTACT QUADRATS (RPC)	ALGAL SCRAPING STATION (AS)	STATION PHOTOGRAPHY (APPROXIMATE LOCATION)	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER
16	+3	632, 708.29 N 1, 147, 783.23 E		○		○		
16	+2	632, 664.12 N 1, 147, 748.62 E					○	
17	+3	(approx.) 632,700 N 1,147,730 E	○	○		○		
18	+3	(approx.) 632,729 N 1,147,840,663.50 E	○	○		○		
18	+2	(approx.) 632,675 N 1,147,790 E					○	
19	+3	632, 922.59 N 1, 148, 958.64 E	●	●		●		
19	+2	632, 891.36 N 1, 148, 977.59 E					●	
19	+1	632, 937.94 N 1, 149, 143.33 E	●	●		●		
20	+3	632, 995.41 N 1, 149.086.69 E	●	●		●		
20	+1	632, 977.05 N 1, 149, 069.25 E	●	●		●		
21	+3	632, 903.71 N 1, 149, 170.01 E	○	○		○		
21	+2	632, 871.80 N 1, 149, 158.64 E					○	
21	+1	632, 921.37 N 1, 149, 146.83 E	○	○		○		

TABLE A-1

INTERTIDAL DATA COLLECTION STATION LOCATIONS,
STATUS AND TYPES OF DATA COLLECTED
(CONTINUED)

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	INTERTIDAL BAND TRANSECT (IBT)	RANDOM POINT CONTACT QUADRATS (RPC)	ALGAL SCRAPING STATION (AS)	STATION (APPROXIMATE LOCATION)	STATION PHOTOGRAPHY	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER
22	+3	634, 077.445 N 1, 146, 673.926 E	●	●		●			
22	+2	(approx.) 634,081.00N 1,146,687.00E					●		
23	+3	635,016.70N 1,146,931.91E	●			●			
23	+2	634, 954.44 N 1, 146, 931.92 E					●		
23	+1	634, 989.13 N 1, 146, 930.09 E	●			●			
24	+2	(approx.) 634,082.00 N 1,146,800.00 E					○		

TABLE A-1

INTERTIDAL DATA COLLECTION STATION LOCATIONS,
STATUS AND TYPES OF DATA COLLECTED
(CONTINUED)

E-85-04

A-7

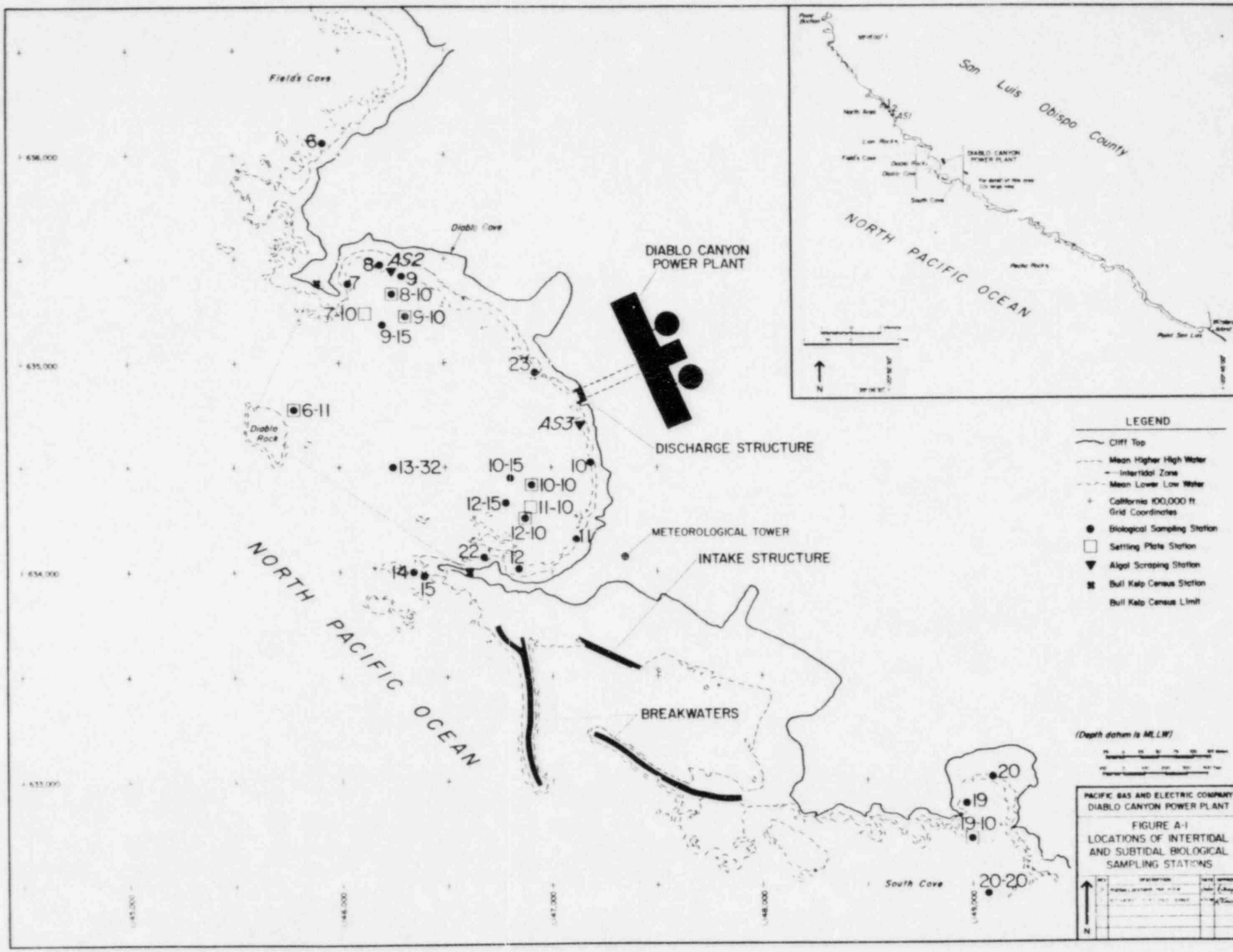

FIGURE A-1
LOCATIONS OF INTERTIDAL AND SUBTIDAL BIOLOGICAL SAMPLING STATIONS

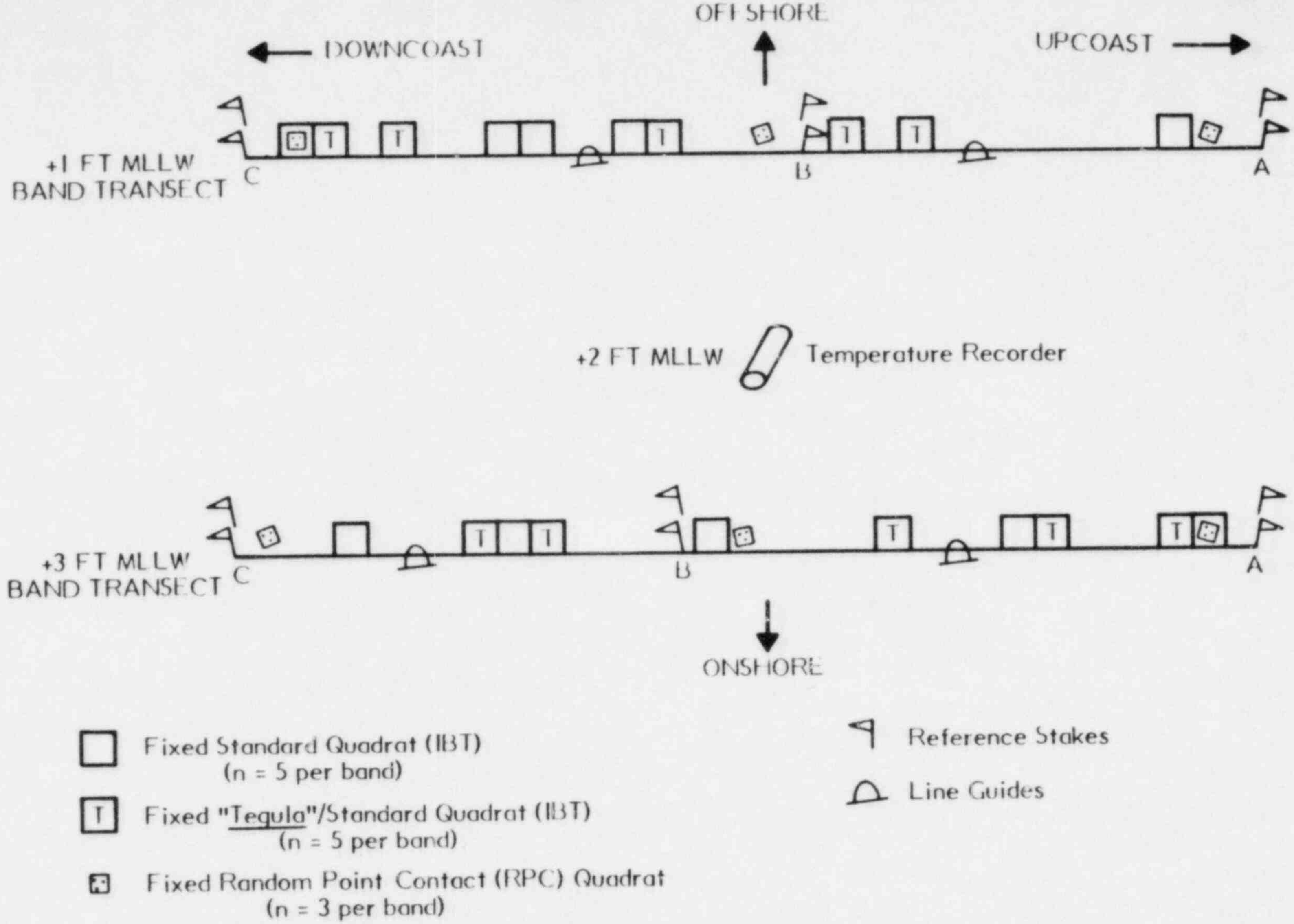

FIGURE A-2

DIAGRAMMATIC EXAMPLE OF
TYPICAL INTERTIDAL STATION

point, a fine metal rod is held perpendicular to the substrate and lowered until a species or the substrate is contacted. All organisms contacted by the rod are recorded. If the individual first contacted overlies other species or the substrate, it is gently moved away and the process is repeated for underlying species until an encrusting species or the substrate is contacted. Additional contacts of any one species at one sampling point are not recorded. A number assigned to each species or the substrate corresponds to the order in which it was contacted as the rod was lowered from the surface layer to the substrate at each sampling point.

A.3 INTERTIDAL ALGAL SCRAPINGS

Algal scrapings are collected biannually from 25 randomly positioned 0.06 m^2 quadrats at permanent stations located near existing intertidal band transects ("AS" stations in FIGURE A-1; see also Map A in pocket). In each sample, percentage cover estimates are obtained for all attached algae and encrusting invertebrates. Additionally, the numbers of individuals of motile invertebrate species encountered are recorded. All attached algae are then removed using a metal scraper, placed in a labeled plastic bag, and returned to the laboratory for processing, or are frozen to await processing.

Laboratory treatment of each sample consists of sorting all algae into specific taxa. Iridaea flaccida, a very common foliose red alga, is further subdivided into life-history stages (juveniles; immature males, females, and tetrasporophytes; mature females; mature tetrasporophytes). Blade counts and blade lengths are then obtained for each life stage. Each of these sorted life-history categories, along with the remaining sorted taxa in the sample, are placed in separate glass dishes and dried for 24 hours at 100 C (212 F). Dry weight measurements are then recorded for all sorted specimens.

A.4 INTERTIDAL BLACK ABALONE TAGGING

Black abalone, Haliotis cracherodii, are individually tagged, measured, and periodically remeasured to estimate and compare average shell growth rates of abalone in four areas in the Diablo Canyon study area.

The location of tagged individuals is recorded as linear distance and compass direction from a permanent relocatable marker. Measurement of abalone consists of determining the longest shell dimension with a pair of machinists' calipers and comparing that distance to a metric ruler, recording length to the nearest millimeter. Precision estimates of the measurement technique are obtained by measuring the same abalone five times using five independent observers.

A.5 INTERTIDAL BLACK ABALONE SURVEY

The purpose of this study is an accurate determination of the number and distribution of black abalone, Haliotis cracherodii, within Diablo Cove. A randomly placed quadrat method is used. Beginning near the discharge and running to the south and to the north, Diablo Cove is divided into segments 100 m long. Two stakes positioned at the discharge structure serve as the origins for the segments in the north and south portions at the cove. A 100-m line marked off in 1-meter segments is placed in the intertidal zone at an elevation of approximately +2 ft MLLW. In practice, the line follows the middle of the intertidal portion of the Iridaea flaccida zone. Changes in direction of the line are marked with a rebar stake or an already established intertidal monument. Distance and bearing (using a hand bearing compass) from the origin stakes and monuments are noted. The end of one 100-m section serves as the origin for the next section. Six sections were established in both the north and south areas of Diablo Cove in such a way that each section can be relocated with reasonable accuracy.

Using the transect line as a reference, the area between the estimated 0 and +4 ft MLLW tide levels is delimited. These levels are generally defined as the upper limit of Phyllospadix spp. and the upper limit of Pelvetia fastigiata, respectively. The area thus delimited is considered to be the zone in which most intertidal black abalone occur. Due to the variable topography of the intertidal zone, the width of the sample area varies considerably within each section.

The total number of square meters encompassed in each 100 m section was determined graphically. Ten percent of the potential 1 m^2 sites within each section are selected on a random basis. The site locations were transferred from these maps to a master data sheet listing the section number (NDC 1-5 or SDC 1-6), the ordinate (1-100 m), and the location of the quadrat to be sampled as onshore (+) or offshore (-) a specified number of meters.

The field team consists of one recorder and four observers. At each sample locus the following data are collected:

- Substrate type (boulder, cobble, sand, or bench rock)
- Amount of relief [low (less than 30 cm); medium (30-70 cm); high (over 70 cm)]
- Predominant algae
- Total number of abalone.

A.6 INTERTIDAL STATION PHOTOGRAPHY

The intertidal station photography consists of taking color Kodachrome and infrared photographs of intertidal stations. The general area ("cliff top") photographs are taken at each fixed station within each of the seven major intertidal areas in the Diablo Canyon study site. All intertidal random point contact (RPC) quadrats are individually photographed.

The photographs from these surveys will be used to document changes in (1) overall area covered by algae within fixed quadrats during comparable seasonal periods, (2) the proportion of green, brown, and red algae, and (3) algal health (bleaching, etc.) condition.

A.7 SUBTIDAL ARC QUADRANT (SAQ)

Each permanent subtidal station at Diablo Canyon is circular, with an area of approximately 28 square meters. During sampling, each station is subdivided

into four equal pie-shaped sections or arc quadrants 7 m^2 in area (TABLE A-2, FIGURES A-1 and A-3). The purpose of the SAQ method is to determine he species composition and the population densities of the more conspicuous, representative, and countable subtidal biota. The number of individuals of each species present in each of the quadrants is recorded. The data from the four arc quadrants will be used to determine spatial variability within the station.

Taxa to be considered by the arc-quadrant method include (1) the larger motile (nonencrusting and nonhabitat forming) benthic invertebrates for which individual count data can be made, and (2) several species of the larger (canopy) algae for which point contact estimates of percentage cover (see RLPC method, Section A.9) are impractical. These algal taxa include Pterygophora californica, Laminaria dentigera, Cystoseira osmundacea, Nereocystis luetkeana, and Egregia menziesii. The invertebrate taxa include all individuals of those taxa printed on the data sheets (Form 7); for those taxa not printed on the data sheets, only individuals greater than 1 in. (2.5 cm) long are counted. Species that occur in abundances too high to efficiently record total numbers over the 7 m^2 arc quadrant (Acmaea mitra, Tonicella lineata, Calliostoma ligatum, Tegula brunnea, and Tegula montereyi) are sampled only in the first one-third of each arc (2.33 m^2).

A.8 SUBTIDAL FIXED QUADRAT (SFQ)

Fixed location quadrats are monitored at each subtidal station to determine the species composition and population densities of the smaller, more cryptic subtidal invertebrates, including "habitat-formers," not quantified by the arc-quadrant count (Section A.7) or the random line point contact methods (Section A.9). Four circular quadrats with an area of 0.25 m^2 are sampled at each station (see FIGURE A-3). Quadrat locations were selected on the basis of physical criteria including uniform hard substrate, with two quadrats at a given station lying nearly horizontally and two quadrats lying more nearly vertically, and on the biological criteria that locations be representative of the arc-quadrant's dominant microfaunal assemblages. There is no maximum size limit for the invertebrate taxa in these quadrats; minimum size limits are fixed by

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DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	SUBTIDAL ARC QUADRANT (SAQ)	SUBTIDAL FIXED QUADRAT (SFQ)	RANDOM LINE POINT CONTACT (RLPC)	SETTLING PLATES	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER	LIGHT RECORDER	WAVE RECORDER	TIDE RECORDER	CURRENT RECORDER
1	-10	641, 024.83 N 1, 141, 398.45 E	○	○	○	○	○					
1	-15	640, 977.21 N 1, 141, 290.05 E	○	○	○							
2	-10	640, 921.06 N 1, 141, 477.33 E	○	○	○	○	○					
2	-15	640, 862.46 N 1, 141, 241.92 E	○	○	○							
3	-10	640, 467.21 N 1, 141, 731.43 E	○	○	○	○	○					
3	-15	640, 368.17 N 1, 141, 506.05 E	○	○	○							
4	-32	635, 104.83 N 1, 145, 423.72 E	○	○	○							
5	-25	(approx.) 634,870 N 1,146,050 E	○	○	○							
6	-11	634, 781.25 N 1,145, 778.19 E	●	●	●	●						
7	-10	635, 246.87 N 1, 146.125.85 E	○	○	○	●	●		●			
7	-15	635, 144.93 N 1, 146, 256.48 E	○	○	○							
8	-10	635, 330.85 N 1, 146, 256.48 E	●	●	●	●	●					
8	-15	635, 237.99 N 1, 146, 200.17 E	○	○	○							
9	-10	635, 235.75 N 1, 146, 317.91 E	●	●	●	●	●				●	

TABLE A-2

SUBTIDAL, ENDECO, AND MISCELLANEOUS DATA COLLECTION
STATION LOCATIONS, STATUS, AND TYPES OF DATA COLLECTED

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	SUBTIDAL ARC QUADRANT (SAQ)	SUBTIDAL FIXED QUADRAT (SFQ)	RANDOM LINE POINT CONTACT (RLPC)	SETTLING PLATES	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER	LIGHT RECORDER	WAVE RECORDER	TIDE RECORDER	CURRENT RECORDER
9	-15	635, 182.55 N 1, 146, 216.87 E	●	●	●							
10	-10	634, 416.17 N 1, 146, 916.25 E	●	●	●	●	●					
10	-15	634, 436.02 N 1, 146, 810.42 E	●	●	●							
11	-10	634, 314.51 N 1, 146, 904.89 E	○	○	○	●	●		●			
11	-15	634, 362.19 N 1, 146, 819.88 E	○	○	○		●		●			
12	-10	634, 259.73 N 1, 146, 877.20 E	●	●	●	●	●					
12	-15	634, 333.87 N 1, 146, 788.58 E	●	●	●							
13	-32	634, 504.38 N 1, 146, 257.59 E	●	●	●		●			●		
14	-55	634, 262.07 N 1, 145, 818.10 E	○	○	○							
15	-50	633, 417.91 N 1, 146, 277.12 E	○	○	○							
17	-10	632, 885.36 N 1, 147, 483.57 E	○	○	○	○						
17	-20	632, 447.55 N 1, 147, 549.99 E	○	○	○							
19	-10	632, 733.35 N 1, 149, 000.98 E	●	●	●	●	●					
19	-15	632, 637.90 N 1, 148, 927.24 E	○	○	○							

TABLE A-2

SUBTIDAL, ENDECO, AND MISCELLANEOUS DATA COLLECTION STATION LOCATIONS, STATUS, AND TYPES OF DATA COLLECTED (CONTINUED)

DIABLO CANYON POWER PLANT
THERMAL EFFECTS MONITORING PROGRAM
SURVEY STATION
DATA MATRIX
DATE: 31 DEC 84

● = ACTIVE ○ = INACTIVE

STATION NUMBER	LEVEL FT (MLLW)	LOCATION	SUBTIDAL ARC QUADRANT (SAQ)	SUBTIDAL FIXED QUADRAT (SFQ)	RANDOM LINE POINT CONTACT (RLPC)	SETTLING PLATES	SEA DATA TEMPERATURE RECORDER	ENDECO TEMPERATURE RECORDER	LIGHT RECORDER	WAVE RECORDER	TIDE RECORDER	CURRENT RECORDER
20	-10	632, 741.83 N 1, 149, 049.99 E	○	○	○	○	○					
20	-20	632, 464.93 N 1, 149, 080.70 E	●	●	●							
21	-10	632, 553.18 N 1, 149, 179.27 E	○	○	○	○	○					
21	-20	632, 373.35 N 1, 149, 269.94 E	○	○	○							
25	-15	634, 681.51 N 1, 146, 613.17 E					●	● [1]				
ENDECO OS	-32	634, 534.43 N 1, 146, 362.81 E						● [1]				
ENDECO NE	-12	635, 215.00 N 1, 146, 280.00 E						● [1]				
ENDECO SE	-12	(approx) 634, 320.00 N 1, 146,870.00 E						● [1]				
ENDECO SC	-15	(approx) 632, 695.00 N 1, 149, 010.00 E						● [1]				
WAVE RECORDER	sfc	(approx) 632, 536.00 N 1, 146, 761.00 E								●		
32 INTAKE	-32	(approx) 633, 515.00 N 1, 147, 280.00 E					●				●	
99 SIMS	+103	(approx) 633, 100.00 1,148, 578.00 E							●			
99 OFFSHORE	-30	(approx) 633,421.00 N 1, 144, 645.00 E					○			○		●

[1] ENDECO DATA COLLECTED UP TO MAY 24, 1984

TABLE A-2

SUBTIDAL, ENDECO, AND MISCELLANEOUS DATA COLLECTION STATION LOCATIONS, STATUS, AND TYPES OF DATA COLLECTED (CONTINUED)

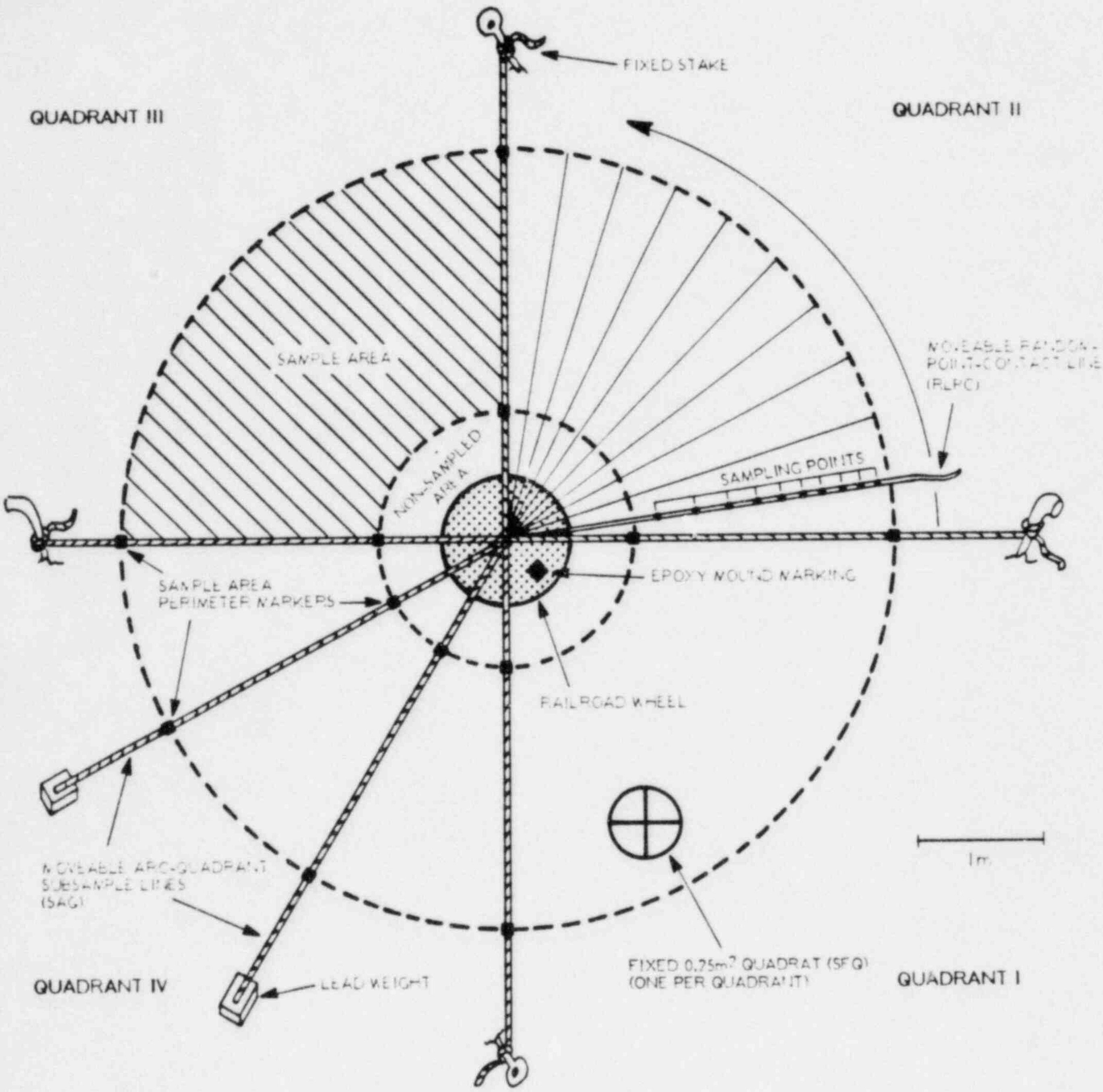


FIGURE A-3

DIAGRAM OF SUBTIDAL SAMPLING STATION

visual discernibility. Habitat-forming and encrusting forms are quantified by the number of square inches they cover; individuals of all other taxa are counted.

A.9 SUBTIDAL LINE CONTACT (SLC)

A subtidal line contact (SLC) method is used to document the percentage area covered by habitat-formers, i.e., all macroscopic occupants of substrate within the 28 m^2 subtidal stations. Although habitat-formers can be either encrusting invertebrates or algae, the predominant habitat-formers on the TEMP subtidal stations are algae, and this procedure was developed primarily to quantify algal abundances.

An equal number of points is sampled within each of the four arc quadrants so that four statistical replicates are obtained (see FIGURE A-3). A weighted line with one end attached to a pin on the railroad wheel at the center of each subtidal station is rotated to locate the sampling loci. The line has 10 points numbered 0 to 9; their position along the line is graded, with point density increasing toward the station perimeter to counteract the "center bias" introduced by the distribution of points on a radius within a circular area. Of 100 possible sampling loci created by positioning the weighted line at 10 equidistant locations across the arc quadrant, 50 points in each quadrant are randomly selected and their location is printed on the SLC data sheet (Form 10, Rev. C). A total of 200 points is sampled at each station. Sampling loci are changed for each bimonthly subtidal survey.

The data collected consist of recording the species lying immediately over or under the loci sampled, including the type of substrate.

A.10 SUBTIDAL CRAB TRAPPING AND TAGGING

A series of standard commercial "Igloo" crab traps are fished at subtidal stations (FIGURE A-4) to obtain data on the rock crab, Cancer antennarius. Weather permitting, the trap set program devised for each survey requires seven consecutive days. Each of the trap set locations is fished for a 24 ± 3 hour period.

E-85-04

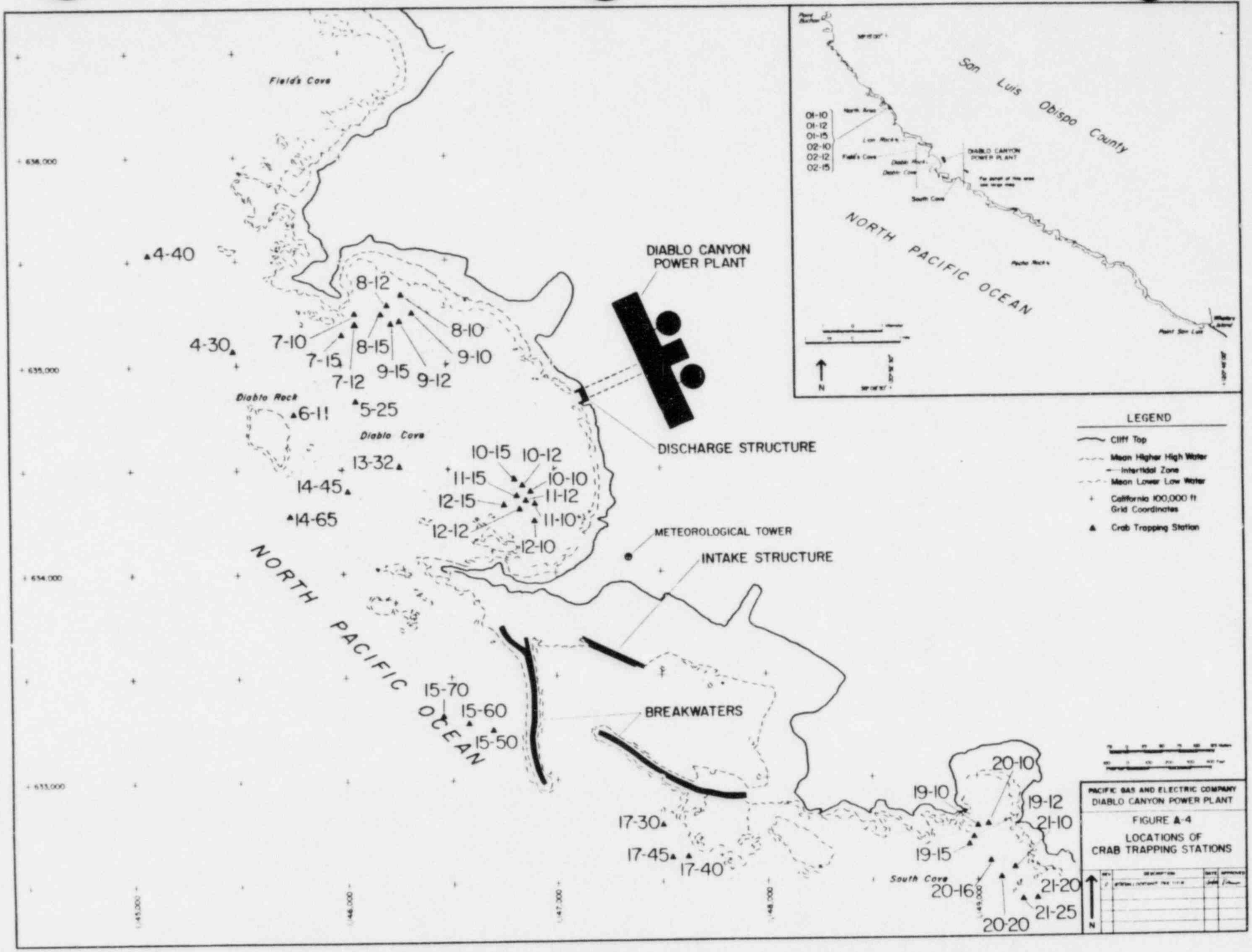


FIGURE A-4
LOCATIONS OF CRAB TRAPPING STATIONS

A-18

Upon retrieval of each trap, the following data are recorded: trap set location, carapace width measurement of individuals, determination of sex, and reproductive condition of females (berried versus non-berried), and molt or intermolt condition of crabs of both sexes. The specimens are tagged using a "Floy" anchor tag and are released in the immediate vicinity of capture. A "claw index" based on the presence or absence and/or size of the chelipeds is recorded for each individual.

Seasonal differences in growth, reproductive condition, migration, and population density are obtained for this species as a result of these detailed tagging and recapture methods.

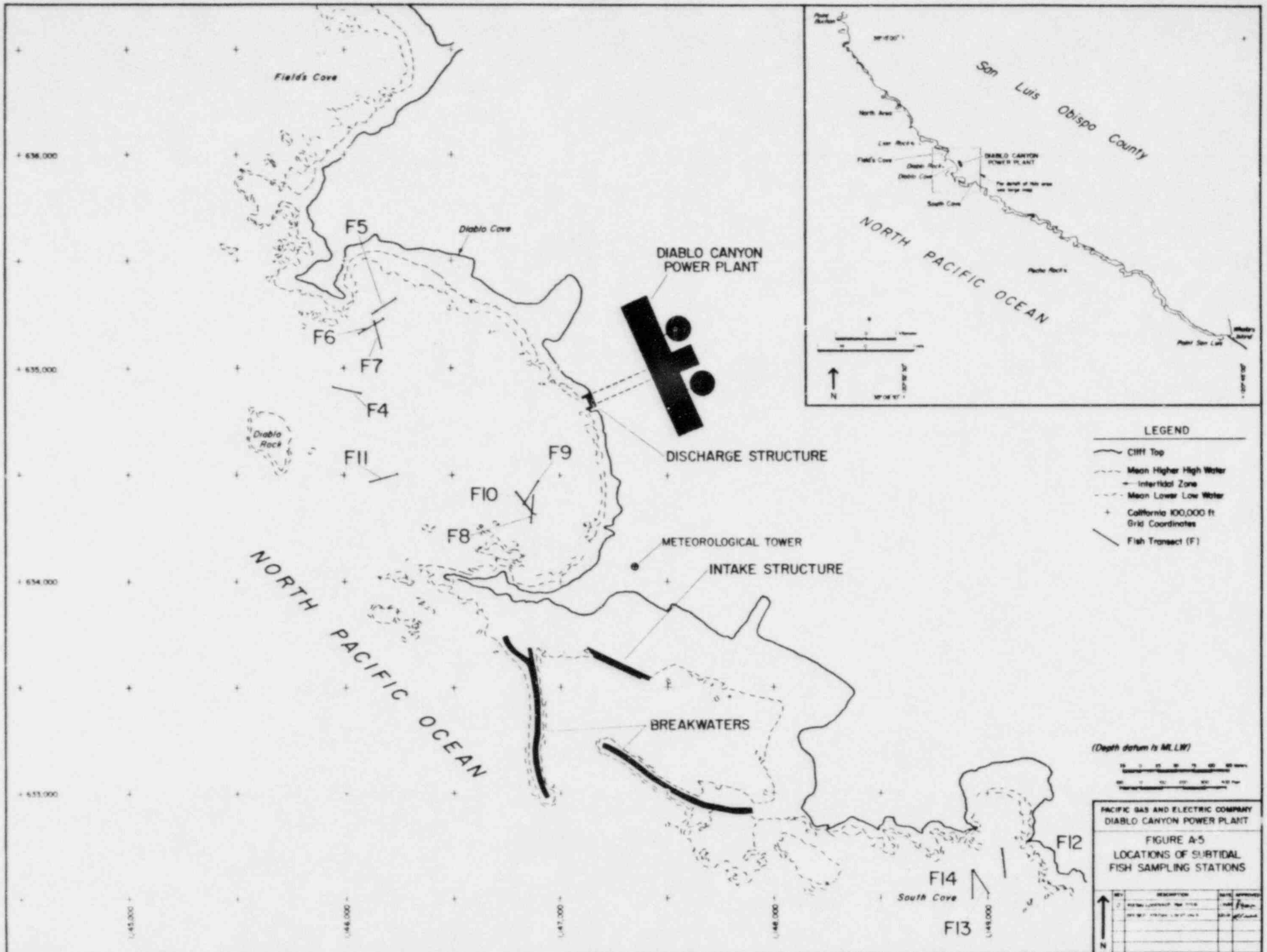
A.11 SUBTIDAL FISH OBSERVATIONS

Visual observations of fish at fixed subtidal transects provide documentation of the species composition and abundances of subtidal fish assemblages of the Diablo Cove area.

A single transect is located at each station, with the origin of the transect line positioned on the station monument and extending in a straight line for 50 m along a fixed compass course (the transect line is oriented from the surface and sunk to the bottom before divers enter the water). The currently active fish observation stations have transect origins ranging in depth from 10 to 32 ft. Each transect may be either horizontally oriented (extending generally along an isobath and parallel to the shore) or vertically oriented (extending generally across isobaths and perpendicular to the shore). Observations are made by benthic and midwater observers along transects (FIGURE A-5) during midday hours (0900-1500). A two-meter distance was judged to be the maximum for accurate fish observations. To avoid the necessity of normalizing the data taken by a "visual acuity size transect" method, transect observations are limited to fish sighted within 2 m on either side of the transect line, and a transect is sampled only when at least 2 m lateral visibility is present.

E-85-04

A-20



PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON POWER PLANT

FIGURE A-5
LOCATIONS OF SUBTIDAL FISH SAMPLING STATIONS

If time and conditions allow, sampling is repeated (replicated) once on each transect within each survey. Water temperature and lateral visibility are measured at each end point of a transect by both benthic and midwater observers.

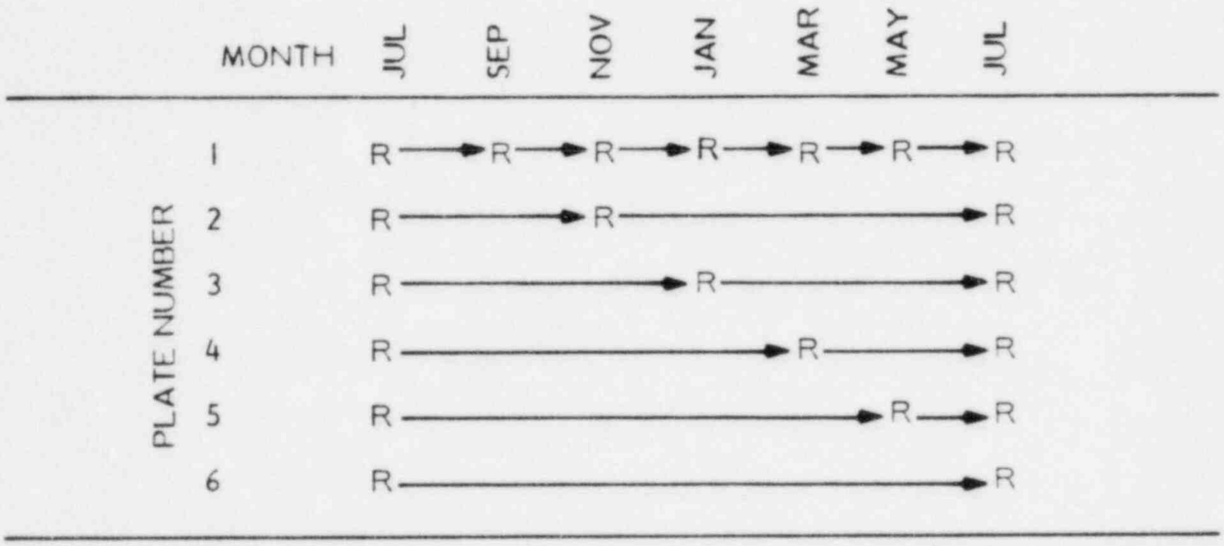
A.12 SUBTIDAL SETTLING PLATES

Subtidal settling plates installed at the shallow subtidal (-10 ft MLLW) stations provide information on the species composition, abundance, distribution, and biomass of fauna and flora that initiate biological processes and participate in community development on newly exposed substrates.

At each of the six station wheels, six vertically-oriented asbestos plates (25.3 x 25.3 x 0.7 cm) are attached parallel to each other in a stainless steel rack. All plates are presoaked in freshwater for 30 days to leach out toxic substances. Each rack is oriented so that its plates are positioned perpendicular to the incoming wave fronts. Two nylon electrical ties attached to one end of the rack identify the left end of the rack facing onshore. Side A of each plate faces left (toward the ties), while side B faces right. The plates are numbered 1 through 6 from left to right, and plates are sequentially replaced every two months.

In July of each year, all plates are removed and new plates are installed (see FIGURE A-6). Every two months, certain plates are removed from the rack, ensuring the identification of sides A and B, and are placed in individual buckets and transported to the laboratory for analysis. A new plate is installed whenever a plate is removed.

In the laboratory, each side of the plate is photographed using Kodachrome color transparency film. A list is made of all taxa found on the plate edge and the outermost 2.6 cm of the plate surface. Any alga over 2.6 cm in length that could possibly affect settlement by sweeping spores and larvae off the plate is categorized as a "sweeper." The length of the longest individual of each sweeper species is measured and recorded. Edges and margins are then scraped clean of remaining material and another photograph is taken of each side of every plate.



Each month shown at the top represents a survey during which one, two, or six plates are removed from each rack and new plates are installed in their place (R).

FIGURE A-6

SEQUENCE OF SETTLING PLATE INSTALLATION AND REPLACEMENT

E-85-04

From Survey 46 onward, the material scraped from the edges and margins will be placed in a labeled plastic bag and then frozen.

Using a seawater-filled chamber with a fixed grid system, an investigator precisely locates random sampling points on the settling plate face. The plate face is designated as that part of the plate located inside of the scraped margin area.

Because of the vertical orientation of the plates in the rack, it seemed likely that differential settlement of algae and invertebrates would occur on the plates due to the varying light levels striking the plate surface. To minimize sampling error, the plate face is divided into three equal portions ("band levels;" see Figure 3.4-3 in PGandE 1980). Sampling intensity was identical in each level.

To determine the abundance of taxa found on the plate face, two methods are used: (1) random point contact (RPC) for the macroscopic habitat formers, and (2) random 9 cm^2 quadrats for the microscopic habitat-formers (individuals less than 2 mm in size). For each band level, 100 RPC points and five quadrats are sampled, determined by randomly selected x and y coordinates. For the RPC method, a vertical line is passed through each coordinate and all "contacts" are recorded. The quadrat method provides a visual estimate of the percentage cover of all individuals less than 2 mm in size. Frequency was recorded as being in one of the following categories: 1 (+ to 1%), 2 (1+ to 5%), 3 (5+ to 20%), 4 (20+ to 50%), 5 (50+ to 75%), or 6 (75+ to 100%). The above procedures are used for the plate faces on both side A and side B.

Upon completion of the above sampling procedures, the plate is removed from the counting chambers and patted dry, and each band level is scraped clean, with the residue weighed to determine wet weight biomass. Dry weight biomass is then determined after oven drying at 100 C (212 F) for 24 hours. Starting with Survey 46, the plate is frozen before the band levels are scraped clean. Accordingly, the wet and dry weight biomasses are not determined.

A.13 SUBTIDAL RED ABALONE SURVEY

The objective of this method is to determine the distribution, abundance, and approximate size structure of the subtidal red abalone, Haliotis rufescens, population in Diablo Cove using a stratified random sampling procedure. A bathymetric chart of Diablo Cove is divided by a grid into equal-sized areas 50 feet square (see FIGURE A-7) and consecutively numbered. Numbered grids, or sampling loci, are selected randomly until the following criteria are met: 1) 24 to 30 sites are chosen; 2) approximately 70 percent of the sites are at a depth of -20 feet MLLW or less; and 3) sites are approximately evenly divided between north and south Diablo Cove. At each of these loci a circular 30 m^2 area is sampled using a method similar to the SAQ method (see Section A.7) by divers using underwater flashlights. The data collected are the number of red abalone in each of three size groups located within the 30 m^2 station. Small abalone are less than 2 inches in length, medium abalone are from 2 inches up to legal size (7 inches), and large abalone are legal size and longer.

A.14 SUBTIDAL VIDEO TRANSECTS

Color videotape recordings are made along subtidal transects in Diablo Cove to document the distribution and relative abundance of dominant algal species and substrate types. Transect lines 100 m in length are deployed from a boat at predetermined depths and locations and marked with surface buoys at each transect origin and terminus. The positions of the transects are then accurately mapped by a shoreside surveying team (FIGURE A-8). It is necessary to have good underwater visibility (minimum 8 m horizontal) and a calm sea state in order to produce acceptable videotapes of the transects. The project director will determine whether conditions are adequate to initiate the videotaping.

The photographer and an assistant descend from the support vessel to the transect origin with SCUBA diving gear and begin taping with a self-contained color videotape unit. The photographer first records a data board listing the appropriate transect designation and then proceeds with the taping by swimming approximately 1 m above the substrate or algal canopy and aiming the videotape

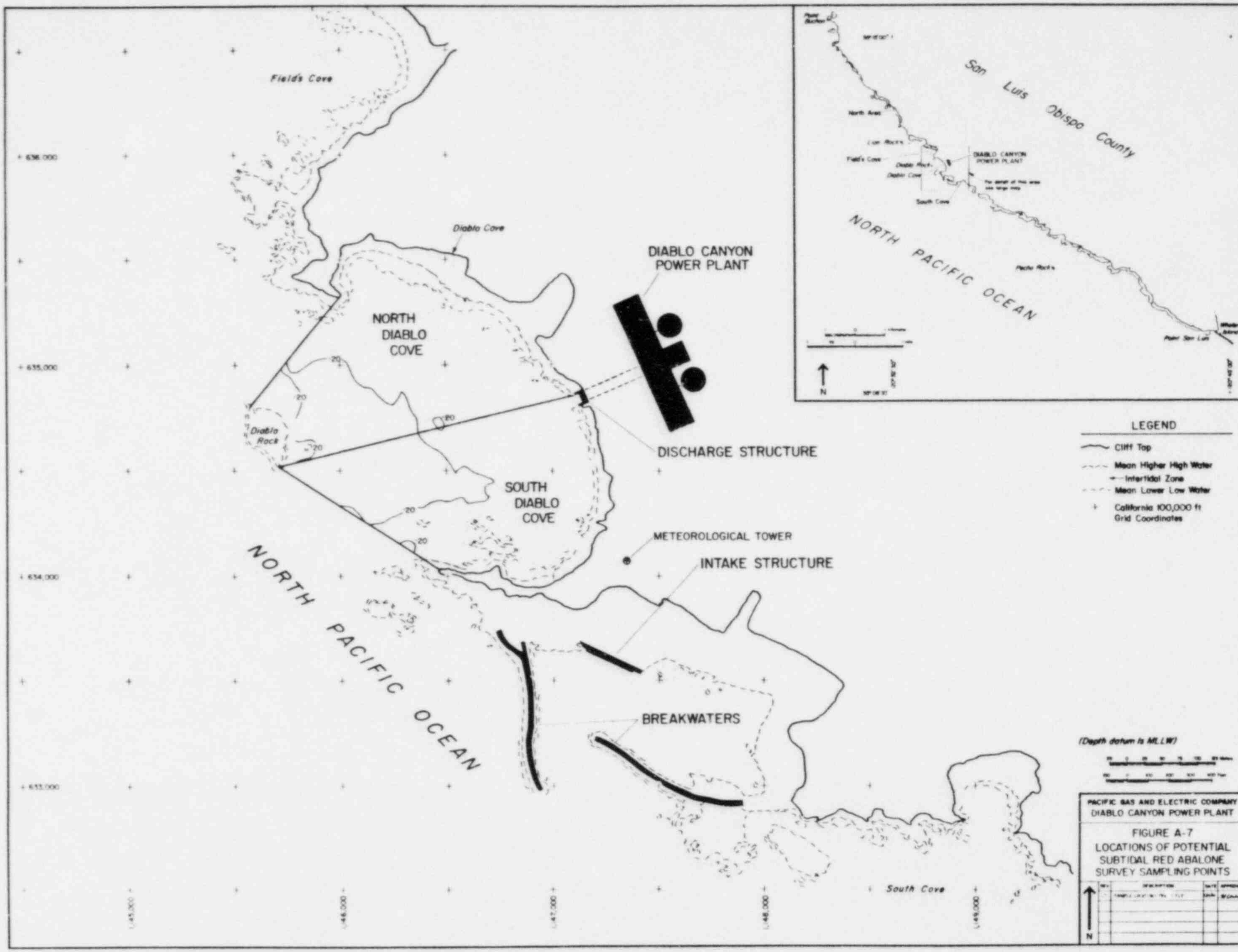


FIGURE A-7
LOCATIONS OF POTENTIAL
SUBTIDAL RED ABALONE
SURVEY SAMPLING POINTS

E-85-04

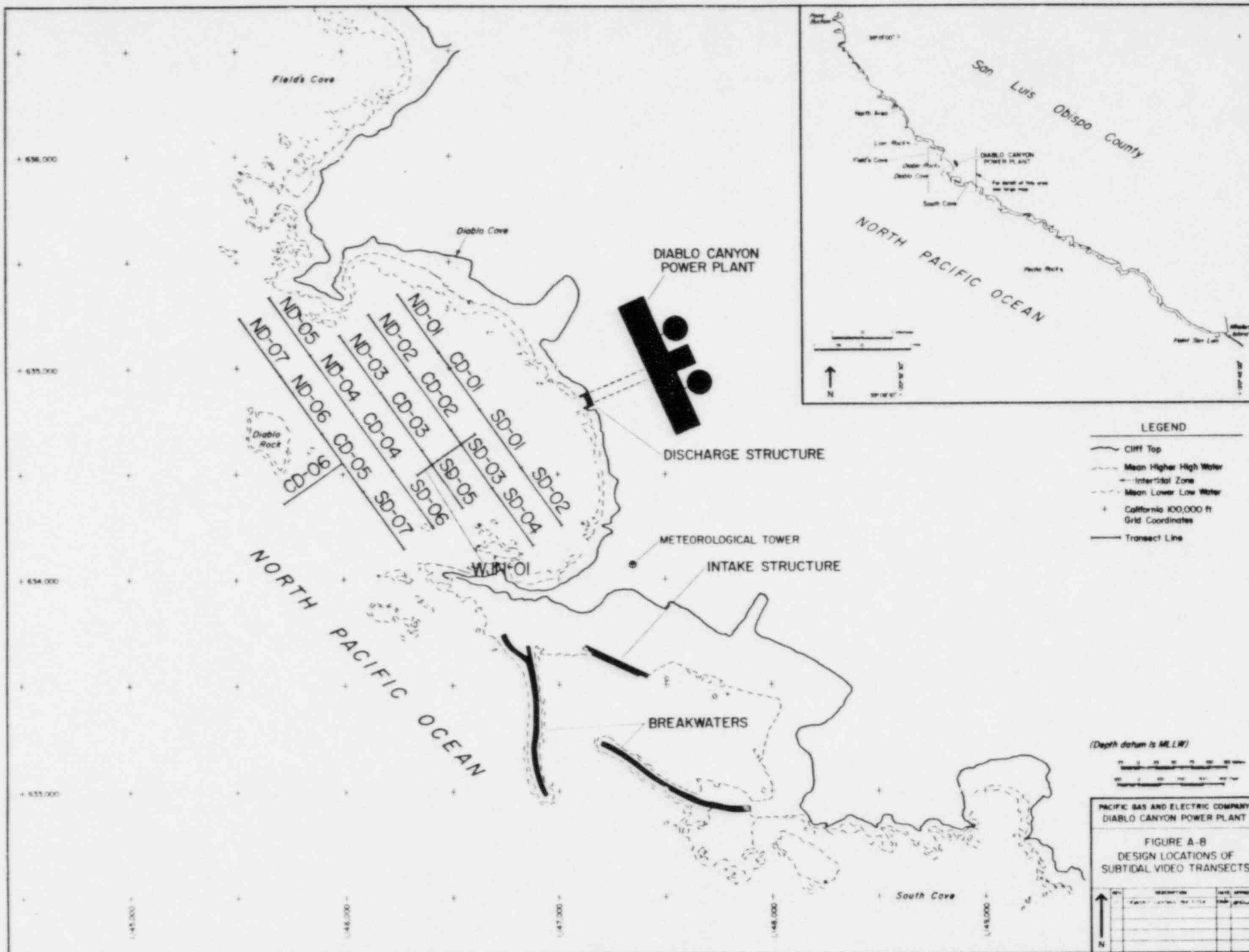


FIGURE A-8
DESIGN LOCATIONS OF
SUBTIDAL VIDEO TRANSECTS

unit along the transect line. At a moderate and continuous swimming speed, one transect can be completed in approximately 10 minutes. The tape cassette length allows two such transects to be completed before the photographic team must return to the support vessel to service the videotape unit. Two days are required for the two photographers and three support personnel to complete the 22 transects in Diablo Cove. When all transects are completed, the master tapes are duplicated and compiled onto a VHS-format tape. Other copies are also made and archived as a permanent data record of the subtidal transects.

A.15 BULL KELP POPULATION ESTIMATES

A census of the total number of bull kelp, Nereocystis luetkeana, individuals within Diablo Cove is conducted annually in October. Counts are obtained from permanently marked cliff-top vantage points in the north and south portions of Diablo Cove. Two investigators, stationed in north Diablo Cove, separately count, then average their totals of all bull kelp surface floats (pneumatocysts) visible in the Diablo Cove sample area (FIGURE A-1). Two other investigators stationed at the south side of Diablo Cove also count and average their Diablo Cove bull kelp float totals. The two team averages are averaged together for a final estimate of the number of bull kelp plants reaching the sea surface within Diablo Cove. Binoculars with a 7x magnification are used to aid in distinguishing individual plants. Spotting scopes with a greater magnification were also used during some surveys previous to 1983.

In addition to counting, each team develops a map based on general agreement among the observers showing the areas in which bull kelp plants occur in Diablo Cove.

Although smaller subsurface plants are not counted by this method, the fall timing of each census is coincident with the peak in surface-occurring floats just before they are removed by winter storms. From 1970 to 1982 this study was conducted by the California State Department of Fish and Game. Starting in 1983 this study has been continued by TEMP personnel. The position of the north

and south Diablo Cove bull kelp cliff-top counting stations and the boundary lines delineating the Diablo Cove sample area are shown in FIGURE A-1.

A.16 IN SITU TEMPERATURE MEASUREMENT

Temperature recording instruments are placed at the + 2 ft MLLW level on the intertidal stations (FIGURE A-9 and TABLE A-1; see also Map B in pocket). Identical instruments are also placed at the -10 ft (MLLW) subtidal stations (FIGURE A-9 and TABLE A-2; see also Map B in pocket.) The data obtained supplement the biological data obtained at intertidal and subtidal stations.

Subtidal and intertidal temperatures are measured in situ at 20-minute intervals and recorded on magnetic tape using Sea Data TR-2 temperature instruments. Temperature data are also recorded by the light and wave/tide measuring instruments (see Sections A.17 and A.18, respectively). Temperature resolution is 0.01 C, with an accuracy of 0.1 C. Instruments are exchanged at approximately 45-day intervals with serviced and calibrated units. Tape records are processed and data are transferred onto computer media for analysis and storage.

A.17 IN SITU LIGHT MEASUREMENT

Light recording instruments are placed at subtidal stations 7-10, 11-10, and 11-15 (FIGURE A-9 and TABLE A-2; see also Map B in pocket). A land-based Solar Irradiance Monitoring System (SIMS) is maintained on the clifftop approximately 1,650 ft southeast of the meteorological tower.

Quantum sensors (LI-COR Model LI-192S, underwater, and Model LI-190S, air) measure PAR (integrated light intensity from 400-700 nm) in units of microeinsteins/m^2/sec, 1 microeinstein being equivalent to 6.02 x 10^{17} photons. At the subtidal stations, measurements integrated over a A-minute period are stored on magnetic tape at 20-minute intervals using Sea Data Model TLR-1 instruments. Temperature data are also recorded at 20-minute intervals. At the terrestrial station, both integrated and instantaneous measurements are recorded

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A-29

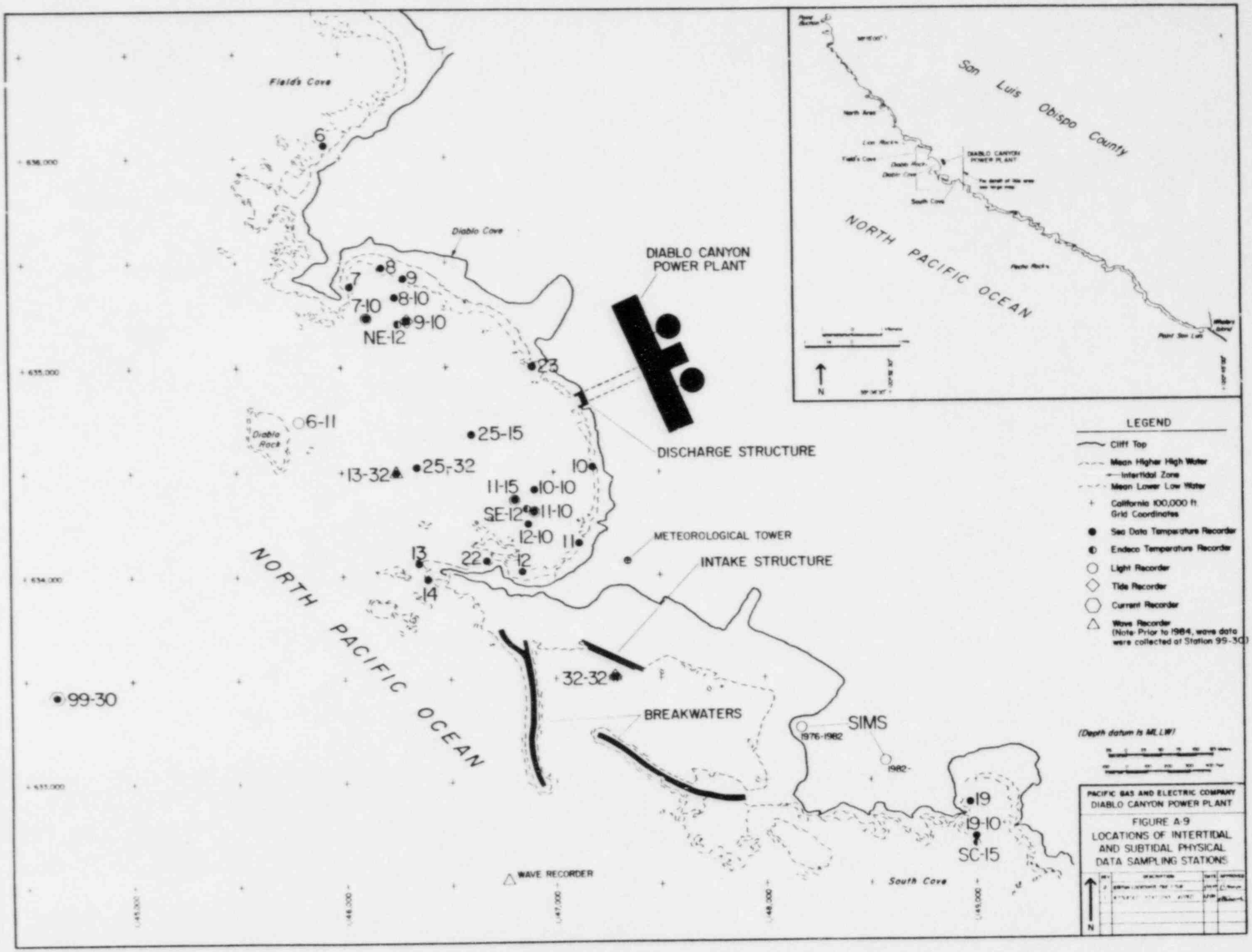

FIGURE A-9
LOCATIONS OF INTERTIDAL AND SUBTIDAL PHYSICAL DATA SAMPLING STATIONS

at 5-minute intervals. Values integrated over a period of time reduce variations in measurement that result from rapidly changing light conditions. A pyranometer sensor (LI-COR Model LI200SB) measures solar energy (Watts/m^2) at the terrestrial location in addition to the PAR measurements. The pyranometer sensor's spectral response does not cover the full range of the solar spectrum (280-2400 nm), but the error introduced is less than $\pm$ 5 percent under most conditions (LI-COR 1981). Both integrated and instantaneous readings of solar energy are recorded at the same interval used in PAR measurement. Instruments at the subtidal locations are exchanged at approximately 45-day intervals with serviced and calibrated units. The permanent terrestrial location has a service interval of approximately two weeks. Tape records are then processed and the data are transferred onto computer media for analysis and storage.

A.18 IN SITU WAVE/TIDE MEASUREMENT

Pressure sensing instruments are employed to record surface wave characteristics and sea level changes resulting primarily from tides. Wave data are recorded with a Sea Data Model TWR instrument located at the bottom of Diablo Cove at station 13-32, approximately 200 ft southeast of Diablo Rock (FIGURE A-9 and TABLE A-2; see also Map B in pocket). Prior to 1984, wave data was recorded offshore at Station 99-30. The instrument records the percent of scale value (approximately 0 - 30 lbs/in.^{2}). Every six hours, the instantaneous value is recorded every 2.5 seconds until 127 readings have been made (at the 128th reading, temperature is recorded). Tide data are recorded with a Sea Data Model TDR-1 instrument located at the bottom at stations 9-10 (in Diablo Cove) and 3A-32 (near the power plant intake structure) (FIGURE A-9 and TABLE A-2; see also Map B in pocket). The instrument records the percent of scale value (approximately 0 - 30 lbs/in.^{2}). Every 20 minutes, readings are integrated over a 2-minute period. The integrated measurements reduce variation caused by transient surface level changes. Temperature data are also recorded at 20-minute intervals. Both types of instruments are exchanged at approximately 45-day intervals with serviced and calibrated units. Tape records are then processed, and the data are converted to psi values and transferred onto computer media for analysis and storage.

APPENDIX B
MASTER SPECIES CODE LISTINGS

CHLOROPHYTA
PRASINOCLADALES
CHLORODENDRACEAE
PRASIOLALES
PRASIOLACEAE
ULOTRICHALES
ULOTRICHACEAE
CHAETOPHORACEAE
MONOSTROMATACEAE
ULVACEAE
ENTEROMORPHA LINZA
ENTEROMORPHA SPP.
GREEN BLADES (JUV.)
ULVA SPP.
ULVA SPP./ENTEROMORPHA SPP.
CLADOPHORALES
CLADOPHORACEAE
CHAETOMORPHA SPP.
CLADOPHORA GRAMINEA
CLADOPHORA SPP.
CLADOPHORA SPP. + EPIPHYTIC DIATOMS
CLADOPHORALES
SPONGOMORPHA SPP.
SPONGOMORPHA SPP. / CLADOPHORA SPP.
SIPHONOCLADALES
SIPHONOCLADACEAE
CODIALES
CODIACEAE
CODIUM FRAGILE
CODIUM SETCHELLII (PROSTRATE)
BRYOPSIDACEAE
BRYOPSIS CORTICULANS
BRYOPSIS HYPNOIDES
BRYOPSIS SPP.
DERBESIACEAE
HALICYSTIS OVALIS (=DERBESIA MARINA)
MISCELLANEOUS
CHLOROPHYTE UNID. A
CHLOROPHYTE UNID. B
CHLOROPHYTE UNID. C
G.A.T.G.O.R.E.
GREEN FILAMENT UNID.

PHAEOPHYTA
ECTOCARPALES
ECTOCARPACEAE
ECTOCARPALES
ECTOCARPUS SPP.
GIFFORDIA GRANULOSA
DESMARESTIALES
DESMARESTIACEAE
DESMARESTIA LIGULATA VAR. FIRMA
DESMARESTIA LIGULATA VAR. LIGULATA

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     SCTYOSIPHONALES
        SCTYOSIPHONACEAE
              COLPOMENIA PEREGRINA
              COLPOMENIA SPP.
              COLPOMENIA SPP./LEATHESIA SPP./SORANTHERA SPP
              SCYTOSIPHON DOTYI
              SCYTOSIPHON LOMENTARIA
              SCYTOSIPHON SPP.
              SCYTOSPIHON DOTYI
     CHORDARIALES
        CHORDARIACEAE
              ANALIPUS JAPONICUS
              ANALIPUS JAPONICUS HOLDFAST
              HAPLOGLOIA ANDERSONII
            MYRIONEMATACEAE
        ELACHISTACEAE
           CORYNOPHLAEACEAE
              CYLINDROCARPUS RUGOSUS
              LEATHESIA NANA
        RALFSIACEAE
              RALFSIA SPP.
     DICTYOSIPHONALES
            STRIARIACEAE
        DICTYSIPHONACEAE
              COILODESME CALIFORNICA
              PHAEOSTROPHION IRREGULARE
           PUNCTARIACEAE
              HALORHIPIS WINSTONII
              SORANTHERA ULVOIDEA
     DICTYOTALES
         DICTYOTACEAE
              DICTYOTA BINGHAMIAE
              DICTYOTA SPP.
     FUCALES
        FUCACEAE
              FUCACEAE UNID.
              FUCUS DISTICHUS
              HESPEROPHYCUS HARVEYANUS
              PELVETIA FASTIGIATA
              PELVETIA FASTIGIATA HOLDFAST
              PELVETIA SPP. / PELVETIOPSIS SPP.
              PELVETIOPSIS LIMITATA
              PELVETIOPSIS SPP.
           SARGASSACEAE
        CYSTOSEIRACEAE
              CYSTOSEIRA OSMUNDACEA
              CYSTOSEIRA OSMUNDACEA (BASAL BLADES)
              CYSTOSEIRA OSMUNDACEA (TOTAL)
              CYSTOSEIRA OSMUNDACEA (UPPER BLADES)
     LAMINARIALES
        LAMINARIACEAE
              LAMINARIA DENTIGERA
              LAMINARIA DENTIGERA (TOTAL)
              LAMINARIA DENTIGERA BARE STIPE
```

LAMINARIA SPP. (JUV.)
LAMINARIA SPP. HOLDFAST
LAMINARIALES
LAMINARIALES BARE STIPE
LAMINARIAN HOLDFAST
LESSONIACEAE
DICTYONEURUM CALIFORNICUM
MACROCYSTIS SPP.
NEREOCYSTIS LUETKEANA
NEREOCYSTIS LUETKEANA BARE STIPE
NEREOCYSTIS LUETKEANA HOLDFAST
ALARIACEAE
ALARIA MARGINATA
ALARIA MARGINATA HOLDFAST
EGREGIA MENZIESII
EGREGIA MENZIESII HOLDFAST
PTERYGOPHORA CALIFORNICA
PTERYGOPHORA CALIFORNICA (TOTAL)
PTERYGOPHORA CALIFORNICA BARE STIPE
PTERYGOPHORA CALIFORNICA HOLDFAST
MISCELLANEOUS
BROWN FILAMENT ERECT
PHAEOPHYTA (JUV.)
PHAEOPHYTA UNID.

RHODOPHYTA
GONIOTRICHALES
GONIOTRICHACEAE
BANGIALES
ERYTHROPELTIDACEAE
ERYTHROTRICHIA SPP.
SMITHORA NAIADUM
BANGIACEAE
PORPHYRA OCCIDENTALIS
PORPHYRA SPP.
NEMALIONALES
ACROCHAETIACEAE
ACROCHAETIUM SPP.
BONNEMAISONIACEAE
GELIDIACEAE
GELIDIUM COULTERI
GELIDIUM COULTERI (JUV.) / G. PUSILLUM (JUV.)
GELIDIUM COULTERI + CORALLINA SPP.
GELIDIUM COULTERI + CORALLINA SPP. (WHITE)
GELIDIUM COULTERI + ULVA SPP.
GELIDIUM COULTERI / G. PUSILLUM + DIATOMS
GELIDIUM PURPURASCENS
GELIDIUM PUSILLUM
GELIDIUM PUSILLUM/CORALLINA SPP. (SMALL, TURF
GELIDIUM PUSILLUM/PTEROCLADIA CALOGLOSSOIDES
GELIDIUM ROBUSTUM
GELIDIUM SPP.
PTEROCLADIA CALOGLOSSOIDES

PTEROCLADIA MEDIA
NEMALIACEAE
NEMALION HELMINTHOIDES
CHAETANGIACEAE
PSEUDOGLOIOPHLOEA CONFUSA
HELMINTHOCLADIACEAE
CUMAGLOIA ANDERSONII
CERAMIALES
CERAMIACEAE
ANTITHAMNION DEFECTUM
ANTITHAMNION DENDROIDEUM
ANTITHAMNION SPP.
ANTITHAMNIONELLA PACIFICA
CALLITHAMNION ACUTUM
CALLITHAMNION PIKEANUM
CALLITHAMNION RUPICOLUM
CALLITHAMNION RUPICOLUM / C. PIKEANUM
CALLITHAMNION SPP. / PLEONOSPORIUM SPP.
CENTROCERAS CLAVULATUM
CERAMIUM EATONIANUM
CERAMIUM SPP.
GRIFFITHSIA PACIFICA
MICROCLADIA BOREALIS
MICROCLADIA CALIFORNICA
MICROCLADIA COULTERI
MICROCLADIA SPP.
NEOPTILOTA DENSA
NEOPTILOTA HYPNOIDES
NEOPTILOTA SPP.
PLATYTHAMNION HETEROMORPHUM
PLATYTHAMNION PECTINATUM
PLATYTHAMNION SPP.
PLATYTHAMNION VILLOSUM
PLEONOSPORIUM SPP.
PLEONOSPORIUM SQUARRULOSUM
TIFFANIELLA SNYDERIAE
TIFFANIELLA SNYDERIAE + SHELL DEBRIS
DELESSERIACEAE
ASTEROCOLAX GARDNERI
BOTRYO. FAR./HYMENENA SPP./POLY. LATT.
BOTRYOGLOSSUM FARLOWIANUM
BRANCHIOGLOSSUM UNDULATUM
CRYPTOPLEURA CORALLINARA
CRYPTOPLEURA LOBULIFERA
CRYPTOPLEURA SPP.
CRYPTOPLEURA VIOLACEA
DELESSERIA DECIPIENS
DELESSERIACEAE (JUV.)
HYMENENA FLABELLIGERA
HYMENENA MULTILOBA
HYMENENA SPP.
HYMENENA SPP. / BOTRYOGLOSSUM SPP.
HYMENENA SPP. / CRYPTOPLEURA SPP.
HYMENENA SPP. ON CORALLINES

MEMBRANOPTERA MULTIRAMOSA
MEMBRANOPTERA SPP.
MEMBRANOPTERA WEEKSIAE
NIENBURGIA ANDERSONIANA
NITOPHYLLUM NORTHII
PHYCODRYS ISABELLIAE
PHYCODRYS SETCHELLII
PHYCODRYS SPP.
POLYNEURA LATISSIMA

DASYACEAE
RHODOPTILUM PLUMOSUM

RHODOMELACEAE
AMPLISIPHONIA PACIFICA
CHONDRIA DECIPIENS
HERPOSIPHONIA PLUMULA
HERPOSIPHONIA VERTICILLATA
JANCZEWSKIA GARDNERI
LAURENCIA BLINKSII
LAURENCIA SPECTABILIS
LAURENCIA SPP.
ODONTHALIA FLOCCOSA
POLYSIPHONIA HENDRYI
POLYSIPHONIA PACIFICA
POLYSIPHONIA PANICULATA
POLYSIPHONIA SPP.
POLYSIPHONIA SPP. ON C.B.S.
PTEROCHONDRIA WOODII (VAR. WOODII)
PTEROSIPHONIA BAILEYI
PTEROSIPHONIA BIPINNATA
PTEROSIPHONIA DENDROIDEA
PTEROSIPHONIA SPP.
RHODOMELA LARIX

RHODYMENIALES

RHODYMENIACEAE
BOTRYOCLADIA PSEUDODICHOTOMA
FAUCHEA LACINIATA
FAUCHEA SPP.
FRYEELLA GARDNERI
HALOSACCION GLANDIFORME
MARIPELTA ROTATA
RHODYMENIA CALIFORNICA
RHODYMENIA PACIFICA
RHODYMENIA SPP.

CHAMPIACEAE
GASTROCLONIUM COULTERI

CRYPTONEMIALES

ENDOCLADIACEAE
ENDOCLADIA MURICATA

GLOIOSIPHONIACEAE
SCHIMMELMANNIA PLUMOSA

DUMONTIACEAE
CRYPTOSIPHONIA WOODII
DILSEA CALIFORNICA
FARLOWIA COMPRESSA

FARLOWIA MOLLIS
FARLOWIA SPP.
PIKEA CALIFORNICA
PIKEA ROBUSTA
PIKEA SPP.
WEEKSIACEAE
WEEKSIA RETICULATA
WEEKSIA SPP.
CORALLINACEAE
BOSSIELLA CALIFORNICA SSP. SCHMITTII
BOSSIELLA PLUMOSA
BOSSIELLA PLUMOSA (WHITE)
BOSSIELLA SPP.
BOSSIELLA SPP. (WHITE)
C.B.S. + GIGARTINA CANALICULATA
C.B.S. + HYMENENA SPP. / CRYPTOPLEURA SPP.
C.B.S. + RED BLADE (JUV.)
CALLIAR. SPP./BOSS. SPP./SERRAT. SPP.
CALLIAR. SPP./BOSS. SPP./SERRAT. SPP. (WHITE)
CALLIARTHRON SPP.
CALLIARTHRON SPP. (WHITE)
CALLIARTHRON TUBERCULOSUM
CLATHROMORPHUM PARCUM
COR. VAN./CERAMIUM EAT./CALLITHAMNION RUP.
CORAL. VAN./CRYPTO. SPP. OR HYMENENA SPP.
CORAL. VAN./GELIDIUM SPP./ENDOCLADIA MURICATA
CORALLINA OFFICINALIS
CORALLINA OFFICINALIS (WHITE)
CORALLINA SPP.
CORALLINA SPP. (WHITE)
CORALLINA SPP. (WHITE) / C.B.S.
CORALLINA SPP. + C.B.S.
CORALLINA SPP. + CRYPTOPLEURA VIOLACEA
CORALLINA VAN. + C. OFFICINALIS
CORALLINA VAN. + C.B.S. + GELIDIUM SPP.
CORALLINA VAN. + GELIDIUM SPP.
CORALLINA VAN./EPIPHYTES/TUBE WORMS/SAND
CORALLINA VANCOUVERIENSIS
CORALLINA VANCOUVERIENSIS (WHITE)
CORALLINE CRUST
CORALLINE CRUST (WHITE)
ERECT CORALLINE (WHITE)
LITHOPHYLLUM SPP.
LITHOTHAMNION PACIFICUM
MELOBESIA MEDIOCRIS
PSEUDOLITHOPHYLLUM NEOFARLOWII
PEYSSONELLIACEAE
HILDENBRANDIACEAE
HILDENBRANDIA SPP.
CHOREOCOLACACEAE
KALLYMENIACEAE
CALLOPHYLLIS CRENULATA
CALLOPHYLLIS FIRMA
CALLOPHYLLIS FLABELLULATA

CALLOPHYLLIS PINNATA
CALLOPHYLLIS SPP.
CALLOPHYLLIS VIOLACEA
ERYTHROPHYLLUM DELESSERIOIDES
RHODYMENIA CALLOPHYLLIDOIDES
CRYPTONEMIACEAE
GRATELOUPIA DORYPHORA
GRATELOUPIA SPP.
HALYM. SPP./SCHIZY. SPP./CRYPTONEM. SPP
HALYMENIA COCCINEA
HALYMENIA SCHIZYMENIOIDES
HALYMENIA SPP.
PRIONITIS AUSTRALIS
PRIONITIS LANCEOLATA
PRIONITIS LANCEOLATA / P. LYALLII
PRIONITIS LYALLII
PRIONITIS SPP.
GIGARTINALES
PETROCELIDACEAE
PETROCELIS FRANCISCANA
PHYLLOPHORACEAE
AHNFELTIA PLICATA
GYMNOGONGRUS LEPTOPHYLLUS
GYMNOGONGRUS LINEARIS
GYMNOGONGRUS PLATYPHYLLUS
BLINKSIACEAE
CRUORIACEAE
SOLIERIACEAE
NEOAGARDHIELLA GAUDICHAUDII
OPUNTIELLA CALIFORNICA
GIGARTINACEAE
GIGARTINA AGARDHII
GIGARTINA CANALICULATA
GIGARTINA CANALICULATA/CORALLINA SPP. (WHITE)
GIGARTINA CORYMBIFERA
GIGARTINA CORYMBIFERA / G. EXASPERATA
GIGARTINA EXASPE./G. HARVEYANA/G. CORY.
GIGARTINA EXASPERATA
GIGARTINA HARVEYANA
GIGARTINA LEPTORHYNCHOS
GIGARTINA PAPILLATA
GIGARTINA SPINOSA
GIGARTINA SPP.
GIGARTINA VOLANS
IRIDAEA CORDATA (HOLDFAST)
IRIDAEA CORDATA VAR. CORDATA
IRIDAEA CORDATA VAR. SPLENDENS
IRIDAEA CORDATA VAR. UNKNOWN
IRIDAEA FLACCIDA
IRIDAEA FLACCIDA (HOLDFAST)
IRIDAEA HETEROCARPA
IRIDAEA LINEARE
IRIDAEA SPP.
RHODOGLOSSUM AFFINE

RHODOGLOSSUM CALIFORNICUM
RHODOGLOSSUM ROSEUM
RHODOGLOSSUM SPP.
NEMASTOMATACEAE
SCHIZYMENIA EPIPHYTICA
SCHIZYMENIA PACIFICA
SCHIZYMENIA SPP.
GRACILARIACEAE
GRACILARIA SJOESTEDTII
PLOCAMIACEAE
PLOCAMIUM CARTILAGINEUM
PLOCAMIUM SPP.
PLOCAMIUM VIOLACEUM
HYPNEACEAE
PHYLLOPHORACEAE
MISCELLANEOUS
R.A.T.G.O.R.E. / B.A.T.G.O.R.E. (RPC'S)
RED ALGA (DEAD)
RED ALGAL TURF (SUBTIDAL)
RED ALGAL TURF 01 (STRAIGHT FILAMENTS)
RED ALGAL TURF 02 (FEATHER-LIKE)
RED ALGAL TURF 03 (FILAMENTOUS EPIPHYTE)
RED BLADES (JUV.) (J. R. B.)
RED FILAMENTS (PROSTRATE)
RHODOPHYTA UNID.

MINOR DIVISIONS
CHRYSOPHYTA
"DIATOM FILM"
CHRYSOPHYTE UNID. A
CHRYSOPHYTE UNID. B
DIATOM CHAINS, UNID. ERECT
LICMOPHORA SPP.
SPERMATOPHYTA
PHYLLOSPADIX SCOULERI (INCLUDING RHIZOME)
PHYLLOSPADIX SCOULERI + SMITHORA NAIADUM
PHYLLOSPADIX SPP.
PHYLLOSPADIX SPP. (HOLDFAST)
ZOSTERA MARINA
CYANOPHYTA
CYANOPHYTA UNID.
MISCELLANEOUS
ALGAL SCRAPS (IDENTIFIABLE)
ALGAL SCRAPS (UNIDENTIFIABLE)
DRIFT ALGAE
DRIFT PHOTOSYNTHETIC MATERIAL
FOAM COVER
NON-CORALLINE CRUST
OVERSTORY ALAGE
UNDERSTORY ALGAE
UNKNOWN 20072, V-190

PROTOZOA
- FOLLICULINA SPP.
- FORAMINIFERA UNID.
- GROMIA OVIFORMIS
- PROTOZOAN UNID
- QUINQUELOCULINA SPP.
- RADIOLARIAN UNID.
- ROSALINA SPP
- SPIRILLINA SPP
- ZOOTHAMNIUM SPP.

PORIFERA
- DEMOSPONGIAE
  - ACARNUS ERITHACUS
  - CLATHRIOPSAMMA PSEUDONAPYA
  - CLIONA SPP.
  - HALICLONA SP. (PROB. PERMOLLIS)
  - HALICLONA SPP.
  - HALISARCA SPP.
  - HYMENAMPHIASTRA CYANOCRYPTA
  - LISSODENDORYX FIRMA
  - LISSODENDORYX SP. (PROB. NOXIOSA)
  - OPHLITASPONGIA PENNATA
  - PARESPIRILLA PSILA
  - PLOCAMIA KARYKINA
  - TETHYA AURANTIA VAR. CALIFORNIANA
  - TETILLA ARB
- CALCAREA
  - CLATHRINA SPP.
  - LEUCANDRA HEATHI
  - LEUCILLA NUTTINGI
  - LEUCOSOLENIA ELEANOR
  - LEUCOSOLENIA SPP
- PORIFERA UNID.
  - PORIFERA SPICULES UNID.
  - PORIFERA UNID. A
  - PORIFERA UNID. B (YELLOW)
  - PORIFERA UNID. C (ORANGE)
  - PORIFERA UNID. D (WHITE ENCRUSTING)
  - PORIFERA UNID. E
  - PORIFERA UNID. ENCRUSTING

CNIDARIA
- HYDROZOA
  - ABIET./SERTULARELLA/SERTULARIA (A.S.S.)
  - ABIETINARIA SPP.
  - AGLAOPHENIA STRUTHIONIDES
  - AGLAOPHENIA STRUTHIONIDES
  - ALLOPORA PORPHYRA
  - ALLOPORA SPP.
  - EUDENDRIUM CALIFORNICUM
  - HYDROID, THECATE UNID. A
  - HYDROID, THECATE UNID. B
  - HYDROID, THECATE UNID. C
  - HYDROIDA

HYDROIDA (AAC)
OBELIA SPP.
PLUMULARIA SPP.
SERTULARELLA SPP.
SERTULARIA SPP.
SLLOPORA PORPHYRA
SYNCORYNE SPP
TUBULARIA SPP.

ANTHOZOA
ANTHOPLEURA ARTEMISIA
ANTHOPLEURA ELEGANTISSIMA
ANTHOPLEURA XANTHOGRAMMICA
ANTHOZOAN UNID.
BALANOPHYLLIA ELEGANS
CACTOSOMA ARENARIA
CERIANTHARIA UNID. A
CERIANTHARIA UNID. B
CERIANTHARIA UNID. C
CLAVULARIA SPP.
CORYNACTIS CALIFORNICA
DIADUMENE SPP.
EPIACTIS PROLIFERA
HALCAMPA SP. (PROB. DECEMTENTACULATA)
PARACYATHUS STEARNSII
TEALIA CORIACEA
TEALIA CRASSICORNIS
TEALIA LOFOTENSIS
TEALIA SPP.

SCYPHOZOA
HALICLYSTUS AURICULA
MANANIA SPP.
PELAGIA NOCTILUCA

PLATYHELMINTHES
EURYLEPTA CALIFORNICA
EURYLEPTA SPP.
HOPLOPLANA CALIFORNICA
PLATYHELMINTHES UNID.
PROSTHECERAEUS BELLOSTRIATUS
PSEUDOSTYLOCHUS BURCHAMI
STYLOCHUS FRANCISCANUS

NEMERTEA
AMPHIPORUS IMPARISPINOSUS
MICRURA VERRILLI
NEMERTEAN UNID. A
NEMERTEAN UNID. B
NEMERTEAN UNID. C
NEMERTOPSIS GRACILIS
PARANEMERTES PEREGRINA
TUBULANUS POLYMORPHUS
TUBULANUS SEXLINEATUS

SIPUNCULA
PHASCOLOSOMA AGASSIZII
SIPUNCULA UNID.

THEMISTE PYROIDES
ANNELIDA
POLYCHAETA
AMPHARETIDAE
AMPHARETIDAE
APHRODITIDAE
APHRODITA SPP.
ARABELLIDAE
ARABELLA IRICOLOR
CHAETOPTERIDAE
CHAETOPTERIDAE
PHYLLOCHAETOPTERUS PROLIFICA
SPIOCHAETOPTERUS COSTARUM
CIRRATULIDAE
DODECACERIA SPP.
FLABELLIGERIDAE
PHERUSA INFLATA
MALDANIDAE
AXIOTHELLA RUBROCINCTA
NEREIDAE
CHEILONEREIS CYCLURUS
NEREIDAE UNID.
NEREIS GRUBEI
NEREIS SPP.
PLATYNEREIS BICANALICULATA
ONUPHIDAE
DIOPATRA ORNATA
POLYCHAETA
POLYNOIDAE
HALOSYDNA BREVISETOSA
POLYNOIDAE
SABELLARIIDAE
PHRAGMATOPOMA CALIFORNICA
PHRAGMATOPOMA SPP.
SABELLARIA CEMENTARIUM
SABELLARIA SPP.
SABELLARIA SPP. / PHRAGMATOPOMA CALIFORNICA
SABELLIDAE
EUDISTYLIA POLYMORPHA
MYXICOLA INFUNDIBULUM
SABELLA SPP.
SABELLIDAE (COUNTS)
SABELLIDAE UNID.
SERPULIDAE
HYDROIDES PACIFICUS
JANUA SPP.
PARADEXIOSPIRA VITREA
PILEOLARIA SPP.
PROTOLAEOSPIRA SPP.
SALMACINA TRIBRANCHIATA
SERPULA VERMICULARIS
SERPULIDAE COLONIAL UNID.
SERPULIDAE UNID.
SPIROBRANCHUS SPINOSUS

SPIRORBIDAE
SPIRORBIS EXIMIUS
SPIRORBIS SPIRILLUM
SPIRORBIS SPP.
SYLLIDAE
SYLLIDAE UNID.
TEREBELLIDAE
PISTA PACIFICA
PISTA SPP.
PISTA SPP/STREBLOSOMA SPP
STREBLOSOMA CRASSIBRANCHIA
TEREBELLIDAE UNID.
PHYLLODOCIDAE
PHYLLODOCIDAE UNID.
POLYCHAETA UNID.
CIRRATULIDAE / TEREBELLIDAE UNID.
POLYCHAETA FRAGMENTS
POLYCHAETA UNID.
WORM TUBE
SPIONIDAE
SPIONIDAE UNID.
OLIGOCHAETA

ARTHROPODA
OSTRACODA
OSTRACODA UNID.
BRANCHIOPODA
EVADNE SPINIFERA
PENILIA AVIROSTRIS
COPEPODA
ACARTIA SPP.
CALANOIDA UNID.
CALANUS MINOR
CALANUS PACIFICUS
CANDACIA SPP.
CENTROPAGES BRADYI
CLAUSOCALANUS ARCUICORNIS
CLAUSOCALANUS FURCATUS
CLAUSOCALANUS JOBEI
CLAUSOCALANUS LIVIDUS
CLAUSOCALANUS MASTIGOPHORUS
CLAUSOCALANUS PARAPERGENS
CLAUSOCALANUS PERGENS
CLAUSOCALANUS SPP.
COPEPODA NAUPLII
CTENOCALANUS VANUS
CYCLOPOIDA UNID.
EUCALANUS SPP.
HARPACTICOIDA UNID.
OITHONA SPINIROSTRIS
ONCAEA MEDITERRANEA
PARACALANUS PARVUS
PARACALANUS SPP.

PLEUROMAMMA SPP.
PSEUDOCALANUS SPP.
RHINCALANUS SPP.
TORTANUS SPP.
CIRRIPEDIA
BALANUS AQUILA
BALANUS CRENATUS
BALANUS GLANDULA
BALANUS NUBILUS
BALANUS PACIFICUS
BALANUS SPP.
BALANUS SPP. / TETRACLITA SPP.
BALANUS TINTINNABULUM CALIFORNICUS
BARNACLE SCAR UNID.
BARNACLES JUVENILE
CHTHAMALUS FISSUS
CIRREPEDIA UNID. A
CIRREPEDIA UNID. B
CIRREPEDIA UNID. C
CYPRIS LARVAE UNID.
LEPAS ANATIFERA
POLLICIPES POLYMERUS
TETRACLITA SQUAMOSA
MALACOSTRACA
MYSIDACEA
MYSIDACEA UNID.
TANAIDACEA (=CHELIFERA)
CHELIFERA UNID.
ISOPODA
CIROLANA SPP.
CIROLANIDAE UNID.
FLABELLIFERA UNID.
GNATHIA SPP.
IDOTEA (I.) UROTOMA
IDOTEA (P.) ACULEATA
IDOTEA (P.) MONTEREYENSIS
IDOTEA (P.) RESECATA
IDOTEA (P.) SCHMITTI
IDOTEA (P.) STENOPS
IDOTEA (P.) WOSNESENSKII
IDOTEA SPP.
ISOPODA UNID.
JAEROPSIS SPP.
JANIRIDAE UNID.
PARACERCEIS CORDATA
SPHAEROMATIDAE UNID.
VALVIFERA UNID.
AMPHIPODA
AMPELISCA SPP.
AMPHIPODA UNID.
AMPITHOE SPP.
AOROIDES COLUMBIAE
AOROIDES SPP.
CAPRELLA EQUILIBRA

CAPRELLA SPP.
CAPRELLIDAE UNID.
COROPHIIDAE UNID.
COROPHIUM SPP. (TUBE)
ELASMOPUS SPP.
ERICHTHONIUS BRASILIENSIS
ERICHTHONIUS BRASILIENSIS TUBE
EUSIRIDAE UNID.
GAMMARIDEAN TUBE UNID.
GAMMARIDEAN UNID
HYALIDAE UNID.
HYPERIIDAE UNID.
JASSA FALCATA
LEUCOTHOE ALATA
LYSIANASSIDAE UNID.
MAERA SIMILE
MAERA SPP.
MAERA VIGOTA
METACAPRELLA KENNERLYI
ORCHESTIA TRASKIANA
PARALLORCHESTES SPP.
PHOTIS CONCHICOLA
PHOTIS SPP.
PHRONIMA SPP.
PLEUSTIDAE UNID.
PODOCERUS SPP.
POLYCHERIA OSBORNI
TALITRIDAE UNID.
TIRON BIOCELLATA

DECAPODA

ALPHEIDAE UNID.
ALPHEUS DENTIPES
ALPHEUS SPP.
ANOMURA UNID.
BLEPHARIPODA OCCIDENTALIS
BRACHYURA UNID. (JUV.) A (CANCER)
BRACHYURA UNID. (JUV.) B
BRACHYURA UNID. (JUV.) C
BRACHYURA UNID. FRAGMENTS
CANCER ANTENNARIUS
CANCER ANTENNARIUS (JUV.)
CANCER ANTHONYI
CANCER BRANNERI (JUV.)
CANCER JORDANI
CANCER PRODUCTUS
CANCER PRODUCTUS (JUV.)
CANCER SPP.
CRANGON SPP.
CRANGON STYLIROSTRIS
CRANGON STYLIROSTRIS
CRANGON STYLIROSTRIS
CRYPTOLITHODES SITCHENSIS
DECAPODA UNID.
GRAPSIDAE (JUV.)

HEMIGRAPSUS NUDUS
HEMIGRAPSUS OREGONENSIS
HEPTACARPUS CARINATUS
HEPTACARPUS CRISTATUS
HEPTACARPUS PICTUS
HEPTACARPUS SPP.
HEPTACARPUS TAYLORI
HIPPOLYTIDAE UNID.
LEBBEUS LAQUNAE
LOPHOPANOPEUS SPP.
LOXORHYNCHUS CRISPATUS
LOXORHYNCHUS SPP.
MAJIDAE (INACHIDAE)
MEGALOPS LARVAE UNID.
MIMULUS FOLIATUS
NATANTIA UNID.
PACHYCHELES PUBESCENS
PACHYCHELES RUDIS
PACHYCHELES SPP.
PACHYGRAPSUS CRASSIPES
PAGURIDAE UNID. A
PAGURIDAE UNID. B
PAGURIDAE UNID. C
PAGURUS SPP.
PANULIRUS INTERRUPTUS (PUERULUS STAGE)
PARAXANTHIAS TAYLORI
PETROLISTHES CINCTIPES
PETROLISTHES ERIOMERUS
PETROLISTHES SPP.
PORCELLANIDAE UNID.
PUGETTIA PRODUCTA
PUGETTIA RICHII
PUGETTIA SPP.
SCYRA ACUTIFRONS
SPIRONTOCARIS SPP.
XANTHIDAE UNID.
ZOEA LARVAE UNID.

PYCNOGONIDA
- ACHELIA CHELATA
- LECYTHORHYNCHUS HILGENDORFI
- PYCNOGONIDA UNID.
- PYCNOGONUM STEARNSI

INSECTA
- CHIRONOMIDAE LARVAE
- COLEOPTERA LARVAE
- DIPTERA LARVAE
- DIPTERA UNID.

ARTHROPODA UNID.
- CRUSTACEA FRAGMENTS

MOLLUSCA

POLYPLACOPHORA
- BASILIOCHITON HEATHII

CHAETOPLEURA GEMMA
CRYPTOCHITON STELLERI
CYANOPLAX HARTWEGII
CYANOPLAX SPP.
ISCHNOCHITON RADIANS
ISCHNOCHITON SPP.
ISCHNOCHITONIDAE
KATHARINA TUNICATA
LEPIDOZONA COOPERI
LEPIDOZONA MERTENSII
LEPIDOZONA SINUDENTATA
LEPIDOZONA SPP.
MOPALIA CILIATA
MOPALIA HINDSII
MOPALIA LIGNOSA
MOPALIA LOWEI
MOPALIA MUSCOSA
MOPALIA SPP.
NUTALLINA SPP.
NUTTALLINA CALIFORNICA
PLACIPHORELLA VELATA
POLYPLACOPHORA UNID. A
POLYPLACOPHORA UNID. B
POLYPLACOPHORA UNID. C
POLYPLACOPHORA UNID. D
POLYPLACOPHORA UNID. E
STENOPLAX FALLAX
STENOPLAX HEATHIANA
STENOPLAX SPP.
TONICELLA LINEATA

GASTROPODA

ARCHAEOGASTROPODA

ACMAEA MITRA
ACMAEA SPP.
ACMAEID UNID. A
ACMAEID UNID. B
ACMAEID UNID. C
ACMAEID UNID. D
ACMAEIDAE (AAC)
ACMAEIDAE UNID.
ARCHAEOGASTROPODS
ASTRAEA GIBBEROSA
CALLIOSTOMA ANNULATUM
CALLIOSTOMA CANALICULATUM
CALLIOSTOMA LIGATUM
CALLIOSTOMA SPP.
COLLISELLA ASMI
COLLISELLA DIGITALIS
COLLISELLA INSTABILIS
COLLISELLA LIMATULA
COLLISELLA OCHRACEA
COLLISELLA PELTA
COLLISELLA SCABRA
COLLISELLA SPP.

COLLISELLA STRIGATELLA
CREPIDULA NUMMARIA
DIODORA ASPERA
DIODORA SPP.
FISSURELLA VOLCANO
HALIOTIS CRACHERODII
HALIOTIS RUFESCENS
HALIOTIS SPP.
HALIOTIS SPP. (JUV.)
HALIOTIS WALALLENSIS
HOMALOPOMA SPP.
LOTTIA GIGANTEA
MARGARITES SALMONEUS
MEGATEBENNUS BIMACULATUS
NOTOACMEA FENESTRATA
NOTOACMEA INSESSA
NOTOACMEA PALEACEA
NOTOACMEA PERSONA
NOTOACMEA SCUTUM
TEGULA BRUNNEA
TEGULA FUNEBRALIS
TEGULA MONTEREYI
TEGULA PULLIGO
TEGULA SPP.
TRICOLIA PULLOIDES
TRICOLIA SPP.
TRIMUSCULUS RETICULATUS

MESOGASTROPODA

ALVINIA SPP.
ASSIMINEA SPP.
BARLEEIA ACUTA
BARLEEIA SPP.
BITTIUM ESCHRICHTII
BITTIUM SPP.
CAECUM CALIFORNICUM
CERITHIOPSIS SPP.
CREPIDULA ADUNCA
CREPIDULA SPP.
DENDROPOMA LITUELLA
DENDROPOMA SPP.
EPITONIUM SPP.
EPITONIUM SPP. / OPALIA SPP.
EPITONIUM TINCTUM
ERATO VITELLINA
HIPPONIX SPP.
LACUNA MARMORATA
LACUNA SPP.
LACUNA UNIFASCIATA
LITTORINA PLANAXIS
LITTORINA SCUTULATA
LITTORINA SPP.
OPALIA CHACEI
OPALIA SPP.
SERPULORBIS (=ALETES) SQUAMIGERUS

TRIVIA SPP.
NEOGASTROPODA
ACANTHINA PUNCTULATA
ACANTHINA SPIRATA
ACANTHINA SPP.
AMPHISSA COLUMBIANA
AMPHISSA SPP.
AMPHISSA VERSICOLOR
CERATOSTOMA FOLIATUM
CONUS CALIFORNICUS
CYSTISCUS JEWETTII
FUSINUS LUTEOPICTUS
GRANULINA MARGARITULA
MITRA IDAE
MITRELLA AURANTIACA
MITRELLA CARINATA
MITRELLA SPP.
NASSARIUS MENDICUS
NASSARIUS SPP.
NUCELLA (=THAIS) SPP.
NUCELLA CANALICULATA
NUCELLA EMARGINATA
NUCELLA SPP.
NUCELLA SPP. / OCENEBRA SPP.
OCENEBRA ATROPURPUREA
OCENEBRA CIRCUMTEXTA
OCENEBRA FOVEOLATA
OCENEBRA INTERFOSSA
OCENEBRA LURIDA
OCENEBRA SPP.
OLIVELLA BIPLICATA
PSEUDOMELATOMA TOROSA
SEARLESIA DIRA
SEARLESIA SPP. / AMPHISSA SPP.
TURRIDAE UNID.
GASTROPODA
NUDIBRANCHIA
ACANTHODORIS LUTEA
AEGIRES ALBOPUNTATUS
AEOLIDIA PAPILLOSA
AEOLIDIACEA UNID. A
AEOLIDIACEA UNID. B
ALDISIA SANGUINEA
ANISODORIS NOBILIS
ARCHIDORIS MONTEREYENSIS
ARCHIDORIS ODHNERI
CADLINA FLAVOMACULATA
CADLINA LUTEOMARGINATA
CADLINA MODESTA
CHROMODORIS MACFARLANDI
CORYPHELLA SPP.
CORYPHELLA TRILINEATA
DENDRODORIS SPP.
DENDRONOTUS IRIS

DIAULULA SANDIEGENSIS
DORIDACEA UNID.
DORIOPSILLA ALBOPUNCTATA
DOTO KYA
EUBRANCHUS RUSTYUS
FLABELLINOPSIS IODINEA
HERMISSENDA CRASSICORNIS
HOPKINSIA ROSACEA
LAILA COCKERELLI
NUDIBRANCHIA EGGS
NUDIBRANCHIA UNID.
PHIDIANA PUGNAX
ROSTANGA PULCHRA
ROSTANGA SPP.
TENELLIA SPP.
TRINCHESIA ALBOCRUSTA
TRIOPHA CARPENTERI
TRIOPHA CATALINAE
TRIOPHA MACULATA
TRIOPHA SPP.
TRITONIA FESTIVA
YELLOW-GILLED POROSTOME

OPISTHOBRANCHIA OTHER

ELYSIA HEDGPETHI
MELIBE LEONINA
ODOSTOMIA SPP.
RICTAXIS PUNCTOCAELATUS

GASTROPODA

PULMONATA

ONCHIDELLA BOREALIS
WILLIAMIA PELTOIDES

GASTROPODA UNID.

GASTROPOD, NEOPIC UNID. A
GASTROPOD, NEOPIC UNID. B
GASTROPOD, NEOPIC UNID. C
GASTROPOD, NEOPIC UNID. D
GASTROPODA FRAGMENTS
GASTROPODA, NEOPIC UNID.
SNAIL, UNID.

BIVALVIA

CHAMA PELLUCIDA
CHAMA SPP.
DIPLODONTA ORBELLA
GLANS SUBQUADRATA
HIATELLA ARCTICA
HIATELLA SPP.
HINNITES MULTIRUGOSUS
LITHOPHAGA PLUMULA KELSEYI
MACOMA NASUTA
MACOMA SPP.
MODIOLUS SPP.
MUSCULUS PYGMAEUS
MYTILIDAE
MYTILUS CALIFORNIANUS

MYTILUS EDULIS
PARAPHOLAS SPP.
PELECYPODA UNID.
PELECYPODA UNID. BORING
PENITELLA CONRADI
PHOLADIDAE UNID.
PODODESMUS CEPIO
PROTOTHACA LACINIATA
PROTOTHACA STAMINEA
PSEUDOCHAMA SPP.
SEPTIFER BIFURCATUS
TRANSENNELLA SPP.
TRANSENNELLA TANTILLA

CEPHALOPODA

OCTOPUS SPP.

BRYOZOA

CTENOSTOMATA

ALCYONIDIUM POLYOUM
FLUSTRELLIDRA (=FLUSTRELLA) CORNICULATA

CYCLOSTOMATA

CRISIA OCCIDENTALIS
CRISIA SPP
DIAPEROECIA SPP.
FILICRISIA FRANCISCANA
FILICRISIA SPP
HETEROPORA SPP.
LICHENOPORA SPP. / TUBULIPORA SPP.

CHEILOSTOMATA

AETEA ANGUINA
ANTROPORA TINCTA
CAULIBUGULA CILIATA
CAULORAMPHUS SPINIFERUM
COSTAZIA ROBERTSONAE
DENDROBEANIA LAXA
EURYSTOMELLA BILABIATA
HIPPODIPLOSIA SPP.
HIPPOTHOA HYALINA
HOLOPORELLA BRUNNEA
MEMBRANIPORA SPP.
MICROPORELLA CALIFORNICA
MICROPORELLA CRIBROSA
MICROPORELLA SPP.
PHIDOLOPORA PACIFICA
PHIDOLOPORA SPP.
RHYNCHOZOON SPP.
SCRUPOCELLARIA SPP.
TRICELLARIA OCCIDENTALIS
TRICELLARIA SPP.

BRYOZOA UNID.

BRYOZOA, UNID. ENCRUSTING
BRYOZOA, UNID. ERECT
BRYOZOA, UNID. FOLIOSE
BRYOZOAN UNID. A

BRYOZOAN UNID. B
BRYOZOAN UNID. C
BRYOZOAN UNID. D
BRYOZOAN UNID. E
ENTOPROCTA
BARENTSIA RAMOSA
BARENTSIA SPP.
ENTOPROCTA UNID. A
ENTOPROCTA UNID. B
ENTOPROCTA UNID. C
ECHINODERMATA
ECHINOIDEA
ECHINOIDEA UNID.
ECHINOIDEA UNID. A
ECHINOIDEA UNID. B
STRONGYLOCENTROTUS FRANCISCANUS
STRONGYLOCENTROTUS PURPURATUS
STRONGYLOCENTROTUS SPP.
ASTEROIDEA
ASTEROIDEA UNID.
DERMASTERIAS IMBRICATA
HENRICIA LEVIUSCULA
LEPTASTERIAS HEXACTIS
LEPTASTERIAS SPP.
ORTHASTERIAS KOEHLERI
PATIRIA MINIATA
PISASTER BREVISPINUS
PISASTER GIGANTEUS
PISASTER GIGANTEUS VAR. CAPITATUS
PISASTER OCHRACEUS
PISASTER/HENRICIA JUV.
PYCNOPODIA HELIANTHOIDES
STYLASTERIAS FORRERI
OPHIUROIDEA
OPHIOPLOCUS ESMARKI
OPHIOPLOCUS SPP.
OPHIOTHRIX SPICULATA
OPHIOTHRIX SPP.
OPHIUROIDEA UNID.
HOLOTHUROIDEA
CUCUMARIA SPP.
EUPENTACTA QUINQUESEMITA
HOLOTHUROIDEA UNID. A
HOLOTHUROIDEA UNID. B
LISSOTHURIA NUTRIENS
PARASTICHOPUS CALIFORNICUS
PARASTICHOPUS PARVIMENSIS
PARASTICHOPUS SPP.
PSOLUS CHITONOIDES
UROCHORDATA
LARVACEA
OIKOPLEURA SPP.
THALIACEA
PELAGIC SALP

THALIACEA UNID.
ASCIDIACEA
(TRI) DIDEMNUM SPP.
APLIDIUM (=AMAROUCIUM) CALIFORNICUM
ARCHIDISTOMA DIAPHANES
ARCHIDISTOMA MOLLE
ARCHIDISTOMA PSAMMION
ARCHIDISTOMA RITTERI
ARCHIDISTOMA SPP.
ASCIDIA CERATODES
ASCIDIA SPP.
BOLTENIA VILLOSA
CHELYOSOMA PRODUCTUM
CHELYOSOMA SPP.
CLAVELINA HUNTSMANI
CNEMIDOCARPA FINMARKIENSIS
CYSTODYTES LOBATUS
DIDEMNUM CARNULENTUM
DISTAPLIA OCCIDENTALIS
DISTAPLIA SMITHI
DISTAPLIA SPP.
LISSOCLINUM CAULLERYI
METANDROCARPA TAYLORI
PEROPHORA ANNECTENS
PYURA HAUSTOR
RITTERELLA AEQUALISIPHONIS
RITTERELLA PULCHRA
RITTERELLA SPP.
STYELA MONTEREYENSIS
STYELA SPP.
SYNOICUM PARFUSTIS
SYNOICUM SPP.
TUNICATA UNID.
TUNICATE, COLONIAL UNID. A (WHITE)
TUNICATE, COLONIAL UNID. B (YELLOW)
TUNICATE, COLONIAL UNID. C (ORANGE)
TUNICATE, SOLITARY UNID.
TUNICATES, COLONIAL / SOCIAL UNID.

VERTEBRATA
OSTEICHTHYS
GOBIESOCIDAE
GOBIESOCIDAE UNID. A
GOBIESOCIDAE UNID. B
GOBIESOX MAEANDRICUS
ATHERINIDAE
ATHERINIDAE UNID.
GASTEROSTEIDAE
AULORHYNCHUS FLAVIDUS
SERRANIDAE
PARALABRAX CLATHRATUS
PARALABRAX CLATHRATUS (JUV.)
GIRELLIDAE

GIRELLA NIGRICANS
EMBIOTOCIDAE
BRACHYISTIUS FRENATUS
BRACHYISTIUS FRENATUS (JUV.)
CYMATOGASTER AGGREGATA
CYMATOGASTER AGGREGATA (JUV.)
DAMALICHTHYS VACCA
DAMALICHTHYS VACCA (JUV.)
EMBIOTOCA JACKSONI
EMBIOTOCA JACKSONI (JUV.)
EMBIOTOCA LATERALIS
EMBIOTOCA LATERALIS (JUV.)
EMBIOTOCIDAE UNID.
EMBIOTOCIDAE UNID. (JUV.)
HYPSURUS CARYI
HYPSURUS CARYI (JUV.)
MICROMETRUS AURORA
PHANERODON ATRIPES
PHANERODON ATRIPES (JUV.)
PHANERODON FURCATUS
PHANERODON FURCATUS (JUV.)
PHANERODON SPP.
RHACOCHILUS TOXOTES
POMACENTRIDAE
CHROMIS PUNCTIPINNIS
CHROMIS PUNCTIPINNIS (JUV.)
LABRIDAE
OXYJULIS CALIFORNICA
OXYJULIS CALIFORNICA (JUV.)
CLINIDAE
CLINIDAE UNID.
GIBBONSIA SPP.
HETEROSTICHUS ROSTRATUS
HETEROSTICHUS ROSTRATUS (JUV.)
NEOCLINUS STEPHENSAE
OSTEICHTHYS
STICHAEIDAE
ANOPLARCHUS PURPURESCENS
CHIROLOPHIS NUGATOR
STICHAEIDAE UNID.
XIPHISTER ATROPURPUREUS
XIPHISTER MUCOSUS
XIPHISTER SPP.
PHOLIDIDAE
APODICHTHYS FLAVIDUS
PHOLIDIDAE / STICHAEIDAE UNID.
PHOLIDIDAE UNID.
XEREPES FUCORUM
ANARHICHADIDAE
ANARRHICHTHYS OCELLATUS
GOBIIDAE
CORYPHOPTERUS NICHOLSII
LETHOPS CONNECTENS
SCORPAENIDAE

SEBASTES ATROVIRENS
SEBASTES ATROVIRENS (JUV.)
SEBASTES AURICULATUS
SEBASTES AURICULATUS(JUV.)
SEBASTES CARNATUS
SEBASTES CARNATUS (JUV.)
SEBASTES CARNATUS / S. CHRYSOMELAS
SEBASTES CAURINUS
SEBASTES CAURINUS (JUV.)
SEBASTES CHRYSOMELAS
SEBASTES CHRYSOMELAS (JUV.)
SEBASTES CHRYSOMELAS / S. CARNATUS (JUV.)
SEBASTES MELANOPS (JUV)
SEBASTES MINIATUS
SEBASTES MYSTINUS
SEBASTES MYSTINUS (JUV.)
SEBASTES NEBULOSUS
SEBASTES PAUCISPINIS (JUV.)
SEBASTES RASTRELLIGER
SEBASTES RASTRELLIGER (JUV.)
SEBASTES SERRANOIDES
SEBASTES SERRANOIDES / S. FLAVIDUS (JUV.)
SEBASTES SERRICEPS
SEBASTES SPP.
SEBASTES SPP. (JUV.)

HEXAGRAMMIDAE
- HEXAGRAMMOS DECAGRAMMUS
- HEXAGRAMMOS DECAGRAMMUS (JUV.)
- HEXAGRAMMOS DECAGRAMMUS EGGS
- OPHIODON ELONGATUS
- OPHIODON ELONGATUS (JUV.)
- OXYLEBIUS PICTUS

COTTIDAE
- ARTEDIUS HARRINGTONI
- ARTEDIUS LATERALIS
- ARTEDIUS SPP.
- COTTIDAE EGGS
- COTTIDAE UNID. A
- COTTIDAE UNID. B
- COTTIDAE UNID. C
- HEMILEPIDOTUS SPINOSUS
- JORDANIA ZANOPE
- LEPTOCOTTUS SPP.
- OLIGOCOTTUS RUBELLIO
- ORTHONOPIAS TRIACIS
- SCORPAENICHTHYS MARMORATUS
- SCORPAENICHTHYS MARMORATUS (JUV.)

BOTHIDAE
- BOTHIDAE UNID. (JUV.)
- CITHARICHTHYS SPP.

PLEURONECTIDAE
- PLEURONECTIDAE UNID. (JUV.)
- PLEURONICHTHYS COENOSUS

OSTEICHTHYS

BATHYMASTERIDAE
RATHBUNELLA HYPOPLECTA
BATRACHOIDIDAE
PORICHTHYS NOTATUS
BROTULIDAE
CEBIDICHTHYIDAE
CEBIDICHTHYS VIOLACEUS
LIPARIDIDAE
SCIAENIDAE
ENGRAULIDAE
ENGRAULIS MORDAX
BLENNIIDAE
BLENNIIDAE UNID. A
BLENNIIDAE UNID. B
BLENNIIDAE UNID. C
AGONIDAE
BOTHRAGONUS SWANII
OSTEICHTHYS *4TH OSTEICHTHYS OF LIST
SYNGNATHIDAE
SYNGNATHUS SPP.
TRACHURUS SYMMETRICUS
CHONDRICHTHYS
CEPHALOSCYLLIUM VENTRIOSUM
MYLIOBATIS CALIFORNICA
PLATYRHINOIDIS TRISERIATA
RAJA SPP.
TRIAKIS SEMIFASCIATA

MISCELLANEOUS ANIMALS
ANIMAL TURF
EGG MASS UNID.
EGGS, UNID.
EYEBALL
FISH SCALES
INVERTEBRATA ENCRUSTING
TELEOST FRAGMENTS

ACMAEIDAE (AAC)

ANIMAL AREAL COVERAGE SPECIES

HYDROIDA (AAC)
ABIET./SERTULARELLA SPP./SERTULARIA (ASS/AAC)
ACANTHINA SPP (AAC)
ACMAEIDAE (AAC)
ANTHOPLEURA ELEGANTISSIMA (AAC)
ANTHOPLEURA XANTHOGRAMMICA (AAC)
ARCHIDISTOMA PSAMMION
BALANUS SPP (AAC)
BRYOZOAN (ENCRUSTING) (AAC)
BRYOZOAN (FOLIOSE) (AAC)
CHTHAMALUS FISSUS (AAC)

CLAVELINA HUNTSMANI (AAC)
COLLISELLA PELTA (AAC)
COLLISELLA SCABRA (AAC)
CORYNACTIS CALIFORNICA (AAC)
DENDROPOMA SPP. (AAC)
DIOPATRA SP. (PROB. ORNATA) (AAC)
DODECACERIA SPP. (AAC)
EPIACTIS PROLIFERA (AAC)
GAMMARID TUBES (AAC)
HALICLONA SPP. (AAC)
HALIOTIS CRACHERODII (AAC)
LACUNA SPP. (AAC)
LEUCOSOLENIA SPP. (AAC)
LEUCOSULENIA ELEANOR (AAC)
MUCOUS MASS (AAC)
MYTILUS CALIFORNIANUS (AAC)
NOTOACMEA SCUTUM (AAC)
NUTTALINA CALIFORNICA (AAC)
PAGURUS SPP. (AAC)
PATIRIA MINIATA (AAC)
PHRAGMATOPOMA CALIFORNICA (AAC)
PHYLLOCHAETOPTERUS PROLIFICA (AAC)
PISASTER OCHRACEUS (AAC)
PISTA SPP. (AAC)
POLLICEPES POLYMERUS (AAC)
PORIFERA UNID ENCRUSTING (AAC)
PYCNOPODIA HELIANTHOIDES (AAC)
SABELLARIA SPP. / PHRAGMATOPOMA SPP. (AAC)
SALMACINA TRIBRANCHIATA (AAC)
SPIROBIDAE (AAC)
SPIRORBIS SPP. (AAC)
STRONGYLOCENTROTUS PURPURATUS (AAC)
TEALIA SPP. (AAC)
TEGULA BRUNNEA (AAC)
TEGULA FUNEBRALIS (AAC)
TETRACLITA SQUAMOSA (AAC)
TUNICATES, COLONIAL/SOCIAL UNID (AAC)

SUBSTRATE

BARE PLATE (ASBESTOS)
BOULDER
BOULDER (TOTAL)
COBBLE
COBBLE (TOTAL)
COLONIZED COBBLE
COLONIZED ROCK
ENTRAPPED SAND
EPOXY
MUD
PEBBLE / GRAVEL
ROCK
ROCK (TOTAL)
ROCK SAND
SAND (SHELL GRAVEL)

SHELL DEBRIS
TIDEPOOL

MISCELLANEOUS
FIBROUS MATERIAL
MUCOUS MASS
SEMI-DIGESTED MATERIAL
UNASSIGNED SPECIES

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