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Pacific Gas and Electric Company
Department of Engineering Research

Environmental Investigations at Diablo Canyon, 1982

June, 1983
San Ramon, California

ENVIRONMENTAL INVESTIGATIONS AT DIABLO CANYON

1982

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH

Ramon F. Cayot, Chief

Edited By

D. W. Behrens

June 1983

San Ramon, California

ENVIRONMENTAL INVESTIGATIONS AT DIABLO CANYON, 1982

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PREFACE

This report, covering the year 1982, is a continuation of a series by Pacific Gas and Electric Company on environmental studies at Diablo Canyon Power Plant, Unit 1 and 2, located near San Luis Obispo, California. Prior reports have covered the years 1966 through 1981.

ENVIRONMENTAL INVESTIGATIONS AT DIABLO CANYON - 1982

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

Chapter

INTRODUCTION AND HISTORICAL OVERVIEW

By

J. W. Warrick
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This report, covering the year 1982, is part of a series beginning in 1966 which describe environmental studies at Diablo Canyon Power Plant (DCPP). A chronology of environmental studies performed by PGandE biologists, environmental specialists and consultants is contained in this chapter and in the Introduction to the last seven reports (Adams, 1974, 1975, 1979 and Warrick 1981a and b, 1982a and b).

Chapter contents include technical reports on the following subjects: a summarization of nearshore oceanographic data collected as part of PGandE's NPDES monitoring and reporting program (C. O. White); an analysis of fourteen years of nearshore seawater temperature collection (C. O. White); a summary of seawater density data for the years 1977 - 1982 (C. O. White); a dye traser study simulating discharge plume dispersion during power plant heat treatment (demusseling) (C. O. White and E. M. Kenzler); a review of continuous ocean current monitoring (R. P. Meek); water circulation tests conducted on the Diablo Canyon physical hydraulic model at the University of California, Berkeley (T. R. Kendall); a review of the revisions made to the Diablo Canyon NPDES permit and its monitoring and reporting program, and a summary of toxicity studies conducted in 1982 (D. W. Behrens); an evaluation of a multivariate statistical technique for analysis of presence and absence data from the intertidal zone (R. A. Pimentel and R. C. Bowker); a study of morphometric variation in the shell of an intertidal gastropod living in Diablo Cove (B. N. Tissot and J. R. Steinbeck); results of Wheeler J. North's intertidal and subtidal surveys (W. J. North, E. K. Anderson and F. A. Chapman); observations of migration and behavior of the California

sea otter at Diablo Canyon (S. V. Benech); observations on peregrine falcons nesting at Diablo Canyon (C. Bennett, D. Thompson and B. Walton); observations of the 1981 - 1982 gray whale migration in the vicinity of Diablo Canyon (D. W. Behrens); an annual progress report on rockfish fisheries studies (D. C. Sommerville and S. J. Krenn); and a report of breakwater repair activities (T. C. Wilson).

Significant Developments in 1982

Significant events affecting environmental programs at the DCPP are listed in Table 1. The scope of ongoing studies continued to emphasize preoperational monitoring designed to define seasonality and background trends in physical and chemical oceanographic parameters, and describe abundances and distribution of key organisms. Table 2 contains a responsibility matrix for these studies. Contract studies performed by Dr. Wheeler J. North of the California Institute of Technology, the Thermal Effects Monitoring Program field team, and the California Department of Fish and Game study team, continued. Significant changes in the waste discharge permit and its monitoring requirements evolving at the end of 1981 following the expiration of the NPDES permit, continued and escalated with the ensuing permit renewal hearings held by the California Water Quality Control Board, Central Coast Region (CCRWQCB).

The most significant environmental event occurring at Diablo Canyon in 1982 was the arrival of a nesting pair of endangered peregrine falcons and the concurrent start of repair work on the intake cove's damaged west breakwater. Walton (1982) described the arrival and early observations of the falcon in the vicinity of the power plant. Details of the nesting and fledging of chicks are described in Chapter 12 of this volume. Breakwater repair is described in Chapter 15.

Table 1

CHRONOLOGY OF EVENTS AT DIABLO CANYON - 1982

Date	Event
January 7	Wheeler J. North Intertidal Survey.
January 14	Continuation of NPDES permit hearings with CCRWQCB, Santa Barbara, California.
January 14	New NPDES permit (Order No. 82-24) adopted by CCRWQCB.
January 21 - 25	Intertidal Fish Survey #17.
March 5 - 7	Intertidal Fish Survey #18.
March 19	CCRWQCB denied PGandE's petition to reconsider Order No. 82-24.
March 31	PGandE submits the Thermal Discharge Assessment and Assessment of Alternative Plans to Reduce the Heat and Volume of Cooling Water Discharge reports to the CCRWQCB.
April 8	Oil spill to Diablo Cove reported.
April 30	1981 Annual Environmental Operating Report submitted to U.S.N.R.C.
May 14	CCRWQCB public hearing to consider modification of paragraph A.6 of NPDES permit (2°F Unit to discharge) held in San Luis Obispo, California.
May 25	Intertidal Fish Survey #19.
June 11	CCRWQCB public hearing to finalize modification to Order 82-24 held in San Luis Obispo. Order 82-54 adopted.
June 28	First observations of peregrine chicks.
June 28	First Mussel Watch sampling effort by California Department of Fish and Game at Diablo Canyon.
June 29	Annual sea urchin count at Pecho Rock conducted.
July 12	Repair of damaged west breakwater begins.
July 23	Intertidal Fish Survey #20.
August 19	Blasting of breakwater debris begins.
August 22 - 28	Presentation by staff biologist at Hazard Assessment of Complex Effluents Workshop, Cody, Wyoming.

Table 1 (Cont.)

CHRONOLOGY OF EVENTS AT DIABLO CANYON - 1982

Date	Events
September 10	CCRWQCB public hearing to approve NPDES self-monitoring program held in Santa Barbara, California. Program modified and approved.
Septeber 15 - 16	Wheeler J. North Intertidal Survey.
October 16	Brush fire burns 1800 acres at DCPP site.
October 21	Barge involved in breakwater repair on site collapses, oil spill reported.
November 1 - 4	Intertidal Fish Survey #21.
December 14	Mussel Watch Sampling by California Department of Fish and Game.

TABLE 2

Matrix of On-going Environmental Studies
at
Diablo Canyon Power Plant

	PG&E	NPDES THERMAL EFFECTS MONITORING	CALIF. DEPT OF FISH & GAME	CONSULTANTS ECOMAR	CONSULTANTS W.J.NORTH
General					
Settling Plates		*S-12			
Cliff top Photos		*I-13			
Quad Photos	I-9	I,S-14, 15			
Algae					
Abundance		S-23, I-24			
Biomass	I-1	I-16	I,S-27, 28		
Infauna					
General		I-16	I,S-27, 28		
Species Specific	I-1				
Kelp counts	10	S-17	28,32		
Percent Cover		I-18			I,S-36,37
Presence-Absence	I-2				
Invertebrates					
Abundance		I,S-16, 17,18, 19	I,S-27, 28,29		I,S-36,37
Abalone					
Abundance		I,S-15, 17,18, 20	I,S-26, 27,28, 29		I,S-36,37
Migration & Growth		I-20			
Presence-Absence	I-2				
Crabs					
Abundance	I-2	I,S-18, 21	I,S-27, 28,29		I,S-36,37
Migration		S-21			
Size Distribution	I-2	S-21	I,S-27, 28,29		
Percent Cover		I-18			I,S-36,37
Presence-Absence	I-2				

	PG&E	NPDES THERMAL EFFECTS MONITORING	CALIF. DEPT OF FISH & GAME	CONSULTANTS ECOMAR	CONSULTANTS W.J.NORTH
Fish					
Abundance	I-2	S-22	I,S-29, 31		S-37
Sport Fisheries	11				
Size Distribution	I-2				
Vertebrates					
Peregrine Falcons	3				
Sea Otters			30	35	
Gray Whales	4				
Physical					
Currents	5			33	
Dissolved Oxygen	5				
Foam Distribution	6				
Light Intensities		S-25			
Salinity	5				
Temperatures	I,S-7	I,S-24		34	
Tides		S-25			
Waves	8	S-25			
Wind	8				

* S = Subtidal Study
* I = Intertidal Study
Numbers Refer to Studies Listed on Following Page

List of Current Studies

PG&E

1) Algal Scrapes - Quarterly collections of four species of habitat forming algae to determine composition of infauna
2) Intertidal Fish - Bimonthly monitoring of fixed perpendicular transects to determine abundances and species composition of intertidal fishes; program also examines community structure through time using presence and absence of fish, invertebrates and algae
3) Peregrine Falcon Watch - Daily observations of nesting pair of American Peregrine Falcons at DCPP; contract work with Santa Cruz Preditory Bird Research Group
4) Whale Survey - Seasonal observations of behavior of migrating Gray Whales
5) Physical Oceanography - Quarterly oceanographic surveys monitoring chemical and physical parameters such as pH, dissolved oxygen, seawater temperature profiles and path and flow current studies
6) Sea Foam Monitoring study - Hourly photo documentation of presence and distribution of sea foam in Diablo Cove using an automatic camera system mounted on a 250 ft. tower
7) Intertidal & Subtidal Temperature Monitoring Study - Hourly records of intertidal and subtidal seawater temperatures using self-contained thermographs at 7 stations
8) Wind & Wave Documentation - Documentation of wind speed and direction using on-site meteological instrumentation; daily measurement of wave direction, period and estimation of height
9) Quad Photos - Bimonthly photo documentation of the condition of intertidal fish program transects
10) Kelp Flights - Aerial photograrhic documentation of size and distrubution of kelp beds in the vicinity of Diablo Canyon performed 3 times each year
11) Rockfish Biology - Partyboat Sampling - Weekly trips on commercial sport fishing boats monitoring angler success, catch species composition, and life history information of principle species

TEMP

12) Settling Plates - Subtidal study monitoring settlement rates of algae and invertebrates
13) Cliff Top Photos - Bimonthly, photographic, qualitative, algal abundance photos taken at each intertidal station
14) Quad Photos - Bimonthly photo documentation of qualitative condition of random point contact station locations
15) Fixed 1/4 Meter Quads (subtidal) - Bimonthly surveys of fixed subtidal quadrats providing quantitative data on the smaller invertebrates
16) Algal Scrapes - Semiannual collections of wet weight algal biomass to determine biomass and growth parameters of key intertidal species
17) Fixed Subtidal Arcs - Bimonthly observations of four fixed quadrants at each subtidal station, totalling 30 square meters of benthic substrate
18) Band Transects - Bimonthly intertidal surveys at fixed locations,

two elevations per location; provides quantitative estimates of algal and invertebrate abundance

19) Tegula Quads - Bimonthly intensive quantitative surveys of selected quadrats for invertebrates
20) Abalone Surveys - Quaterly abundance estimates of black abalone from selected stations; data provides growth estimates and information on movement
21) Crab Trapping - Bimonthly subtidal study examining growth, movement and population dynamics of the rock crab
22) Fish Observations - Bimonthly subtidal study examining abundance and diversity of nearshore fish populations
23) Random Line Point Contact (subtidal) - Bimonthly subtidal study documenting abundance of habitat forming algae and substrate
24) Random Point Contact (intertidal) - Bimonthly intertidal study documenting abundance of habitat forming algae and substrate
25) Physical Data Monitoring Study - Monthly monitoring of intertidal and subtidal seawater temperature, tide height, wave height and period, and surface and subtidal light intensity using self-contained, in situ data recorders

CDF&G

26) Perminent Transects (Abalone counts) - Counts of red and black abalone along intertidal transects performed twice each year
27) Random Transects (Algae, Invertebrates & Abalone) - Monitoring of randomly selected horizontal band transects in Diablo Cove and at control locations twice each year
28) 1/4 Meter Square Subtidal Quadrtats - Surveys of small randomly selected quadrats for invertebrates and algae performed once each year
29) 30 Meter Square Arcs - Surveys of large randomly selected arcs for invertebrate species composition and selected algal species performed once each year
30) Sea Otter Counts - Regular observations of abundance and behavior of Sea Otters in the vicinity of Diablo Cove
31) Random Baited Fish Stations - Random baited subtidal stations monitored by divers to determine abundance and species composition of resident fishes
32) Nereocystis Counts - Annual total count of Bull kelp plants in Diablo Cove

ECOMAR

33) Current Meter - Monitoring of current velocity and direction at a fixed nearshore location near the mouth of Diablo Cove
34) Temperature Recorder - Monitoring of temperature at a fixed nearshore location near the mouth of Diablo Cove
35) Sea Otter Observations - Monthly observations of abundance and behavior of Sea Otters between port San Luis Obispo and point Buchon

W.J.North

36) Intertidal Transects - Regular monitoring of fixed perpendicular intertidal transects in Diablo Cove and at control locations by W.J.North
37) Subtidal Transects - Regular monitoring of fixed subtidal transects in Diablo Cove and at control locations by W.J.North

California Water Quality Control Board

NPDES permit (Order No. 76-11) expired in June 1981. Application for reissuance of the permit was completed June 26, 1981. Public hearings were held by the Regional Board (September 11 and 24; October 9, 29, and 30; November 13 and 14, 1981; January 14, 1982) to allow the Board and the public to cross examine PGandE technical experts and consultants concerning the new permit. The Board adopted Order 82-24 on January 14, 1982. Two additional hearings (May 14 and June 11, 1982) were held to modify this order. Revision of the self-monitoring program was publicly discussed by the Board on September 10, 1982.

Amended Order 82-24 contains the fourth revision to the DCPP monitoring and reporting program since the first permit was adopted in 1976 (see Behrens 1978). A summary of revisions found in amended Order 82-24 and the ensuing Regional Board hearing of September 10, 1982, are presented in Chapter 7 of this volume.

The two technical reports required in Order 82-24, provision D.2, were submitted to the Board prior on April 1, 1982. One, an evaluation of alternatives to reduce the heat and volume of the cooling water discharge was entitled "Assessment of Alternatives to the Existing Cooling Water System" (PGandE, 1982a). The other, "Thermal Discharge Assessment Report" (PGandE, 1982b), is a synthesis of laboratory thermal effects data and population distribution information for animals living in the area of the power plant discharge. The report integrates this information with effluent flow and predicted temperature isotherms to produce risk assessment maps for key species.

Studies by the California Department of Fish and Game

Studies conducted at Diablo Canyon by the California Department of Fish and Game (CDF&G) under contract to PGandE began in 1969 with environmental investigations required under a 1966 agreement with the California State Resources Agency. This early marine research is described in Burge and Schultz (1973). The contract was renewed in 1973 and has subsequently been funded annually. The resulting study effort conducted by an onsite research team and reported upon in CDF&G annual reports, has documented the influence of the sea otter on the marine community in the vicinity of Diablo Canyon. A final preoperational phase report will be issued as a separate volume.

Thermal Effects Monitoring Program

The studies previously referred to as the 316(a) demonstration program were renamed the Thermal Effects Monitoring Program (TEMP) during 1981, due to inaction by the U. S. Enviromental Protection Agency to repromulgate the remanded guidance for implementation of Section 316(a) of the Federal Water Pollution Control Act amendments of 1972. Although, apparently no longer required under the act, a thermal effects assessment program continues to be a requirement of the CCRWQCB under the receiving water monitoring section in the NPDES permit. The 316(a) program's experimental design and monitoring stations will be maintained to meet the NPDES requirement.

PGandE's TEMP program entered its sixth year of preoperational intertidal and subtidal biological research in 1982. A modified program was established which will remain in effect until the startup of DCPP. A thorough treatment of TEMP field biology and thermal effects laboratory experimentation was included in Mayer et al. (1981, 1982).

Endangered Species

In October 1979, the U. S. Fish and Wildlife Service (USFWS) Acting Regional Director in Portland, Oregon, contacted the USNRC Acting Chief of Environmental Projects in Washington D.C. expressing concern over possible power plant impacts to five endangered species: the California brown pelican, American peregrine falcon, California least tern, southern sea otter, and the gray whale. USFWS requested a formal consultation with NRC representatives as stipulated in Section 7 of the Endangered Species Act of 1972 (Publc Law 83-205 amended by PL 95-632). In January 1980, the consultation meeting was held in the USFWS offices in Sacramento, California, and included representatives of USFWS, USNRC, and the CDF&G DCPP field team. Arrangements were made to provide USFWS with copies of Pacific Gas and Electric Company reports pertaining to baseline studies of the marine biota in the vicinity of Diablo Cove, and concerning ocean currents and thermal plume modeling investigations.

Following the meeting, USNRC formally requested USFWS to render a determination pursuant to Section 7 of the Endangered Species Act, as to the effects of the operation of Diablo Canyon Power Plant on the five endangered species, and to prepare an opinion on "whether the plant operation would result in any effect on critical habitat or would jeopardize the continued existance of the five species."

January 19, 1980, the Regional Director of USFWS office in Portland responded in a ten page letter discussing the status of the southern sea otter, the California brown pelican, the California least tern and the American peregrine falcon on the west coast. The Regional Director concluded that, "it is the opinion of the Service that operation of DCPP is not likely to jeopardize the continued existence of the (five) species." The USFWS

letter went on to urge NRC to encourage PGandE to pursue eight study elements covering a variety of environmental concerns. The USFWS acknowledged that some of the activities were already established as part of an on-going PGandE monitoring program. Jurisdiction over the gray whale was determined to be the responsibility of the National Marine Fisheries Service (NMFS), thus, the Regional Director of this agency responded to the NRC request. The NMFS Regional Director's letter to USNRC concluded that, "the operation of the nuclear generating station at Diablo Canyon, California, is not likely to jeopardize the continued existance of any of the threatened or endangered species under the purview of the National Marine Fisheries Service." The gray whale was mentioned specifically as were the more pelagic humpback whale, sperm whale, right whale, blue whale, fin whale and sei whale.

Prior to this agency review of the status of endangered species at Diablo Canyon, PGandE had supported a program of twice monthly observations of California sea otter behavior and movement along the coast near the power plant site. This work which was began in 1973 continued throughout 1982. The results of the program are presented in Chapter 11 of this volume.

Following the confirmed sitings of a pair of American peregrine falcons in March 1981, on the nearshore rock islands adjacent to the DCPP site, PGandE funded an observer from the Santa Cruz Predatory Bird Research Group (SCPBRG) at the University of California, Santa Cruz to watch the birds during the nesting season. The results of this work were reported in Walton (1982). A summary report on observations during the 1982 nesting season appears as Chapter 12 of this report.

Concerns expressed by intervenors during the DCPP NPDES hearings concerning the possible influence of the power plant thermal discharge on migrating gray whales prompted PGandE to initiate a program of regular observations of whale behavior as they pass near the plant site. The results of the first year of whale observations (1981 - 1982 season) prior to power plant operation are contained in Chapter 13.

Acknowledgements

The guidance for the studies described herein was provided by the California State Water Resources Control Board; the California Department of Fish and Game and the United States Nuclear Regulatory Commission. The PGandE study effort directed by R. F. Cayot, Chief, Department of Engineering Research, was under the immediate supervision of Dr. J. R. Adams, Supervising Biologist, Ecological Sciences Section. Mr. J. W. Warrick, Senior Biologist, was on-site coordinator of all studies for NPDES, TEMP, CDF&G, and was the line supervisor of on-site DER personnel. Mr. M. J. Doyle, Jr., Senior Environmental Specialist, directed the physical oceanographic studies, and Mr. B. F. Waters, Senior Biologist, was Project Manager for the Thermal Effects Monitoring Program.

Groups under contract to PGandE for various services include:

American Aerial Surveys, Inc., Sacramento, California
Battelle Pacific Northwest Laboratories, Richland, Washington
California Polytechnic State University Foundation, San Luis Obispo, California
California Department of Fish and Game, Sacramento, California
Cenco, San Luis Obispo, California
ECOMAR, Inc., Goleta, California
Environmental Devices Corporation, Marion, Massachusetts
Intersea Research, Solana Beach, California
Kaiser Engineers, Inc., Oakland, California
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PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH

OCEANOGRAPHIC STUDIES, 1982
DIABLO CANYON POWER PLANT

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

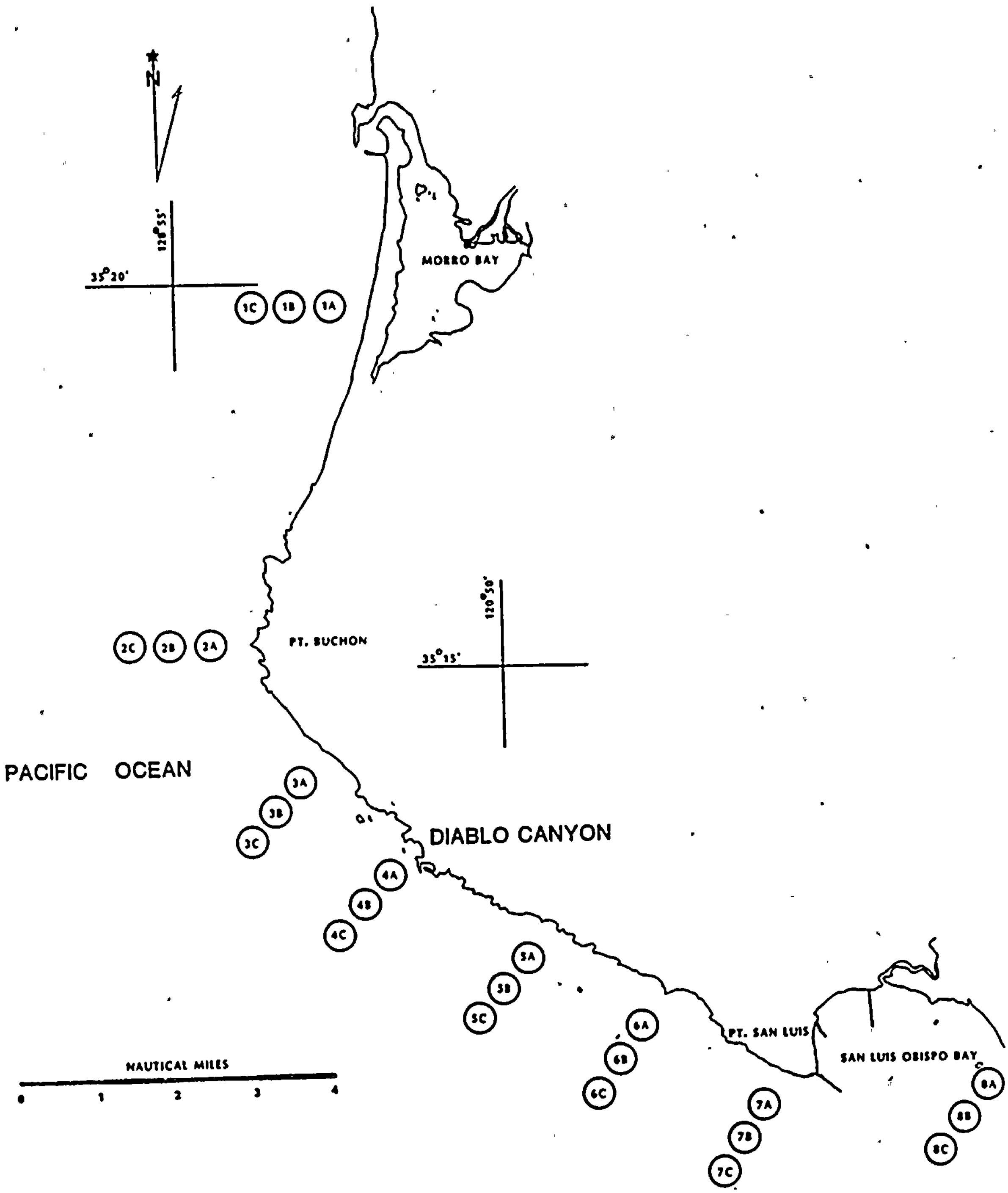
Oceanographic studies were conducted by Pacific Gas and Electric Company in the vicinity of the Diablo Canyon Power Plant. Temperature, salinity, and dissolved oxygen were monitored at 27 stations in February, June, and September during the year of 1982. pH was sampled at 12 stations in and near Diablo Cove. Temperature profiles, from surface to bottom, were made at each station. Water samples were collected just below the surface, at mid water column, and 0.5m above the bottom at each station. Surface drogues were released six times during the year to measure offshore currents.

INTRODUCTION AND OBJECTIVES

This report contains the Diablo Canyon oceanographic data obtained during studies conducted in 1982 by the Department of Engineering Research (DER) of the Pacific Gas and Electric Company (PGandE). The studies were designed to monitor physical parameters (currents, density characteristics, and water quality) in the area and to augment the preoperational environmental data base for PGandE's power plant at Diablo Canyon. Similar data have been obtained from 1966 through 1981 and may be found in the Diablo Canyon Environmental Report and its supplements 1 through 6; the 1975-1977 Annual Report; and the 1978, 1979, 1980, and 1981 Annual Reports.

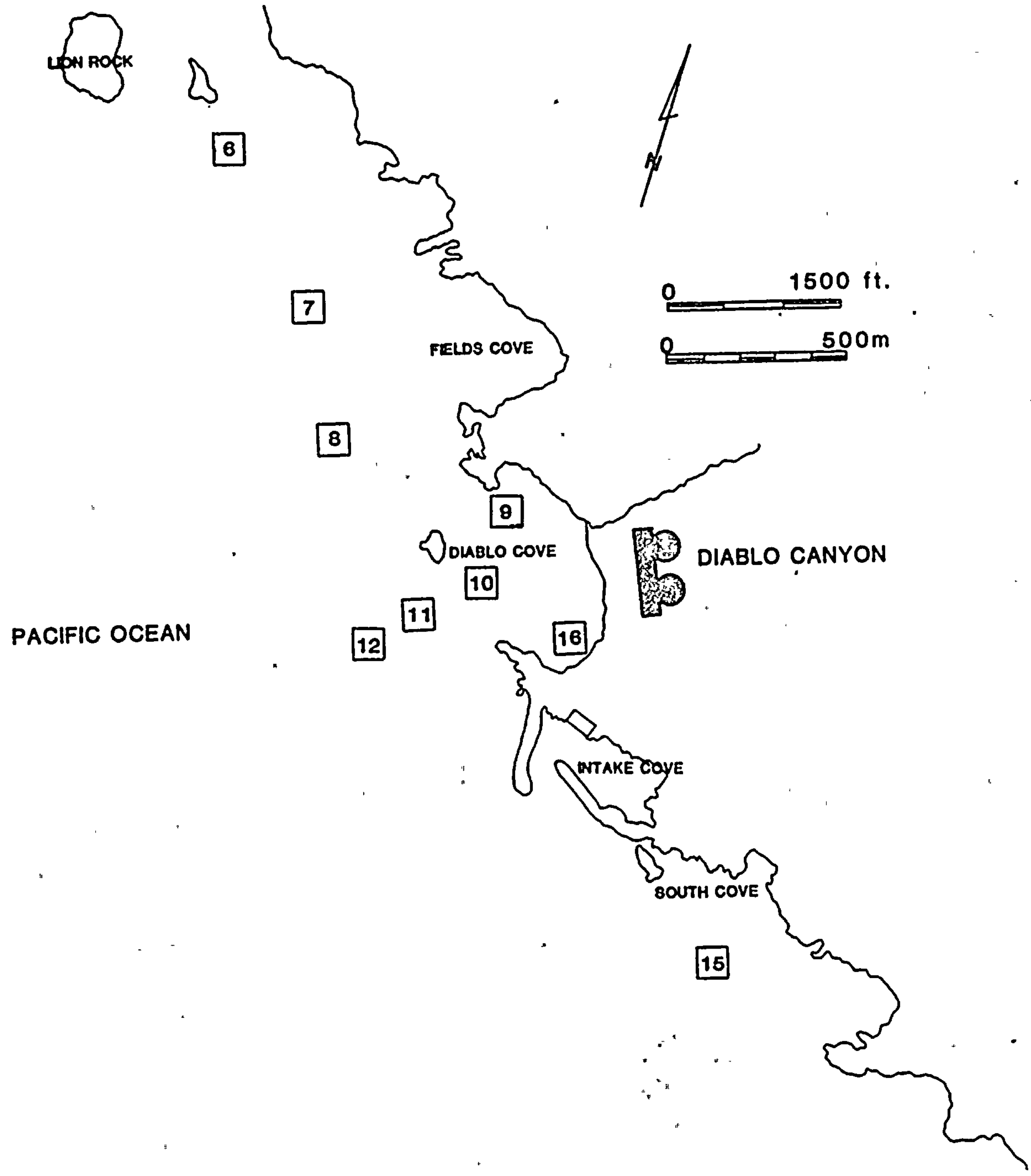
Beginning in 1972, temperature, dissolved oxygen, and salinity data were collected at 24 stations (Figure 1) three times during the year. The pH samples were collected at stations 3A through 5C. These station locations were selected to provide data from within and beyond the predicted thermal plume.

The California Department of Fish and Game (CDF&G) designated nine additional stations (Figure 2) in the vicinity of Diablo Cove for monitoring. Light transmittance measurements were to be made at all nine stations when the circulating water pumps (CWP's) were in operation. At CDF&G stations 10, 11, and 12 temperature, dissolved oxygen, salinity, and pH samples were taken to coincide with the sampling of oceanographic stations. The water quality sampling design is summarized in Table 1.



OCEANOGRAPHIC STATIONS

FIGURE 1



CDFandG DESIGNATED MONITORING STATIONS

FIGURE 2

STATION NO.	DEPTH FT.	DEPTH M.	temp.	sal.	diss. O_2	pH	% light trans
			PARAMETER TO BE MEASURED				
1A	65	19.5	X	X	X		
1B	100	30.0	X	X	X		
1C	138	42.1	X	X	X		
2A	85	25.9	X	X	X		
2B	165	50.3	X	X	X		
2C	195	58.5	X	X	X		
3A	125	37.5	X	X	X	X	
3B	175	45.0	X	X	X	X	
3C	200	60.0	X	X	X	X	
4A	130	39.0	X	X	X	X	
4B	175	53.3	X	X	X	X	
4C	200	60.0	X	X	X	X	
5A	70	21.0	X	X	X	X	
5B	95	28.5	X	X	X	X	
5C	105	31.5	X	X	X	X	
6A	70	21.0	X	X	X		
6B	80	24.0	X	X	X		
6C	120	36.6	X	X	X		
7A	60	18.0	X	X	X		
7B	85	25.5	X	X	X		
7C	120	36.0	X	X	X		
8A	40	12.2	X	X	X		
8B	40	12.2	X	X	X		
8C	60	18.0	X	X	X		X
6	38	11.5					X
7	55	16.6					X
8	50	15.0					X
9	20	6.0					X
10	24	7.0	X	X	X	X	X
11	54	16.0	X	X	X	X	X
12	70	21.0	X	X	X	X	X
15	60	18.0	X	X	X	X	X
16	13	4.0	X	X	X	X	X

DIABLO CANYON MONITORING

TABLE 1

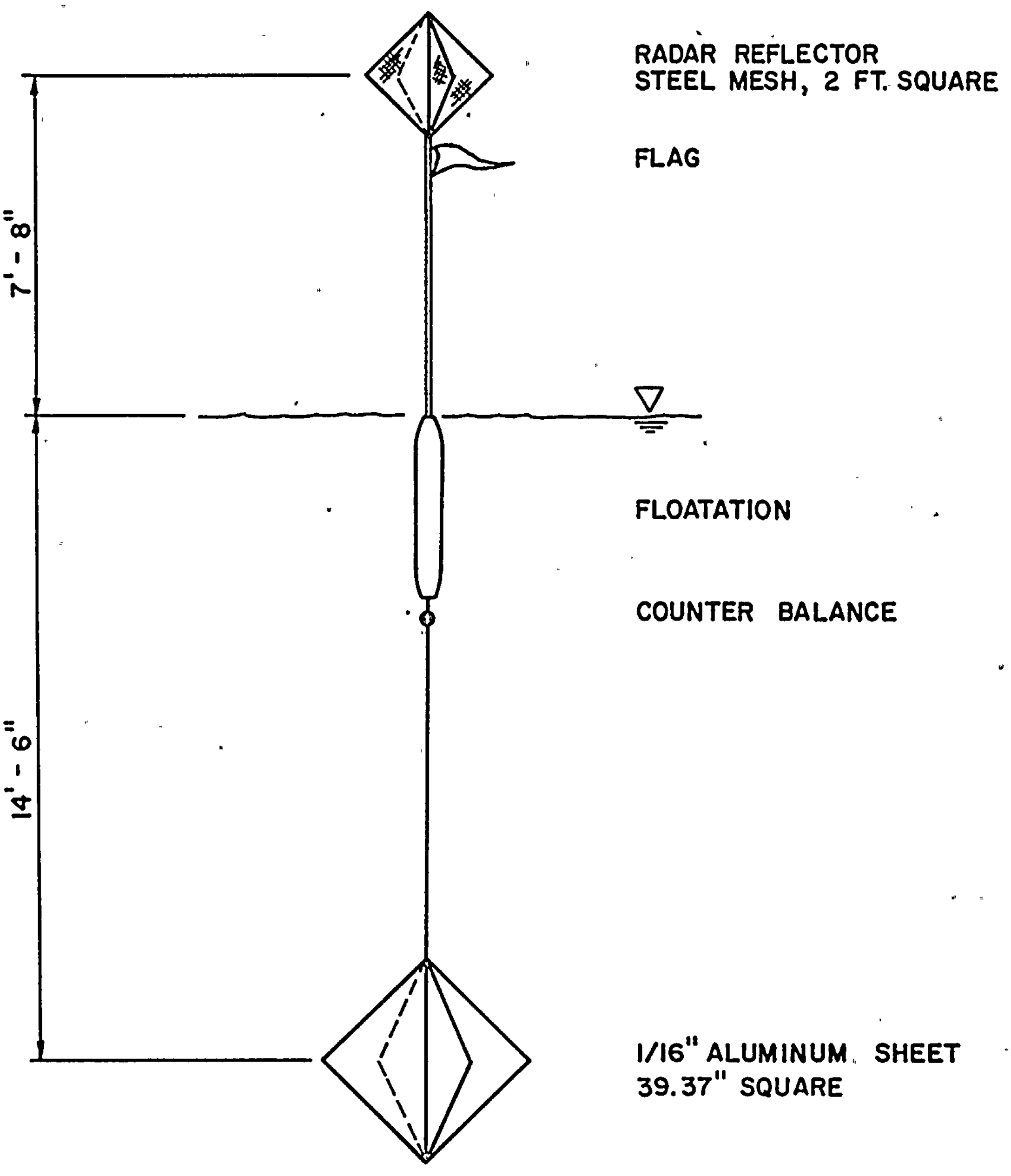
Surface current drogues were released six times during the year. Drogue studies were used to provide information on the local and seasonal influences on the coastal current system in the vicinity of Diablo Canyon.

METHODS

A bathythermograph was used to obtain surface to bottom temperature profiles. Surface temperature values were measured with a bucket and/or digital thermometer. Frautschy bottles were used to collect the salinity, dissolved oxygen, and pH samples. These samples were collected just below the surface, mid-depth, and at 0.5m above the bottom. The dissolved oxygen samples were immediately preserved with alkaline iodide azide and manganous sulfate. Samples were transported to the on-site oceanography laboratory for processing.

A Grundy Model 6230N laboratory salinometer was used to determine salinity concentrations. The salinometer was routinely standardized with Copenhagen Standard Seawater during the analysis as outlined in the basic operating procedures. Dissolved oxygen was determined by the Standard Winkler Titration, Alsteberg Modification Method. The pH measurements were made with an Orion Model 407A pH meter.

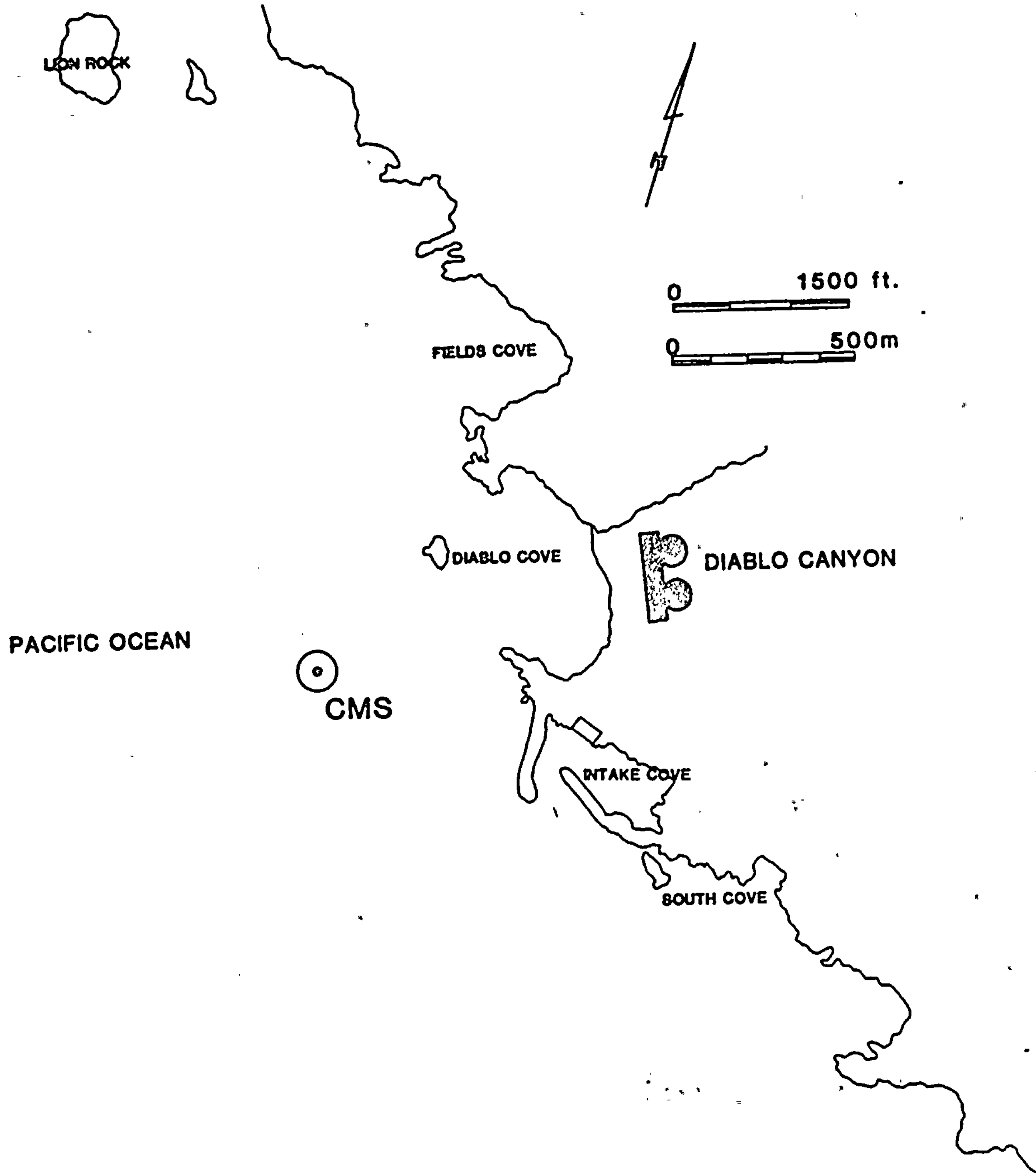
The Lagrangian method was used to determine ocean currents in the area. Six current studies were conducted throughout the year. Each survey consisted of releasing a current drogue (Figure 3) at a known reference



CURRENT DROGUE

1/4" = 1'-0"

FIGURE 3



CURRENT METER STATION

FIGURE 4

station (Figure 4), and the determining its position with a shipboard digital ranging radar system.

RESULTS

The data collected during the 1981 Oceanographic studies is summarized in Appendix A. Data collected for the CDF&G Stations 10, 11, and 12 are presented in the reports titled "The Quarterly Report on Waste Discharge Monitoring at Diablo Canyon Power Plant Site."

Subsurface light measurements were not made during 1982 since the CWP's were not operated for a sustained period of time.

CDFandG Stations 10, 11, and 12 were not sampled during the June oceanographic survey. These stations were not sampled because of their close proximity to a peregrine falcon nesting site on Diablo Rock. Peregrine falcons are both a state and federal endangered species.

Also during the June survey, unusually high dissolved oxygen levels were noticed at the down coast stations, near Point San Luis and within San Luis Obispo Bay. These levels were probably due to the phytoplankton bloom that had been observed in that area (R. Massengill, Tera Corp., personal communication).

REFERENCES

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Supplement No. 1:
Information required by 10CFR50 Appendix D, as amended effective 9/9/71; AEC document "Scope of Applicant's Environmental Reports with Respect of Transportation, Transmission Lines, and Accidents" 9/1/71. (11/9/71)

Supplement No. 2:
Vol. I - Responses to the questions attached to AEC's 7/12/72 letter; cost-benefit information prepared in accordance with AEC 5/72 guide; information supplementing and updating information previously submitted. Vol. II - Appendices. (7/28/72)

Supplement No. 3:
Two additional appendices covering construction manpower data and a model investigation of Unit 1 discharge structure. (8/25/72)

Supplement No. 4:
"Environmental Investigations at Diablo Canyon, 1972-73"; "Chemical, Biological, and Corrosion Investigations Related to the Testing of the Diablo Canyon Unit 1 Cooling Water Systems." (5/16/75)

Supplement No. 5:
"Environmental Investigations at Diablo Canyon, 1974"; updated information concerning need for Units 1 and 2 at Diablo Canyon site. (8/1/75)

Supplement No. 6:
Updated information concerning environmental impacts of construction and operation and related studies and investigations. (8/18/75)

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APPENDIX A

Report Issued: APR 0 3 1983

Report 411-82.222

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH

DIABLO CANYON POWER PLANT NEARSHORE SEAWATER TEMPERATURE ANALYSIS, 1978-1982

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M. J. DOYLE, Senior Environmental Specialist

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TABLE OF CONTENTS

LIST OF FIGURES

Report 411-82.222

ABSTRACT

Seawater temperatures were monitored from October 1978 to December 1982, by Pacific Gas and Electric (PGandE) offshore of the Diablo Canyon Power Plant. Temperature data was collected on an hourly basis at a station approximately 2,000 feet off the entrance of Diablo Cove. The station is in 100 feet of water and a single recording thermograph was bouyed 10 feet below the surface.

Daily and monthly mean seawater temperatures, along with seasonal trends for the 51 month period are discussed. These data are compared to the seawater temperature data for the subtidal zone that were reported by Holmbeck and Warrick (1979) and Warrick (1979).

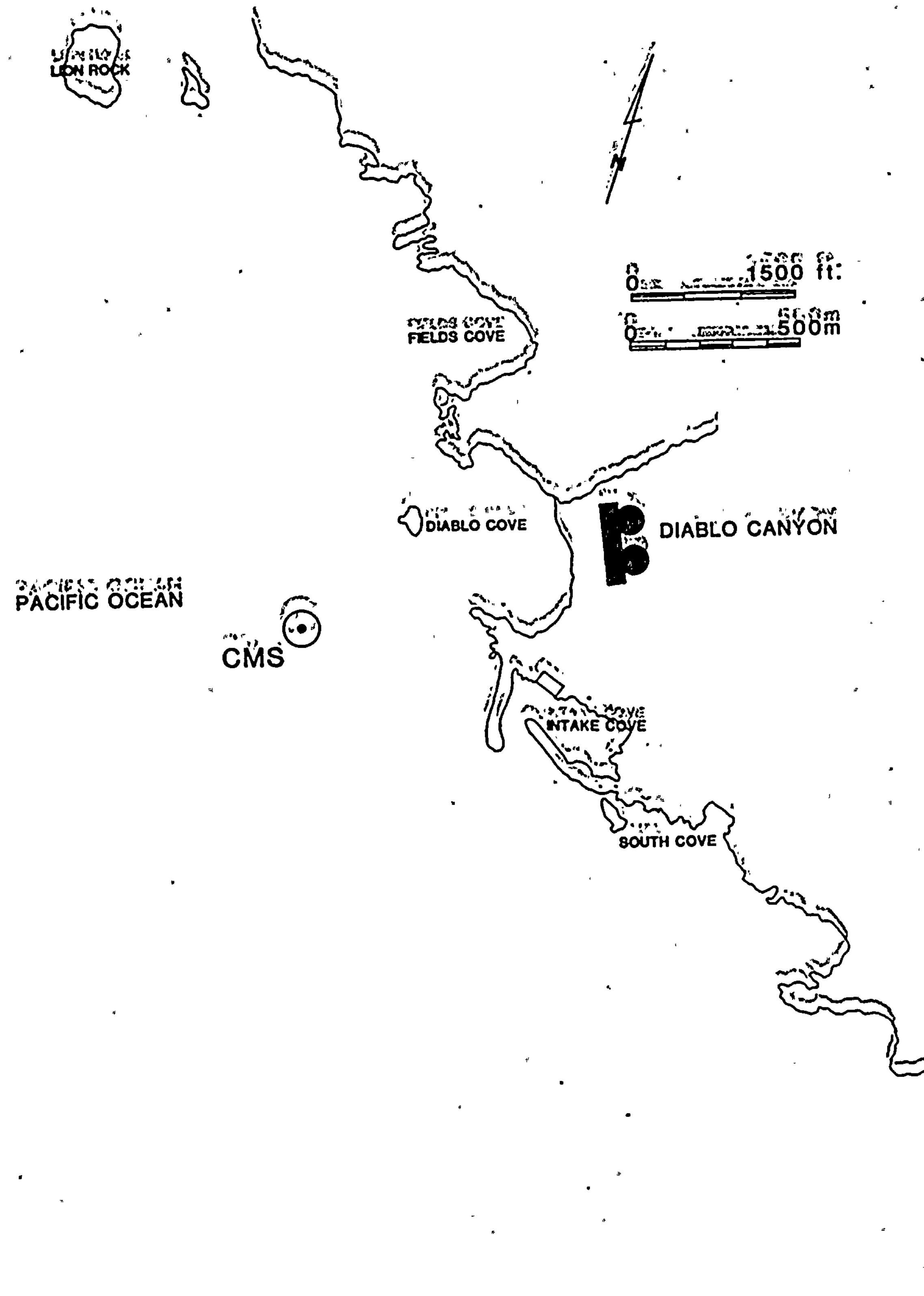
INTRODUCTION

This report presents the results of the nearshore seawater temperature measurements made in the vicinity of Pacific Gas and Electric's (PGandE) Diablo Canyon Power Plant (DCPP) on the Central California Coast (Figure 1). The objectives of this report are; 1) to supply ancillary information to the existing seawater temperature analysis for the intertidal and subtidal zones; and 2) to document annual variations in the nearshore temperature regime within the study area before DCPP becomes operational.

BACKGROUND INFORMATION

Temperature data has been collected in the vicinity of Diablo Canyon since 1967. Before water temperatures were monitored at Diablo Canyon, Kritikos and Gromly (1967) used temperature data reported by Scripps Institution of Oceanography (SIO) in annual temperature reports from Morro Bay and Avila Beach to predict surface seawater temperatures near Diablo Cove. By averaging these data, Kirtikos and Gormly predicted an annual mean temperature at Diablo Canyon to be 13.7°C $\pm$ SD (standard deviation) 1.6°C. Kirtikos and Gormly also used data from Islay Creek, which is located closer to Diablo Canyon, and developed a more probable annual mean of 13.1°C $\pm$ SD 1.4°C. They also predicted that the maximum temperature for any one year is expected to range between 15.9°C and 17.5°C (in August) and the minimum would be approximately 10.5° (in March).

Holmbeck and Warrick (1979) compared these water temperature predictions with data collected at a subtidal station (3m depth), just south of Diablo Canyon during 1967, 1968, and 1970 through 1975.



CMS TEMPERATURE MONITORING STATION

FIGURE 1

Their report indicated that temperature values for Diablo Canyon were generally lower than the annual mean values reported from Morro Bay and Avila Beach. However, the annual mean temperatures reported by Holmbeck and Warrick (ranging from 11.3°C to 13.1°C), were similar to the prediction of Kritikos and Gormly (1967) from the Islay Creek data.

The annual maximum temperature reported by Holmbeck and Warrick (1979) for Diablo Canyon ranged from 15.1°C to 17.4°C. This range was consistent with the 15.1°C to 17.5°C predicted by Kritikos and Gormly (1967). The maximum temperatures occurred during the late summer and early fall. Holmbeck and Warrick (1979) also reported that the yearly minimum seawater temperature ranged from a low of 6.7° in April of 1973 to 9.4°C in April of 1968.

Warrick (1979) reported subtidal temperatures from 4 stations in Diablo Cove from August 1972 to December 1977. These stations ranged in depth from 1.0 m to 9.1 m. The study reported that minimum temperatures for the subtidal zone occurred around February and March of each year and ranged from 8.2°C to 9.1°C. Annual maximum temperature was measured in the late summer or early fall, and fluctuated between 14.6°C and 20.2°C. These maximum temperatures are somewhat higher than those predicted by Kritikos and Gormly (1967) and the temperatures reported by Holmbeck and Warrick (1979). This is probably due to the temperature stratification reported by Warrick (1979) throughout Diablo Cove during the annual warming trend (June through October).

DIABLO CANYON CMS MONITORING STATION

LORAN. C	27786.0	42089.4
SONAR	95' - 100'	
CALIF. COORDINATES	633,365 N	1,145,020 E
LONGITUDE & LATITUDE	35° 12' 27"	120° 51' 47"

	TARGET	DIABLO ROCK	WEST BREAKWATER	LION ROCK
RADAR	RANGE NAUTICAL MILES	.23	.35	.69
	BEARING MAGNETIC	18°	81°	314°

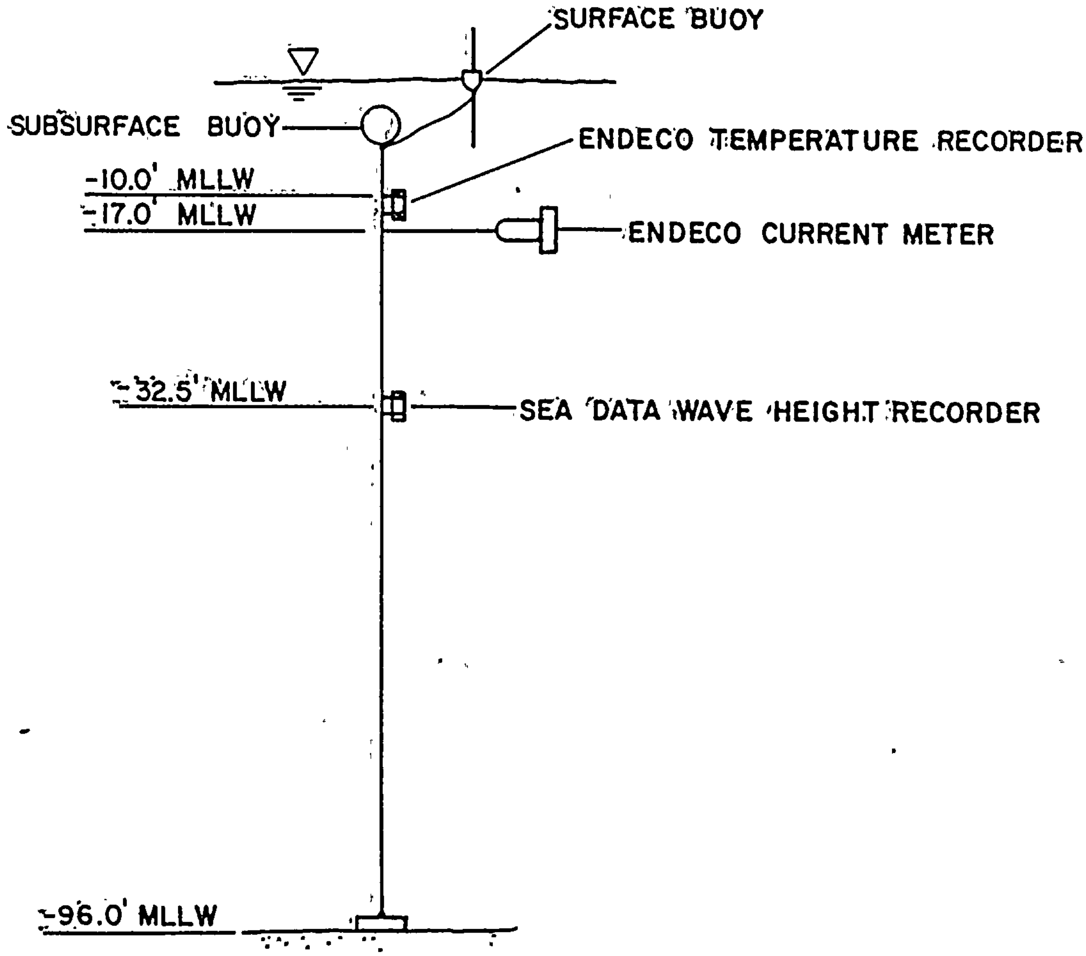


FIGURE 22

METHODS

Temperature measurements were made on a hourly basis from October of 1978 to the present. Data was collected at a fixed current meter station (CMS) which is approximately 2,000 feet off the entrance of Diablo Cove (Figure 2). The station is in 100 feet of water and a single ENDECO Type 109 recording thermograph was bouyed 10 feet below the surface.

The ENDECO thermograph unit photographically records an hourly mean temperature from a precision glass/mercury thermometer. The standard temperature accuracy of the instrument is ±0.2°C with a time accuracy of ±1.5 seconds/day.

The recording thermograph was retrieved and serviced on a monthly schedule by SCUBA divers. The film package which contained the recorded data was sent to ENDECO and/or ECOMAR for preliminary processing (for data conversion processing procedures, see Appendix B).

RESULTS AND DISCUSSION

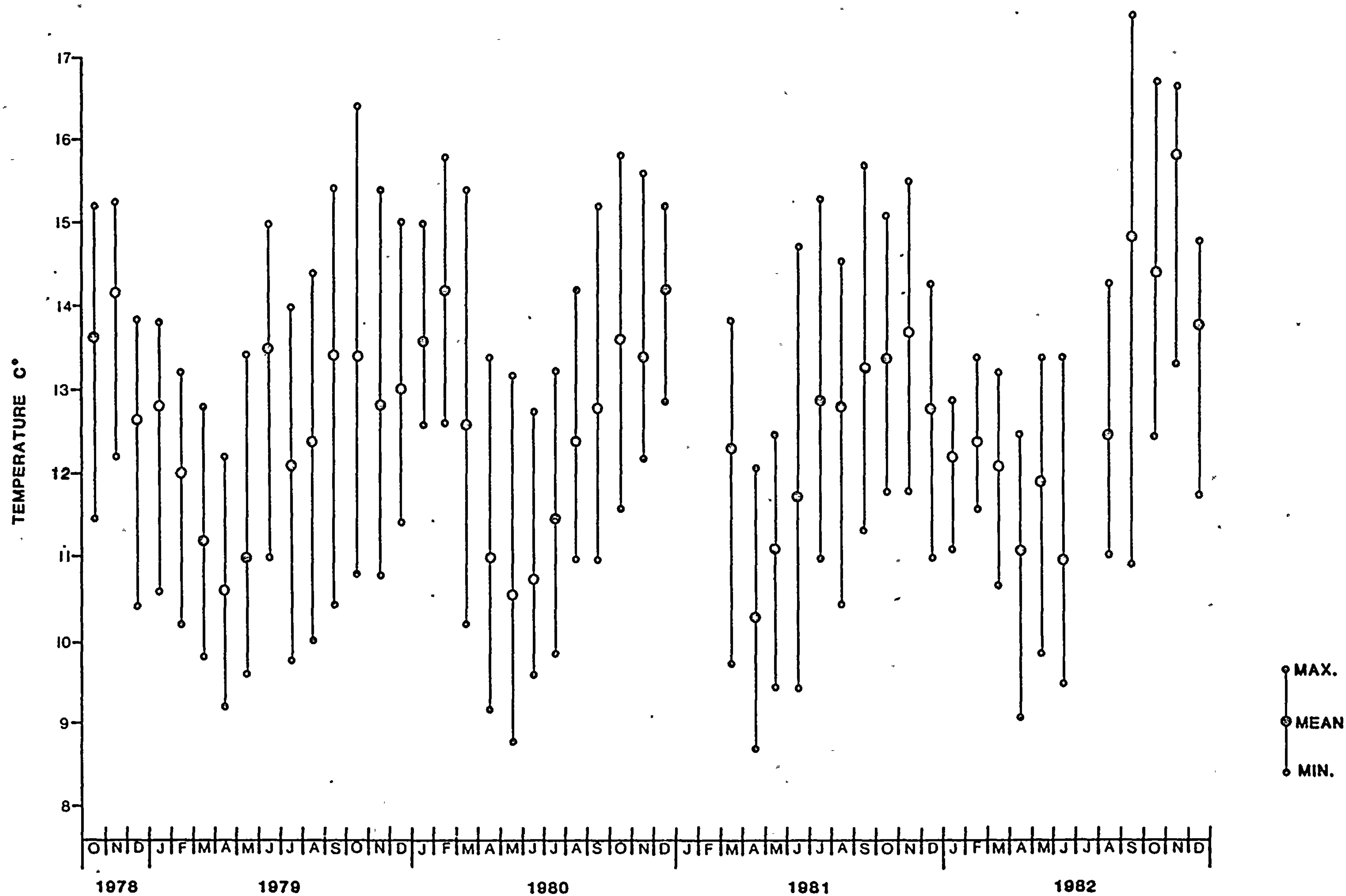
Seawater temperatures were collected for 51 months between October of 1978 to December of 1982. Temperatures ranged from a high of 17.5°C on September 22, 1982, to a low of 8.7°C on May 24, 1980 and April 7, 1981. These seawater temperature values were consistent with the minimum and maximum range (8.2°C to 20.2°C) reported by Warrick (1979) for the subtidal zone within Diablo Cove. The annual mean seawater temperature in the nearshore region off Diablo Cove ranged from 12.3°C to 13.0°C. The temperature data from 1978 was not included in the range since the yearly mean would have been based on only 3 months of data. The range of the

annual means for this study were compatible with the range (11.3°C to 13.1) of the annual means reported by Holmbeck and Warrick (1979).

The seawater temperature regime of the nearshore area off Diablo Canyon exhibited seasonal fluctuations. Figure 3 shows the annual variation of the mean monthly temperatures recorded at the CMS monitoring station. The illustrations show that a cooling trend begins between February and March, with mean monthly temperature reaching a minimum in April or May. A seasonal warming trend generally starts in May or June, and the maximum mean monthly temperatures occur in September or October. These findings are consistent with the findings of the temperature studies conducted by Warrick (1979), which reported a distinct and abrupt cooling trend beginning in March, with the lowest mean monthly temperatures being recorded during March, April, and May. Warrick (1979) also reported a gradual warming trend in mean monthly temperature generally beginning in June, which usually produced the highest mean monthly temperatures in October.

Although these seasonal temperature patterns were similar in onset and duration times during these warming and cooling periods, there was considerable variation in their respective mean monthly temperatures from year to year.

The minimum monthly mean temperatures for each year ranged from a low of 10.3°C ± SD 0.6°C in June of 1982 to a high of 11.0°C ± SD 0.8°C in May of 1980 (Figure 3). These minimum temperatures recorded in the late spring coincide with the Upwelling Period of the California Current System. During the Upwelling Period,



Nearshore Mean Monthly Temperatures off Diablo Canyon

FIGURE 3

under the influence of the prevailing strong west-northwest winds, surface water is transported away from the coast and is replaced by subsurface water which is uniformly colder (Gosink and Weigel 1979).

The maximum mean monthly temperatures for each year, which were usually recorded in the early fall, ranged from 15.8°C ± SD 0.5°C in November of 1982 to 13.5°C ± SD 1.1°C in October of 1979 (Figure 3). These maximum temperatures in the early fall are expected during the Davidson Current Period (Cannon, Laird, and Ryan 1979). These maximum and minimum mean monthly temperature values coincide with the mean monthly temperature range (high 16.6°C, low 10.3°C) reported by Warrick (1979), for the subtidal zone in the vicinity of Diablo Canyon between 1972 and 1977.

Figures 4 through 8, which show the mean daily temperatures recorded at the CMS monitoring station for each of the survey years, also shows several short periods of natural warming and cooling fluctuations within the typical seasonal warming (June through October) and cooling (November through May) periods. These short term temperature fluctuations in the seasonal patterns ranged in duration from less than a day to of over a week. Many of these short term heating and cooling cycles exhibited temperature variations of several degrees in a 24-hour period.

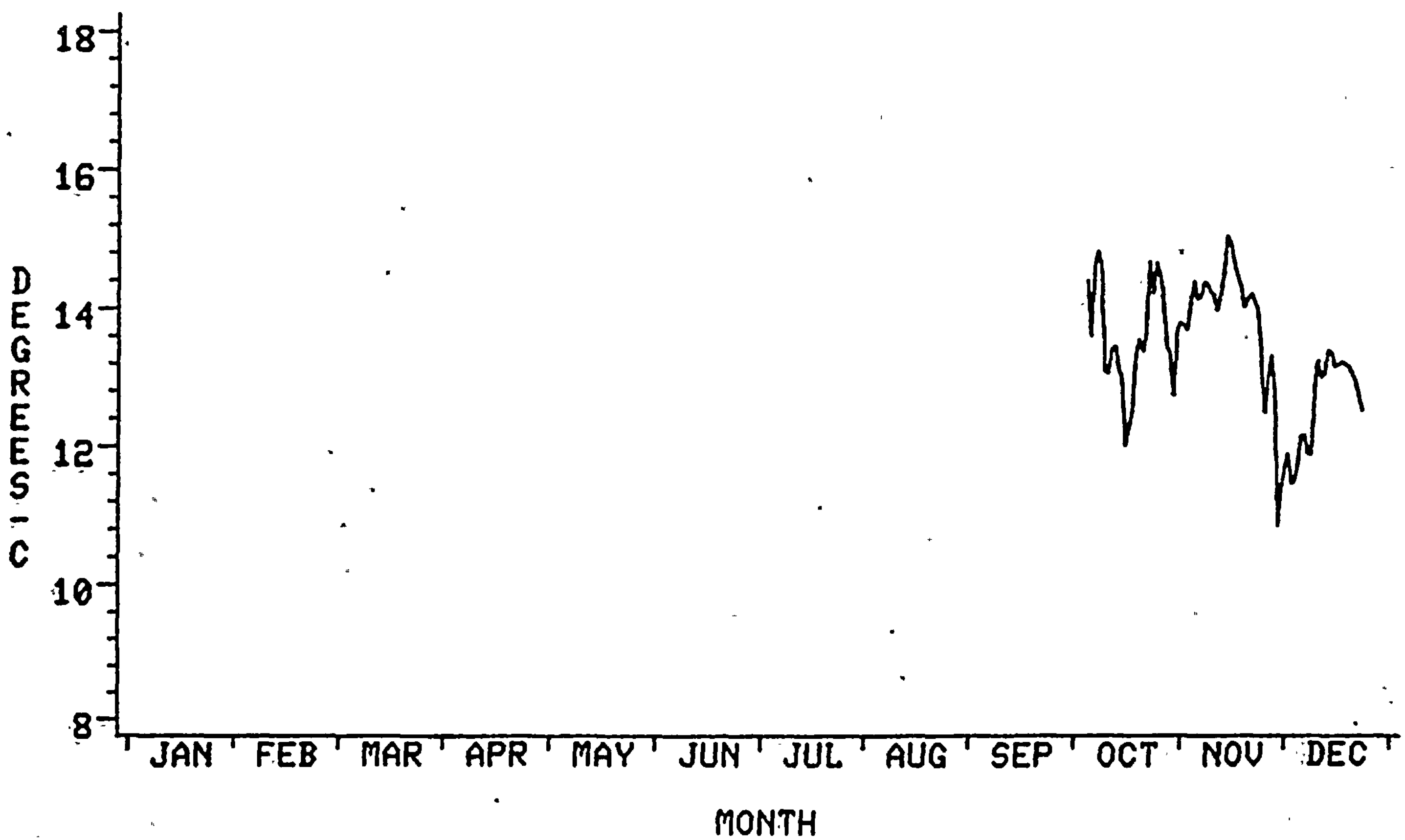
Daily variations in seawater temperatures are summarized as daily range (Appendix A). The largest variation in the daily range (2.5°C) was observed on June 1, 1980, when the temperature ranged from a high of 12.8°C to a low of 10.4°C. The smallest fluctuation (0.4°C), in daily temperatures occurred on several days during December, January, and February in several of the survey years. Daily ranges for each month were

averaged in order to document the monthly and seasonal trends in daily seawater temperature fluctuations. Minimum mean daily ranges (0.5°C to 0.6°C) generally occurred during the months of December and January. The mean daily range usually increased to a maximum (1.4°C to 1.8°C) during August and September for each year. The overall trend in the mean daily range shows an increase during the middle of spring, with a peak usually in late summer, and then begins to diminish in the early fall. These findings are in agreement with the trends reported by Warrick (1979), who concluded that the lowest mean daily ranges (0.5°C to 1.0°C) occurred during the winter and that the mean daily range increased during the spring to a maximum (1.2°C to 1.7°C) in the summer.

CMS TEMPERATURE MONITORING STATION

MEAN DAILY TEMPERATURE

YEAR=1978



CMS TEMPERATURE MONITORING STATION

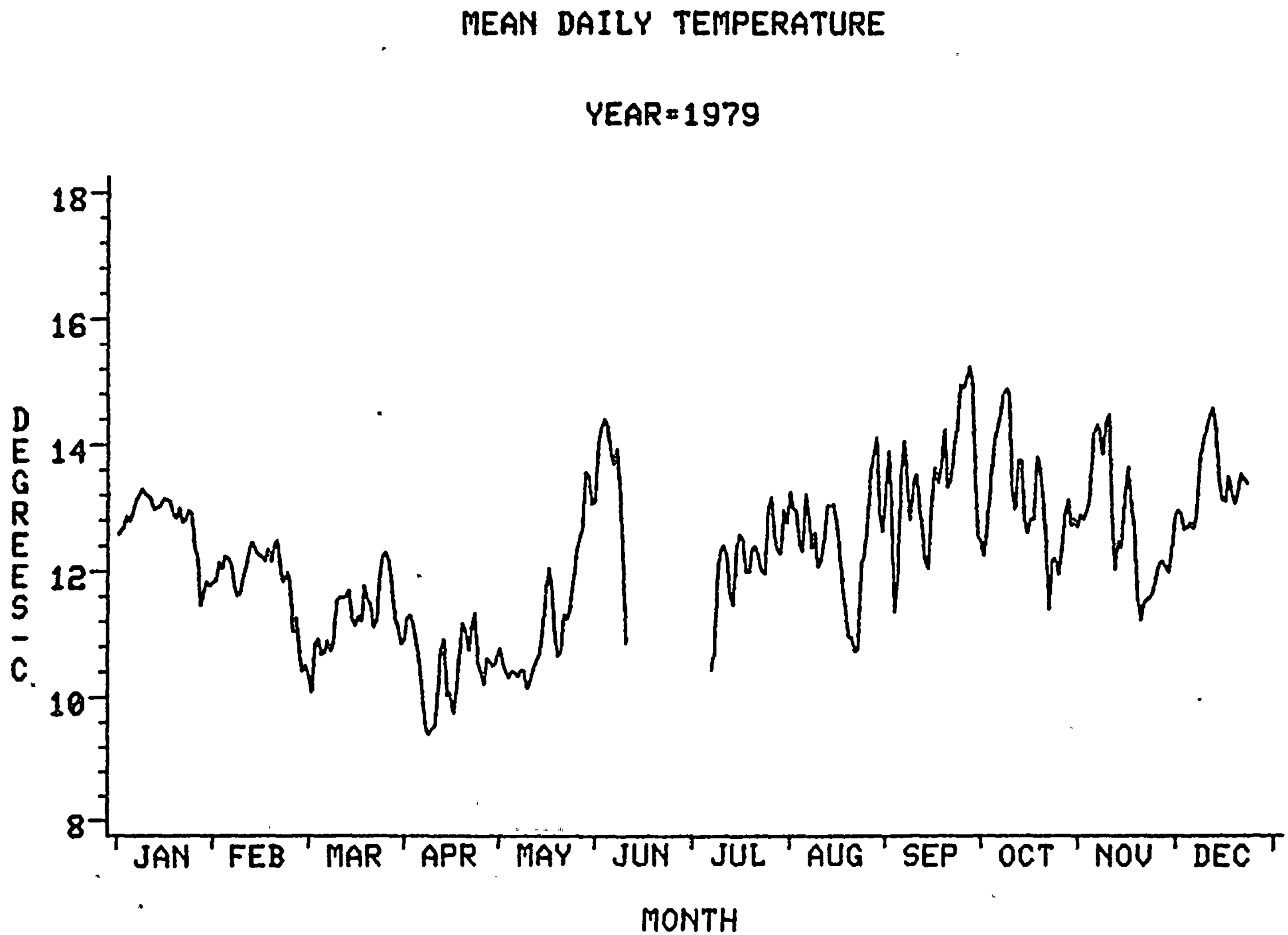
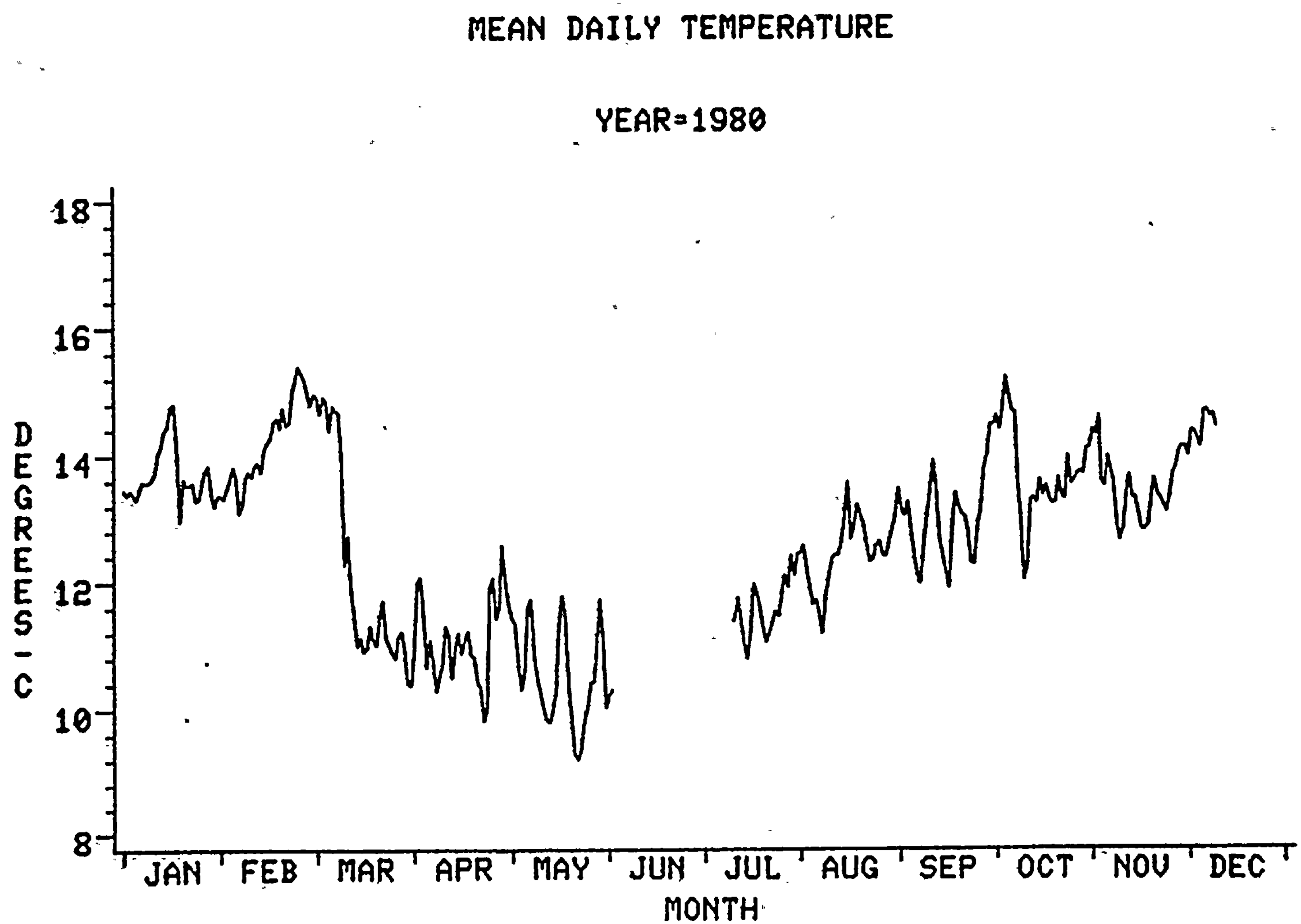


FIGURE 5

CMS TEMPERATURE MONITORING STATION



CMS TEMPERATURE MONITORING STATION

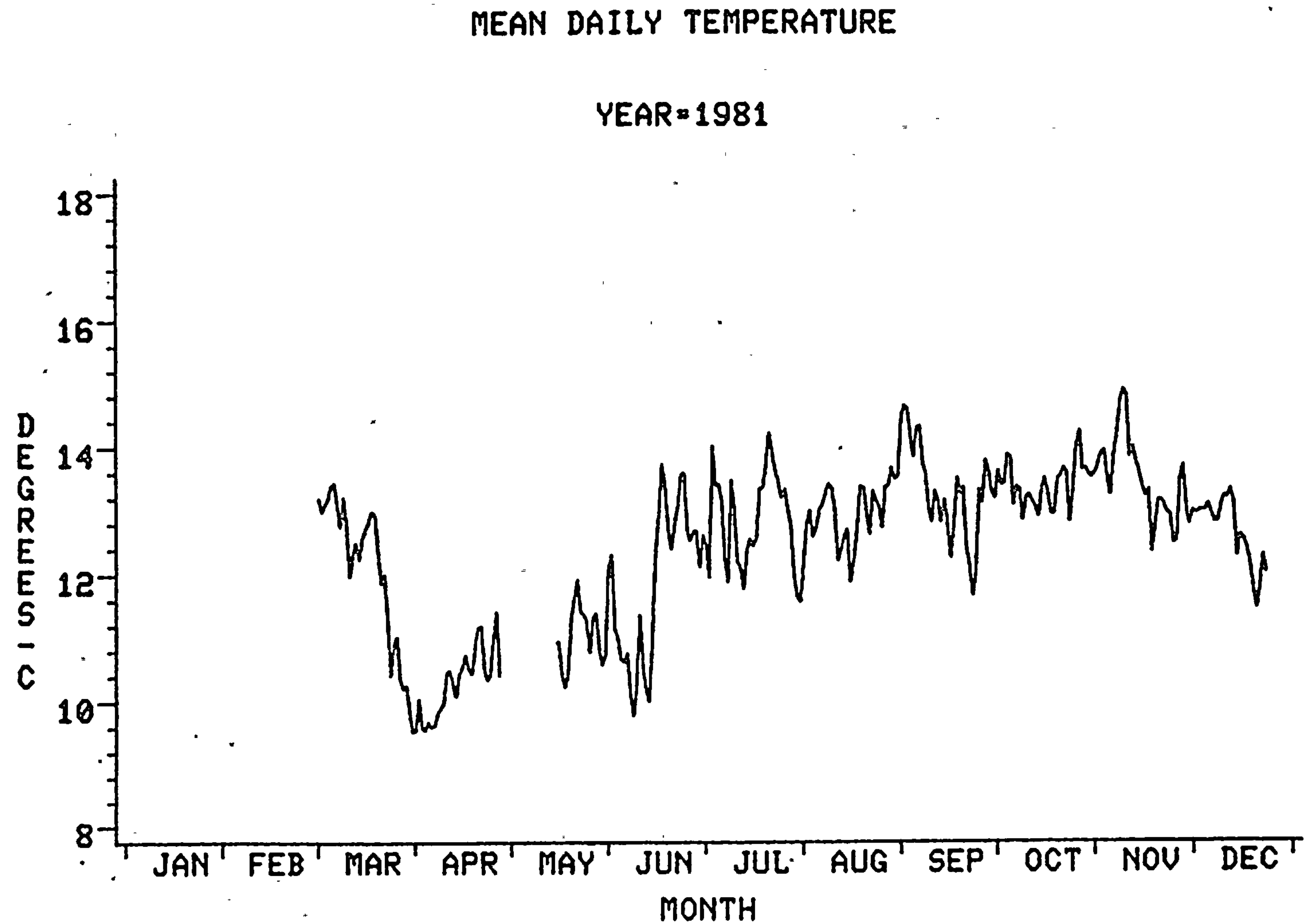
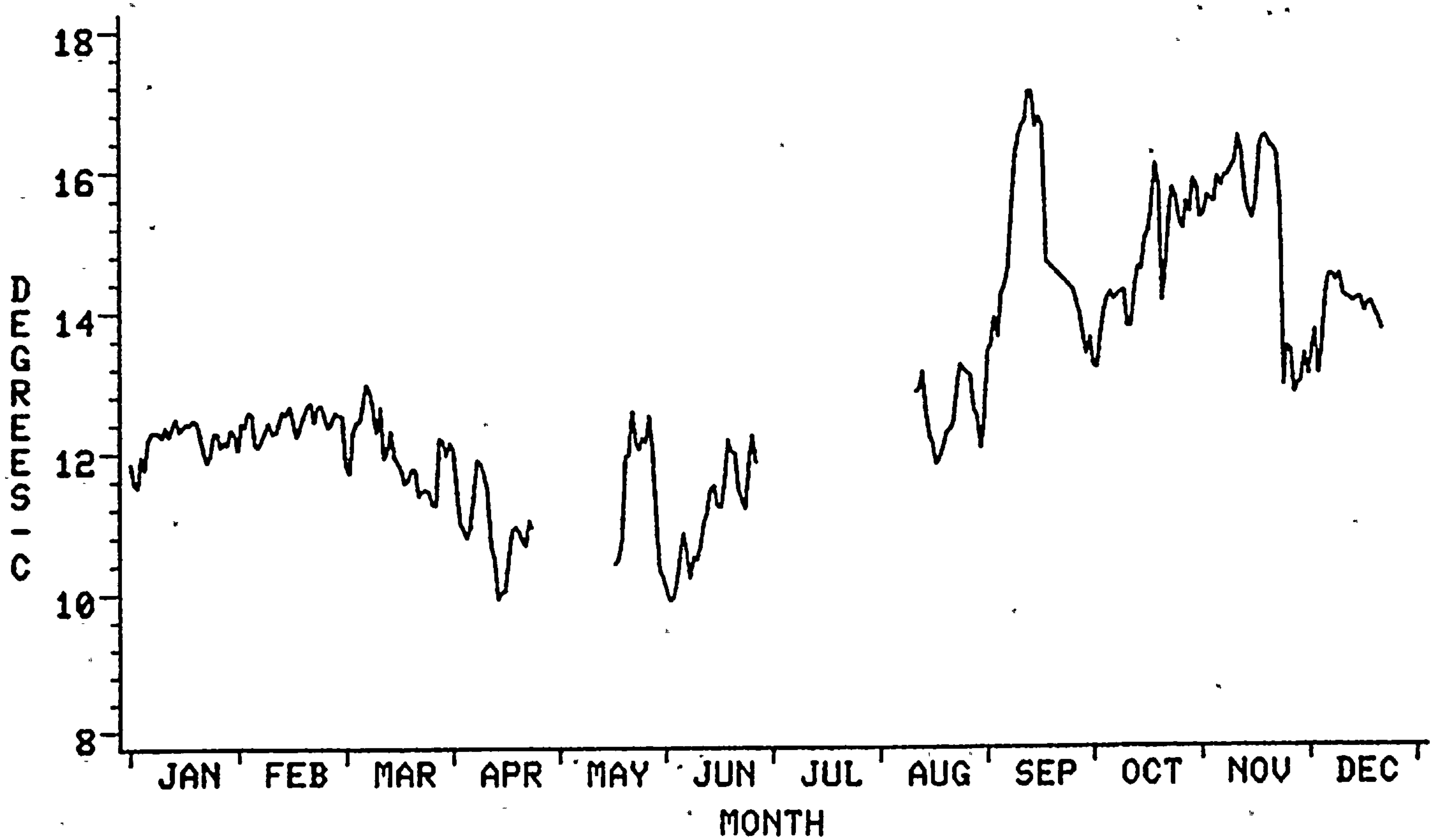


FIGURE 7

CMS TEMPERATURE MONITORING STATION

MEAN DAILY TEMPERATURE

YEAR=1982



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APPENDIX A

* INDEX TO TEMPERATURE STATISTICS

Skewness - symmetry of data distribution as compared to a normal distribution curve. The degree that the frequency distribution is based to the left (-) or to the right (+).

Kurtosis - peakedness or flatness of data distribution as compared to a normal distribution curve. The wider the range of values in the distribution, the flatter (-) the curve. When almost all data values are near the mean, the more pointed (+) the curve.

KSD_{max} -Kolmogorov - Smirnov Dmax - test for normality. Procedure produces a test statistic for the null hypothesis that the data are a random sample from a normal distribution.

Serr Corr - Serial correlation test - for randomness. Measures the closeness of a linear relationship between two or more variables.

*From "SAS User's Guide: Basics", SAS Institute Inc., 1982
"Frequency Distribution" Third Edition, University of Phoenix, 1979.

SYMBOL TABLE

NODAYS = # OF DAYS OF COMPLETE DATA (80%)
MEAN_P,MEAN_M = MEAN 95% CONFIDENCE LIMITS
SER_CORR = SERIAL CORRELATION COEFFICIENT
MDR = MEAN DAILY RANGE
MDR_P,MDR_M = MDR 95% CONFIDENCE LIMITS

-- YEAR=1978 --

MONTH	STN	NODAYS	MEAN	STD	MAX	MIN	MEAN_P	MEAN_M	SKEWNESS	KURTOSIS	KSD_MAX	SER_CORR	MDR	MDR_P	MDR_M
OCTOBER	CM	20	13.6	0.9	15.4	11.3	14.0	13.2	-0.0418	-0.4397	0.0782	0.9762	1.1	1.3	0.9
NOVEMBER	CM	28	14.1	0.5	15.2	12.2	14.3	13.9	-0.7289	1.3145	0.1118	0.9534	0.7	0.9	0.5
DECEMBER	CM	31	12.6	0.7	13.8	10.3	12.9	12.3	-0.6985	-0.6149	0.1918	0.9875	0.6	0.8	0.5

SYMBOL TABLE

NODAYS = # OF DAYS OF COMPLETE DATA (80%)
MEAN_P,MEAN_M = MEAN 95% CONFIDENCE LIMITS
SER_CORR = SERIAL CORRELATION COEFFICIENT
MDR = MEAN DAILY RANGE
MDR_P,MDR_M = MDR 95% CONFIDENCE LIMITS

YEAR=1979

MONTH	STN	NODAYS	MEAN	STD	MAX	MIN	MEAN_P	MEAN_M	SKEWNESS	KURTOSIS	KSD_MAX	SER_CORR	MDR	MDR_P	MDR_M
JANUARY	CM	31	12.8	0.5	13.8	10.6	12.9	12.6	-1.3666	1.5938	0.1896	0.9675	0.5	0.6	0.4
FEBRUARY	CM	28	12.0	0.4	13.2	10.2	12.2	11.9	-0.6229	1.8571	0.1319	0.9446	0.6	0.7	0.5
MARCH	CM	31	11.2	0.6	12.7	9.7	11.5	11.0	0.0560	-0.8064	0.0804	0.9595	0.9	1.1	0.8
APRIL	CM	30	10.5	0.7	12.1	9.1	10.8	10.3	-0.1399	-0.8335	0.0738	0.9445	1.1	1.2	1.0
MAY	CM	31	10.9	0.7	13.4	9.6	11.2	10.6	0.8535	0.1825	0.1214	0.9511	1.1	1.2	1.0
JUNE	CM	14	13.6	0.8	15.0	11.1	14.0	13.1	-0.4269	-0.0750	0.0832	0.9265	1.4	1.8	1.1
JULY	CM	19	12.2	0.6	14.1	9.8	12.5	11.9	-0.2522	2.3549	0.0997	0.9435	1.1	1.4	0.9
AUGUST	CM	31	12.3	0.8	14.4	10.0	12.7	12.0	-0.5362	-0.0031	0.1233	0.9554	1.3	1.5	1.1
SEPTEMBER	CM	30	13.3	0.9	15.3	10.3	13.6	13.0	-0.4484	0.1696	0.0564	0.9525	1.6	1.8	1.4
OCTOBER	CM	31	13.5	1.1	16.4	10.8	13.9	13.1	0.0923	-0.6354	0.0581	0.9656	1.6	1.8	1.4
NOVEMBER	CM	30	12.9	1.0	15.3	10.7	13.2	12.5	0.1238	-0.6577	0.0529	0.9722	1.2	1.4	1.1
DECEMBER	CM	31	13.1	0.8	15.0	11.4	13.4	12.8	0.1792	-0.5766	0.0560	0.9790	0.8	0.9	0.7

SYMBOL TABLE

NODAYS = # OF DAYS OF COMPLETE DATA (80%)
MEAN_P,MEAN_M = MEAN 95% CONFIDENCE LIMITS
SER_CORR = SERIAL CORRELATION COEFFICIENT
MDR = MEAN DAILY RANGE
MDR_P,MDR_M = MDR 95% CONFIDENCE LIMITS

YEAR=1980

MONTH	STN	NODAYS	MEAN	STD	MAX	MIN	MEAN_P	MEAN_M	SKEWNESS	KURTOSIS	KSD_MAX	SER_CORR	MDR	MDR_P	MDR_M
JANUARY	CM	31	13.7	0.5	14.9	12.6	13.9	13.5	0.8222	0.3610	0.1784	0.9804	0.5	0.6	0.4
FEBRUARY	CM	29	14.2	0.7	15.8	12.5	14.4	13.9	0.2539	-0.7674	0.1167	0.9808	0.7	0.8	0.6
MARCH	CM	31	12.5	1.7	15.3	10.1	13.1	11.9	0.4450	-1.5578	0.2109	0.9926	1.0	1.2	0.8
APRIL	CM	30	11.0	0.8	13.3	9.2	11.2	10.7	0.5984	0.1698	0.0898	0.9086	1.6	1.8	1.4
MAY	CM	31	10.6	0.9	13.2	8.7	11.0	10.3	0.5020	-0.4894	0.1014	0.9542	1.2	1.4	1.0
JUNE	CM	4	10.8	0.8	12.8	9.6	12.1	9.5	0.5110	-0.6713	0.1084	0.8999	1.4	2.5	0.4
JULY	CM	17	11.5	0.6	13.2	9.9	11.7	11.2	0.0085	0.1158	0.0460	0.8047	1.5	1.7	1.2
AUGUST	CM	31	12.4	0.7	14.2	11.0	12.6	12.1	0.2150	-0.4200	0.0650	0.9095	1.5	1.7	1.3
SEPTEMBER	CM	30	12.8	0.6	15.2	11.0	13.1	12.6	0.2170	0.1551	0.0529	0.8922	1.4	1.6	1.2
OCTOBER	CM	30	13.7	0.8	15.7	11.6	14.0	13.4	0.0081	-0.0935	0.0665	0.9530	1.3	1.5	1.1
NOVEMBER	CM	30	13.5	0.6	15.5	12.1	13.7	13.3	0.2229	0.0722	0.0645	0.9454	1.0	1.2	0.8
DECEMBER	CM	15	14.2	0.5	15.2	12.9	14.4	13.9	-0.4756	-0.4793	0.1006	0.9255	0.9	1.1	0.6

SYMBOL TABLE

NODAYS = # OF DAYS OF COMPLETE DATA (80%)
MEAN_P,MEAN_M = MEAN 95% CONFIDENCE LIMITS
SER_CORR = SERIAL CORRELATION COEFFICIENT
MDR = MEAN DAILY RANGE
MDR_P,MDR_M = MDR 95% CONFIDENCE LIMITS

YEAR=1981

MONTH	STN	NODAYS	MEAN	STD	MAX	MIN	MEAN_P	MEAN_M	SKEWNESS	KURTOSIS	KSD_MAX	SER_CORR	MDR	MDR_P	MDR_M
MARCH	CM	27	12.3	1.0	13.8	9.7	12.7	11.9	-0.9107	-0.2126	0.1673	0.9745	0.9	1.1	0.7
APRIL	CM	30	10.3	0.6	12.1	8.7	10.5	10.1	0.3164	-0.3461	0.0746	0.9183	0.9	1.1	0.8
MAY	CM	11	11.1	0.6	12.5	9.5	11.5	10.7	-0.0444	-0.6713	0.0850	0.9385	1.0	1.2	0.8
JUNE	CM	28	11.7	1.3	14.7	9.5	12.2	11.3	0.2770	-1.0865	0.1208	0.9780	1.4	1.7	1.1
JULY	CM	31	12.9	0.8	15.3	11.0	13.2	12.6	0.4212	-0.4078	0.1099	0.9252	1.7	1.9	1.4
AUGUST	CM	31	12.8	0.7	14.6	10.5	13.0	12.5	-0.3002	-0.1149	0.0744	0.8921	1.7	1.9	1.6
SEPTEMBER	CM	30	13.3	0.9	15.7	11.3	13.7	13.0	-0.0470	-0.4668	0.0426	0.9449	1.5	1.7	1.3
OCTOBER	CM	31	13.4	0.4	15.1	11.8	13.5	13.2	-0.1797	0.5369	0.0693	0.8760	1.2	1.3	1.0
NOVEMBER	CM	30	13.7	0.6	15.5	11.8	13.9	13.5	0.1335	0.3529	0.0807	0.9463	0.9	1.0	0.8
DECEMBER	CM	31	12.8	0.6	14.3	11.0	13.0	12.6	-0.5632	0.4971	0.1300	0.9277	0.8	0.9	0.7

SYMBOL TABLE

NODAYS = # OF DAYS OF COMPLETE DATA (80%)
MEAN_P,MEAN_M = MEAN 95% CONFIDENCE LIMITS
SER_CORR = SERIAL CORRELATION COEFFICIENT
MDR = MEAN DAILY RANGE
MDR_P,MDR_M = MDR 95% CONFIDENCE LIMITS

YEAR=1982

MONTH	STN	NODAYS	MEAN	STD	MAX	MIN	MEAN_P	MEAN_M	SKEWNESS	KURTOSIS	KSD_MAX	SER_CORR	MDR	MDR_P	MDR_M
JANUARY	CM	31	12.2	0.3	12.9	11.1	12.3	12.1	-0.8328	0.4182	0.1587	0.8197	0.7	0.8	0.6
FEBRUARY	CM	28	12.4	0.3	13.4	11.6	12.5	12.3	0.2639	0.4486	0.1001	0.8192	0.7	0.8	0.6
MARCH	CM	31	12.1	0.5	13.2	10.7	12.3	11.9	-0.0367	-0.9672	0.0878	0.9445	0.8	0.9	0.7
APRIL	CM	26	11.1	0.7	12.5	9.1	11.4	10.8	-0.2480	-0.6387	0.0598	0.9044	1.3	1.4	1.1
MAY	CM	10	11.9	0.8	13.4	9.9	12.4	11.3	-0.7839	0.0835	0.1778	0.9360	1.3	1.7	0.9
JUNE	CM	30	11.0	0.8	13.4	9.6	11.3	10.7	0.5106	-0.3024	0.0746	0.9196	1.4	1.6	1.1
AUGUST	CM	14	12.5	0.6	14.3	11.1	12.9	12.2	0.5217	-0.1638	0.1040	0.9164	1.3	1.6	1.1
SEPTEMBER	CM	22	14.8	1.8	17.5	10.9	15.6	14.0	-0.0616	-1.3873	0.1478	0.9873	1.4	1.7	1.1
OCTOBER	CM	30	14.4	0.9	16.8	12.5	14.7	14.1	0.4343	-0.2384	0.0991	0.9681	1.1	1.3	1.0
NOVEMBER	CM	30	15.8	0.5	16.7	13.3	16.0	15.6	-0.3148	0.1943	0.0766	0.9388	0.8	1.0	0.7
DECEMBER	CM	28	13.8	0.6	14.8	11.8	14.0	13.6	-0.5706	-0.6454	0.1596	0.9461	0.9	1.1	0.8

APPENDIX B

ECOMAR ANALOG/DIGITAL DATA CONVERSION PROCESSING:

*1. RAW DATA ENTRY-
DIGITIZATION OF ANALOG
FILM-STRIP INFORMATION

1. ERROR-CHECK AND
CORRECTION LOOP

1. RAW DATA STORAGE:
DIGITIZED INFORMATION
STORED ON-LINE DISK

2. CONVERSION OF RAW DIGITIZED
DATA TO USER UNITS--SPEED
AND DIRECTION (CURRENTS) OR
DEGREES OF TEMPERATURE.
(ECOMAR SAS SOFTWARE)
REQUIRES 105 OR 109 METER
CALIBRATION DATA TABLE.

2. DATA CORRECTION
ROUTINE

2. ERROR CHECKING PROCEDURE:
TEST DATA FOR OVER- OR
UNDER-LIMIT VALUES, CHECK
FOR LARGE DELTA BETWEEN
OBSERVATIONS.

2. ON-LINE DISK STORAGE OF
CORRECTED DATASET IN
USER UNITS.

3. ASSEMBLY OF USER DATA SUB-
SETS INTO USER DEFINED
DATASET FORMAT.

BM-SL 9-TRK MAG.
APE COPY OF RAW
ND FINAL USER
ATASETS.

3. TABULAR PRINT-OUT OF
ASSEMBLED DATASET IN
USER-SPECIFIED FORMAT

5. ACCESSORY DATA PRESEN-
TATIONS: PROGRESSIVE
VECTOR PLOTS, POLAR
HISTOGRAMS, ETC.

* SEE NOTES.

NOTES: ANALOG/DIGITAL DATA CONVERSION PROCESSING

1. Data filmstrips are loaded into a Beseler 23-CII photographic enlarger. Analog record images are projected onto the sensing screen of a Houston Instruments "HIPAD" digitizer. The HIPAD is first calibrated for speed, direction or temperature limits by a preliminary examination of the entire filmstrip. The average position of about 30 random (thermistor) or representative (current meter) lower and upper limits is located on the HIPAD screen. About 2000 HIPAD units are available between these limits for discrimination of data points between them, allowing great accuracy of data-point determination (examples: if full scale represents 360 compass degrees, accuracy of directional data can be achieved to the nearest 360/2000 or 0.18 degrees; similarly if the full scale represents 3.5 knots current speed, accuracy can be achieved to the nearest 3.5/2000 or 0.002 knots). The filmstrip is then rerun through the projector, image by image, locating each record image data point and transmitting this data to an on-line disc file to await further processing. During this digitization process, the operator may stop, correct data entry errors, and continue digitizing. As sections of data are digitized, they are written out to an on-line disc file for temporary storage.

2. Utilizing SAS (Statistical Analysis System, SAS Institute, Raleigh, North Carolina) subroutines, the digitized raw data file is used to create a second file; the information is in user-units (current speed in knots or cm/sec, direction in magnetic degrees, temperature in degrees Celsius or Fahrenheit). As each record is converted from HIPAD to user-units, it is checked for validity -- over limit, under limit, or excessive variation from the previous record. Erroneous values are flagged for analysis and correction by the quality control operator. The corrected user-unit dataset is then stored in an on-line disc file.

3. For production of user-specified output, data files for each meter/thermistor are assembled into a combined dataset. From this set a tabular printed output can be made in user-specified format.

4. IBM Standard Label (SL) 9-track magnetic tape copies can be made of the raw dataset, user-units individual datasets or assembled composite datasets.

5. Other data representations (e.g., graphics) can be produced from individual user-units or composite user-units datasets.

DIFFERENCES/SIMILARITIES
ENDECO/ECOMAR DATA REDUCTION SERVICES

Basic difference in Data Entry.

ENDECO - Operator reads microfiche vernier scale, hand-enters (keyboard) numerical scale interpretation. Subject to interpolation error, and the unconscious operator scale-interpretation bias.

ECOMAR - Operator positions digitizer cursor over record image data point, pushes button. No hand-entry of numerical information, no vernier scale reading subject to interpretation or unconscious operator bias. Digitizer pad has greater point-discrimination accuracy than microfiche projector and vernier scale.

Similarities.

From the point at which data entry is complete to the printed and plotted output, procedures are much the same. All numerical information is stored on a computer mass storage device -- disc or tape. Programs access raw data to produce desired output, with appropriate error-checking controls.

Report Issued: APR 05 1983

Report 411-82.300

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH

SEAWATER DENSITIES IN THE VICINITY OF DIABLO CANYON POWER PLANT 1977-1982

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TABLE OF CONTENTS

LIST OF FIGURES

Report 411-82.300

ABSTRACT

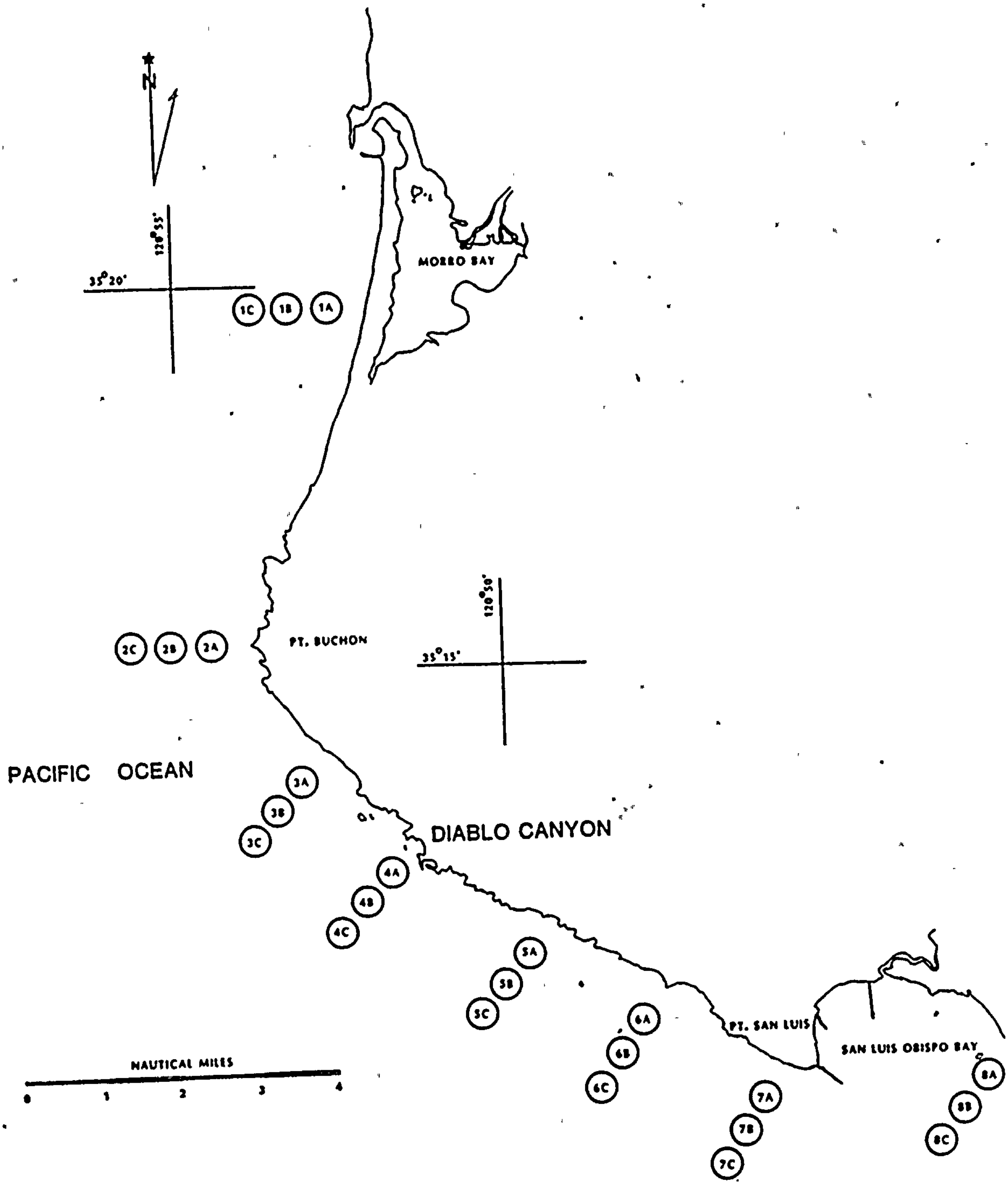
Oceanographic data were obtained at 24 locations in the vicinity of Diablo Canyon from 1977 to 1982. From these data, seawater densities were calculated and expressed in $sigma_t$ (σ_t). Seawater density contours were plotted and combined with those from 1972 to 1976 reported by Orvosh (1979) in the Environmental Investigations at Diablo Canyon, 1975-1977 Annual. By combining these 11 years of density data, it is possible to examine the seasonal variability in the local seawater density structure offshore of Diablo Canyon.

INTRODUCTION

This report contains the results and discussion of the salt water density studies conducted in the vicinity of the Diablo Canyon Power Plant (DCPP) from 1977 to 1982. The study was designed to monitor densities in the area and to provide ancillary information to the preoperational data base being compiled for Diablo Canyon. Densities were determined for 24 stations from Morro Bay to Avila Beach (Figure 1). The density values reported between 1977 and 1982, combined with the density values from 1972 to 1976 which were reported by Orvosh (1979), will provide an overview of the salt water density structure in the vicinity of Diablo Canyon.

METHODS

Since 1972, PGandE has conducted oceanographic studies that are designed to monitor physical water quality parameters (currents, temperature, salinity, dissolved oxygen, and pH) in the ocean waters near Diablo Canyon. These data are collected in order to examine the existing nature of the receiving water offshore of the power plant's cooling water discharge. Temperature, salinity and dissolved oxygen measurements were made at 24 stations three times during each year (Banuet-Hutton 1981, White 1981, 1982a, 1982b, 1983a). Station locations were selected to provide data from within and beyond the influence of the predicted cooling water discharge plume. Water temperature profiles from surface to bottom were made with a bathythermograph. Water samples, for dissolved oxygen and salinity, were collected just below the surface, at mid-water column, and at 0.5M above the



OCEANOGRAPHIC STATIONS

FIGURE

bottom. A Grundy Model 6230N laboratory salinometer was used to determine salinity values. From the temperature and salinity data, density values, expressed in σ_t, were computed (Appendix A) by the methods outlined by Knudsen (1952) using the following formula:

$$\sigma_t = \Sigma_t + (\sigma_o + 0.1324)(1 - A_t + B_t\,(\sigma_o - 0.1324))$$

$$\Sigma_t = -\frac{(t - 3.98)^2(t + 283)}{(503.570)(t + 67.26)}$$

$$A_t = t\,(4.7867 - 0.09815t + 0.0010843t^2) \times 10^{-3}$$

$$B_t = t(18.030 - 0.8164t + 0.01667\,t^2) \times 10^{-6}$$

$$\sigma_o = -0.069 + 1.4708\,Cl - 0.001570\,Cl^2 + 0.0000398\,Cl^3$$

$$CL = S \div 1.80655$$

where:

Cl = the weight of chlorine in grams per 1000 grams of seawater

σS = salinity of seawater

σ_o = the density of seawater at 0°C

t = water temperature in degrees Celsius

A_t from Knudsen table of constants

B_t from Knudsen table of constants

DATA PREPARATION

Computer generated data tables including σ_t values, salinity, temperature, and depth of Station for each of the 17 oceanographic surveys were produced (Appendix C).

Density contours were constructed by placing Stations 1 'A' through 8 'A' (located 0.5 nautical miles offshore and perpendicular to the coastline) on a graph's abscissa and the water depth as the ordinate. Then the σ_t values were plotted with their corresponding station locations and depths. The 'B' (1.0 nautical mile offshore) and 'C' (1.5 nautical miles offshore) station graphs were constructed in the same manner. The result of this process is a graphical representation of the density structure in the vicinity of Diablo Canyon. By viewing the contours between all 24 stations on the 'A', 'B', and 'C' graphs, a three-dimensional view of the density profiles can be obtained. This information, along with current patterns and temperature, can assist in characterizing the seasonal water structure in the vicinity of Diablo Canyon.

The general distribution of density is closely related to the character of the currents (Sverdrup et al. 1942), and therefore the current system in the vicinity of Diablo Canyon will be reviewed as part of this report.

CURRENT REGIME

The California Current. The California Current is the broad, slow moving eastern limb of the clockwise current gyre of the north Pacific Ocean, and is part of the western wind drift. It is a continuation of the Aleutian Current where subarctic water converges with equatorial water. The California Current flows along the California coast predominantly northeast to southwest. It flows toward the equator from a latitude of 48°N to a latitude of 23°N, where it starts to turn westward and becomes part of the west flowing north equatorial current (Sverdrup et al. 1942).

The California Current System, alongshore, is composed of three "periods". The first of these is the Upwelling Period, during which the prevailing northwesterly winds (from mid-February to the end of July) cause an overturning of the upper layers and water of relatively low temperature is brought to the surface from depths that probably do not exceed 1,000 feet. The current during this period flows in a southwesterly direction, parallel to the coast.

Toward the end of the summer, upwelling gradually decreases and current flow alternates both towards and away from the coast. This period, referred to as the Oceanic Period, lasts from the end of July to the middle of November. Near the end of this period a counter current develops in the surface layers. During the Oceanic Period, water temperatures are more stratified and are slightly less dense.

From the middle of November until the middle of February, a northward flowing current, known as the Davidson Current, appears. During this

Davidson Period the waters are characterized by higher and more uniform temperatures and lower dissolved oxygen concentrations.

There is a considerable variation from year to year in the starting date, strength, and duration of these current seasons. The currents in the vicinity of Diablo Canyon are moderately complex and variable. The relatively large embayments upcoast (Estero Bay) and down coast (San Luis Obispo Bay) from the plant site, with their large eddies, have a major effect on the water circulation in the study area (Gosink and Weigel, 1979).

UPWELLING INDICES

A local upwelling index as described by Bakun (1973) was obtained from the National Oceanic Atmospheric/National Marine Fisheries Service Pacific Environmental Group (Monterey, California) data bank (Appendix D). This is an index of the conditions that drive upwelling. A positive upwelling index signifies upwelling of bottom water and a net offshore movement of surface water. A negative upwelling index indicates downwelling of surface water at the coast and a net shoreward movement of surface water. These upwelling indices were obtained for comparison with the density contours, and to assist in determining the current regimes along the coast.

DISCUSSION

Fifty-one seawater density contour graphs were produced from the 17 oceanographic surveys conducted between 1977 and 1982 (Appendix C). There were 42 density contours produced for the 14 oceanographic studies conducted from 1972 to 1976 (Orvosh 1979: Appendix B). By combining this density information, the seasonal variability in the local seawater density structure for the 11 years of hydrographic observations can be examined.

Density Observations

The σ_t values from the 1977 through 1982 oceanographic surveys, ranged from a low of 23.34 (near surface, Sta. 1B, Sept. 1979) to a high of 26.36 (0.5M above the bottom, Sta. 7C, June 1980). These σ_t values extended beyond the range reported for the oceanographic surveys from 1972 to 1976, which had a low value of 23.97 in October of 1976 and a high measurement of 26.22 in June of 1976 (Orvosh, 1979).

The overall horizontal density gradients for the 11 years of observations can be characterized by higher values in the close proximity to Diablo Canyon (Stations 2 through 5). These higher density values may be the result of the fact that most of this area is south of the headland created by Point Buchon. It has been demonstrated (Arthur 1965) that Upwelling is intensified to the south of capes and headlands. The increased upwelling activity would in turn cause higher density values throughout the water column for Station 2 through 5.

The analysis of data collected during this study shows that the density regime undergoes seasonal changes which are mostly related to varying seasonal current patterns. However, daily differences in current intensity and direction have been observed offshore of Diablo Cove (Meek 1981, 1982).

The variations in density contours and water structure patterns during the 31 oceanographic surveys (conducted from 1972 through 1982) were highly dependent on the seasonal current patterns. The density contours for the early spring oceanographic surveys typically had higher temperature and lower density values, with moderate variation in the density structure from the surface to the bottom. This water structure regime would be consistent with what is expected during the Davidson Period. The lower density values are reflective of the annual temperature trends at Diablo Canyon, in which the highest seawater temperatures are recorded during September through November (White 1983b).

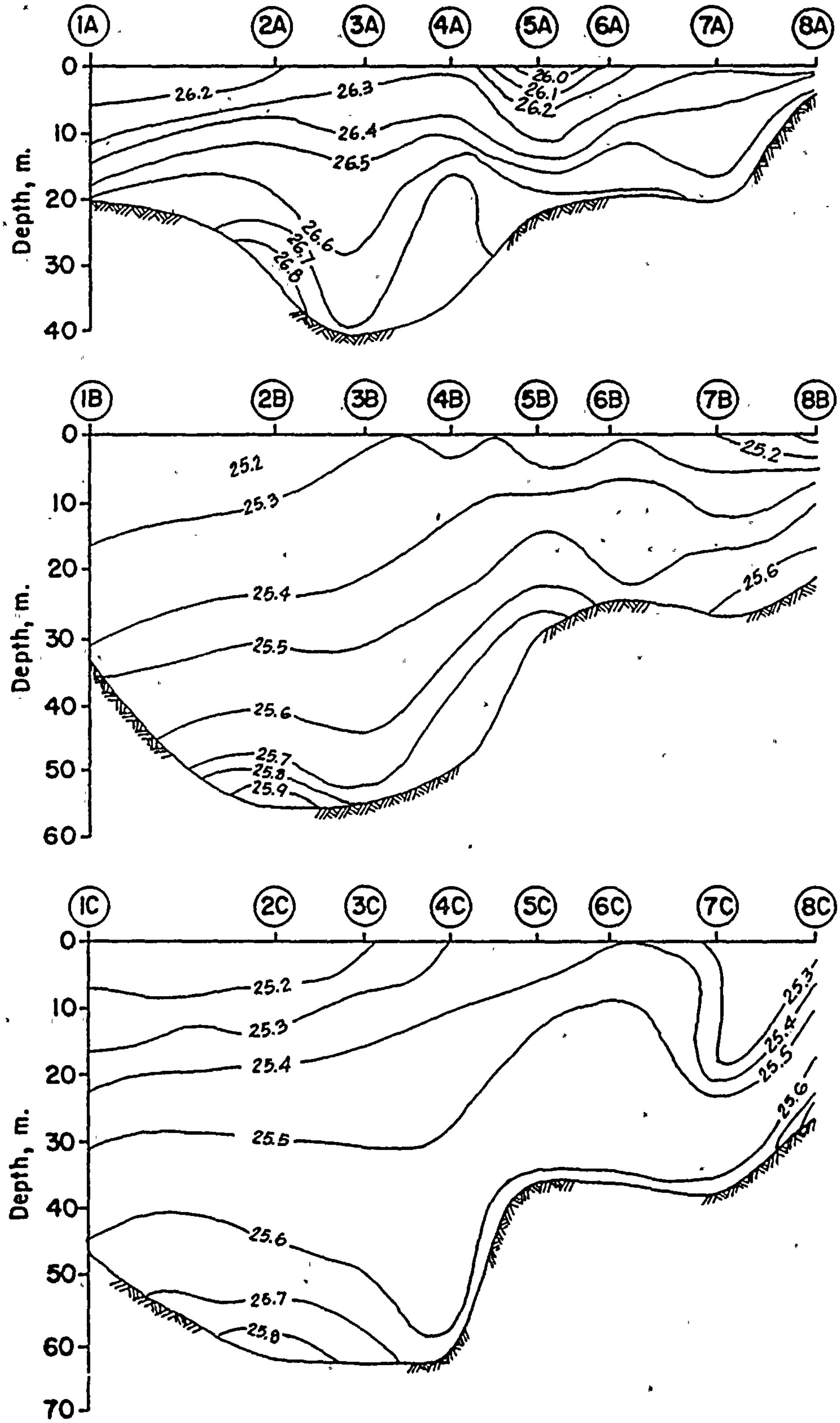
Higher density values occurred during the early summer oceanographic surveys. These higher density values, along with lower temperatures are usually associated with the Upwelling Period. These early summer density contours at Diablo Canyon, exhibited a somewhat larger variation between stations and depths than what is expected for the entire California Coast. As discussed earlier, a portion of the study area is located south of a headland, which in turn intensifies Upwelling. This concentration of vertical mixing encompasses most of the stations while the remainder are under the influence of the eddies of Estero and San Luis Obispo Bays. This

may explain the variability in the density structure gradients in the study area during the Upwelling season.

The overall density values were slightly lower during the fall oceanographic surveys. The time frame, along with the more stratified temperatures and lower density values, corresponds with the Oceanic Period occurring offshore of Diablo Canyon. The density contours for the study area were not always similar during the fall periods (see density contours for September 27, 1973 and September 27, 1979 in Appendices B and C, respectively). The non-uniform patterns seen in many of the density contours from the fall oceanographic studies may be reflective of a transition period between the end of the Upwelling Period and a fully developed Oceanic Period.

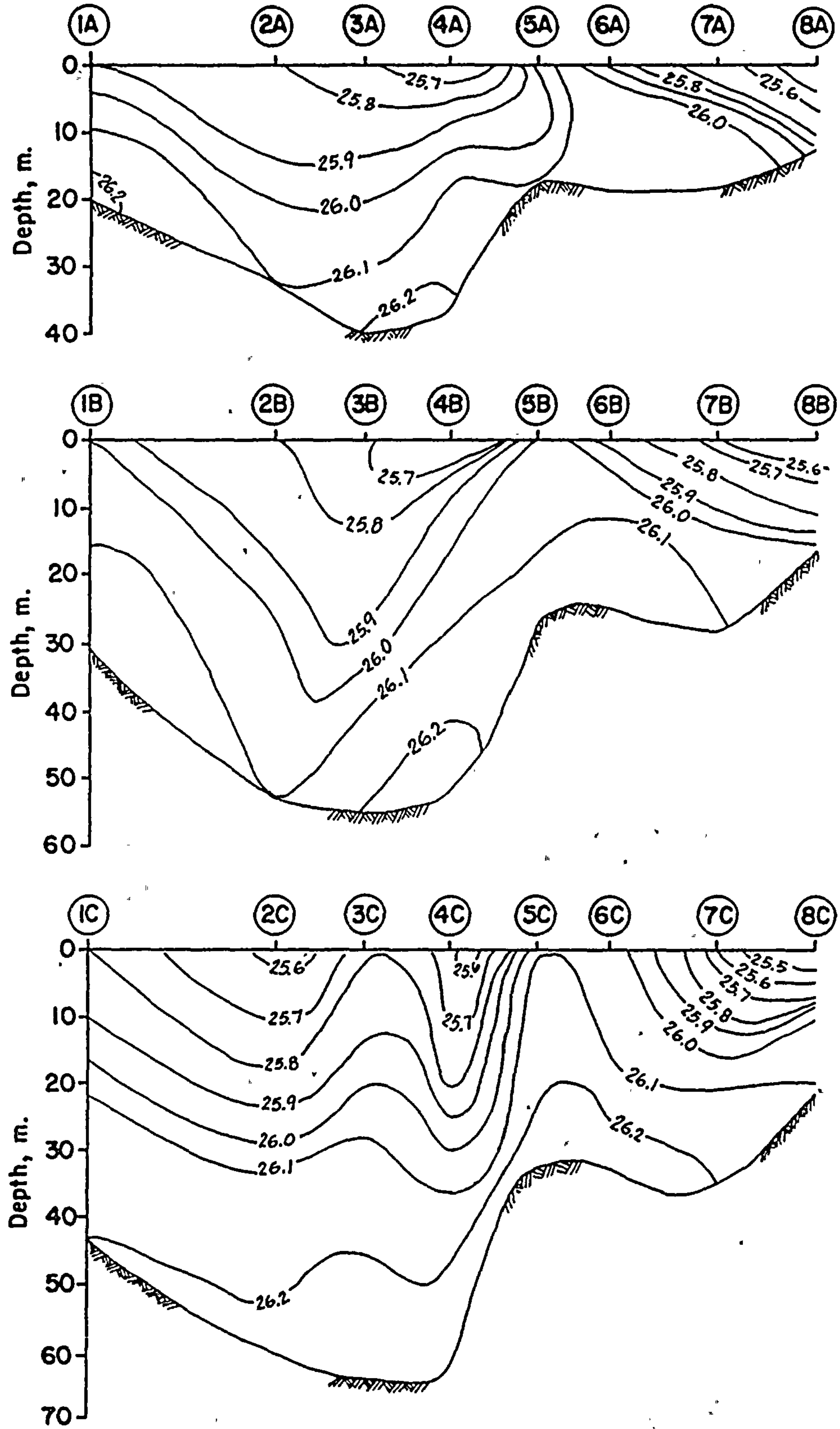
Figures 2, 3, and 4 are selected density contours that illustrate each of the California Current seasons density regimes measured in the study area.

The density contour for September 10, 1980 (Figure 2), is indicative of Oceanic Period; the density values are lower, and the water column is more stratified. The June 16, 1981 density contours (Figure 3), are representative of the Upwelling condition. The values are higher throughout the water column and there is less variation from surface to bottom. Figure 4 is from the February 26, 1980 survey and is the water structure expected under a Davidson Current period. The values are somewhat lower than during the Oceanic Period, but there is a moderate difference between values throughout the water column.



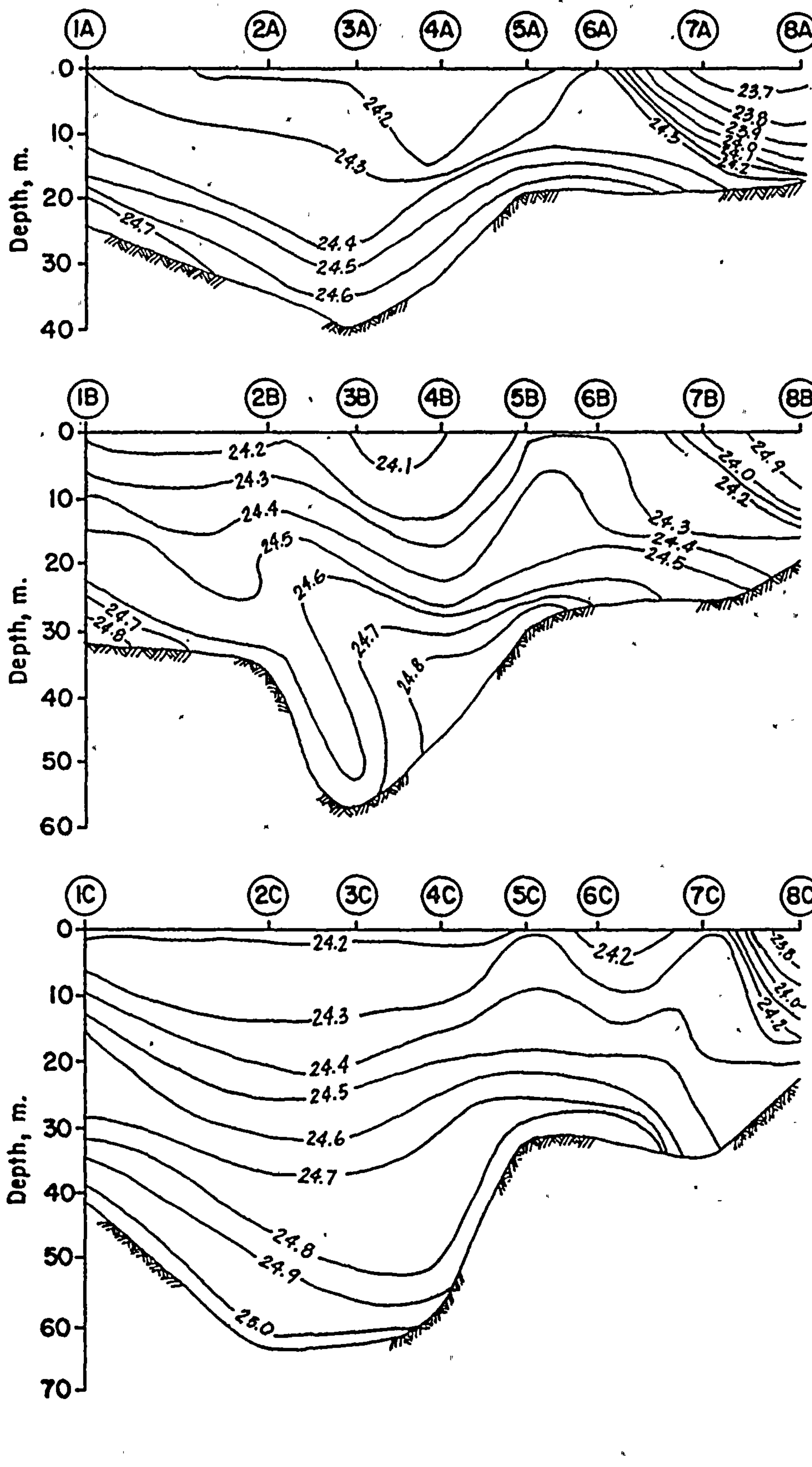
Density Contours for September 10, 1980

FIGURE



Density Contours for June 16, 1981

FIGURE 3



Density Contours for February 26, 1980

FIGURE

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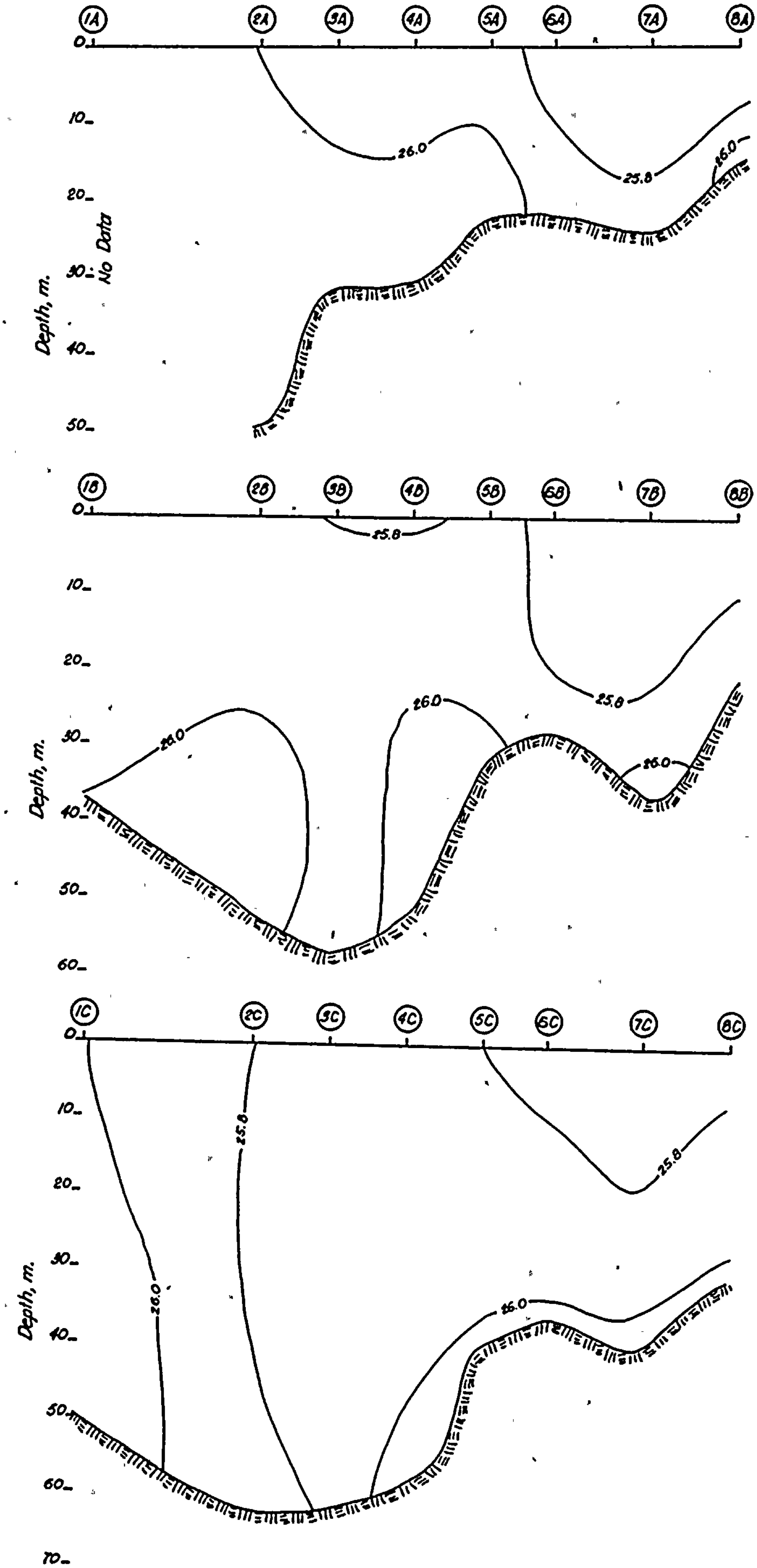
APPENDIX A

```
10 DISP "ENTER FILE#";
20 INPUT L
81 MERGE L
90 DIM E$[90],D$[90]
100 READ E$
110 N=0
120 READ D$
130 IF D$="FINISH" THEN 9998
140 READ F
150 FOR I=1 TO 3
160 READ T[I]
170 GOSUB I OF 560,580,580
180 NEXT I
190 FOR I=1 TO 3
200 READ S[I]
210 NEXT I
220 FOR I=1 TO 3
230 READ D[I]
240 NEXT I
250 FOR I=1 TO 3
260 T[I]=(100/180)*(T[I]-32)
270 C[I]=S[I]/1.80655
280 Z[I]=0.3048*F[I]
290 G[I]=-0.069+1.4708*C[I]-1.57E-03*C[I]↑2+3.98E-05*C[I]↑3
300 A[I]=4.7867E-03*T[I]-9.8185E-05*T[I]↑2+1.0843E-06*T[I]↑3
310 B[I]=1.803E-05*T[I]-8.164E-07*T[I]↑2+1.667E-08*T[I]↑3
320 H[I]=(-(T[I]-3.98)↑2)*(T[I]+283)/(503.57*(T[I]+67.26))
330 J[I]=H[I]+(G[I]+0.1324)*(1-A[I]+B[I]*(G[I]-0.1324))
340 NEXT I
350 IF N=1 THEN 410
360 PRINT "SIGMA-T FOR D.C. OCEANOGRAPHY: ";E$
370 PRINT
380 PRINT
390 PRINT
400 PRINT "SAMPLE    SIG-T    S(0/00)  DEG.C    DEPTH,M  D.O.PPM"
410 PRINT
420 PRINT
430 P=1E+04*(J[2]-J[1])/(Z[2]-Z[1])
440 Q=1E+04*(J[3]-J[2])/(Z[3]-Z[2])
450 FIXED 2
460 PRINT D$;TAB(9),J[1];TAB(19),S[1];TAB(24);T[1];TAB(37);0.5;TAB(45);D[1]
480 PRINT TAB(9),J[2];TAB(19),S[2];TAB(24);T[2];TAB(37);Z[2];TAB(45);D[2]
500 PRINT TAB(9),J[3];TAB(19),S[3];TAB(24);T[3];TAB(37);Z[3];TAB(45);D[3]
510 PRINT
520 PRINT
530 N=1
540 GOTO 120
550 STOP
560 F[I]=2
570 RETURN
580 F[I]=F/(4-I)
590 RETURN
9997 DATA "FINISH"
9998 PRINT "END OF JOB"
9999 END
```

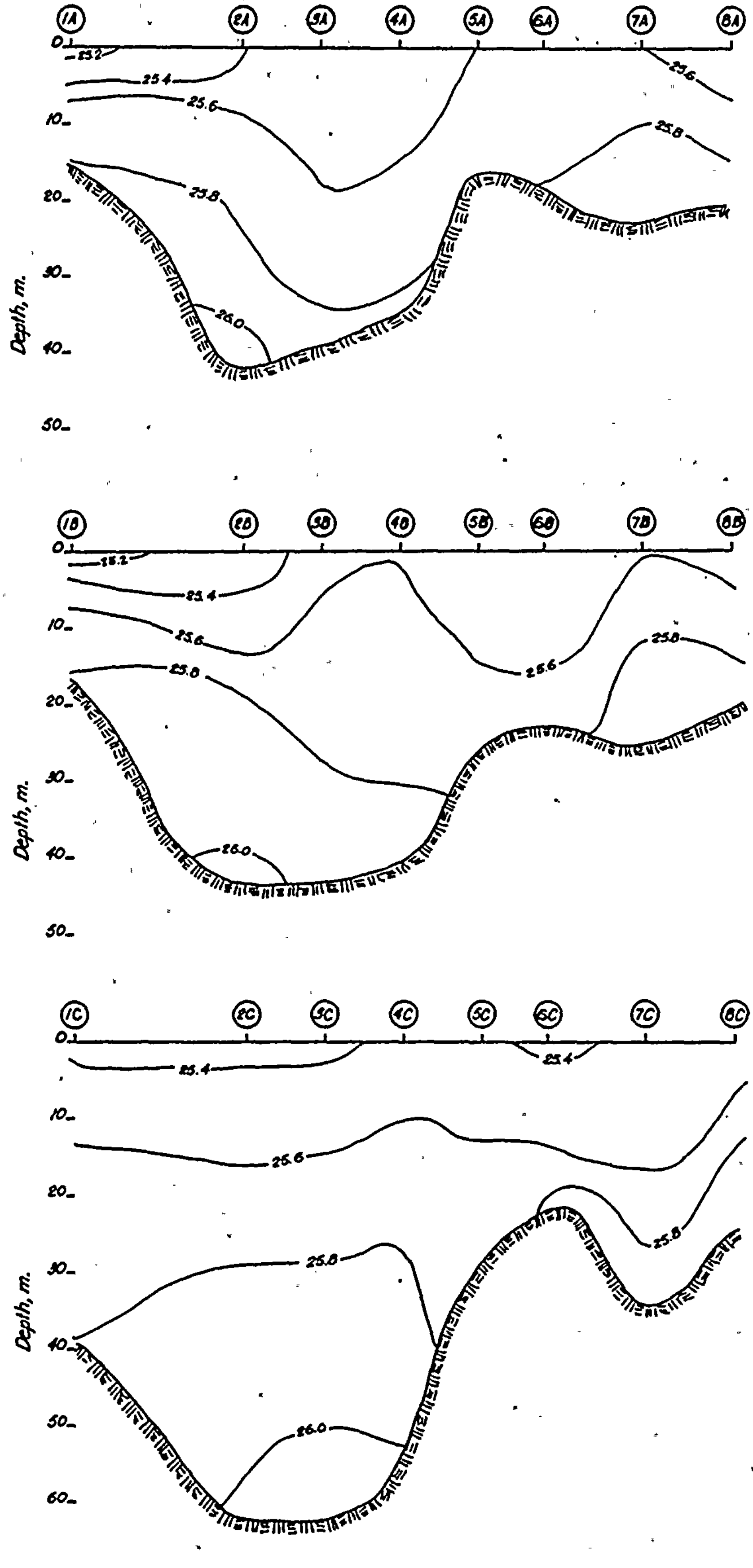
APPENDIX B



Density Contour for 4-13-72

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1B	25.92	33.77	10.56	0.61	8.20
	25.87	33.71	10.56	18.29	8.00
	25.95	33.75	10.28	36.58	8.00
1C.	25.96	33.85	10.67	0.61	5.80
	25.98	33.80	10.33	24.38	5.80
	26.05	33.80	9.89	48.77	5.50
2A	25.84	33.77	11.00	0.61	6.90
	25.95	33.72	10.17	24.38	6.30
	26.12	33.81	9.56	48.77	5.00
2B	25.86	33.74	10.72	0.61	6.70
	25.95	33.73	10.17	25.91	5.80
	26.07	33.76	9.61	51.82	5.10
2C	25.84	33.70	10.67	0.61	6.30
	25.84	33.70	10.67	30.48	6.20
	25.87	33.71	10.56	60.96	6.20
3A	25.86	33.73	10.72	0.61	6.30
	25.95	33.78	10.39	15.24	6.10
	25.99	33.72	9.89	30.48	6.30
3B	25.81	33.72	10.94	0.61	6.30
	25.86	33.71	10.61	28.19	5.40
	25.91	33.77	10.61	56.39	0.00
3C	25.79	33.71	11.00	0.61	6.60
	25.78	33.67	10.89	30.48	6.50
	25.81	33.66	10.67	60.96	0.00
4A	25.86	33.78	10.94	0.61	6.40
	26.01	33.77	10.00	15.24	4.90
	26.05	33.79	9.89	30.48	4.70
4B	25.84	33.74	10.83	0.61	6.30
	26.01	33.74	9.89	25.91	5.00
	26.07	33.81	9.83	51.82	4.70
4C	25.85	33.70	10.61	0.61	6.60
	25.85	33.69	10.61	30.48	6.40
	26.08	33.80	9.72	60.96	6.10
5A	25.89	33.84	11.00	0.61	6.30
	26.04	33.82	10.06	10.97	6.10
	26.12	33.79	9.44	21.95	5.80
5B	25.85	33.79	11.00	0.61	6.40
	25.93	33.73	10.28	15.24	5.60
	26.01	33.77	10.00	30.48	5.00
5C	25.83	33.75	10.94	0.61	6.50
	25.92	33.77	10.56	19.81	6.40
	26.00	33.75	10.00	39.62	6.00
6A	25.71	33.81	11.89	0.61	7.10
	25.84	33.74	10.83	11.43	6.80
	25.92	33.78	10.56	22.86	5.70
6B	25.68	33.76	11.83	0.61	7.20
	25.69	33.73	11.67	13.72	7.10
	25.81	33.76	11.11	27.43	5.30
6C	25.68	33.75	11.78	0.61	6.80
	25.86	33.77	10.89	18.29	6.20
	25.95	33.79	10.44	36.58	5.10
7A	25.66	33.79	12.06	0.61	8.10
	25.73	33.79	11.67	11.89	6.90
	25.92	33.78	10.56	23.77	5.50
7B	25.65	33.77	12.00	0.61	8.30
	25.83	33.78	11.11	24.38	6.30
	26.03	33.79	10.00	36.58	5.30
7C	25.68	33.76	11.83	0.61	8.40
	25.83	33.78	11.11	20.12	7.30
	26.03	33.79	10.00	40.23	5.50
8A	25.63	33.74	12.00	0.61	8.10
	25.79	33.73	11.11	7.32	7.80
	25.99	33.74	10.00	14.63	6.80
8B	25.60	33.73	12.11	0.61	8.20
	25.83	33.78	11.11	10.97	7.60
	26.01	33.77	10.00	21.95	7.30
8C	25.70	33.86	12.11	0.61	9.20
	25.94	33.83	10.67	15.24	6.60
	26.04	33.85	10.22	30.48	5.00

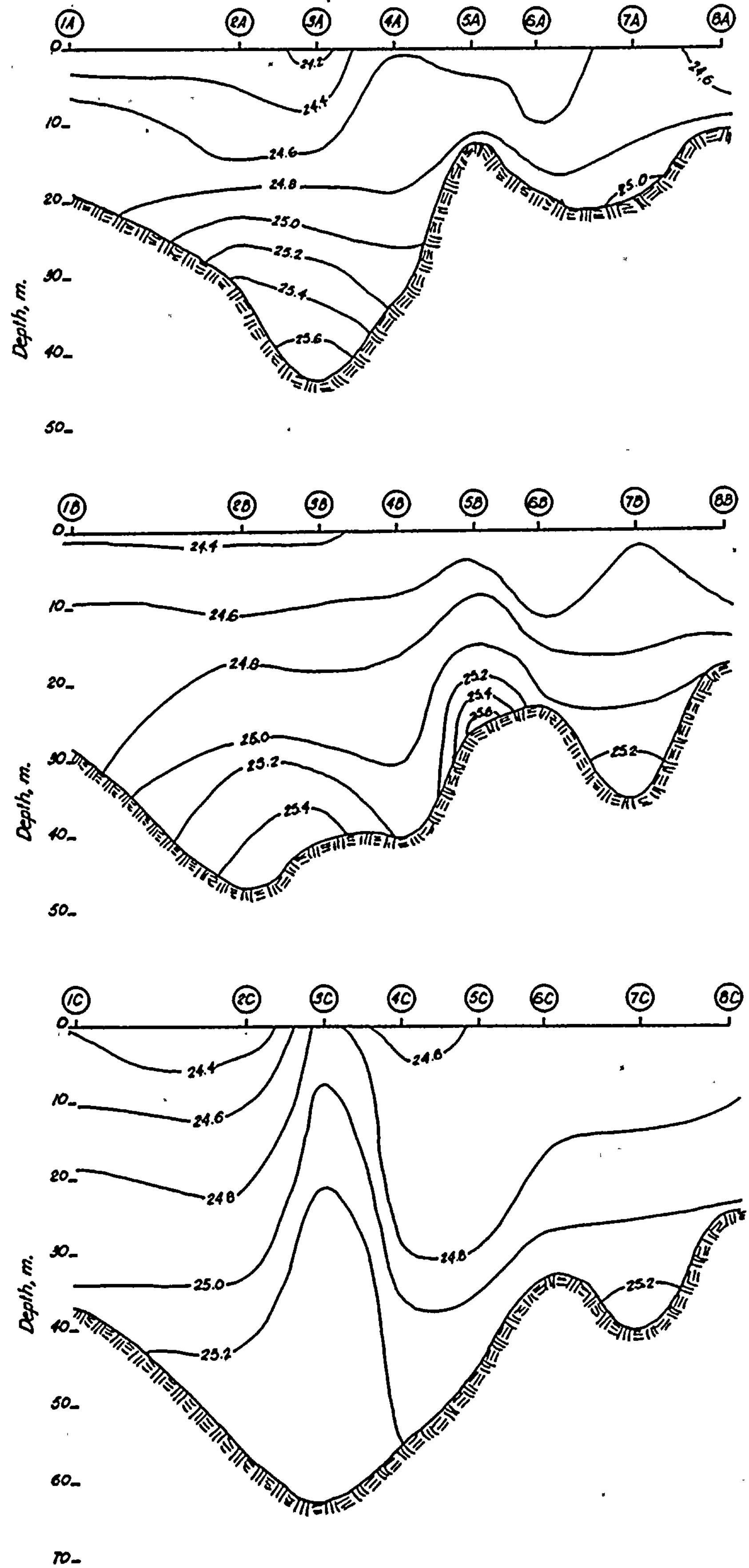
4-19-72



Density Contour for 6-20-72

SAMPLE.	SIG-T	S (0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.20	33.85	14.56	0.61	11.60
	25.62	33.75	12.11	7.62	10.60
	25.76	33.72	11.22	15.24	6.80
1B	25.41	33.70	13.00	0.61	9.80
	25.60	33.69	11.94	12.95	9.60
	25.75	33.71	11.22	25.91	7.60
1C	25.38	33.69	13.11	0.61	9.30
	25.65	33.69	11.67	19.05	9.30
	25.78	33.70	11.00	38.10	8.00
2A	25.42	33.75	13.11	0.61	10.00
	25.81	33.74	11.06	20.57	6.60
	25.96	33.80	10.44	41.15	5.20
2B	25.30	33.76	13.78	0.61	11.60
	25.79	33.73	11.11	21.34	7.20
	25.98	33.80	10.33	42.67	5.20
2C	25.38	33.70	13.11	0.61	9.80
	25.79	33.77	11.28	30.48	6.70
	26.04	33.86	10.28	60.96	5.20
3A	25.53	33.70	12.39	0.61	9.60
	25.64	33.67	11.67	20.57	8.00
	25.83	33.73	10.89	38.10	6.50
3B	25.46	33.69	12.67	0.61	9.70
	25.73	33.69	11.28	21.34	7.50
	25.93	33.79	10.56	42.67	6.40
3C	25.46	33.69	12.67	0.61	10.00
	25.82	33.75	11.00	30.48	6.60
	26.05	33.84	10.11	60.96	5.30
4A	25.53	33.67	12.22	0.61	8.40
	25.64	33.71	11.83	16.76	7.90
	25.84	33.77	11.00	33.53	5.70
4B	25.57	33.67	12.06	0.61	8.00
	25.71	33.70	11.39	20.57	7.40
	25.87	33.81	11.00	38.10	6.80
4C	25.53	33.64	12.11	0.61	8.40
	25.75	33.65	11.00	26.67	7.00
	25.96	33.84	10.61	53.34	5.20
5A	25.57	33.71	12.22	0.61	8.20
	25.58	33.69	12.06	7.62	8.10
	25.71	33.69	11.39	15.24	6.80
5B	25.49	33.65	12.39	0.61	8.40
	25.49	33.65	12.39	12.19	7.70
	25.71	33.69	11.39	24.38	6.80
5C	25.53	33.60	11.94	0.61	8.00
	25.58	33.55	11.50	13.72	7.50
	25.62	33.61	11.50	27.43	7.50
6A	25.57	33.66	12.00	0.61	7.30
	25.65	33.65	11.50	9.14	6.80
	25.81	33.72	10.94	18.29	6.00
6B	25.50	33.63	12.22	0.61	8.00
	25.53	33.62	12.06	9.91	7.60
	25.69	33.67	11.39	22.86	6.80
6C	25.39	33.57	12.56	0.61	8.80
	25.53	33.60	11.94	15.24	8.10
	25.78	33.72	11.11	30.48	6.60
7A	25.55	33.74	12.44	0.61	7.80
	25.81	33.79	11.22	9.91	6.40
	25.82	33.80	11.22	22.86	5.50
7B	25.60	33.71	12.06	0.61	7.60
	25.82	33.77	11.11	12.19	6.40
	25.85	33.80	11.06	24.38	5.30
7C	25.54	33.68	12.22	0.61	7.80
	25.60	33.68	11.94	16.76	7.60
	25.80	33.75	11.11	33.53	6.00
8A	25.26	33.86	14.33	0.61	0.00
	25.73	33.86	11.94	6.86	0.00
	25.71	33.83	11.94	13.72	0.00
8B	25.51	33.83	13.17	0.61	10.20
	25.66	33.83	12.22	9.91	9.60
	25.88	33.86	11.17	19.81	5.80
8C	25.51	33.86	13.11	0.61	10.60
	25.79	33.83	11.50	12.19	10.20
	25.91	33.85	10.94	24.38	5.00

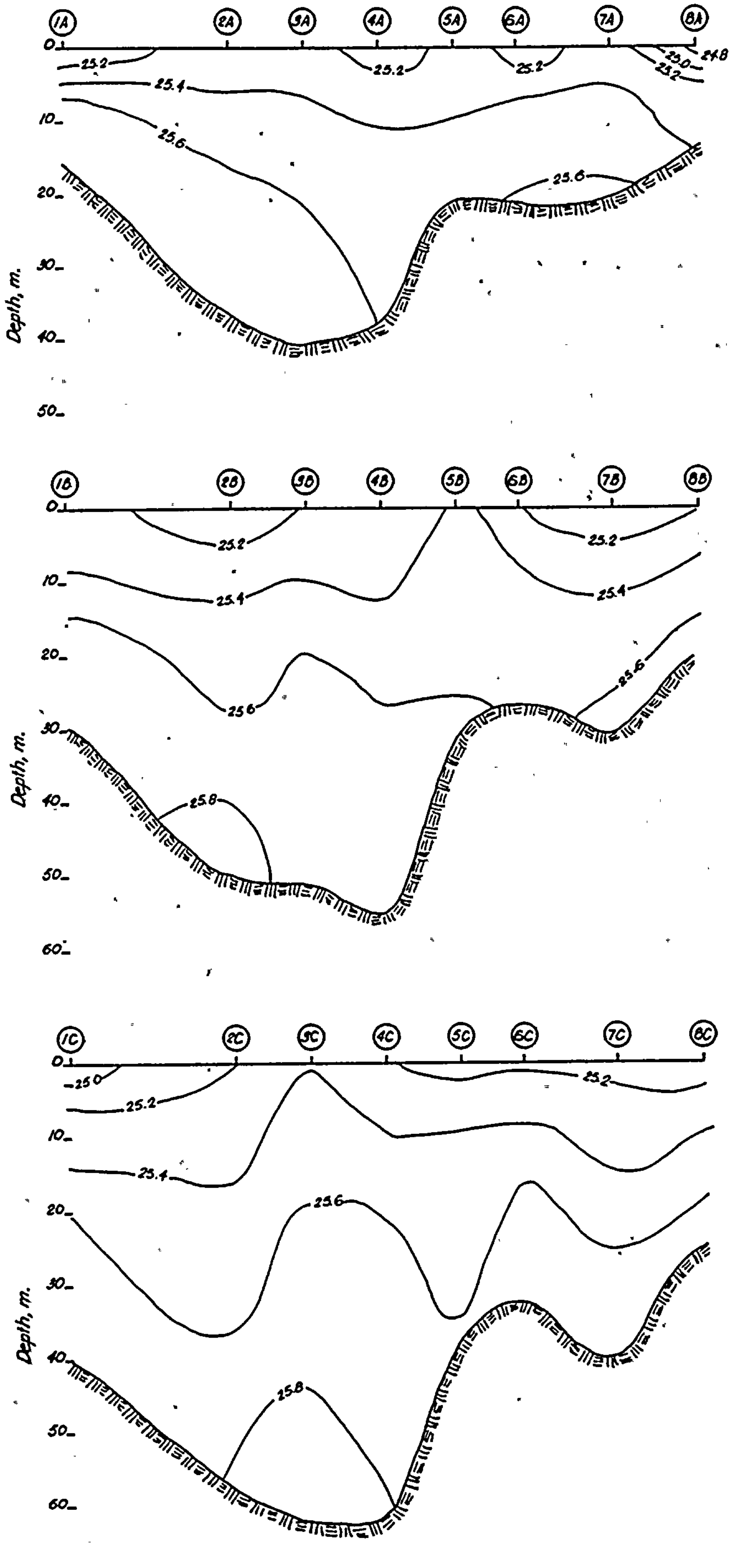
6-20-72



Density Contour for 10-23-72

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	24.34	33.58	17.44	0.61	7.90
	24.66	33.59	16.11	9.14	8.00
	24.58	33.49	16.11	18.29	8.00
1B	24.36	33.59	17.39	0.61	8.00
	24.75	33.60	15.72	13.72	7.90
	24.74	33.57	15.67	27.43	7.80
1C	24.43	33.52	16.89	0.61	8.00
	24.78	33.47	15.17	18.29	7.40
	25.04	33.50	14.06	36.58	6.90
2A	24.34	33.48	17.11	0.61	7.80
	24.63	33.52	16.00	14.48	7.80
	25.42	33.52	12.22	29.26	6.50
2B	24.39	33.45	16.83	0.61	7.90
	24.80	33.45	14.61	22.86	7.30
	25.48	33.46	11.67	45.72	6.50
2C	24.33	33.46	17.11	0.61	7.80
	24.90	33.50	14.72	27.43	6.90
	25.46	33.45	11.72	54.86	6.50
3A	24.19	33.49	17.78	0.61	7.90
	24.88	33.48	14.72	21.64	6.90
	25.66	33.70	11.67	43.28	6.50
3B	24.36	33.50	17.11	0.61	7.80
	24.92	33.50	14.61	24.69	6.90
	25.49	33.50	11.78	49.38	6.60
3C	24.58	33.49	16.11	0.61	7.60
	25.30	32.51	12.78	38.10	0.00
	25.60	33.52	11.22	76.20	0.00
4A	24.55	33.52	16.33	0.61	7.60
	24.65	33.47	15.72	15.54	7.10
	25.05	33.50	14.00	31.09	6.50
4B	24.52	33.49	16.39	0.61	8.00
	24.94	33.51	14.56	24.69	6.70
	25.13	33.50	13.61	49.38	6.20
4C	24.52	33.48	16.33	0.61	7.20
	24.68	33.46	15.56	27.43	7.10
	25.15	33.48	13.44	54.86	7.10
5A	24.54	33.47	16.22	0.61	7.80
	24.65	33.46	15.72	5.49	7.10
	24.75	33.47	15.28	10.97	6.70
5B	24.54	33.49	16.28	0.61	8.00
	24.91	33.49	14.61	12.80	6.80
	25.14	33.54	13.72	25.60	6.50
5C	24.56	33.50	16.22	0.61	8.00
	24.71	33.54	15.72	10.97	7.80
	24.72	33.52	15.61	21.95	7.80
6A	24.51	33.46	16.33	0.61	8.00
	24.60	33.48	16.00	9.14	7.60
	24.82	33.45	14.89	18.29	6.60
6B	24.51	33.46	16.33	0.61	8.00
	24.59	33.48	16.06	10.97	7.90
	25.03	33.48	14.00	21.95	6.50
6C	24.55	33.46	16.17	0.61	8.00
	24.83	33.46	14.89	15.54	6.70
	25.11	33.46	13.56	31.09	6.60
7A	24.56	33.49	16.22	0.61	8.10
	24.59	33.50	16.11	10.06	7.50
	25.01	33.49	14.17	20.12	6.70
7B	24.56	33.49	16.22	0.61	8.10
	24.84	33.50	15.00	17.37	7.10
	25.20	33.52	13.33	34.75	6.50
7C	24.56	33.49	16.22	0.61	8.00
	24.85	33.47	14.83	20.12	7.30
	25.26	33.50	12.94	40.23	6.50
8A	24.58	33.49	16.11	0.61	8.00
	24.63	33.50	15.94	5.49	7.00
	24.83	33.46	14.89	10.97	6.60
8B	24.59	33.48	16.06	0.61	8.10
	24.63	33.52	16.00	9.14	7.60
	25.01	33.49	14.17	18.29	6.50
8C	24.55	33.47	16.17	0.61	8.00
	24.93	33.50	14.56	11.89	7.30
	25.04	33.43	13.78	23.77	6.50

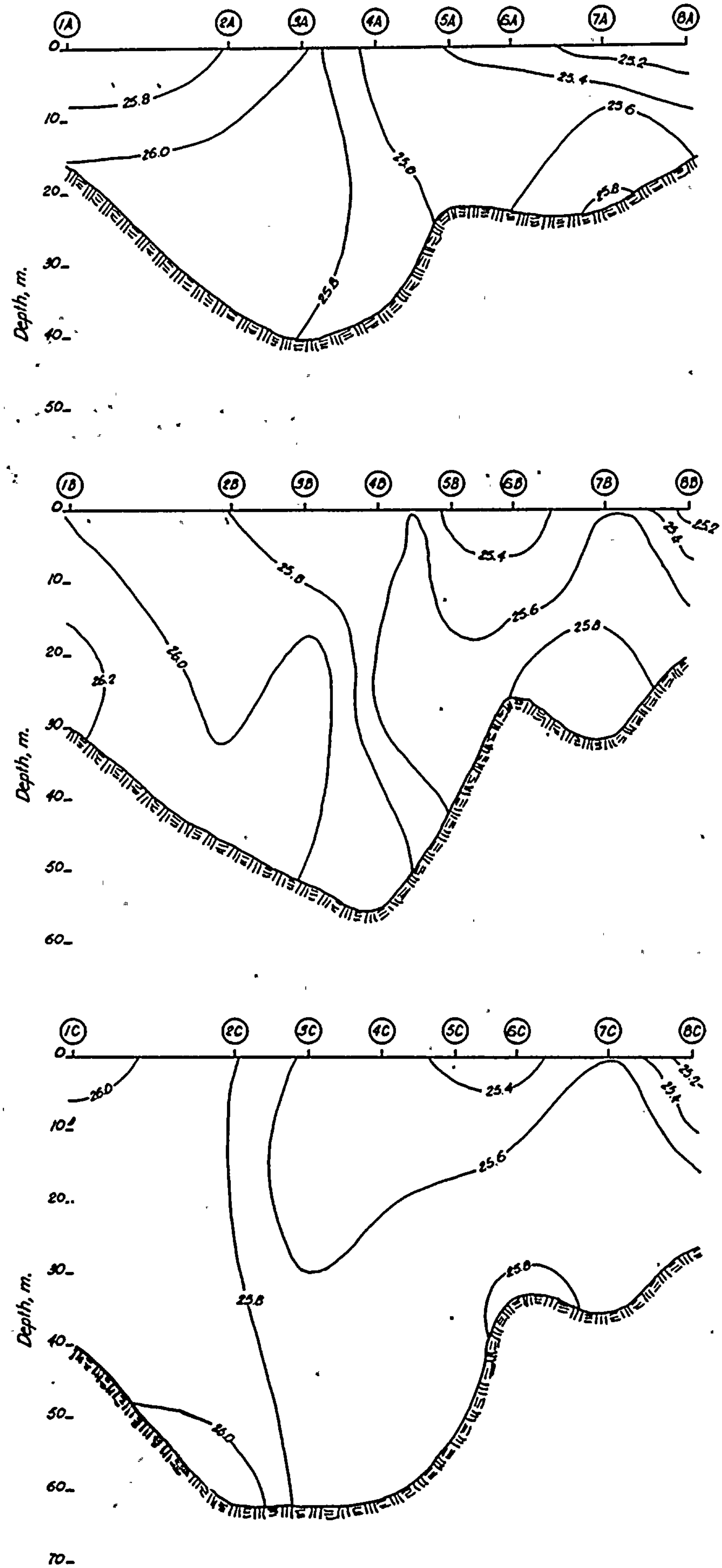
10-25-72



Density Contour for 8-7-73

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.11	33.70	14.44	0.61	10.00
	25.60	33.78	12.33	7.32	8.00
	25.59	33.72	12.11	14.63	6.60
1B	25.12	33.78	14.67	0.61	10.20
	25.60	33.75	12.22	14.48	7.60
	25.62	33.69	11.83	28.96	6.80
1C	25.08	33.62	14.67	0.61	10.40
	25.62	33.71	11.94	19.81	7.20
	25.70	33.75	11.67	39.62	6.00
2A	25.28	33.74	13.78	0.61	8.60
	25.57	33.72	12.22	17.07	7.40
	25.65	33.69	11.67	34.14	6.20
2B	25.32	33.73	13.56	0.61	8.60
	25.54	33.57	11.78	24.38	6.50
	25.90	33.75	10.56	48.77	5.00
2C	25.22	33.69	13.89	0.61	8.60
	25.53	33.69	12.33	27.89	8.10
	25.80	33.68	10.83	55.78	5.80
3A	25.31	33.70	13.50	0.61	8.90
	25.58	33.68	12.00	19.81	7.40
	25.74	33.73	11.39	39.62	6.50
3B	25.22	33.62	13.61	0.61	8.40
	25.65	33.69	11.67	25.30	6.30
	25.70	33.69	11.44	50.60	6.40
3C	25.35	33.77	13.56	0.61	8.80
	25.69	33.71	11.56	30.48	7.20
	25.94	33.75	10.33	60.96	5.80
4A	25.20	33.71	14.06	0.61	9.20
	25.48	33.71	12.67	18.59	7.80
	25.57	33.72	12.22	37.19	6.80
4B	25.22	33.69	13.89	0.61	9.20
	25.60	33.68	11.94	27.43	7.20
	25.63	33.73	11.94	54.86	6.40
4C	25.20	33.71	14.06	0.61	7.30
	25.69	33.73	11.67	30.48	6.40
	25.81	33.73	11.00	60.96	5.30
5A	25.32	33.71	13.44	0.61	8.00
	25.41	33.69	12.94	10.06	6.40
	25.51	33.66	12.33	20.12	6.00
5B	25.38	33.71	13.17	0.61	7.20
	25.42	33.66	12.78	15.85	6.80
	25.65	33.69	11.67	31.70	5.20
5C	25.31	33.68	13.39	0.61	7.80
	25.46	33.64	12.50	18.75	7.20
	25.63	33.69	11.78	37.49	6.20
6A	25.22	33.71	13.94	0.61	8.10
	25.53	33.66	12.22	10.36	6.40
	25.55	33.69	12.22	20.73	6.20
6B	25.23	33.71	13.89	0.61	8.00
	25.43	33.68	12.78	12.95	6.40
	25.50	33.70	12.50	25.91	5.80
6C	25.24	33.69	13.78	0.61	8.80
	25.56	33.70	12.22	15.54	6.20
	25.61	33.66	11.78	31.09	6.40
7A	25.27	33.77	13.94	0.61	8.45
	25.53	33.71	12.39	10.36	7.20
	25.59	33.75	12.28	20.73	6.00
7B	25.12	33.74	14.56	0.61	9.00
	25.49	33.64	12.33	15.54	6.20
	25.66	33.72	11.78	31.09	5.60
7C	25.22	33.72	14.00	0.61	8.10
	25.51	33.71	12.50	19.81	8.40
	25.64	33.70	11.78	39.62	5.60
8A	24.84	33.75	15.83	0.61	7.60
	25.25	33.73	13.89	6.71	11.40
	25.43	33.75	13.06	13.41	6.40
8B	25.15	[illegible].75	14.44	0.61	9.00
	25.53	33.73	12.50	10.06	9.40
	25.67	33.71	11.67	20.12	5.80
8C	25.11	33.66	14.28	0.61	10.00
	25.49	33.68	12.50	12.19	8.40
	25.70	33.75	11.67	24.38	5.00

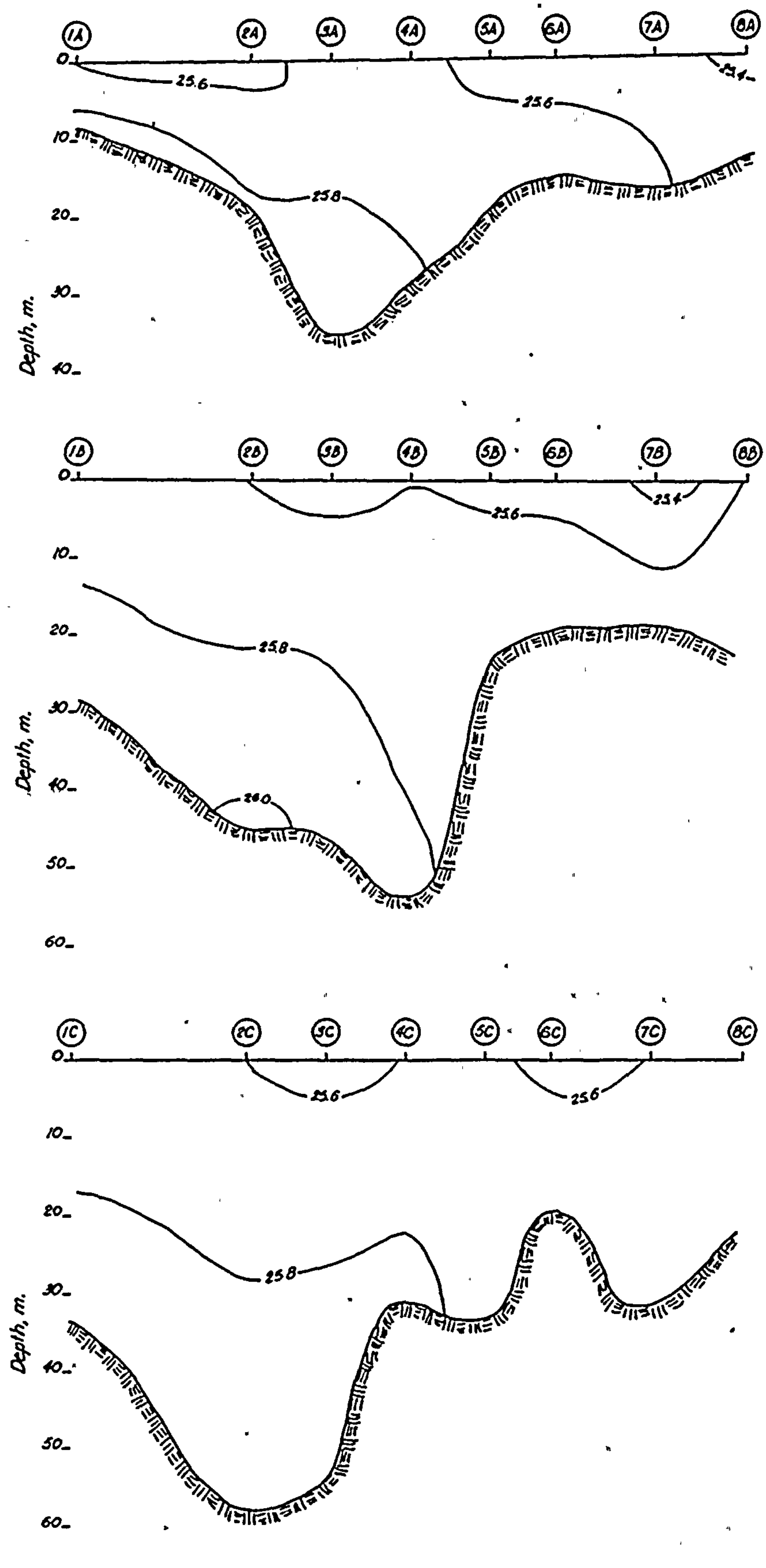
8-7-73



<u>Density Contour for 9-27-73</u>

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.77	33.95	12.11	0.61	7.55
	25.84	33.95	11.78	7.62	5.20
	25.98	34.13	11.78	15.24	5.20
1B	25.99	34.31	12.44	0.61	7.30
	26.16	34.31	11.56	17.68	5.30
	26.18	34.31	11.44	29.26	5.00
1C	25.98	34.31	12.50	0.61	7.40
	25.84	33.95	11.78	20.27	5.80
	26.19	34.31	11.39	40.54	4.80
2A	25.81	34.31	13.33	0.61	7.50
	26.06	34.31	12.05	16.76	5.90
	26.13	34.31	11.72	33.53	5.50
2B	25.75	34.31	13.61	0.61	7.40
	25.92	34.31	12.78	22.86	7.40
	26.05	34.31	12.11	45.72	6.00
2C	25.83	34.13	12.56	0.61	7.30
	25.78	33.95	12.00	35.05	6.50
	26.05	34.13	11.39	70.10	5.30
3A	26.00	34.50	13.33	0.61	8.50
	25.89	34.30	12.89	19.81	6.60
	25.78	34.13	12.78	39.62	6.40
3B	25.66	34.13	13.39	0.61	8.90
	26.03	34.31	12.22	24.54	6.00
	25.90	34.13	12.17	49.07	4.90
3C	25.52	33.95	13.39	0.61	7.70
	25.64	33.95	12.78	32.00	6.40
	25.74	33.77	11.56	64.01	4.90
4A	25.50	33.77	12.78	0.61	8.05
	25.66	33.77	11.94	18.29	5.80
	25.87	33.95	11.61	36.58	5.20
4B	25.66	34.13	13.39	0.61	8.60
	25.60	33.77	12.28	27.43	6.50
	25.85	33.95	11.72	54.86	4.80
4C	25.51	33.95	13.44	0.61	7.00
	25.72	33.95	12.39	35.05	6.30
	25.84	33.95	11.78	70.10	4.80
5A	25.39	33.77	13.33	0.61	9.10
	25.30	33.56	13.06	10.67	8.00
	25.50	33.77	12.78	21.34	6.60
5B	25.42	33.77	13.22	0.61	7.60
	25.61	33.77	12.22	19.35	6.60
	25.63	33.77	12.11	38.71	6.60
5C	25.44	33.77	13.11	0.61	7.50
	25.71	33.77	11.72	26.56	5.80
	25.71	33.77	11.72	52.73	5.60
6A	25.25	33.58	13.33	0.61	9.40
	25.47	33.77	12.94	20.42	8.00
	25.60	33.95	12.83	22.56	7.30
6B	25.37	33.77	13.44	0.61	9.00
	25.53	33.77	12.67	12.50	7.30
	25.75	33.95	12.22	24.99	5.80
6C	25.37	33.77	13.44	0.61	8.10
	25.69	33.95	12.56	16.00	6.40
	25.75	33.95	12.22	32.00	5.90
7A	25.14	33.77	14.56	0.61	11.40
	25.65	33.95	12.72	10.97	6.30
	25.76	33.95	12.17	21.95	5.00
7B	25.56	33.95	13.22	0.61	7.70
	25.78	33.95	12.06	15.85	6.60
	25.86	33.95	11.67	31.70	5.20
7C	25.64	33.95	12.78	0.61	7.50
	25.72	33.77	11.67	17.53	6.00
	25.86	33.95	11.67	35.05	4.90
8A	25.10	32.95	15.39	0.61	11.70
	25.28	33.77	13.89	7.62	10.80
	25.61	33.77	12.22	15.24	4.60
8B	25.17	33.95	15.06	0.61	12.20
	25.53	33.77	12.67	9.91	8.00
	25.70	33.77	11.76	19.81	4.20
8C	25.12	33.77	14.67	0.61	12.40
	25.41	33.53	12.50	12.34	7.20
	25.70	33.77	11.78	24.69	4.60

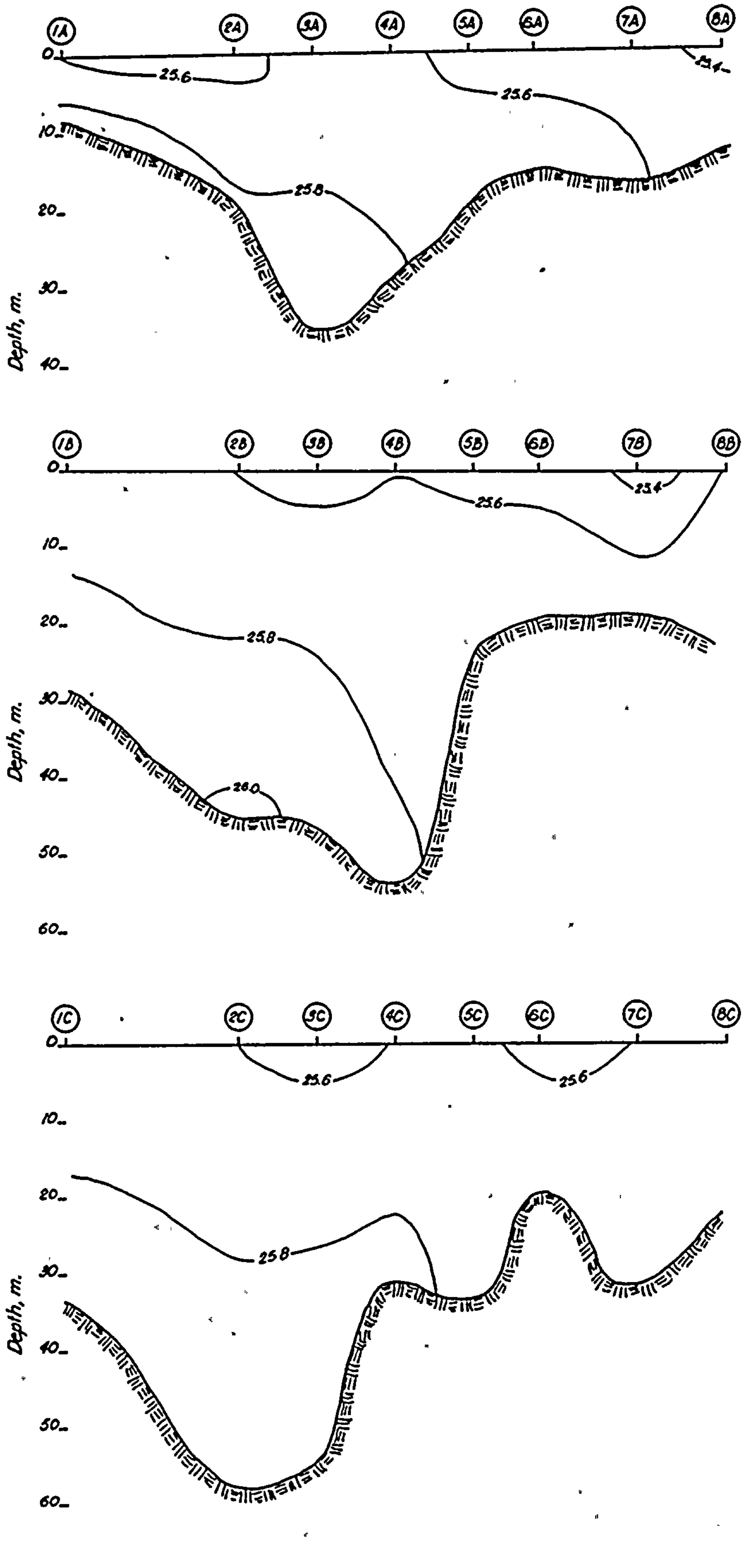
9-27-73



Density Contour for 1-29-74

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.63	33.60	11.44	0.61	7.30
	25.69	33.60	11.11	4.27	7.70
	25.85	33.70	10.61	8.53	5.80
1B	25.59	33.59	11.61	0.61	7.80
	25.76	33.63	10.83	13.72	7.40
	25.90	33.73	10.50	27.43	5.80
1C	25.59	33.60	11.67	0.61	8.00
	25.80	33.63	10.61	16.46	7.40
	25.89	33.73	10.56	32.92	7.70
2A	25.64	33.59	11.33	0.61	8.30
	25.66	33.59	11.22	9.14	7.60
	25.82	33.66	10.61	18.29	6.40
2B	25.61	33.56	11.39	0.61	6.20
	25.84	33.69	10.67	21.95	6.40
	25.97	33.75	10.17	43.89	4.20
2C	25.62	33.61	11.50	0.61	2.60
	25.81	33.70	10.83	28.35	6.30
	25.93	33.77	10.50	56.69	6.20
3A	25.68	33.62	11.22	0.61	7.80
	25.81	33.64	10.61	17.37	6.80
	25.91	33.75	10.50	34.75	6.00
3B	25.66	33.62	11.33	0.61	7.80
	25.78	33.67	10.89	22.86	6.30
	25.91	33.74	10.44	45.72	5.60
3C	25.67	33.67	11.50	0.61	8.00
	25.82	33.71	10.83	27.43	6.00
	25.94	33.78	10.44	54.86	5.40
4A	25.66	33.59	11.22	0.61	7.60
	25.70	33.63	11.17	14.48	7.40
	25.75	33.66	11.00	28.96	7.00
4B	25.63	33.58	11.23	0.61	7.80
	25.72	33.64	11.11	26.67	6.60
	25.83	33.71	10.78	53.34	5.80
4C	25.64	33.59	11.33	0.61	7.80
	25.73	33.65	11.11	15.21	6.60
	25.89	33.74	10.56	80.35	5.60
5A	25.54	33.45	11.28	0.61	8.20
	25.62	33.54	11.22	9.14	7.60
	25.64	33.55	11.17	18.29	7.60
5B	25.50	33.40	11.28	0.61	8.20
	25.65	33.58	11.22	10.97	8.20
	25.69	33.60	11.11	21.95	7.10
5C	25.66	33.60	11.28	0.61	7.60
	25.66	33.60	11.28	16.46	7.20
	25.72	33.64	11.11	32.92	6.40
6A	25.49	33.46	11.61	0.61	8.20
	25.56	33.55	11.61	7.32	7.80
	25.58	33.57	11.56	14.63	7.40
6B	25.53	33.49	11.50	0.61	7.70
	25.65	33.59	11.28	9.14	7.00
	25.66	33.61	11.28	18.29	7.20
6C	25.53	33.45	11.33	0.61	7.60
	25.68	33.63	11.28	9.14	7.30
	25.67	33.61	11.22	18.29	5.30
7A	25.47	33.46	11.72	0.61	8.40
	25.49	33.46	11.61	8.23	8.00
	25.60	33.60	11.61	16.46	7.40
7B	25.43	33.44	11.83	0.61	8.40
	25.52	33.54	11.78	9.14	7.40
	25.57	33.59	11.72	18.29	7.40
7C	25.59	33.58	11.56	0.61	7.00
	25.61	33.56	11.39	15.54	7.60
	25.63	33.56	11.28	31.09	6.80
8A	25.44	33.54	12.17	0.61	8.40
	25.48	33.53	11.94	6.40	8.00
	25.51	33.54	11.83	12.80	8.40
8B	25.51	33.56	11.89	0.61	8.20
	25.52	33.56	11.85	9.14	8.00
	25.53	33.56	11.78	18.29	7.50
8C	25.55	33.56	11.67	0.61	8.20
	25.56	33.56	11.61	10.97	7.80
	25.62	33.61	11.50	21.95	7.20

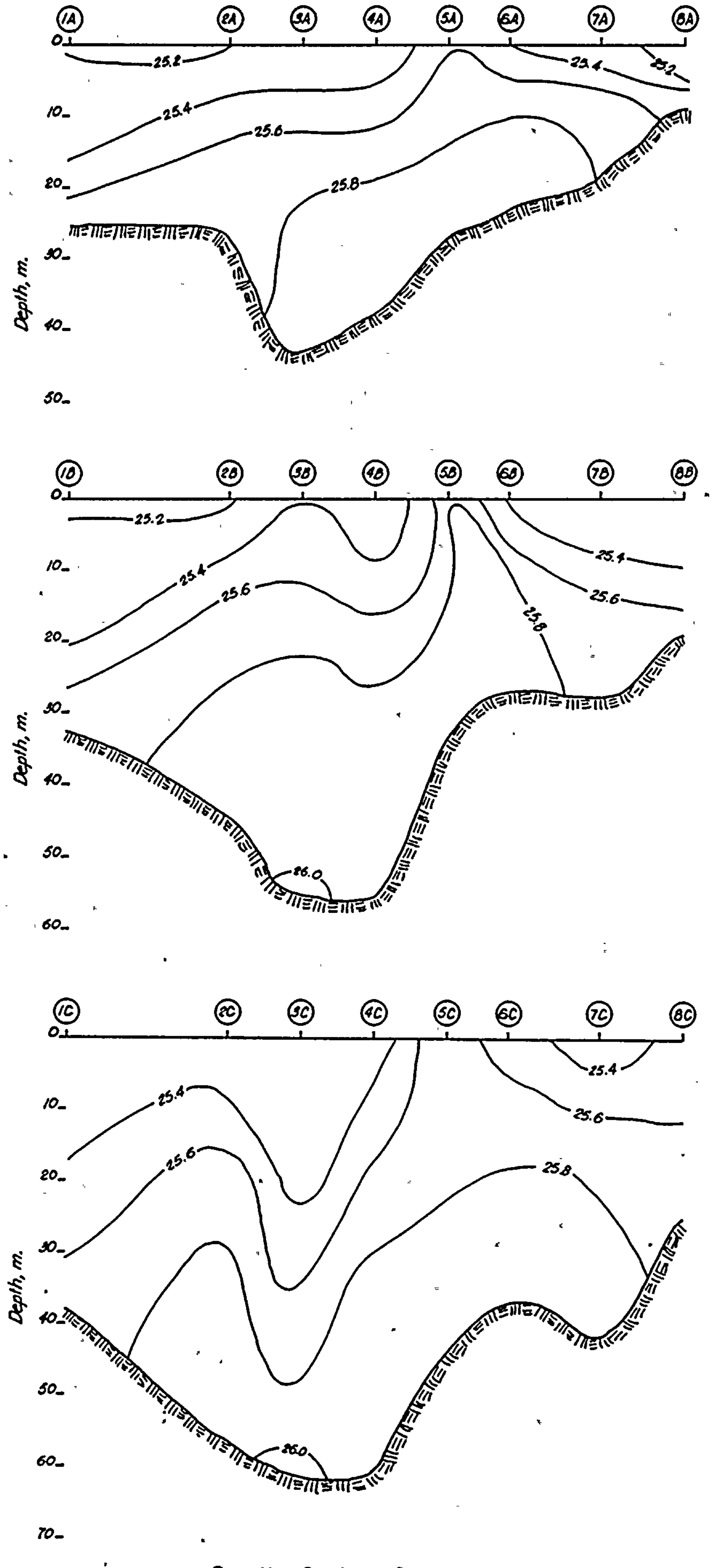
1-29-74



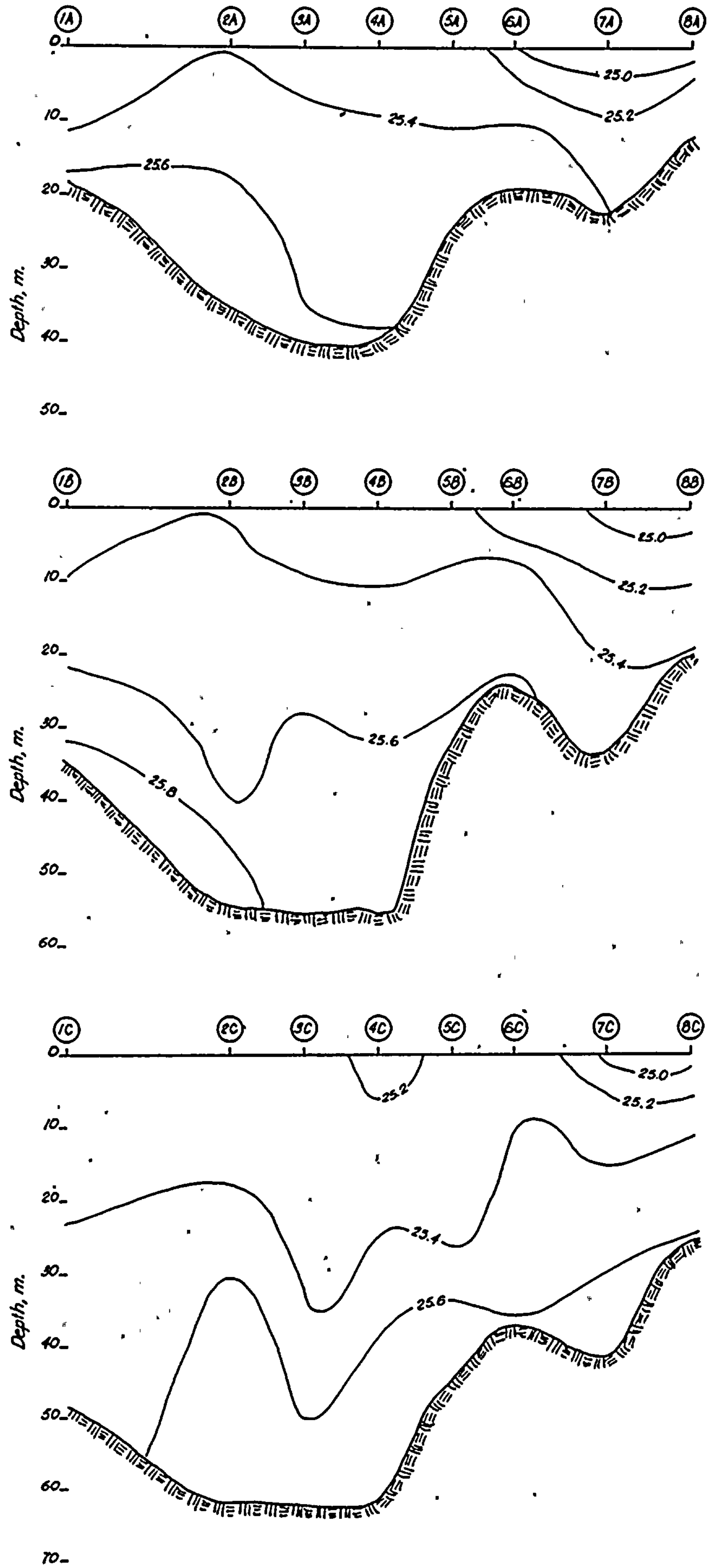
Density Contour for 1-29-74

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.21	33.71	14.00	0.61	10.00
	25.26	33.72	13.80	12.19	9.40
	25.73	33.75	11.50	24.38	8.20
1B	25.23	33.71	13.90	0.61	9.90
	25.32	33.72	13.50	15.70	8.60
	25.73	33.75	11.50	31.39	7.60
1C	25.26	33.72	13.80	0.61	8.20
	25.39	33.68	13.60	18.29	9.00
	25.73	33.75	11.50	36.58	7.20
2A	25.22	33.70	13.90	0.61	8.50
	25.57	33.74	12.30	12.80	6.00
	25.60	33.72	12.10	25.60	6.65
2B	25.22	33.70	13.90	0.61	8.45
	25.71	33.74	11.60	20.73	7.20
	25.85	33.73	11.00	41.45	6.00
2C	25.34	33.75	13.50	0.61	8.20
	25.84	33.77	11.00	27.43	6.30
	25.93	33.77	10.50	54.86	5.80
3A	25.33	33.70	13.40	0.61	8.00
	25.79	33.73	11.10	21.34	7.40
	25.87	33.76	10.80	42.67	6.10
3B	25.37	33.73	13.30	0.61	8.00
	25.87	33.77	10.80	27.43	6.25
	25.95	33.76	10.30	54.86	5.60
3C	25.29	33.76	13.80	0.61	8.60
	25.46	33.75	12.90	33.53	8.00
	25.96	33.79	10.40	67.06	5.80
4A	25.33	33.71	13.40	0.61	8.15
	25.75	33.72	11.30	18.29	6.80
	25.77	33.73	11.20	36.58	7.00
4B	25.33	33.70	13.40	0.61	7.70
	25.76	33.74	11.30	27.43	5.50
	25.84	33.77	11.00	54.86	6.20
4C	25.34	33.72	13.40	0.61	7.50
	25.84	33.77	11.00	34.75	5.60
	25.91	33.79	10.70	69.49	5.80
5A	25.61	33.76	12.20	0.61	7.50
	25.79	33.76	11.20	13.11	6.40
	25.87	33.79	10.90	26.21	5.60
5B	25.76	33.88	11.90	0.61	6.00
	25.78	33.79	11.40	16.46	6.40
	25.86	33.80	11.00	32.92	3.10
5C	25.73	33.80	11.70	0.61	6.60
	25.82	33.79	11.20	21.95	5.80
	25.94	33.85	10.80	43.89	5.40
6A	25.40	33.79	13.40	0.61	8.20
	25.64	33.80	12.20	10.97	5.80
	25.77	33.80	11.50	21.95	6.20
6B	25.42	33.79	13.30	0.61	7.90
	25.77	33.80	11.50	13.26	6.20
	25.86	33.82	11.10	26.52	5.20
6C	25.45	33.81	13.20	0.61	8.80
	25.83	33.81	11.20	18.29	6.00
	25.90	33.83	10.90	36.58	5.80
7A	25.29	33.79	13.90	0.61	9.40
	25.68	33.80	12.00	9.30	6.30
	25.77	33.80	11.50	18.59	5.00
7B	25.22	33.78	14.20	0.61	9.20
	25.55	33.84	12.80	14.33	6.60
	25.66	33.80	12.10	28.65	5.30
7C	25.31	33.79	13.80	0.61	8.80
	25.84	33.79	11.10	20.42	4.90
	25.86	33.77	10.90	40.84	5.80
8A	25.07	33.75	14.80	0.61	9.80
	25.20	33.69	14.00	4.88	7.90
	25.47	33.73	12.80	9.75	8.20
8B	25.26	33.75	13.90	0.61	8.60
	25.38	33.74	13.30	9.60	7.80
	25.74	33.76	11.50	19.20	6.10
8C	25.54	33.77	12.00	0.61	6.80
	25.60	33.77	12.30	11.89	5.80
	25.73	33.79	11.70	23.77	5.20

7-13-74



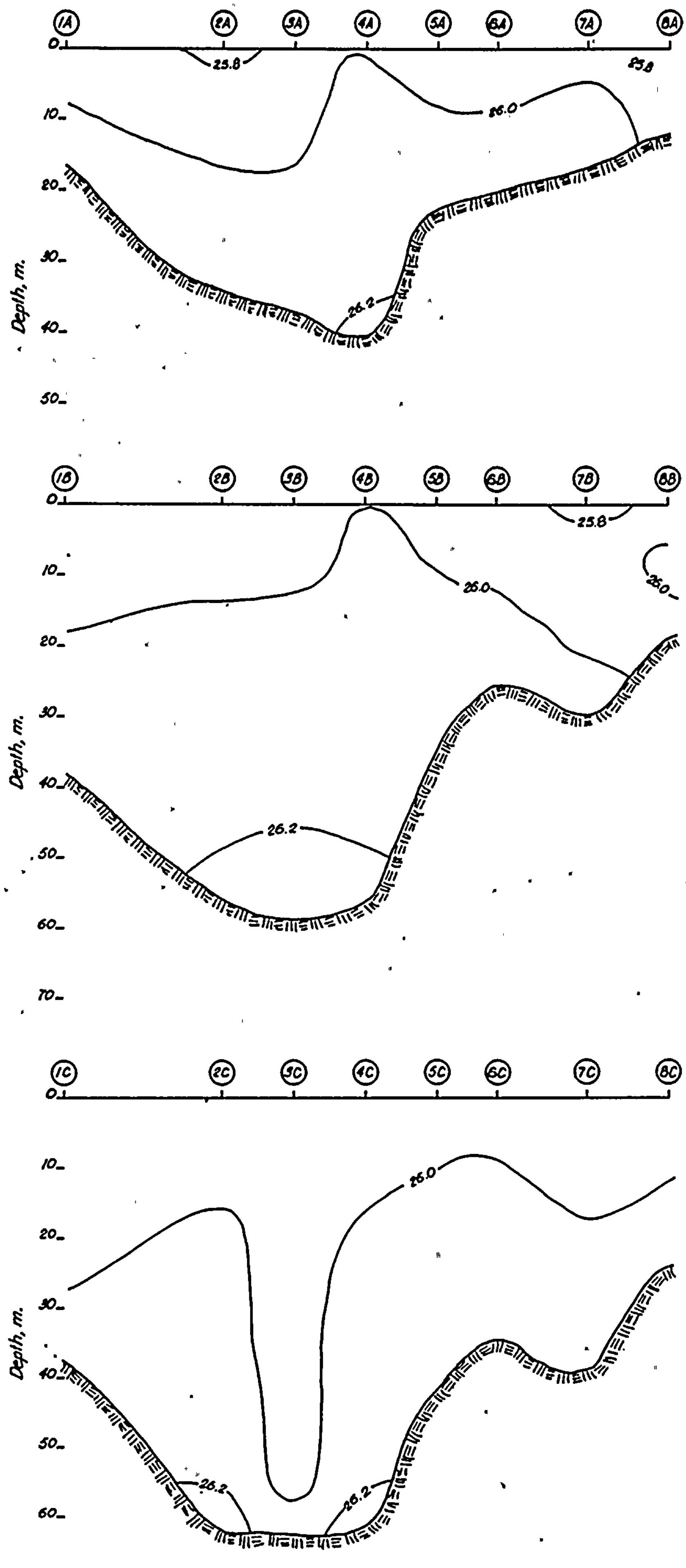
Density Contour for 7-13-74



Density Contour for 9-23-74

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.29	33.60	13.20	0.61	7.80
	25.33	33.60	13.00	6.99	7.50
	25.56	33.62	11.90	17.98	6.00
1B	25.26	33.62	13.40	0.61	7.00
	25.50	33.65	12.30	16.76	6.10
	25.75	33.61	10.80	33.53	5.90
1C	25.28	33.61	13.30	0.61	7.60
	25.44	33.62	12.50	23.62	6.30
	25.53	33.63	12.10	47.24	6.10
2A	25.36	33.62	12.90	0.61	5.30
	25.56	33.63	11.90	17.07	6.70
	25.73	33.65	11.10	34.14	5.90
2B	25.36	33.62	12.90	0.61	4.20
	25.42	33.59	12.50	26.52	5.80
	25.75	33.66	11.00	53.04	5.50
2C	25.33	33.57	12.90	0.61	5.90
	25.59	33.69	12.00	30.48	7.00
	25.72	33.57	10.80	60.96	4.20
3A	25.32	33.56	12.90	0.61	3.90
	25.50	33.57	12.00	19.51	1.70
	25.64	33.58	11.30	39.01	2.60
3B	25.30	33.54	12.90	0.61	6.70
	25.59	33.57	11.50	26.52	6.40
	25.70	33.62	11.10	53.04	5.00
3C	25.36	33.64	13.00	0.61	5.40
	25.30	33.51	12.80	30.48	2.30
	25.67	33.53	10.90	60.96	4.30
4A	25.31	33.57	13.00	0.61	5.00
	25.52	33.60	12.00	19.51	4.70
	25.62	33.61	11.50	39.01	4.10
4B	25.32	33.62	13.10	0.61	7.00
	25.47	33.58	12.20	27.43	4.90
	25.63	33.59	11.40	54.86	5.10
4C	25.23	33.57	13.40	0.61	5.00
	25.52	33.57	11.90	30.48	6.00
	25.75	33.65	11.00	60.96	2.70
5A	25.28	33.62	13.30	0.61	4.20
	25.40	33.61	12.70	11.58	4.30
	25.50	33.59	12.10	23.16	5.70
5B	25.28	33.56	13.10	0.61	4.80
	25.50	33.57	12.00	15.85	4.90
	25.57	33.59	11.70	31.70	4.70
5C	25.31	33.57	13.00	0.61	5.80
	25.33	33.57	12.90	21.34	6.70
	25.81	33.62	10.50	42.67	4.80
6A	24.98	33.58	14.60	0.61	2.80
	25.35	33.57	12.80	9.14	3.00
	25.49	33.61	12.20	18.29	3.80
6B	24.89	33.57	15.00	0.61	3.80
	25.49	33.58	12.10	11.28	1.80
	25.55	33.59	11.80	22.56	1.80
6C	25.27	33.58	13.20	0.61	4.20
	25.49	33.58	12.10	17.98	6.00
	25.61	33.61	11.60	35.97	4.40
7A	24.90	33.58	15.00	0.61	4.20
	25.19	33.58	13.60	11.13	3.60
	25.39	33.58	12.60	22.25	3.80
7B	24.96	33.58	14.70	0.61	3.90
	25.32	33.56	12.90	16.46	4.00
	25.47	33.58	12.20	32.92	4.00
7C	25.03	33.58	14.40	0.61	4.60
	25.51	33.58	12.00	20.42	3.60
	25.64	33.63	11.50	40.84	3.20
8A	24.88	33.58	15.10	0.61	4.60
	25.24	33.56	13.30	5.79	4.40
	25.30	33.56	13.00	11.58	4.60
8B	24.96	33.60	14.80	0.61	3.00
	25.22	33.54	13.30	10.06	5.00
	25.36	33.54	12.60	20.12	4.00
8C	24.98	33.60	14.70	0.61	3.60
	25.40	33.57	12.50	12.80	3.00
	25.51	33.58	12.00	25.60	3.80

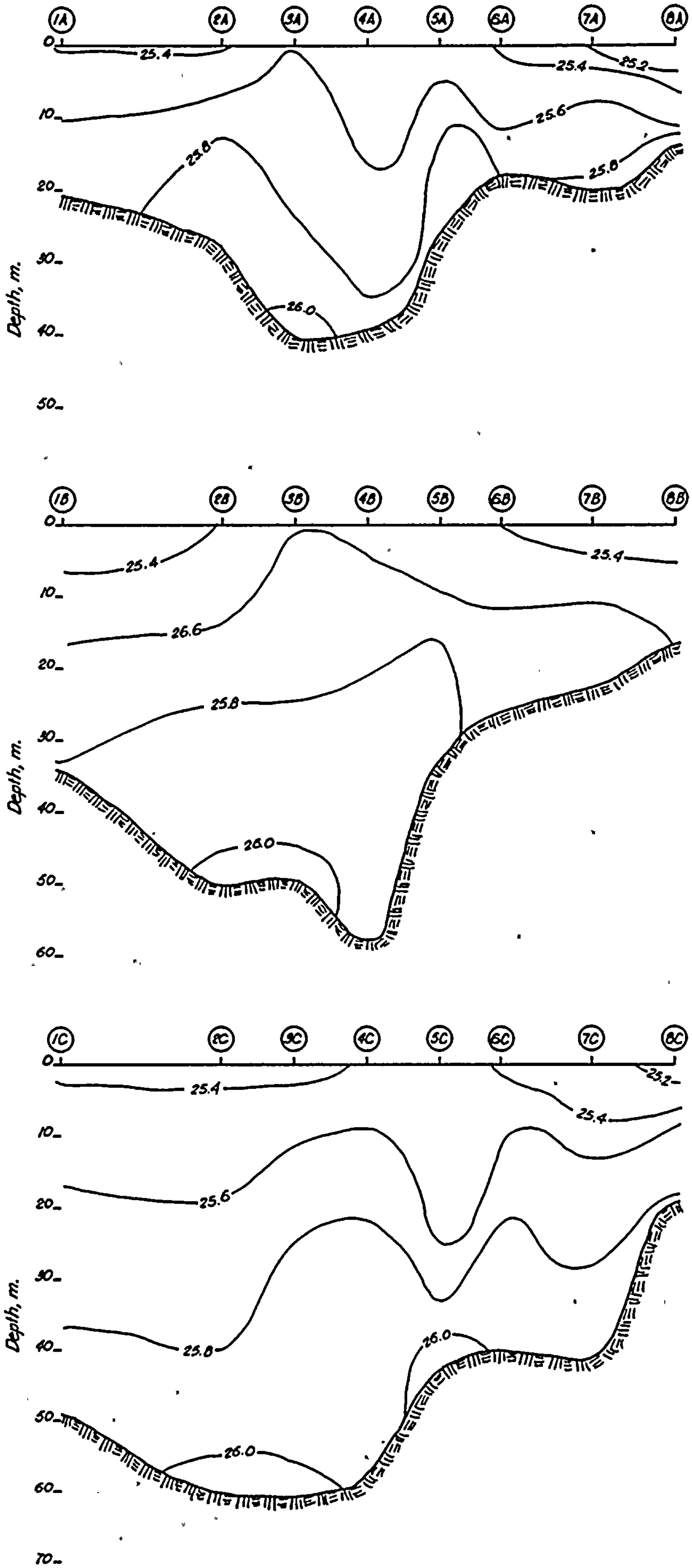
9-23-74



Density Contour for 2-27-75

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.93	33.73	10.30	0.61	7.20
	25.97	33.74	10.10	7.77	7.20
	26.00	33.79	10.15	15.54	7.40
1B	25.92	33.74	10.40	0.61	7.20
	25.98	33.78	10.22	18.29	7.20
	26.05	33.80	9.90	36.58	5.80
1C	25.91	33.75	10.50	0.61	7.20
	25.94	33.74	10.30	18.29	7.40
	26.09	33.82	9.80	36.58	5.60
2A	25.82	33.68	10.70	0.61	7.40
	25.98	33.77	10.20	17.53	6.00
	26.01	33.78	10.05	32.00	5.70
2B	25.91	33.68	10.20	0.61	5.50
	26.07	33.80	9.80	26.67	4.40
	26.19	33.88	9.45	53.34	4.40
2C	25.90	33.73	10.50	0.61	7.00
	26.10	33.84	9.80	30.48	5.50
	26.18	33.88	9.50	60.96	4.20
3A	25.91	33.75	10.50	0.61	7.00
	26.03	33.88	10.40	18.29	5.60
	26.10	33.82	9.70	36.58	5.10
3B	25.91	33.73	10.40	0.61	7.10
	26.13	33.84	9.60	28.96	5.00
	26.18	33.88	9.50	57.91	4.40
3C	25.90	33.74	10.50	0.61	7.00
	25.92	33.72	10.30	30.48	6.20
	26.02	33.80	10.10	60.96	5.90
4A	26.01	33.79	10.10	0.61	6.80
	26.09	33.82	9.80	19.81	5.30
	26.15	33.88	9.70	39.62	5.00
4B	25.95	33.73	10.20	0.61	6.50
	26.10	33.82	9.70	28.19	5.20
	26.15	33.84	9.50	56.39	4.70
4C	25.93	33.73	10.30	0.61	7.00
	26.13	33.82	9.50	30.48	5.00
	26.18	33.87	9.45	60.96	4.40
5A	25.94	33.79	10.50	0.61	6.50
	26.03	33.81	10.10	10.67	5.65
	26.12	33.80	9.90	21.34	5.27
5B	25.87	33.72	10.60	0.61	6.80
	26.04	33.80	10.00	16.76	5.70
	26.10	33.82	9.70	33.53	4.80
5C	25.85	33.72	10.70	0.61	6.20
	26.09	33.83	9.80	21.34	5.10
	26.13	33.85	9.70	42.67	4.80
6A	25.88	33.75	10.70	0.61	8.50
	26.04	33.81	10.00	9.91	7.40
	26.05	33.81	9.95	19.81	6.60
6B	25.88	33.82	11.00	0.61	8.00
	25.98	33.82	10.40	12.19	6.40
	26.05	33.84	10.10	24.38	5.30
6C	25.91	33.81	10.80	0.61	8.00
	26.05	33.82	10.00	16.76	5.90
	26.08	33.83	9.90	33.53	5.30
7A	25.80	33.77	11.20	0.61	9.15
	26.06	33.83	10.00	8.38	7.20
	26.10	33.88	10.00	16.76	6.10
7B	25.81	33.76	11.10	0.61	8.80
	25.92	33.83	10.80	15.24	6.40
	26.04	33.83	10.10	30.48	6.20
7C	25.86	33.80	11.00	0.61	9.00
	26.03	33.82	10.10	19.81	6.20
	26.10	33.86	9.90	39.62	4.80
8A	25.74	33.85	11.90	0.61	9.80
	25.92	33.83	10.80	6.10	9.20
	25.93	33.82	10.70	12.19	8.20
8B	25.86	33.85	11.20	0.61	8.80
	26.07	33.85	10.00	9.14	6.60
	25.87	33.84	11.10	18.29	8.80
8C	25.86	33.84	11.20	0.61	8.80
	25.99	33.83	10.40	12.19	8.00
	26.10	33.82	9.70	24.38	5.70

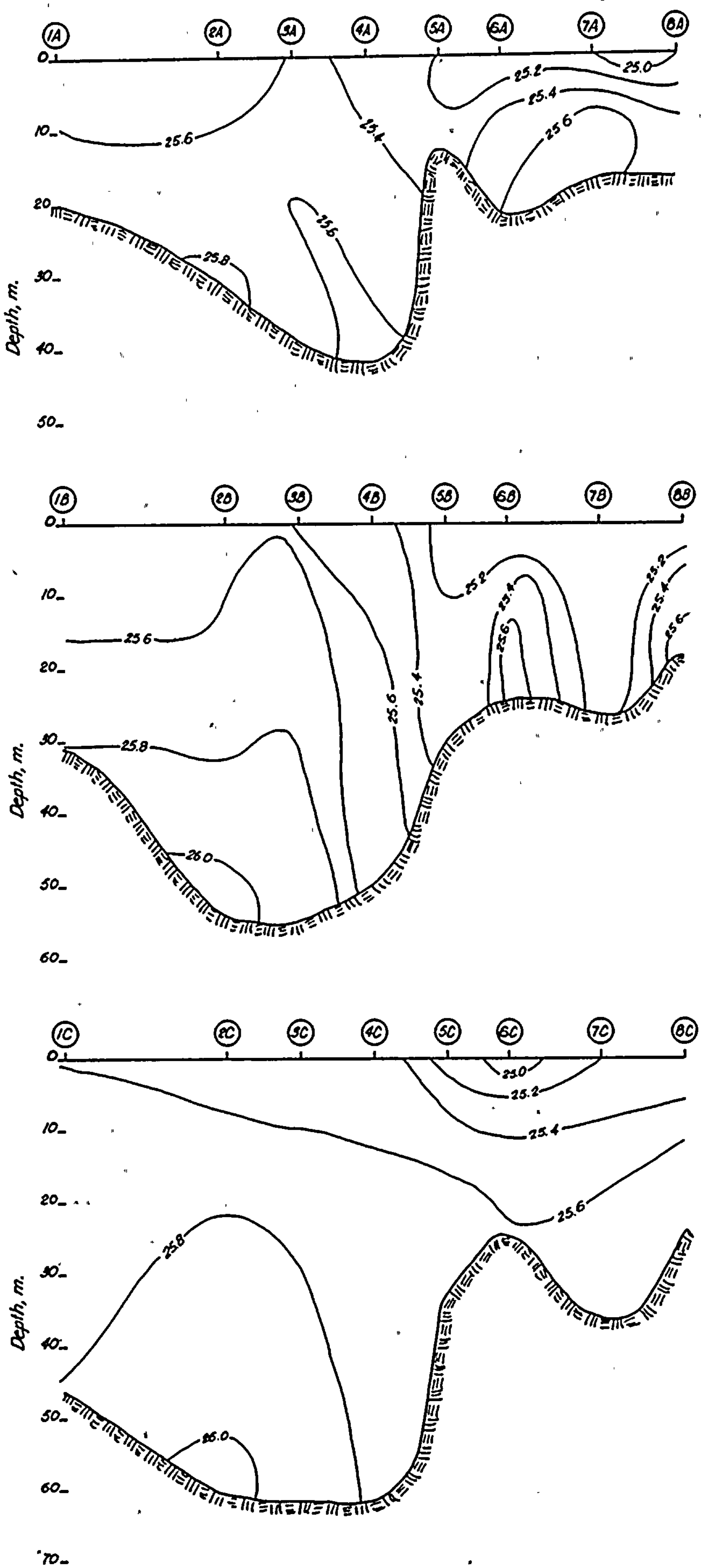
2-27-75



Density Contour for 6-9-75

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.44	33.72	12.90	0.61	8.35
	25.56	33.70	12.20	10.06	7.70
	25.65	33.71	11.00	20.12	7.70
1B	25.33	33.71	13.40	0.61	10.10
	25.56	33.70	12.20	16.46	8.40
	25.80	33.74	11.10	32.92	6.90
1C	25.33	33.69	13.10	0.61	9.10
	25.74	33.73	11.40	23.62	7.10
	25.89	33.79	10.80	47.24	6.60
2A	25.47	33.71	12.70	0.61	9.10
	25.76	33.74	11.30	12.80	6.50
	25.88	33.78	10.80	25.60	5.50
2B	25.44	33.72	12.90	0.61	9.60
	25.80	33.79	11.30	24.69	5.40
	26.00	33.87	10.50	49.38	4.50
2C	25.38	33.69	13.10	0.61	10.00
	25.74	33.73	11.40	29.57	7.00
	26.04	33.74	9.70	59.13	4.40
3A	25.60	33.72	12.10	0.61	7.90
	25.66	33.72	11.75	19.51	7.40
	25.95	33.78	10.40	39.01	5.10
3B	25.56	33.70	12.20	0.61	7.90
	25.76	33.71	11.20	24.08	6.60
	26.02	33.80	10.10	48.16	4.70
3C	25.45	33.68	12.70	0.61	8.40
	25.93	33.69	10.10	29.57	8.00
	25.96	33.72	10.10	59.44	6.30
4A	25.45	33.68	12.70	0.61	8.20
	25.60	33.68	11.90	18.90	7.90
	25.84	33.70	10.70	37.80	7.90
4B	25.47	33.71	12.70	0.61	8.40
	25.95	33.73	10.20	28.04	7.20
	25.93	33.69	10.10	56.08	7.20
4C	25.48	33.69	12.60	0.61	9.80
	25.93	33.69	10.10	28.96	6.40
	25.91	33.73	10.40	57.91	6.00
5A	25.48	33.69	12.60	0.61	8.00
	25.83	33.69	10.70	11.89	6.40
	25.80	33.70	10.90	23.77	6.00
5B	25.45	33.68	12.70	0.61	8.40
	25.81	33.69	10.80	14.94	6.40
	25.84	33.70	10.70	29.87	5.70
5C	25.48	33.69	12.60	0.61	9.10
	25.54	33.67	12.20	21.34	8.05
	26.00	33.73	9.90	42.37	5.40
6A	25.39	33.70	13.10	0.61	8.40
	25.50	33.69	12.50	8.38	8.00
	25.66	33.70	11.70	16.76	7.40
6B	25.39	33.70	13.10	0.61	9.60
	25.58	33.65	11.90	12.65	7.30
	25.73	33.70	11.30	25.30	6.10
6C	25.38	33.69	13.10	0.61	8.50
	25.75	33.68	11.10	19.81	7.00
	25.83	33.69	10.70	39.62	6.00
7A	25.24	33.72	13.90	0.61	9.60
	25.72	33.69	11.30	10.21	8.70
	25.75	33.70	11.20	20.42	6.50
7B	25.33	33.68	13.30	0.61	9.90
	25.55	33.69	12.20	11.43	7.80
	25.72	33.69	11.30	22.86	6.20
7C	25.34	33.67	13.20	0.61	9.10
	25.71	33.70	11.40	20.57	6.20
	25.80	33.70	10.90	41.15	5.75
8A	25.13	33.69	14.30	0.61	9.65
	25.20	33.51	13.00	6.55	9.80
	25.77	33.68	11.00	13.11	8.70
8B	25.12	33.70	14.40	0.61	9.80
	25.46	33.69	12.70	8.23	10.30
	25.62	33.70	11.90	16.46	9.00
8C	25.11	33.66	14.30	0.61	10.20
	25.59	33.69	12.00	9.91	9.30
	25.75	33.72	11.30	19.81	4.20

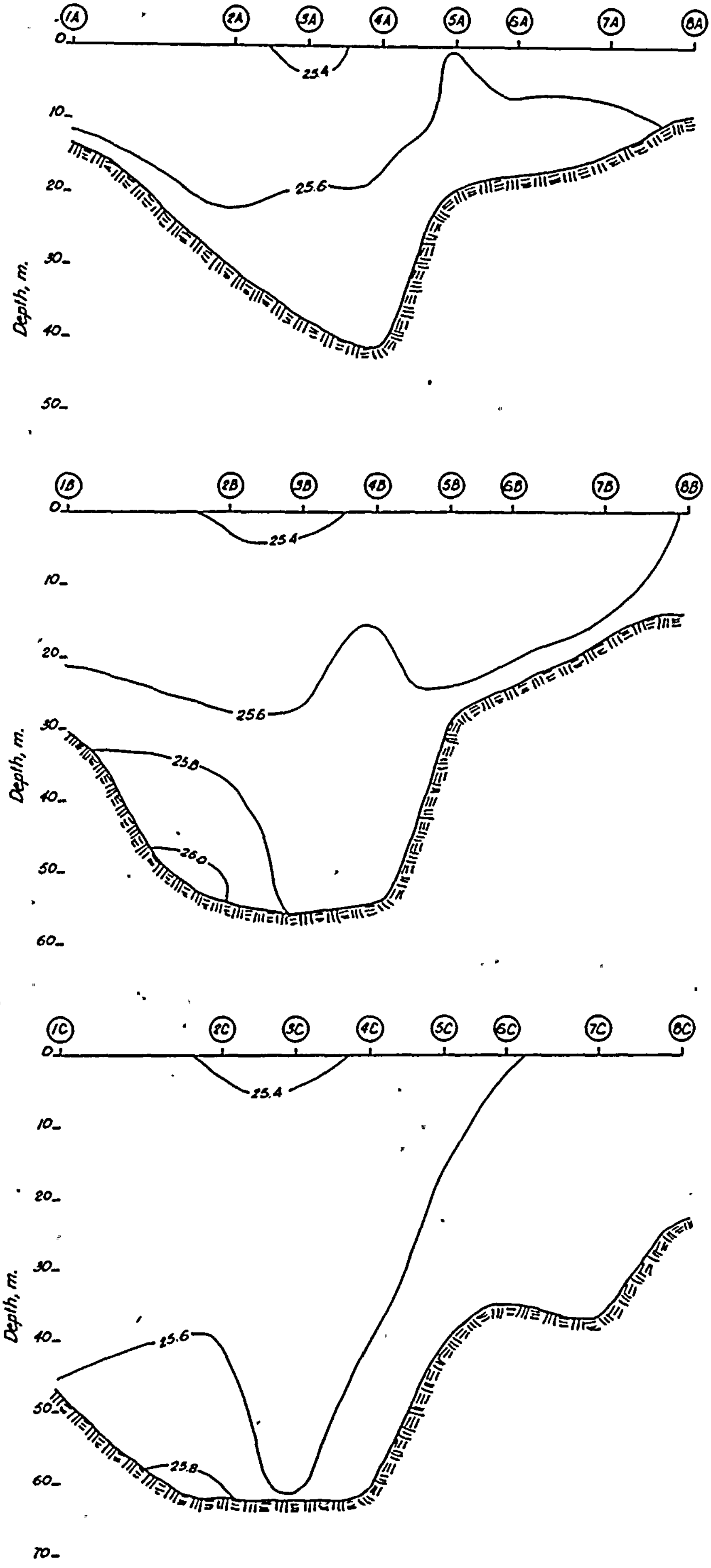
6-9-75



Density Contour for 9-23-75

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM	SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.49	33.72	12.67	0.61	8.40	5A	25.22	33.71	13.94	0.61	9.00
	25.63	33.71	11.89	9.91	8.10		25.24	33.70	13.83	5.33	7.60
	25.74	33.73	11.39	19.81	6.50		25.31	33.71	13.50	10.67	7.40
1B	25.48	33.71	12.67	0.61	2.60	5B	25.13	33.69	14.33	0.61	11.50
	25.62	33.70	11.89	15.24	7.80		25.21	33.71	14.00	14.02	8.00
	25.80	33.74	11.11	30.48	5.90		25.24	33.70	13.83	28.04	6.40
1C	25.55	33.72	12.33	0.61	2.60	5C	25.06	33.70	14.67	0.61	11.20
	25.60	33.69	11.94	22.86	1.70		25.57	33.65	11.94	15.85	8.60
	25.80	33.74	11.11	45.72	2.00		25.65	33.69	11.67	31.70	6.80
2A	25.50	33.71	12.56	0.61	5.10	6A	25.14	33.72	14.39	0.61	11.00
	25.68	33.70	11.56	14.94	7.80		25.46	33.70	12.72	10.67	8.60
	25.78	33.72	11.11	29.87	5.80		25.59	33.72	12.11	21.34	6.40
2B	25.52	33.72	12.50	0.61	5.40	6B	25.07	33.67	14.50	0.61	10.20
	25.68	33.77	11.89	26.52	4.20		25.62	33.69	11.83	11.89	7.90
	26.06	33.86	10.11	53.04	5.80		25.64	33.67	11.67	23.77	6.40
2C	25.48	33.73	12.72	0.61	3.00	6C	24.99	33.70	15.00	0.61	7.20
	25.86	33.79	10.94	29.87	4.60		25.40	33.63	12.61	12.80	9.80
	26.01	33.83	10.28	59.74	1.80		25.63	33.69	11.78	25.60	6.60
3A	25.59	33.71	12.11	0.61	8.00	7A	24.95	33.71	15.22	0.61	11.40
	25.64	33.72	11.89	18.75	7.80		25.57	33.69	12.11	8.23	8.40
	25.74	33.74	11.39	37.49	6.40		25.59	33.71	12.11	16.46	6.40
3B	25.58	33.72	12.17	0.61	8.20	7B	24.94	33.68	15.17	0.61	10.80
	25.80	33.74	11.11	26.06	5.80		24.93	33.69	15.00	12.95	6.90
	25.94	33.76	10.39	52.43	5.20		25.02	33.71	14.89	25.91	5.60
3C	25.52	33.71	12.44	0.61	8.80	7C	25.16	33.68	14.11	0.61	11.80
	25.82	33.75	11.00	30.48	5.50		25.64	33.68	11.39	18.29	8.40
	25.92	33.76	10.50	60.96	5.60		25.73	33.72	11.39	36.58	6.60
4A	25.34	33.73	13.44	0.61	10.50	8A	24.98	33.72	15.11	0.61	9.20
	25.53	33.73	12.50	20.27	7.70		25.37	33.68	13.11	8.08	12.00
	25.60	33.73	12.11	40.54	6.40		25.54	33.75	12.50	16.15	5.90
4B	25.45	33.72	12.83	0.61	8.80	8B	25.09	33.74	14.67	0.61	10.70
	25.69	33.73	11.67	24.69	6.90		25.50	33.70	12.50	8.69	8.80
	25.74	33.73	11.39	49.38	5.60		25.67	33.71	11.67	17.37	5.20
4C	25.46	33.74	12.89	0.61	9.90	8C	25.21	33.71	14.00	0.61	11.70
	25.72	33.73	11.50	30.48	6.00		25.56	33.70	12.22	12.19	7.60
	25.78	33.75	11.22	60.96	5.40		25.68	33.72	11.67	24.38	5.30

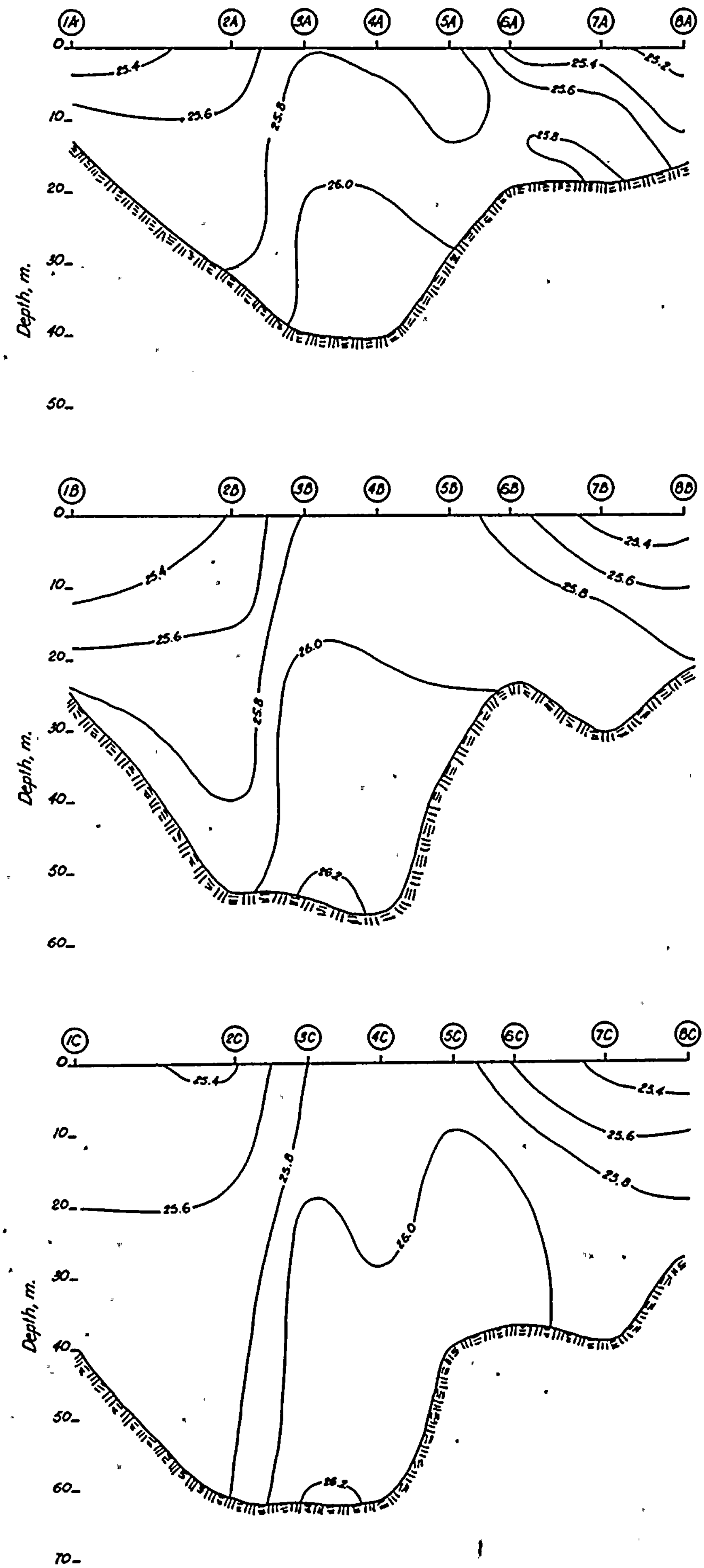
9-23-75



Density Contour for 2-24-76

SAMPLE	SIG-T	Y S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	25.54	33.62	12.00	0.61	8.80
	25.54	33.62	12.00	6.10	9.00
	25.55	33.63	12.00	12.19	8.30
1B	25.51	33.61	12.10	0.61	8.60
	25.51	33.61	12.10	14.48	8.70
	25.70	33.66	11.30	28.96	7.40
1C	25.49	33.61	12.20	0.61	9.00
	25.53	33.61	12.00	22.86	8.60
	25.70	33.61	11.10	45.72	6.80
2A	25.47	33.60	12.30	0.61	8.40
	25.50	33.59	12.10	14.48	8.20
	25.72	33.67	11.20	28.96	6.90
2B	25.41	33.60	12.60	0.61	8.70
	25.59	33.62	11.70	25.91	8.00
	25.95	33.75	10.30	51.82	5.70
2C	25.40	33.61	12.70	0.61	8.60
	25.54	33.62	12.00	30.48	8.40
	25.77	33.68	11.00	60.96	6.80
3A	25.42	33.61	12.60	0.61	8.60
	25.55	33.61	11.90	18.29	8.50
	25.64	33.65	11.60	36.58	8.00
3B	25.42	33.62	12.60	0.61	8.60
	25.60	33.63	11.70	27.43	8.00
	25.81	33.67	10.70	54.86	6.30
3C	25.42	33.61	12.60	0.61	8.80
	25.51	33.61	12.10	30.48	8.40
	25.63	33.64	11.60	60.96	7.40
4A	25.50	33.64	12.30	0.61	8.80
	25.58	33.63	11.80	19.81	8.50
	25.59	33.64	11.80	39.62	8.30
4B	25.48	33.62	12.30	0.61	8.65
	25.65	33.65	11.50	26.67	7.40
	25.77	33.68	11.00	53.34	6.70
4C	25.46	33.62	12.40	0.61	8.60
	25.54	33.62	12.00	30.48	8.20
	25.71	33.68	11.30	60.96	6.90
5A	25.55	33.66	12.10	0.61	8.90
	25.57	33.64	11.90	9.14	8.40
	25.64	33.66	11.60	18.29	7.40
5B	25.50	33.64	12.30	0.61	7.50
	25.52	33.62	12.10	13.72	8.10
	25.63	33.66	11.70	27.43	7.40
5C	25.53	33.63	12.10	0.61	8.60
	25.55	33.63	12.00	19.05	8.00
	25.73	33.68	11.20	38.10	6.60
6A	25.54	33.65	12.10	0.61	8.90
	25.55	33.64	12.00	8.38	8.70
	25.55	33.64	12.00	16.76	8.40
6B	25.54	33.65	12.10	0.61	8.80
	25.53	33.64	12.10	11.43	8.10
	25.55	33.64	12.00	22.86	7.90
6C	25.57	33.64	11.90	0.61	8.60
	25.59	33.64	11.80	16.76	8.00
	25.71	33.67	11.30	33.53	7.15
7A	25.54	33.65	12.10	0.61	8.90
	25.55	33.64	12.00	6.86	8.70
	25.57	33.64	11.90	13.72	8.70
7B	25.54	33.65	12.10	0.61	9.20
	25.53	33.64	12.10	9.91	8.80
	25.57	33.64	11.90	19.81	8.30
7C	25.56	33.65	12.00	0.61	9.00
	25.57	33.64	11.90	18.29	9.00
	25.69	33.65	11.30	36.58	7.00
8A	25.54	33.65	12.10	0.61	7.40
	25.53	33.64	12.10	4.57	8.80
	25.53	33.64	12.10	9.14	8.80
8B	25.55	33.64	12.00	0.61	9.00
	25.55	33.63	12.00	6.86	9.00
	25.55	33.64	12.00	13.72	8.70
8C	25.58	33.65	11.90	0.61	8.80
	25.57	33.64	11.90	11.43	8.70
	25.57	33.64	11.90	22.86	8.80

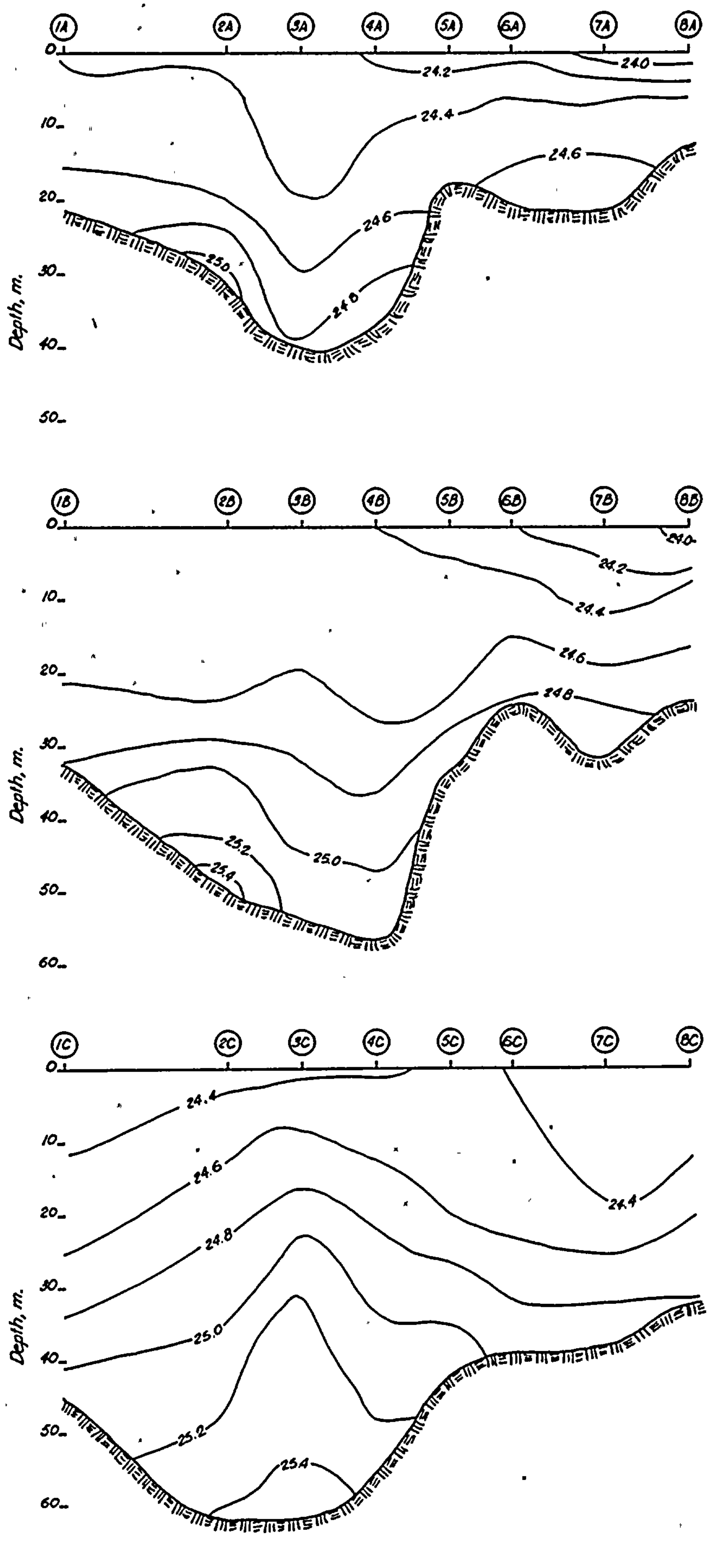
2-24-76



Density Contour for 6-21-76

SAMPLE	SIG-T	SAL(0/00)	TEMP. C	DEPTH,M.	D.O.PPM						
1A	[illegible]	[illegible]	[illegible]	[illegible]	9.90	5A	25.92	33.86	10.94	0.61	5.90
	25.48	[illegible]	[illegible]	[illegible]	10.10		25.76	33.85	11.78	13.72	6.20
	25.80	33.85	11.56	12.19	8.60		25.98	33.84	10.50	27.43	5.40
1B	25.42	33.86	13.56	0.61	9.90	5B	25.88	33.85	11.11	0.61	6.10
	25.41	33.84	13.50	12.19	10.40		25.93	33.84	10.78	16.76	6.50
	25.82	33.87	11.56	24.38	7.00		26.06	33.85	10.11	33.53	5.20
1C	25.45	33.84	13.33	0.61	10.05	5C	25.88	33.85	11.11	0.61	7.00
	25.55	33.83	12.78	19.81	9.80		26.05	33.86	10.17	19.81	5.00
	25.89	33.87	11.17	39.62	7.10		26.11	33.89	10.00	39.62	4.50
2A	25.53	33.85	12.94	0.61	7.70	6A	25.21	33.80	14.33	0.61	8.40
	25.65	33.83	12.28	15.24	8.30		25.68	33.80	12.00	9.14	7.20
	25.84	33.81	11.17	30.48	6.50		25.86	33.81	11.06	18.29	5.60
2B	25.43	33.84	13.44	0.61	9.20	6B	25.71	33.80	11.83	0.61	8.25
	25.65	33.78	12.06	25.91	8.30		25.90	33.82	10.89	11.43	6.80
	25.88	33.83	11.06	51.82	6.25		25.97	33.82	10.50	22.86	6.30
2C	25.42	33.83	13.44	0.61	9.55	6C	25.55	33.81	12.72	0.61	8.20
	25.70	33.77	11.78	30.48	8.30		25.98	33.81	10.39	18.29	6.00
	25.84	33.79	11.06	60.96	7.60		26.04	33.84	10.17	36.58	6.20
3A	25.83	33.87	11.50	0.61	6.80	7A	25.27	33.86	14.28	0.61	8.40
	26.01	33.88	10.50	19.81	5.20		25.68	33.77	11.89	9.14	7.80
	26.10	33.90	10.06	39.62	5.20		25.84	33.79	11.06	18.29	6.20
3B	25.79	33.86	11.67	0.61	7.10	7B	25.26	33.78	14.00	0.61	8.40
	26.10	33.89	10.06	25.91	4.90		25.85	33.79	11.00	15.24	6.50
	26.15	33.92	9.89	51.82	4.20		25.90	33.80	10.78	30.48	6.00
3C	25.81	33.86	11.56	0.61	6.60	7C	25.26	33.78	14.00	0.61	8.00
	26.07	33.84	10.00	30.48	4.40		25.90	33.80	10.78	19.81	5.90
	26.22	33.93	9.50	60.96	5.20		25.94	33.80	10.56	39.62	5.40
4A	25.87	33.85	11.17	0.61	6.00	8A	24.99	33.76	15.22	0.61	8.40
	26.01	33.85	10.39	19.81	5.60		25.26	33.74	13.89	7.62	8.10
	26.08	33.89	10.17	39.62	4.50		25.51	33.75	12.67	15.24	7.70
4B	25.86	33.85	11.22	0.61	6.00	8B	25.26	33.75	13.89	0.61	8.65
	26.06	33.86	10.11	27.43	4.70		25.62	33.76	12.17	10.67	8.00
	26.13	33.90	9.89	54.86	4.20		25.80	33.78	11.28	21.34	7.60
4C	25.84	33.89	11.50	0.61	5.80	8C	25.36	33.77	13.50	0.61	7.90
	25.97	33.86	10.67	30.48	5.40		25.65	33.76	12.00	13.72	6.00
	26.10	33.92	10.17	60.96	4.10		25.89	33.78	10.78	27.43	5.50

6-21-76

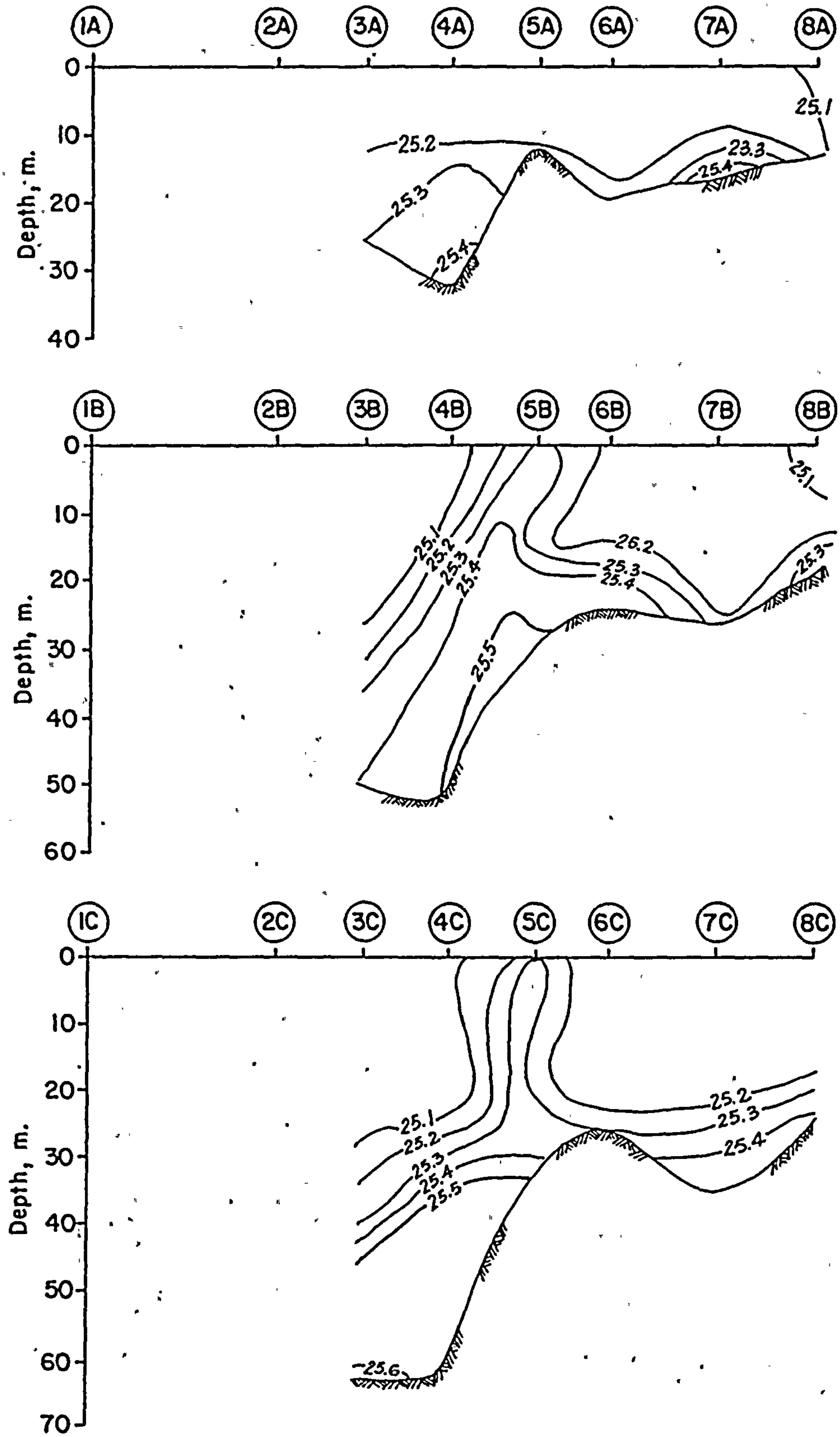


Density Contour for 10-7-76

SAMPLE	SIG-T	S(0/00)	DEG. C	DEPTH,M.	D.O.PPM
1A	24.38	33.53	17.11	0.61	8.40
	24.53	33.54	16.50	10.67	8.20
	24.65	33.55	16.00	21.34	8.10
1B	24.40	33.55	17.11	0.61	10.00
	24.47	33.53	16.72	16.00	8.30
	24.77	33.55	15.50	32.00	9.00
1C	24.35	33.53	17.22	0.61	9.20
	24.47	33.53	16.72	22.10	8.40
	25.10	33.59	14.11	44.20	7.00
2A	24.36	33.54	17.22	0.61	8.60
	24.51	33.54	16.61	14.48	8.40
	24.96	33.58	14.72	28.96	7.60
2B	24.39	33.54	17.11	0.61	9.00
	24.59	33.53	16.22	24.38	9.20
	25.35	33.60	12.89	48.77	8.40
2C	24.44	33.54	16.89	0.61	9.20
	24.94	33.57	14.78	30.48	8.60
	25.39	33.61	12.72	60.96	8.00
3A	24.32	33.53	17.39	0.61	7.75
	24.38	33.53	17.11	19.51	7.60
	24.76	33.54	15.50	39.01	7.80
3B	24.32	33.53	17.39	0.61	8.60
	24.72	33.55	15.72	25.91	7.00
	25.06	33.58	14.22	51.82	6.60
3C	24.38	33.53	17.11	0.61	8.30
	25.21	33.57	13.50	30.48	5.80
	25.39	33.62	12.78	60.96	7.40
4A	24.22	33.53	17.78	0.61	7.60
	24.47	33.53	16.72	17.98	8.20
	24.91	33.57	14.89	35.97	7.60
4B	24.35	33.53	17.22	0.61	7.75
	24.64	33.53	16.00	27.43	7.60
	25.14	33.62	14.00	54.86	6.60
4C	24.38	33.53	17.11	0.61	8.20
	24.91	33.53	14.78	28.19	7.80
	25.25	33.57	13.28	56.39	6.80
5A	24.19	33.53	17.89	0.61	8.00
	24.42	33.51	16.89	8.38	7.50
	24.46	33.53	16.78	16.76	6.80
5B	24.15	33.54	18.11	0.61	8.40
	24.34	33.53	17.28	15.39	8.80
	24.88	33.56	15.00	30.78	7.10
5C	24.20	33.54	17.89	0.61	7.20
	24.56	33.54	16.39	19.81	7.60
	25.10	33.59	14.11	39.62	6.30
6A	24.19	33.53	17.89	0.61	9.80
	24.53	33.54	16.50	9.91	8.20
	24.72	33.57	15.78	19.81	7.80
6B	24.19	33.52	17.89	0.61	9.40
	24.53	33.54	16.50	11.43	9.20
	24.75	33.56	15.61	22.86	8.00
6C	24.42	33.54	17.00	0.61	9.40
	24.53	33.54	16.50	18.59	10.00
	24.86	33.59	15.22	37.19	7.70
7A	23.97	33.47	18.61	0.61	10.35
	24.51	33.54	16.61	10.36	8.60
	24.71	33.56	15.78	20.73	7.20
7B	24.12	33.56	18.28	0.61	8.80
	24.84	33.57	15.22	15.54	7.60
	24.99	33.59	14.61	31.09	7.80
7C	24.24	33.54	17.72	0.61	8.60
	24.42	33.54	17.00	19.05	9.90
	25.00	33.60	14.61	38.10	8.40
8A	23.98	33.54	18.78	0.61	8.60
	24.41	33.53	17.00	6.10	7.80
	24.51	33.55	16.61	12.19	6.60
8B	24.01	33.56	18.72	0.61	8.70
	24.49	33.55	16.72	11.43	8.50
	24.72	33.57	15.78	22.86	8.00
8C	24.10	33.57	18.39	0.61	8.40
	24.49	33.55	16.72	15.54	7.80
	24.81	33.57	15.39	31.09	7.80

10-7-76

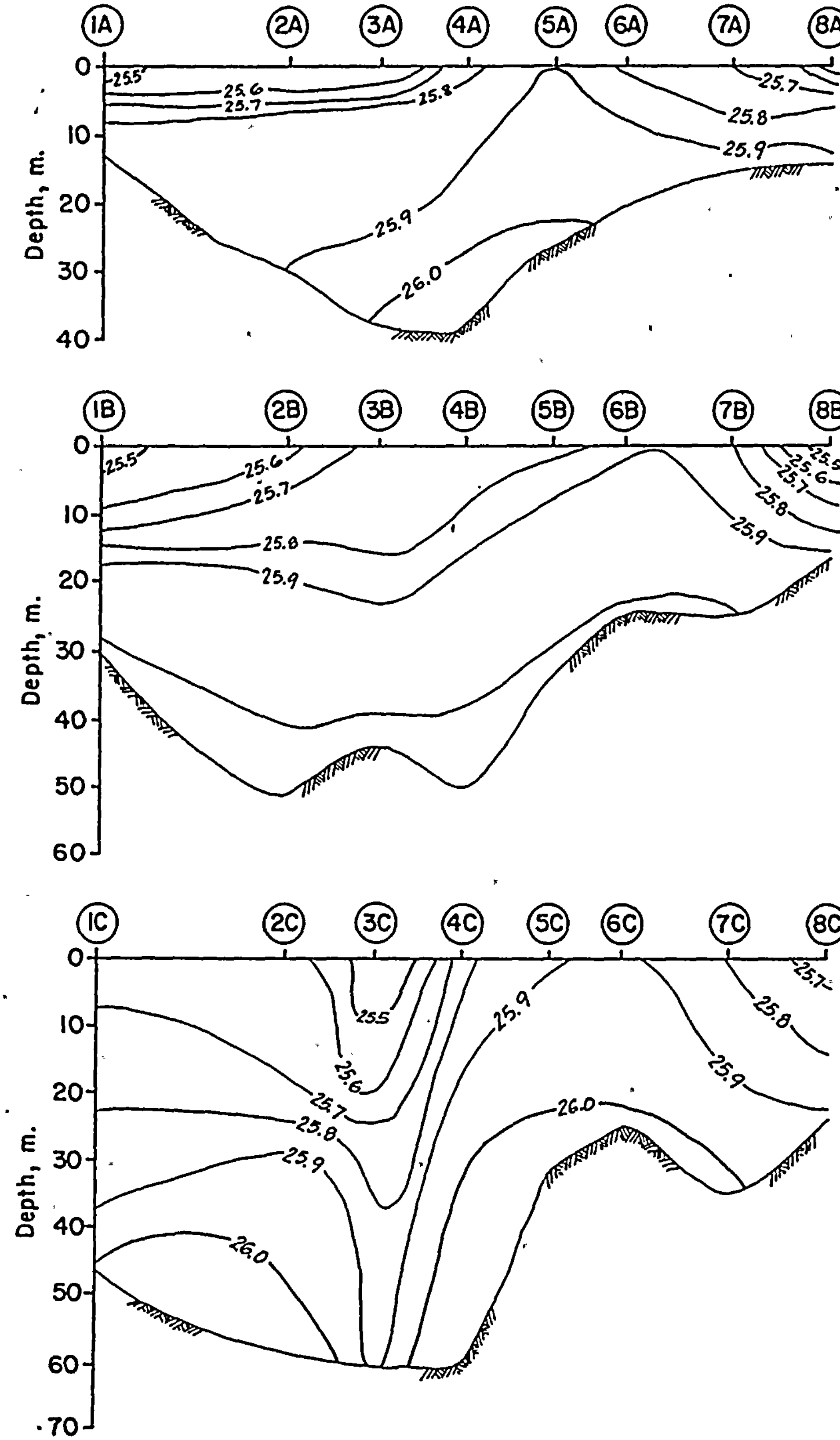
APPENDIX C



Density Contours for February 23, 1977

SIGMA-T FOR D.C. OCEANOGRAPHY:
DIABLO CANYON SALINITIES,DENSITIES, 23 FEB 77

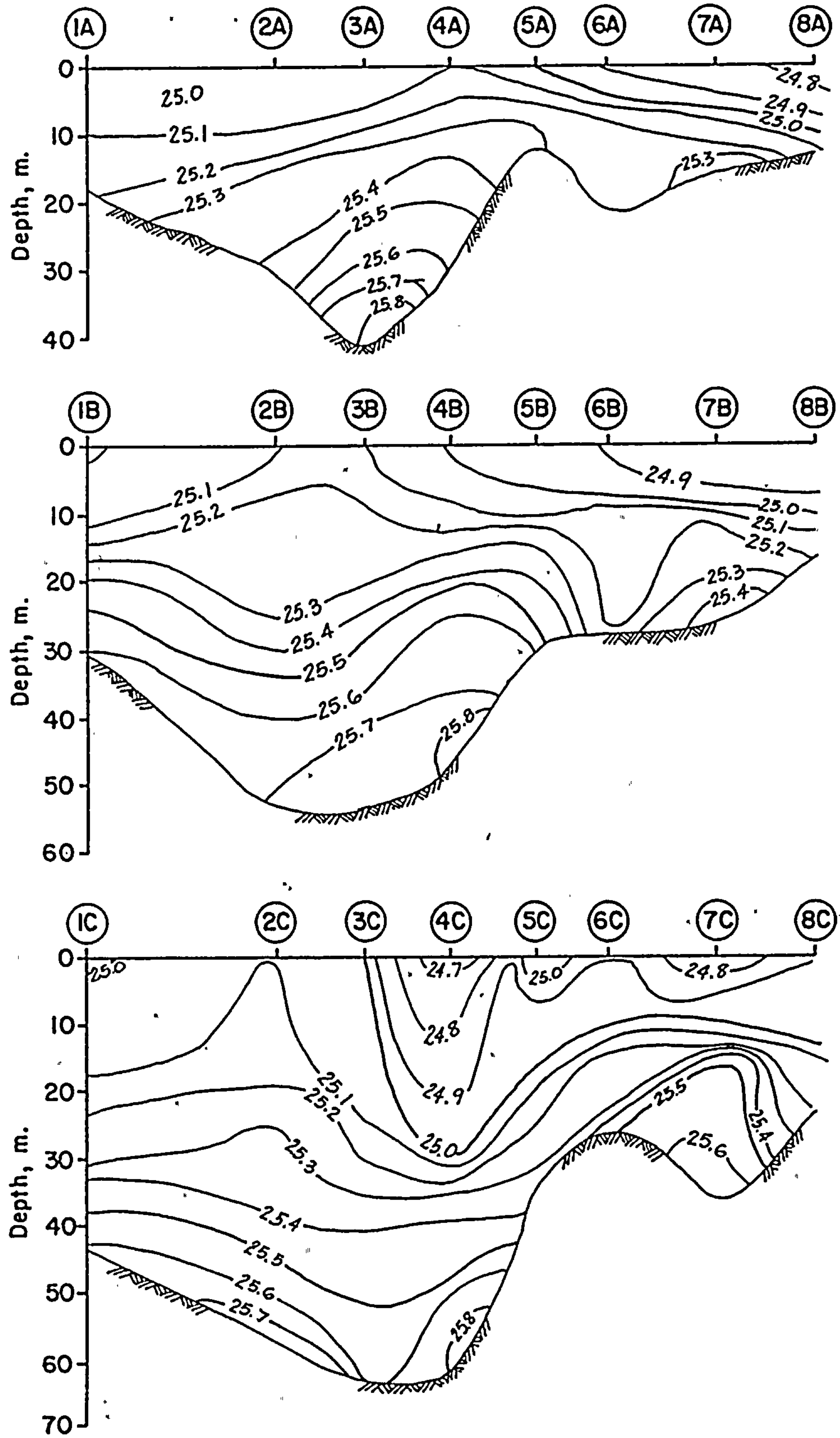
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
3A	25.17	33.43	13.17	0.25
	25.23	33.51	13.17	12.04
	25.27	33.52	13.00	24.08
3B	25.11	33.48	13.61	0.25
	25.15	33.50	13.50	24.69
	25.39	33.57	12.56	49.38
3C	25.07	33.46	13.78	0.25
	25.22	33.50	13.17	30.48
	25.56	33.62	11.89	60.96
4A	25.22	33.50	13.17	0.25
	25.27	33.53	13.06	15.85
	25.41	33.58	12.50	31.70
4B	25.18	33.50	13.39	0.25
	25.39	33.57	12.56	25.91
	25.54	33.57	11.78	51.82
4C	25.13	33.47	13.50	0.25
	25.43	33.86	13.50	30.48
	25.48	33.56	12.06	60.96
5A	25.25	33.50	13.00	0.25
	25.25	33.49	13.00	6.10
	25.25	33.49	13.00	12.19
5B	25.26	33.51	13.00	0.25
	25.25	33.50	13.00	14.48
	25.50	33.57	12.00	28.96
5C	25.26	33.51	13.00	0.25
	25.25	33.52	13.07	16.00
	25.49	33.57	12.06	32.00
6A	25.19	33.51	13.33	0.25
	25.19	33.50	13.33	9.91
	25.17	33.33	12.78	19.81
6B	25.20	33.52	13.33	0.25
	25.19	33.51	13.33	12.19
	25.44	33.56	12.28	24.38
6C	25.21	33.53	13.33	0.25
	25.19	33.50	13.33	12.95
	25.30	33.51	12.78	25.91
7A	25.18	33.56	13.61	0.25
	25.17	33.52	13.50	8.38
	25.45	33.51	12.00	16.76
7B	25.20	33.52	13.33	0.25
	25.19	33.50	13.33	12.95
	25.25	33.50	13.00	25.91
7C	25.23	33.51	13.17	0.25
	25.21	33.49	13.17	18.29
	25.45	33.51	12.00	36.58
8A	25.11	33.55	13.89	0.25
	25.10	33.54	13.89	6.40
	25.14	33.53	13.67	12.80
8B	25.13	33.55	13.78	0.25
	25.12	33.53	13.78	9.14
	25.30	33.53	12.89	18.29
8C	25.17	33.54	13.56	0.25
	25.16	33.53	13.56	11.43
	25.38	33.54	12.50	22.86



Density Contours for June 14, 1977

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES,14 JUNE 1977

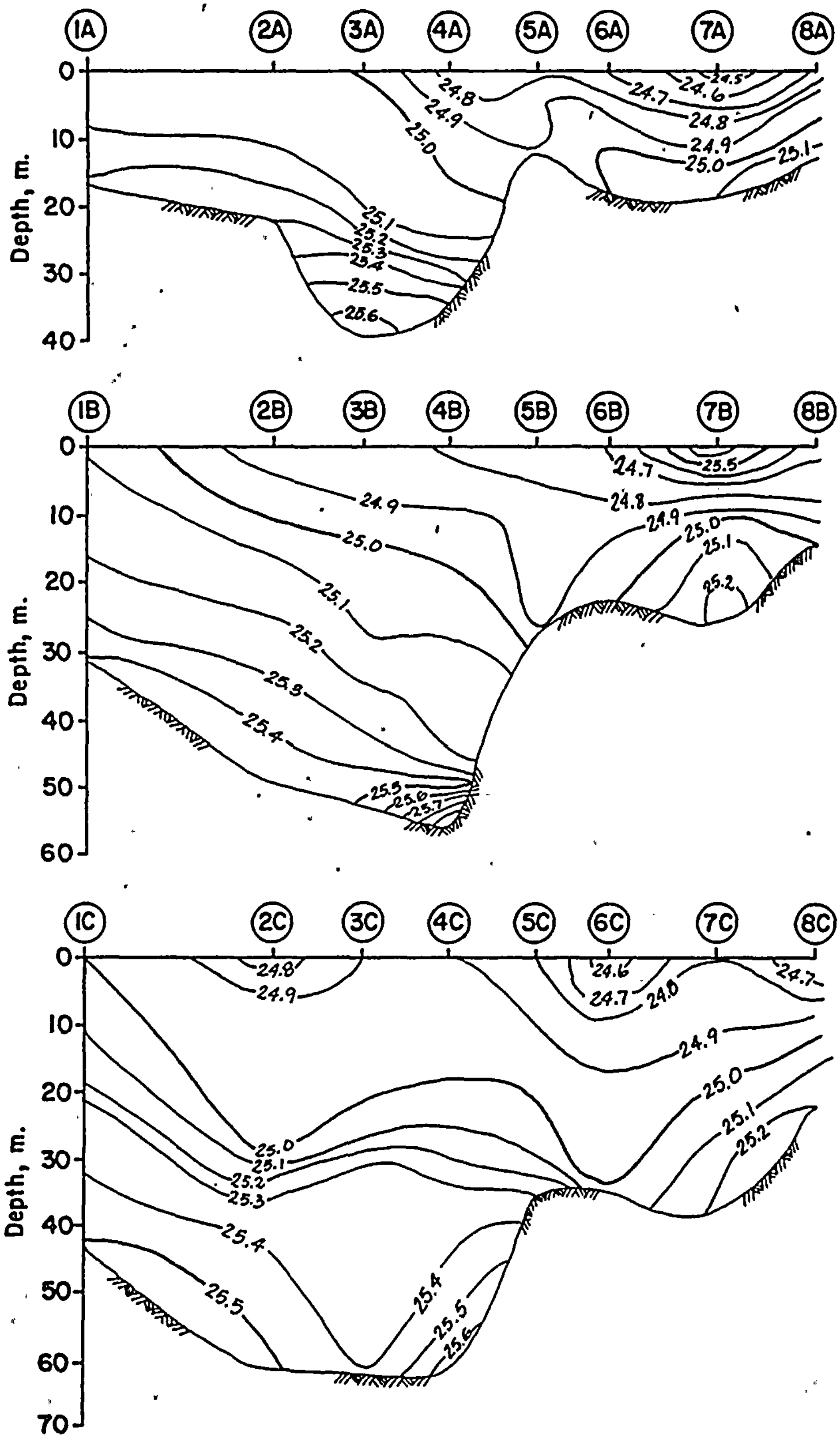
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	25.48	33.84	13.20	0.25
	25.77	33.82	11.60	6.55
	25.83	33.85	11.40	13.11
1B	25.46	33.84	13.30	0.25
	25.88	33.85	11.10	14.94
	25.96	33.88	10.80	29.87
1C	25.55	33.84	12.80	0.25
	25.80	33.84	11.50	23.47
	26.01	33.90	10.60	46.94
2A	25.61	33.83	12.50	0.25
	25.77	33.90	11.90	14.48
	25.94	33.94	11.20	28.96
2B	25.62	33.82	12.40	0.25
	25.90	33.89	11.20	25.45
	25.96	33.90	10.90	50.90
2C	25.63	33.81	12.30	0.25
	25.89	33.84	11.00	29.26
	26.01	33.87	10.50	58.52
3A	25.59	33.86	12.70	0.25
	25.86	33.87	11.30	19.05
	25.95	33.89	10.90	38.10
3B	25.80	33.86	11.60	0.25
	25.93	33.89	11.00	21.49
	26.03	33.92	10.60	42.98
3C	25.54	33.79	12.70	0.25
	25.75	33.84	11.80	30.02
	25.93	33.89	11.00	60.05
4A	25.78	33.86	11.70	0.25
	25.89	33.88	11.20	19.05
	25.98	33.90	10.80	38.10
4B	25.81	33.87	11.60	0.25
	25.92	33.88	11.00	24.99
	25.99	33.92	10.80	49.99
4C	25.77	33.87	11.80	0.25
	25.97	33.91	10.90	30.02
	26.03	33.93	10.60	60.05
5A	25.86	33.87	11.30	0.25
	25.90	33.87	11.10	12.95
	25.95	33.89	10.90	25.91
5B	25.84	33.86	11.40	0.25
	25.89	33.84	11.00	16.00
	25.98	33.90	10.80	32.00
5C	25.86	33.87	11.30	0.25
	25.92	33.88	11.00	16.00
	25.96	33.90	10.90	32.00
6A	25.82	33.88	11.60	0.25
	25.92	33.88	11.00	10.06
	25.94	33.88	10.90	20.12
6B	25.88	33.89	11.30	0.25
	25.93	33.89	11.00	12.04
	25.97	33.89	10.80	24.08
6C	25.92	33.88	11.00	0.25
	25.92	33.88	11.00	12.50
	25.96	33.90	10.90	24.99
7A	25.73	33.89	12.10	0.25
	25.83	33.90	11.60	7.47
	25.92	33.90	11.10	14.94
7B	25.80	33.89	11.70	0.25
	25.94	33.92	11.10	12.95
	25.96	33.92	11.00	25.91
7C	25.80	33.89	11.70	0.25
	25.93	33.91	11.10	17.98
	25.96	33.92	11.00	35.97
8A	25.47	33.91	13.50	0.25
	25.88	33.89	11.30	7.92
	25.90	33.90	11.20	15.85
8B	25.49	33.91	13.40	0.25
	25.79	33.90	11.80	8.99
	25.93	33.91	11.10	17.98
8C	25.68	33.90	12.40	0.25
	25.80	33.93	11.90	12.04
	25.94	33.92	11.10	24.08



Density Contours for September 26, 1977

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 26 SEPT 1977

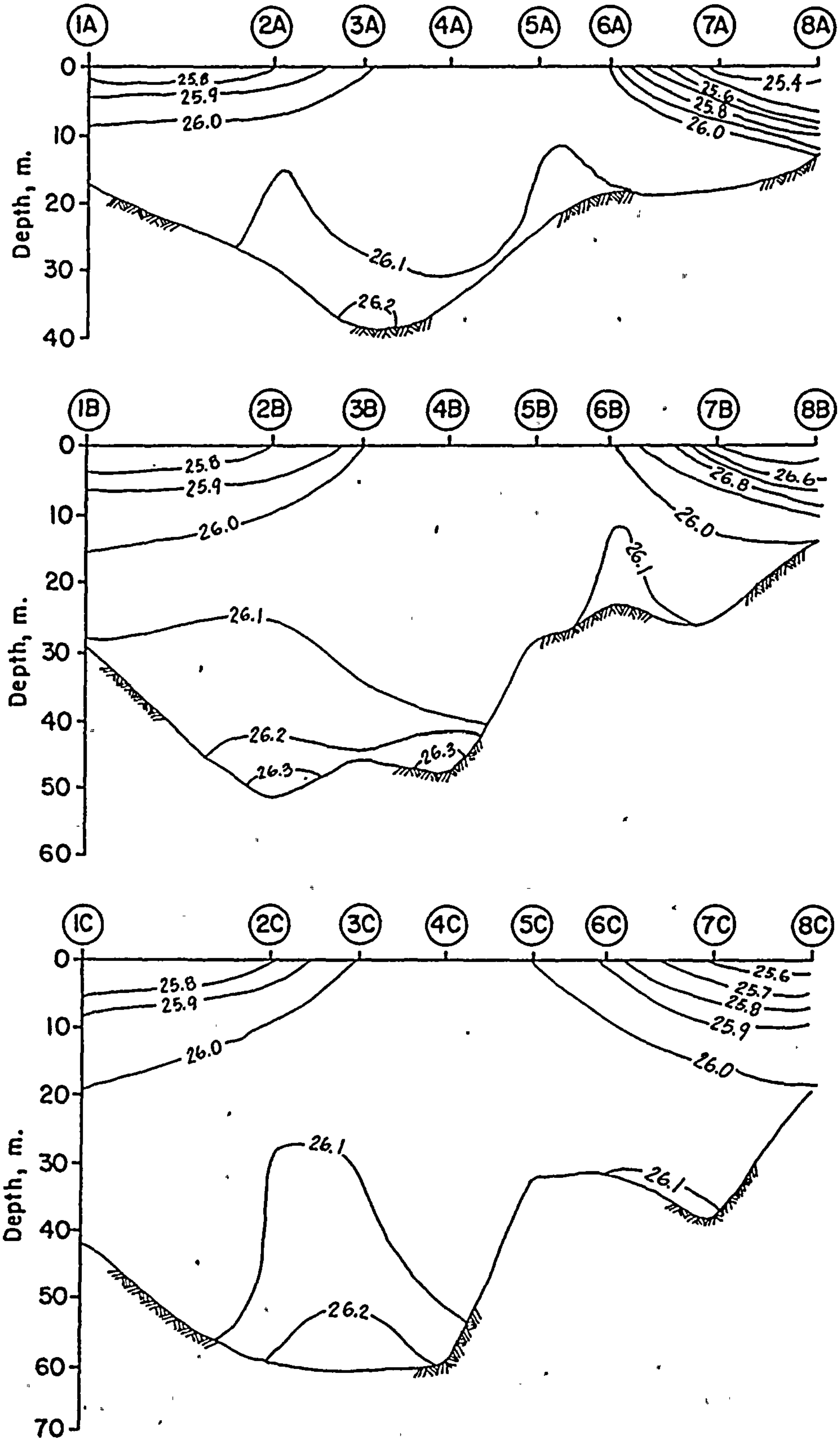
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH, M	SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH, M
1A	24.96	33.58	14.72	0.25	3A	24.97	33.59	14.72	0.25
	25.08	33.56	14.06	9.14		25.18	33.59	13.72	5.33
	25.25	33.58	13.33	18.29		25.31	33.57	13.00	10.67
1B	24.98	33.57	14.61	0.25	5B	24.98	33.58	14.61	0.25
	25.31	33.57	13.00	14.48		25.30	33.56	13.00	14.78
	25.58	33.56	11.56	28.96		25.61	33.64	11.72	29.57
1C	24.99	33.56	14.50	0.25	5C	24.96	33.57	14.67	0.25
	25.20	33.56	13.50	21.18		25.03	33.53	14.22	16.00
	25.64	33.63	11.50	42.37		25.26	33.57	13.22	32.00
2A	25.05	33.58	14.28	0.25	6A	24.92	33.57	14.89	0.25
	25.34	33.61	13.00	14.94		25.15	33.58	13.83	10.67
	25.41	33.62	12.67	29.87		25.22	33.57	13.44	21.34
2B	25.09	33.58	14.11	0.25	6B	24.94	33.58	14.83	0.25
	25.34	33.61	13.00	25.91		25.21	33.58	13.50	13.11
	25.66	33.63	11.39	51.82		25.34	33.58	12.89	26.21
2C	25.08	33.57	14.11	0.25	6C	24.94	33.58	14.83	0.25
	25.21	33.57	13.50	27.43		25.23	33.57	13.39	13.56
	25.40	33.59	12.61	54.86		25.46	33.58	12.28	27.13
3A	25.10	33.59	14.11	0.25	7A	24.88	33.56	15.00	0.25
	25.49	33.63	12.28	20.42		25.13	33.57	13.89	8.38
	25.76	33.69	11.11	40.84		25.30	33.56	13.00	16.76
3B	25.14	33.59	13.89	0.25	7B	24.88	33.56	15.00	0.25
	25.53	33.63	12.11	26.21		25.24	33.56	13.28	12.95
	25.71	33.67	11.28	52.43		25.45	33.57	12.28	25.91
3C	24.97	33.56	14.61	0.25	7C	24.85	33.56	15.17	0.25
	25.16	33.58	13.78	30.48		25.46	33.57	12.22	17.83
	25.58	33.60	11.72	60.96		25.57	33.60	11.78	35.66
4A	25.08	33.57	14.11	0.25	8A	24.78	33.60	15.61	0.25
	25.38	33.59	12.72	15.70		24.90	33.58	15.00	5.94
	25.65	33.67	11.61	31.39		25.14	33.56	13.78	11.89
4B	25.03	33.58	14.39	0.25	8B	24.86	33.58	15.17	0.25
	25.65	33.64	11.50	23.93		25.00	33.57	14.50	8.38
	25.79	33.70	11.00	47.85		25.21	33.55	13.39	16.76
4C	24.73	33.53	15.61	0.25	8C	24.86	33.57	15.17	0.25
	25.03	33.53	14.22	30.48		24.99	33.56	14.50	10.67
	25.82	33.65	10.61	60.96		25.19	33.55	13.50	21.34



Density Contours for March 1, 1978

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 01 MARCH 1978

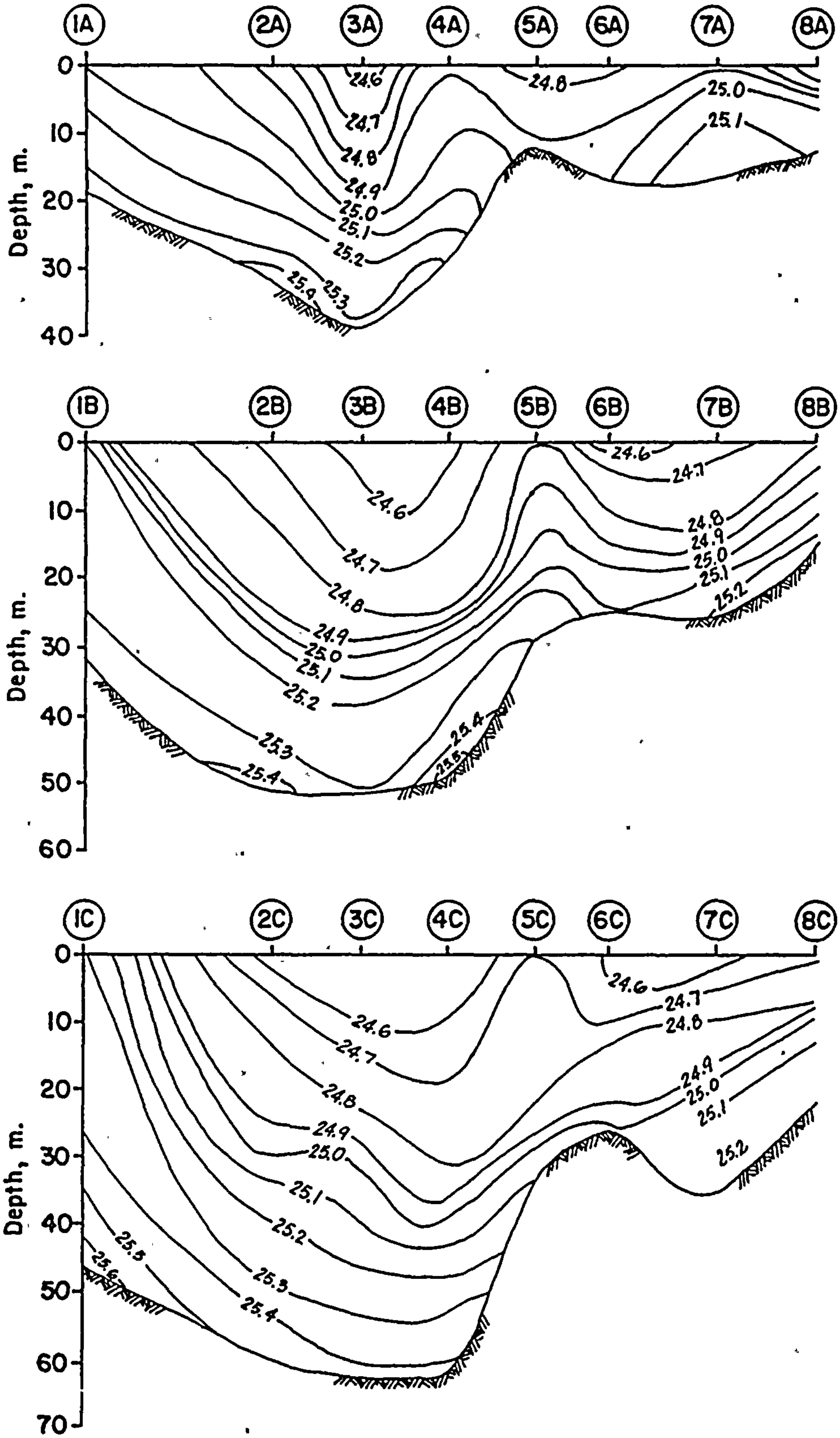
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	25.03	33.34	13.50	0.25
	25.14	33.41	13.20	8.53
	25.22	33.46	13.00	17.07
1B	25.06	33.35	13.40	0.25
	25.18	33.41	13.00	15.24
	25.38	33.49	12.30	30.48
1C	24.98	33.27	13.50	0.25
	25.27	33.44	12.70	21.18
	25.51	33.54	11.80	42.37
2A	24.94	33.33	13.90	0.25
	25.09	33.36	13.30	11.43
	25.31	33.47	12.60	22.86
2B	24.94	33.33	13.90	0.25
	25.19	33.42	13.00	24.69
	25.43	33.50	12.10	49.38
2C	24.83	33.29	14.30	0.25
	24.97	33.40	14.00	30.48
	25.50	33.54	11.90	60.96
3A	24.97	33.32	13.70	0.25
	25.10	33.35	13.20	19.81
	25.47	33.53	12.00	39.62
3B	24.88	33.23	13.80	0.25
	25.12	33.38	13.20	25.91
	25.53	33.58	11.90	51.82
3C	24.86	33.31	14.20	0.25
	25.29	33.47	12.70	30.48
	25.42	33.52	12.20	60.96
4A	24.85	33.24	14.00	0.25
	24.99	33.31	13.60	17.53
	25.40	33.51	12.30	35.05
4B	24.84	33.31	14.30	0.25
	25.06	33.33	13.30	27.43
	25.59	33.56	11.50	54.86
4C	24.92	33.33	14.00	0.25
	25.18	33.41	13.00	30.48
	25.59	33.56	11.50	60.96
5A	24.84	33.23	14.00	0.25
	24.93	33.24	13.60	5.33
	24.93	33.24	13.60	10.67
5B	24.68	33.10	14.30	0.25
	24.91	33.32	14.00	13.72
	24.95	33.32	13.80	27.43
5C	24.83	33.27	14.20	0.25
	25.02	33.36	13.60	18.29
	25.34	33.46	12.40	36.58
6A	24.69	33.12	14.30	0.25
	24.95	33.29	13.70	9.45
	25.01	33.32	13.50	18.90
6B	24.69	33.11	14.30	0.25
	24.92	33.28	13.80	10.67
	25.07	33.34	13.30	21.34
6C	24.62	33.05	14.40	0.25
	24.94	33.28	13.70	17.53
	25.08	33.33	13.20	35.05
7A	24.54	32.95	14.40	0.25
	24.77	33.14	14.00	9.14
	25.06	33.38	13.50	18.29
7B	24.35	32.72	14.50	0.25
	25.08	33.35	13.30	12.95
	25.23	33.45	12.90	25.91
7C	24.83	33.27	14.20	0.25
	25.10	33.38	13.30	19.05
	25.21	33.45	13.00	38.10
8A	24.81	33.27	14.30	0.25
	25.00	33.30	13.50	6.10
	25.11	33.39	13.30	12.19
8B	24.71	33.14	14.30	0.25
	24.79	33.25	14.30	7.62
	25.01	33.26	13.30	15.24
8C	24.65	33.09	14.40	0.25
	25.05	33.31	13.30	11.28
	25.18	33.41	13.00	22.56



Density Contours for June 20, 1978

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 20 JUNE 1978

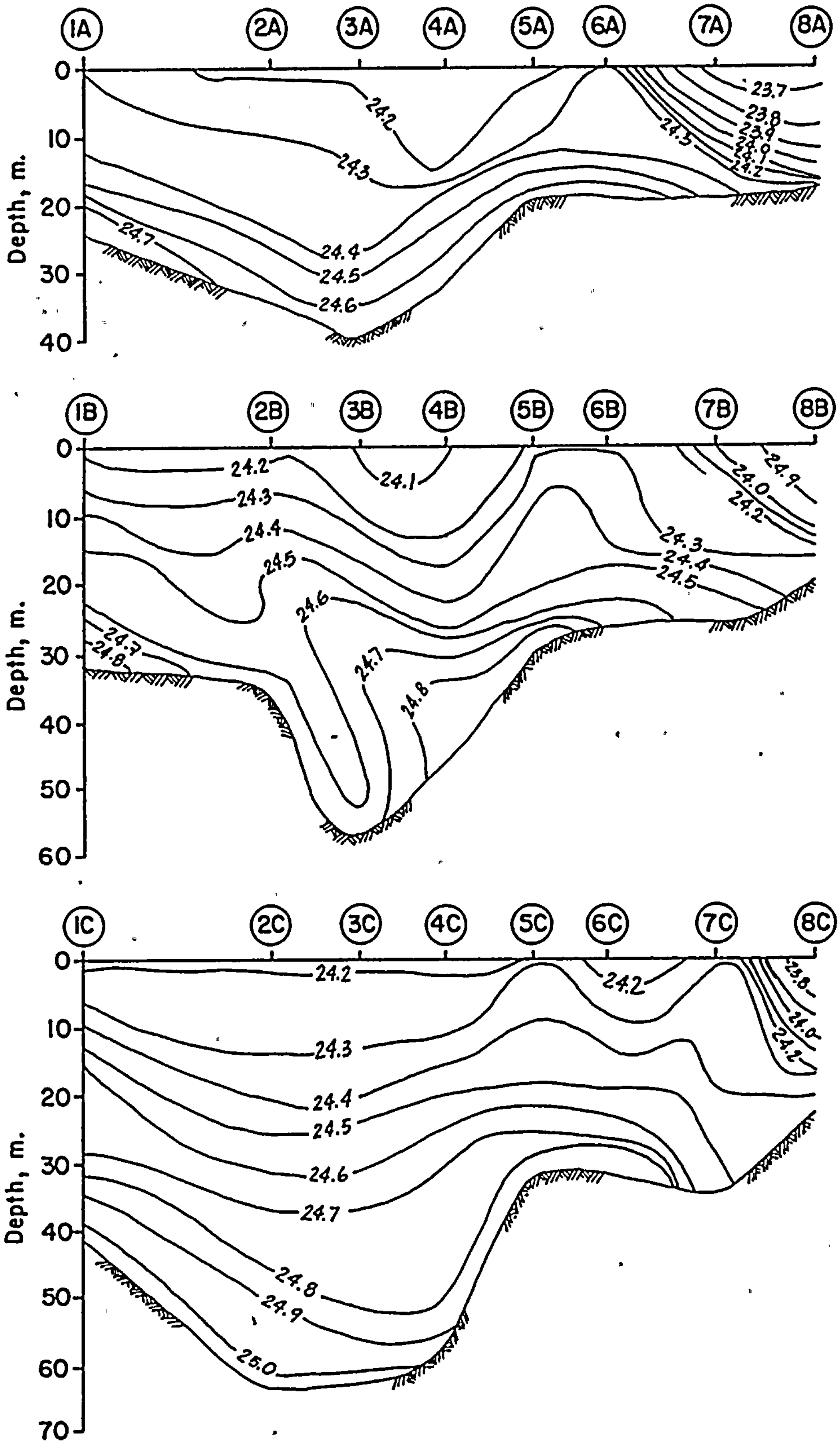
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M					
1A	25.83	33.73	10.90	0.25	5A	26.05	33.84	10.10	0.25
	26.00	33.75	10.00	8.84		26.07	33.84	10.00	11.58
	26.04	33.78	9.90	17.68		26.07	33.82	9.90	23.16
1B	25.81	33.75	11.10	0.25	5B	26.04	33.83	10.10	0.25
	26.01	33.77	10.00	14.63		26.01	33.76	10.00	14.02
	26.09	33.82	9.80	29.26		26.02	33.71	9.70	28.04
1C	25.80	33.74	11.10	0.25	5C	26.01	33.79	10.10	0.25
	25.96	33.74	10.20	20.57		25.97	33.73	10.10	16.00
	26.03	33.71	9.60	41.15		26.00	33.71	9.80	32.00
2A	25.82	33.75	11.00	0.25	6A	26.00	33.79	10.20	0.25
	26.08	33.83	9.90	14.94		26.04	33.81	10.00	8.69
	-0.18	0.00	9.60	29.87		26.06	33.81	9.90	17.37
2B	25.80	33.74	11.10	0.25	6B	26.00	33.80	10.20	0.25
	26.08	33.84	9.90	25.15		26.06	33.81	9.90	11.58
	26.26	33.98	9.50	50.29		26.06	33.81	9.90	23.16
2C	25.80	33.74	11.10	0.25	6C	25.92	33.69	10.20	0.25
	26.11	33.89	10.00	28.96		26.00	33.75	10.00	15.54
	26.24	33.99	9.70	57.91		26.09	33.82	9.80	31.09
3A	26.03	33.79	10.00	0.25	7A	25.44	33.79	13.20	0.25
	26.05	33.78	9.80	19.05		25.96	33.75	10.20	8.53
	26.17	33.86	9.50	38.10		26.04	33.83	10.10	17.07
3B	25.98	33.75	10.10	0.25	7B	25.50	33.72	12.60	0.25
	26.05	33.80	9.90	22.10		26.04	33.82	10.10	12.95
	26.15	33.86	9.60	44.20		26.02	33.73	9.80	25.91
3C	25.97	33.76	10.20	0.25	7C	25.56	33.70	12.20	0.25
	26.13	33.84	9.60	29.72		26.04	33.81	10.00	18.75
	26.19	33.87	9.40	59.44		26.08	33.83	9.90	37.49
4A	26.00	33.77	10.10	0.25	8A	25.42	33.72	13.00	0.25
	26.05	33.79	9.90	18.29		25.51	33.70	12.50	5.79
	26.13	33.86	9.70	36.58		25.96	33.72	10.10	11.58
4B	25.99	33.76	10.10	0.25	8B	25.49	33.71	12.60	0.25
	26.05	33.79	9.90	24.38		25.70	33.71	11.50	6.86
	26.24	33.97	9.60	48.77		25.97	33.73	10.10	13.72
4C	25.96	33.75	10.20	0.25	8C	25.65	33.74	11.90	0.25
	26.09	33.81	9.70	29.72		25.98	33.73	10.50	9.75
	26.22	33.89	9.30	59.44		26.02	33.74	9.80	19.51



Density Contours for October 24, 1978

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 24 OCTOBER 1978

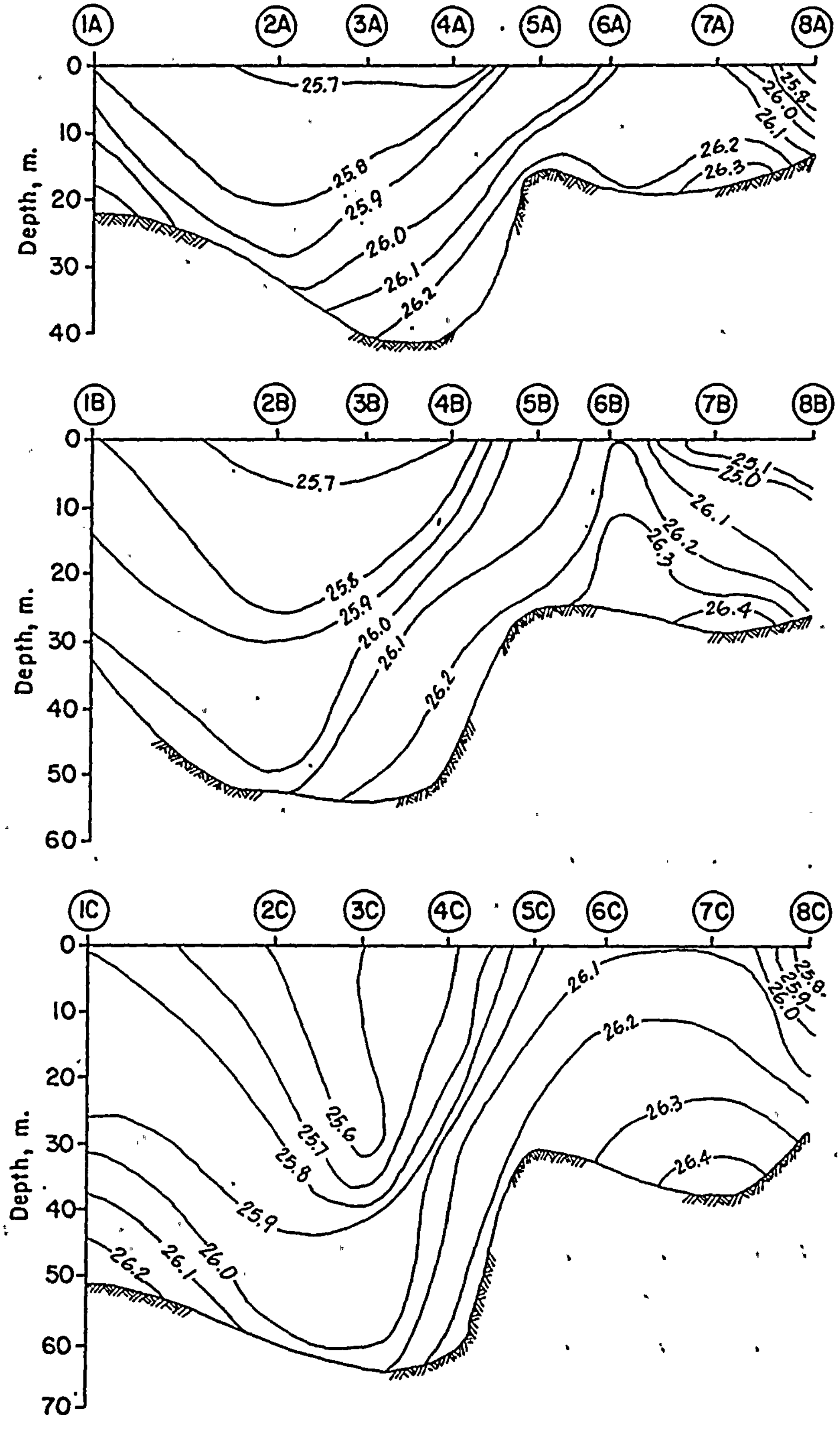
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M					
1A	25.09	33.52	13.90	0.25	5A	24.81	33.49	15.10	0.25
	25.17	33.52	13.50	9.91		24.88	33.50	14.80	5.33
	25.19	33.52	13.40	19.81		24.92	33.52	14.70	10.67
1B	25.15	33.52	13.60	0.25	5B	24.83	33.49	15.00	0.25
	25.23	33.52	13.20	15.24		24.99	33.51	14.30	14.48
	25.28	33.53	13.00	30.48		25.28	33.53	13.00	28.96
1C	25.27	33.52	13.00	0.25	5C	24.67	33.63	16.20	0.25
	25.27	33.52	13.00	22.86		24.68	33.49	15.70	16.00
	25.58	33.58	11.60	45.72		25.11	33.50	13.70	32.00
2A	24.90	33.50	14.70	0.25	6A	24.82	33.51	15.10	0.25
	25.08	33.51	13.90	15.70		24.92	33.50	14.60	8.38
	25.33	33.55	12.80	31.39		25.09	33.52	13.90	16.76
2B	24.70	33.49	15.60	0.25	6B	24.62	33.48	15.90	0.25
	24.92	33.49	14.60	25.15		24.81	33.49	15.10	12.19
	25.36	33.54	12.60	50.29		25.09	33.52	13.90	24.38
2C	24.64	33.50	15.90	0.25	6C	24.59	33.49	16.10	0.25
	24.97	33.51	14.40	29.72		24.83	33.49	15.00	13.26
	25.39	33.57	12.60	59.44		25.03	33.48	14.00	26.52
3A	24.63	33.49	15.90	0.25	7A	24.87	33.49	14.80	0.25
	24.88	33.50	14.80	19.51		25.06	33.51	14.00	8.38
	25.17	33.52	13.50	39.01		25.09	33.52	13.90	16.76
3B	24.64	33.50	15.90	0.25	7B	24.65	33.48	15.80	0.25
	24.83	33.49	15.00	25.45		24.82	33.48	15.00	12.80
	25.32	33.53	12.80	50.90		25.22	33.51	13.20	25.60
3C	24.64	33.50	15.90	0.25	7C	24.58	33.48	16.10	0.25
	24.94	33.49	14.50	30.48		24.94	33.49	14.50	18.29
	25.34	33.56	12.80	60.96		25.26	33.48	12.90	36.58
4A	24.91	33.51	14.70	0.25	8A	24.67	33.51	15.80	0.25
	25.01	33.50	14.20	14.78		25.02	33.51	14.20	6.71
	25.25	33.52	13.10	29.57		-0.57	0.00	13.30	13.41
4B	24.56	33.49	16.20	0.25	8B	24.78	33.51	15.30	0.25
	24.83	33.49	15.00	24.69		24.99	33.50	14.30	7.62
	25.51	33.56	11.90	49.38		25.16	33.53	13.60	15.24
4C	24.58	33.48	16.10	0.25	8C	24.74	33.51	15.50	0.25
	24.80	33.51	15.20	30.48		25.07	33.52	14.00	10.67
	25.45	33.48	11.90	60.96		25.22	33.53	13.30	21.34



Density Contours for February 26, 1980

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 26 FEBRUARY 1980

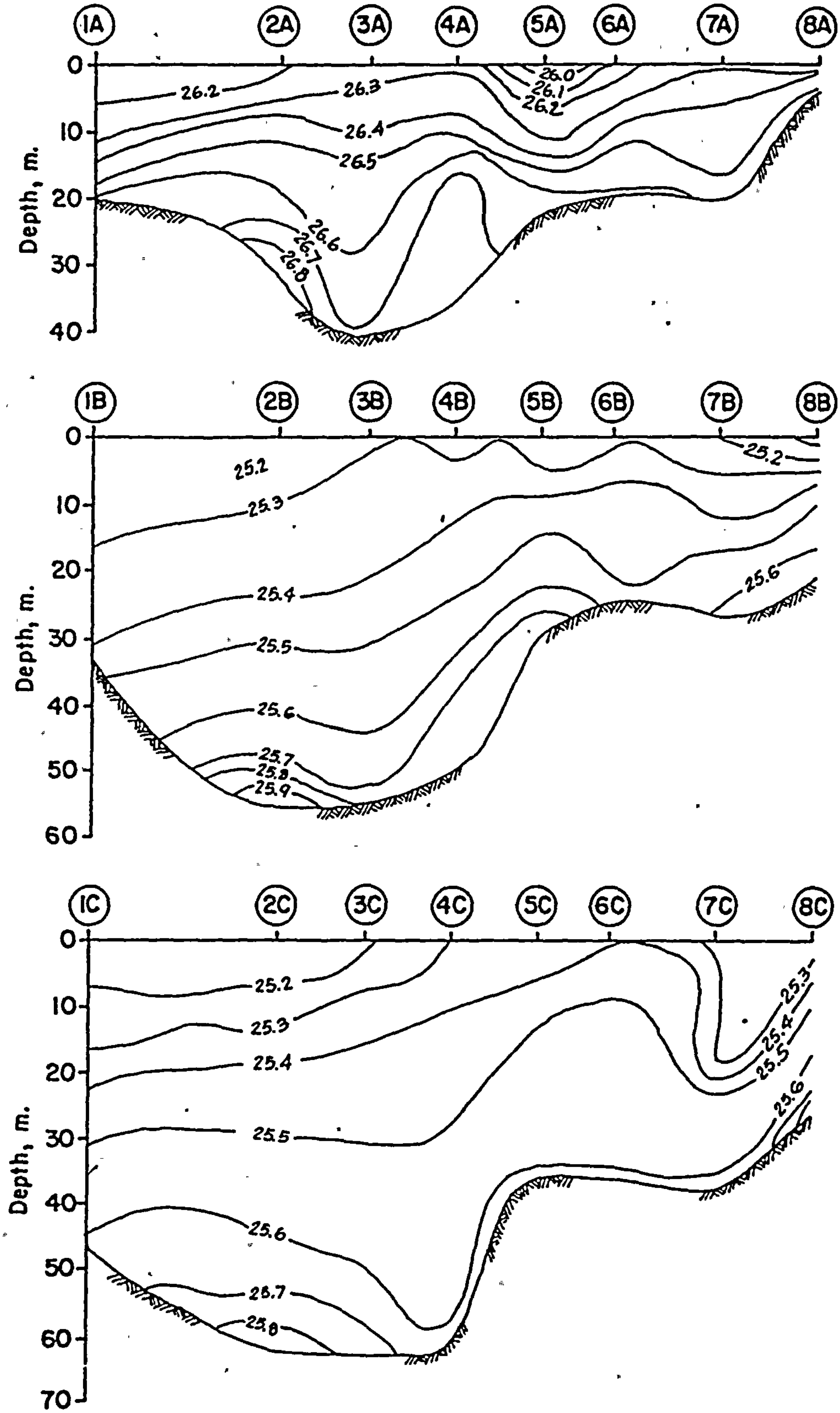
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	24.30	32.91	15.40	0.25
	24.43	33.00	15.10	10.67
	24.72	33.18	14.40	21.34
1B	24.25	32.88	15.50	0.25
	24.48	33.00	14.90	15.24
	24.90	33.28	13.90	30.48
1C	24.24	32.84	15.40	0.25
	24.64	33.07	14.40	19.81
	25.02	33.28	13.30	39.62
2B	24.15	32.81	15.70	0.25
	24.54	33.11	15.00	16.76
	24.61	33.07	14.50	33.53
2C	24.24	32.87	15.50	0.25
	24.60	33.16	14.90	30.48
	25.04	33.33	13.40	60.96
3A	24.22	32.92	15.80	0.25
	24.34	33.02	15.60	19.05
	24.59	33.15	14.90	38.10
3B	24.13	32.89	16.10	0.25
	24.67	33.23	14.80	27.43
	24.59	32.87	13.90	54.86
3C	24.18	32.87	15.80	0.25
	24.63	33.14	14.70	30.48
	24.97	33.37	13.90	60.96
4A	24.17	32.92	16.00	0.25
	24.25	32.91	15.60	16.76
	24.61	33.20	15.00	33.53
4B	24.11	32.87	16.10	0.25
	24.45	33.19	15.70	22.86
	24.83	33.35	14.50	45.72
4C	24.18	32.87	15.80	0.25
	24.72	33.23	14.60	28.96
	24.94	33.36	14.00	57.91
5A	24.25	32.97	15.80	0.25
	24.32	32.94	15.40	9.14
	24.58	33.16	15.00	18.29
5B	24.26	32.98	15.80	0.25
	24.40	32.96	15.10	14.48
	24.78	33.28	14.50	28.96
5C	24.26	32.98	15.80	0.25
	24.43	32.97	15.00	15.24
	24.80	33.28	14.40	30.48
6A	24.32	32.97	15.50	0.25
	24.37	32.97	15.30	9.14
	24.52	33.09	15.00	18.29
6B	24.25	32.96	15.80	0.25
	24.34	32.97	15.40	12.19
	24.59	33.15	14.90	24.38
6C	24.22	32.96	15.90	0.25
	24.42	32.95	15.00	15.24
	24.82	33.26	14.20	30.48
7A	23.66	32.08	15.40	0.25
	23.93	32.43	15.40	9.14
	24.41	33.06	15.40	18.29
7B	23.98	32.49	15.40	0.25
	25.05	33.86	15.30	12.19
	24.55	33.13	15.00	24.38
7C	24.31	32.93	15.40	0.25
	24.31	32.93	15.40	16.76
	24.52	33.11	15.10	33.53
8A	23.69	32.21	15.70	0.25
	23.76	32.27	15.60	8.38
	24.17	32.71	15.30	16.76
8B	23.76	32.26	15.60	0.25
	23.76	32.26	15.60	9.14
	24.29	32.82	15.10	18.29
8C	23.86	32.37	15.50	0.25
	23.83	32.27	15.30	10.67
	24.45	32.99	15.00	21.34



Density Contours for June 18, 1980

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 18 JUNE 1980

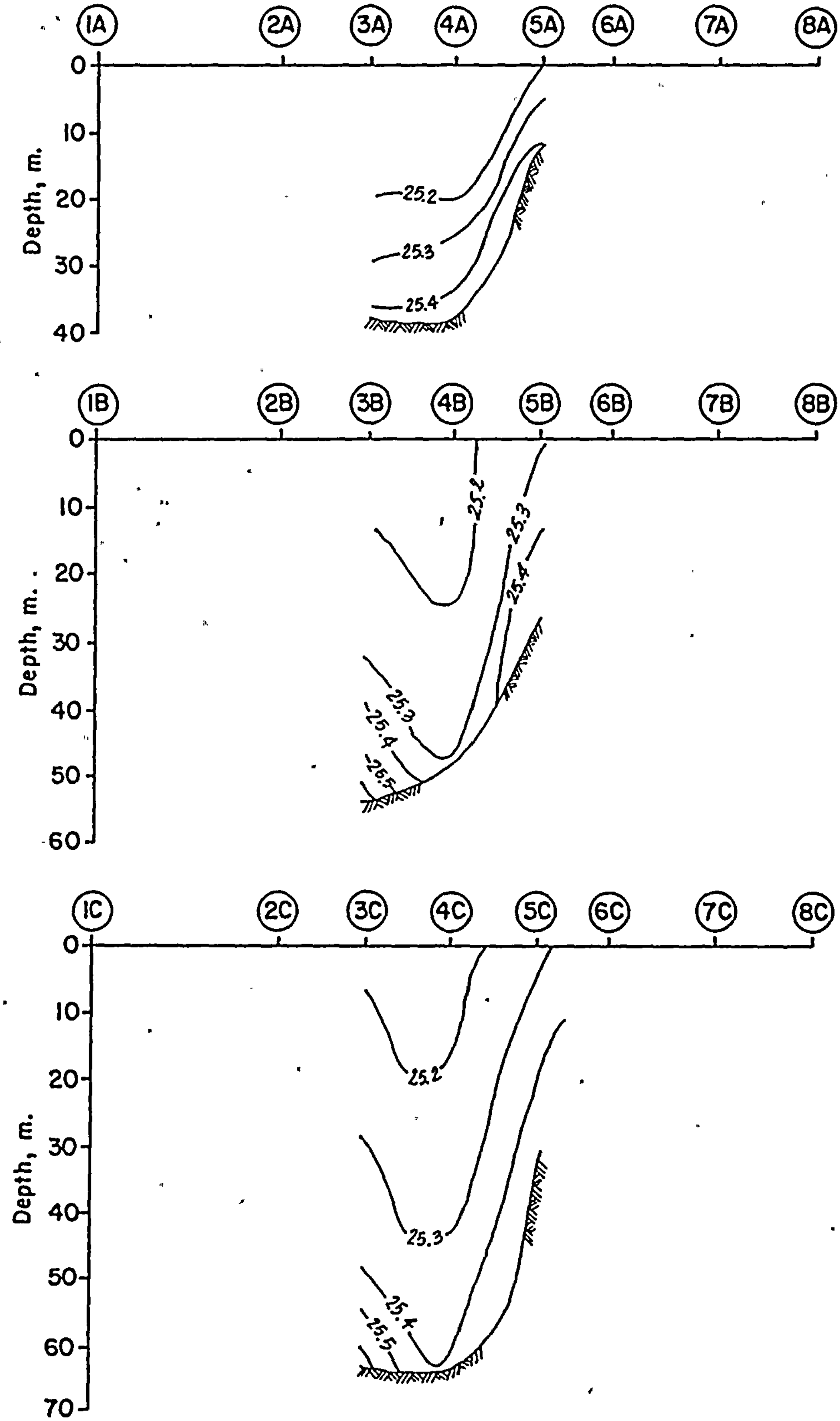
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH, M
1A	25.76	33.72	11.20	0.25
	25.98	33.77	10.20	10.36
	26.13	33.88	9.80	20.73
1B	25.82	33.70	10.80	0.25
	25.91	33.72	10.40	15.24
	26.14	33.87	9.70	30.48
1C	25.81	33.66	10.70	0.25
	25.94	33.72	10.20	24.38
	26.27	33.93	9.20	48.77
2A	25.72	33.64	11.10	0.25
	25.75	33.61	10.80	14.94
	25.87	33.69	10.50	29.87
2B	25.71	33.60	11.00	0.25
	25.82	33.66	10.60	25.60
	26.01	33.77	10.00	51.21
2C	25.66	33.59	11.20	0.25
	25.83	33.65	10.50	28.96
	26.03	33.75	9.80	57.91
3A	25.73	33.61	10.90	0.25
	25.93	33.75	10.40	19.81
	26.16	33.91	9.80	39.62
3B	25.72	33.59	10.90	0.25
	25.95	33.76	10.30	25.76
	26.16	33.92	9.80	51.51
3C	25.56	33.55	11.60	0.25
	25.64	33.56	11.20	30.48
	26.01	33.75	9.90	60.96
4A	25.71	33.60	11.00	0.25
	25.95	33.78	10.40	18.29
	26.18	33.92	9.70	36.58
4B	25.70	33.59	11.00	0.25
	25.99	33.78	10.20	25.30
	26.21	33.92	9.50	50.60
4C	25.70	33.59	11.00	0.25
	26.07	33.82	9.90	30.48
	26.17	33.88	9.60	60.96
5A	26.12	33.88	9.90	0.25
	26.12	33.87	9.80	6.71
	26.17	33.88	9.60	13.41
5B	26.11	33.87	9.90	0.25
	26.12	33.87	9.80	12.19
	26.23	33.90	9.30	24.38
5C	25.95	33.77	10.40	0.25
	26.08	33.83	9.90	14.94
	26.20	33.90	9.50	29.87
6A	26.13	33.88	9.80	0.25
	26.28	33.90	9.00	9.14
	26.30	33.91	8.90	18.29
6B	26.22	33.88	9.30	0.25
	26.29	33.92	9.00	12.34
	26.29	33.92	9.00	24.69
6C	26.13	33.88	9.80	0.25
	26.21	33.87	9.30	16.31
	26.32	33.93	8.90	32.61
7A	25.59	33.79	12.40	0.25
	26.22	33.86	9.20	9.14
	26.29	33.89	8.90	18.29
7B	25.88	33.82	11.00	0.25
	26.07	33.84	10.00	14.33
	26.22	33.89	9.30	28.65
7C	26.07	33.84	10.00	0.25
	26.23	33.88	9.20	18.29
	26.36	33.92	8.60	36.58
8A	25.50	33.80	12.90	0.25
	25.83	33.80	11.20	5.79
	26.05	33.82	10.00	11.58
8B	25.59	33.81	12.50	0.25
	25.96	33.83	10.60	7.77
	26.11	33.85	9.80	15.54
8C	25.73	33.82	11.80	0.25
	26.00	33.89	10.60	12.95
	26.21	33.85	9.20	25.91



Density Contours for September 10, 1980

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 10 SEPTEMBER 1980

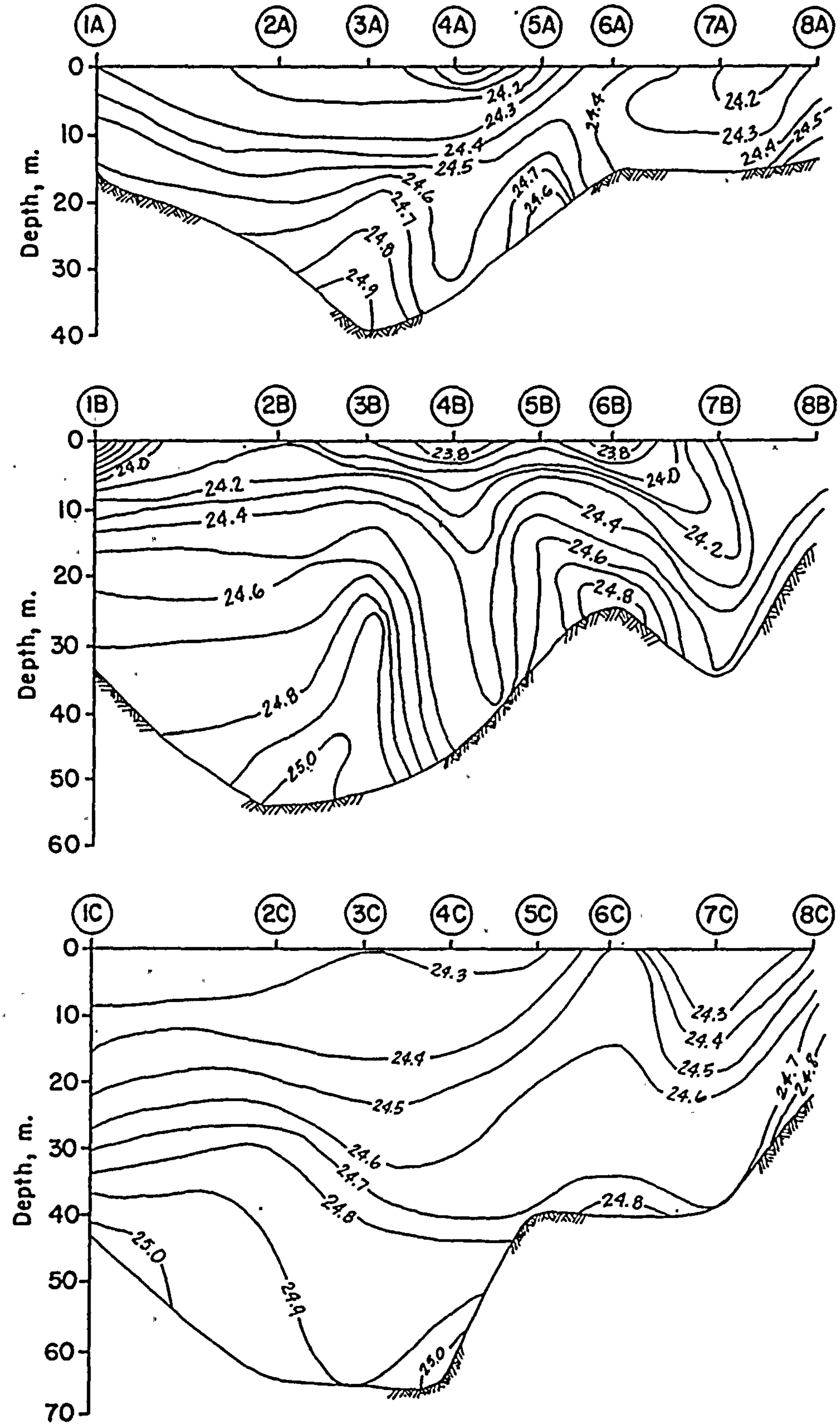
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH, M
1A	25.17	33.63	13.90	0.25
	25.32	33.64	13.20	9.91
	25.55	33.63	12.00	19.81
1B	25.18	33.64	13.90	0.25
	25.35	33.62	13.00	15.24
	25.41	33.63	12.70	30.48
1C	25.19	33.63	13.80	0.25
	25.44	33.62	12.50	22.25
	25.61	33.64	11.70	44.50
2A	25.18	33.61	13.80	0.25
	25.62	33.61	11.50	14.48
	25.76	33.67	11.00	28.96
2B	25.16	33.62	13.90	0.25
	25.51	33.61	12.10	26.52
	25.94	33.83	10.70	53.04
2C	25.16	33.62	13.90	0.25
	25.53	33.61	12.00	29.87
	25.77	33.66	10.90	59.74
3A	25.29	33.60	13.20	0.25
	25.55	33.64	12.00	19.81
	25.71	33.65	11.20	39.62
3B	25.26	33.59	13.30	0.25
	25.53	33.61	12.00	26.82
	25.75	33.65	11.00	53.64
3C	25.24	33.59	13.40	0.25
	25.53	33.59	11.90	30.48
	25.69	33.65	11.30	60.96
4A	25.30	33.59	13.10	0.25
	25.42	33.59	12.50	17.68
	25.74	33.66	11.10	35.36
4B	25.23	33.58	13.40	0.25
	25.46	33.59	12.30	24.38
	25.73	33.65	11.10	48.77
4C	25.26	33.59	13.30	0.25
	25.49	33.58	12.10	30.48
	25.59	33.61	11.70	60.96
5A	25.46	33.69	12.70	0.25
	25.53	33.61	12.00	10.67
	25.62	33.67	11.80	21.34
5B	25.35	33.63	13.00	0.25
	25.54	33.70	12.30	13.87
	25.71	33.63	11.10	27.74
5C	25.31	33.63	13.20	0.25
	25.54	33.62	12.00	17.53
	25.61	33.64	11.70	35.05
6A	25.39	33.63	12.80	0.25
	25.46	33.61	12.40	9.45
	25.60	33.65	11.80	18.90
6B	25.31	33.63	13.20	0.25
	25.50	33.62	12.20	11.58
	25.54	33.64	12.10	23.16
6C	25.36	33.61	12.90	0.25
	25.48	33.59	12.20	17.53
	25.60	33.62	11.70	35.05
7A	25.30	33.64	13.30	0.25
	25.49	33.61	12.20	9.91
	25.53	33.63	12.10	19.81
7B	25.15	33.66	14.10	0.25
	25.40	33.61	12.70	12.95
	25.59	33.64	11.80	25.91
7C	25.27	33.58	13.20	0.25
	25.34	33.59	12.90	18.59
	25.57	33.64	11.90	37.19
8A	25.14	33.64	14.10	0.25
	25.35	33.63	13.00	6.40
	25.52	33.65	12.20	12.80
8B	25.06	33.65	14.50	0.25
	25.47	33.61	12.30	9.75
	25.55	33.63	12.00	19.51
8C	25.31	33.65	13.30	0.25
	25.59	33.61	11.70	12.95
	25.69	33.63	11.20	25.91



Density Contours for February 21, 1979

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES,21 FEBRUARY 1979

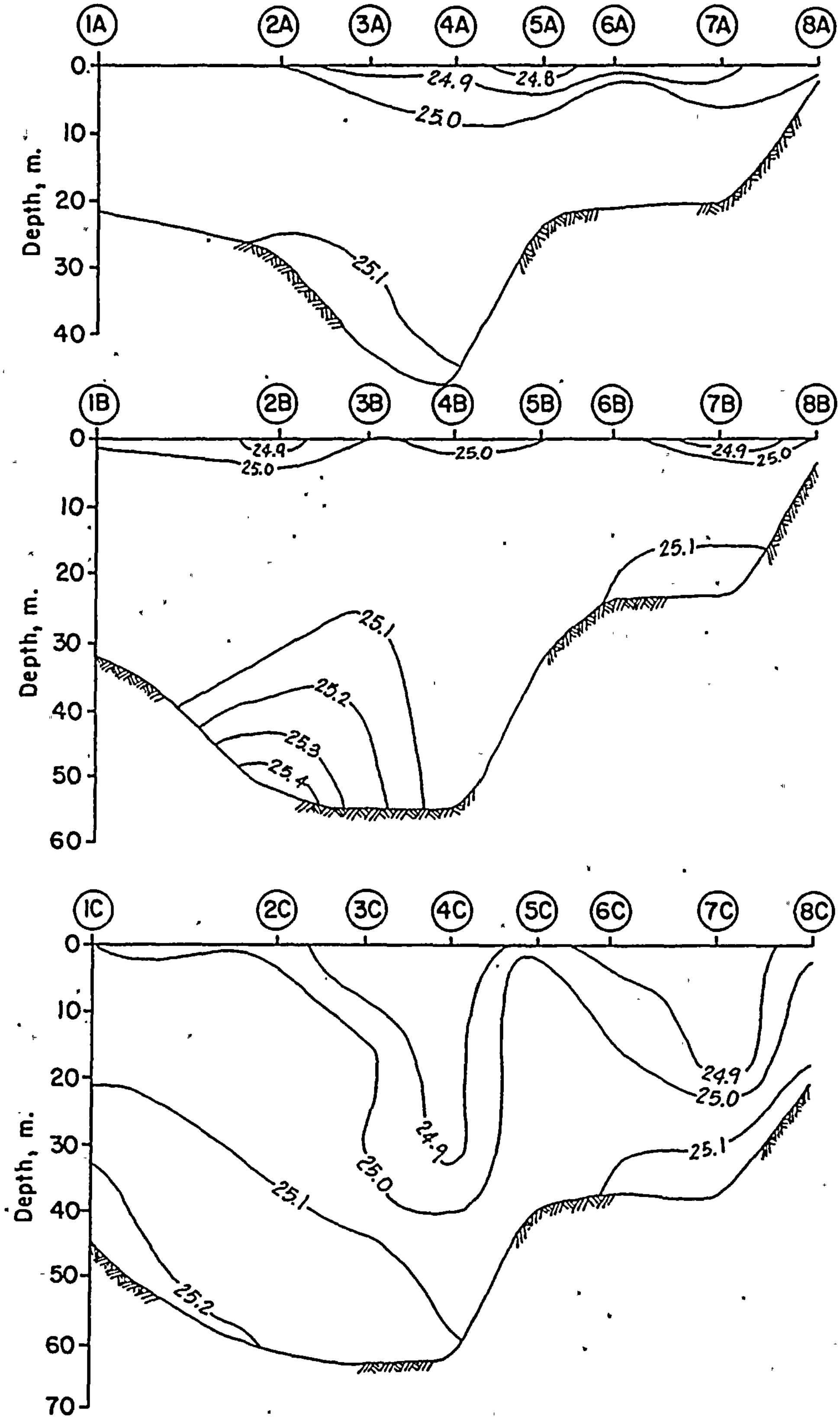
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
3A	25.22	33.30	12.40	0.25
	25.22	33.30	12.40	19.05
	25.44	33.40	11.60	38.10
3B	25.20	33.30	12.50	0.25
	25.19	33.29	12.50	26.67
	25.46	33.54	12.10	53.34
3C	25.18	33.30	12.60	0.25
	25.34	33.36	12.00	30.48
	25.64	33.54	11.10	60.96
4A	25.24	33.33	12.40	0.25
	25.23	33.32	12.40	19.05
	25.45	33.46	11.80	38.10
4B	25.23	33.32	12.40	0.25
	25.22	33.31	12.40	24.38
	25.32	33.39	12.20	48.77
4C	25.21	33.29	12.40	0.25
	25.26	33.36	12.40	30.48
	25.43	33.41	11.70	60.96
5A	25.25	33.32	12.30	0.25
	25.34	33.34	11.90	5.33
	25.39	33.38	11.80	10.67
5B	25.26	33.33	12.30	0.25
	25.40	33.42	11.90	13.72
	25.45	33.45	11.80	27.43
5C	25.27	33.34	12.30	0.25
	25.40	33.42	11.90	16.00
	25.47	33.46	11.70	32.00



Density Contours for September 27, 1979

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES,27 SEPTEMBER 1979

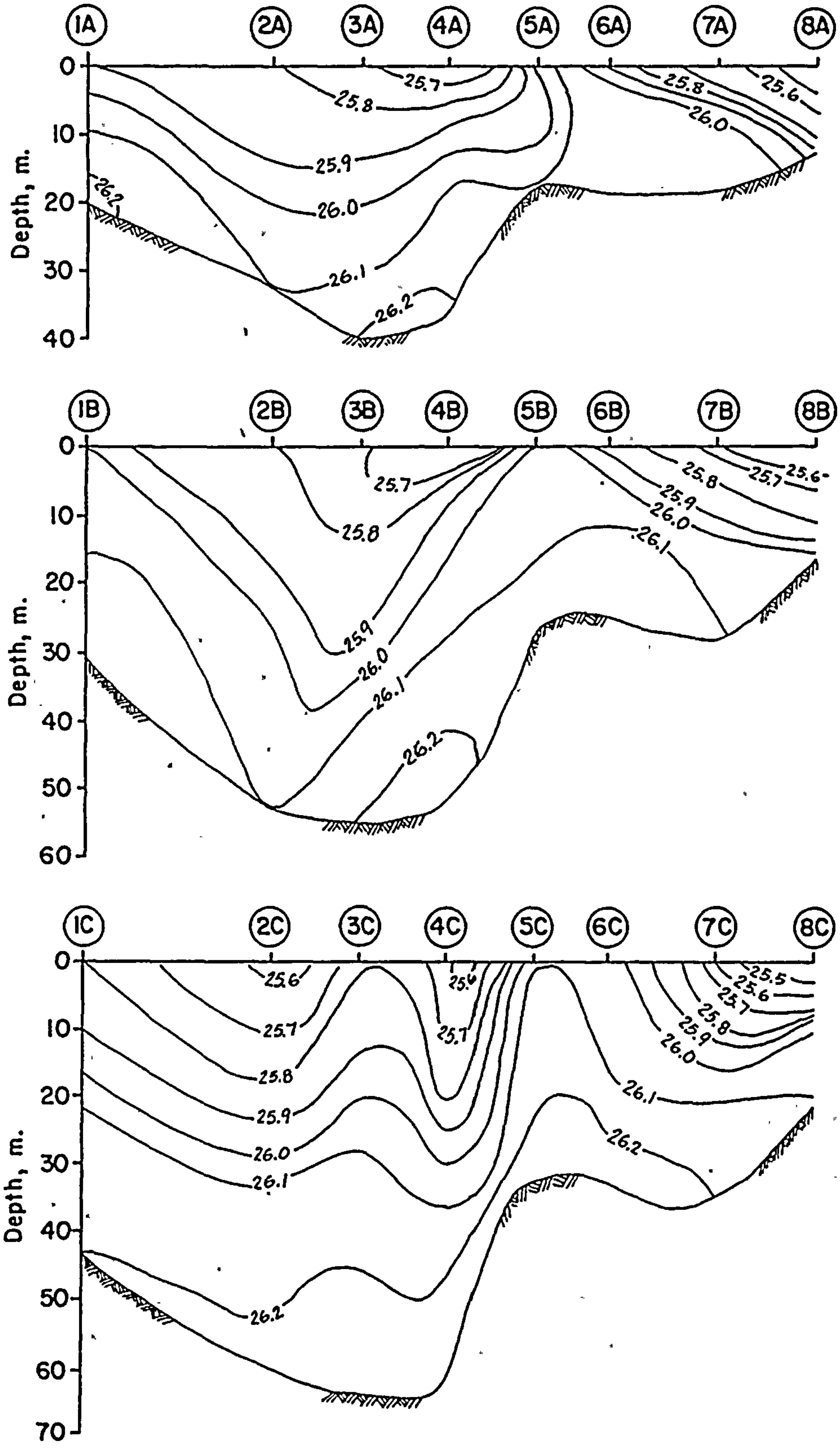
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M	SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	24.29	32.87	15.30	0.25	5A	24.29	32.87	15.30	0.25
	24.54	33.03	14.70	7.62		24.54	32.87	14.10	12.19
	24.63	32.74	13.20	15.24		24.77	32.87	13.00	24.38
1B	23.34	31.55	15.00	0.25	5B	23.98	32.67	16.00	0.25
	24.52	32.81	14.00	15.24		24.61	32.74	13.30	15.24
	24.73	32.74	12.70	30.48		24.65	32.67	12.80	30.48
1C	23.61	32.01	15.40	0.25	5C	24.29	32.59	14.30	0.25
	24.54	32.81	13.90	21.34		24.61	32.74	13.30	19.81
	24.97	33.03	12.60	42.67		24.67	32.67	12.70	39.62
2A	24.15	32.81	15.70	0.25	6A	24.44	32.74	14.10	0.25
	24.52	33.03	14.80	14.94		24.33	32.59	14.10	8.38
	24.68	32.81	13.20	29.87		24.44	32.74	14.10	16.76
2B	24.13	32.81	15.80	0.25	6B	23.82	32.15	14.90	0.25
	24.68	32.96	13.80	26.67		24.38	32.66	14.10	11.43
	24.95	33.03	12.70	53.34		24.78	32.96	13.30	22.86
2C	23.95	32.52	15.60	0.25	6C	24.52	32.87	14.20	0.25
	24.83	32.87	12.70	30.48		24.61	32.74	13.30	19.81
	24.86	32.87	12.50	60.96		24.79	32.87	12.90	39.62
3A	24.23	32.52	14.30	0.25	7A	24.16	32.67	15.20	0.25
	24.69	32.87	13.40	19.81		24.25	32.59	14.50	7.62
	24.91	33.11	13.20	39.62		24.44	32.74	14.10	15.24
3B	24.52	32.87	14.20	0.25	7B	24.30	32.74	14.80	0.25
	24.89	33.03	13.00	25.91		24.25	32.52	14.20	16.76
	24.88	32.87	12.40	51.82		24.50	32.52	13.00	33.53
3C	24.32	33.03	15.70	0.25	7C	23.70	31.93	14.70	0.25
	24.61	32.87	13.80	30.48		24.54	32.81	13.90	19.81
	24.87	33.03	13.10	60.96		24.73	32.74	12.70	39.62
4A	23.90	32.01	14.00	0.25	8A	24.46	33.18	15.60	0.25
	24.57	32.67	13.20	18.29		24.53	33.18	15.30	6.86
	24.61	32.59	12.70	36.58		24.67	33.03	14.10	13.72
4B	23.75	31.84	14.10	0.25	8B	24.45	33.11	15.40	0.25
	24.42	32.45	13.10	22.86		24.40	32.96	15.10	6.86
	24.53	32.37	12.20	45.72		24.67	33.03	14.10	13.72
4C	24.23	32.51	14.30	0.25	8C	24.53	33.18	15.30	0.25
	24.63	32.59	12.60	30.48		24.84	33.18	13.80	10.67
	24.96	32.89	12.10	60.96		24.80	32.96	13.20	21.34



Density Contours for January 14, 1981

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES,14 JANUARY 1981

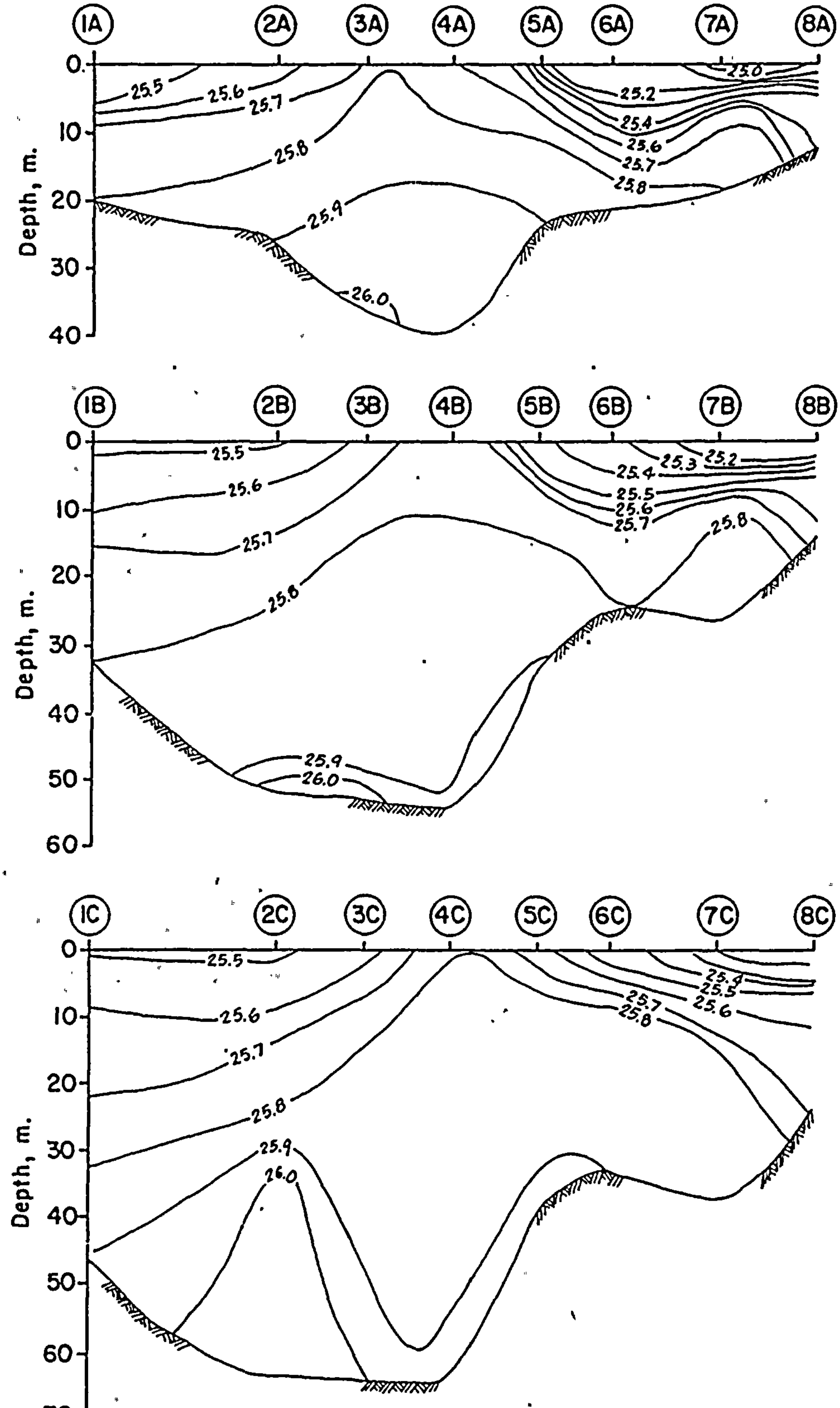
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M					
1A	25.01	33.56	14.40	0.25	5A	24.75	33.28	14.60	0.25
	25.00	33.54	14.40	10.06		24.97	33.51	14.40	11.43
	24.99	33.50	14.30	20.12		25.01	33.50	14.20	22.86
1B	24.98	33.52	14.40	0.25	5B	24.95	33.56	14.70	0.25
	25.03	33.53	14.20	15.24		24.97	33.56	14.60	15.70
	25.07	33.55	14.10	30.48		25.05	33.55	14.20	31.39
1C	25.04	33.57	14.30	0.25	5C	24.96	33.57	14.70	0.25
	25.07	33.55	14.10	21.03		24.95	33.53	14.60	19.35
	25.20	33.56	13.50	42.06		25.05	33.53	14.10	38.71
2A	24.95	33.56	14.70	0.25	6A	24.98	33.54	14.50	0.25
	25.00	33.55	14.40	13.11		25.03	33.53	14.20	10.06
	25.07	33.55	14.10	26.21		25.05	33.53	14.10	20.12
2B	24.94	33.55	14.70	0.25	6B	24.95	33.54	14.60	0.25
	24.97	33.53	14.50	25.15		25.05	33.53	14.10	12.19
	25.44	33.59	12.40	50.29		25.07	33.53	14.00	24.38
2C	24.96	33.57	14.70	0.25	6C	24.94	33.55	14.70	0.25
	-0.67	0.00	14.00	29.72		25.01	33.53	14.30	16.76
	-0.65	0.00	13.90	59.44		25.07	33.53	14.00	33.53
3A	24.94	33.55	14.70	0.25	7A	24.94	33.55	14.70	0.25
	24.98	33.55	14.50	19.81		25.06	33.54	14.10	9.75
	25.11	33.58	14.00	39.62		25.05	33.53	14.10	19.51
3B	24.95	33.56	14.70	0.25	7B	24.92	33.55	14.80	0.25
	25.09	33.55	14.00	26.67		25.02	33.54	14.30	12.19
	25.16	33.54	13.60	53.34		25.08	33.54	14.00	24.38
3C	24.93	33.57	14.80	0.25	7C	24.92	33.55	14.80	0.25
	24.98	33.55	14.50	30.48		24.91	33.54	14.80	18.29
	25.13	33.52	13.70	60.96		25.08	33.54	14.00	36.58
4A	24.94	33.58	14.80	0.25	8A	25.00	33.57	14.50	0.25
	24.98	33.54	14.50	20.27		25.02	33.54	14.30	6.10
	25.09	33.53	13.90	40.54		25.05	33.55	14.20	12.19
4B	24.94	33.55	14.70	0.25	8B	24.99	33.56	14.50	0.25
	24.97	33.53	14.50	26.67		25.02	33.54	14.30	6.10
	25.04	33.54	14.20	53.34		25.04	33.54	14.20	12.19
4C	24.93	33.54	14.70	0.25	8C	24.96	33.57	14.70	0.25
	24.93	33.54	14.70	30.48		25.02	33.54	14.30	9.60
	25.08	33.54	14.00	60.96		25.06	33.54	14.10	19.20



Density Contours for June 16, 1981

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 16 JUNE 1981

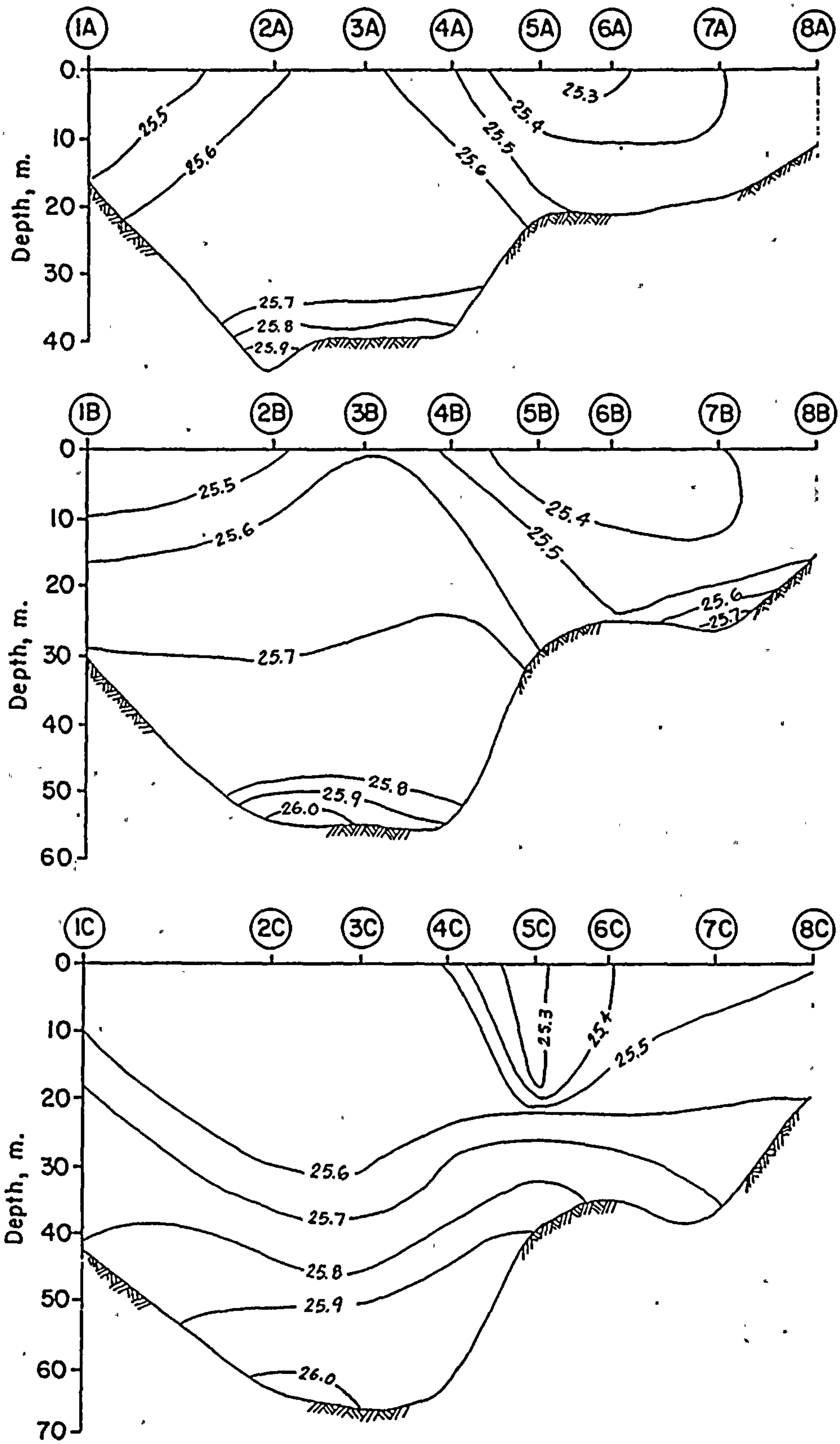
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH, M
1A	25.92	33.97	11.40	0.25
	26.10	33.95	10.30	9.91
	26.15	33.97	10.10	19.81
1B	25.95	33.96	11.20	0.25
	26.09	33.93	10.30	14.80
	26.16	33.98	10.10	29.60
1C	25.86	33.96	11.70	0.25
	26.14	33.93	10.00	21.66
	26.23	33.98	9.70	43.31
2A	25.83	33.95	11.80	0.25
	25.88	33.92	11.40	15.70
	26.11	33.96	10.30	31.39
2B	25.82	33.84	11.40	0.25
	25.99	33.90	10.70	25.89
	26.11	33.96	10.30	51.79
2C	25.67	33.79	12.00	0.25
	26.05	33.91	10.40	29.40
	26.16	33.96	10.00	58.80
3A	25.74	33.93	12.20	0.25
	26.01	33.94	10.80	19.51
	26.17	33.97	10.00	39.01
3B	25.69	33.92	12.40	0.25
	25.94	33.90	11.00	26.35
	26.19	33.97	9.90	52.70
3C	25.77	33.87	11.80	0.25
	26.10	33.92	10.20	30.50
	26.15	33.94	10.00	60.99
4A	25.65	33.94	12.70	0.25
	26.13	33.92	10.00	18.00
	26.24	33.99	9.70	36.00
4B	25.60	33.93	12.90	0.25
	26.14	33.95	10.10	25.15
	26.20	33.97	9.80	50.29
4C	25.65	33.94	12.70	0.25
	25.97	33.92	10.90	30.50
	26.20	33.97	9.80	60.99
5A	26.06	33.96	10.60	0.25
	26.04	33.94	10.60	8.40
	26.07	33.93	10.40	16.79
5B	26.07	33.95	10.50	0.25
	26.12	33.93	10.10	13.30
	26.13	33.94	10.10	26.61
5C	26.07	33.95	10.50	0.25
	26.10	33.93	10.20	16.00
	26.15	33.94	10.00	32.00
6A	25.77	33.94	12.10	0.25
	26.07	33.93	10.40	9.60
	26.13	33.94	10.10	19.20
6B	25.84	33.94	11.70	0.25
	26.11	33.91	10.10	11.90
	26.14	33.93	10.00	23.80
6C	25.97	33.96	11.10	0.25
	26.11	33.92	10.10	16.00
	26.18	33.96	9.90	32.00
7A	25.60	33.93	12.90	0.25
	25.95	33.91	11.00	9.14
	26.10	33.92	10.20	18.29
7B	25.50	33.93	13.40	0.25
	26.04	33.92	10.50	13.70
	26.12	33.93	10.10	27.40
7C	25.54	33.92	13.20	0.25
	26.05	33.93	10.50	17.50
	26.15	33.93	9.90	34.99
8A	25.26	33.94	14.60	0.25
	25.47	33.91	13.50	6.40
	25.89	33.91	11.30	12.80
8B	25.34	33.93	14.20	0.25
	25.66	33.90	12.50	7.89
	25.98	33.91	10.80	15.79
8C	25.40	33.93	13.90	0.25
	25.98	33.91	10.80	10.65
	26.12	33.93	10.10	21.31



Density Contours for September 30, 1981

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 30 SEPTEMBER 1981

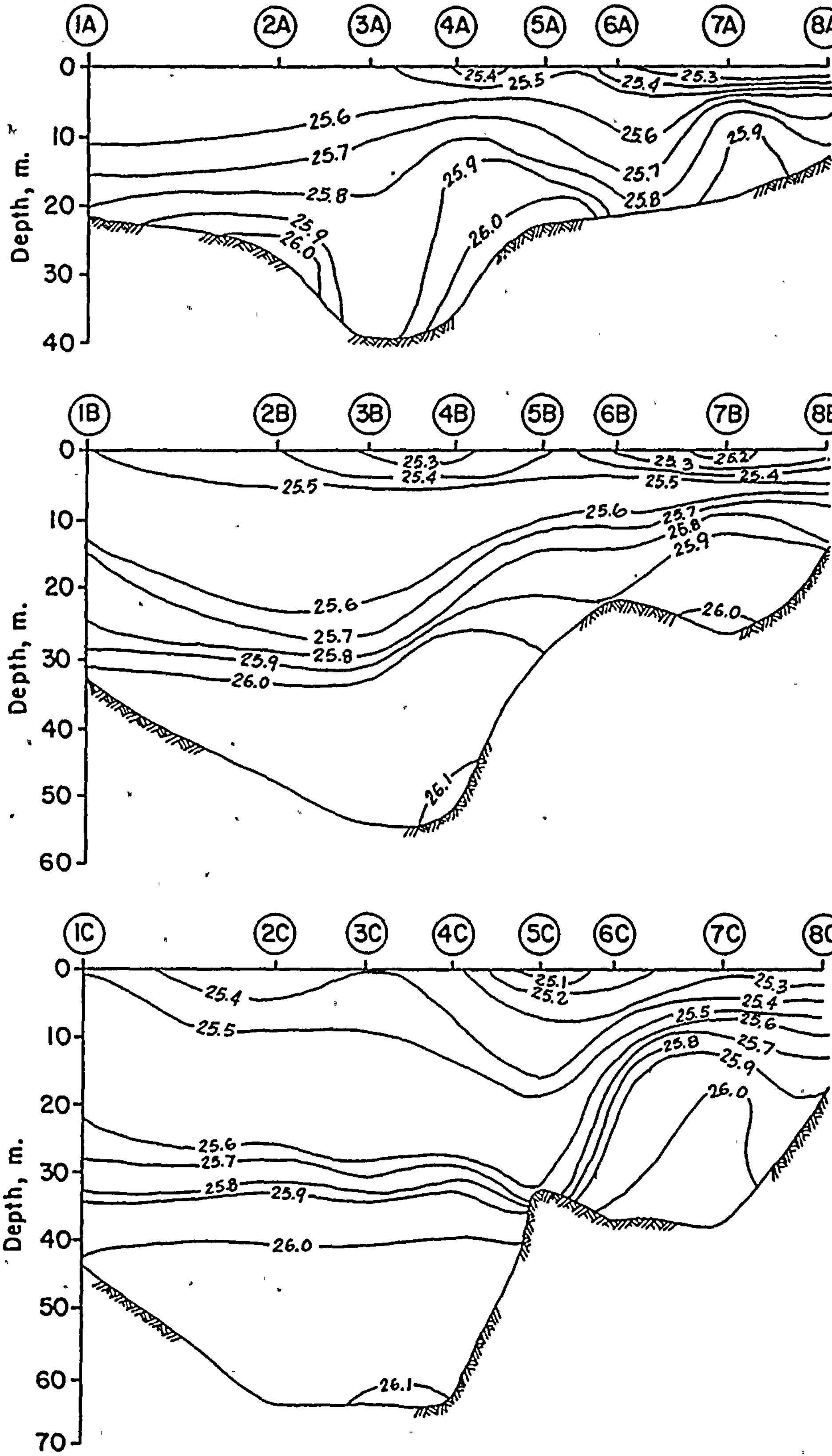
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	25.45	33.70	12.80	0.25
	25.75	33.70	11.20	9.91
	25.81	33.71	10.90	19.81
1B	25.52	33.69	12.40	0.25
	25.72	33.69	11.30	16.00
	25.85	33.71	10.70	32.00
1C	25.52	33.72	12.50	0.25
	25.73	33.68	11.20	21.95
	25.89	33.72	10.50	43.89
2A	25.60	33.72	12.10	0.25
	25.79	33.71	11.00	12.95
	25.90	33.73	10.50	25.91
2B	25.49	33.70	12.60	0.25
	25.83	33.71	10.80	25.15
	25.95	33.73	10.20	50.29
2C	25.47	33.68	12.60	0.25
	25.95	33.73	10.20	30.48
	26.01	33.77	10.00	60.96
3A	25.80	33.74	11.10	0.25
	25.87	33.72	10.60	18.29
	25.96	33.74	10.20	36.58
3B	25.68	33.71	11.60	0.25
	25.82	33.70	10.80	25.91
	25.97	33.74	10.10	51.82
3C	25.64	33.70	11.80	0.25
	25.79	33.73	11.10	30.48
	25.96	33.74	10.20	60.96
4A	25.70	33.73	11.60	0.25
	25.86	33.73	10.70	19.66
	25.94	33.74	10.30	39.32
4B	25.67	33.69	11.60	0.25
	25.79	33.70	11.00	26.67
	25.93	33.70	10.20	53.34
4C	25.74	33.74	11.40	0.25
	25.82	33.70	10.80	30.48
	25.94	33.70	10.10	60.96
5A	25.13	33.66	14.20	0.25
	25.81	33.73	11.00	11.43
	25.90	33.73	10.50	22.86
5B	25.41	33.68	12.90	0.25
	25.82	33.72	10.90	15.24
	25.91	33.70	10.30	30.48
5C	25.57	33.71	12.20	0.25
	25.84	33.73	10.80	19.81
	25.94	33.72	10.20	39.62
6A	25.13	33.66	14.20	0.25
	25.63	33.67	11.70	10.67
	25.79	33.70	11.00	21.34
6B	25.34	33.66	13.20	0.25
	25.72	33.68	11.30	12.19
	25.81	33.71	10.90	24.38
6C	25.44	33.67	12.70	0.25
	25.81	33.71	10.90	16.76
	25.89	33.72	10.50	33.53
7A	25.05	33.64	14.50	0.25
	25.68	33.68	11.50	9.45
	25.79	33.70	11.00	18.90
7B	25.03	33.64	14.60	0.25
	25.78	33.69	11.00	12.95
	25.79	33.70	11.00	25.91
7C	25.10	33.67	14.40	0.25
	25.75	33.70	11.20	19.05
	25.76	33.71	11.20	38.10
8A	25.06	33.68	14.60	0.25
	25.37	33.65	13.00	6.10
	25.44	33.52	12.10	12.19
8B	24.97	33.53	14.50	0.25
	25.47	33.65	12.50	6.10
	25.57	33.66	12.00	12.19
8C	25.07	33.66	14.50	0.25
	25.57	33.66	12.00	10.67
	25.65	33.71	11.80	21.34



Density Contours for February 23, 1982

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES,23 FEBRURARY 1982

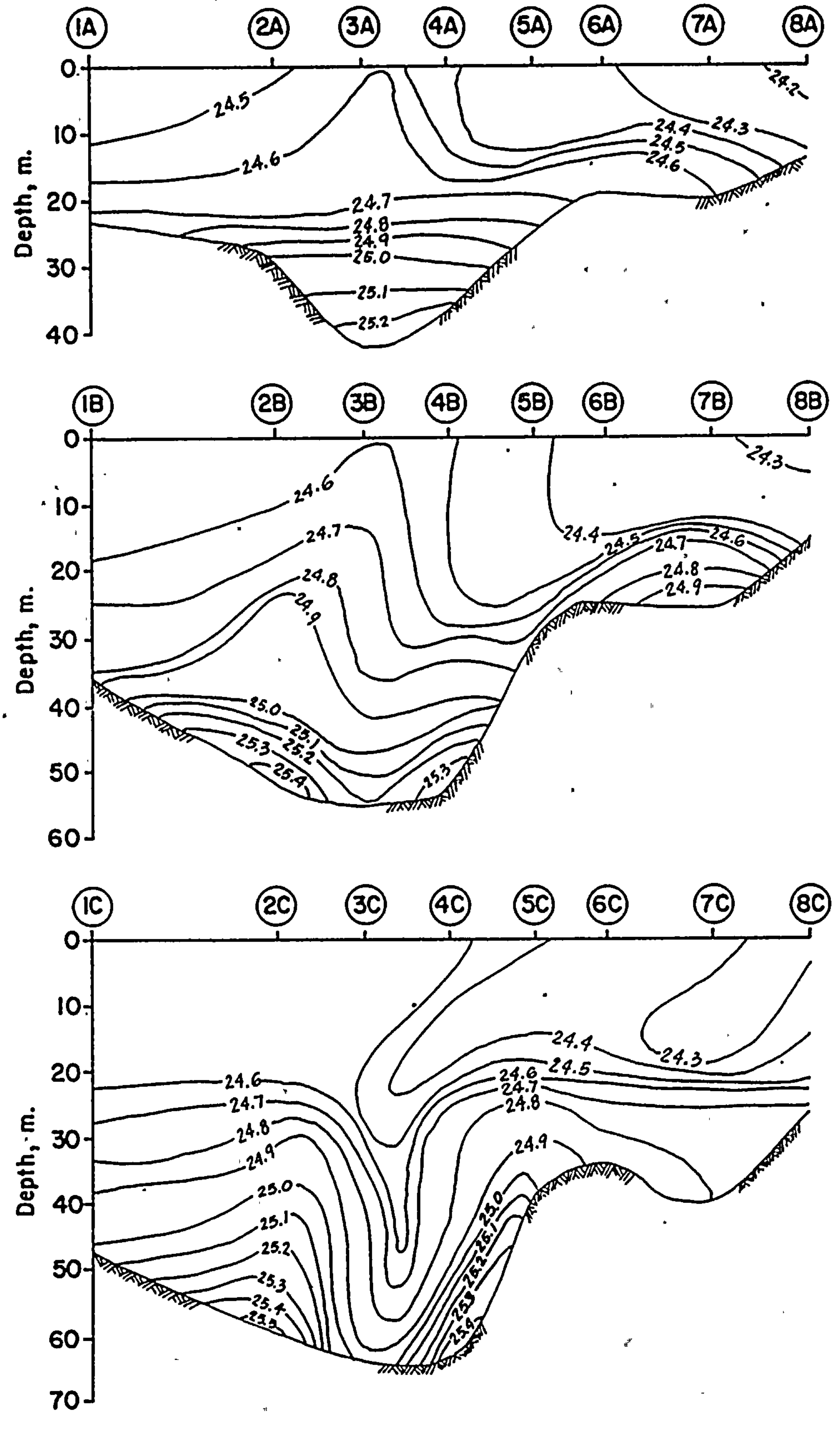
SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M	SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	25.52	33.60	12.00	0.25	5A	25.34	33.56	12.80	0.25
	25.45	33.50	12.00	8.23		25.41	33.55	12.40	10.36
	25.52	33.59	12.00	16.46		25.51	33.58	12.00	20.73
1B	25.49	33.56	12.00	0.25	5B	25.31	33.58	13.00	0.25
	25.60	33.62	11.70	14.63		25.53	33.59	11.90	14.48
	25.66	33.63	11.40	29.26		25.58	33.62	11.80	28.96
1C	25.49	33.56	12.00	0.25	5C	25.31	33.58	13.00	0.25
	25.66	33.61	11.30	20.73		25.34	33.56	12.80	19.51
	25.82	33.70	10.80	41.45		25.88	33.73	10.60	39.01
2A	25.57	33.63	11.90	0.25	6A	25.30	33.54	12.90	0.25
	25.62	33.61	11.50	22.86		25.44	33.54	12.20	10.67
	25.89	33.75	10.60	45.72		25.50	33.57	12.00	21.34
2B	25.49	33.58	12.10	0.25	6B	25.44	33.56	12.30	0.25
	25.57	33.59	11.70	26.67		25.45	33.55	12.20	12.19
	25.96	33.77	10.30	53.34		25.51	33.58	12.00	24.38
2C	25.49	33.58	12.10	0.25	6C	25.39	33.58	12.60	0.25
	25.60	33.58	11.50	30.94		25.48	33.57	12.10	16.76
	25.98	33.79	10.30	61.87		25.67	33.65	11.40	33.53
3A	25.55	33.64	12.00	0.25	7A	25.40	33.56	12.50	0.25
	25.65	33.62	11.40	19.20		25.44	33.56	12.30	9.45
	25.80	33.69	10.90	38.40		25.52	33.60	12.00	18.90
3B	25.57	33.63	11.90	0.25	7B	25.44	33.59	12.40	0.25
	25.68	33.64	11.30	26.67		25.44	33.57	12.30	12.95
	25.99	33.78	10.20	53.34		25.67	33.67	11.50	25.91
3C	25.52	33.60	12.00	0.25	7C	25.44	33.59	12.40	0.25
	25.61	33.61	11.60	32.77		25.47	33.58	12.20	18.75
	25.95	33.73	10.20	65.53		25.73	33.67	11.20	37.49
4A	25.48	33.59	12.20	0.25	8A	25.50	33.59	12.10	0.25
	25.61	33.61	11.60	19.20		25.50	33.57	12.00	5.79
	25.80	33.70	10.90	38.40		25.50	33.57	12.00	11.58
4B	25.50	33.59	12.10	0.25	8B	25.46	33.57	12.20	0.25
	25.68	33.64	11.30	26.67		25.47	33.56	12.10	7.16
	25.88	33.73	10.60	53.34		25.50	33.57	12.00	14.33
4C	25.48	33.57	12.10	0.25	8C	25.48	33.59	12.20	0.25
	25.68	33.61	11.20	30.48		25.46	33.57	12.20	9.75
	25.87	33.70	10.50	60.96		25.62	33.65	11.70	19.51



Density Contours for June 26, 1982

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 26 JUNE 1982

SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH, M					
1A	25.47	33.71	12.70	0.25	5A	25.52	33.70	12.40	0.25
	25.60	33.73	12.10	10.06		25.71	33.70	11.40	10.97
	25.82	33.74	11.00	20.12		25.98	33.79	10.30	21.95
1B	25.50	33.70	12.50	0.25	5B	25.45	33.65	12.60	0.25
	25.73	33.74	11.50	15.24		25.82	33.74	11.00	14.63
	26.00	33.80	10.20	30.48		25.97	33.78	10.30	29.26
1C	25.50	33.70	12.50	0.25	5C	25.01	33.53	14.30	0.25
	25.63	33.72	11.90	21.03		25.42	33.56	12.40	16.00
	25.98	33.82	10.40	42.06		25.62	33.68	11.80	32.00
2A	25.44	33.66	12.70	0.25	6A	25.33	33.74	13.50	0.25
	25.51	33.66	12.30	13.11		25.65	33.74	11.90	10.36
	25.79	33.75	11.20	26.21		25.85	33.79	11.00	20.73
2B	25.41	33.63	12.70	0.25	6B	25.24	33.75	14.00	0.25
	25.63	33.66	11.70	23.47		25.67	33.80	12.00	10.97
	25.95	33.71	10.10	46.94		25.87	33.77	10.80	21.95
2C	25.28	33.74	13.80	0.25	6C	25.19	33.74	14.20	0.25
	25.79	33.71	11.00	30.48		25.86	33.78	10.90	18.29
	26.00	33.79	10.20	60.96		25.99	33.81	10.30	36.58
3A	25.48	33.72	12.70	0.25	7A	25.15	33.74	14.40	0.25
	25.76	33.81	11.60	19.35		25.87	33.78	10.90	9.14
	25.91	33.84	10.90	38.71		25.92	33.79	10.60	18.29
3B	25.32	33.61	13.10	0.25	7B	25.14	33.70	14.30	0.25
	25.66	33.75	11.90	26.52		25.88	33.78	10.80	12.95
	26.04	33.85	10.20	53.04		25.98	33.80	10.30	25.91
3C	25.36	33.68	13.20	0.25	7C	25.31	33.76	13.70	0.25
	25.71	33.69	11.40	30.48		26.00	33.79	10.20	18.29
	26.08	33.84	9.90	60.96		26.04	33.82	10.10	36.58
4A	25.43	33.75	13.10	0.25	8A	25.19	33.73	14.20	0.25
	25.86	33.78	10.90	17.98		25.66	33.75	11.90	6.10
	26.02	33.82	10.20	35.97		25.75	33.75	11.40	12.19
4B	25.28	33.62	13.30	0.25	8B	25.17	33.74	14.30	0.25
	25.99	33.80	10.30	25.91		25.54	33.74	12.50	6.86
	26.11	33.85	9.80	51.82		25.83	33.76	11.00	13.72
4C	25.29	33.63	13.30	0.25	8C	25.14	33.72	14.40	0.25
	25.79	33.78	11.00	30.48		25.62	33.72	12.00	9.14
	26.11	33.83	9.70	60.96		25.88	33.78	10.80	18.29



Density Contours for September 24, 1982

SIGMA-T FOR D.C. OCEANOGRAPHY: DIABLO CANYON DENSITIES, 24 SEPTEMBER 1982

SAMPLE	SIG-T	S(0/00)	DEG.C	DEPTH,M
1A	24.47	33.46	16.50	0.25
	24.52	33.47	16.30	10.97
	24.74	33.49	15.40	21.95
1B	24.45	33.46	16.60	0.25
	24.56	33.48	16.20	17.07
	24.75	33.47	15.30	34.14
1C	24.46	33.47	16.60	0.25
	24.62	33.47	15.90	22.86
	25.01	33.47	14.10	45.72
2A	24.52	33.47	16.30	0.25
	24.65	33.49	15.80	13.72
	24.98	33.55	14.50	27.43
2B	24.47	33.46	16.50	0.25
	24.88	33.53	14.90	25.15
	25.36	33.61	12.90	50.29
2C	24.52	33.46	16.30	0.25
	24.90	33.53	14.80	29.72
	25.48	33.64	12.40	59.44
3A	24.58	33.48	16.10	0.25
	24.66	33.50	15.80	20.57
	25.22	33.51	13.20	41.15
3B	24.56	33.49	16.20	0.25
	24.71	33.51	15.60	27.43
	25.20	33.62	13.70	54.86
3C	24.49	33.48	16.50	0.25
	24.45	33.49	16.70	30.48
	24.87	33.54	15.00	60.96
4A	24.37	33.51	17.10	0.25
	24.52	33.50	16.40	17.53
	25.15	33.57	13.80	35.05
4B	24.46	33.51	16.70	0.25
	24.54	33.49	16.30	25.15
	25.32	33.59	13.00	50.29
4C	24.50	33.50	16.50	0.25
	24.82	33.50	15.10	30.48
	25.46	33.64	12.50	60.96
5A	24.35	33.51	17.20	0.25
	24.35	33.51	17.20	11.43
	24.85	33.51	15.00	22.86
5B	24.35	33.51	17.20	0.25
	24.41	33.50	16.90	14.48
	24.74	33.52	15.50	28.96
5C	24.37	33.51	17.10	0.25
	24.49	33.51	16.60	19.20
	24.95	33.56	14.70	38.40
6A	24.31	33.49	17.30	0.25
	24.36	33.50	17.10	9.91
	24.57	33.50	16.20	19.81
6B	24.33	33.52	17.30	0.25
	24.29	33.50	17.40	11.89
	24.76	33.51	15.40	23.77
6C	24.35	33.51	17.20	0.25
	24.29	33.50	17.40	16.76
	24.80	33.51	15.20	33.53
7A	24.27	33.50	17.50	0.25
	24.27	33.50	17.50	9.75
	24.62	33.50	16.00	19.51
7B	24.30	33.51	17.40	0.25
	24.30	33.51	17.40	12.95
	24.86	33.50	14.90	25.91
7C	24.32	33.51	17.30	0.25
	24.34	33.50	17.20	19.81
	24.81	33.49	15.10	39.62
8A	24.12	33.50	18.10	0.25
	24.16	33.49	17.90	6.40
	24.31	33.49	17.30	12.80
8B	24.25	33.51	17.60	0.25
	24.27	33.50	17.50	7.32
	24.27	33.50	17.50	14.63
8C	24.30	33.51	17.40	0.25
	24.41	33.50	16.90	12.50
	24.74	33.51	15.50	24.99

APPENDIX D

The following pages display daily and weekly means of six hourly upwelling indices computed with the method that was outlined by Bakun (1973) for a coastal location at 36N, 122W, over a six-year period from 1977 to 1982.

The left column indicates the calendar date of the Sunday which begins a particular week. The seven columns to the right contain the daily averages progressing from Sunday through the following Saturday. Each daily average summarizes the synoptic computations at 4 a.m., 10 a.m., 4 p.m., and 10 p.m. PST. The average of the seven daily means is listed in the right column of numbers (Bakun 1973).

The units are metric tons and/or cubic meters per second per 100m of coastline. These units may be thought of as the average amount of water upwelled each second along each 100m of a straight line directed along the dominant trend of the coast on a scale of about 200 miles. Because of uncertainties associated with some of the constants and other reasons outlined by Bakun (1973), these indices should be considered as indicative of relative fluctuations rather than as quantitative measures of absolute magnitude.

To the right of each weekly row of numerical values, the daily values are plotted as horizontal lines and the weekly means as vertical bars.

The upwelling indices are courtesy of Andrew Bakun of the NOAA/NMFS, Pacific Environmental Group in Monterey.

These coastal upwelling Indices were included to support the data and discussion for the Upwelling Period.

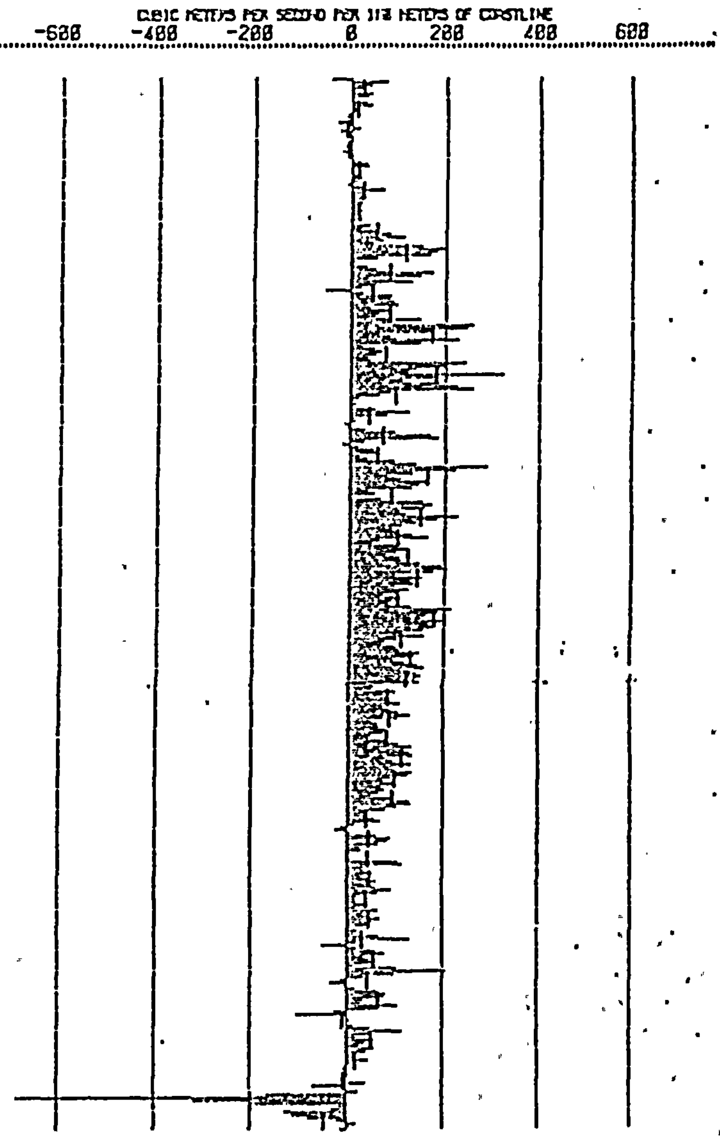
The intensity of the conditions that produce Upwelling can be examined by reviewing the Coastal Upwelling Indices. During inspection of the density contours for the 11 years of oceanographic data (Orvosh 1979, White 1983), an apparent correlation between the CUI values and the density structure was noticed. The oceanographic data that was collected during surveys when lower CUI values were reported, showed slightly lower density values and a less uniform density structure than what was normal for the Upwelling Period (e.g., June 14, 1977). Oceanographic data collected on our surveys that coincided with periods of higher than normal CUI values (June 16, 1981; June 26, 1982) had slightly higher density values which were more uniformly stratified.

NOAA/NMFS PACIFIC ENVIRONMENTAL GROUP - MONTEREY, CALIFORNIA

COASTAL UPWELLING INDICES, DAILY AND WEEKLY MEANS

DURING 1977 AT 36N, 122W

WEEK BEGINNING	DAILY VALUES SUN	MON	TUE	WED	THU	FRI	SAT	WEEKLY MEAN
2 JAN	-48	74	41	10	0	42	34	25
9 JAN	4	30	41	17	12	-9	-8	12
16 JAN	-6	-27	-12	18	-22	-6	-7	-9
23 JAN	-6	-8	-12	-9	-18	-5	-8	-6
30 JAN	4	32	34	-3	-3	18	10	13
6 FEB	15	-8	28	66	28	28	27	26
13 FEB	24	10	17	23	16	8	6	16
20 FEB	6	38	21	59	65	115	68	55
27 FEB	48	158	202	106	168	58	18	116
6 MAR	5	34	53	178	145	39	128	82
13 MAR	57	27	-51	26	65	87	82	46
20 MAR	86	45	78	60	52	148	83	82
27 MAR	256	245	168	68	68	220	149	172
3 APR	98	58	68	52	90	41	242	74
10 APR	166	138	121	321	183	114	187	181
17 APR	228	200	84	62	10	0	12	96
24 APR	6	63	122	70	13	11	-11	39
1 MAY	-4	33	98	188	165	32	-15	71
8 MAY	17	50	54	22	95	84	190	59
15 MAY	288	223	191	81	108	162	144	163
22 MAY	190	48	51	6	67	153	160	68
29 MAY	150	109	118	225	182	137	100	148
5 JUN	98	103	131	163	67	49	105	102
12 JUN	126	88	78	184	107	147	182	122
19 JUN	204	173	98	155	128	134	100	142
26 JUN	124	104	75	100	88	84	192	102
3 JUL	212	187	181	151	183	187	178	178
10 JUL	157	113	156	101	78	71	88	111
17 JUL	111	147	198	83	117	143	155	129
24 JUL	198	142	158	141	147	82	58	122
31 JUL	53	88	78	84	82	109	75	84
7 AUG	84	106	120	104	52	82	64	86
14 AUG	70	74	51	48	70	106	153	81
21 AUG	118	120	134	82	84	138	88	112
28 AUG	97	132	124	81	77	87	72	99
4 SEP	78	88	55	80	127	133	104	93
11 SEP	88	39	98	58	68	18	-12	48
18 SEP	-22	9	62	88	84	65	20	45
25 SEP	98	0	3	7	108	114	98	43
2 OCT	98	44	33	50	82	52	62	49
9 OCT	83	85	21	19	22	44	21	41
16 OCT	65	37	43	87	54	44	9	46
23 OCT	22	15	68	129	21	-49	23	33
30 OCT	68	77	98	48	58	13	104	56
6 NOV	205	87	34	-9	-92	-2	17	44
13 NOV	62	80	78	39	98	164	68	66
20 NOV	-24	-103	1	7	1	19	58	-8
27 NOV	113	47	23	59	97	28	58	52
4 DEC	41	14	18	44	18	-2	-5	17
11 DEC	-2	5	-7	2	48	-68	-7	-5
18 DEC	24	-164	-605	-317	-202	-15	-20	-198
25 DEC	-128	-112	-66	-28	18	5	-11	-47

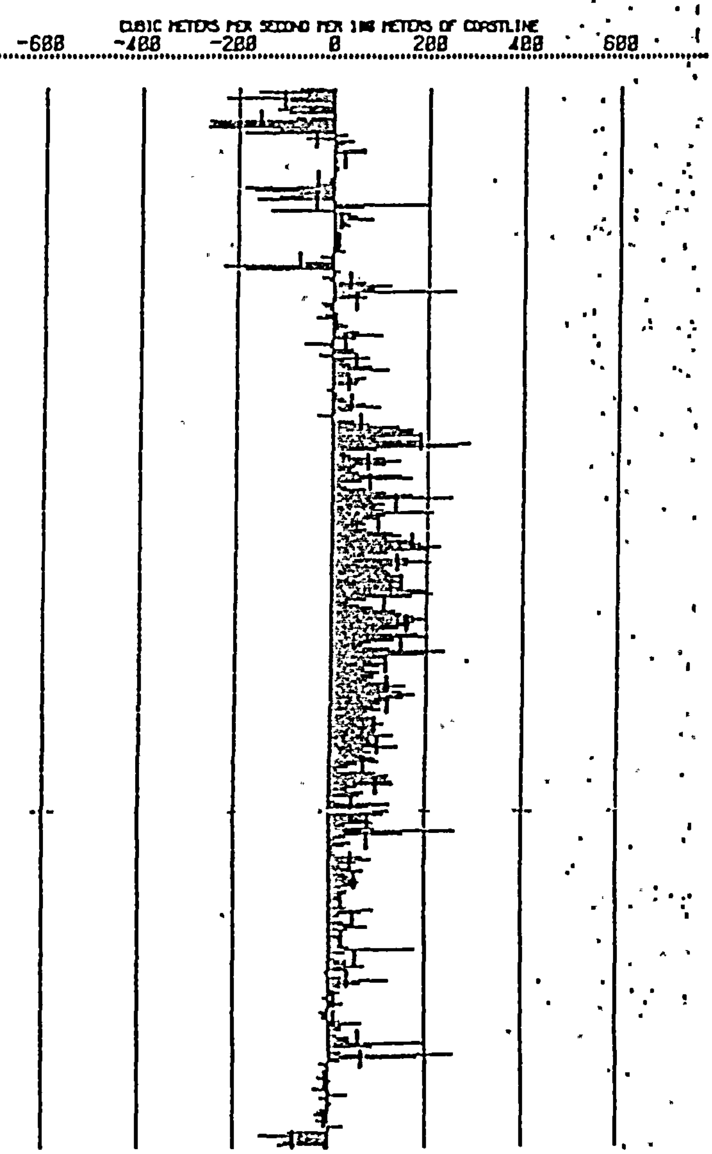


NOAA/NMFS PACIFIC ENVIRONMENTAL GROUP - MONTEREY, CALIFORNIA

COASTAL UPWELLING INDICES, DAILY AND WEEKLY MEANS

DURING 1978 AT 36N, 122W

WEEK BEGINNING	DAILY VALUES SUN	MON	TUE	WED	THU	FRI	SAT	WEEKLY MEAN
1 JAN	-75	-158	-58	-224	-183	-8	-198	-185
8 JAN	-117	-88	-2	-82	-268	-255	-262	-154
15 JAN	-118	-188	25	-58	38	18	13	-38
22 JAN	88	87	1	8	7	-8	8	22
29 JAN	7	2	2	-7	-12	-48	-188	-33
5 FEB	-167	-76	-114	-158	18	184	82	-36
12 FEB	-128	95	48	81	28	31	12	15
19 FEB	6	11	12	8	11	15	5	18
26 FEB	22	-5	-28	-8	-64	-228	-185	-78
5 MAR	12	1	-23	-7	67	121	85	37
12 MAR	257	58	88	8	-22	-18	-8	49
19 MAR	1	-16	-53	12	23	31	18	5
26 MAR	55	182	48	-4	-58	-8	44	26
2 APR	44	-28	78	24	98	81	118	58
9 APR	98	32	68	55	58	4	-9	34
16 APR	18	18	22	38	71	188	42	41
23 APR	18	-28	-8	48	78	148	167	59
30 APR	168	188	85	188	287	282	84	183
7 MAY	52	41	113	142	112	58	43	76
14 MAY	55	146	168	62	28	32	73	79
21 MAY	118	169	252	87	188	84	118	134
28 MAY	213	114	97	67	68	57	75	99
4 JUN	128	143	128	187	187	226	283	168
11 JUN	123	76	163	289	181	113	123	138
18 JUN	125	158	133	139	128	142	283	146
25 JUN	288	187	73	43	61	88	195	111
2 JUL	148	173	183	174	168	142	182	157
9 JUL	168	283	134	88	87	121	235	147
16 JUL	183	119	85	119	182	76	182	115
23 JUL	91	88	81	125	154	128	148	117
30 JUL	174	151	128	185	84	188	78	119
6 AUG	73	84	97	113	83	87	82	94
13 AUG	131	83	87	182	148	72	88	101
20 AUG	78	87	185	59	42	23	188	72
27 AUG	125	122	132	134	81	42	71	98
3 SEP	65	-1	17	132	84	35	-2	47
10 SEP	73	116	72	78	85	38	88	81
17 SEP	262	153	98	18	48	35	14	81
24 SEP	12	18	71	88	81	28	53	47
1 OCT	72	38	48	83	85	62	31	54
8 OCT	41	39	29	29	8	1	41	27
15 OCT	83	78	23	16	52	58	88	52
22 OCT	42	8	24	23	24	28	44	28
29 OCT	178	38	5	14	58	42	75	55
5 NOV	42	-5	-1	38	123	87	27	41
12 NOV	18	23	12	-8	11	38	18	13
19 NOV	-4	-15	-18	-18	25	69	91	12
26 NOV	28	8	28	45	48	187	83	62
3 DEC	4	28	257	182	24	-15	-5	68
10 DEC	1	-8	-8	-18	6	3	-8	-5
17 DEC	-28	4	37	-18	-4	7	-3	-1
24 DEC	-16	-22	-25	-7	-22	8	31	-9
31 DEC	2	-84	-144	-82	-82	-184	-8	-73

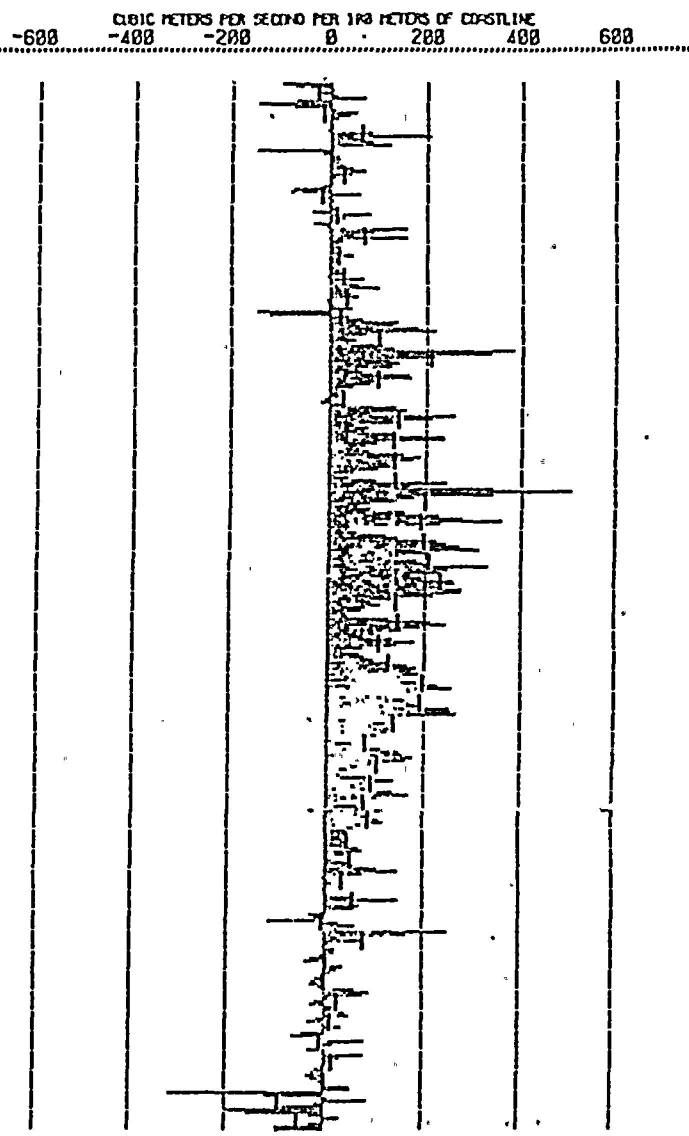


NOAA/NMFS PACIFIC ENVIRONMENTAL GROUP - MONTEREY, CALIFORNIA

COASTAL UPWELLING INDICES, DAILY AND WEEKLY MEANS

DURING 1979 AT 36N, 122W

WEEK BEGINNING	DAILY VALUES SUN	MON	TUE	WED	THU	FRI	SAT	WEEKLY MEAN
7 JAN	-93	-74	3	-28	11	89	-78	-27
14 JAN	-146	-73	11	52	98	16	-2	-15
21 JAN	2	3	-8	83	208	66	87	63
28 JAN	122	-3	-147	-13	17	20	17	2
4 FEB	27	45	70	45	8	-8	1	28
11 FEB	-14	-74	-80	60	-7	6	8	-15
18 FEB	5	14	-35	82	92	25	-32	13
25 FEB	-8	156	98	50	155	27	21	70
4 MAR	18	8	21	48	18	12	1	18
11 MAR	15	21	27	-5	68	10	57	28
18 MAR	80	34	44	56	-8	-4	11	34
25 MAR	43	-145	-123	38	68	139	198	22
1 APR	180	217	71	38	53	37	103	101
8 APR	192	380	334	222	193	140	128	210
15 APR	61	65	161	166	100	82	48	98
22 APR	24	17	18	-9	-17	25	196	28
29 APR	158	86	298	214	141	53	78	141
6 MAY	73	132	237	238	87	74	72	132
13 MAY	82	148	185	173	122	125	180	134
20 MAY	58	14	98	88	245	169	348	136
27 MAY	508	340	174	136	84	70	83	199
3 JUN	159	228	277	358	292	43	98	191
10 JUN	63	117	148	227	243	271	318	196
17 JUN	288	156	188	183	218	330	249	207
24 JUN	295	173	185	260	262	238	278	234
1 JUL	276	221	128	88	184	76	67	137
8 JUL	98	43	123	213	245	188	153	143
15 JUL	85	73	193	178	142	72	28	103
22 JUL	63	77	82	124	164	182	173	125
29 JUL	180	163	157	188	228	255	193	197
5 AUG	165	132	161	166	194	251	255	189
12 AUG	268	122	88	118	81	128	194	135
19 AUG	101	32	24	48	88	111	147	78
26 AUG	154	174	168	88	68	44	28	102
2 SEP	29	82	196	84	57	97	136	98
9 SEP	163	185	23	18	62	81	77	75
16 SEP	78	64	82	189	115	80	58	86
23 SEP	42	48	34	37	48	38	67	44
30 SEP	73	48	18	15	43	80	184	49
7 OCT	147	77	-5	6	15	3	-2	34
14 OCT	0	3	59	148	58	70	68	57
21 OCT	3	-38	-28	-114	27	63	27	-6
28 OCT	251	185	31	71	18	-2	22	78
4 NOV	18	-8	-28	-39	5	38	28	2
11 NOV	13	-5	-18	-24	-27	-18	63	-1
18 NOV	88	78	8	-18	-25	18	28	26
25 NOV	41	49	-14	-29	8	34	1	12
2 DEC	-44	-62	-8	88	21	-12	-38	-8
9 DEC	3	79	31	15	5	-4	-16	16
16 DEC	-22	-32	-24	-8	-4	51	54	2
23 DEC	-314	-118	8	86	-15	-97	-183	-93
30 DEC	-155	-28	31	3	-27	-96	-83	-52

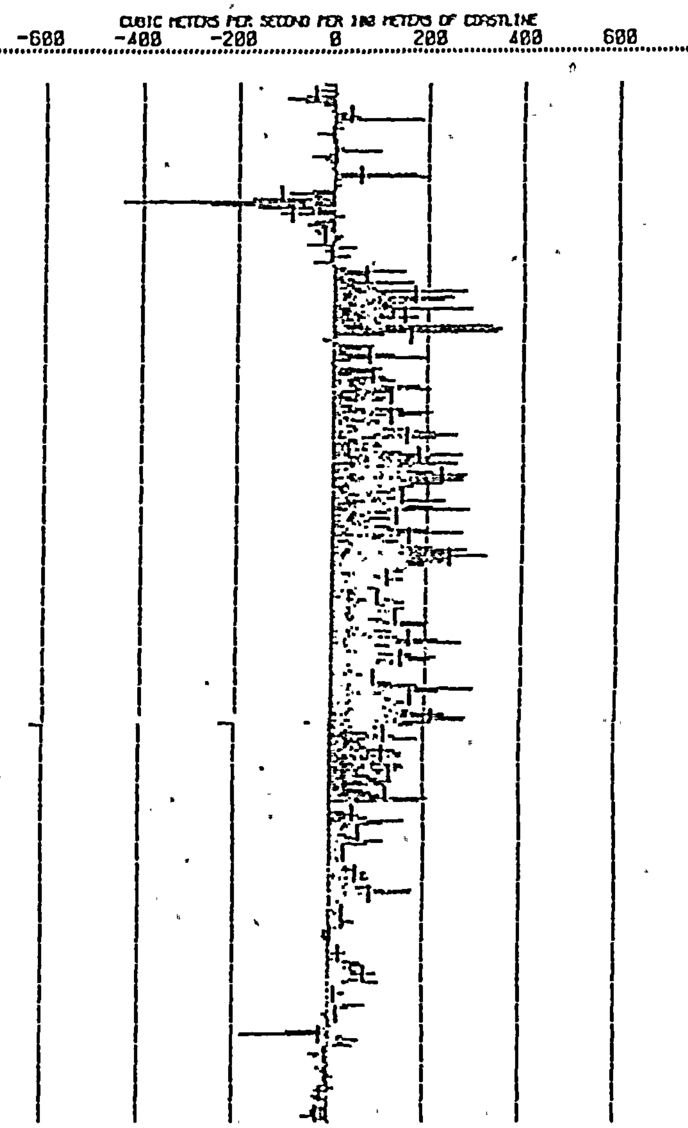


NOAA/NMFS PACIFIC ENVIRONMENTAL GROUP – MONTEREY, CALIFORNIA

COASTAL UPWELLING INDICES, DAILY AND WEEKLY MEANS

DURING 1980 AT 36N, 122W

WEEK BEGINNING	SUN	MON	TUE	WED	THU	FRI	SAT	WEEKLY MEAN
6 JAN	-21	1	-93	7	-62	-108	-65	-39
13 JAN	-25	-2	-8	24	54	108	14	35
20 JAN	-8	16	-6	-35	-7	8	8	-2
27 JAN	0	20	98	-13	-46	-20	-11	4
3 FEB	3	-7	7	171	200	13	-1	55
10 FEB	15	4	-45	-84	-45	-171	-439	-111
17 FEB	-258	-181	-48	-111	28	-12	-45	-88
24 FEB	-55	-31	-41	-36	18	13	-7	-20
2 MAR	-56	46	-18	3	33	-10	-41	-6
9 MAR	-7	24	148	75	21	42	108	68
16 MAR	78	88	278	110	251	232	159	171
23 MAR	123	289	194	130	178	81	182	158
30 MAR	333	352	345	106	15	-10	14	164
6 APR	85	50	98	129	195	36	-3	76
13 APR	11	101	81	40	113	133	105	83
20 APR	104	287	191	87	100	185	27	121
27 APR	42	149	211	186	68	88	85	121
4 MAY	108	148	217	263	228	51	98	157
11 MAY	183	77	143	270	287	206	261	181
18 MAY	179	160	210	280	274	273	232	238
25 MAY	171	143	121	79	131	235	198	145
1 JUN	214	285	114	71	128	80	59	135
8 JUN	122	204	275	150	104	138	145	163
15 JUN	214	281	244	324	245	235	188	249
22 JUN	158	152	87	182	158	86	73	115
29 JUN	83	72	58	40	134	152	134	96
6 JUL	153	128	81	65	107	206	208	134
13 JUL	151	126	75	138	225	272	167	165
20 JUL	185	98	169	222	211	136	89	146
27 JUL	68	43	66	57	83	128	185	89
3 AUG	208	238	109	113	139	156	138	169
10 AUG	118	167	245	283	281	214	105	213
17 AUG	178	113	48	82	138	186	64	114
24 AUG	65	79	148	153	151	89	87	111
31 AUG	154	159	149	187	87	182	197	127
7 SEP	116	49	72	88	106	208	102	110
14 SEP	5	-1	3	31	64	82	156	49
21 SEP	113	44	29	21	99	66	111	61
28 SEP	81	25	18	7	8	32	94	29
5 OCT	95	38	55	77	75	82	22	55
12 OCT	54	83	177	174	98	28	29	84
19 OCT	93	20	24	22	8	28	55	28
26 OCT	37	34	-18	-8	-13	-7	2	5
2 NOV	5	-1	9	36	14	26	69	22
9 NOV	73	51	68	188	42	81	107	73
16 NOV	2	3	9	35	14	10	15	12
23 NOV	79	44	2	-10	-4	3	13	18
30 NOV	21	-8	-87	-182	91	81	93	-19
7 DEC	58	-7	-12	-39	-29	-6	3	-6
14 DEC	-2	-22	-15	7	19	-0	-8	-4
21 DEC	-11	11	-28	-21	-30	-26	-3	-15
28 DEC	-3	-25	-34	-33	-52	-28	4	-24

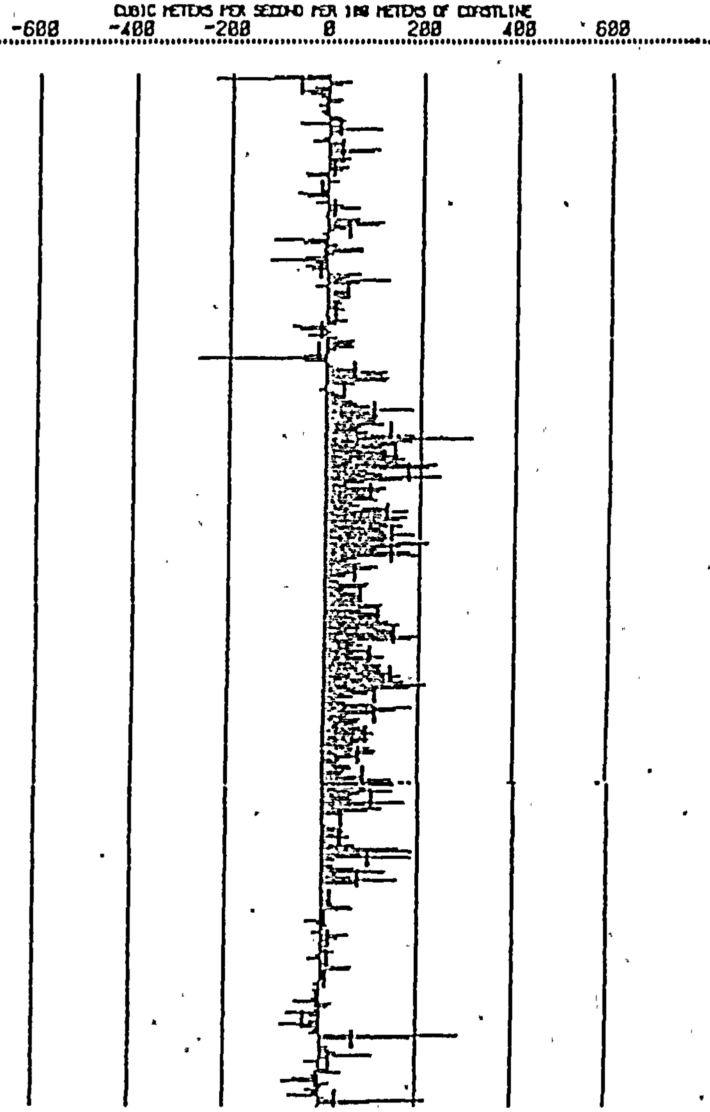


NOAA/NMFS PACIFIC ENVIRONMENTAL GROUP - MONTEREY, CALIFORNIA

COASTAL UPWELLING INDICES, DAILY AND WEEKLY MEANS

DURING 1982 AT 36N, 122W

WEEK BEGINNING	SUN	MON	TUE	WED	THU	FRI	SAT	WEEKLY MEAN
3 JAN	-115	-235	45	26	-92	-81	-98	-59
10 JAN	-17	25	22	-20	-6	-17	-11	-3
17 JAN	28	34	-58	20	108	27	0	23
24 JAN	-10	-30	28	17	105	83	19	31
31 JAN	45	35	18	41	27	-48	-49	11
7 FEB	5	23	0	-1	-14	-81	-41	-13
14 FEB	1	-23	92	66	21	2	-4	14
21 FEB	70	116	105	37	11	-10	-5	46
28 FEB	-110	-40	20	72	73	19	-48	-4
7 MAR	-115	-25	-45	-93	2	71	40	-14
14 MAR	120	69	-21	0	48	96	49	44
21 MAR	90	30	24	33	3	-2	0	18
28 MAR	41	10	-60	-54	11	-97	25	-9
4 APR	57	51	55	20	0	-47	-263	-17
11 APR	-43	7	18	88	128	118	120	68
18 APR	124	60	-2	-13	18	35	49	38
25 APR	58	87	85	183	98	110	108	102
2 MAY	183	120	73	70	81	166	308	136
9 MAY	182	149	118	128	128	154	164	146
16 MAY	151	233	218	82	121	242	158	173
23 MAY	83	49	124	111	84	85	108	93
30 MAY	63	73	195	173	198	171	158	130
6 JUN	192	181	118	129	185	138	124	140
13 JUN	218	158	119	178	185	67	52	140
20 JUN	77	110	85	65	49	14	98	63
27 JUN	83	87	47	68	72	77	82	75
4 JUL	118	114	77	111	117	184	195	111
11 JUL	158	129	148	142	282	181	70	147
18 JUL	82	89	85	184	125	184	88	97
25 JUL	121	110	121	146	158	159	169	141
1 AUG	214	180	113	84	65	39	40	107
8 AUG	108	184	153	185	58	78	74	108
15 AUG	72	88	84	186	83	88	78	98
22 AUG	68	181	109	107	78	39	94	77
29 AUG	68	62	48	44	88	147	148	85
5 SEP	98	144	78	60	66	171	82	101
12 SEP	121	86	47	4	0	1	11	40
19 SEP	40	47	92	55	14	12	70	39
26 SEP	150	185	84	184	91	7	25	96
3 OCT	69	130	98	65	156	70	1	75
10 OCT	6	0	1	8	16	28	63	18
17 OCT	68	0	8	2	-96	-8	17	9
24 OCT	7	-15	58	36	11	-2	18	16
31 OCT	18	28	-8	-24	8	20	64	15
7 NOV	62	13	8	12	-3	-10	-5	11
14 NOV	-12	-4	-1	-15	-52	24	17	-6
21 NOV	-16	-87	-20	-5	-20	-78	-37	-34
28 NOV	-12	-18	288	187	8	4	21	68
5 DEC	21	36	188	14	-28	-2	-2	21
12 DEC	24	46	-18	-54	-78	21	8	-7
19 DEC	-28	-13	-63	13	221	187	-3	34



Report Issued: MAR 11 1983

Report 411-83.1

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH

DIABLO CANYON POWER PLANT
DYE TRACER SIMULATION OF
HEAT TREATMENT PLUME DISPERSION

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Cont')

ABSTRACT

A dye tracer study was conducted at Diablo Canyon Power Plant to simulate the dispersion and dilution of the cooling water discharge plume during heat treatment of the main steam condensers. Rhodamine W.T. tracer dye was injected into the cooling water system and then dye concentrations were measured at several sampling stations in Diablo Cove as well as one station in the cooling system after the point of injection. The study was conducted during two selected discharge cooling water flow conditions.

Plume configuration and dye concentration levels varied significantly between Test 1 and Test 2. During Test 1, which had a combined discharge flow from Units 1 and 2 of 2,500 cubic feet per second (cfs), most of the fluorescent dye moved directly out of Diablo Cove before it began to mix with the offshore waters. There was very little residual dye within the cove after the dye injection concluded. During Test 2, Unit 1 flow was 500 cfs and Unit 2 had no flow, the dye plume had a longer residence time within the cove.

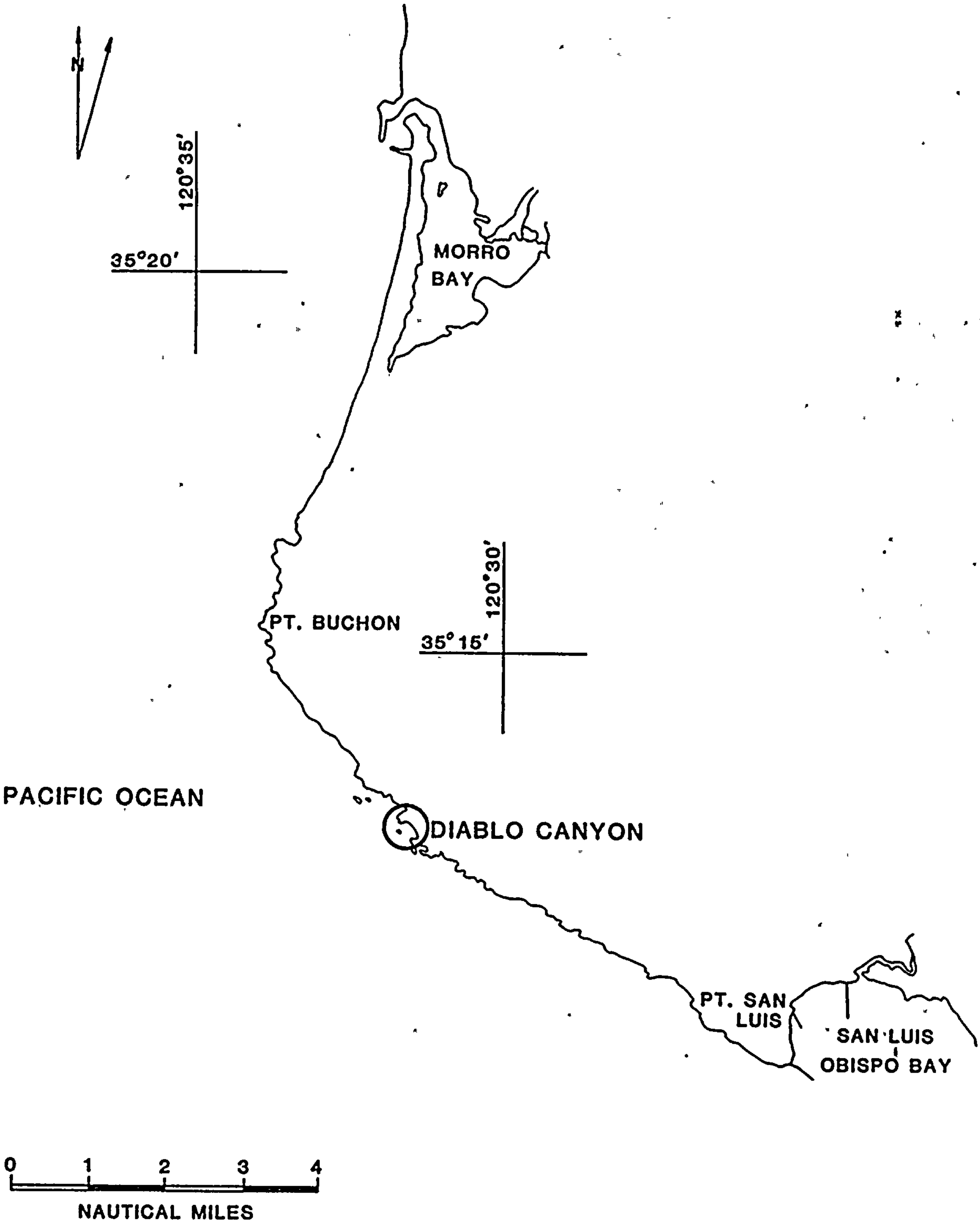
INTRODUCTION

This report presents the results of a dye tracer study conducted on June 6, 1982 at Pacific Gas and Electric's (PGandE) Diablo Canyon Nuclear Power Plant (DCPP) (Figure 1). The purpose of the study was to use dye as a tracer to simulate variations in thermal dilution and dispersion of the cooling water discharge plume during heat treatment periods. The heat treatment process is used to remove the biological fouling communities within the main condensers of the power plant. During this process, the cooling water is recirculated through the steam condensers of the unit being treated. This process reduces the unit's cooling water discharge flow to 25% (500 cfs) of normal and increases the discharge temperature to 100°F. Once a month, each of the four condensers will be heat treated for approximately one hour.

METHODS

Two separate 180 minute dye tests were conducted under two different cooling water discharge flow conditions. Test 1 was conducted from 0652 to 0952 with Unit 1 discharge flow rate was controlled to 500 cubic feet per second (the heat treatment condition). Unit 2 was at its normal discharge rate of 2000 cfs. During Test 2, conducted from 1314 to 1614, Unit 1's circulating water flow was again held at 500 cfs, and Unit 2 had no cooling water flow.

Rhodimine WT fluorescent dye solution was injected into the approach chamber of the discharge structure by a constant displacement metered



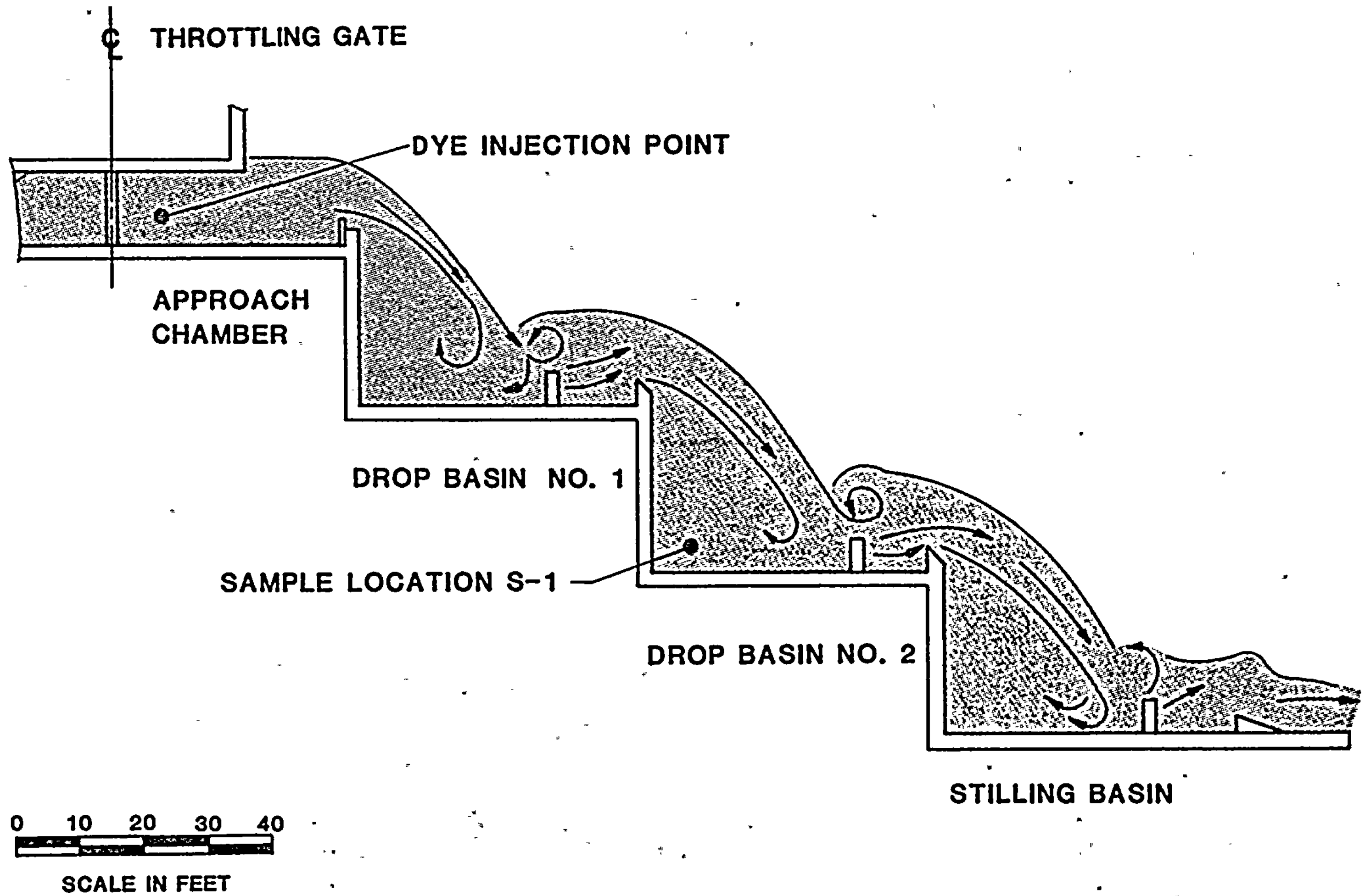
STUDY SITE

FIG.

pump. The dye solution was released in a stepwise manner in order to simulate the gradual increase of the recirculated cooling water to maximum temperature, and the corresponding return to normal operating temperatures. During the first hour of the study no dye was released for the first 20 minutes. Injection began at a rate of 8 lbs of dye per hour for the second 20 minutes, and was increased to 12 lbs/hr for the remaining 20 minutes of the hour. The dye injection rate was then increased and maintained at a rate of 15 lbs/hr for the entire 2nd hour of the test. The injection rate was then reduced for the last 60 minutes in a stepwise manner but inverse to the steps of the first hour. The method of dye release was the same for both tests.

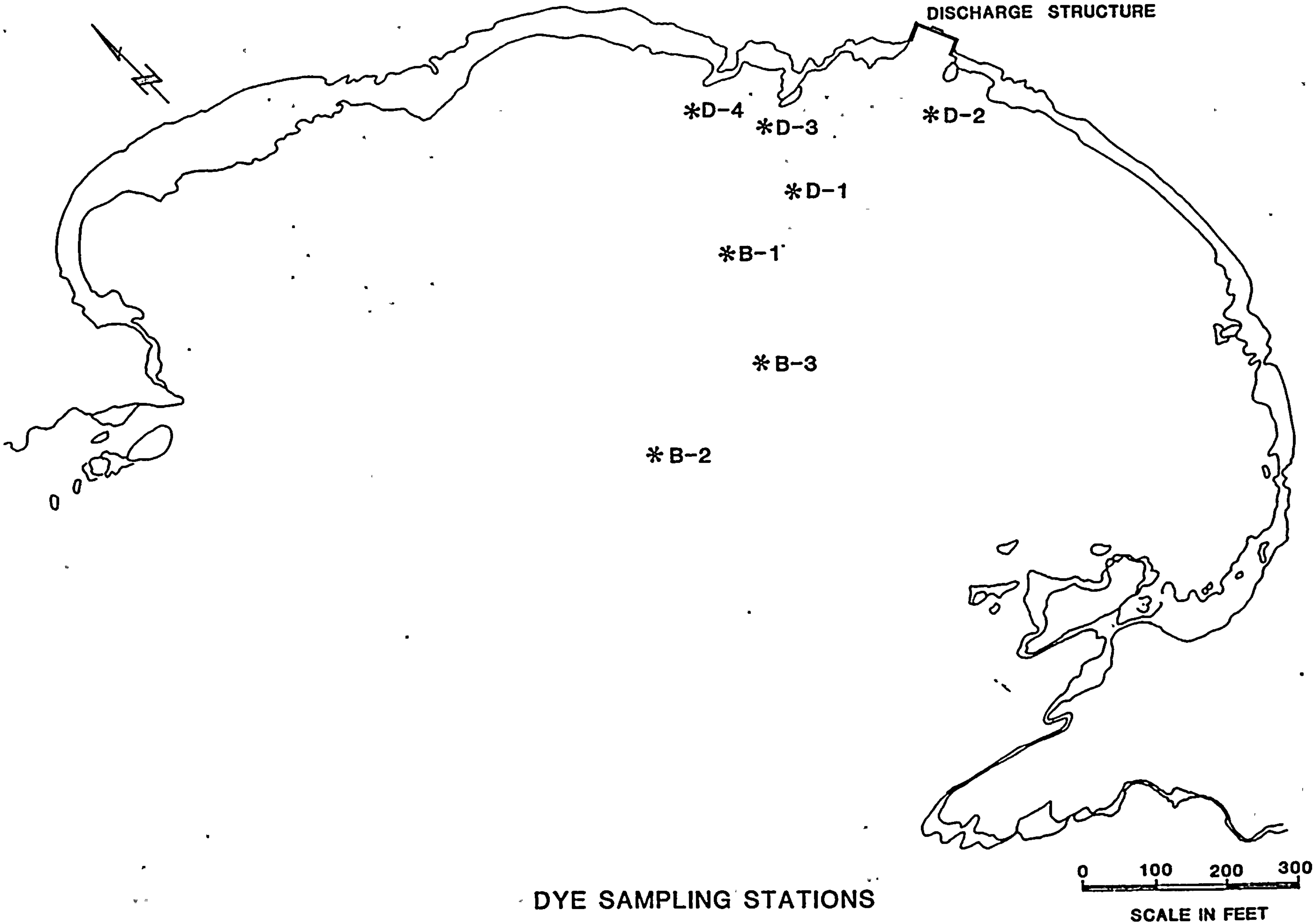
Samples designated "Discharge" were collected at the discharge structure in the No. 2 drop basin of unit number one (Figure 2). Samples were collected from a single point outlet at 5 minute intervals.

Station locations with the designation "B" (Figures 3 and 4) were sampled within Diablo Cove using a hydrocast array of Frautschy type water sampling bottles. Water samples were collected just below the surface, at mid-depth, and 0.5 meter above the bottom at 5 minute intervals. Diablo Cove sampling locations varied between tests in order to assure that samples were taken within the influence of the discharge plume. Sample locations with the designation "D" (Figures 3 and 4) were those where divers collected water samples from 1 meter below the surface at varying time intervals.



DIABLO CANYON DISCHARGE STRUCTURE

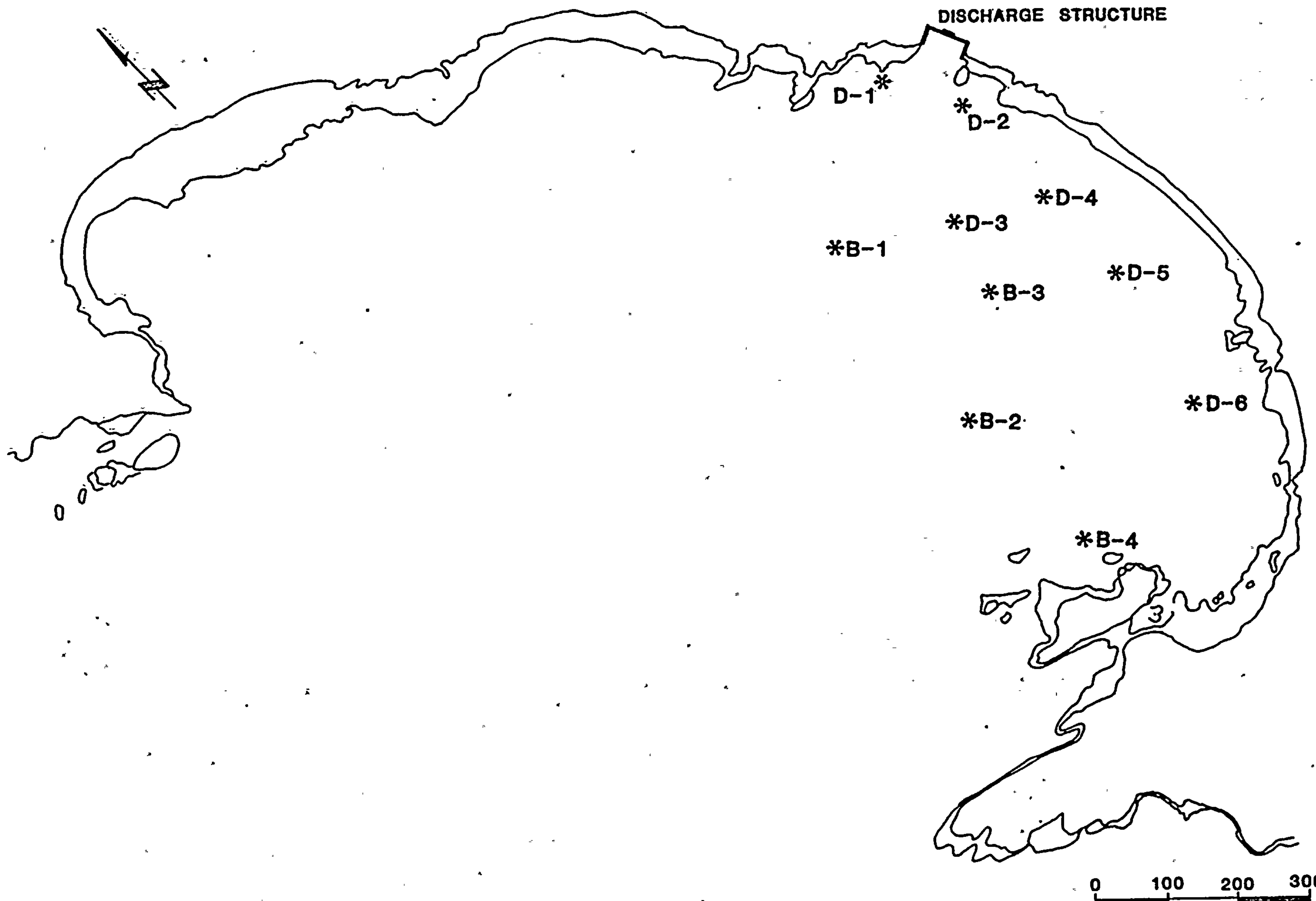
FIG. 2



DYE SAMPLING STATIONS

TEST No. 1 JUNE 6, 1982

FIG. 3



DYE SAMPLING STATIONS

TEST No. 2 JUNE 6, 1982

FIG.-4

RESULTS

A total of 564 water samples were collected and returned to the Department of Engineering Research's oceanography laboratory. Each sample was analyzed for dye concentrations levels using a Turner Designs Model 10-005 precision laboratory fluorometer. Dye data were then entered into a computer and plots of dye concentration versus time were produced (Figures 8-14 and 16-25). Where more than one depth was sampled simultaneously at a station, the dye concentrations for each depth are superimposed on a single graph.

Diablo Cove was photographed from positions on the discharge structure throughout the test. Both still photographs and videotapes were made to record the surface configuration of the dye plumes, to document sampling stations, and to provide a permanent visual record of the tests. These photographs and tapes are archived at PGandE's Engineering Research Center in San Ramon, California. No aerial photographs of the dye plumes were taken due to the possibility of the aircraft disturbing a peregrine falcon nesting site on Diablo Rock. Peregrine falcons are a designated endangered species by State and Federal agencies.

Current velocities within the discharge plume were measured using two Marsh-McBirney Model 501 Electro-magnetic current meters. The current meters were deployed at Station B-2 for both tests (Figures 3 and 4). The currents were monitored at two-tenths and eight-tenths of the station depth. Results of velocity measurements are presented in Appendix A, Figure 1.

Wind speed and direction values were obtained from the on-site meteorological monitoring station. This data is summarized in the form of wind roses in Appendix A, Figure 2. Tide datum was derived from the NOS 1982 Predicted Tide Tables (Appendix A, Figure 3).

DISCUSSION

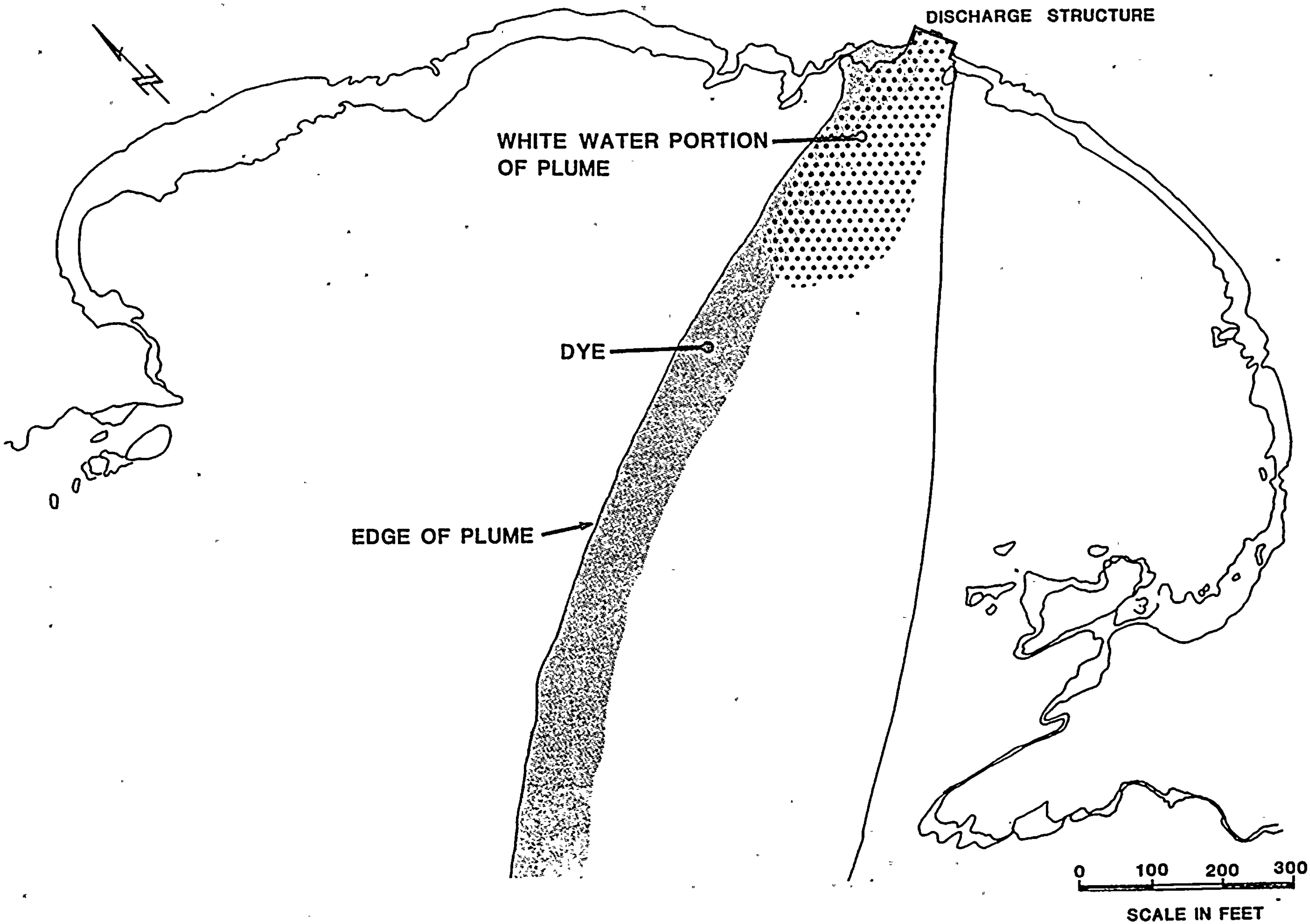
Plume Configuration

The discharge plume configuration varied distinctly between the 2500 cfs, and 500 cfs flow conditions of the dye tracer simulation study. The illustrations (Figures 5 and 6) of the discharge plume, white water area, and dye patterns, were developed from on-site visual perspectives as well as 35 mm camera photographs taken from the discharge structure.

Test 1 - 2500 cfs Flow

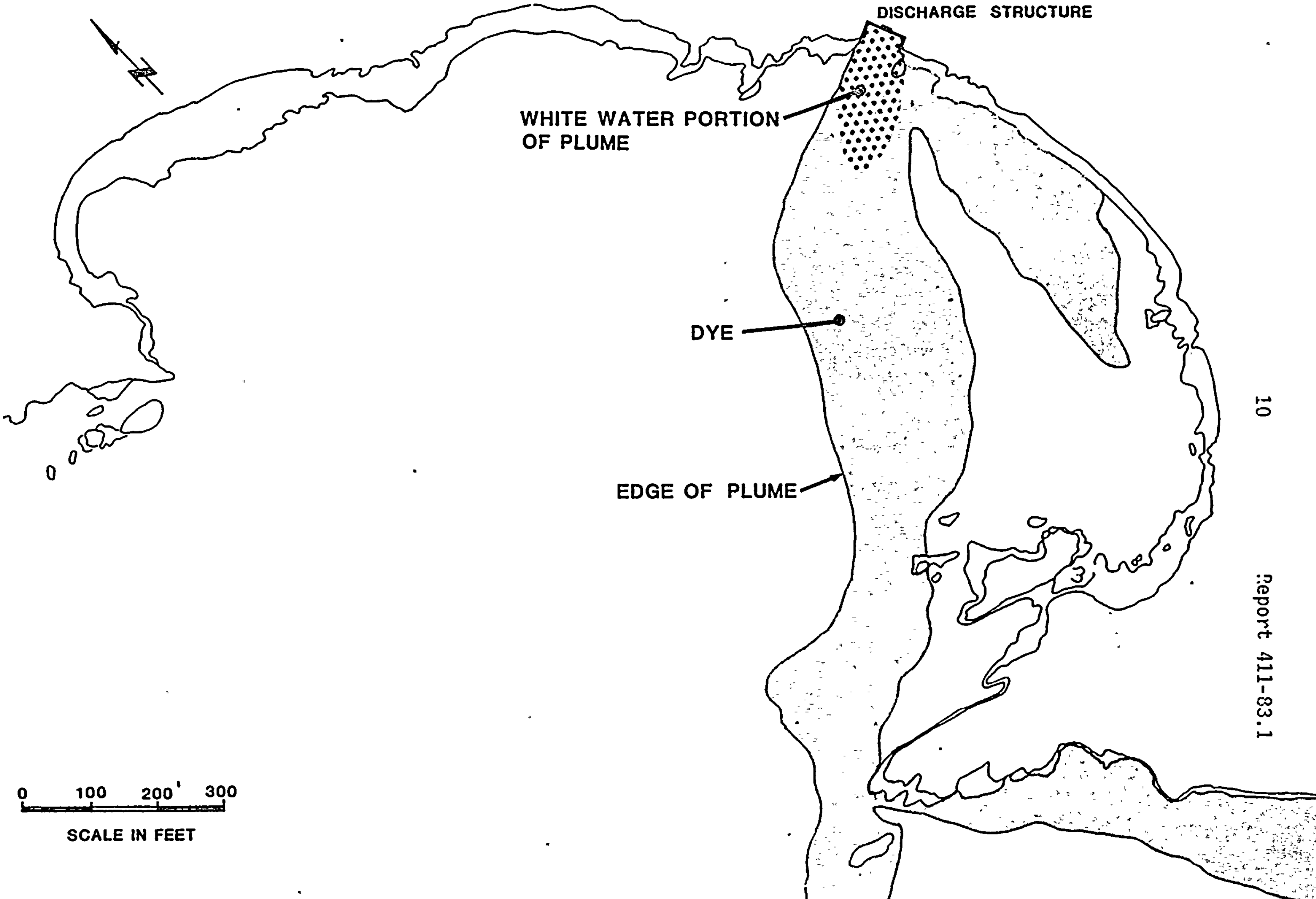
During Test 1 the Rhodamine WT tracer dye was concentrated on the north side of the discharge effluent (Figure 5). This tracer dye "strip" was approximately a 10 meter wide section of the overall plume. As the effluent continued to move through the center of the cove, the dye remained on the plumes outer edge, until it was out of Diable Cove, where it then began to disperse. Very little of the highly visable dye remained within the cove after the dye injection ended.

Current velocities recorded at station B-2 during Test 1 (Appendix A) were fairly constant throughout the test. Surface velocity remained between 0.9 to 1.1 feet per second (fps) moving west, while the mid depth currents varied from 0.5 to 1.3 fps.



PLUME CONFIGURATION FOR TEST 1 JUNE 6, 1982

FIG. 5



PLUME CONFIGURATION FOR TEST 2 JUNE 6, 1982

FIG. 6

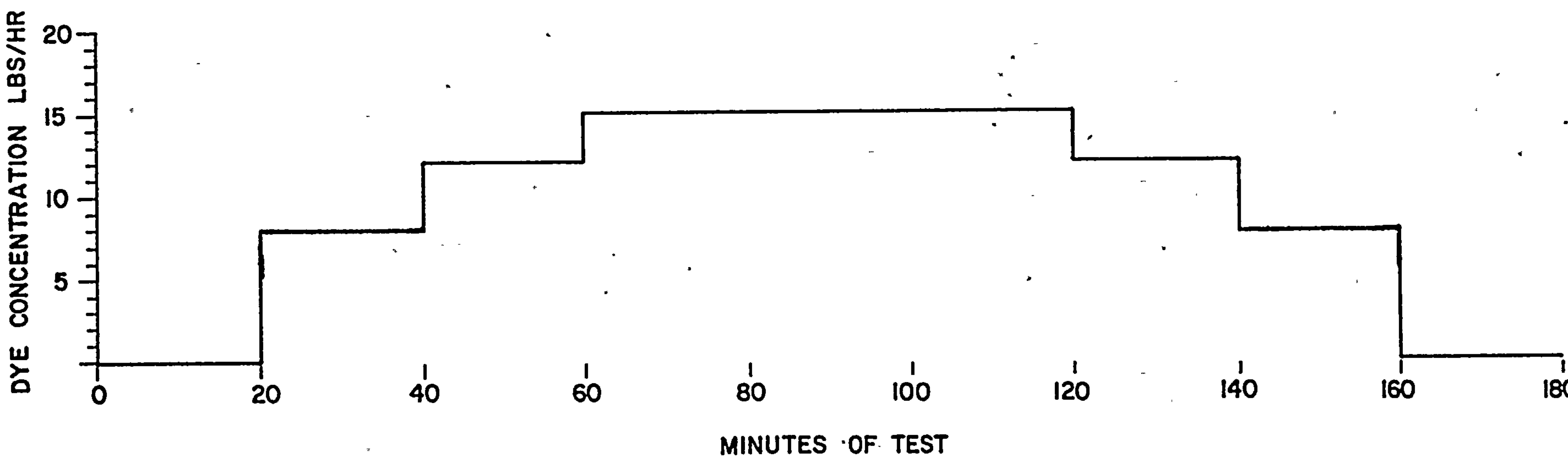
Test 2 - 500 cfs Flow

During Test 2 in which Unit 1 discharge flow was 500 cfs and Unit 2 had no circulating water flow, the plume configuration was considerably different than that of Test 1 (Figure 6). During Test 2 the tracer dye was concentrated within the southeastern portion of Diablo Cove. Most of the dye moved slowly across the southeastern portion of Diablo Cove until it came in contact with the shoreline, where it continued along near the shoreline as it moved out of the cove. A considerable amount of dye remained within Diablo Cove just south of the point of discharge, after the dye injection was concluded.

The measured velocities were stronger and more stable near the surface than near the bottom where the current velocities were more variable (see Appendix A, Figure A-2). Current direction was also variable, but with a trend toward the southwest.

Dye Concentrations

A total of 297 and 267 water samples were taken during Tests 1 and 2, respectively, for determination of dye concentrations throughout Diablo Cove. During Test 1, with a combined flow of 2500 CFS from Units 1 and 2, there were wide variations in dye concentrations between the stations (Figures 7 through 14). Stations B-1 and B-3, which were on the edge of the dye concentration strip, showed lower overall dye concentration levels than Station B-2, which was located within the dye strip. The analysis of the data from Stations D-2 and D-3 indicated the same results, that the



DIABLO CANYON TEST NO. 1 FLOW: 2500 FT^3/SEC

JUNE 6, 1982 0652-0952

(UNIT 1 500 FT^3/SEC)

(UNIT 2 2000 FT^3/SEC)

FIG. 7

TEST 1 DISCHARGE

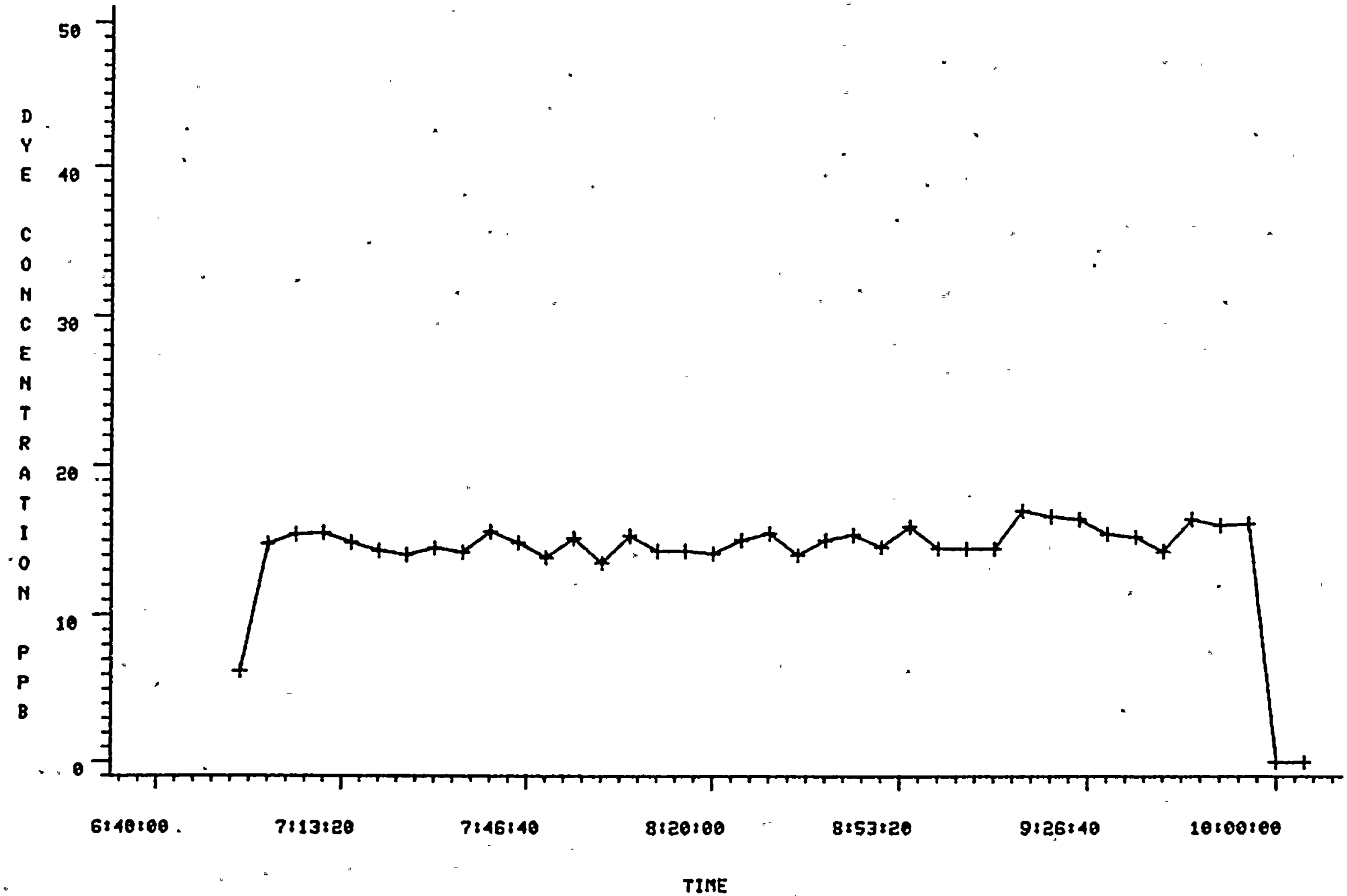
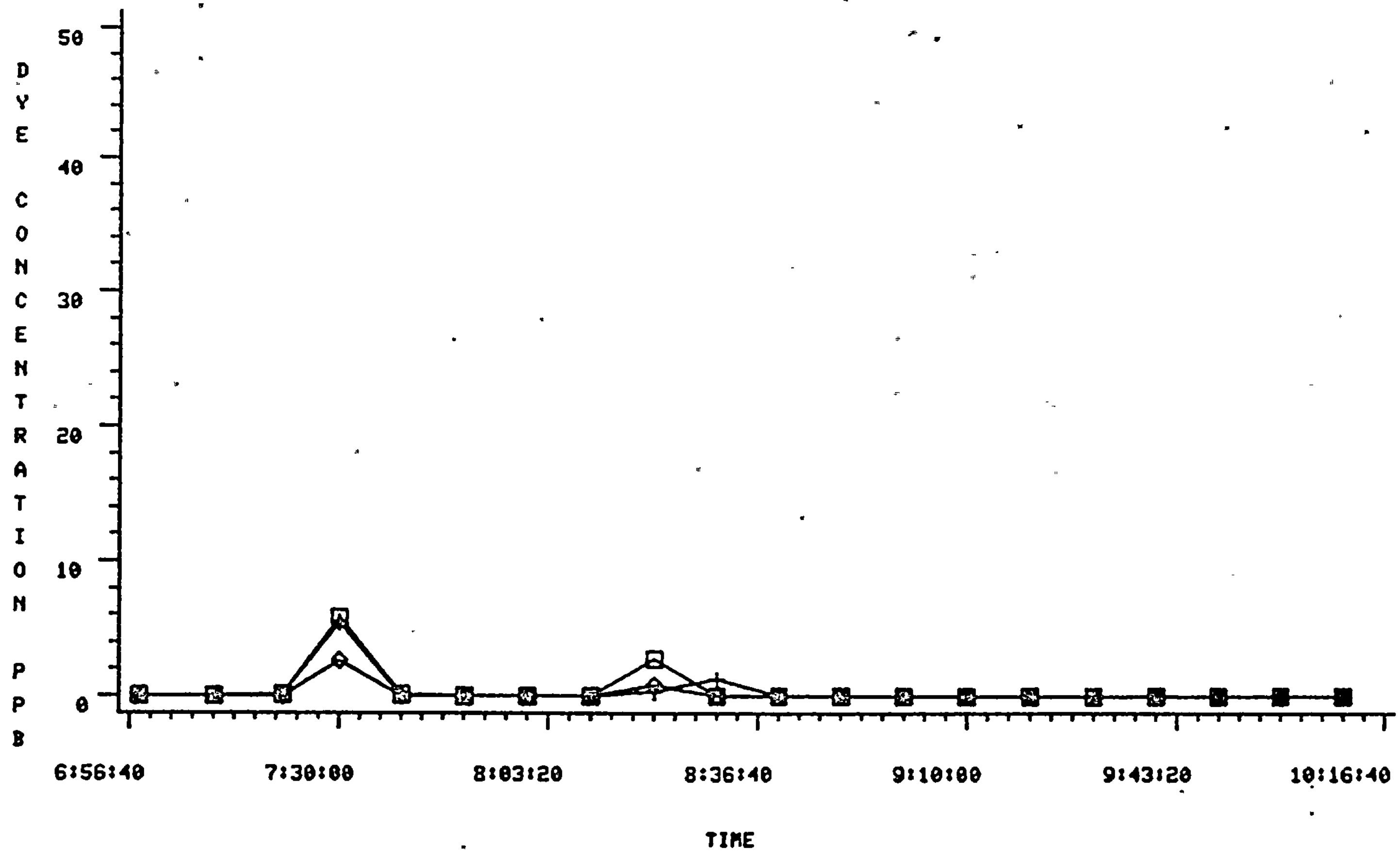


FIG. 8

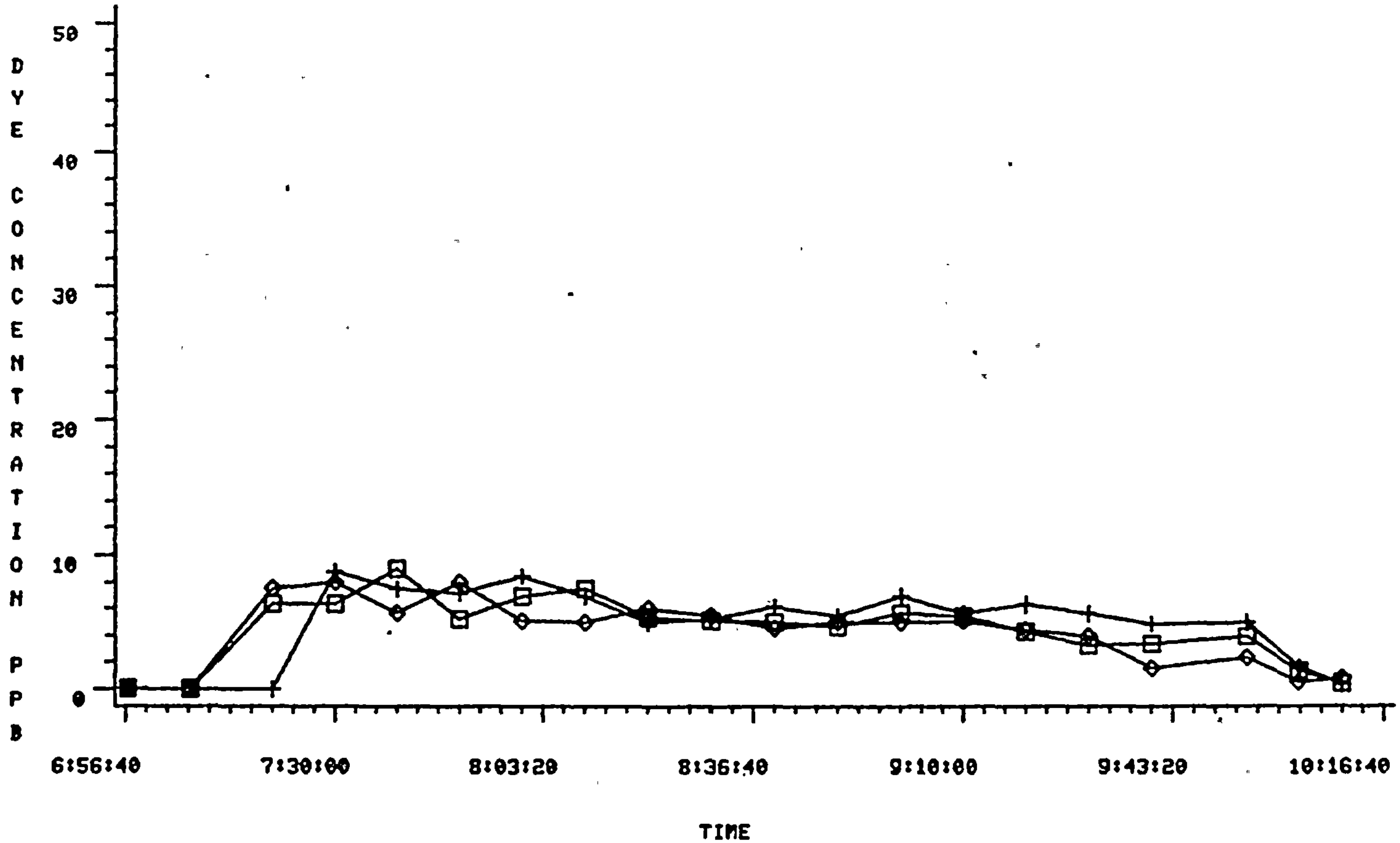
TEST 1 B-1



PLUS= TOP READINGS
SQUARE= MIDDLE READINGS
DIAMOND= BOTTOM READINGS

FIG. 9

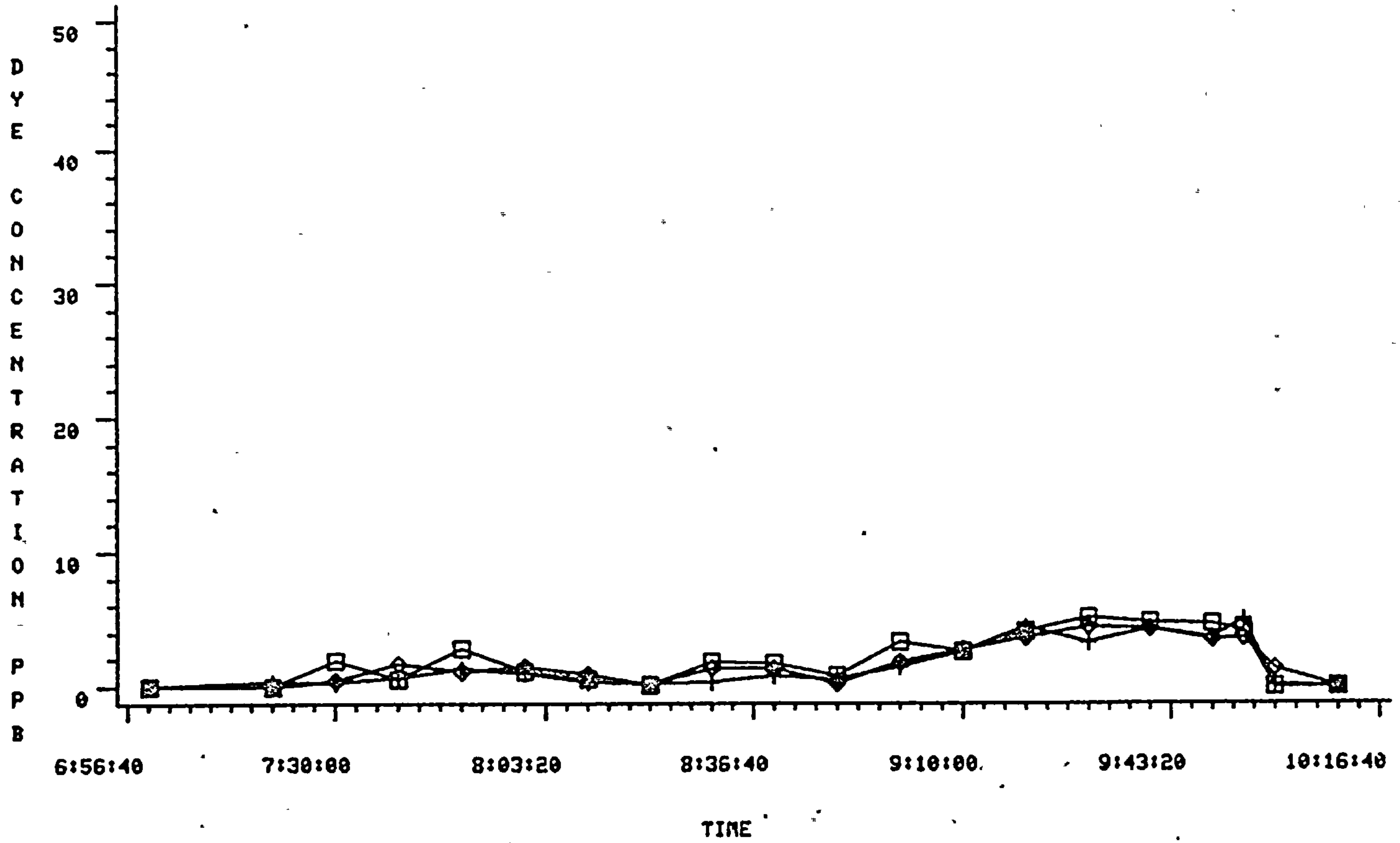
TEST 1 B-2



PLUS= TOP READINGS
SQUARE= MIDDLE READINGS
DIAMOND= BOTTOM READINGS

FIG. 10

TEST 1 B-3



PLUS= TOP READINGS
SQUARE= MIDDLE READINGS
DIAMOND= BOTTOM READINGS

FIG. 11

TEST 1 D-1

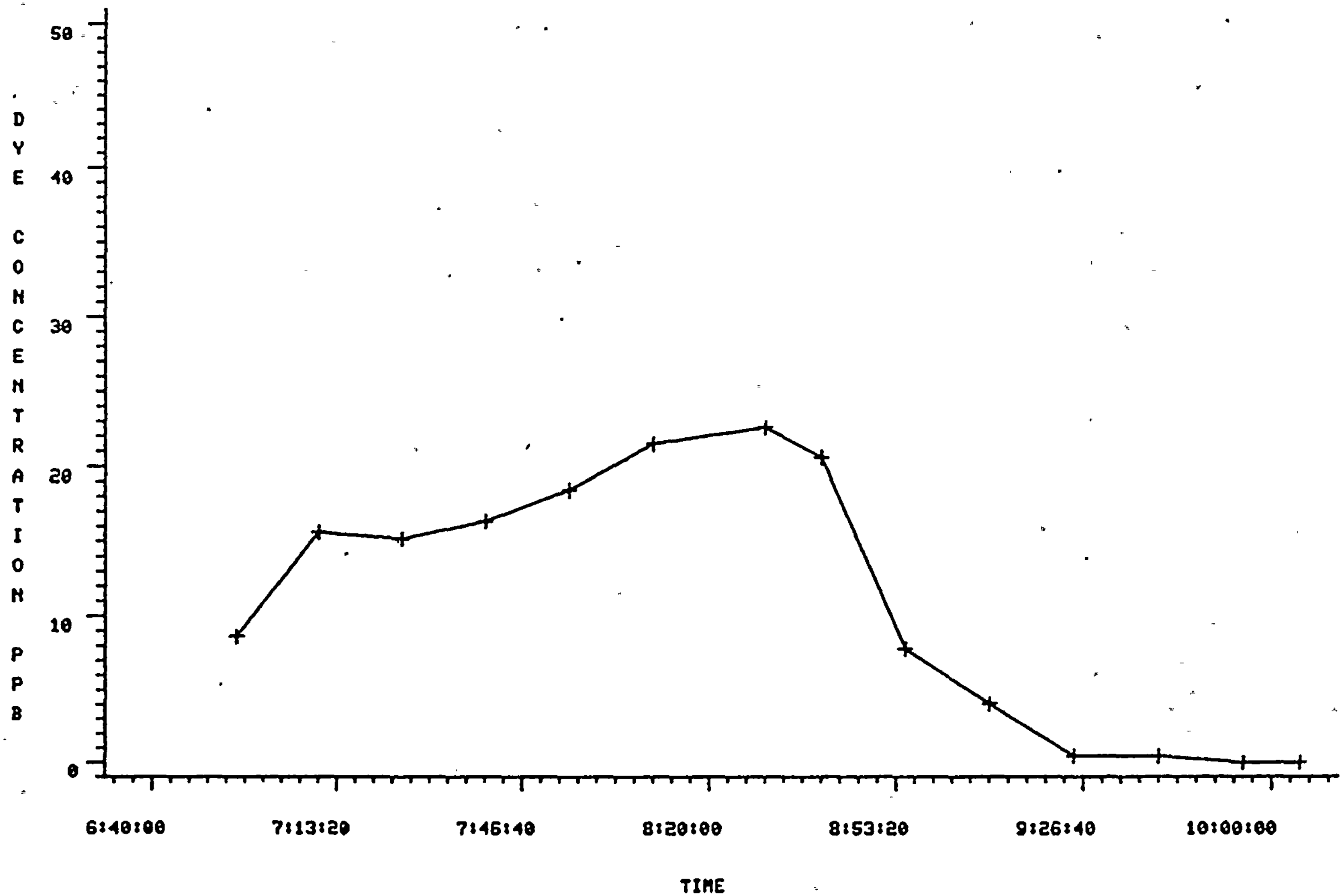


FIG. 12

TEST 1 D-2

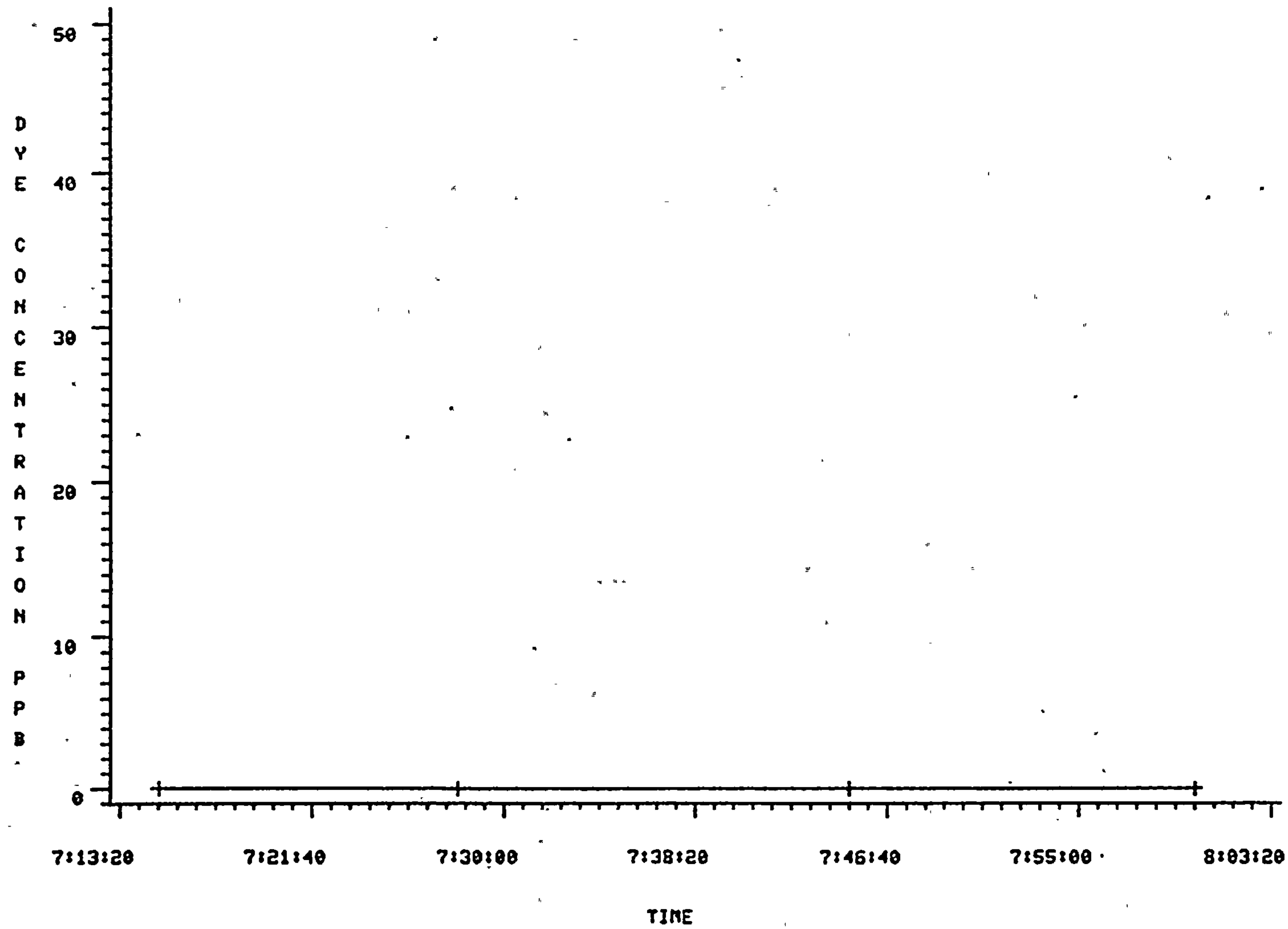


FIG. 13

TEST 1 D-3

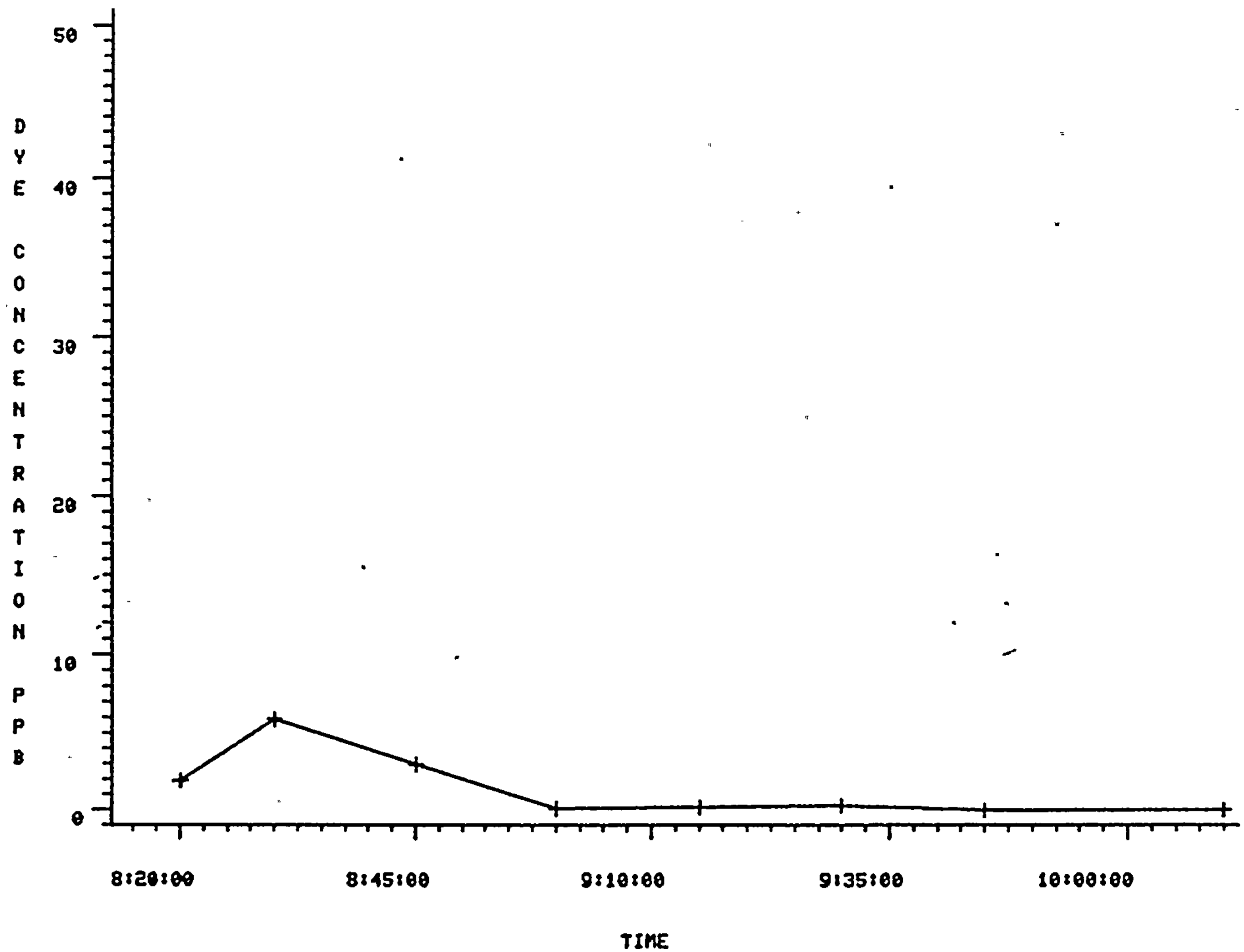
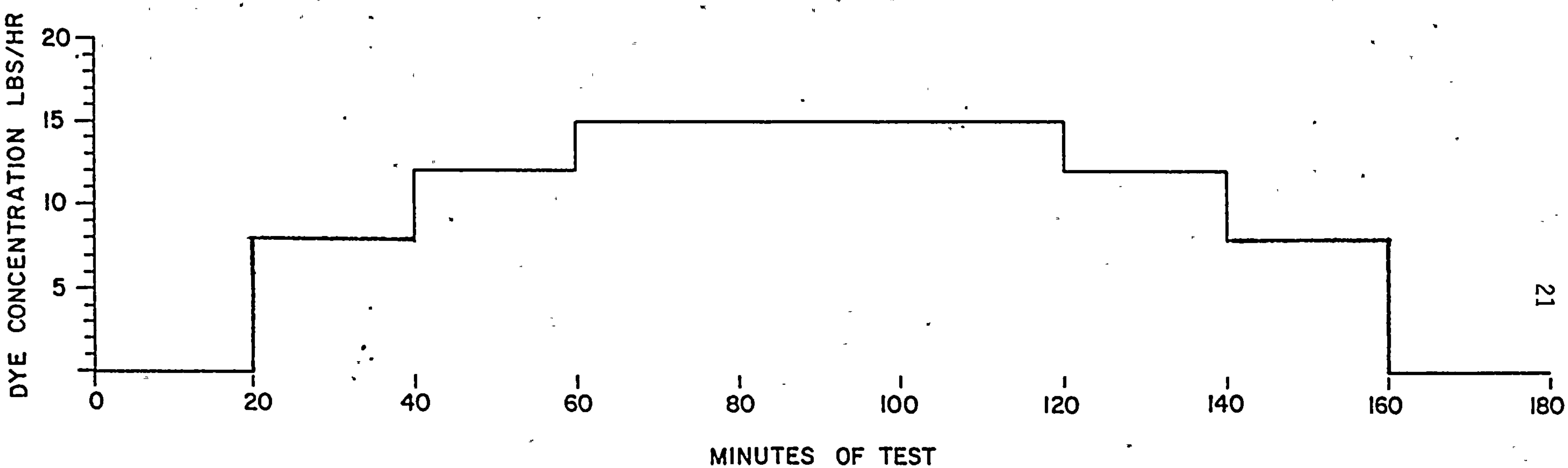


FIG. 14

majority of the dye moved out of the cove in a narrow tract, and did not mix appreciably with the main portion of the discharge plume within the cove.

The results from Test 2 (500 cfs) showed higher levels of Rhodamine WT dye within Diablo Cove (Figures 15 through 25). All "B" stations showed high concentrations of the tracer dye, with Station B-3 recording the highest level among the "B" Stations (Figure 19). Stations D-2 and D-3 exhibited the highest levels measured during the study (Figures 22 and 23, respectively). These levels were higher than the levels recorded at the discharge sampling station, (Figure 16). This indicates that the dye was accumulating just south of the point of discharge.



DIABLO CANYON TEST No. 2

JUNE 6, 1982 1314–1614

FLOW: 500 FT^3/SEC
(UNIT 1 500 FT^3/SEC)
(UNIT 2 0 FT^3/SEC)

FIG. 15

TEST 2 DISCHARGE STRUCTURE

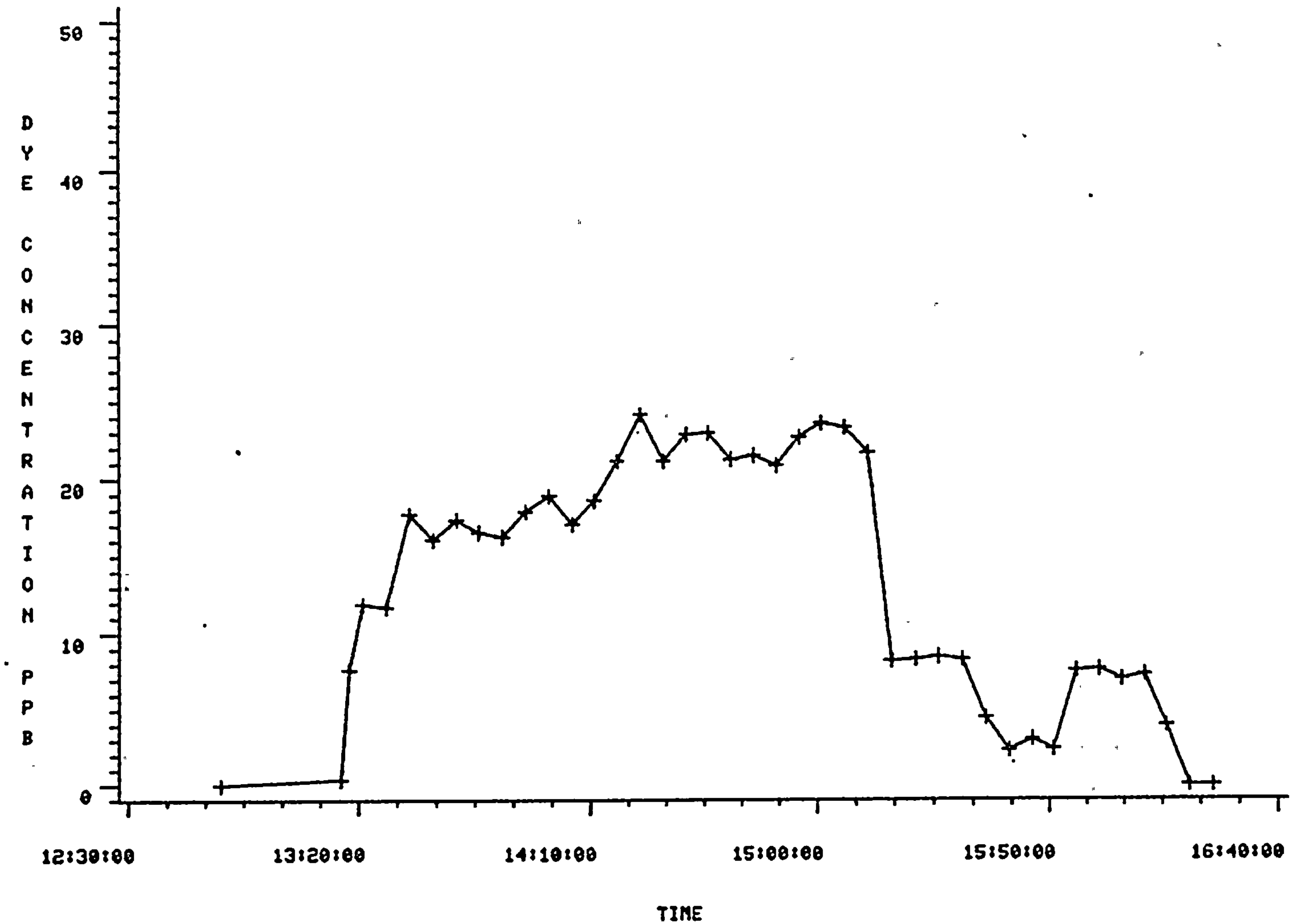
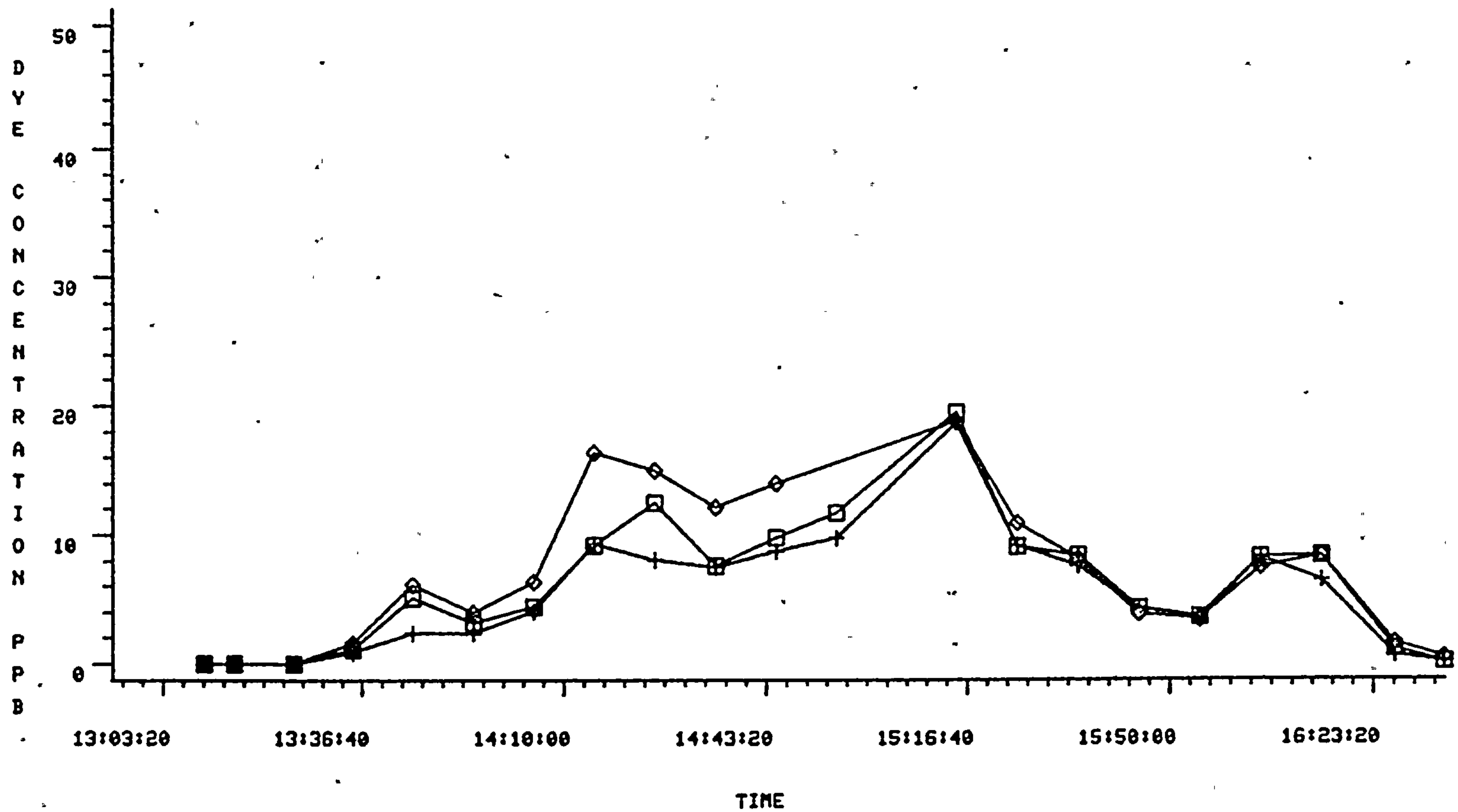


FIG. 16

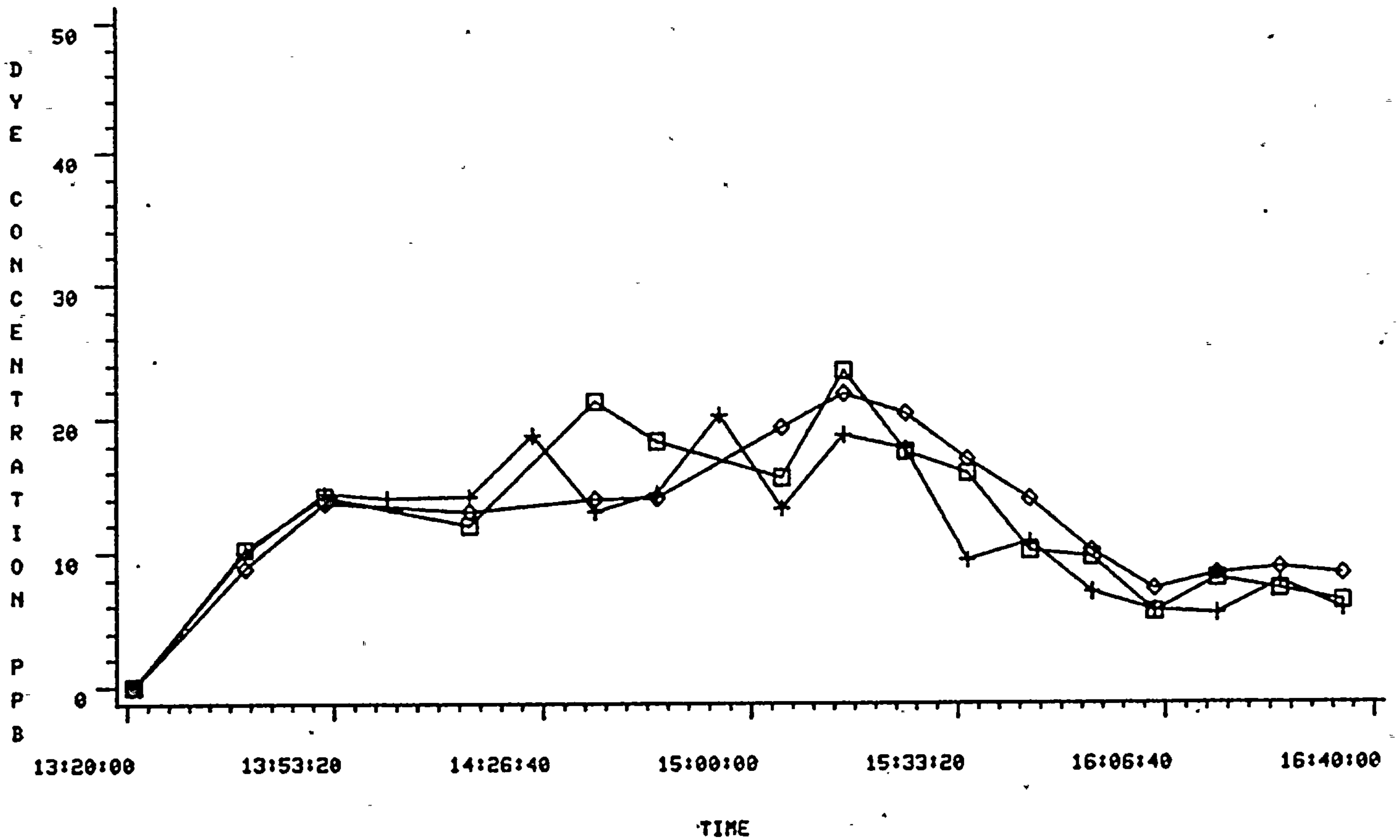
TEST 2 B-1



PLUS= TOP READINGS
SQUARE= MIDDLE READINGS
DIAMOND= BOTTOM READINGS

FIG. 17

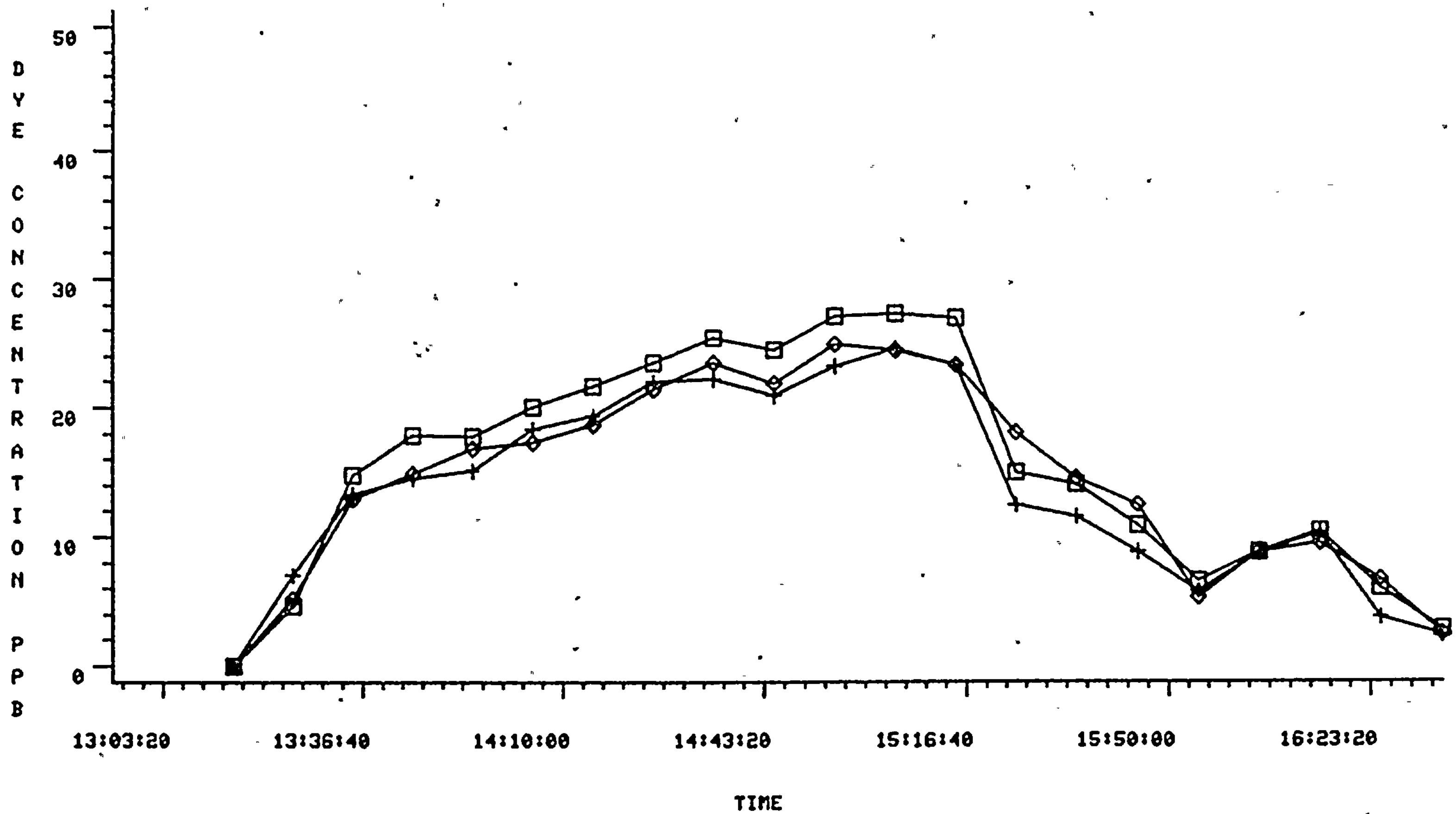
TEST 2 B-2



PLUS= TOP READINGS
SQUARE= MIDDLE READINGS
DIAMOND= BOTTOM READINGS

FIG. 18

TEST 2 B-3



PLUS= TOP READINGS
SQUARE= MIDDLE READINGS
DIAMOND= BOTTOM READINGS

FIG. 19

TEST 2 B-4

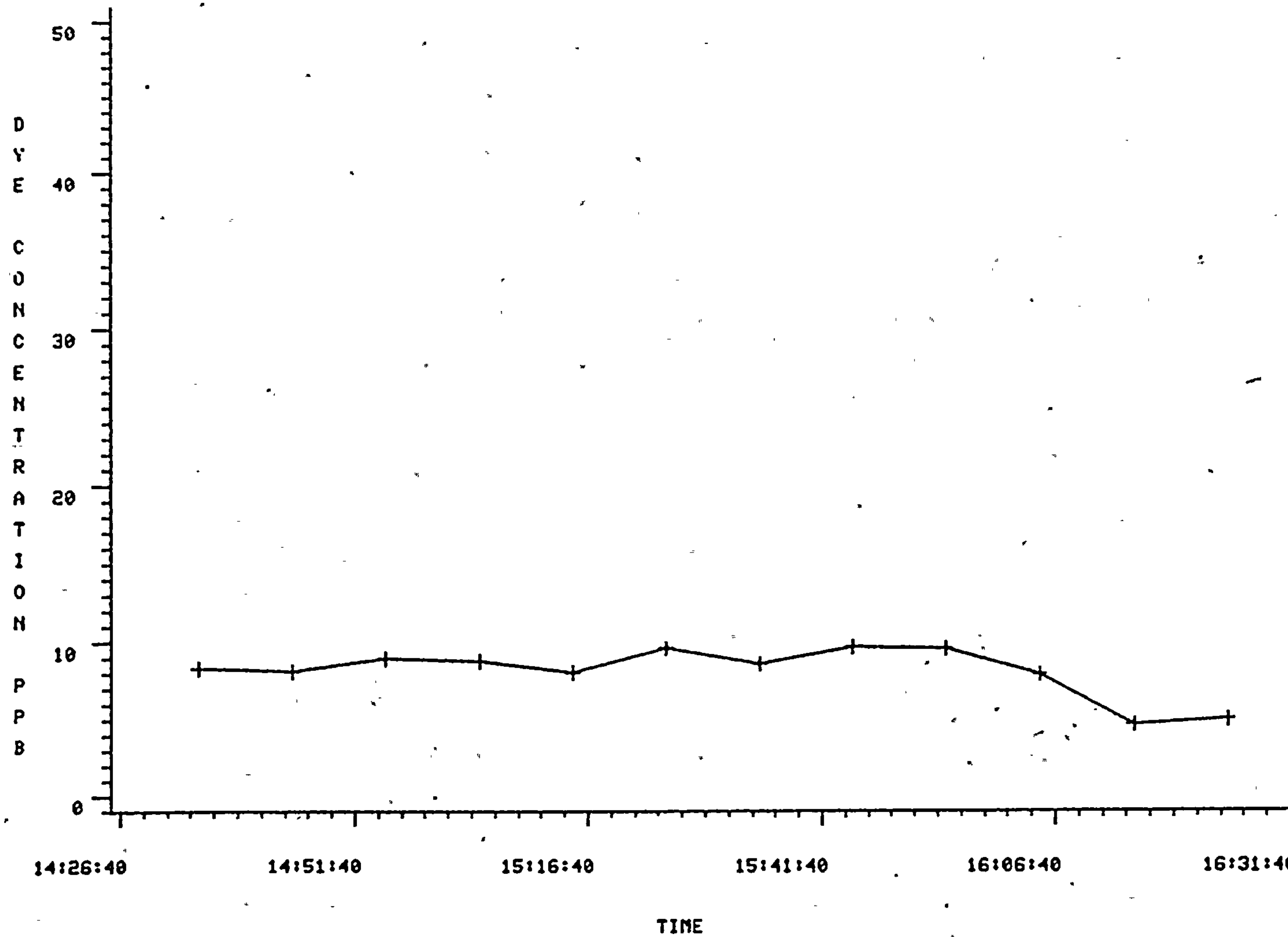


FIG. 20

TEST 2 D-1

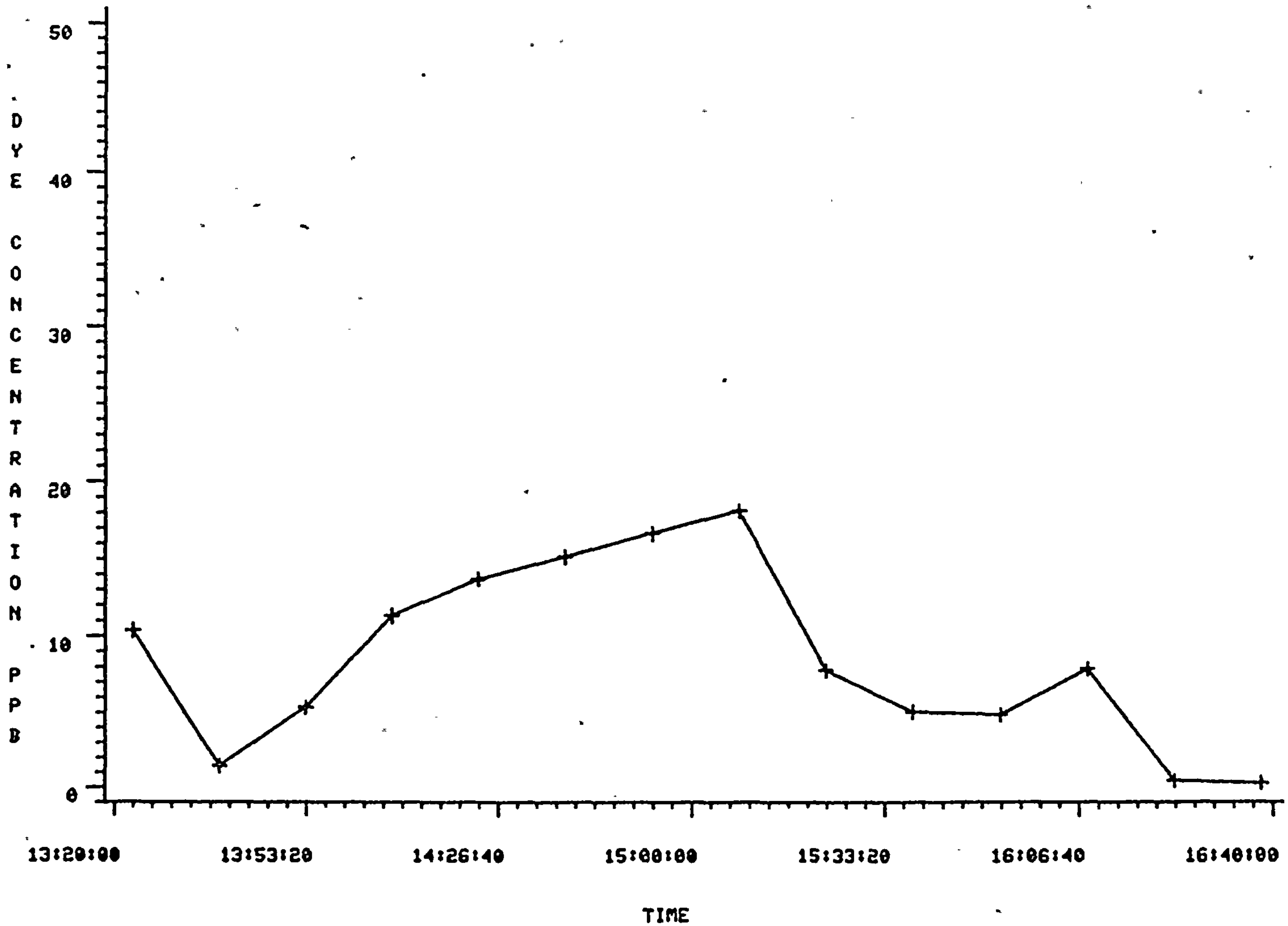


FIG. 21

TEST 2 D-2

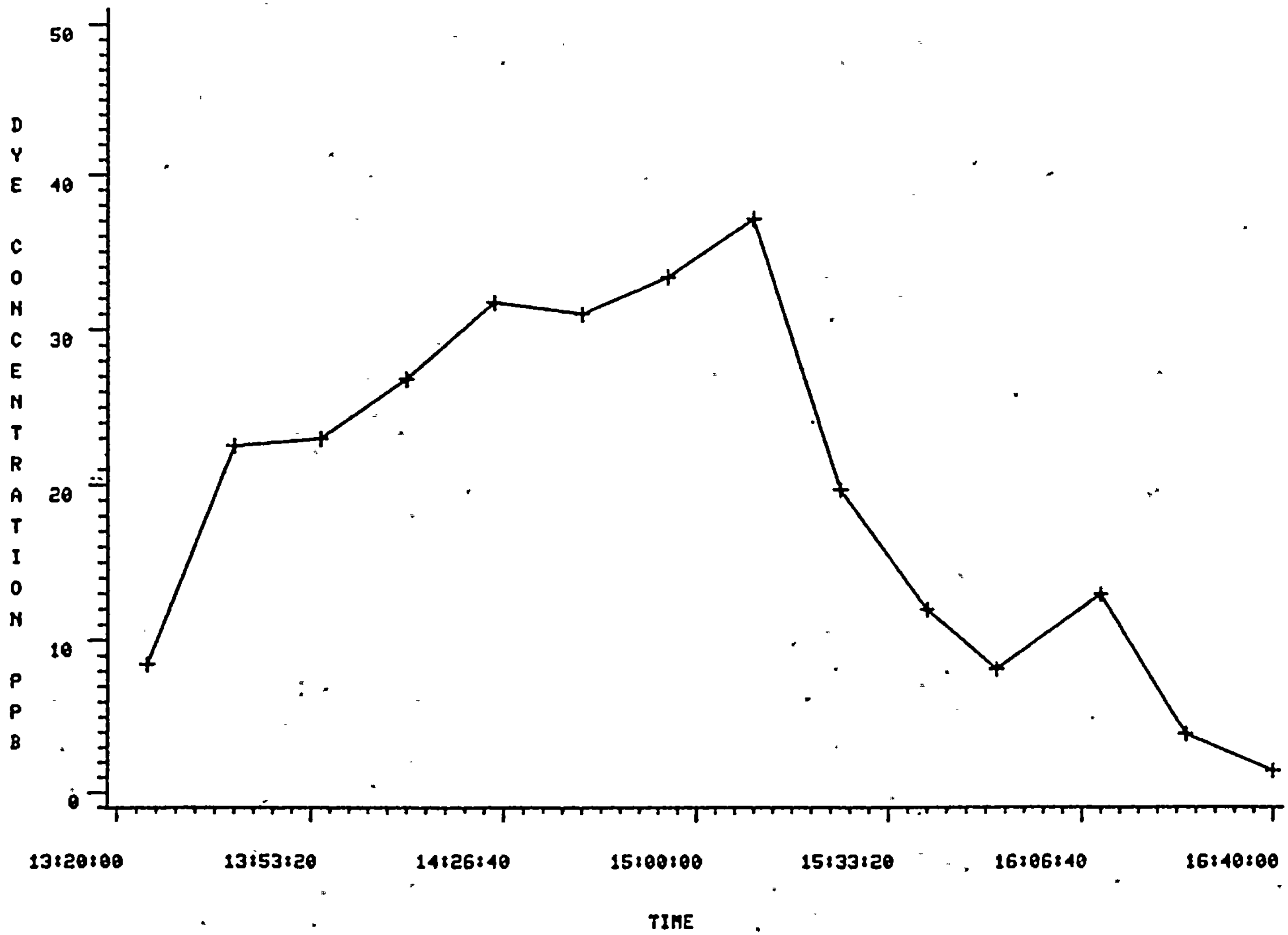


FIG. 22

TEST 2 D-4

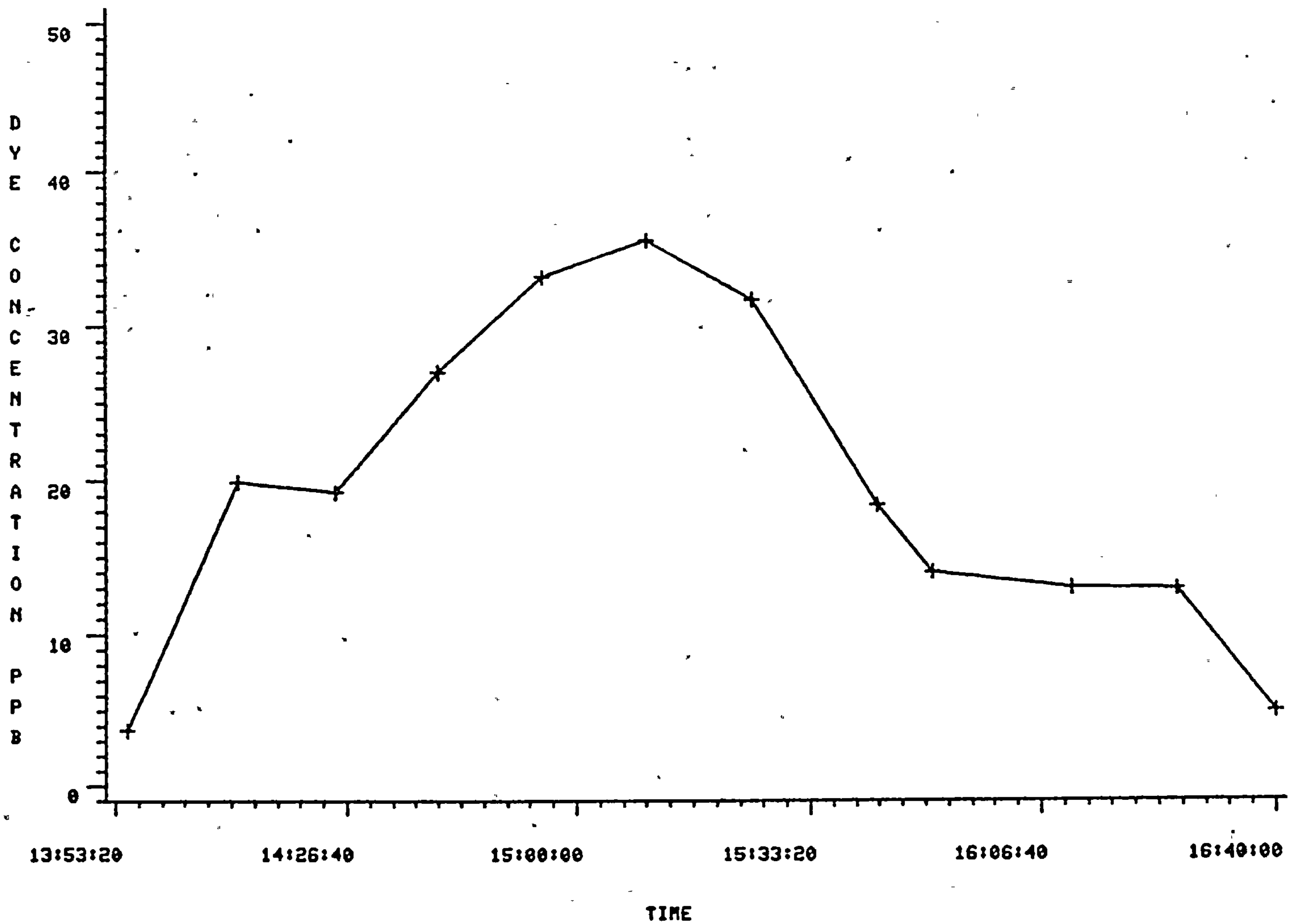
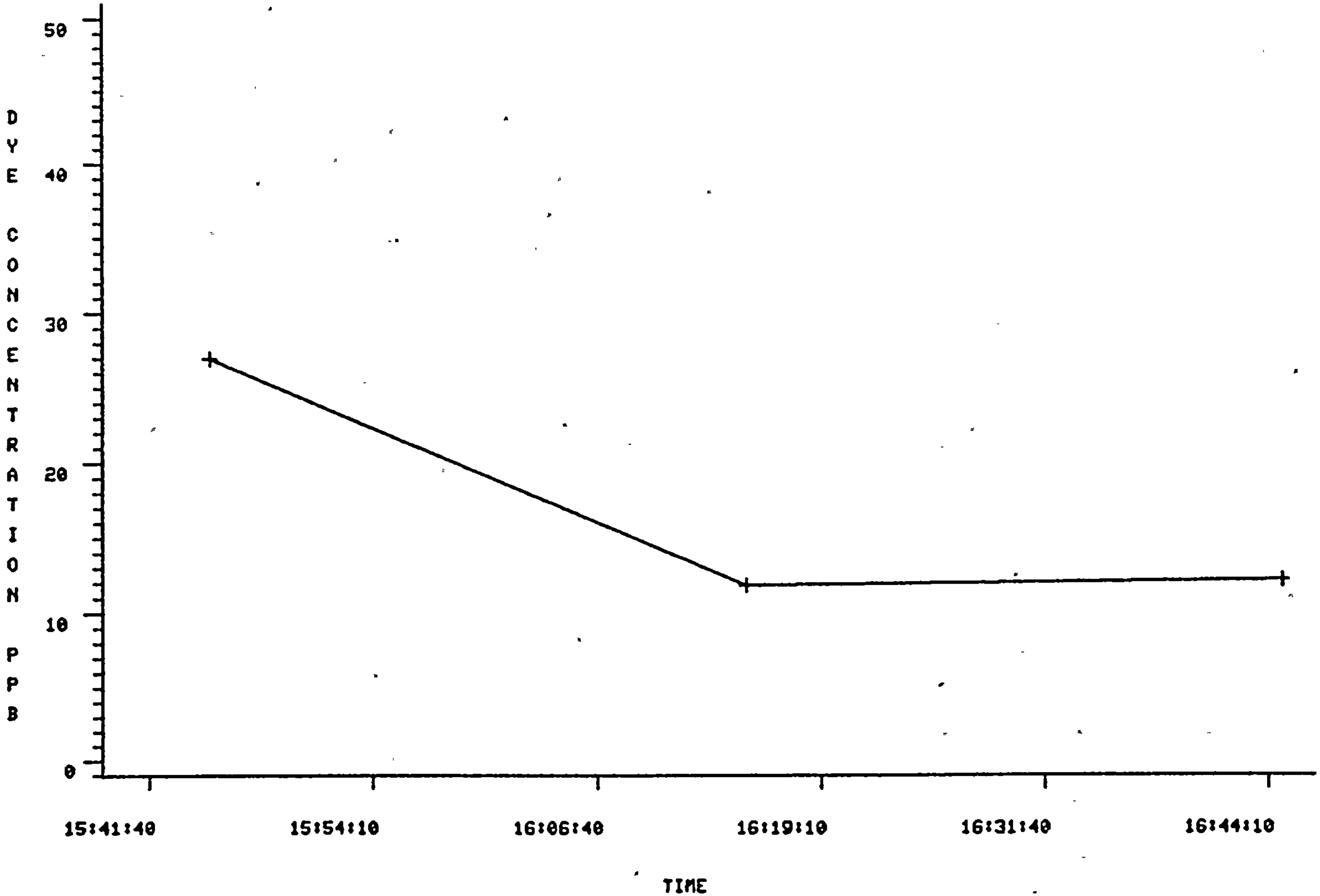


FIG. 23

TEST 2 D-5



Report 411-83.1

FIG. 24

TEST 2 D-6

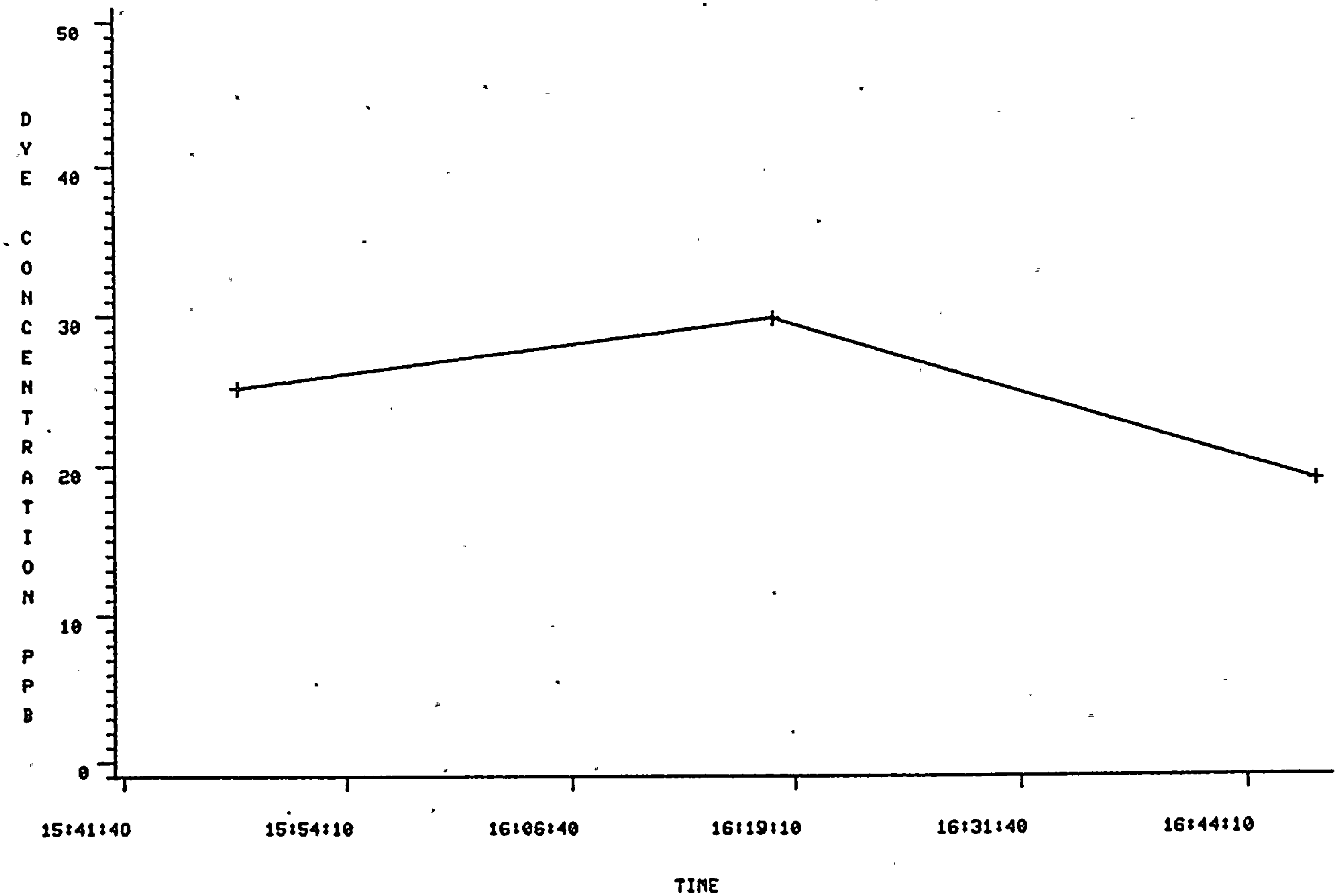


FIG. 25

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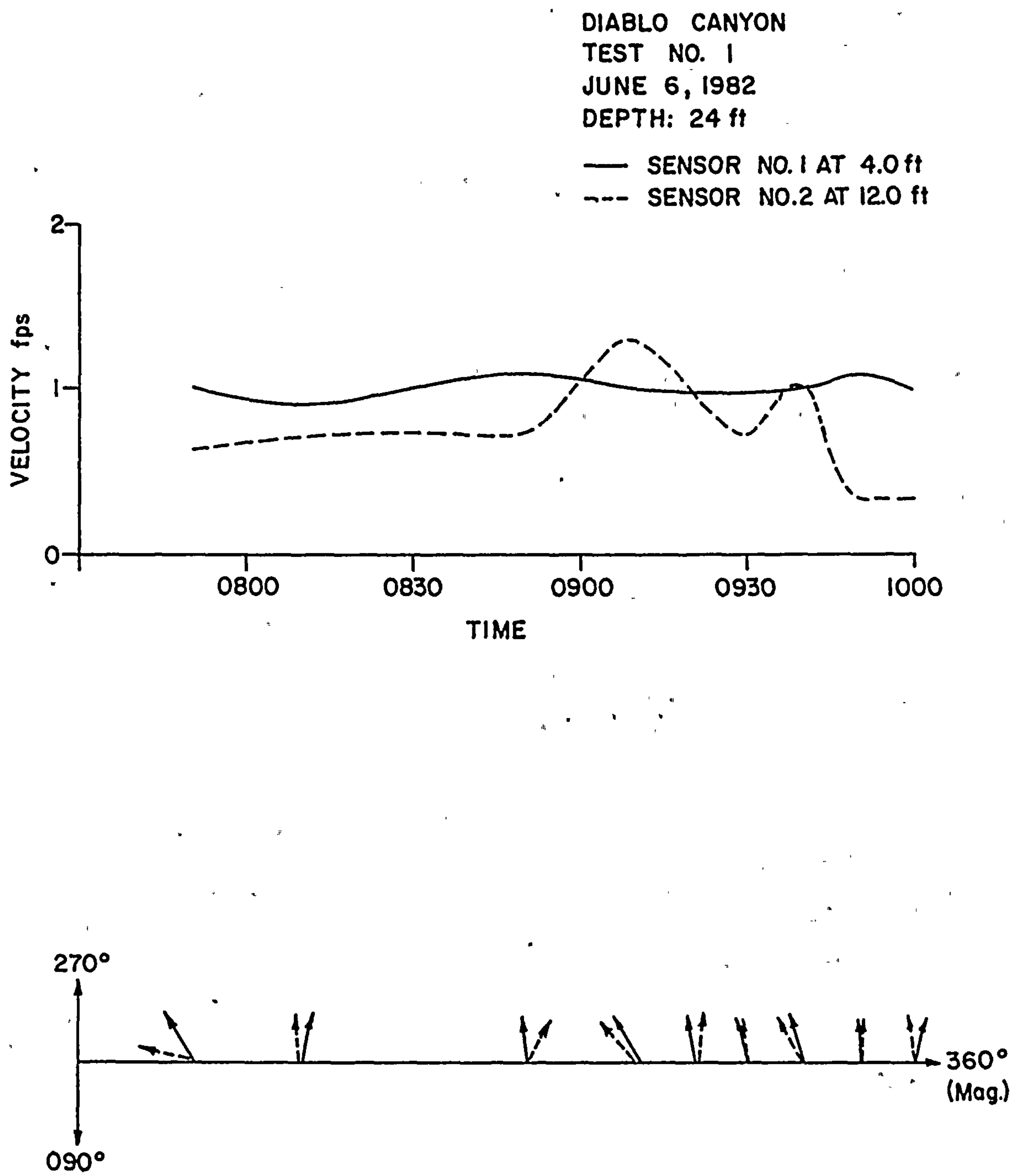
Cobb, E. D and J. F. Bailey "Measurement of Discharge by Dye-Dilution Methods" Surface Water Techniques, USGS, 1965.

"Fluormetric Facts, Flow Measurements" Turner Designs, 76

"Tide Tables 1982, NOAA, Nos.

Tera Corporation, "Thermal Discharge Assessment Report, Diablo Canyon Power Plant." 1982

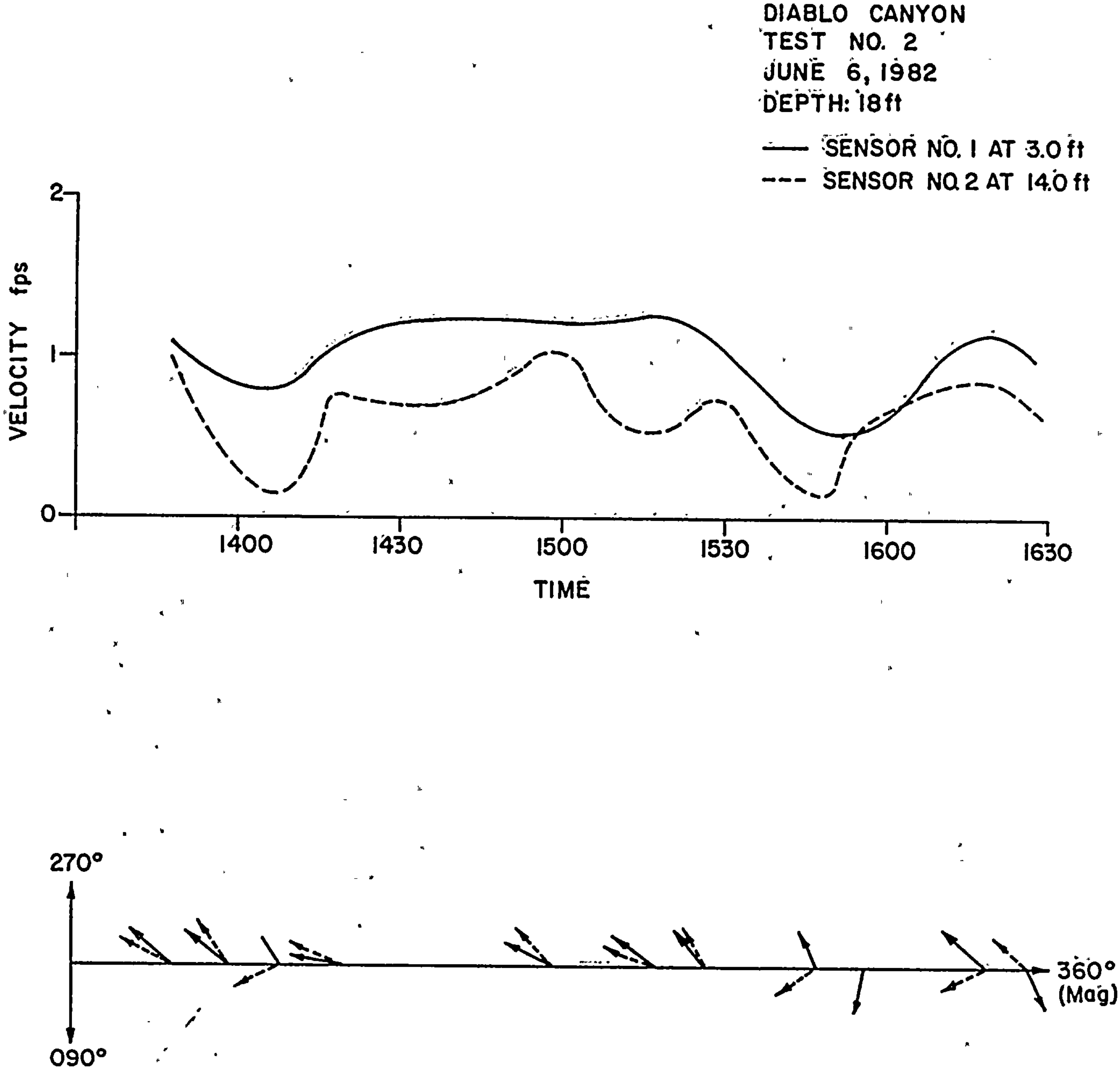
APPENDIX A



DIABLO COVE CURRENTS

SAMPLING LOCATION B-2

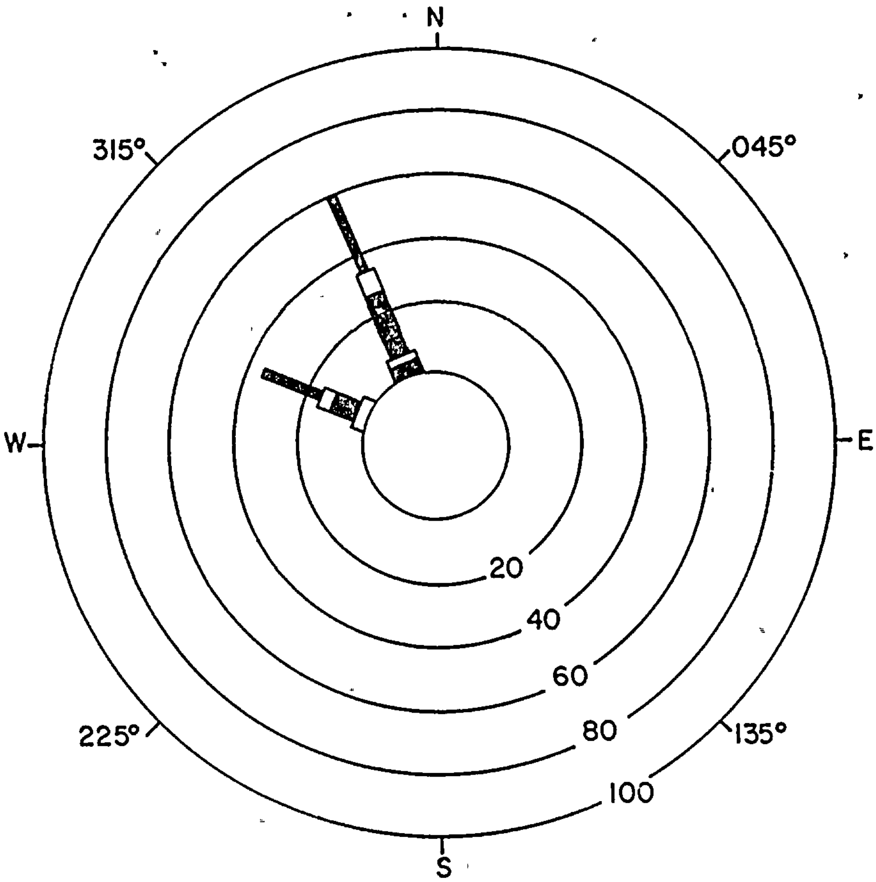
FIG. A-1



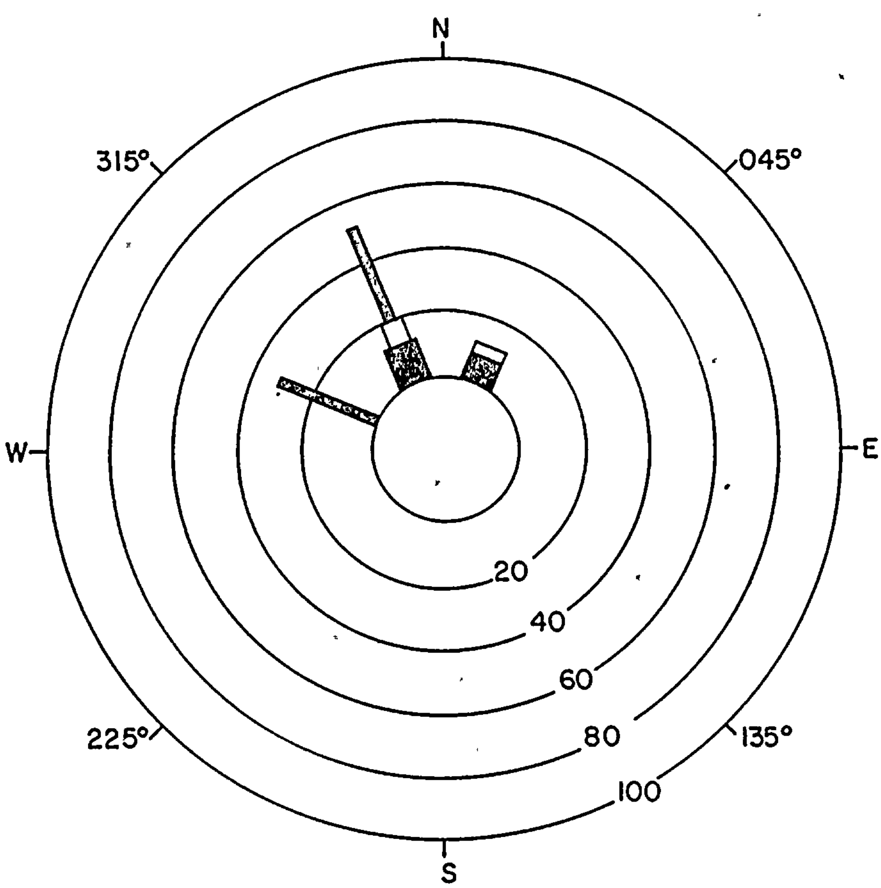
DIABLO COVE CURRENTS

SAMPLING LOCATION B-2

FIG. A-2



WIND ROSE FOR JUNE 5, 1982



WIND ROSE FOR JUNE 6, 1982

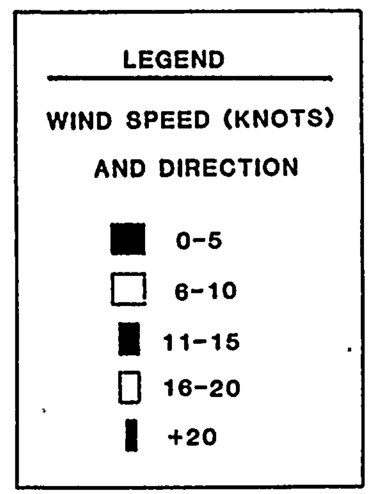
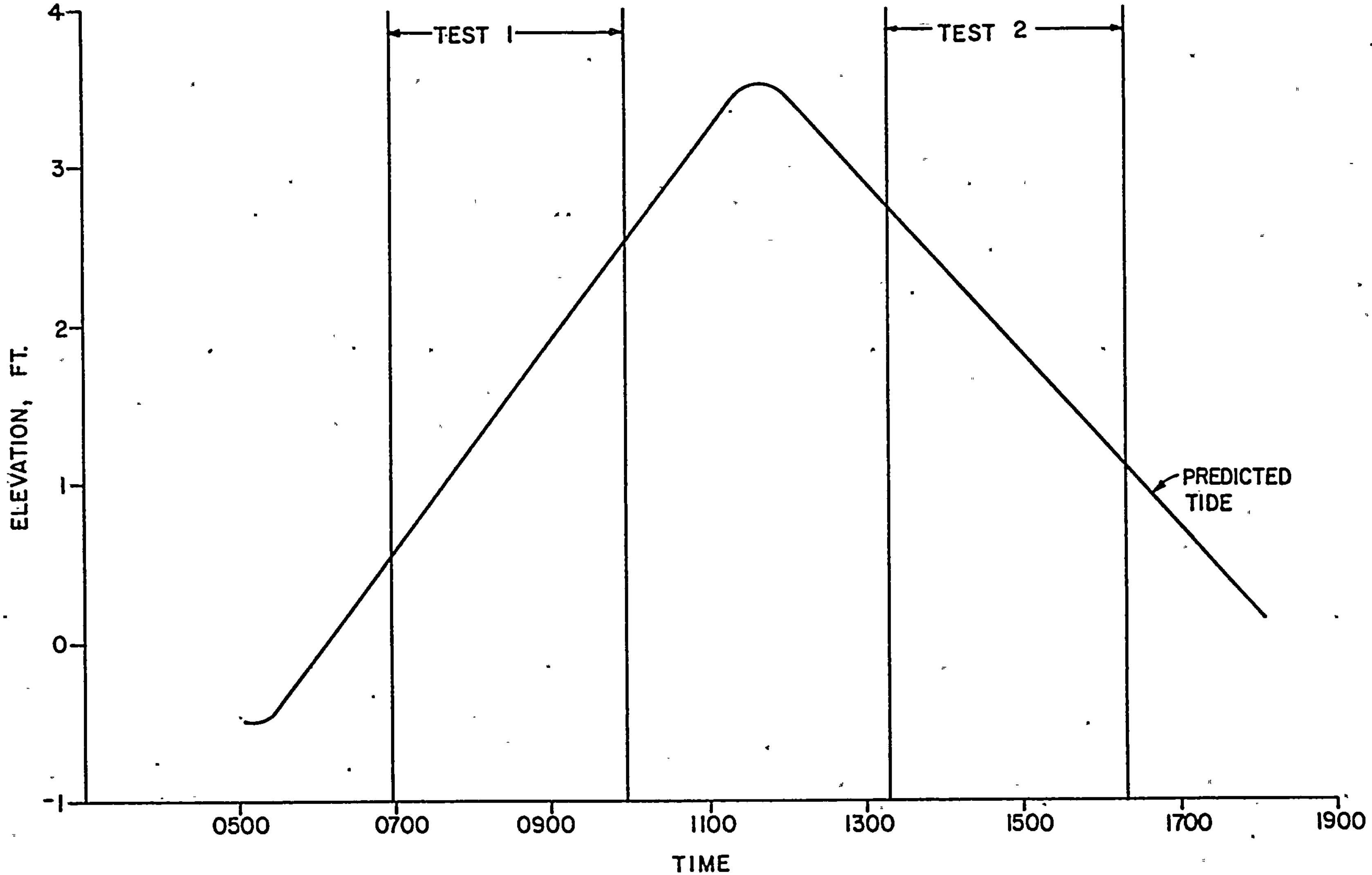


FIG. A-3



PREDICTED TIDAL ELEVATIONS NEAR DIABLO CANYON
JUNE 6, 1982

NOS TIDE TABLES, LOS ANGELES (OUTER HARBOR)
REF. STATION: AVILA BEACH, CALIFORNIA

FIG. A-4

DIABLO CANYON CONTINUOUS CURRENT MEASUREMENTS

June, 1979 through April, 1982

PREPARED BY:

Robert P. Meek, Ph.D.

ECOMAR, INC.

GOLETA, CA.

January, 1983

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DIABLO CANYON CONTINUOUS CURRENT MEASUREMENTS

INTRODUCTION

As part of the physical oceanographic studies prior to operations at the Diablo Canyon Nuclear Power Plant, continuous _in situ_ current measurements were initiated in May, 1978. These measurements were designed to provide additional detail to other water motion and physical studies (drogue drift and hydrographic profiling) which continue on a seasonal basis at the site. The data from these other oceanographic programs are presented yearly (e.g. White 1982). This report summarizes the results of the _in situ_ current measurement program from June, 18, 1981 through April 27, 1982. Previous reports summarize continuous current measurements from June, 1978 through June, 1981.

OBJECTIVES

The objectives of the current measurement program are:

1. collect detailed (continuous current flow records to accurately describe the potential trajectories and horizontal dispersion characteristics of the thermal plume.

2. examine the predictability (seasonality) of current flow monthly and yearly, and evaluate the persistence of current velocity patterns from year to year.

3. examine locally measured forcing mechanisms (winds and tides) to establish the predictive value of these local

measures to current flow characteristics.

The principal objective of the current studies at Diablo Canyon is to describe and understand the important water motions to provide trajectory information for the thermal plume to be produced with operation of the plant. Current along with drogue drift information provides one basis for understanding the trajectory and potential horizontal dispersion of the thermal plume in the receiving waters.

The predictability and persistence of water flow patterns with time is important to understanding the most likely and predominant thermal plume trajectories and dispersion patterns. If monthly current patterns are predictable by oceanographic season, then reasonable predictions can be made to following years. Also, broader seasonal oceanographic patterns and data bases can be used to predict general flow at the site.

The predictable effects of important forcing mechanisms, principally winds and tides, which can be locally measured can be of benefit in two ways. First, understanding the nature of the effects of these phenomena on local currents will provide insight into the origin of measured local flows. Second, if these measures, combined or independently, can be used to predict local flows with some accuracy, measurements of only these variables need continue.

METHODS

METERING SYSTEM

Steady current data were obtained with a single Environmental Devices Corporation (ENDECO) Model No. 105 ducted impeller current meter (See Appendix 1). The meter is completely self-contained and has recording capabilities of up to 72 days *in situ*. The ENDECO 105 meter was chosen because its design allows the meter to maintain orientation in areas of moderate wave-induced water motion. This design includes a tether that allows the neutrally buoyant meter to float at the end of a 2-meter nylon line, which diminishes the potential effect of surge on direction and velocity measurements.

The meter records direction and velocity information on 16 mm film. Rotation of the impeller, caused by water movement past the meter, revolves a gear train connected to an opaque drum operating a transparent helix. As the gears rotate, the helix extends in length proportional to the number of impeller revolutions. The helix back is illuminated by a light-emitting diode. When activated each 30 minutes, the diode exposes the film which is advanced in partial-frame increments. The advancing helix produces an analog bar graph on film proportional to current speeds. The meter can measure steady currents up to 3.5 knots (51.5 cm/sec = 1 knot) during each 30-minute sampling interval.

The directional component of the current is recorded in a similar manner by a compass, rotating freely in the meter housing. Light passes through a small slit in the compass card and exposes a point on the film frame. The position of the exposed area is directly related to current flow direction.

The meter is coated externally with vinyl copper paint to minimize marine growth.

INSTALLATION

Special swivel clamps and D-rings, allowing 360-degree meter rotation were used to secure the meter to a 5/8 inch stainless steel cable at a depth of -16 feet MLLW (Figure 1). The cable was weighted at the sea floor by a 600 pound steel weight and suspended taut by a subsurface buoy. The current meter array was positioned in approximately 100 feet of water directly offshore from the outflow structure (Figures 2 and 3).

SERVICING

The meter was serviced monthly by divers. The meter was retrieved, checked externally, the exposed film packet and batteries were replaced, simple function tests were conducted and the meter was reassembled and replaced *in situ*.

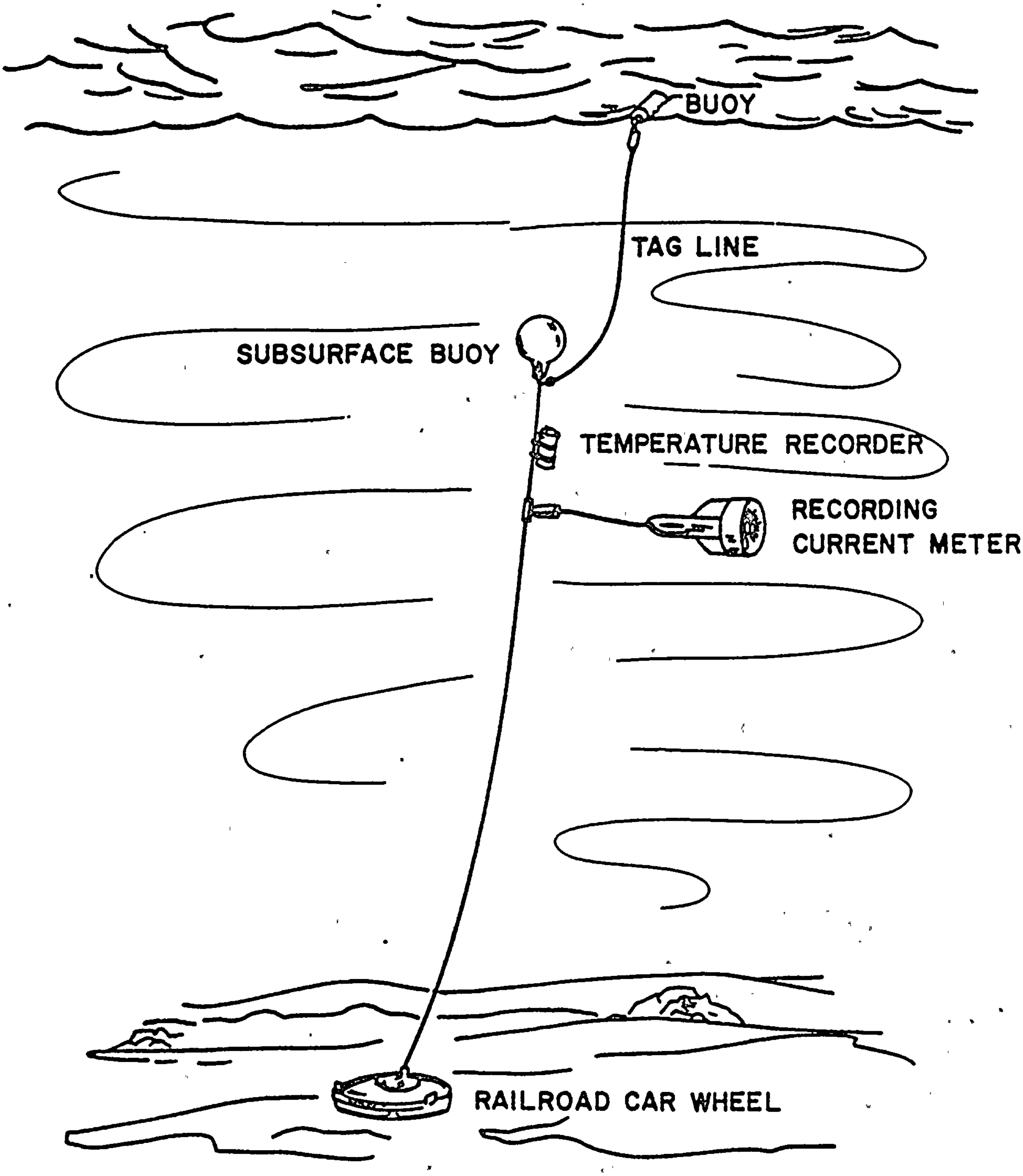


FIGURE 1

CURRENT METER INSTALLATION

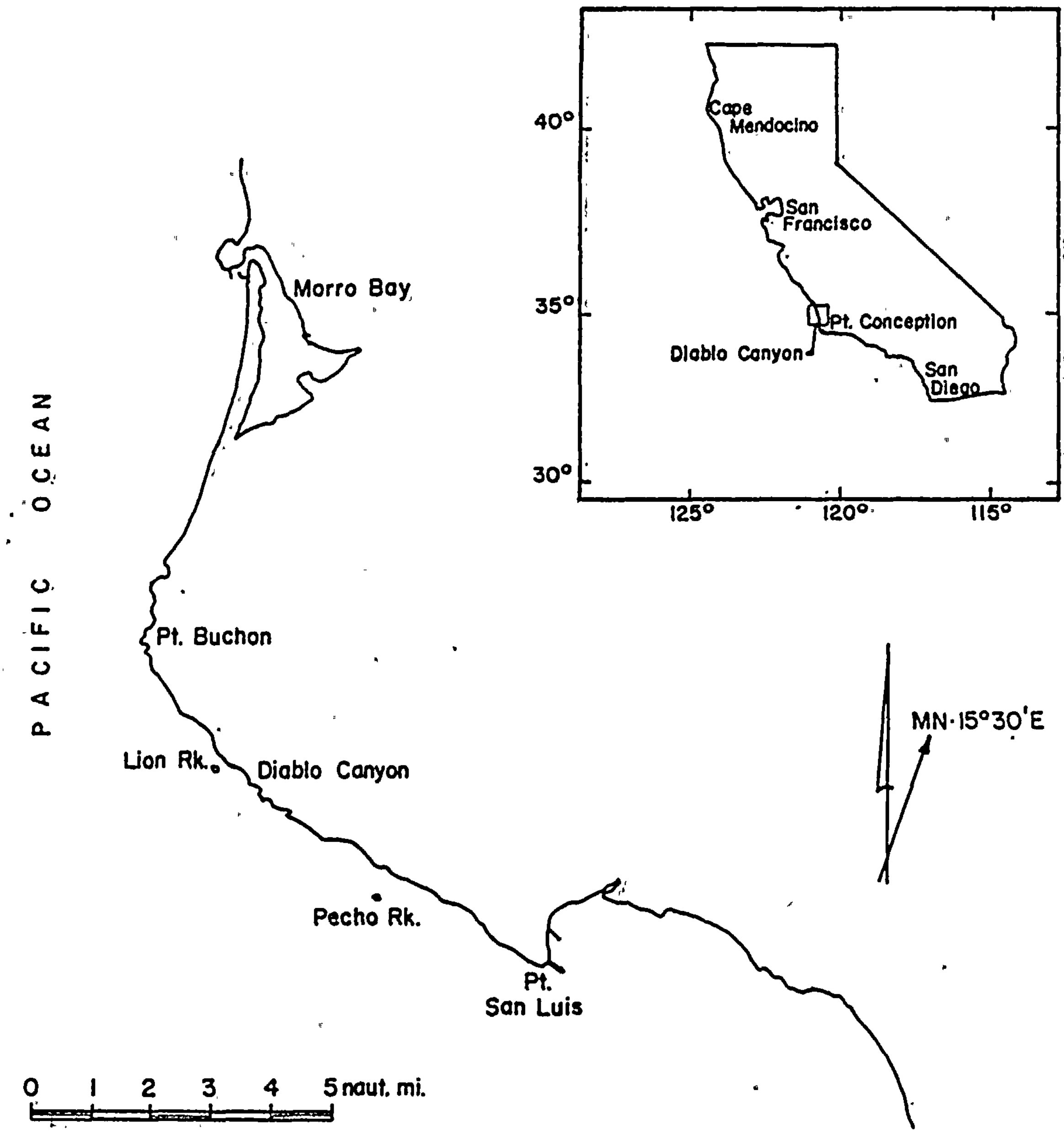


FIGURE 2

AREA MAP

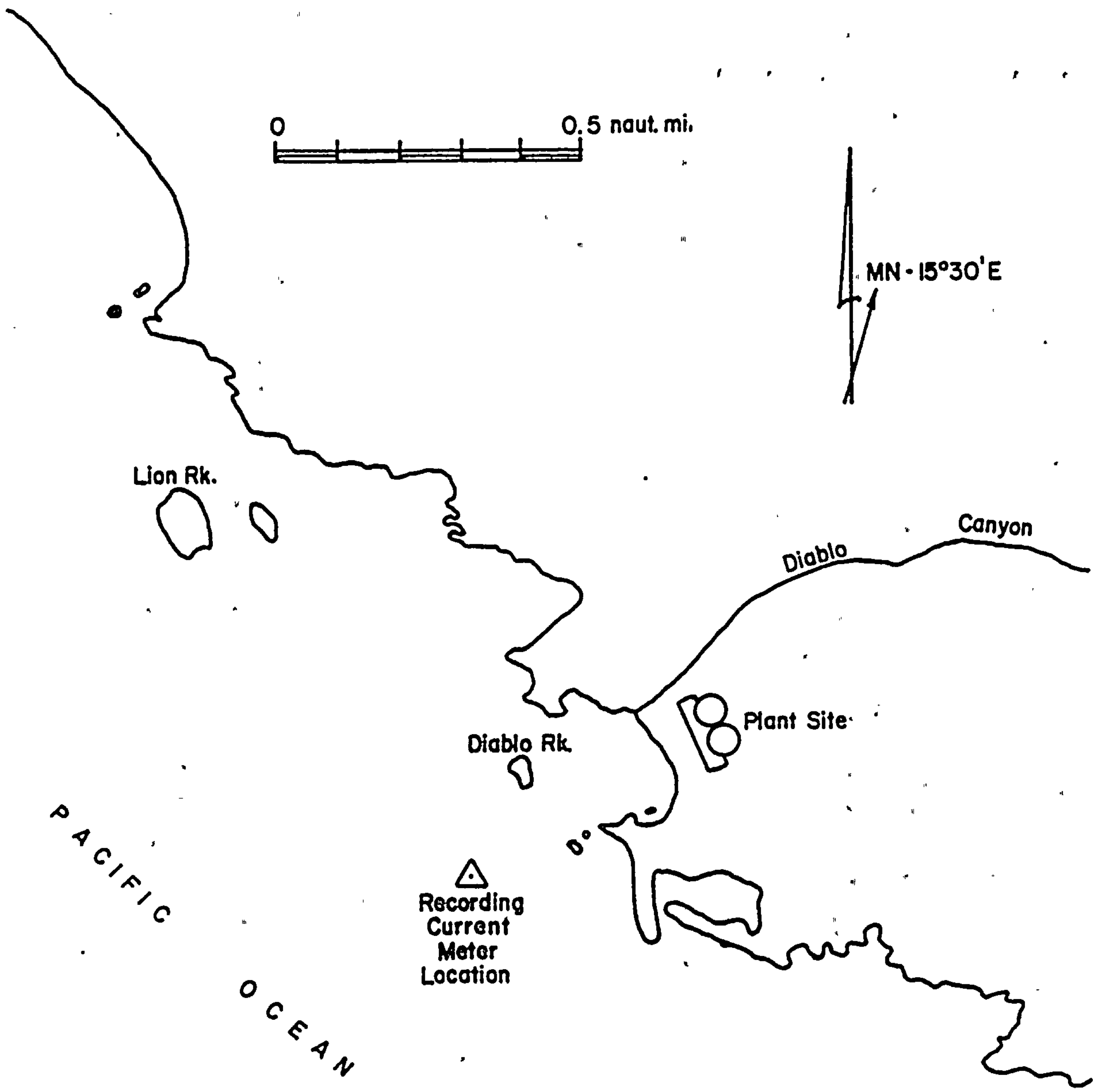


FIGURE 3

CURRENT METER LOCATION

DATA ANALYSIS

The exposed film cartridges were developed at Hollywood Film Enterprise and the information analyzed and computerized at ECOMAR, INC. The film was first examined visually to establish quality and then digitized for computer analysis and various displays. The information is digitized by projecting the developed film onto an electronic analog to digital conversion pad. The resulting values are recorded and entered directly for transformation to user units (including a correction for meter calibration), manipulation, and data presentations.

All original data films are archived at Ecomar Inc.. All digitized data files are formated in date, speed and direction files and on 9 track IBM standard label tapes at our data processing facility.

METER CALIBRATION

The metering system was calibrated annually. Directional deviations were tabulated and used to correct all directional recordings prior to tabulation and display. Test RPM's (Revolutions per minute) were used to calibrate speed recordings, any deviations were again tabulated and simple algorithms were used to correct measured speeds prior to data tabulation and display.

DATA PRESENTATIONS

PROGRESSIVE VECTOR DIAGRAM

The progressive vector diagrams are considered a clear presentation of the salient characteristics of the current recorded by the meter at the -16 foot depth. Each pair of speed and direction values are considered to be representative of the current velocity during the time interval between it and the succeeding pair; under this assumption, the speed scale can, therefore, also be considered as denoting distances through which the water has moved. The distance between the initial and final vectors of the sampling period can suggest the net, or resultant, movement of the water past the sampling location during that period.

The plot is placed in x-y coordinates where the y axis represents the magnetic north/south direction and the x axis represents the magnetic east/west directions of water movement. Plots are indexed in time at the beginning of each record period (servicing interval). The corresponding month, day, and year are recorded at each index point.

POLAR HISTOGRAMS

This data display of the current meter information shows the scaled cummulative number of average daily vectors of currents in terms of magnetic direction of flow. The data are presented as vectors of frequency of occurrence versus

direction radiating from a common point.

The polar histograms show combinations of the frequency of occurrence of the tidal flow directions, directed steady current flow directions, random directional components of turbulence and other periodic flow. Purely tidal flow would be represented by a polar histogram having an elliptical envelope with its major axis passing through the origin of the histogram and aligned parallel to the direction of maximum flow during flood and ebb stages. Perfectly turbulent flow would produce a polar histogram having a circular envelope since all directions of flow are equally probable. Persistent steady current flow would produce a tight fan-shaped protuberance in the envelope of the polar histogram. The orientation of the protuberance would indicate the preferred flow direction.

RESULTS

Current Flows

A total of 13343 half-hour vectors were measured during the interval between June 18, 1981 to April 27, 1982 (Table 1). This represents a 93 percent data retrieval for the ten months of this reporting interval. Normally these data are summarized from June to June. The May data was lost due to data film cannister malfunction and the June data was lost due to fouling of the current meter impeller early in the record period by large kelp stipes (Nereocystis sp.). For the twelve month period data retrieval was approximately 83 percent.

TABLE 1

SUMMARY OF SPEED AND DIRECTION CATEGORIES

6/18/81 through 4/27/82

	0.–23.	23.–45.	45.–68.	68.–90.	90.–113.	113.–135.	135.–158.	158.–180.	180.–203.	203.–225.	225.–248.	248.–270.	270.–293.	293.–315.	315.–338.	338.–360.	TOTAL	PERCENT
0.00–0.05	60	70	55	54	93	101	87	100	66	52	66	82	125	147	61	70	1289	9.66
0.05–0.10	46	29	55	63	113	122	114	129	64	73	62	106	154	194	35	24	1383	10.36
0.10–0.15	42	37	78	103	183	169	210	162	86	91	84	171	342	361	92	67	2278	17.07
0.15–0.20	39	31	73	83	197	228	253	137	68	37	42	121	291	387	49	35	2171	16.27
0.20–0.25	14	14	27	53	196	226	217	70	11	6	12	59	349	308	53	14	1629	12.21
0.25–0.30	2	8	9	38	199	186	140	35	8	2	5	29	257	218	35	4	1175	8.81
0.30–0.35	1	3	5	19	122	179	76	17	2	1	0	9	183	196	26	8	847	6.35
0.35–0.40	1	2	0	17	139	150	64	11	3	1	0	8	139	152	20	4	711	5.33
0.40–0.45	0	2	2	6	101	146	32	6	1	1	2	0	92	106	6	2	505	3.78
0.45–0.50	0	0	0	9	85	121	24	3	1	1	1	5	55	78	8	1	392	2.94
0.50–0.55	0	0	3	8	59	90	12	0	2	0	1	1	38	80	3	1	298	2.23
0.55–0.60	1	0	0	8	43	59	13	2	1	0	0	1	21	45	0	1	195	1.46
0.60–0.65	1	0	0	2	27	48	2	3	3	0	1	0	6	27	1	1	122	0.91
0.65–0.70	0	0	0	3	28	36	5	2	0	1	0	0	7	17	1	1	101	0.76
0.70–0.75	0	0	0	1	21	23	2	2	1	0	0	0	5	14	1	2	72	0.54

TABLE 1 (cont'd)

SUMMARY OF SPEED AND DIRECTION CATEGORIES
6/18/81 through 4/27/82

	0.	23.	45.	68.	90.	113.	135.	158.	180.	203.	225.	248.	270.	293.	315.	338.	360.	TOTAL	PERCENT
0.75																			
	0	0	0	2	17	21	1	1	1	0	0	0	2	5	0	0		50	0.37
0.80																			
	1	0	1	3	17	9	0	0	1	0	0	0	3	5	1	1		42	0.31
0.85																			
	0	0	0	1	7	5	1	2	0	0	0	0	1	1	1	0		19	0.14
0.90																			
	0	0	0	1	6	10	0	0	0	0	0	0	0	0	0	0		17	0.13
0.95																			
	0	0	0	2	2	6	0	0	0	0	0	0	1	0	0	0		11	0.08
1.00																			
	0	0	0	0	4	5	1	0	0	0	0	0	0	0	1	0		11	0.08
1.05																			
	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1		4	0.03
1.10																			
	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0		2	0.01
1.15																			
	0	0	0	0	2	6	0	0	0	0	0	0	0	0	0	0		8	0.06
1.20																			
	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0		2	0.01
1.25																			
	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0		4	0.03
1.30																			
	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0		4	0.03
1.35																			
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0.00
1.40																			
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0.00
1.45																			
	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0		1	0.01
1.50																			
TOTAL	209	196	504	476	1667	1880	1254	682	318	267	278	565	2171	2245	394	237		13343	
PERCENT	1.57	1.47	3.78	3.57	12.49	14.09	9.40	5.11	2.38	2.00	2.08	4.23	16.27	16.83	2.95	1.78			100.00

The modal current speed was between 0.15 and 0.25 knots, typical of currents along the California Coast. The maximum recorded speed was 1.50 knots; this value is about the same as observed elsewhere (e.g. Santa Barbara Channel, Monterey Bay, So. California Bight).

Measured speeds ranging from 1 to 1.5 knots were relatively rare and occurred only about 2.6 percent of the time. Slower speeds (less than 0.05 knots occurred in nearly 10% of the one half-hour measurements. A large proportion of these very low water flow measurements are a consequence of impeller fouling by eel grass. This is a seasonal occurrence in the study locale and when present can partially bind the meter impeller producing artificially low current speed measurements. As discussed in previous reports this fouling is evidenced during servicing and usually effects a small percentage of measurements near the end of the record period.

Another source of error in previously reported current values was discovered during this year's analyses. In previous years the data set used for yearly summary analyses was produced from transformations of daily net current vectors to net daily average speed and direction. These transformations resulted in artificially low average values and subsequently low summary statistics. All of the data presented here have been developed from the actual one half-hour current measurements and do not reflect the bias

introduced by transformation.

The currents were (as in previous years) bimodal in direction; over 40% of the measured water motion was toward the southeast (centered on 124 degrees magnetic and about 40% of the currents flowed toward the northwest (centered on 293 degrees magnetic). Flows in any other direction (22.5 degree sectors) were infrequent (usually less than 5% of the time) and were distributed in these other sectors somewhat uniformly. These lesser flows probably represented components of random turbulent motion.

The time history of water motion at the meter as depicted by the progressive vector plot (Figure 4) shows that the water motion was largely parallel to the coast. Flow was usually uni-directional upcoast or downcoast (Northwest or Southeast). From June 18, to October 27, 1981, currents flowed with few reversals to the southeast. Flows reversed toward the end of this period, and demonstrated relatively unidirectional northwest flow from October to January, 1982. This period was followed by some reversing flows and a return to nearly unidirectional southeast currents from mid-March through the end of the record (4/27/82).

The distribution of current directions during this ten month interval was substantially similar to previous year's measured distributions. Flow directions were definitively directed up and down coast with few inshore or offshore water motions (Figure 5).

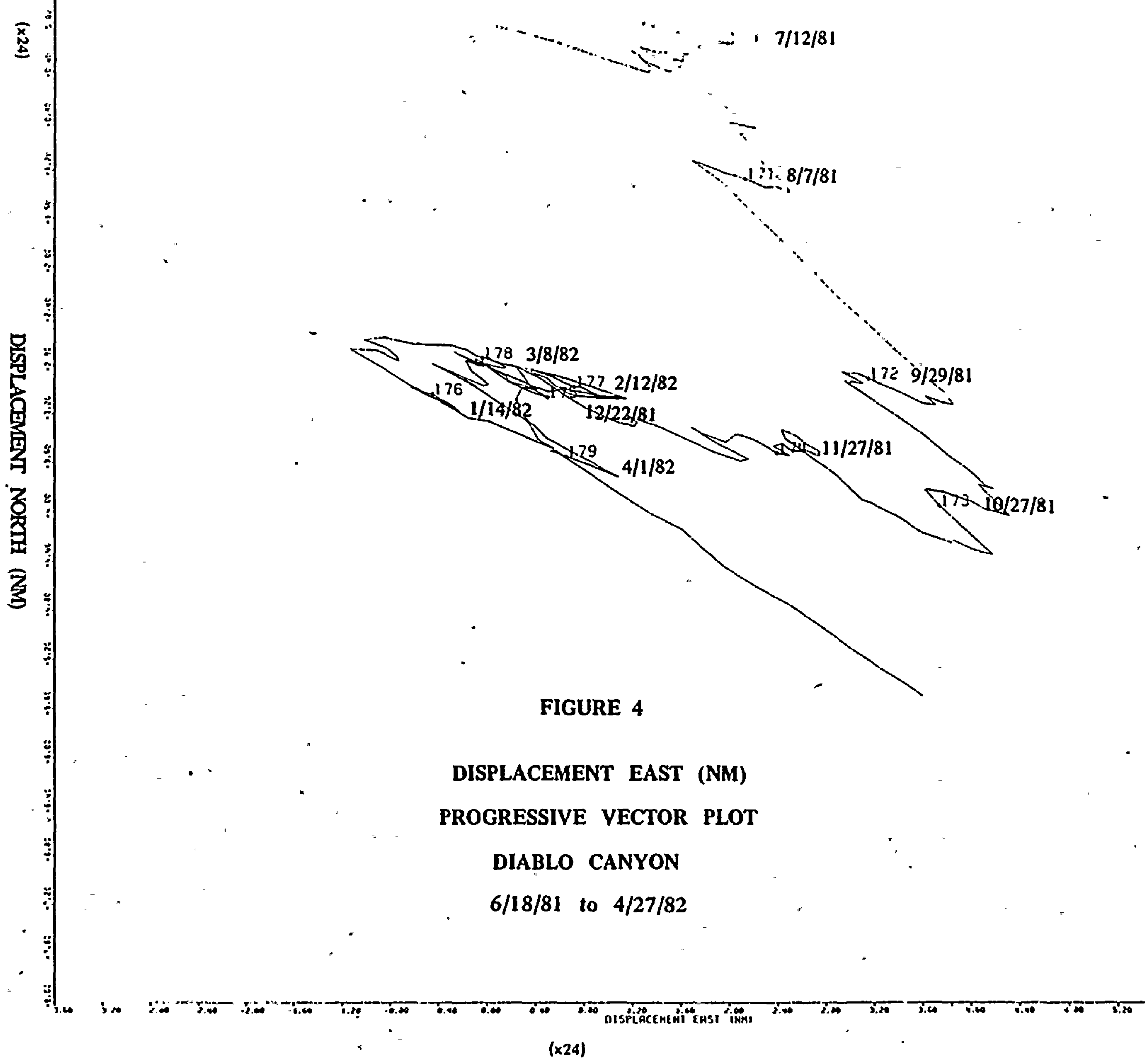


FIGURE 4

DISPLACEMENT EAST (NM)

PROGRESSIVE VECTOR PLOT

DIABLO CANYON

6/18/81 to 4/27/82

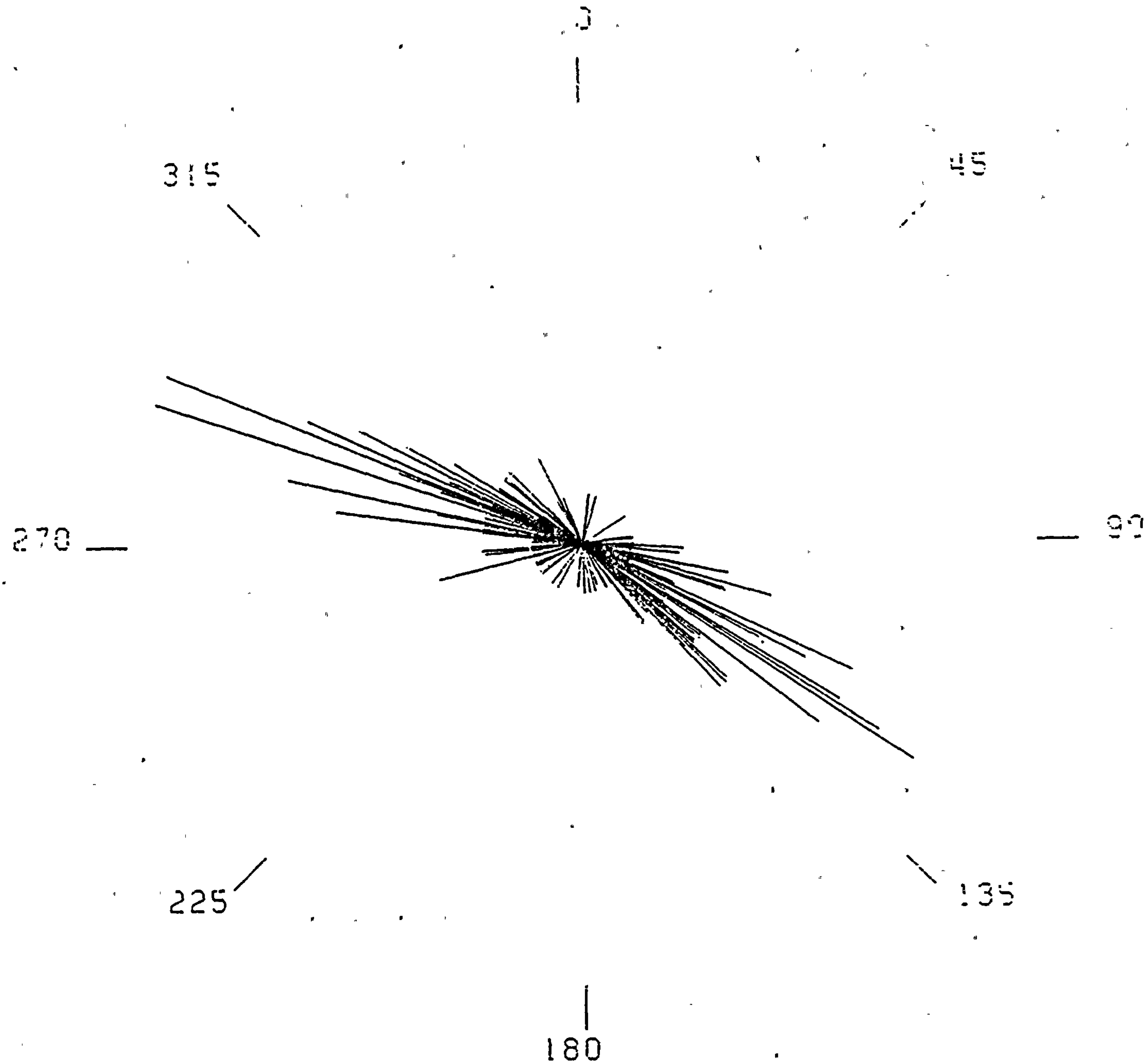


FIGURE 5

6/18/81 - 4/27/82

POLAR HISTOGRAM OF CURRENT DIRECTION
DIABLO CANYON

No.
of
Obs.

In summary, the current regime at the site continues to show coast-wise flow following bathymetric contours only slightly modified by tidal reversals and large scale turbulent events. Reversals of flow direction occur on a scale of days rather than hours indicating an interplay of a major coastal current and a countercurrent.

The ten month record shows a pattern of current flow direction which would be predicted by many previous studies along the Pacific coast (Reid and Swartzlose, 1962; Pirie and Steller 1977; Griggs 1974). The predictable seasonal flow patterns suggested by these investigators are: Down-coast flow during the Oceanic and upwelling periods when the California current dominates the nearshore flow regime during the late winter through late summer months along the central California coast.

Upcoast flow during the fall and winter months when the California current's influence weakens nearshore and the Davidson countercurrent predominates in the nearshore waters.

The majority of previous records from the site show this "classical" pattern of seasonal flow directions.

<u>Long Term Cyclical Velocity Trends</u>

As the data base has expanded for this locale certain trends in measured speeds and directions have appeared. Figure 6 is a histogram of average current velocity during each

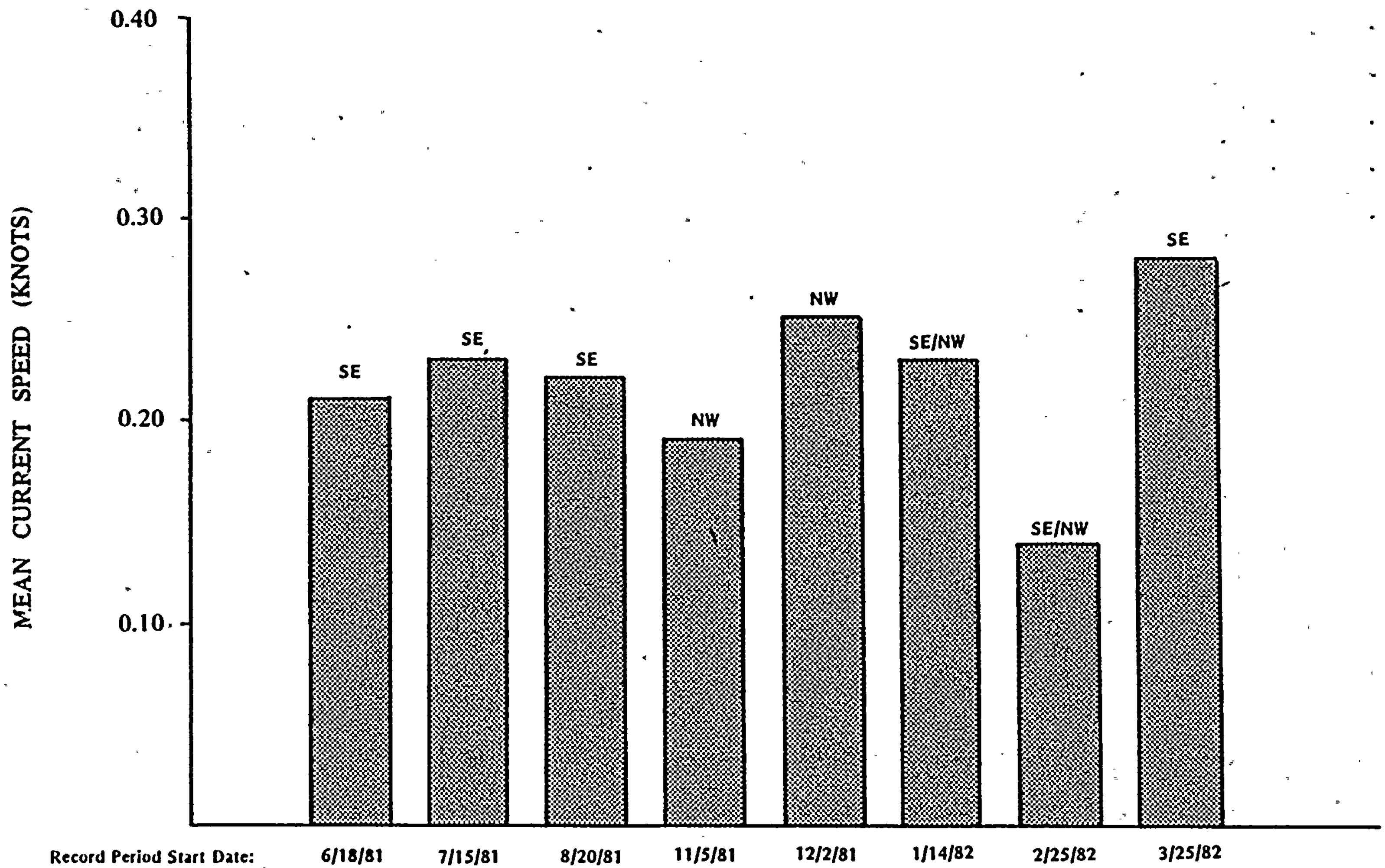


FIGURE 6
AVERAGE CURRENT SPEED

6/18/81 through 4/27/82

approximately one month service period from 6/18/81 through 4/27/82. These data show a number of important, possibly predictable patterns in current velocity. The peak average flow speeds were consistently recorded during prolonged southeasterly (SE) flows. The next highest average speeds were generally associated with relatively steady northwesterly (NW) flows. Generally the lowest speeds were recorded during periods of reversing flow, southeast/northwest (SE/NW).

The general character of the measured currents in a single year may persist from year to year (Figure 7). Each of the years presented have similar general trends although peak average speeds are different and the flow characteristics (as shown by the progressive vector plots) were sometimes dissimilar. The records begin in June of 1979 with the apparent end of dominant southeasterly flow followed by a reversing period lasting through April, 1979. From September through December of 1979 the current flowed uniformly upcoast. This flow was relatively abruptly reversed by March 1980. Peak velocities increased markedly and swift flow continued to the southeast through June, 1980. From July through November, 1980 flow reversed and meandered; almost precisely the same characteristics and time interval as the previous year. As in 1979 this reversing period was followed by approximately two months of persistent northwest flow. Unlike the previous year this northwest flow was followed by some reversing prior to the

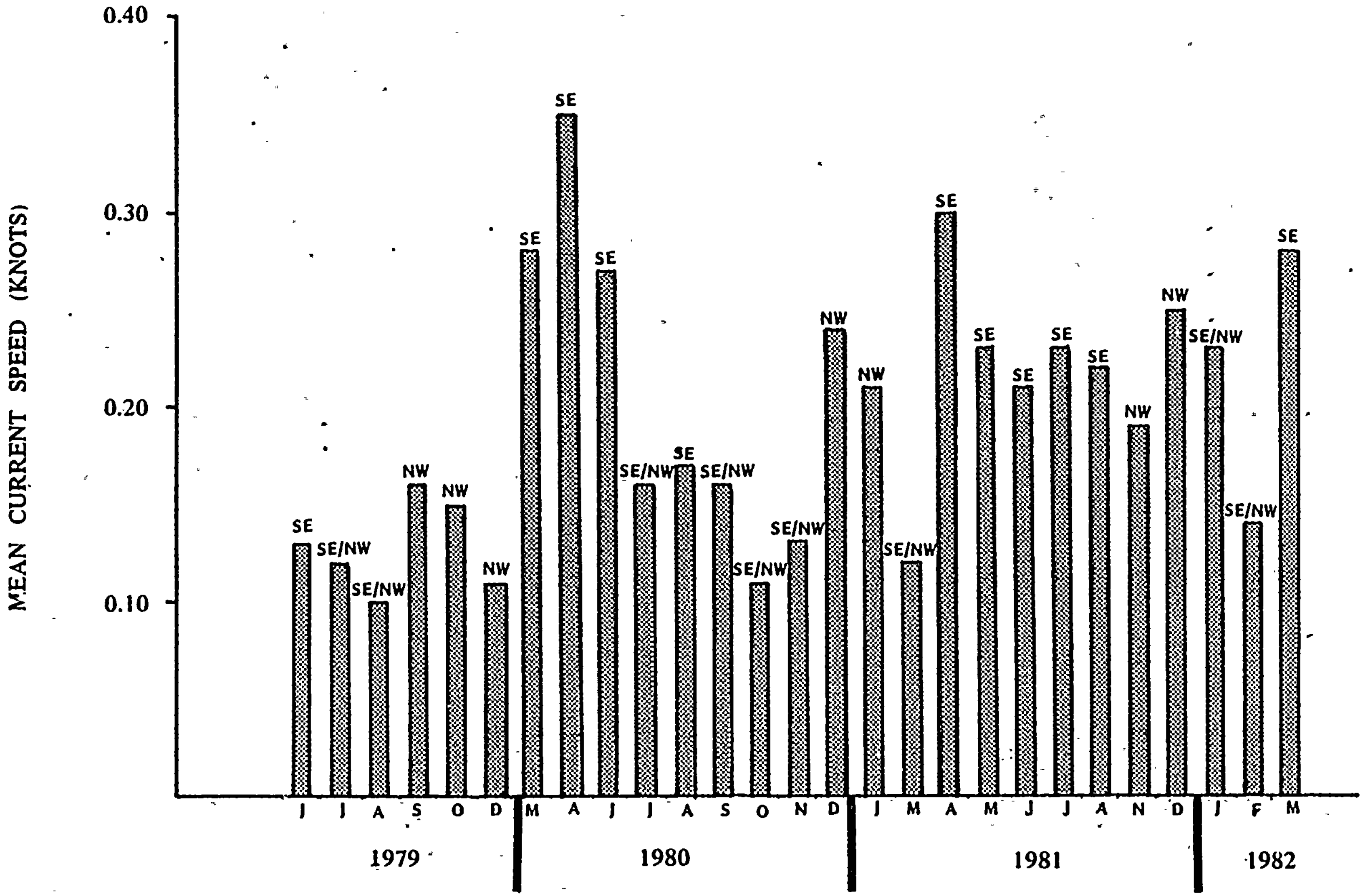


FIGURE 7
AVERAGE CURRENT SPEEDS
6/15/79 through 4/27/82

on-set of persistent southeasterly currents. The peak speeds were also much lower when flows persisted to the southeast.

Many authors have discussed the periodicity of flow directions and speeds (Reid and Schwartzlose, 1962; Schwartzlose, 1963; Griggs, 1974; Berstein, et al., 1977) as well as the forcing mechanisms (Pirie and Steller, 1977) and the potential coupling of atmospheric phenomena and current patterns (Neshyba and Sakou 1972) as well as decadal cycles in the California current system (Huang, 1972). The periodicity of patterns is somewhat unarguable, but often only measureable some distance from shore sufficiently removed from perturbing influences such as bathymetry or embayments. The seasonality in current flow is quite apparent in the foregoing data and may be consistently measurable at the site.

The long term periodicity in these measured seasonal patterns (e.g. duration of reversing flows, peak speeds) could be decadal, or shorter or longer and may not be reasonably predictable. Huang suggests such cycles may be indirectly linked to atmospheric phenomena through sea level variations.

The years of data evaluated here indicate a number of important elements in this possibly recurring cycle. The periods from June through August, 1979 and July to November, 1980 both showed a yearly pattern of reversing flow

following the southeast flows characteristic of the California current influence and just prior to northwest flow characteristic of the Davidson current influence in this nearshore locale. The first half of the records (June, 1979 through July, 1980) are probably indicative of a period when the California current flow was relatively nearshore in the study area. This is supported by a relatively weak Davidson influence, an abrupt change to southeasterly flow following the weakened Davidson flow, and marked peak speeds during persistent southeasterly flows. The remainder of the record is probably indicative of a period during which the southeasterly California flow remained more distant from shore. This is supported by the relatively strong Davidson flow speeds, the less than abrupt change from Davidson (northwesterly) to California (southeasterly) flows, and the apparently weakened southeasterly flows in the summer months of 1981 and Spring of 1982.

These longer term cycles in the strength of seasonal current flows may show recurring patterns within the time frame of this measurement program. If this occurs, valuable predictive data may be available for future modeling or monitoring studies.

<u>Local Forcing Mechanisms and Measured Currents</u>

In previous analyses of currents offshore of Diablo Canyon, attempts were made to evaluate the effects and predictability of locally measured forcing mechanisms such

as winds and tides on measured These analyses met with little success (Meek, 1981).

Wind vectors showed little correspondence to current vectors even when winds were strong and unidirectional for extended periods. With the expanded data base and the discovery of the cyclical nature of current velocities a comparison was made between and current speeds for the period of 6/15/79 through 1/19/80 (Meek, 1982). This comparison also met with little success. Wind induced current speeds and the general patterns of wind velocity showed little relationship to measured currents. This could be the result of the depth of current measurement (-16f ft. MLLW) and/or locally measured winds were and are of insufficient fetch to produce predicted wind driven water movements.

A preliminary analysis of the effects of tides on locally measured currents (Meek, 1981) was restricted to evaluations of the effects of tides on periodic rotations in current direction. These analyses showed little predictable results. Although tidal "loops" were often prevalent in progressive vector plot displays, they were absent even during major tidal excursions; apparently due to masking by relatively strong unidirectional steady currents.

Additional analyses were conducted during the previous years summary (Meek, 1982) which indicated tides were significant effectors of flow speeds measured at the site. Peak current speeds were coincident with the diurinal and semi-diurinal

tides. Spectral analysis of these same data confirmed the contribution of both the diurnal and semi-diurinal component of the tide to measured current speed at the site.

Summary

The current data collected to date at the Diablo Canyon site indicates:

- peak current speeds are associated with relatively unidirectional flow patterns

- these unidirectional flows are coincident with two relatively predictable yearly seasonal current influences: the Davidson and the California currents.

- peak current speeds are also influenced significantly by both the diurnal and semidiurnal tides.

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APPENDIX 1

SPECIFICATIONS
ENDECO SELF-CONTAINED TETHERED CURRENT METER
TYPE 105

CURRENT VELOCITY

Sensor Type:	Ducted Impeller
Sensitivity:	53.7 rpm/knot
Speed Range:	0 - 1.75 knots (0 - 90.1 cm/sec) @ 1 reading/60 min. 0 - 3.5 knots (0 - 180.2 cm/sec) @ 1 reading/60 min. 0 - 7.0 knots (0 - 360.4 cm/sec) @ 1 reading/60. min.
Impeller Threshold:	Less than 0.05 knot (2.57 cm/sec)
Resolution:	.05 knot
Speed Accuracy:	± 3% of full scale

CURRENT DIRECTION

Magnetic Direction:	0 - 360°
Sensitivity:	± 5° at 0.05 knot (2.57 cm/sec)
Resolution:	± 1°
Accuracy:	2% above 0.05 knot, when referenced to computer calibration

TILT

The instrument orients to the flow thus eliminating the need for tilt indication or correction.

RECORDING TIME AND RATE

Number of Readings:	3600
Recording Rate:	1 Reading/15 min. 1 Reading/30 min. 1 Reading/60 min.
Time Reference Mark:	24 hour light emitting diode indication provided by timer
Maximum Recording Period:	75 days @ 1 reading/30 min.
Time Stability:	± 1.5 seconds/day @ 20° C ± 4 seconds/day @ -5 to +30° C
Timer Type:	ENDECO Type 124 Crystal Timer

APPENDIX 1 con't

Specifications - Current Meter Type 105 (cont'd)

RECORDER

Method:	Direct photographic time exposure of sensor outputs
Light Source:	Light emitting diodes continuously energized
Format:	Analog/bar graph
Film Cartridge:	50 feet - 16 mm Cine Kodak magazine
Film Type:	Kodak Tri-X
Power:	Four, 1½ volt standard "D" size cells

OPERATING ENVIRONMENT

Operating Medium:	Salt, fresh or polluted water
Operating Temperature Range:	-2° to +45°C (28° to 113°F)
Storage Temperature Range:	-34° to +65°C (-29° to 149°F)
Maximum Depth:	500 feet (pressure cases to 10,000 psi available)

INSTRUMENT HOUSING

Material:	P.V.C. plastic
Finish:	All surfaces painted for resistance to marine growth
Hardware:	300 series stainless steel and plastic

PHYSICAL SIZE

Weight:	27 pounds (in air)
Buoyancy:	Approximately neutral - adjustable for salt, fresh, or polluted water
Dimensions:	30 inches long x 16 inches diameter
Shipping Weight:	45 pounds
Shipping Crate Dimensions:	38 inches long x 22 inches diameter

ECOMAR INC.

METER NUMBER
1 0 5 0 3 5 5

17 MAR 81

REAL HDG	IND. HDG.	DEV.
0	-4	-4
15	10	-5
30	20	-10
45	38	-7
60	54	-6
75	69	-6
90	85	-5
105	101	-4
120	118	-2
135	134	-1
150	153	3
165	170	5
180	186	6
195	200	5
210	216	6
225	234	9
240	249	9
255	263	8
270	280	10
285	294	9
300	306	6
315	319	4
330	333	3
345	345	0

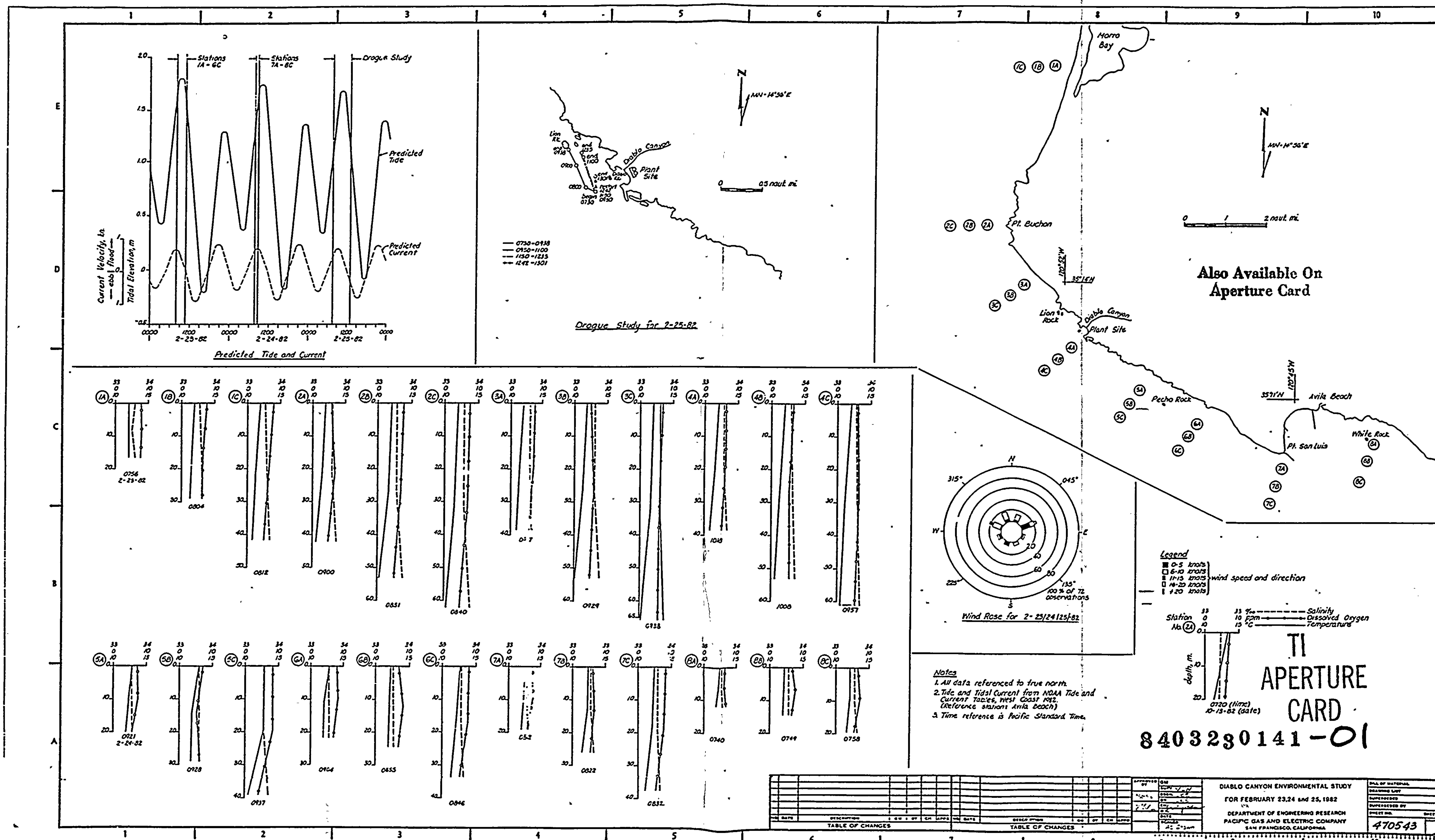
SPEED SECTION:

RAW DATA: 141 252 16 125 242 347 103

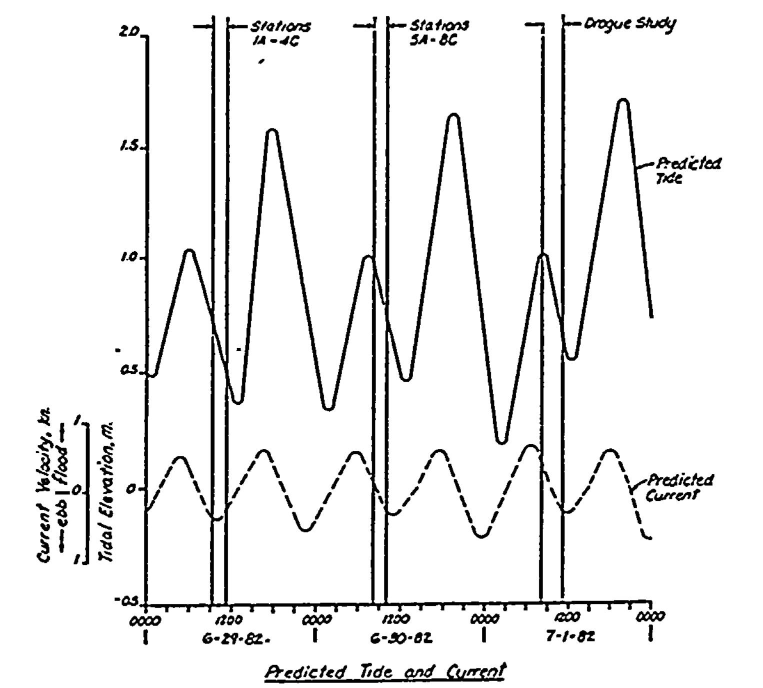
PERCENTS: 31.8 32.7 31.2 33.4 30.1 30.4

AVG. PERCENT= 31.6 COMPUTED SPEED RANGE= 3.424
RDGS PER HR.= 2 TEST RPM= 60 ROTOR= 772

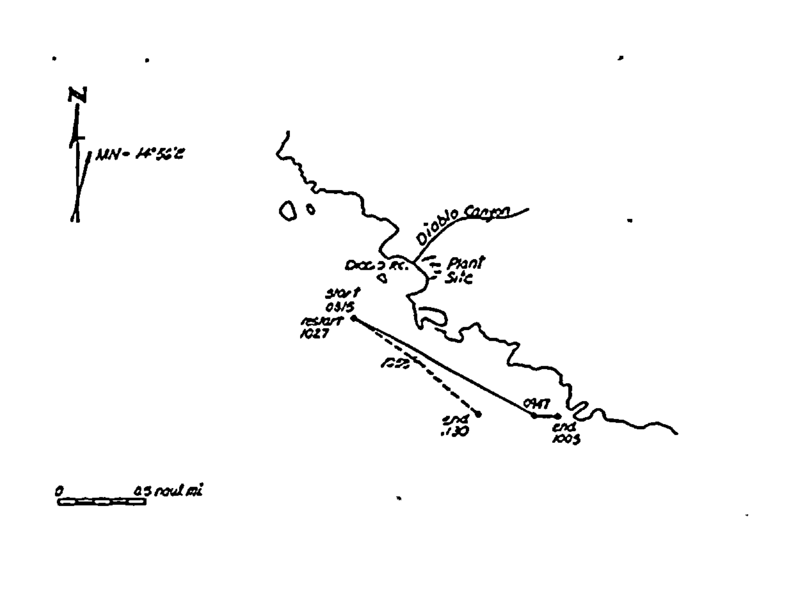
ACCEPTED BY BS REJECTED BY______ DATE 3/17/81



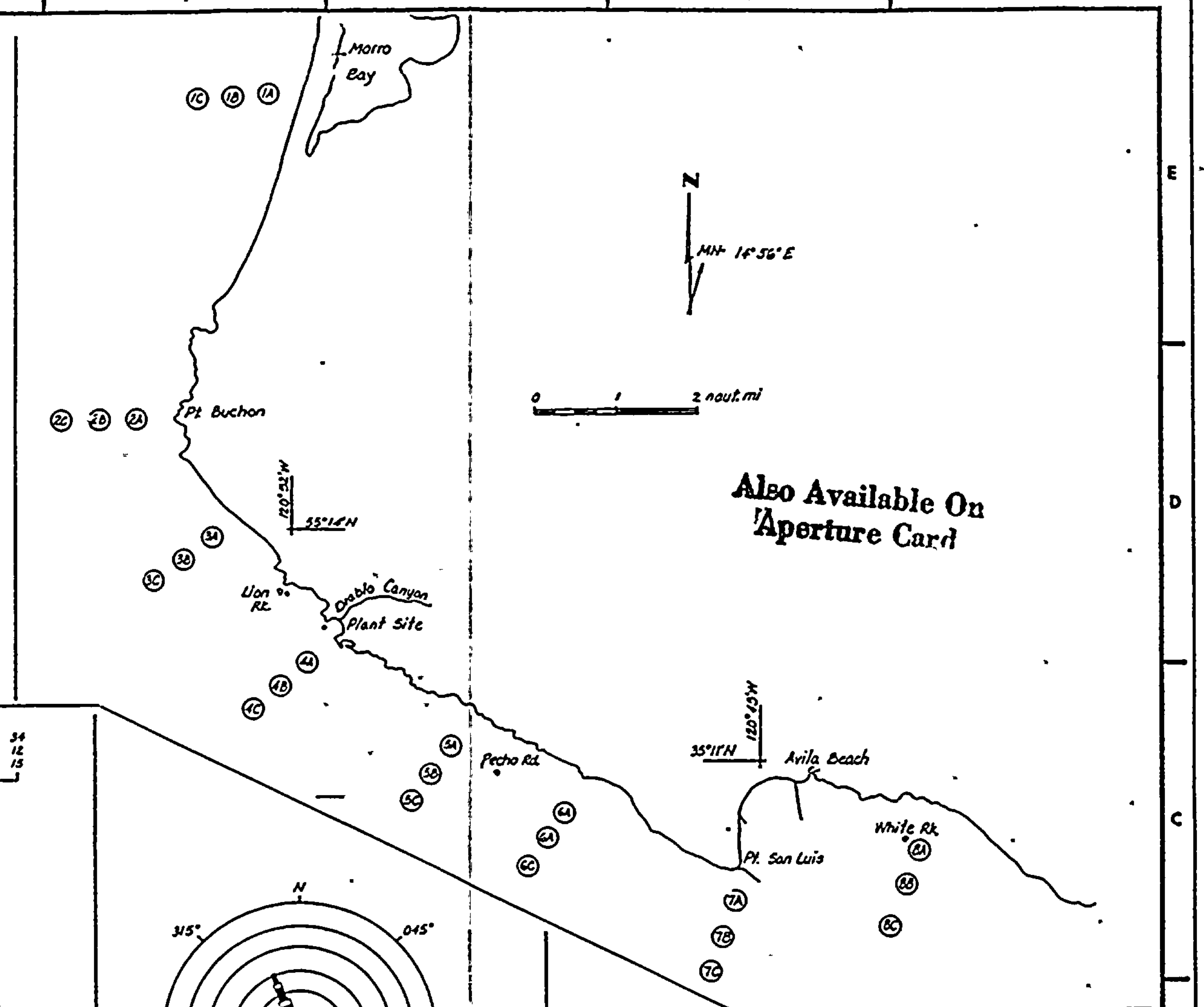
Stations 1A - 6C
Stations 7A - 8C
Drogue Study
Predicted Tide
Predicted Current
Current Velocity, kn. — ebb flood
Tidal Elevation, m
2-23-82
2-24-82
2-25-82
Predicted Tide and Current
Lion Rk.
Diablo Canyon
Plant Site
0.5 naut. mi.
MN-14°36'E
0730-0938
0950-1100
1150-1235
1242-1301
Drogue Study for 2-25-82
Morro Bay
Pt. Buchon
Lion Rock
Diablo Canyon
Plant Site
Pecho Rock
Avila Beach
Pt. San Luis
White Rock
35°15'N
120°52'W
35°11'N
120°45'W
2 naut. mi.
Also Available On Aperture Card
Wind Rose for 2-23/24/25/-82
100 % of 72 observations
Legend
0-5 knots
6-10 knots
11-15 knots
16-20 knots
+20 knots
wind speed and direction
Station No. 2A
Salinity
Dissolved Oxygen
Temperature
depth, m.
0720 (time)
10-13-82 (date)
Notes
1. All data referenced to true north.
2. Tide and Tidal Current from NOAA Tide and Current Tables, West Coast 1982. (Reference station: Avila Beach)
3. Time reference is Pacific Standard Time.
TI APERTURE CARD
8403230141-01
TABLE OF CHANGES
DIABLO CANYON ENVIRONMENTAL STUDY
FOR FEBRUARY 23,24 and 25, 1982
DEPARTMENT OF ENGINEERING RESEARCH
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA
470543



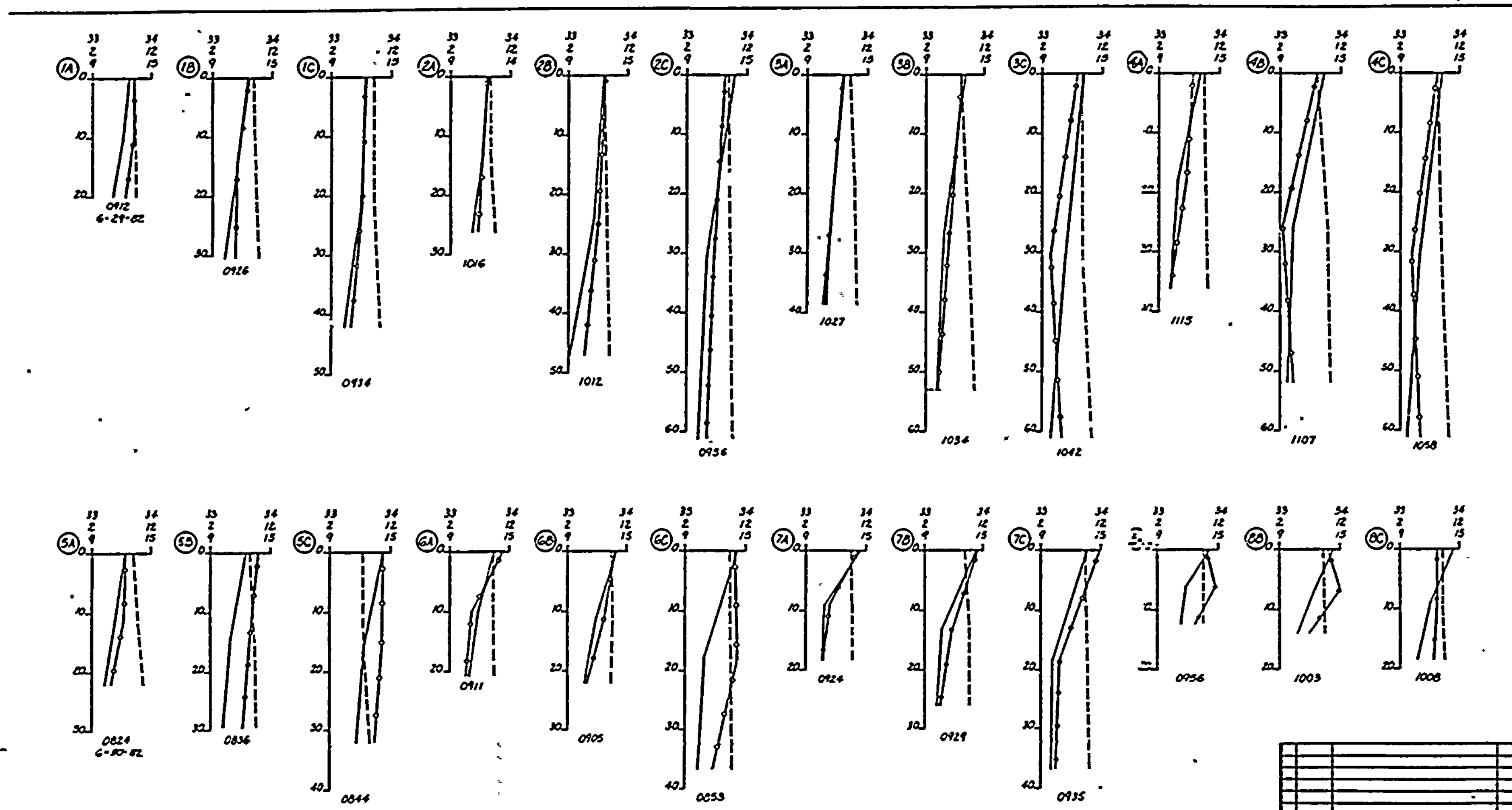
Predicted Tide and Current

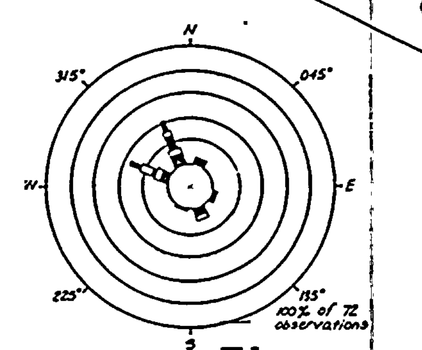


Drogue Study for 7-1-82

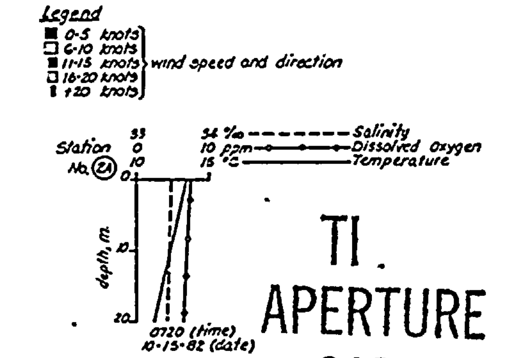


Also Available On Aperture Card





Wind Rose for 6-29/30, 7-1, 1982



Notes
1. All data referenced to true north
2. Tide and Tidal Current from NOAA Tide and Current Tables, West Coast 1982. (Reference station: Avila Beach)
3. Time reference is Pacific Daylight Savings Time.

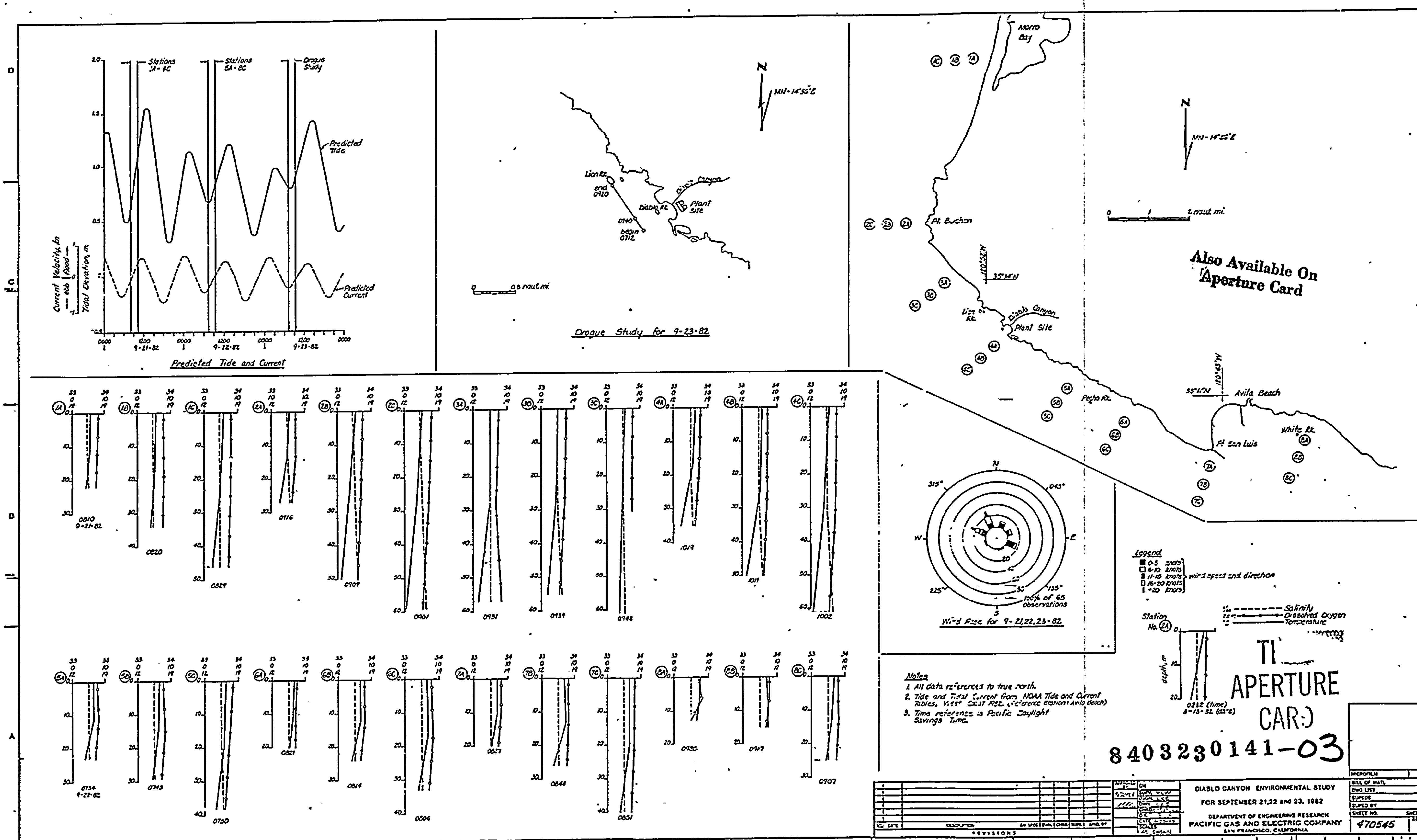
TI APERTURE CARD

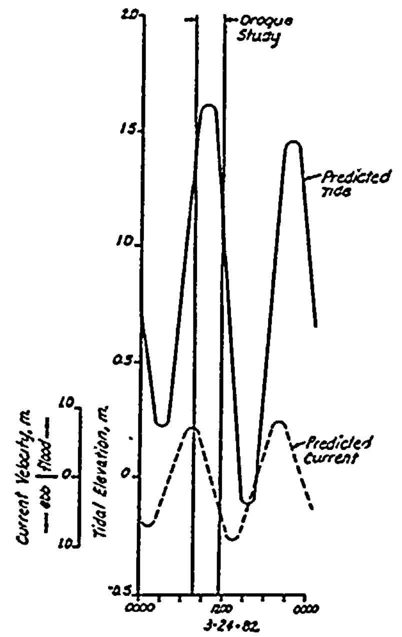
8403230141-02

DIABLO CANYON ENVIRONMENTAL STUDY
FOR JUNE 29, 30 and JULY 1, 1982
DEPARTMENT OF ENGINEERING RESEARCH
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA

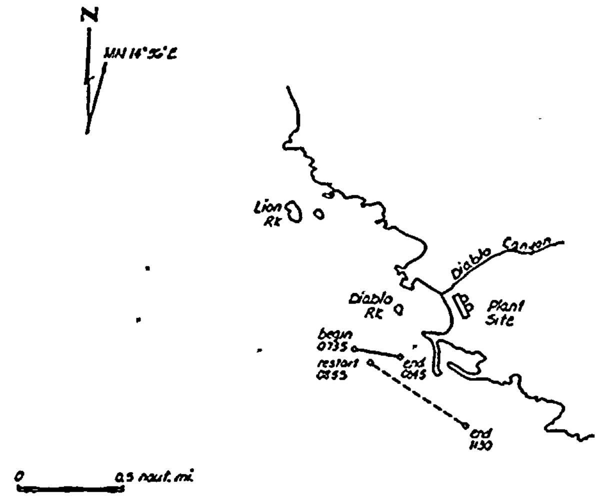
470544

TABLE OF CHANGES

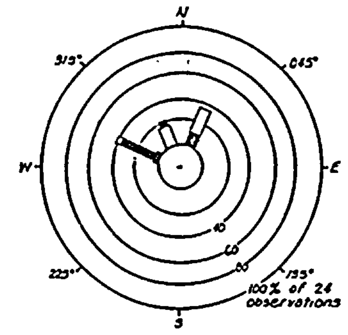

Stations 1A-4C
Stations 5A-8C
Drogue Study
Predicted Tide
Predicted Current
Current Velocity, kn
ebb flood
Tidal Elevation, m
9-21-82
9-22-82
9-23-82
Predicted Tide and Current
Lion Rk.
end 0920
begin 0712
Diablo Rk.
Diablo Canyon
Plant Site
MN-14°50'E
0.5 naut mi.
Drogue Study for 9-23-82
Morro Bay
Pt. Buchon
35°15'N
120°53'W
Lion Rk.
Diablo Canyon
Plant Site
Pecho Rk.
Avila Beach
Pt San Luis
White Rk.
35°11'N
120°45'W
2 naut mi.
Also Available On Aperture Card
N
045°
E
135°
S
225°
W
315°
100% of 65 observations
Wind Rose for 9-21,22,23-82
Legend
0-5 knots
6-10 knots
11-15 knots
16-20 knots
+20 knots
wind speed and direction
Station No.
Salinity
Dissolved Oxygen
Temperature
depth, m
0232 (time)
8-13-82 (date)
Notes
1. All data referenced to true north.
2. Tide and Tidal Current from NOAA Tide and Current Tables, West Coast 1982. (Reference station: Avila Beach)
3. Time reference is Pacific Daylight Savings Time.
APERTURE CARD
8403230141-03
DIABLO CANYON ENVIRONMENTAL STUDY
FOR SEPTEMBER 21,22 and 23, 1982
DEPARTMENT OF ENGINEERING RESEARCH
PACIFIC GAS AND ELECTRIC COMPANY
SAN FRANCISCO, CALIFORNIA
REVISIONS
470545



Predicted Tide and Current



Drogue Study for 3-24-82



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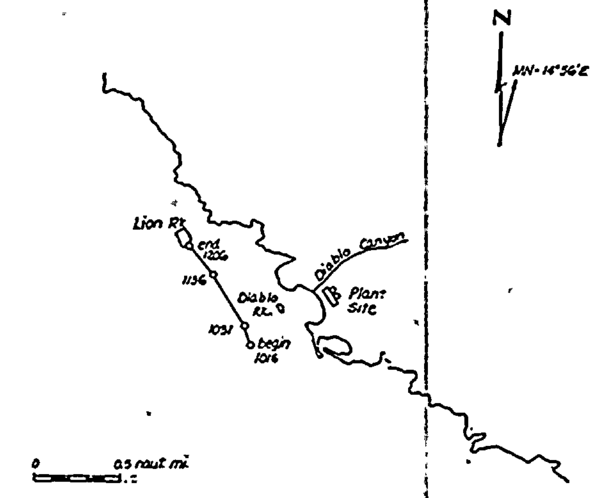

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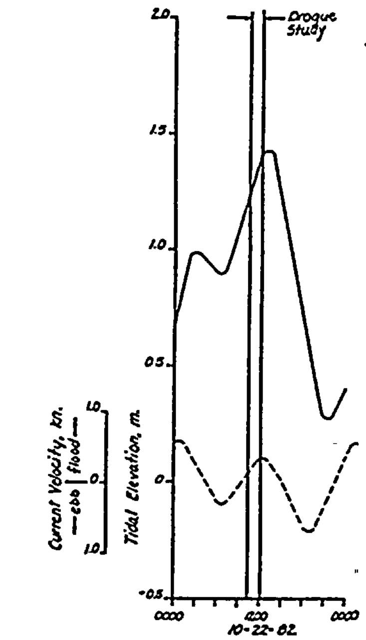

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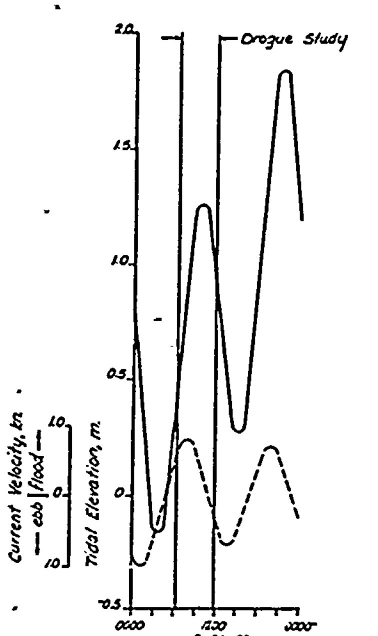

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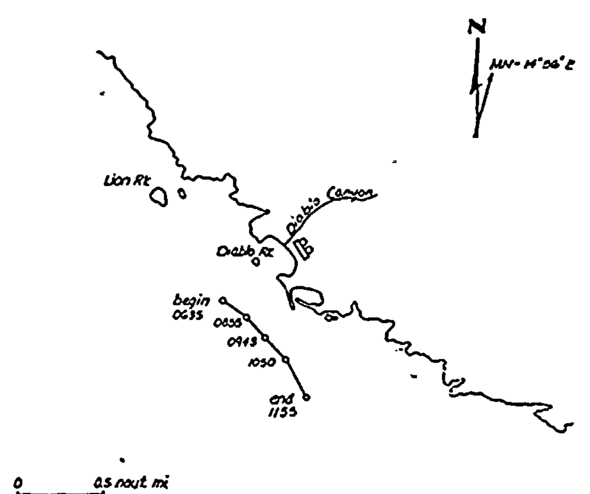

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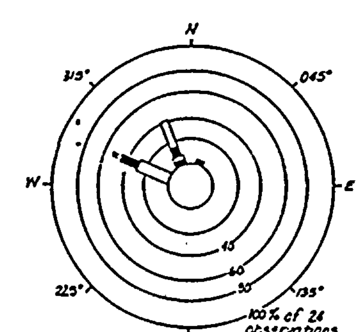

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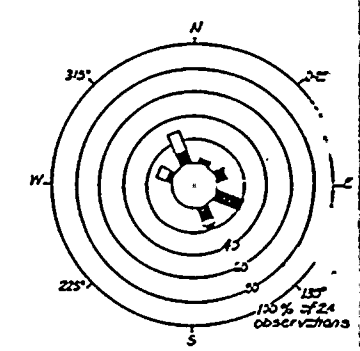

Wind Rose for 10-22-83

Also Available On Aperture Card

Legend
- 0-5 knots
- 6-10 knots
- 11-15 knots
- 16-20 knots
- +20 knots

wind speed & direction

Notes
1. Tide and tidal current from NOAA Tide and Current Tables, West Coast 1982. (Reference Station: Avila Beach)
2. Time reference for March is Pacific Standard Time, for May and October is Pacific Daylight Savings Time.
3. All data referenced to true north.

TI APERTURE CARD

REVISIONS

DIABLO CANYON CURRENT STUDIES
FOR MARCH, MAY AND OCTOBER 1982

DEPARTMENT OF ENGINEERING RESEARCH
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A THREE DIMENSIONAL STUDY OF CIRCULATION PATTERNS IN DIABLO COVE CAUSED BY THE COOLING WATER DISCHARGE AND COASTAL CURRENTS: PG&E DIABLO CANYON, CA, POWER PLANT HYDRAULIC MODEL

by

Thomas R. Kendall

Berkeley, California

June 1982

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Table of Contents

Preface

Most of the flow visualization studies referred to in this report were filmed and appear in the ambiguously titled movie "Mixing of a Thermal Discharge." Some simplified conclusions were made in the movie which, due to more recent data and an effort to go into more detail in this report, will differ slightly from those presented here.

Acknowledgements

The author would particularly like to thank Professor Robert L. Wiegel for his continuous support during this project. Special thanks also go to Hubert Burnett for his invaluable assistance, suggestions, and good humor. In addition, the author would like to thank Ed White for providing necessary equipment; Ed Caine for the photography, and Jim Doyle (Department of Engineering Research, PG&E) for the funding.

Introduction

The nuclear power plant at Diablo Canyon, California when in full operation will reject a considerable amount of heat. For a cooling system, the plant will pump approximately 2,000 CFS of coolent water (~50° F) through each of two reactor units (≈4,000 CTS total).

There is no larger source of cooling water than the ocean and the system will operate by taking in cool ocean water from an "intake cove" and discharging the warmer water (temperatures elevated by about 20° F ≅ 11° C) at Diablo cove (the "discharge cove").

An extensive series of tests was conducted at the University of California's Richmond Field Station in 1975 (5) using a 1:75 scale undistorted hydraulic model of the shoreline adjacent to the plant. The study indicated that the designed cooling system was effective in that essentially none of the discharged warmer waters were recirculated back through the cooling system. In addition, the model study was used to gain a better uderstanding of water motion and temperatures in the discharge cove for making a more detailed assessment of the environmental impact associated with the warm discharge.

The 1976 project report (5) that followed these tests included a qualitative discussion of the circulation in Diablo Cove for the case of reacter unit I being cooled (i.e. 2000 CFS of coolent water being discharged into Diablo Cove). The present report is a sort of addendum to the 1976 report so that

the case of both reactor units being cooled (i.e. discharging 4000 CFS of coolent water) is also addressed.

The present report follows a study which involved the use of dye to develop a qualitative and, in some cases, rough quantitative description of the circulation and mixing in Diablo Cove. In addition, the temperature distribution within the cove resulting from the two unit discharge is summarized. Three current cases were considered: zero, strong downcast, and moderate upcoast. All tests were conducted at mean sea level without wind or waves.

Experimental Procedures

Model

The tests were conducted in the previously mentioned 1:75 scale hydraulic model at the University of California's Richmond Field Station. A detailed description of the 64 by 90 foot hydraulic model is given in Reference 5.

The modelling is based on maintaining the same source Densimetric Froude number (N_{Fo}) inthe model as in the prototype where:

$$N_{Fo} = U_o/((\Delta\rho/\rho_o)gH_o)^{\frac{1}{2}}$$

in which

U_o = speed of discharging jet,

$\Delta\rho$ = difference in density between the receiving and discharging water,

ρ_o = density of discharge water,

g = acceleration of gravity, and

H_o = dimension of the discharge.

Taking H_o to be the depth of flow at the discharge structure (between 6 and 7 feet) and with U_o = 10 FPS, the Densimetric Froude number ranges from 15 to 18½.

The model's discharge is provided by a pump system which is supplied with water from the model intake. The water is circulated through two independent heaters (the "reactor units") and is discharged through the model's discharge structure with

two independently controlled discharge chutes.

The turbulence in the discharge chutes ideally eliminates the need to model Reynolds number within the discharge cove. Outside the cove, current crosses are used to induce turbulence artificially.

The coastal currents are generated by a series of manifolds located along the north and south ends of the model. Depending on what current direction is desired, the pumps can be set so as to have either side's manifolds in suction while the other side discharges.

The currents generated by this closed manifold system were to model a prototype "strong" downcoast current of about .87 FPS and a prototype "moderate" upcoast current of about .61 FPS. (a zero current case was also run). To calibrate these currents, a streak of dye was shot across the basin with a syringe; the dye streak, along with various drogues, served to trace the movement of the water which could be timed. The distribution of current velocities proved to be highly variable and unpredictable, especially in the region extending about eight feet (model) off the end of the west entrance to Diablo Cove. Current reversals were often observed in this region, although these reversals usually occurred only near the surface. While it initially seems disturbing to have such "irregular" unsteady velocity distributions, one must not forget that the velocity distributions found in the ocean are hardly uniform or steady and that perhaps the irregular velocity distributions observed are more representative, being more compatible

with the coastline features and bathymetry.

Another problem involved the formation of a film on the water surface which could modify circulation and temperatures. Such a film could form as quick as 15 minutes (the time allowed for establishing equilibrium of the currents and discharge before a test was run). While this problem was usually taken care of by continuously skimming the surface layer with an overflow weir, occasional unexplained fluctuations were still observed in surface flows in the cove.

Another possible source of error was due to the fact that many of the runs lasted up to one and a half hours causing heating of the upper surface layer offshore and a thermocline in the ambient waters that would not be realized in the prototype. This problem was acclerated by the lighting used during long photography sessions. Again skimming with the weir helped remedy this.

Temperatures at the intake and discharge were monitored during all tests with digital thermometers and the water level was carefully monitored during all tests to assure that it remained at mean sea level. Since waves were not modelled in the study, caution must be taken when interpreting the results for the "south cove" of Diablo Cove (see Figure 1) as this shallow area is actually in the surf zone.

Flow Visualization

For each coastal current case four types of flow visualiza-

tion techniques were used. The first involved laying a grid of dye over the cove. The subsequent deformation of the grid reflected the surface circulation. The second technique involved placing dye crystals on the bottom and observing the dye "vectors" formed in the lee of the crystals, thus indicating bottom flow. The third method involved placing vertical streaks of dye at various locations in the basin. The subsequent spreading and shearing of each dye column served as an indication of the velocity profile there. The final technique involved placing dye in the discharge chute which then traces the discharged water.

Numerous observations were made using these methods and all but the vertical dye streaks were phtoographed from a bridge crane above the model. The photographs were taken at an angle so that there is some optical distortion.

DYEGRID

An overlay has been placed on a photograph in Figure 1 to demonstrate how the distortion of a dye grid is used to determine surface circulation. Note that Figure 1 alone is not sufficient to come up with the circulation given on the overlay. To do this requires examination of the complete dye grid sequence (Plates 1 through 8 in this case).

The use of a dye grid is a good supplement to the more standard technique of placing dye in the discharge in that it indicates flow patterns in regions not reached by the traced

discharge and clearly demonstrates eddies.

The dye used to lay the dye grids was not light enough to remain strictly on the surface and some of the dye sank to different layers of the water column. This proved not to be a problem as long as first hand observations were made as to which dye pattern was tracing which layer. For example, Plate 49 shows a dye line that originally ran along the north entrance, now split into two lines, one exiting the cove (a mid-depth layer), and one entering the cove (a surface layer).

One final note on the dye grid technique. The syringe used to create the red dye lines had a relatively large opening which unfortunatley tended to produce rather wide "lines".

DYE CRYSTAL VECTORS

Potassium permanganate crystals were sprinkled over the cove to create the bottom dye vectors. (Figure 3 illustates the formation of these vectors.) Through the use of overlays, Figures 4, 12, and 18 demonstrate how this method lends itself to an interpretation of bottom flows. Photographs in Figures 12 and 18 are taken from tests conducted by Frederick et al. (2). These photographs were used since they were shot at less of an angle and the tests used fewer dye crystals, resulting in much clearer pictures for illustrative purposes. These photographs, however, do not provide sufficient detail around the north entrance to the cove.

To come up with sketches of the bottom flows, first hand

observation was primarily relied on, especially in areas nearer the jet axis where high velocities cause the dye vectors to run together before dye vectors elsewhere can fully form. A certain amount of judgement was required in developing bottom flow descriptions since some dye vectors merely form as the result of gravity flows and do not represent the larger scale pattern of interest. This type of judgement was especially needed when working in the irregular bathymetry of the cove's west entrance.

VERTICAL DYE STREAKS

To create the vertical dye streaks used for observing stratified flows, the dye was injected (carefully) with a long needle syringe, straight up from the bottom. The deformation of the dye line provided a qualitative idea of the velocity profile at the point of injection. Discrete patches of dye were then placed over the point at specific depths and their motion was timed in order to provide a rough quantitative idea of the velicity profile.

It must be emphasized that the profiles presented in this report show much more accuracy than can really be expected. The quantitative approach was only intended to provide a better idea of how the velocity profiles changed with the introduction of this or that current. They are not intended to be absolute as much as comparative.

Velocity profiles were established in this way along the

north and west entrances to the cove. Vertical dye streaks were also placed in the suspected lift-off region (where the effluent cloud detaches from thebottom of the basin) to see if strong shearing was exhibited.

DYE IN THE DISCHARGE

After the other three tests, a fairly good three-dimensional description could be made of the circulation in the cove. Placing dye in the discharge (e.g. Plates 9-18) more or less confirmed this description and indicated which areas of the cove would be most affected by the discharge. This demonstration of which areas were most affected by the discharge was subsequently confirmed by the temperature distribution in the cove.

Temperatures

Temperature data were taken at various locations within the cove using a digital thermometer. These values were then averaged in with published and unpublished temperature data taken for the project report of January 1976 (5). These data were taken with mounted thermistor probles. Additional data was also averaged in for the downcoast current case after a new series of tests was conducted in February 1982. This most recent series also used a digital thermometer. In order to assure accurate readings with depth, the thermometer probe was mounted horizontally to a point gage attached to a carriage

which traversed the basin.

Temperatures are reported here at depths of .025 feet (~ 2 feet prototype) and .225 feet (~ 17 feet prototype) below mean sea level. These are merely averages of limited data that exhibited great scatter. The most data existed for the down-coast current case and the least for the zero current case.

Presentation of Results

All results are presented graphically in the figures and plates at the back of this report and will be discussed in the following sections.

General Behavior of the Buoyant Surface Set

As indicated in Figures 1 and 2, the bulk of the discharge proceeded out the west entrance while eddies formed off either side of the jet axis. The jet generally took less than a minute (around 8 minutes prototype time) to reach the west entrance.

The behavior of the buoyant surface jet and the mixing and final temperature distribution within the cove are principally a function of jet momentum and buoyancy, local bathymetry, and the direction and magnitude of the flow through the north and west entrances to the coves. This flow provides a flushing action which is greatly affected by the type of coastal current that is acting. Other factors not treated in the tests include winds, waves, and tidal flushing.

The vertically acting buoyancy forces which result when the discharge enters the cooler ambient are translated into a horizontal radial pressure gradient which acts uniformly in all horizontal directions. This, in turn, tends to spread out the buoyant liquid at the surface. Since the warm discharge also causes density stratification in the cove waters, flows at the surface can be quite different from those at lower depths.

This was often demonstrated when the warmer surface layer advected away from the axis of the jet while bottom flows still entrained towards it (contrast Figure 2 with Figure 5).

The jet is initially momentum dominated and attached to the basin floor. At this point there is a large entrainment demand due to a momentum pump effect which draws in the surrounding fluid as a result of the low pressures in the wake of the jet.

Taylor (1) hypothesized that the velocity of inflow of diluting water into any jet would be proportional to the mean velocity in the jet at the point of inflow. This is consistent with the observation of much stronger entrainment in the higher velocity regions nearer the discharge structure.

As the entrainment demand becomes less and less, some of the spreading surface layer circulates back to be reentrained into areas along the jet axis where the entrainment demand is not being adequately met by fresh ambient waters. This unmet demand situation especially exists along the shallower areas since the jet is attached and the entrainment demand can only be met from the sides of the jet, not the bottom. Since heated water circulates back to reentrain into the jet, dilution is reduced. The exact location, size and depth of the circulation cells or eddies that result are a function of the coastline features, bathymetry, and currents.

The lift-off region or separation point (see Figures 7 and 8) is described by Safaie (4) as occurring when the small

scale turbulent eddies in the flow do not have enough kinetic energy in the vertical direction to overcome the opposing buoyant force and reach the bottom. The separation point is one way of defining when the momentum dominated region gives way to the buoyancy dominated region. As shown in Figure 8, this point occurs in all cases just off cove rock. Note how the dye crystals in Figures 4, 12, and 18 are washed away prior to this point, reflecting that the turbulent core has not yet detached. The separation point is also evidenced by a noticeable drop in bottom temperatures.

Safaie (4) has shown that the depth at lift-off, H is related to the discharge depth, H_o by the equation:

$$H = .914\ H_o(N_{Fo}(H_o))^{\frac{1}{2}},$$

where $N_{Fo}(H_o)$ is the source Densimetric Froude number defined previously, with the dimension of the discharge again being taken as the depth of flow at the discharge structure. As judged from application to the PG&E model for different N_{Fo}'s, this relationship appears to hold in regions of rather complicated shoreline geometry and bathymetry.

In our case ($H_o \cong 6'$ and $N_{Fo} \cong 16$), this equation predicts $H = 22'$ which is quite consistent with the depths of around 20 feet (prototype) which occur along the jet axis near cove rock.

It is interesting to note that Safaie's relationship is independent of the aspect ration of the discharge. Since running unit II in addition to unit I only changes the width of the discharge structure not the depth or velocity, Safaie's rela-

tionship would predict the same lift off location (depth) to occur. This turned out to be true in that the 1976 project report (5), indicated that the lift-off region for the single unit case was also near cove rock.

As the jet passes over the relatively shallow center of the west entrance (prototype depths between 10 and 20 feet), the jet depth is once again approximately equal to the water depth and the jet is reattached briefly. This is evidenced by the fairly uniform velocity profiles (representative of attached flows) that were observed there (e.g., see Section 5 of Figure 6).

Case I: Zero Current Results

Figures 1 and 2 illustrate the surface circulation as determined from first hand observations and the use of Plates 1 through 8 (dye grid) and Plates 9 through 18 (dye in the discharge).

A counterclockwise eddy forms off the south side of the jet axis, turning into the south cove just before cove rock. This eddy "gears" with a clockwise eddy further back in south cove. With the exception of the first foot or so (model scale) off the east bank and the beginnings of the counterclockwise eddy, all surface flow from the south cove is entraining into the jet. The section near the east bank which heads away from the discharge does so only at the very surface. Just below the surface, all but the flows snug against the bank are

entraining into the jet.

The circulation (as well as temperatures) in the south cove seemed relatively insensitive to currents and behaved similarly in all three cases.

To the north of the discharge, dye occasionally sloshed away from the discharge along the east bank and remained trapped in a sort of dead zone; however, just off the bank the flow was entraining. The clockwise eddy formation on the north side is much more extensive and much slower than the south side eddy.

The north end eddy is shown best by the blue dye line in the center of Figure 1 and Plates 1 through 8. Note that it pivots about a point roughly halfway between the second and third north-south running mounting rods. Cases II and III will show how the introduction of currents will cause the location of the northside eddy to shift.

A fairly uniform surface inflow occurred over the north entrance. Unfortunately, Plates 1 through 8 show an unusually strong inflow near the west end of the north entrance; this was not found to be typical. The splitting of the dye line at the bottom of the picture in Plates 1 through 8 resulted from some of the dye sinking to lower depths where the inflow was slower. The northeast corner of the cove remained relatively stagnant.

Figures 4 and 5 illustrate the bottom circulation observed. The very north end of the cove is cropped out of the photograph

in Figure 4, however, Plate 9 shows this area quite well.

The south cove is quite shallow and the eddy pair observed near the bottom was found to be similar to that found near the surface. Entrainment was evidenced along most of the jet core. Inflow occurred along the entire north entrance. The west entrance showed an inflow near the northwest rock and at the far south end of the entrance, while flows in the middle of the entrance were out. This is due to the fact that there are deep channels at both ends of the entrance through which the cooler strata flow in. Just above these coolor strata, warmer strata are flowing out (see sections 4 and 6 of Figure 6).

Figure 6 shows three-dimensional velocity profiles as well as a rough breakdown of the depths along each entrance. For the actual nearshore topography, the reader is referred to the 1976 project report (5). The 30-foot (prototype) depth at section 6 (the extreme south end of the west entrance) only exists a little ways into the cove before it rises back to a 10 to 15 foot depth. Because of this, bottom flows tended to head in this deep passage only to climb up to the shallower areas where warmer outflowing strata would drive them out again, thus creating a sort of vertical circulation cell.

Figure 9 shows the temperature distribution which results for the zero current case. Temperature rises are given at prototype depths of approximately 2 and 17 feet below mean sea level. In areas where it was too shallow, the second reading

was not given.

The thermal stratification is fairly apparent from the readings for the north and west entrances. The temperature distribution is very indicative of where the discharged warm water goes (e.g. compare the hot spots with the heavy dye concentration spots in Plates 9 through 18). Clearly the slow wide sweeping eddy of the north end does not introduce as much heat (relatively speaking) to the north entrance areas as the rapid circulation of the south end eddy brings to the shallow south cove.

Cases II and III will demonstrate how the introduction of currents (and therefore new flushing characteristics) will alter the temperatures shown in Figure 9.

Case II: Strong Downcoast Current Results

Figures 10 and 11 along with Plates 19 through 30 (dye grid) and 31 through 40 (dye in discharge) show the surface circulation for the downcoast current case. The south cove pattern is very similar to the zero current case; however, as the result of the stronger inflow through the north entrance, the primary clockwise eddy of the north end is pushed further out and a secondary counterclockwise eddy forms nearer shore.

Figures 12 and 13 demonstrate the bottom flows for the strong downcoast case. The best available photograph for a downcoast current is from tests by Frederick et al. (2) for a moderate current which was found to demonstrate qualitatively

a very similar bottom circulation. This photograph has therefore been used in Figure 12.

The major difference in bottom flows between the zero current case and the downcoast, is that we now see a clearly defined flow in the north entrance and out the west.

Comparing velocity profiles along the north entrance for the downcoast case (Figure 14) with those for the zero current case (Figure 6), it is clear that the mid-depth (and total) inflow is much stronger as a result of the downcaost current. Note that this conclusion could not be drawn from the dye grid alone since the surface layer actually exits at both ends of the north entrance. Although the way in which the north entrance dye line folds into a spike protruding into the cove does reflect the southeast heading of the midlayer flow of the west end. Note too that the inflow over the lower portion of section 4 on the west entrance has been reduced by the introduction of the downcoast current.

There is more of a trend for flow in the north and out the west under the strong downcoast current. Because of this increased circulation and flushing with cool outside waters, the cove temperatures are generally cooler. For example, comparing Figure 15 with Figure 9, we see that the west entrance and areas north of the discharge have dropped between 1 and 3 degrees Celsius while the south end temperatures are only up ½ degree.

Case III: Moderate Upcoast Current

Figures 16 and 17 along with Plates 41 through 49 (dye grid) and 50 through 62 (dye in discharge) show the surface circulation for the moderate upcoast current case.

Plates 50 through 62 show a dye in the discharge run which used much more dye than previous runs. As a result, it provides evidence of a subtlety previously mentioned, i.e., the small spreading along thebanks to the north and south of the discharge structure.

The south cove pattern is once again very similar to the zero current case, however, as a result of stronger mid-depth inflows from the west and the initiation of a mid-depth outflow along the north entrance, the clockwise eddy of the north end is now pushed back further into the cove than it was in the zero current case.

The splitting of the dye line at the north entrance is due to some dye sinking down to follow the exi ting midlayer.

The surface layer at the west end of the north entrance is shown in Figure 17 to be heading out but is labeled "unstable." While the flow here is usually out, a notable exception shows up in Plates 58 through 62 in which a blue dye line in laid along the north entrance and the whole surface layer is shown to head in not out. As this is more the exception than the rule based on numerous observations outside of the photo session it was suspected that this occurred because of the formation of a thermocline in the ambient that did not exist

during the ealier dye grid sequence (Plates 41-49).

Bottom flows shown in Figures 18 and 19 are now in along the west entrance and out over half of the north entrance (almost a complete reverse from the downcoast case).

Velocity profiles shown in Figure 20 demonstrate that the upcoast current causes much stronger inflows in the two deep areas of the west entrance and force mid-depth outflows at the north entrance.

Figure 21 shows that the additional flushing provided by the upcoast current caused lower temperatures at the west entrance by about one degree. On the other hand, the temperature at the north entrance is up a degree since the upcoast current draws more warm water to the north entrance.

Conclusions

Based on thermal data and several flow visualization tests, the following generalized conclusions can be made about the circulation patterns in Diablo Cove.

The buoyant surface jet issued into Diablo Cove is attached to the basin floor until it reaches about a twenty foot depth (near cove rock). The jet then detaches and most of it proceeds out the west entrance. Just before cove rock, however, some of the effluent turns into the south cove and forms an eddy pair. Similarly, a slower much more extensive clockwise eddy fills the northern part of the cove. The eddies reentrain previously discharged water back into the jet thus reducing dilution.

The introduction of a downcoast current increases the flow of cool flushing water through the north entrance and out the west. This causes generally cooler temperatures within the cove. The downcoast current also tends to shift the north eddy further offshore. The circulation in the south cove appears unaffected by currents.

The introduction of an upcoast current causes increased inflow through the west entrance and an outflow at the north. this provides better flushing than existed without a current, and temperatures drop at the west entrance, however, not as much as they did during a downcoast current. Since the upcoast current draws more warm water to the north entrance, tempera-

tures there are warmer than for the zero current case. The upcoast current tends to shift the north eddy further into the cove.

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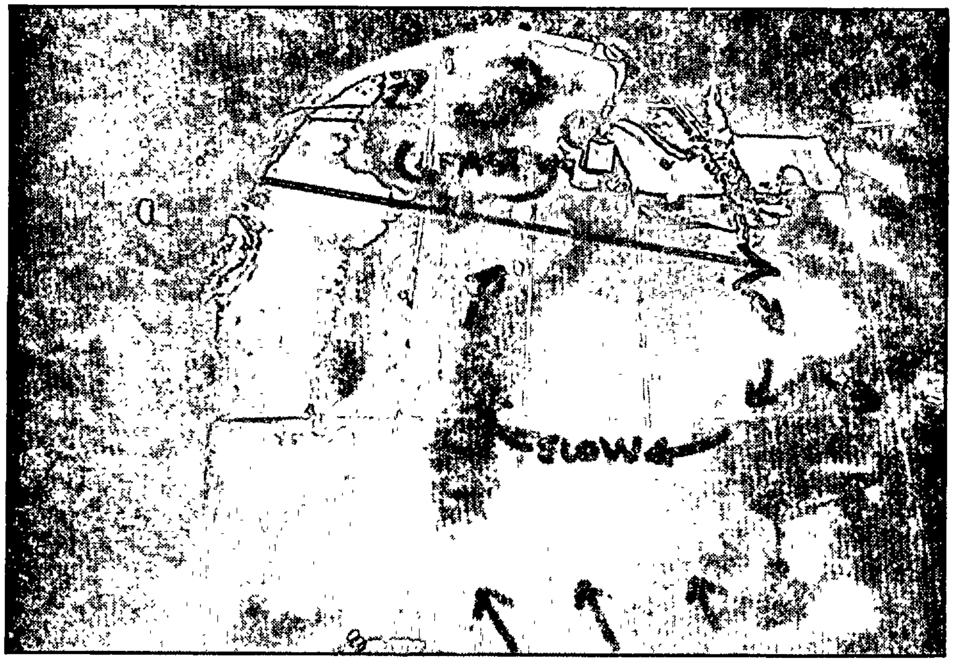
South Cove

N

Discharge

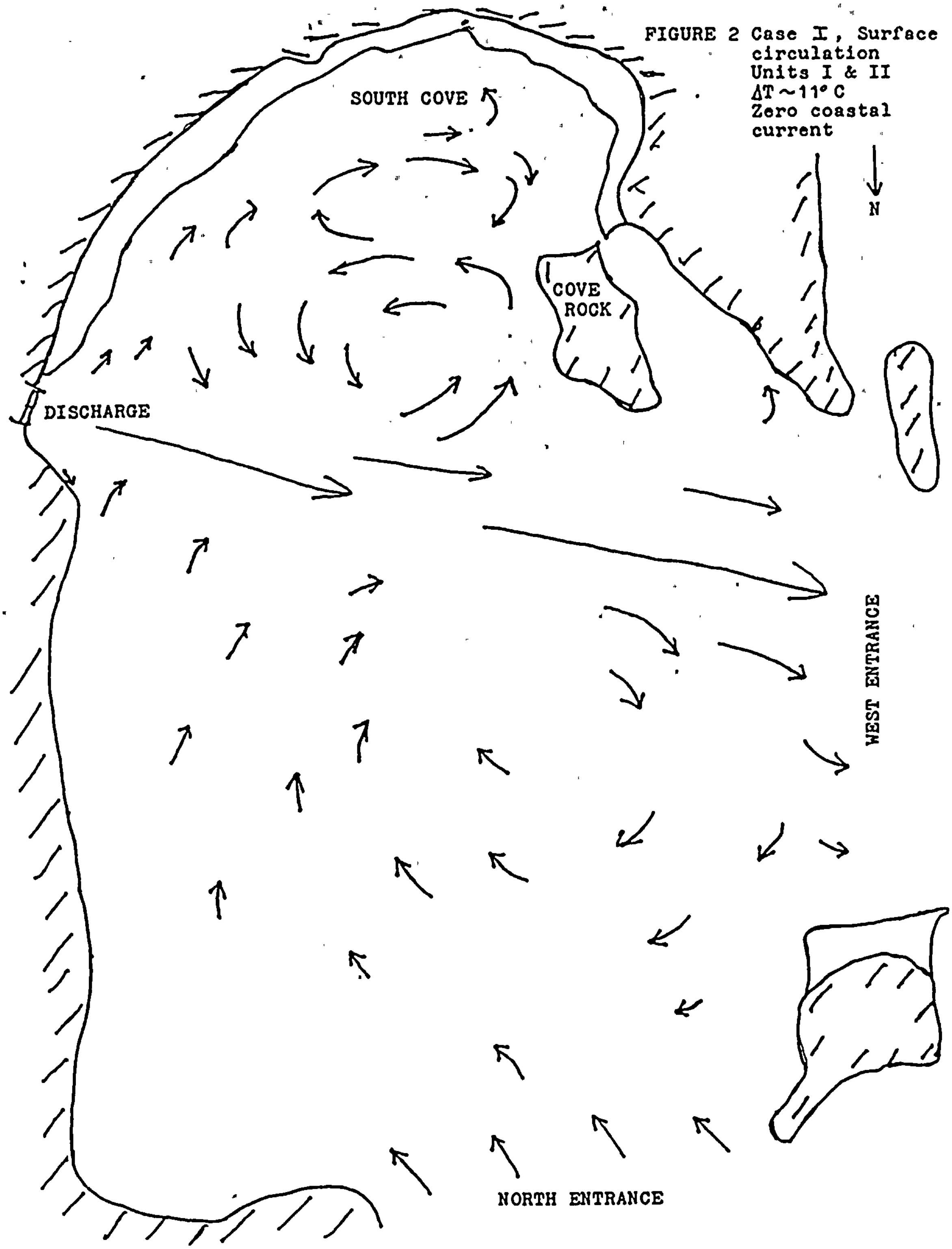


West Entrance

North Entrance

FIGURE 1:. Case, I, Use of a dye grid to determine the surface circulation resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and zero coastal current.

FIGURE 2 Case I, Surface circulation
Units I & II
ΔT ~ 11° C
Zero coastal current



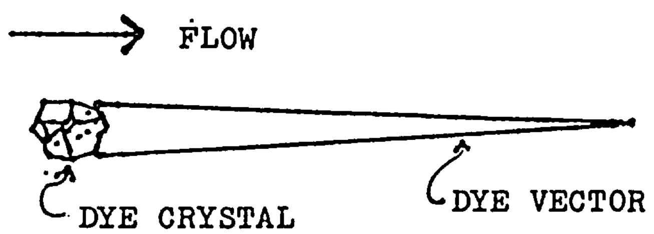


FIGURE 3 Bottom flows are determined by placing dye crystals on the bottom and observing the dye "vector" formed in the lee of the crystal.

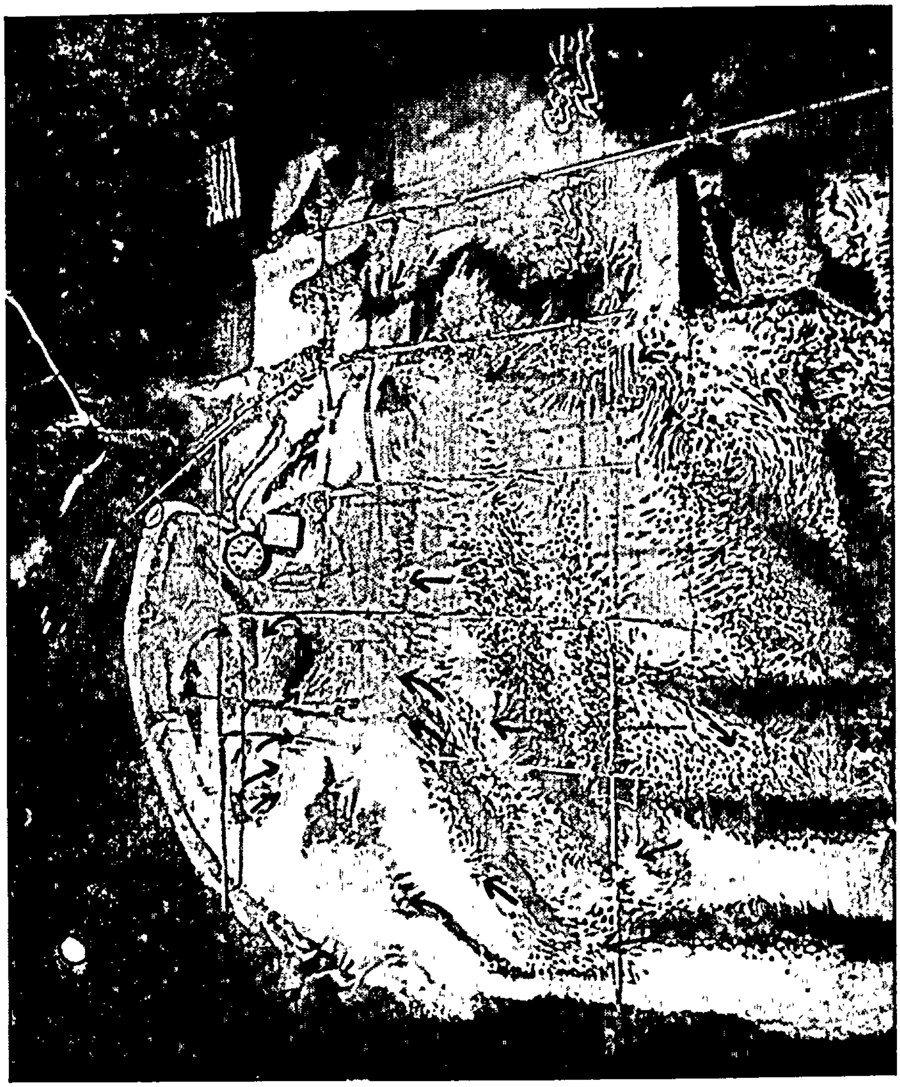
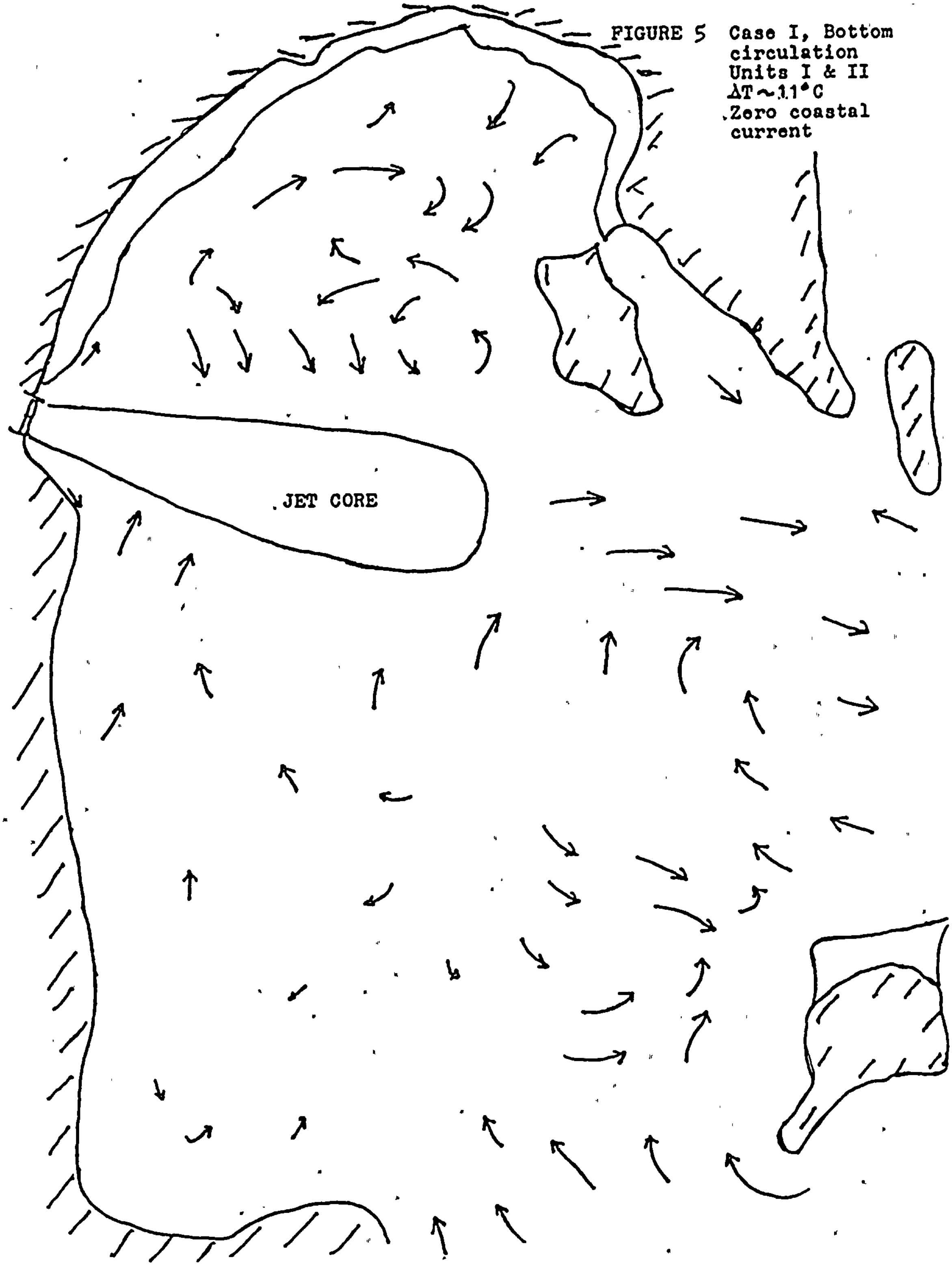
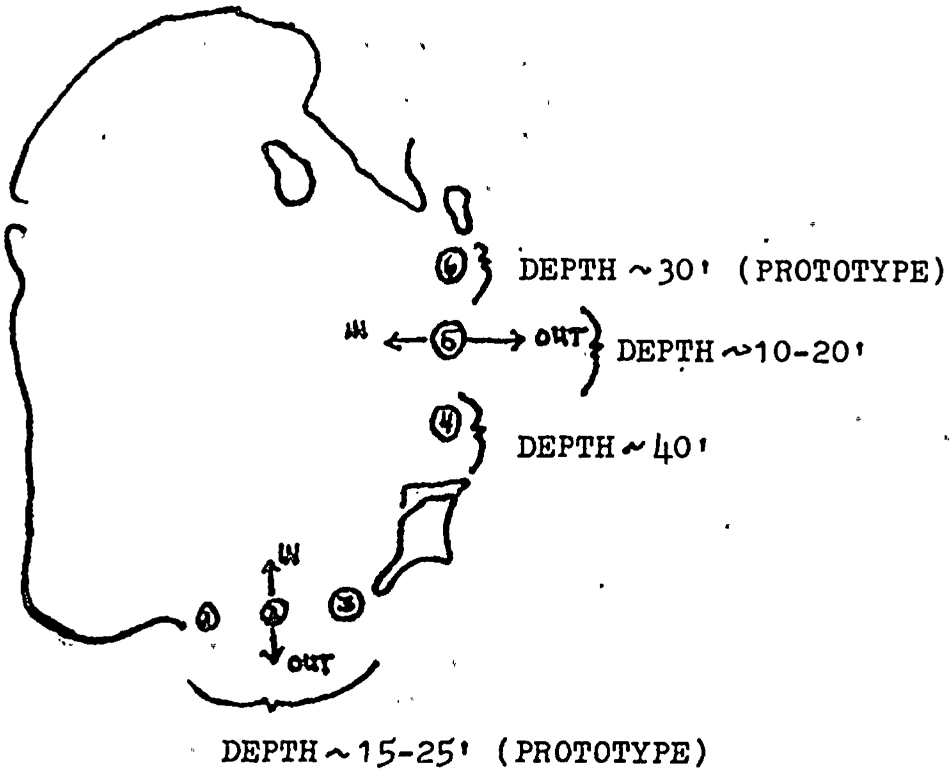


FIGURE 4: Case I, Use of dye crystals to determine the bottom circulation resulting from a warm cooling water discharge with both Units I & II operating and zero coastal current.

FIGURE 5 Case I, Bottom circulation Units I & II $\Delta T \sim 11°C$ Zero coastal current





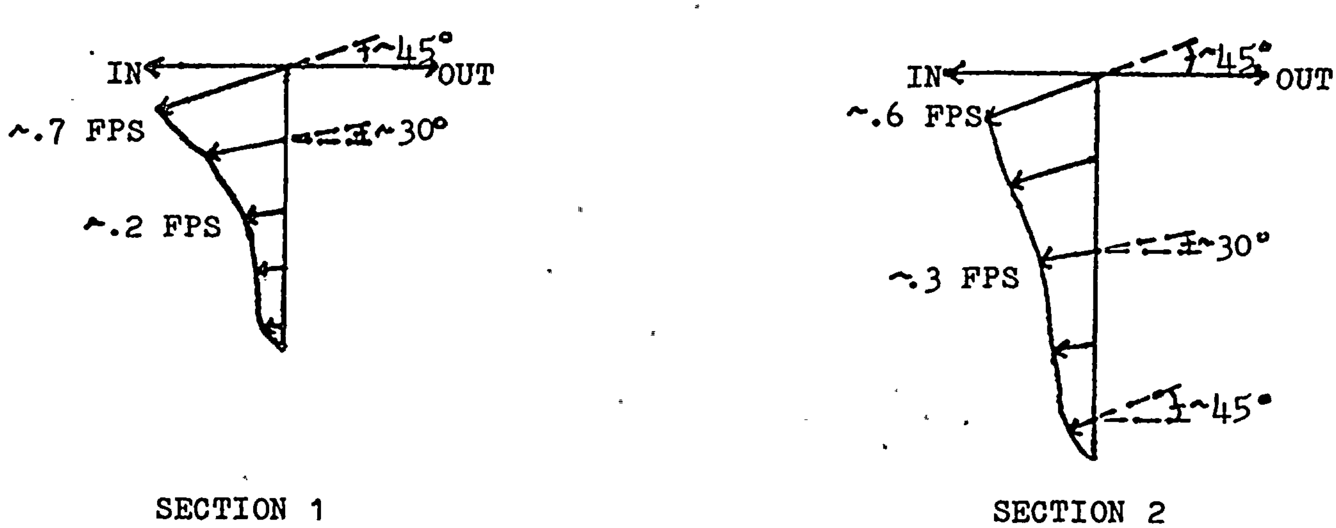


FIGURE 6a Case I, Cove entrance velocity profiles (converted to prototype values) resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and zero coastal current.

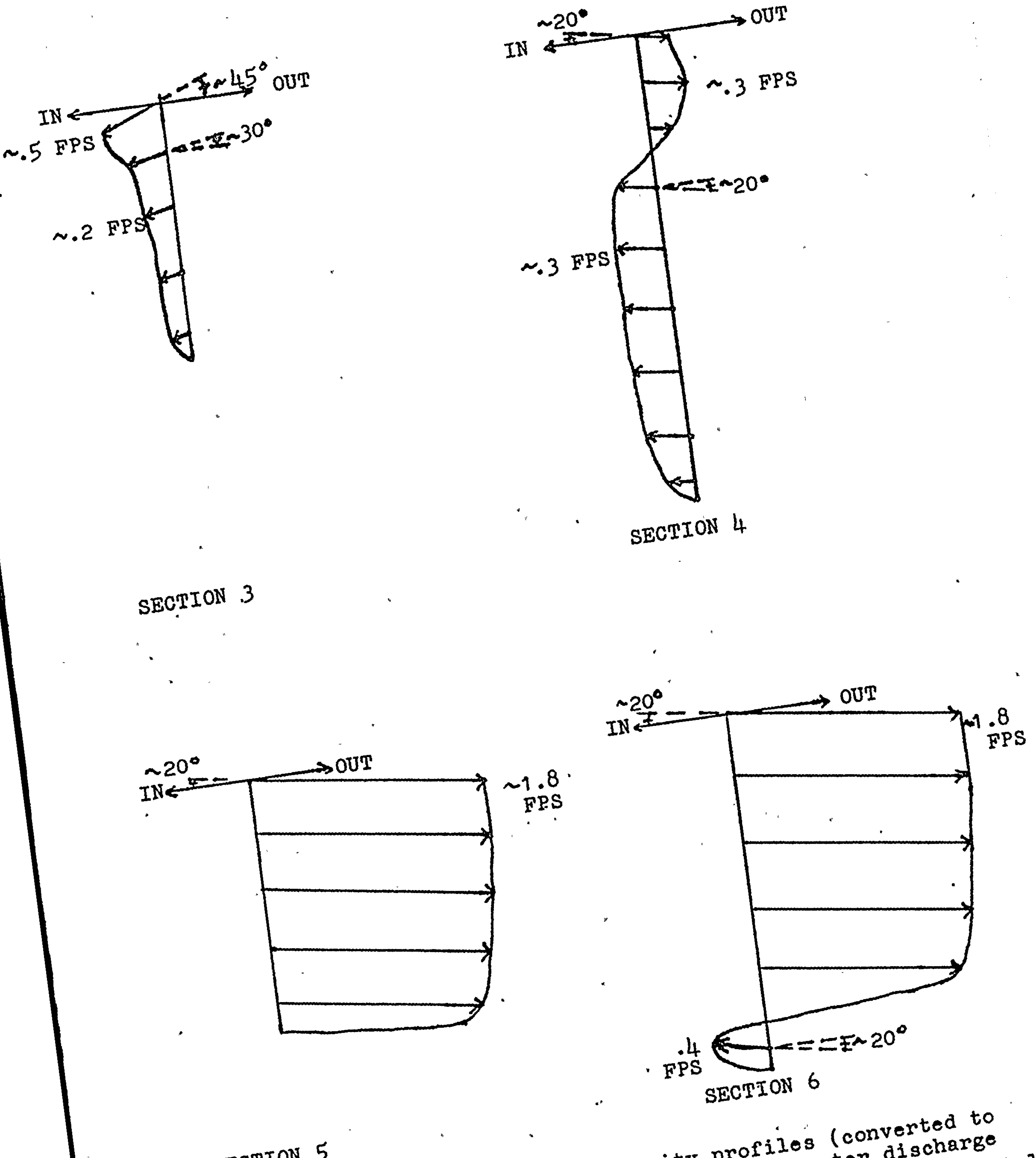
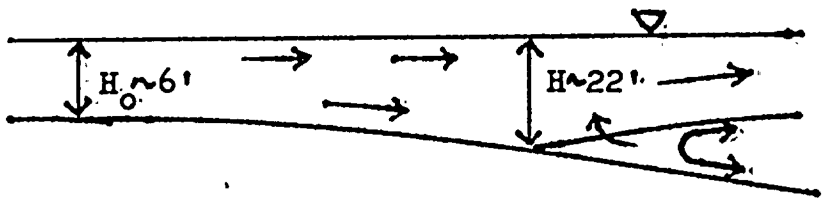


FIGURE 6b Case I, Cove entrance velocity profiles (converted to prototype values) resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and zero coastal



$$H = .914 H_o (N_{F_o}(H_o))^{1/2}$$

FIGURE 7 Depth at separation point

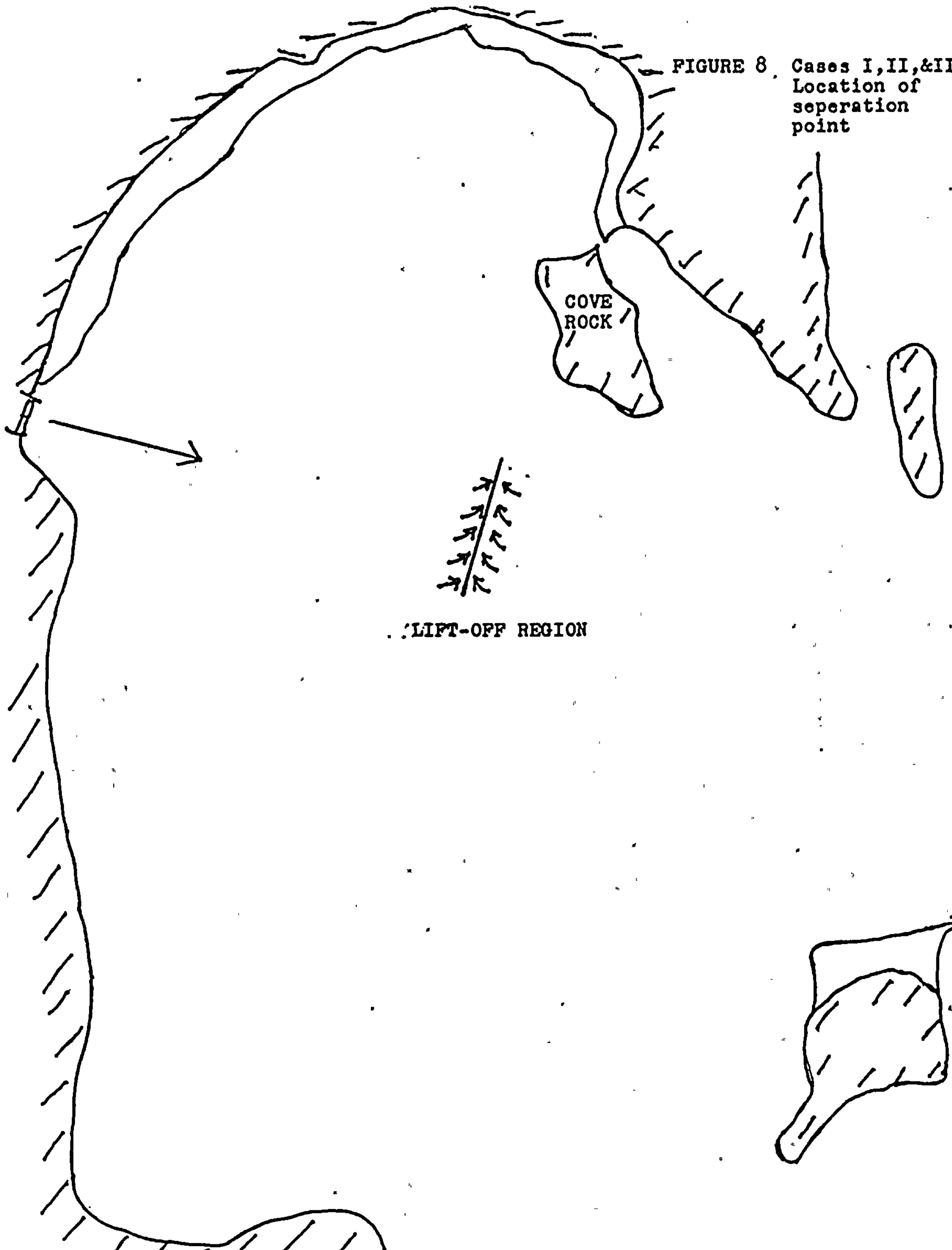
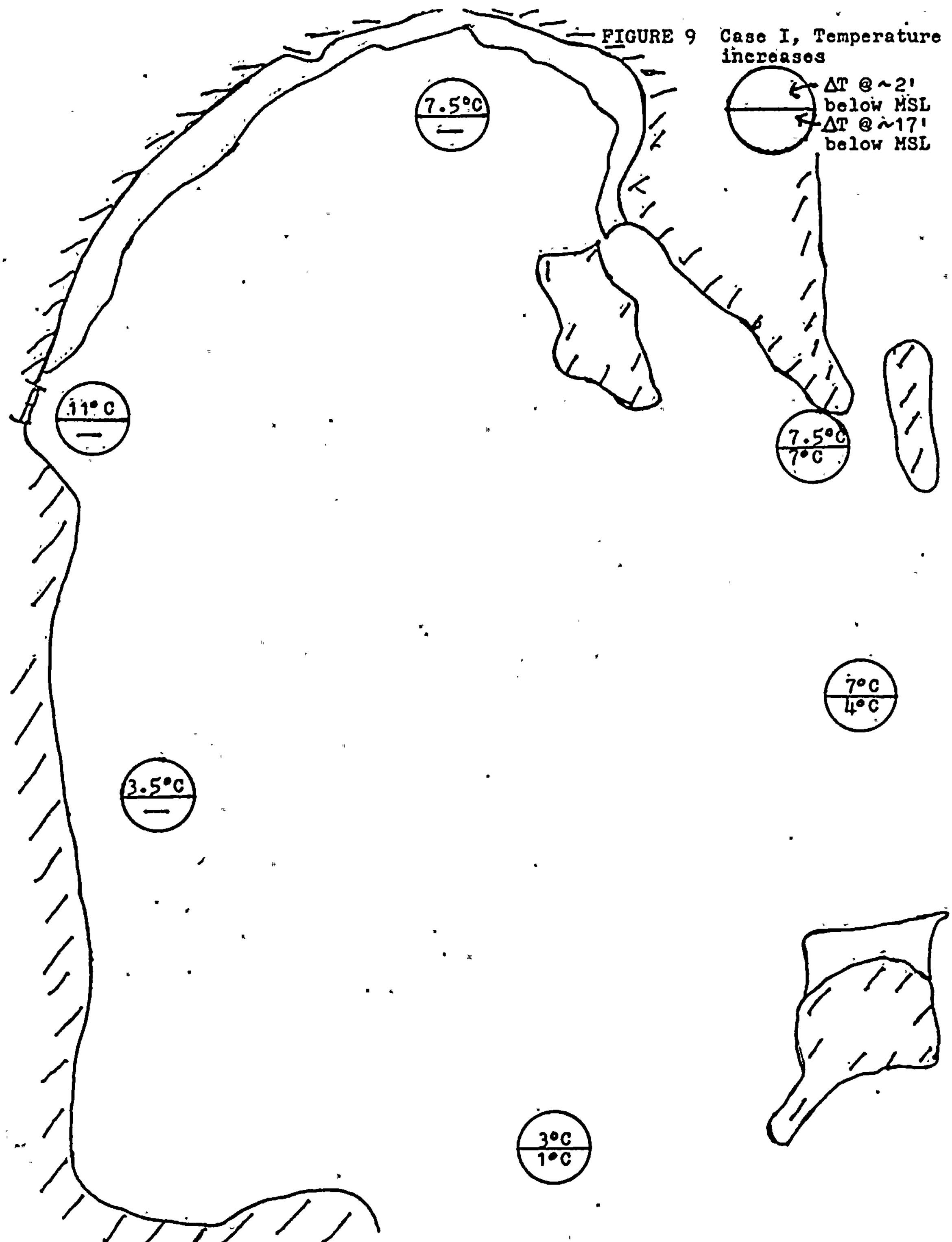


FIGURE 8 Cases I,II,&III Location of seperation point

FIGURE 9 Case I, Temperature increases



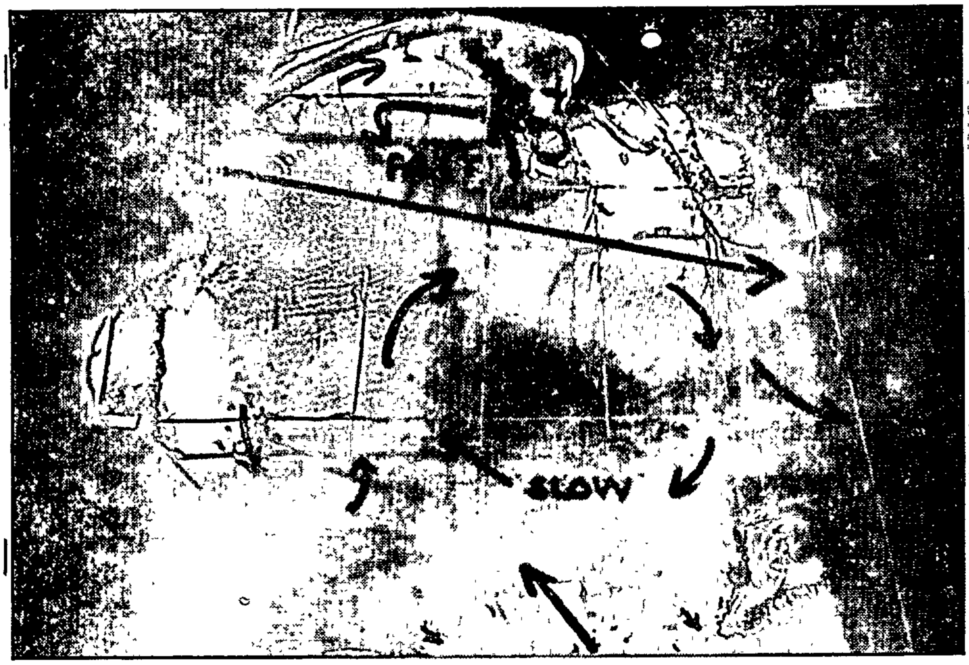


FIGURE 10: Case II, Use of a dye grid to determine the surface circulation resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and a strong downcoast current.

FIGURE 11 Case II, Surface circulation
Units I & II
$\Delta T \sim 11°C$
Strong downcoast current

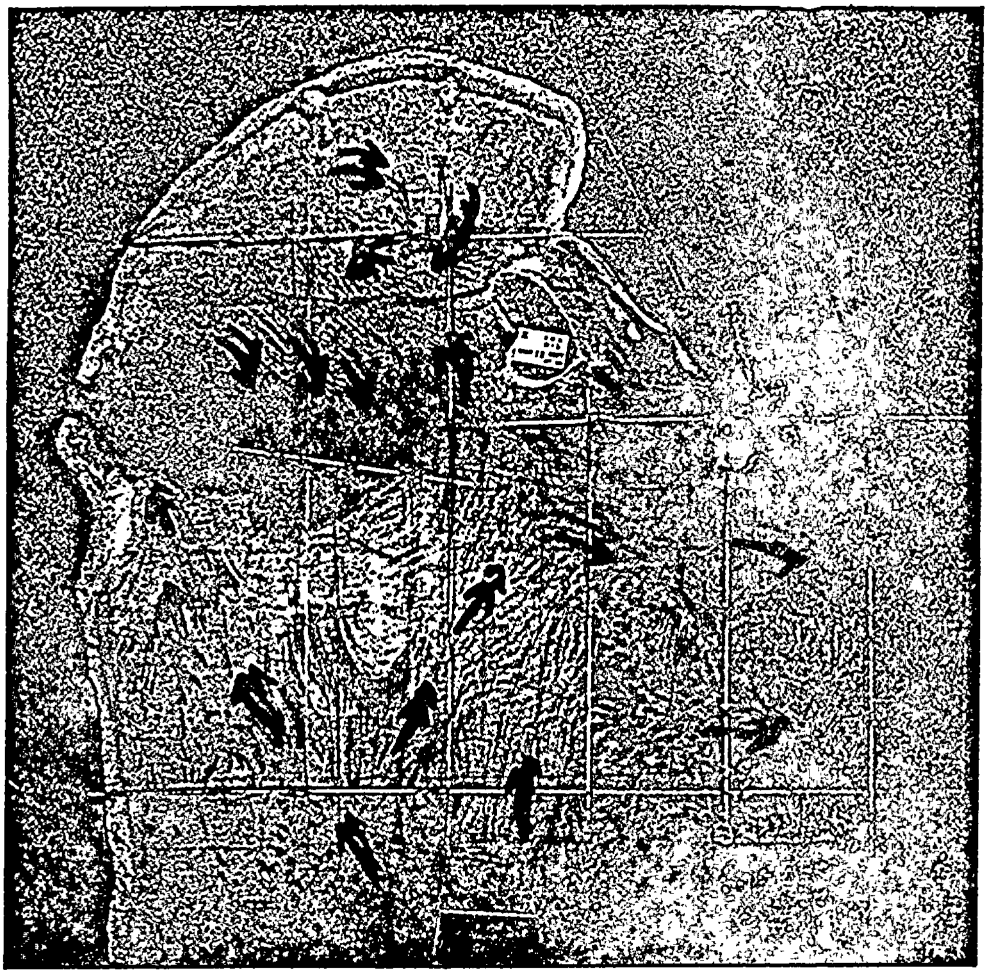


FIGURE 12 Case II, Use of dye crystals to determine the bottom circulation resulting from a warm cooling water discharge with both Units I & II operating and a moderate* downcoast current.

*similar results for strong downcoast current

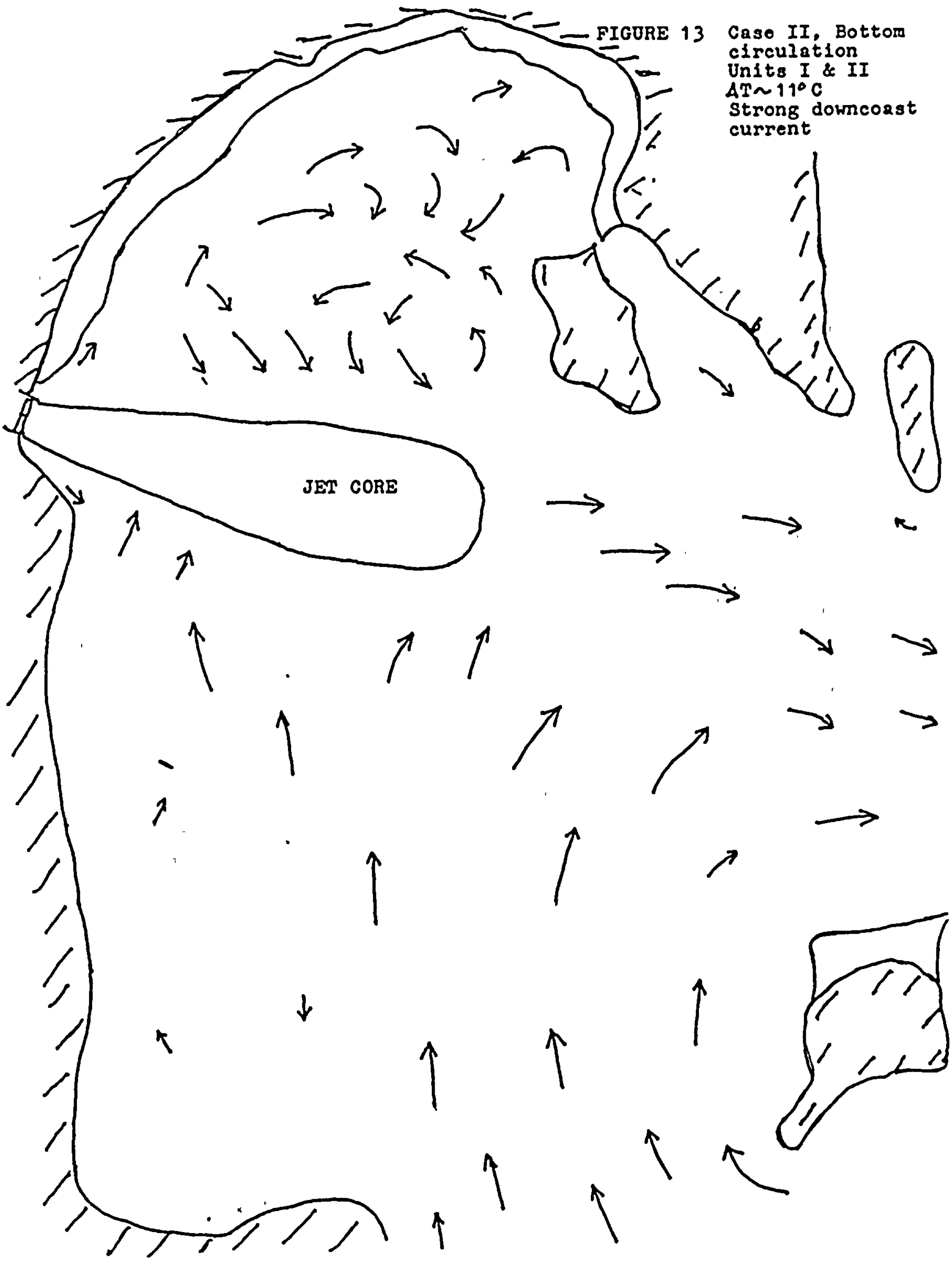
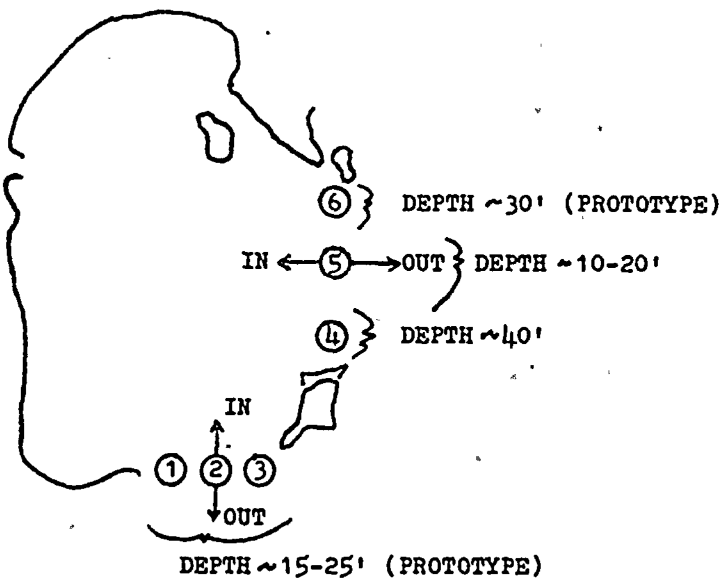


FIGURE 13 Case II, Bottom circulation
Units I & II
ΔT~11° C
Strong downcoast current



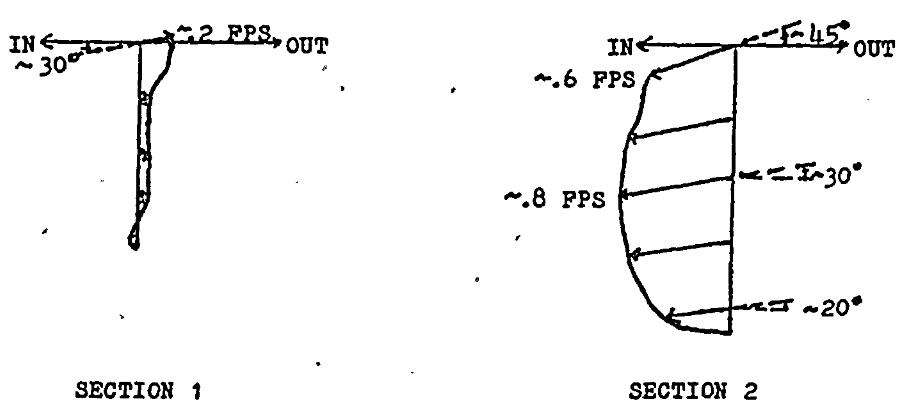


FIGURE 14a Case II, Cove entrance velocity profiles (converted to prototype values) resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and a strong downcoast current.

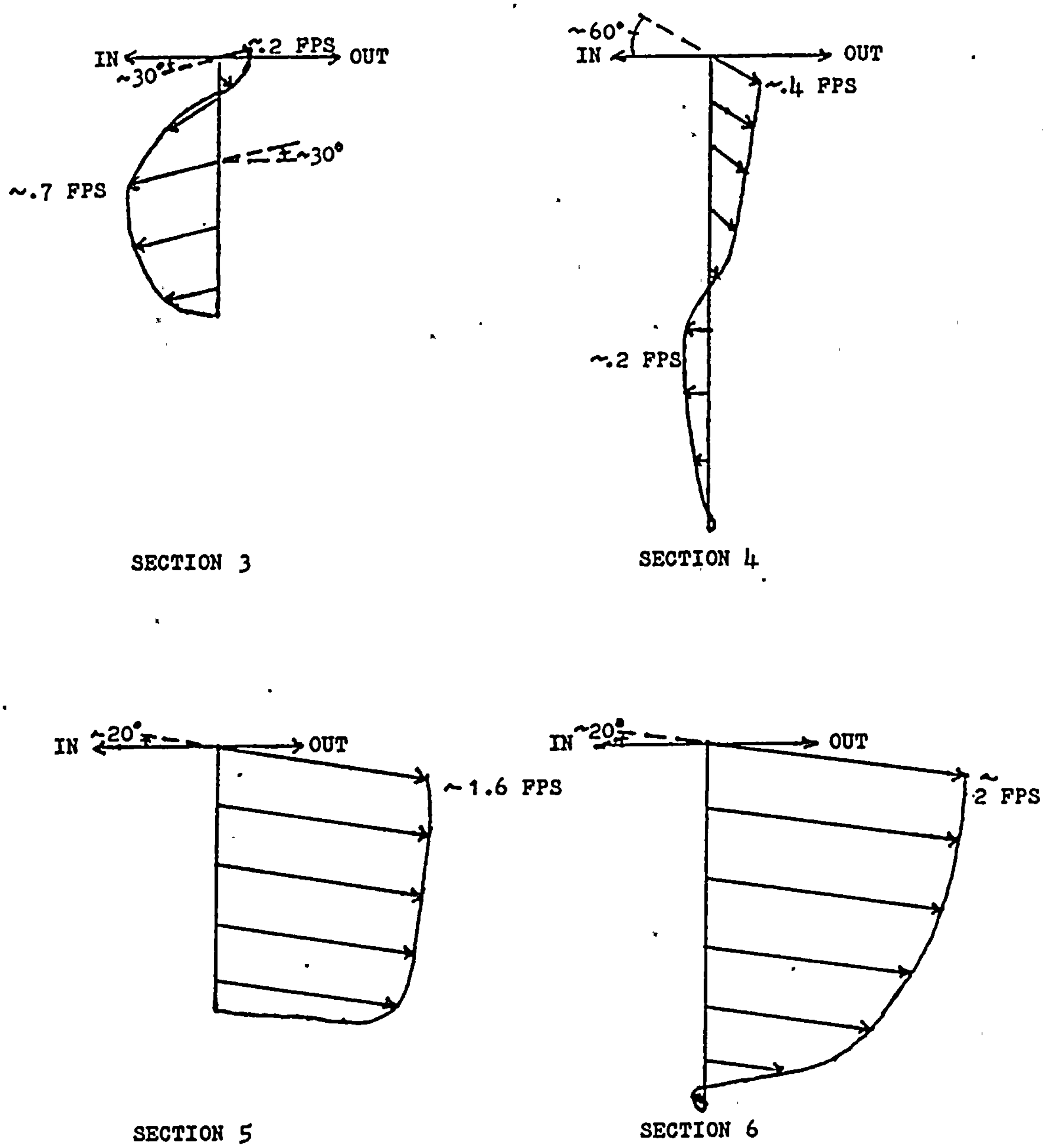


FIGURE 14b Case II, Cove entrance velocity profiles (converted to prototype values) resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and a strong downcoast current.

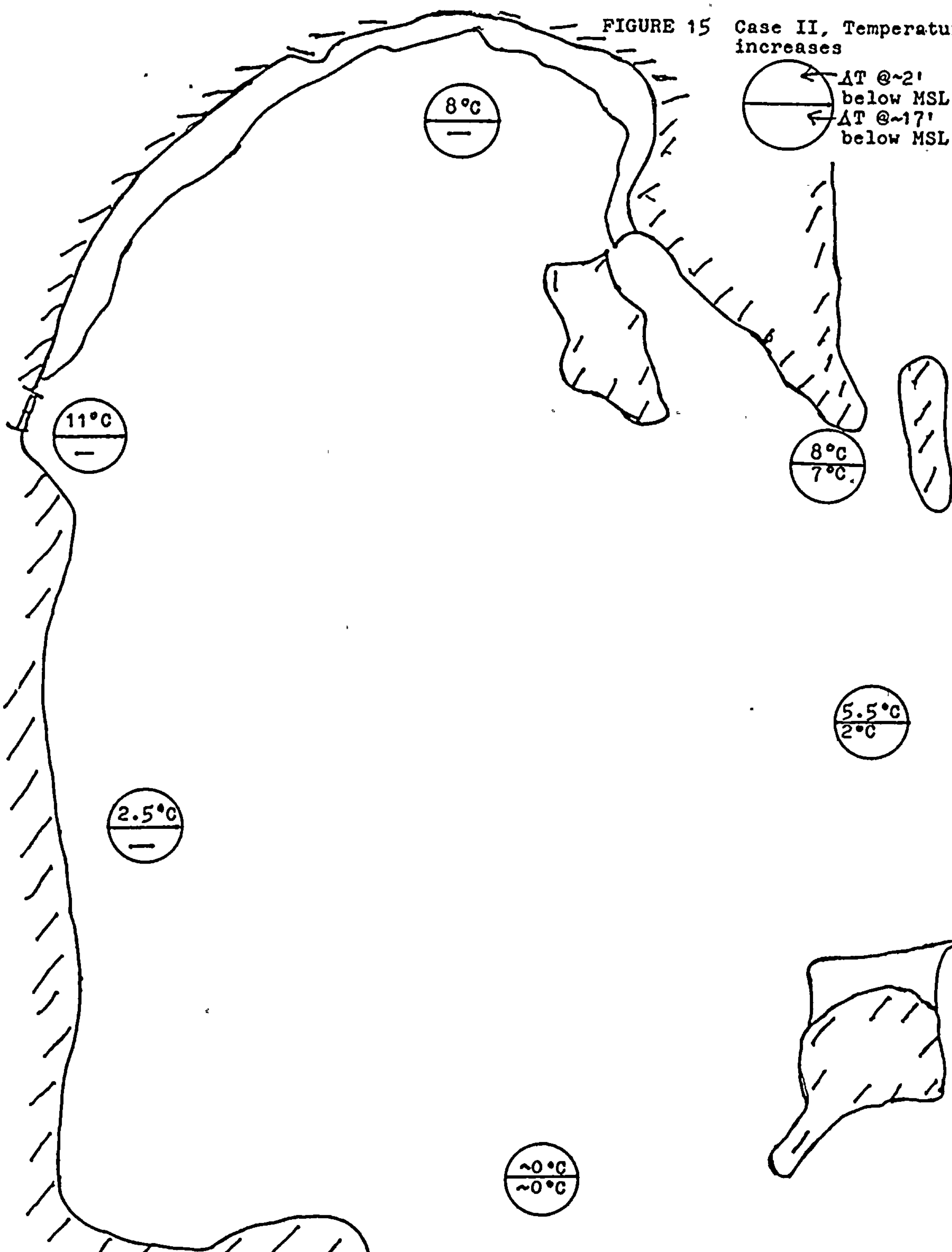


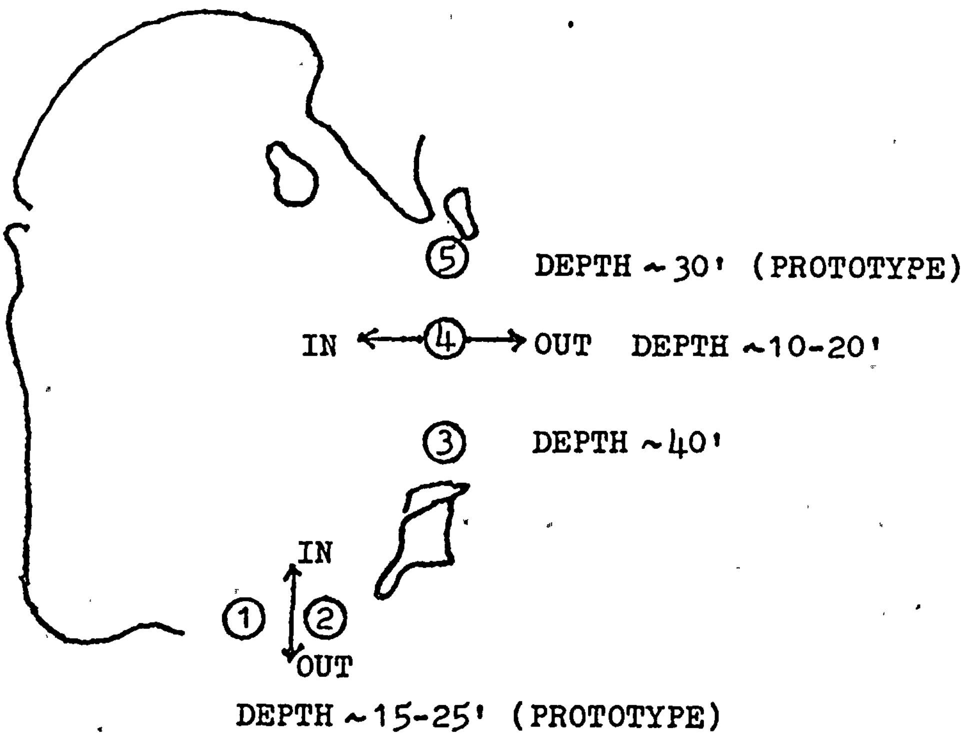
FIGURE 15 Case II, Temperature increases

FIGURE 16: Case III, Use of a dye grid to determine the surface circulation resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and a moderate upcoast current.

FIGURE 17 Case III, Surface circulation
Units I & II
ΔT ~ 11°C
Moderate upcoast current

FIGURE 18 Case III, Use of dye crystals to determine the bottom circulation resulting from a warm cooling water discharge with both Units I & II operating and a moderate upcoast current.

FIGURE 19 Case III, Bottom circulation Units I & II $\Delta T \sim 11°C$ Moderate upcoast current



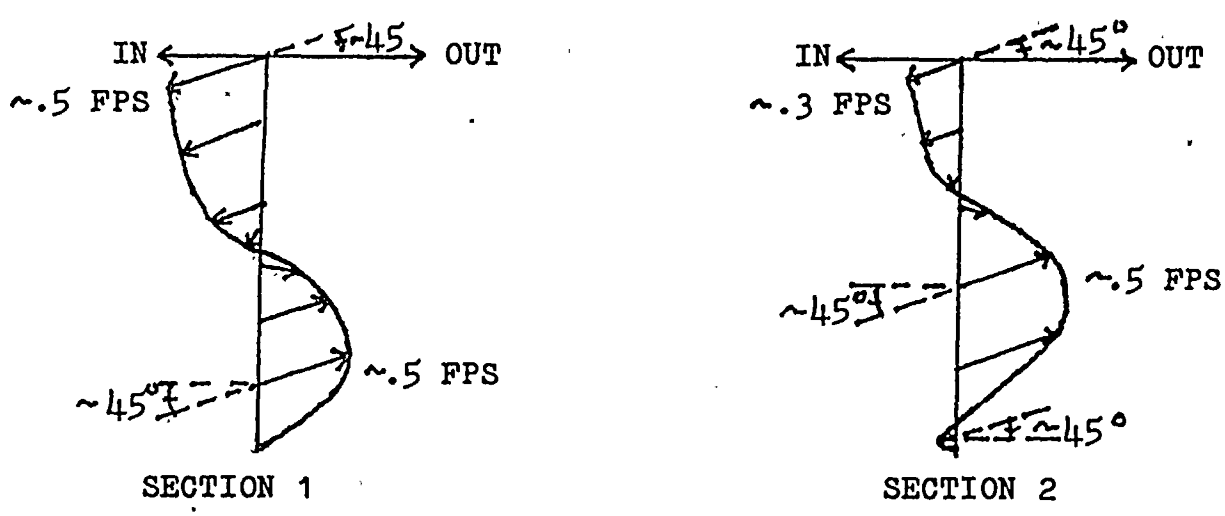


FIGURE 20a Case III, Cove entrance velocity profiles (converted to prototype values) resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and a moderate upcoast current.

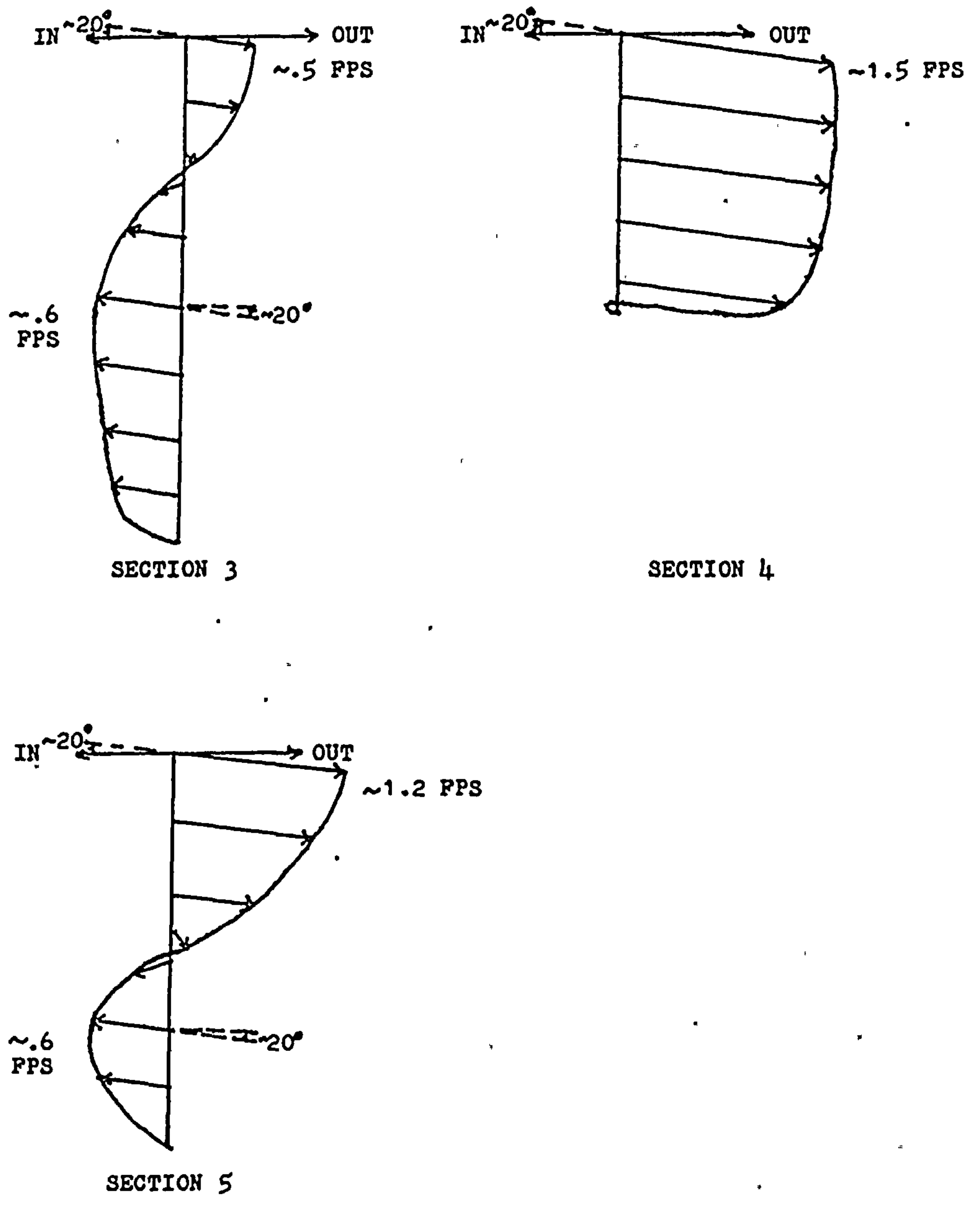
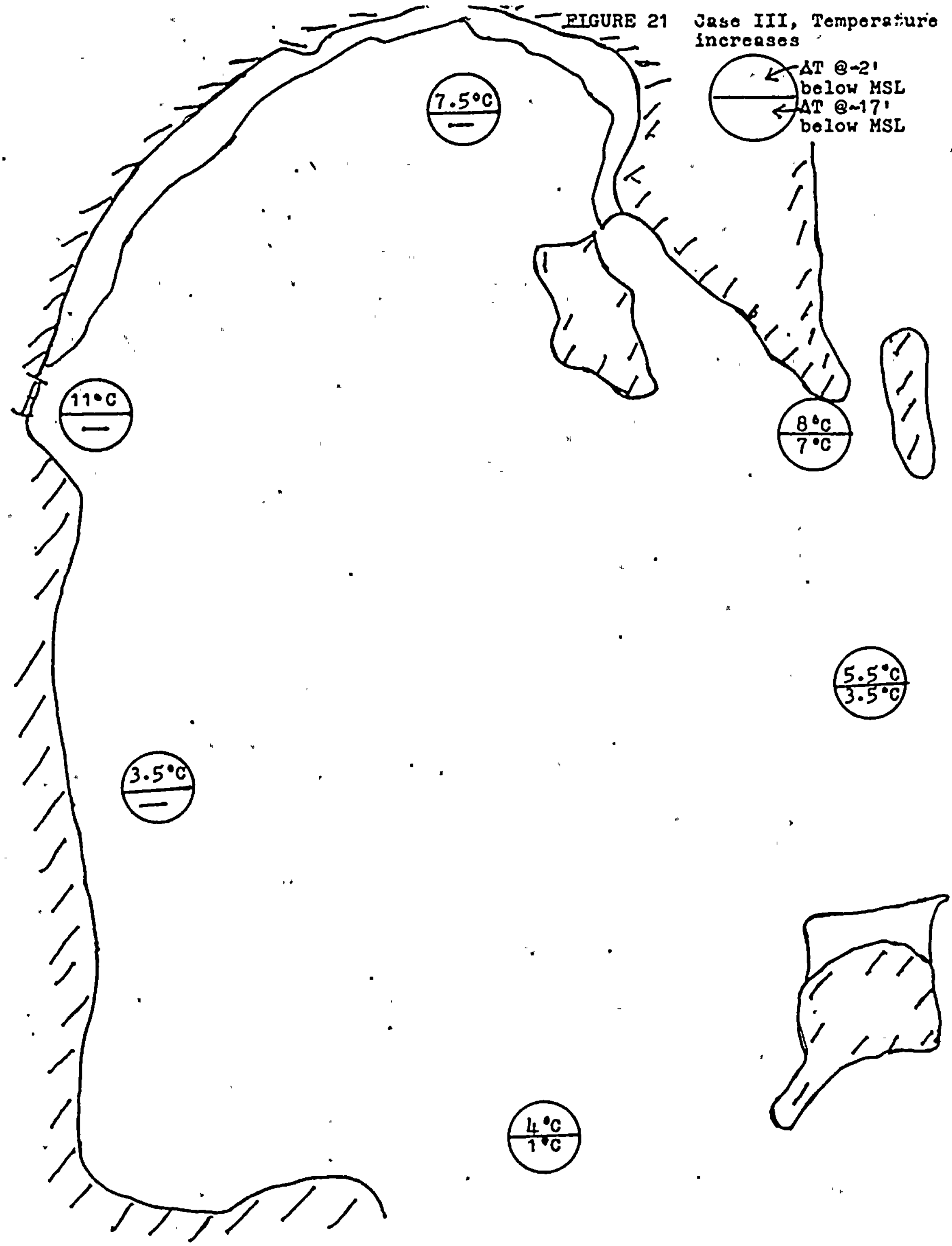


FIGURE 20b Case III, Cove entrance velocity profiles (converted to prototype values) resulting from a warm cooling water discharge into Diablo Cove with both Units I & II operating and a moderate upcoast current.

FIGURE 21 Case III, Temperature increases



Examples of color photographs of tests.

					model	prototype
Plate 1	Case I	zero current	dye grid	time:	0s	0s
Plate 2	"	"	"	"	8s	1m 9s
Plate 3	"	"	"	"	16s	2m 19s
Plate 4	"	"	"	"	18s	2m 36s
Plate 5	"	"	"	"	25s	3m 37s
Plate 6	"	"	"	"	32s	4m 37s
Plate 7	"	"	"	"	42s	6m 4s
Plate 8	"	"	"	"	57s	8m 14s
Plate 9	"	"	dye in discharge	"	5s	43s
Plate 10	"	"	"	"	21s	3m 2s
Plate 11	"	"	"	"	33s	4m 46s
Plate 12	"	"	"	"	45s	6m 30s
Plate 13	"	"	"	"	53s	7m 39s
Plate 14	"	"	"	"	4m 54s	42m 26s
Plate 15	"	"	"	"	6m 8s	53m 7s
Plate 16	"	"	"	"	6m 16s	54m 16s
Plate 17	"	"	"	"	8m 30s	73m 37s
Plate 18	"	"	"	"	8m 45s	75m 47s
Plate 19	Case II	strong downcoast current	dye grid	time:	0s	0s
Plate 20	"	"	"	"	5s	43s
Plate 21	"	"	"	"	11s	1m 35s
Plate 22	"	"	"	"	41s	5m 55s
Plate 23	"	"	"	"	54s	7m 48s
Plate 24	"	"	"	"	1m 22s	11m 50s
Plate 25	"	"	"	"	3m 38s	31m 28s
Plate 26	"	"	"	"	3m 55s	33m 55s

					model	prototype
Plate 27	Case II	strong downcoast current	dye grid	time:	4m 7s	35m 39s
Plate 28	"	"	"	"	4m 14s	36m 40s
Plate 29	"	"	"	"	4m 19s	37m 23s
Plate 30	"	"	"	"	4m 27s	38m 32s
Plate 31	"	"	dye in discharge	"	3s	26s
Plate 32	"	"	"	"	17s	2m 27s
Plate 33	"	"	"	"	32s	4m 37s
Plate 34	"	"	"	"	41s	5m 55s
Plate 35	"	"	"	"	56s	8m 5s
Plate 36	"	"	"	"	1m 9s	9m 58s
Plate 37	"	"	"	"	1m 28s	12m 42s
Plate 38	"	"	"	"	1m 38s	14m 9s
Plate 39	"	"	"	"	1m 56s	16m 45s
Plate 40	"	"	"	"	2m 14s	19m 20s
Plate 41	Case III	moderate upcoast current	dye grid	time:	0s	0s
Plate 42	"	"	"	"	2s	17s
Plate 43	"	"	"	"	*	*
Plate 44	"	"	"	"	*	*
Plate 45	"	"	"	"	*	*
Plate 46	"	"	"	"	*	*
Plate 47	"	"	"	"	*	*
Plate 48	"	"	"	"	*	*
Plate 49	"	"	"	"	*	*

*clock stopped

		moderate upcoast current	dye in discharge	time:	model	prototype
Plate 50	Case III				5s	43s
Plate 51	"	"	"	"	15s	2m 10s
Plate 52	"	"	"	"	30s	4m 20s
Plate 53	"	"	"	"	47s	6m 47s
Plate 54	"	"	"	"	1m 14s	10m 41s
Plate 55	"	"	"	"	1m 17s	11m 7s
Plate 56	"	"	"	"	1m 55s	16m 36s
Plate 57	"	"	"	"	2m 45s	23m 49s
Plate 58	"	"	"	"	4m 50s	41m 51s
Plate 59	"	"	"	"	5m 26s	47m 3s
Plate 60	"	"	"	"	5m 59s	51m 49s
Plate 61	"	"	"	"	6m 25s	55m 34s
Plate 62	"	"	"	"	7m 10s	62m 4s

Plate 1: Case I, 0s (model time)

Plate 2: Case I, 8s

Plate 3: Case I. 16s

Plate 4: Case I. 18s

Plate 5: Case I. 25s

Plate 6: Case I. 32s

Plate 7: Case I. 42s

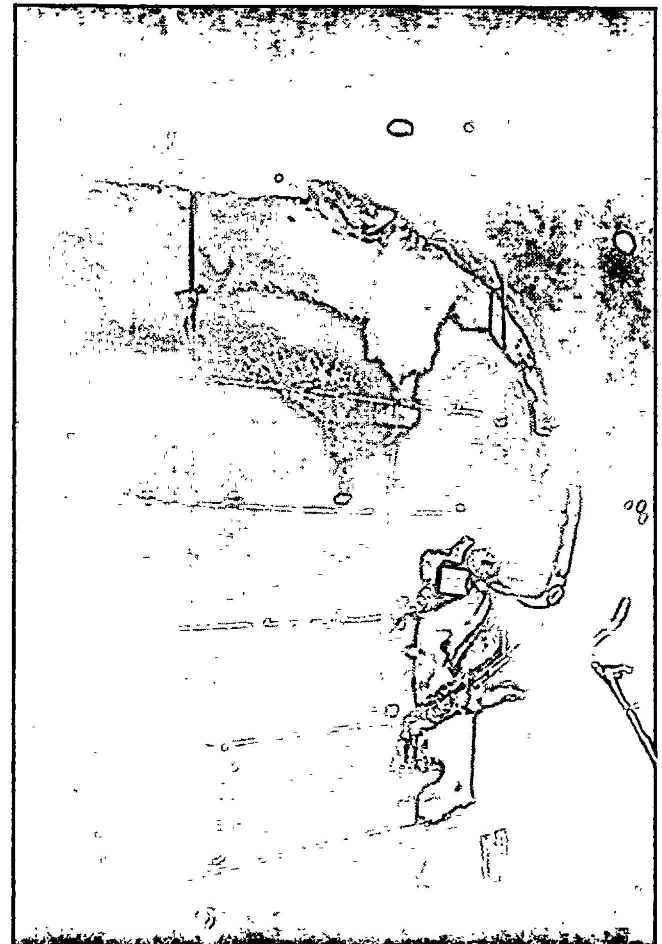


Plate 8: Case I, 57s

Plate 9: Case I, 5s

Plate 10: Case I, 21s

Plate 11: Case I, 33s

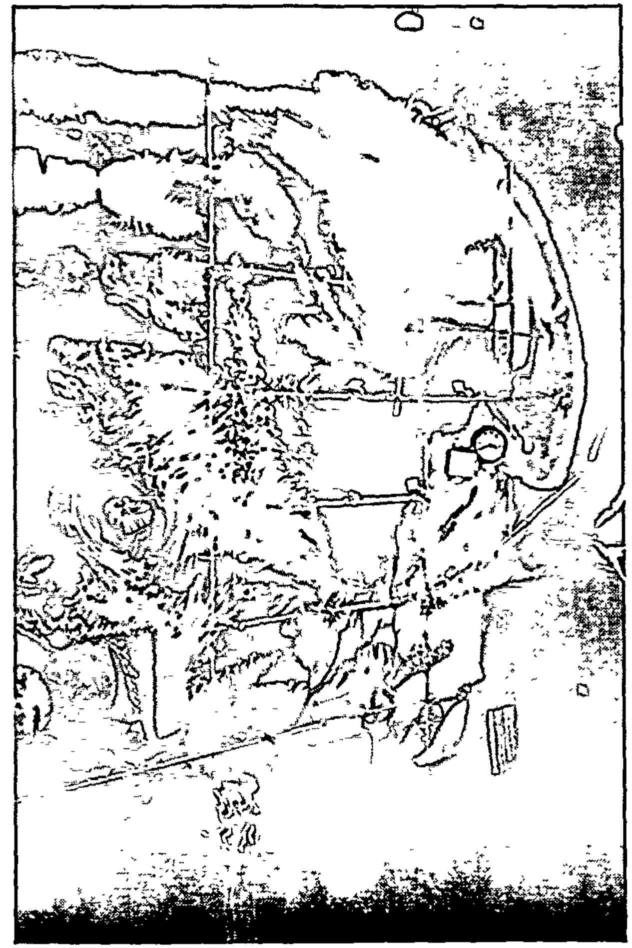


Plate 12: Case I, 45s

Plate 13: Case I, 53s

Plate 14: Case I, 4m 54s

Plate 15: Case i, 6m 8s

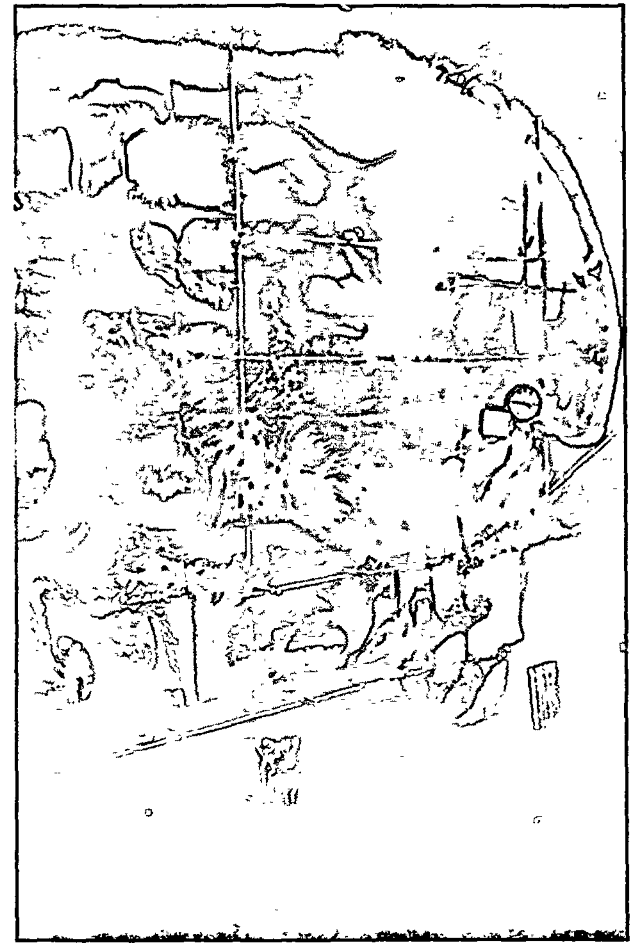


Plate 16: Case I, 7m 16s

Plate 17: Case I, 8m 30s

Plate 18: Case I, 8m 45s

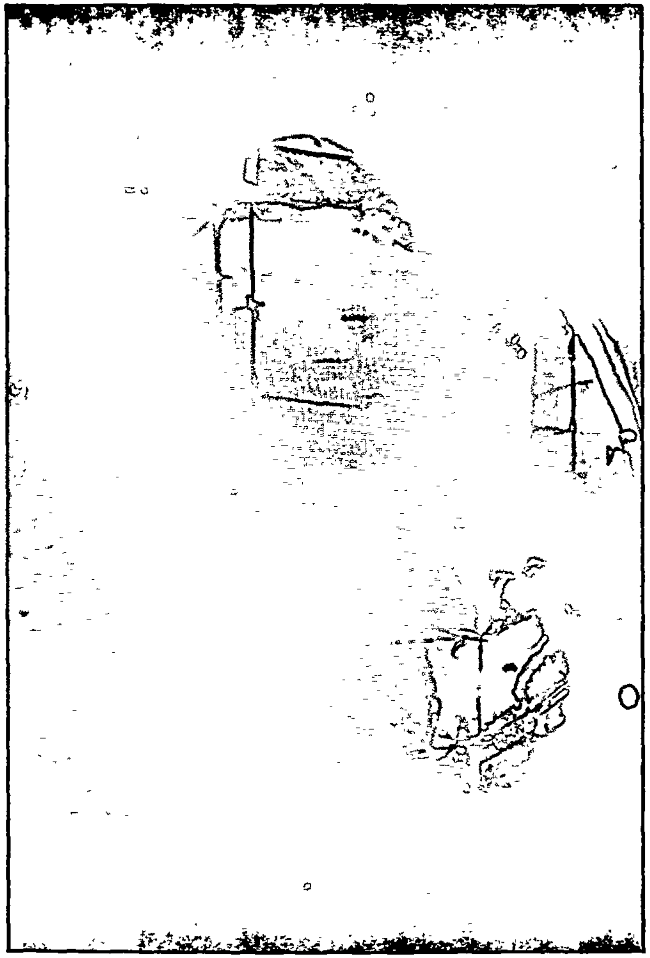


Plate 19: Case II, 0s

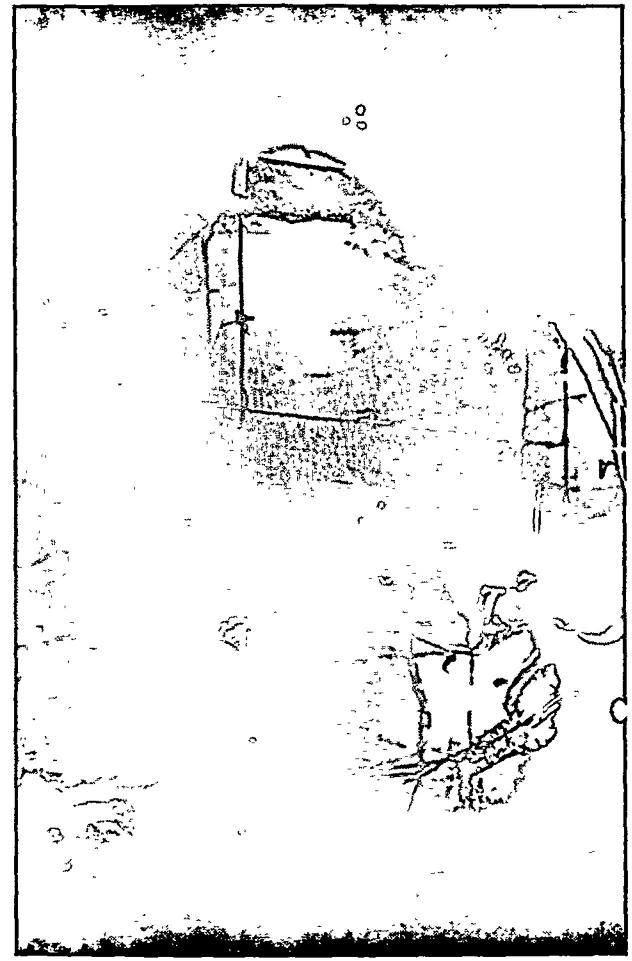


Plate 20: Case II, 5s

Plate 21: Case II, 11s

Plate 22: Case II, 41s

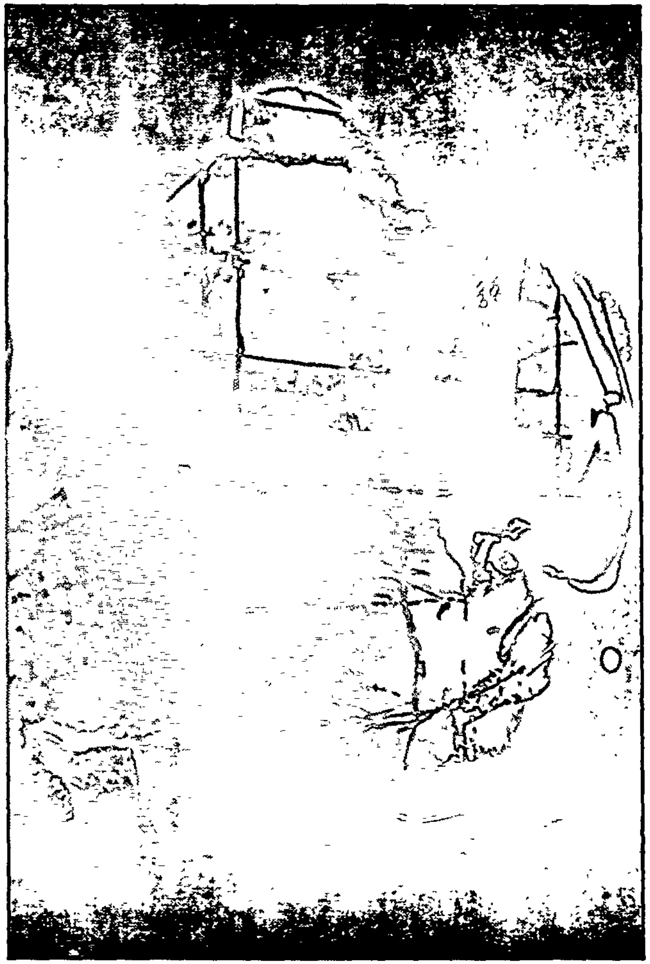


Plate 23: Case II, 54s

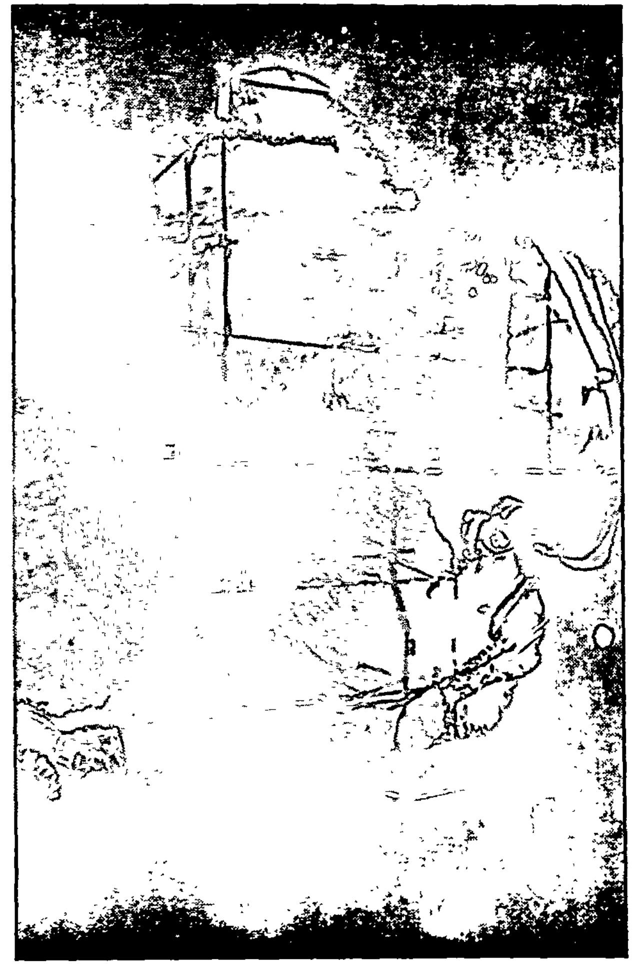


Plate 24: Case II, 1m 22s

Plate 25: Case II, 3m 38s

Plate 26: Case II, 3m 55s

Plate 27: Case II, 4m 7s

Plate 28: Case II, 4s 14s

Plate 29: Case II, 4m 19s

Plate 30: Case II, 4m 27s

Plate 31: Case II, 3s

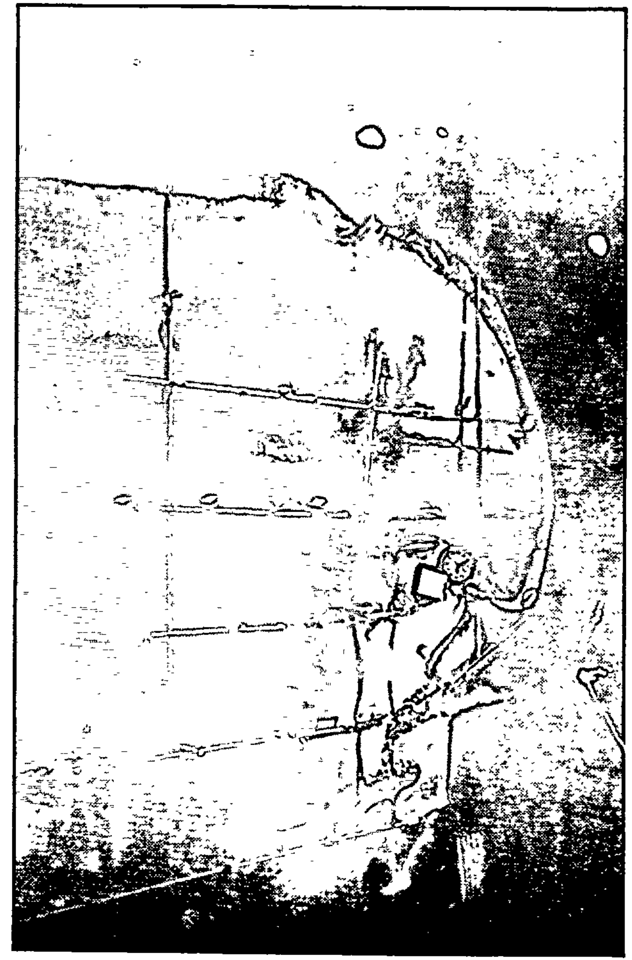


Plate 32: Case II, 17s

Plate 33: Case II, 32s

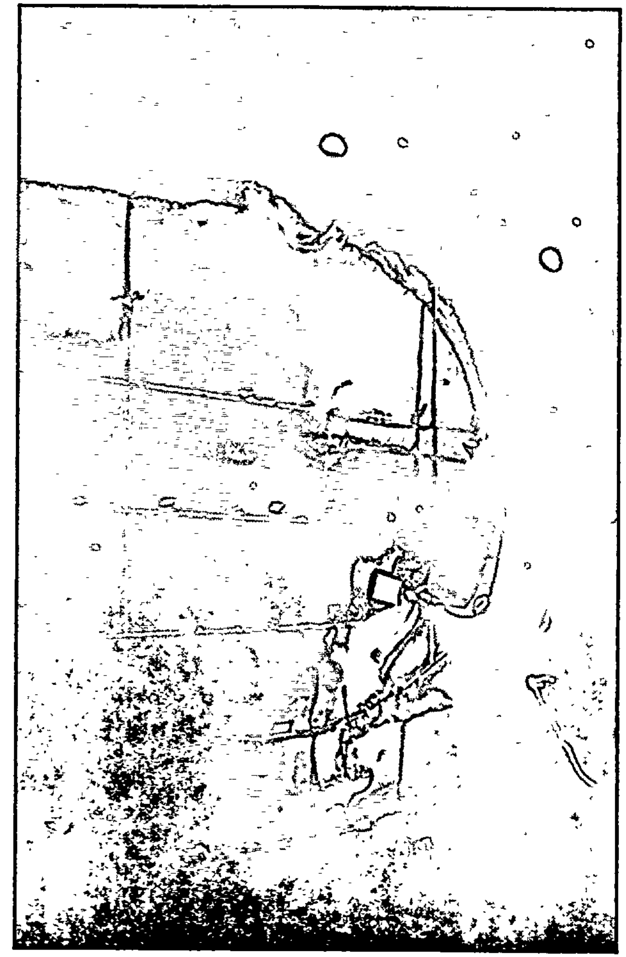


Plate 34: Case II, 41s

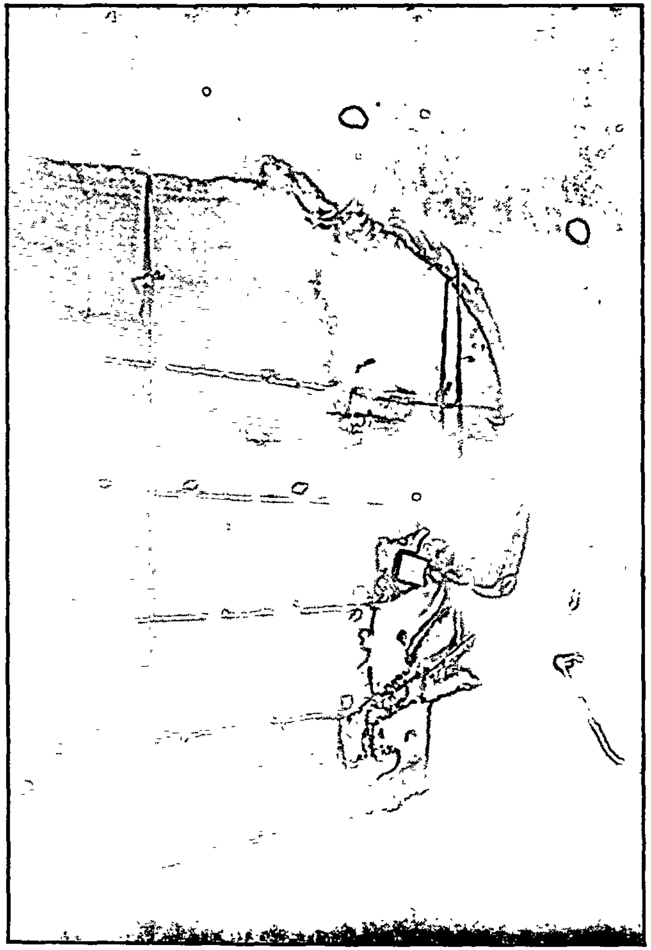


Plate 35: Case II, 56s

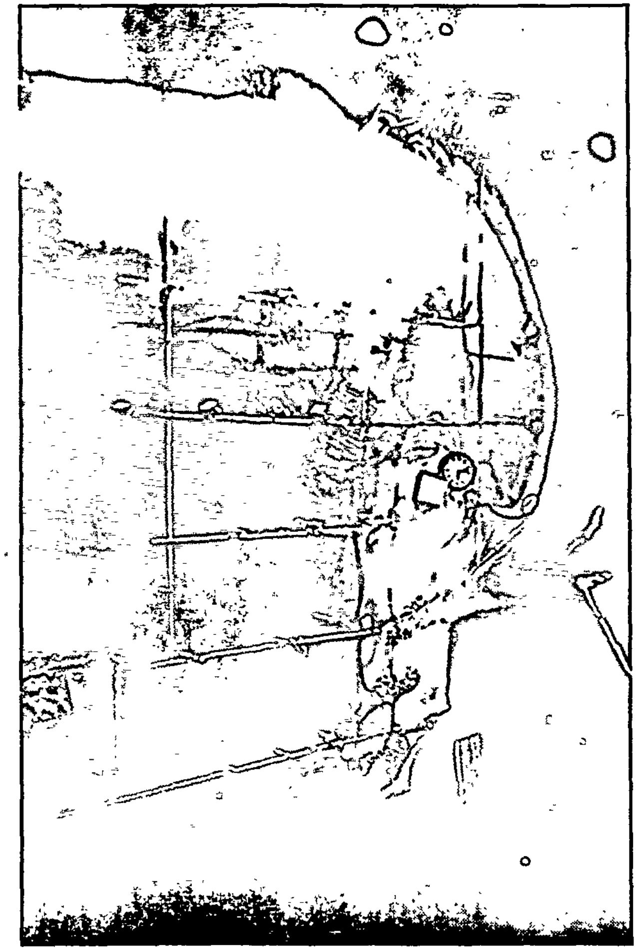


Plate 36: Case II, 1m 9s

Plate 37: Case II, 1m 28s

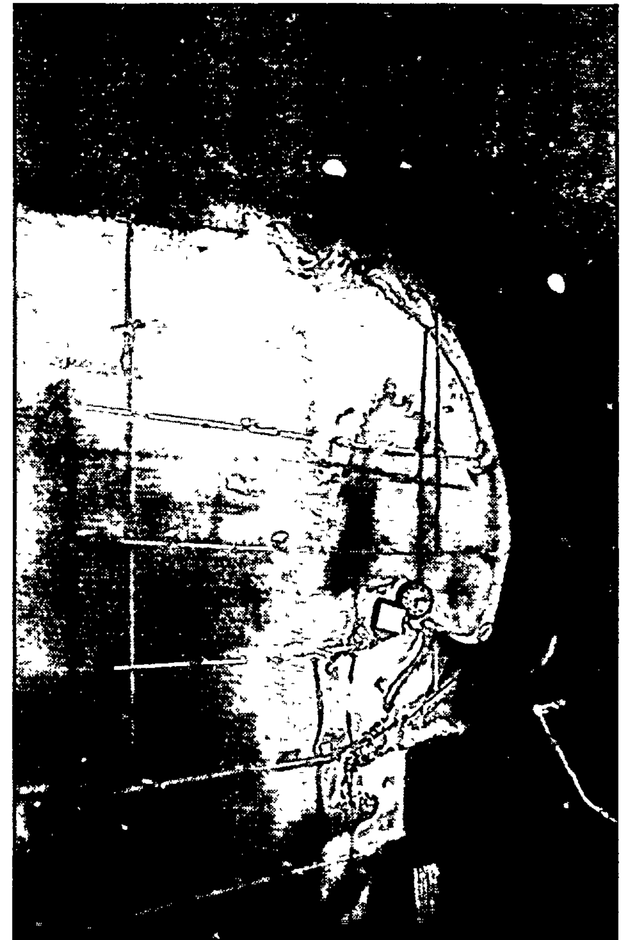


Plate 38: Case II, 1m 38s

Plate 39: Case II, 1m 56s

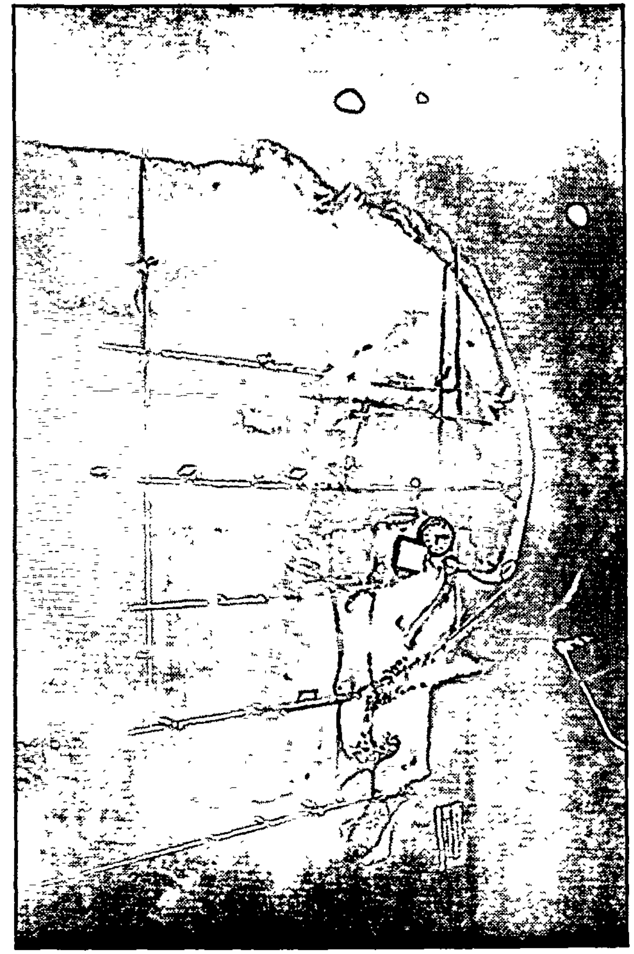


Plate 40: Case II, 2m 14s

Plate 41: Case III, 0s

Plate 42: Case III, 2s

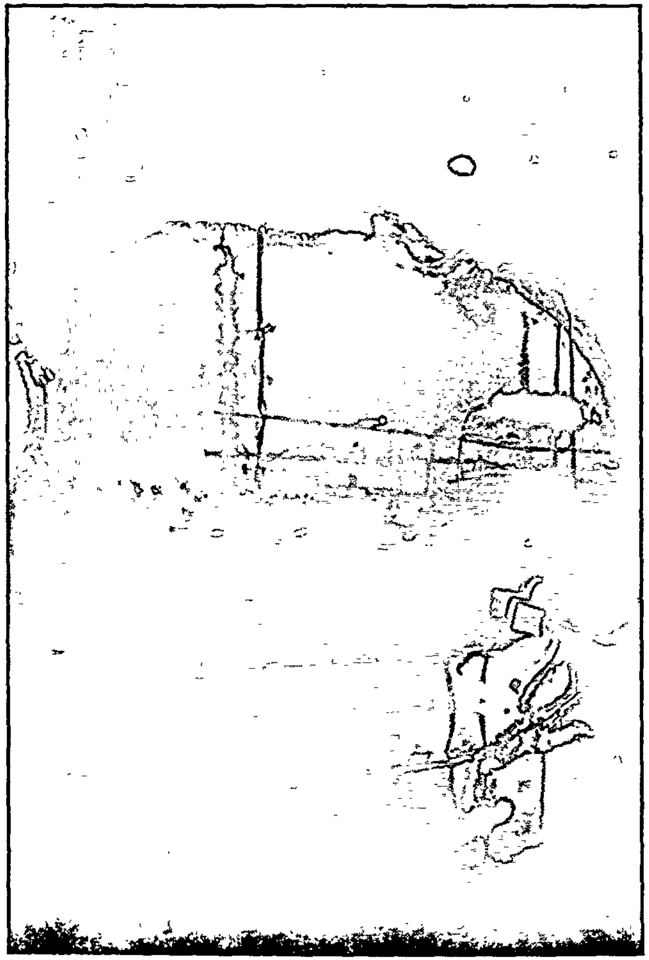


Plate 43: Case III, *
*Clock stopped

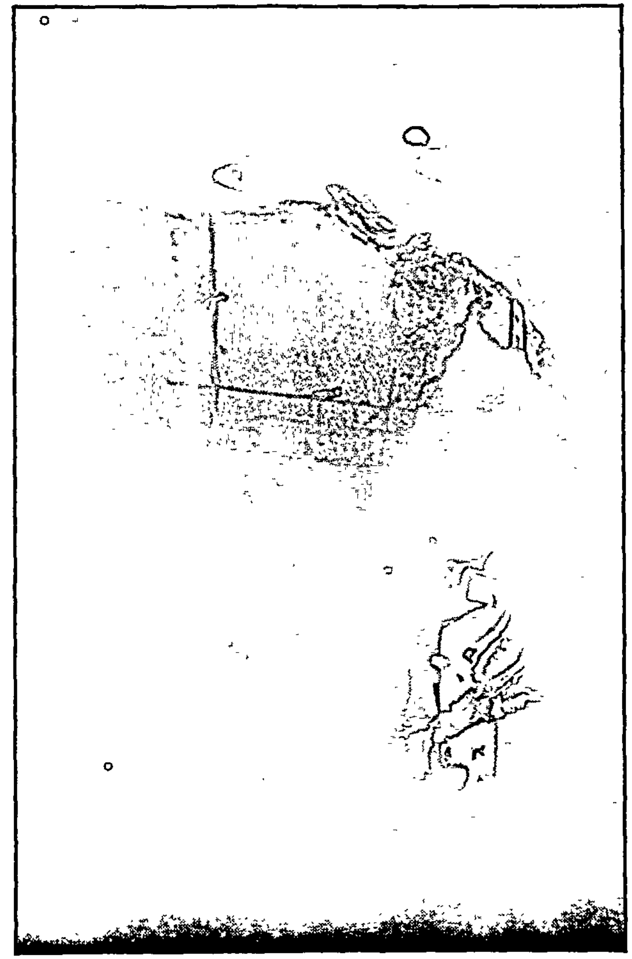


Plate 44: Case III, *

Plate 45: Case III, *
* Clock stopped

Plate 46: Case III, *

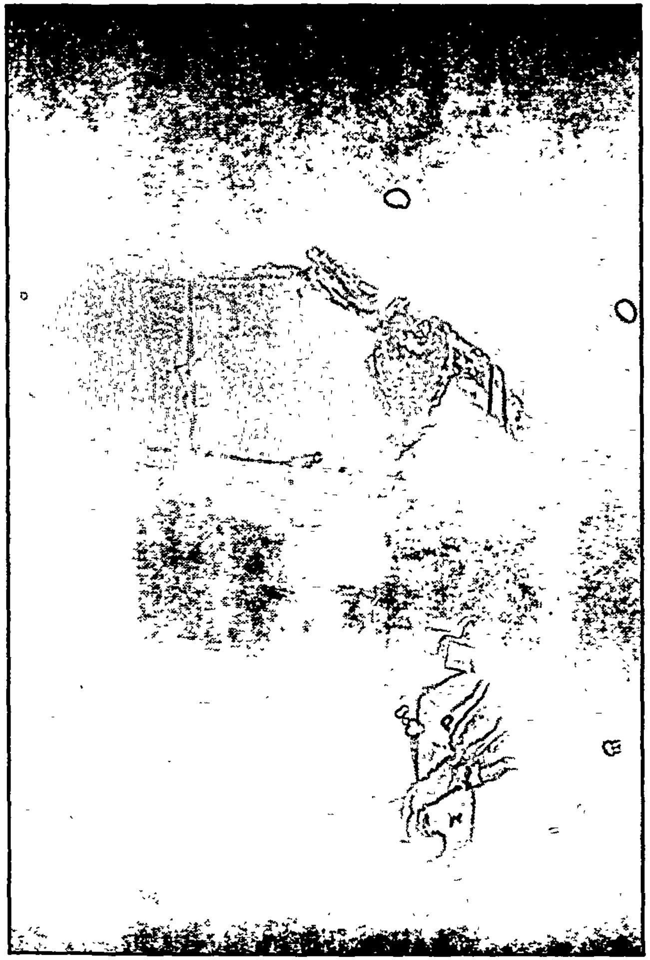


Plate 47: Case III, *

* Clock stopped

Plate 48: Case III, *

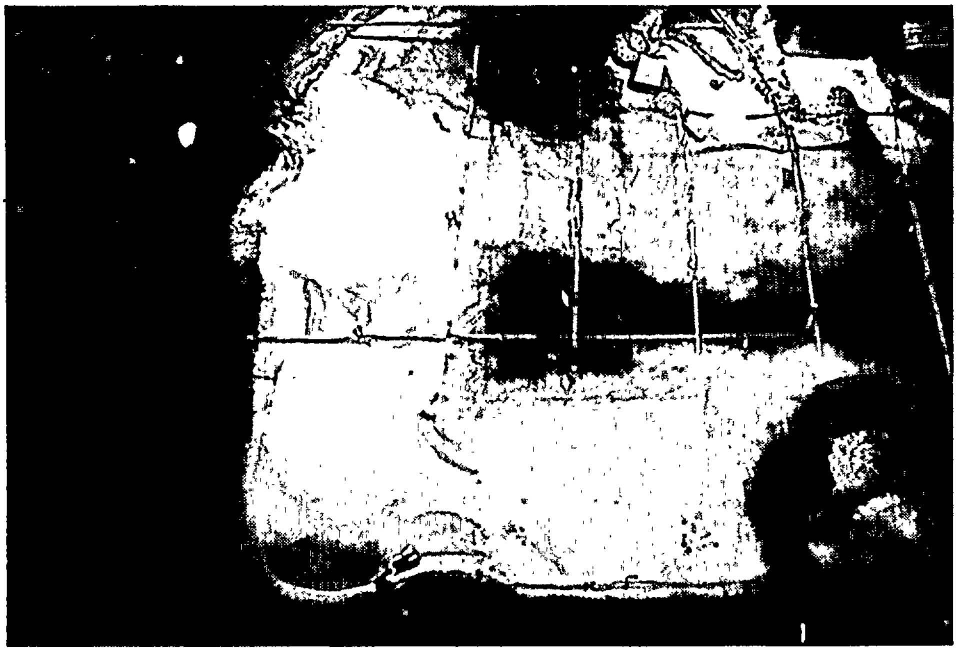


Plate 49: Case III, *
* Clock stopped

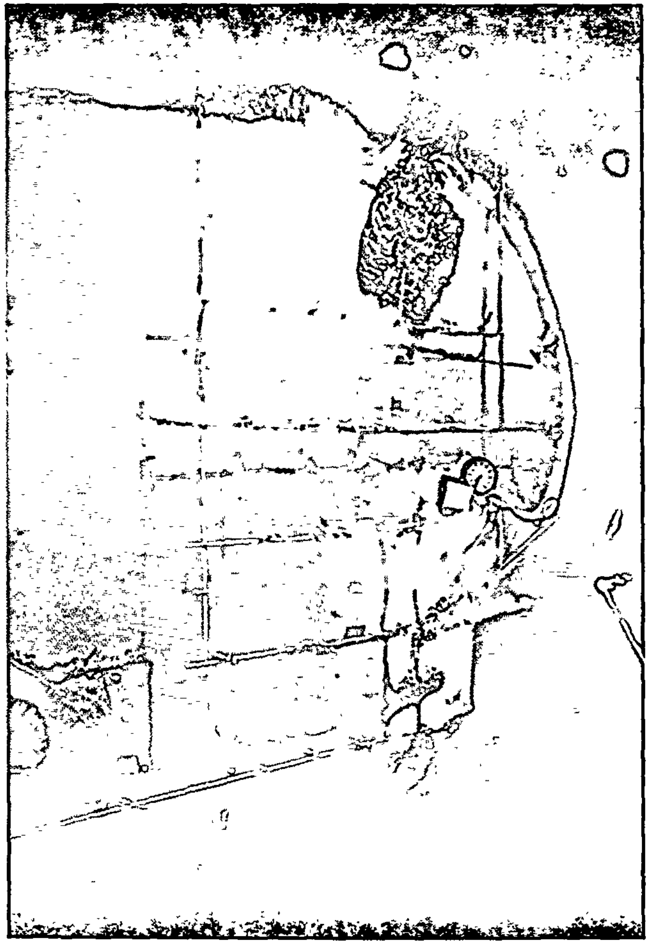


Plate 50: Case III, 5s

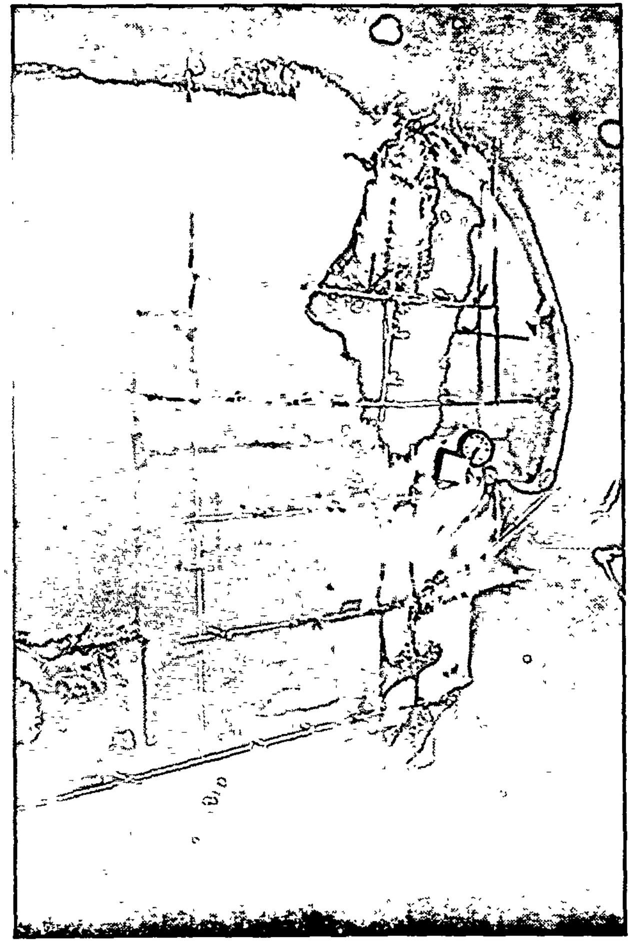


Plate 51: Case III, 15s

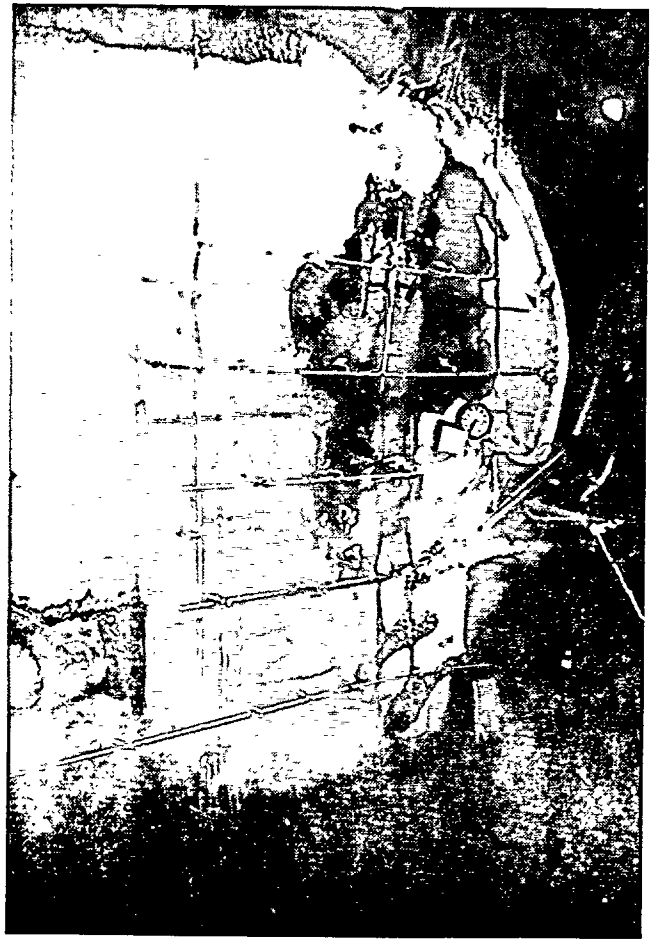


Plate 52: Case III, 30s

Plate 53: Case III, 47s

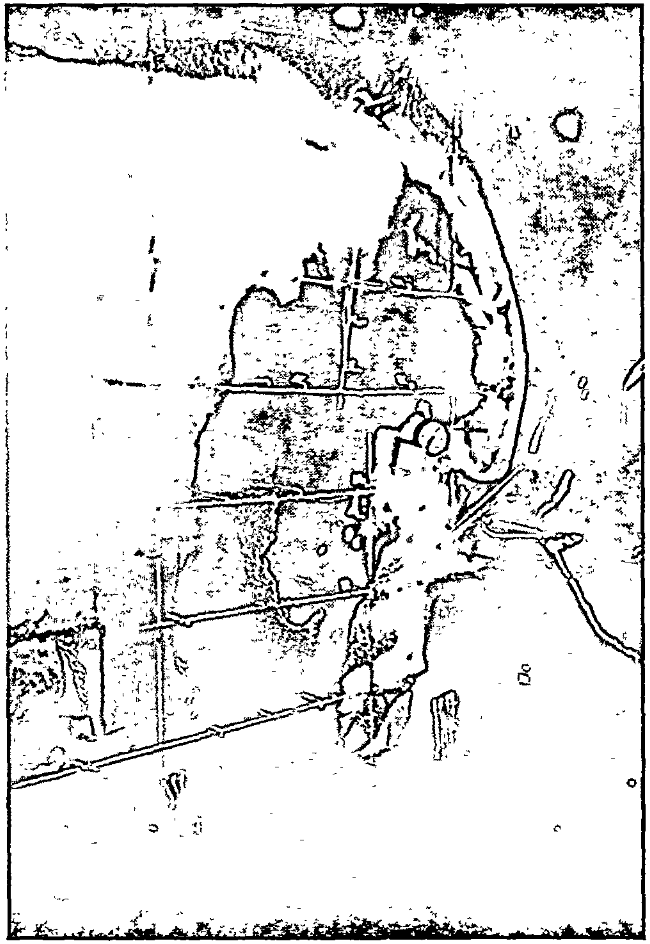


Plate 54: Case III, 1m 14s

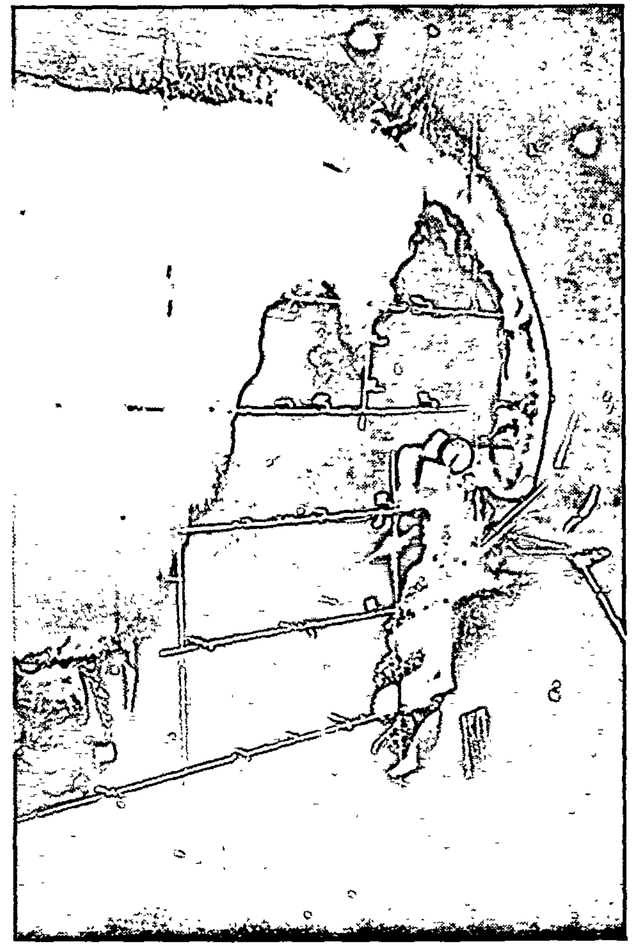


Plate 55: Case III, 1m 17s

Plate 56: Case III, 1m 55s

Plate 57: Case III, 2m 45s

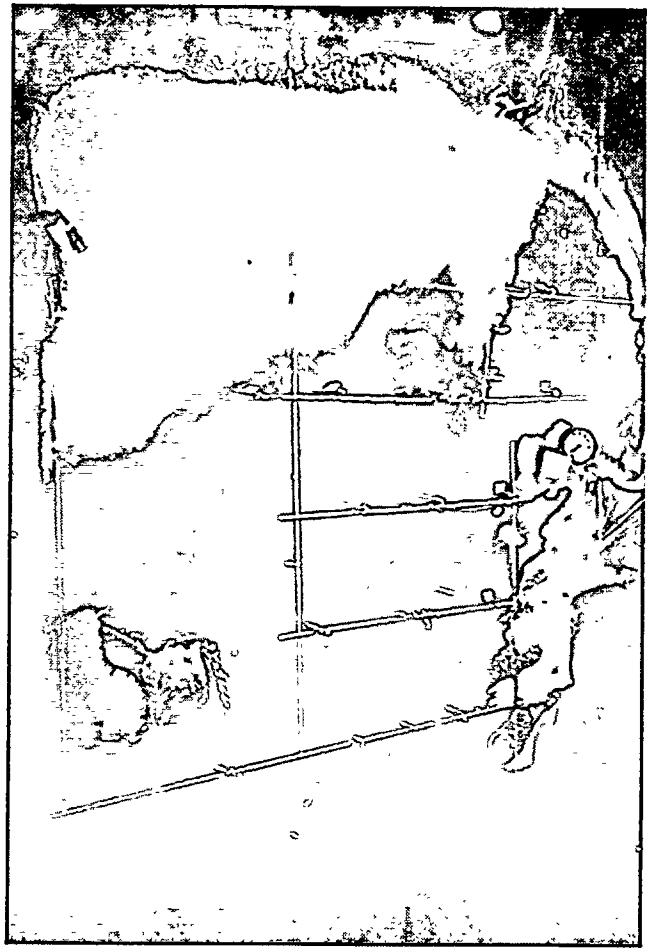


Plate 58: Case III, 4m 50s

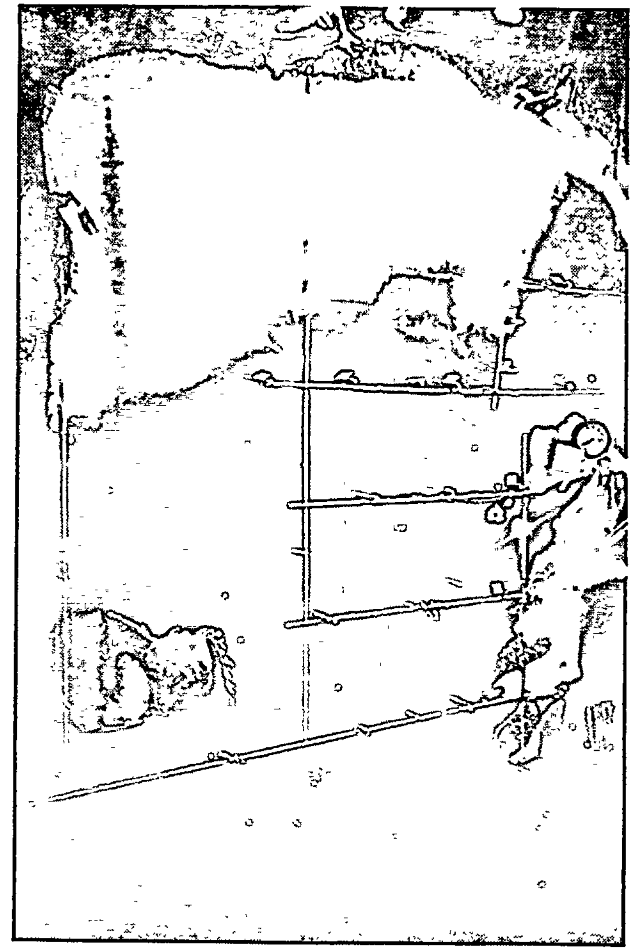


Plate 59: Case III, 5m 26s

Plate 60: Case III, 5m 59s

Plate 61: Case III, 6m 25s

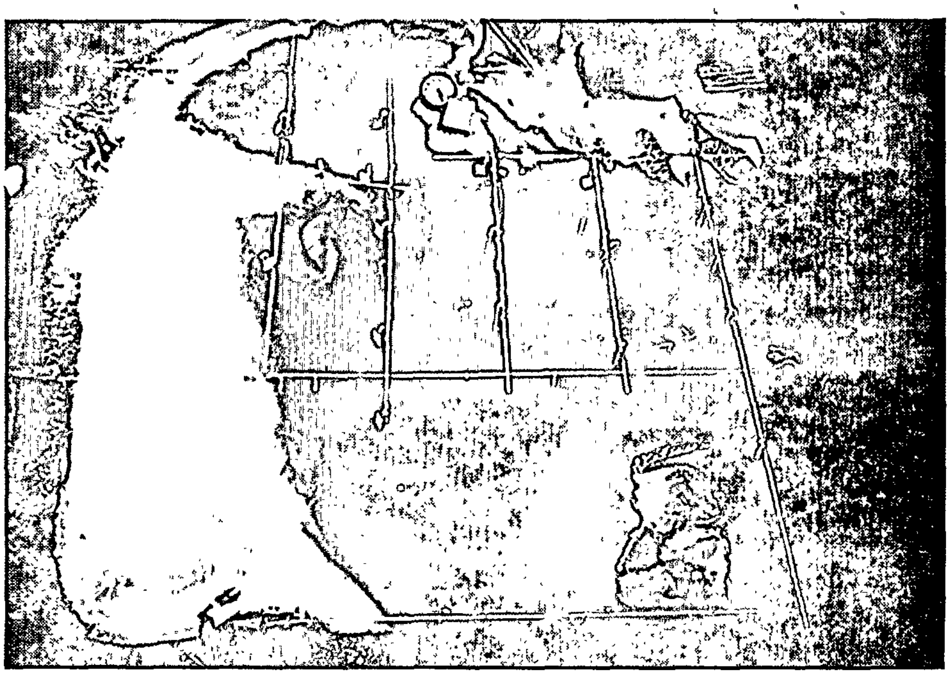


Plate 62: Case III, 7m 10s

APPENDIX

Additional photographs not used in main body of report:

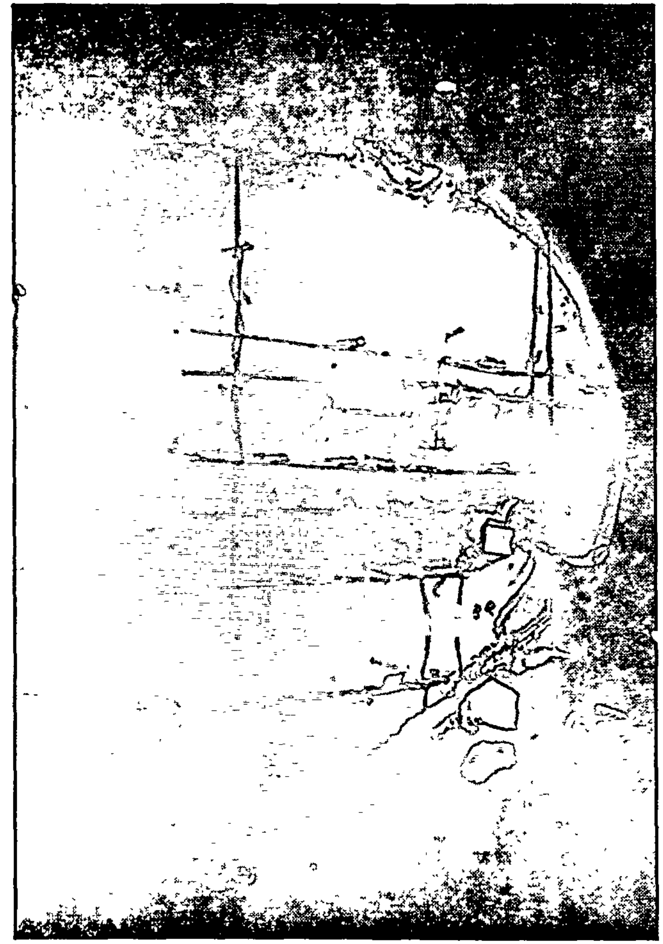
Appendix Plate:	Case/ Current:	Dye Type:	Model Time:	Prototype Time:	Plate number corresponding to those in main report:
AP-1	I/no current	dye grid	35s	5m 03s	Plate 6a
AP-2	"	"	48s	6m 56s	Plate 7a
AP-3	"	dye crystals	-	-	(preceeds Figure 4 and Plates 9 - 18)
AP-4	"	"	-	-	
AP-5	"	"	-	-	"
AP-6	"	dye in discharge	13s	1m 53s	Plate 9a
AP-7	"	"	26s	3m 45s	Plate 10a
AP-8	"	"	42s	6m 04s	Plate 11a
AP-9	"	"	1m 02s	8m 57s	Plate 13a } (over-
AP-10	"	"	1m 15s	10m 50s	Plate 13b } lapped)
AP-11	"	"	5m 16s	45m 37s	Plate 14a
AP-12	"	"	5m 43s	49m 30s	Plate 14b
AP-13	"	"	6m 25s	55m 34s	Plate 15a
AP-14	"	"	6m 50s	59m 11s	Plate 15b
AP-15	"	"	7m 07s	61m 38s	Plate 15c
AP-16	"	"	7m 33s (?) (difficult to	65m 23s (?) read clock)	Plate 16a
AP-17	"	"	8m 00s	69m 17s	Plate 16b
AP-18	II/strong downcoast current	dye crystals	-	-	(preceeds Plate 19)
AP-19		"	-	-	"
AP-20	"	"	-	-	"
AP-21	"	dye grid	1m 05s	9m 23s	Plate 23a
AP-22	"	"	1m 41s	14m 35s	Plate 24a
AP-23	"	"	2m 08s	18m 29s	Plate 24b
AP-24	"	"	3m 36s	31m 11s	Plate 24c

Appendix Plate:	Case/ Current:	Dye Type:	Model Time:	Prototype Time:	Plate number corresponding to those in main report:
AP-25	II/strong downcoast current	dye in discharge	09s	1m 18s	Plate 31a
AP-26		"	23s	3m 19s	Plate 32a
AP-27	III/moderate upcoast current	dye grid	clock stopped		Plate 45a
AP-28		"	"	"	Plate 46a
AP-29	"	"	"	"	Plate 46b
AP-30	"	"	"	"	Plate 49a
AP-31	"	"	"	"	Plate 49b
AP-32	"	"	"	"	Plate 49c

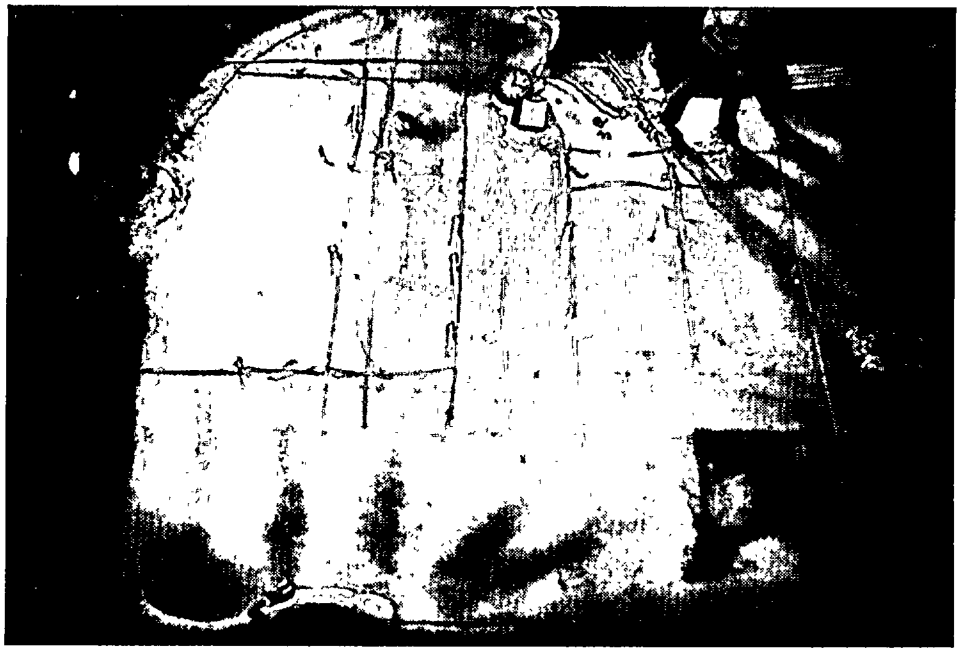
AP-1: Case I, 35s (model time) (Plate 6a)

AP-2: Case I, 48s (Plate 7a)

AP-3: Case 1 (placing of dye crystals prior to Plate 9 - 18 and Figure 4)



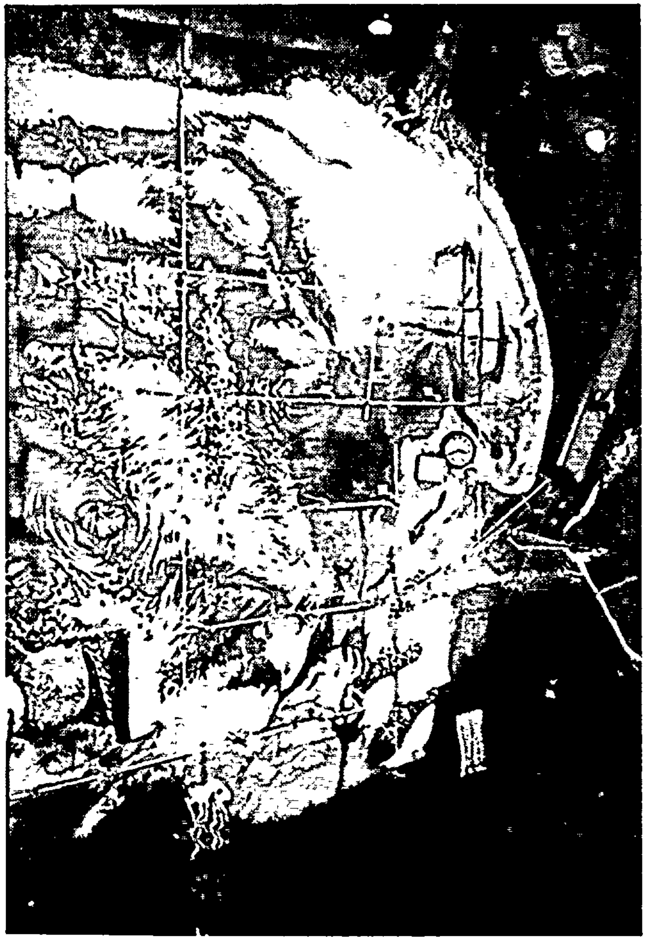
AP-4: Case I (placing of dye crystals prior to Plate 9 - 18 and Figure 4)



AP-5: Case I (placing of dye crystals prior to Plates 9 - 18 and Figure 4)

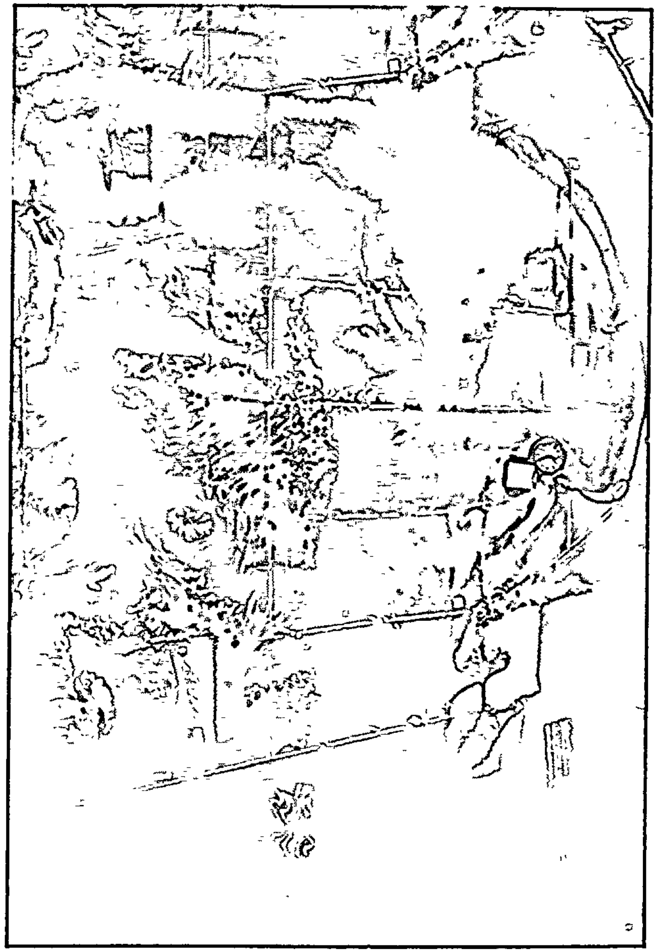
AP-6: Case I, 13s (Plate 9a)

AP-7: Case I, 26s (Plate 10a)



AP-8: Case I, 42s (Plate 11a)

AP-9: Case I, 1m 02s (Plate 13a)
(overlapped with AP-10)

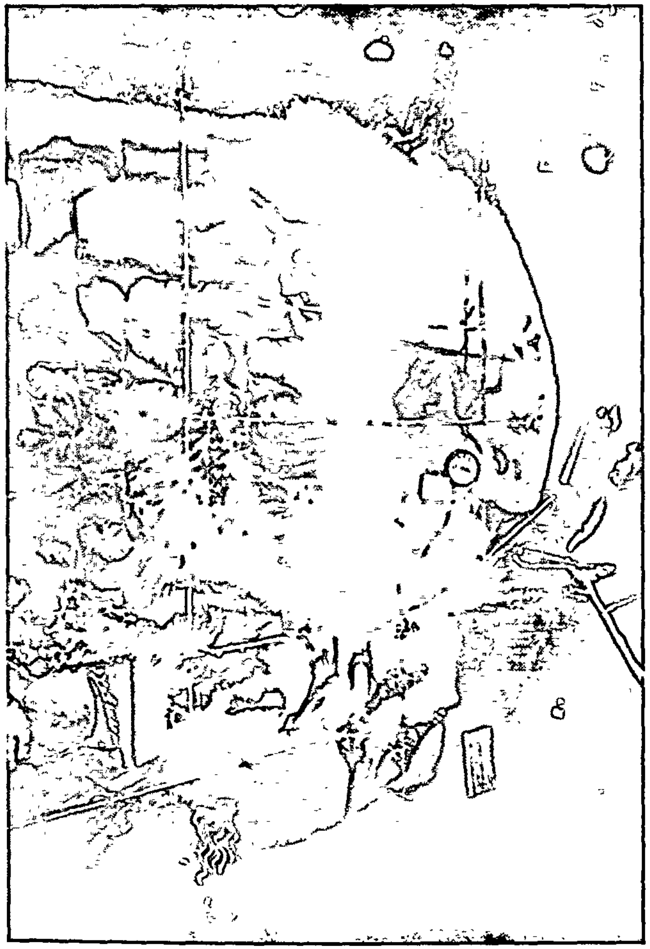


AP-10: Case I, 1m 15s (Plate 13b) (overlapped with AP-9)

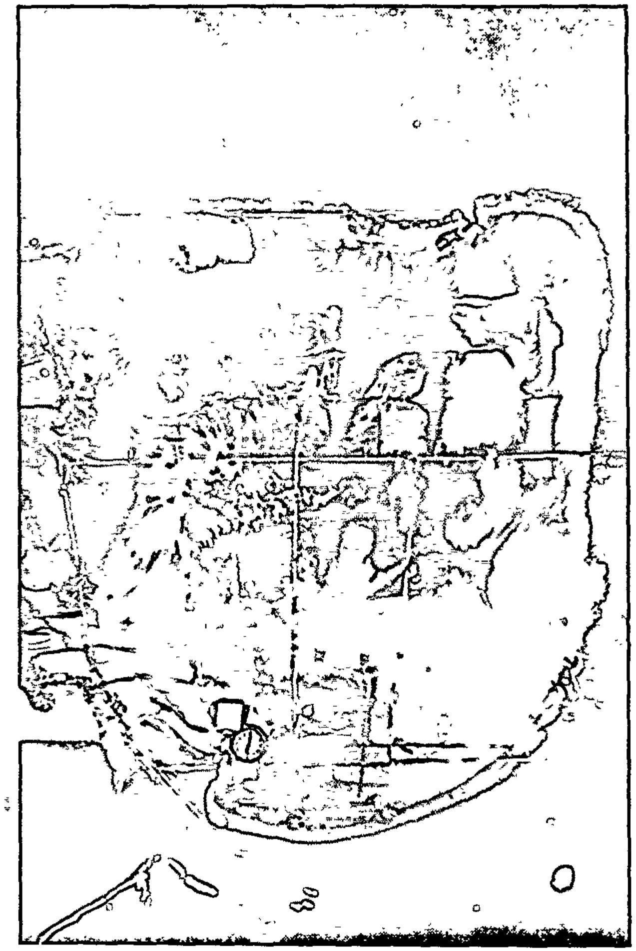
AP-11: Case I, 5m 16s (Plate 14s)

AP-12: Case I, 5m 43s (Plate 14b)

AP-13: Case I, 6m 25s (Plate 15a)



AP-14: Case I, 6m 50s (Plate 15b)



AP-15: Case I, 7m 07s (Plate 15c)

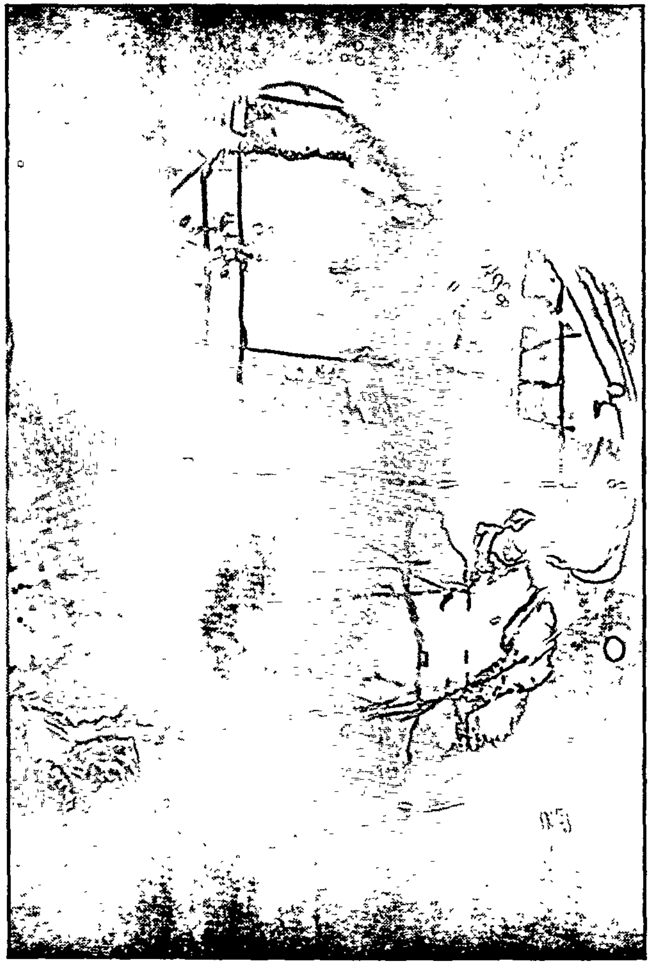
AP-16: Case I, 7m 33s (?) (Plate 16a)
(difficult to read clock)

AP-17: Case I, 8m 00s (Plate 16b)

AP-18: Case II, (dye crystals placed in basin prior to Plate 19 photograph)

AP-19: Case II, (dye crystals placed in basin prior to Plate 19 photograph)

AP-20: Case II, (dye crystals placed in basin prior to Plate 19 photograph)

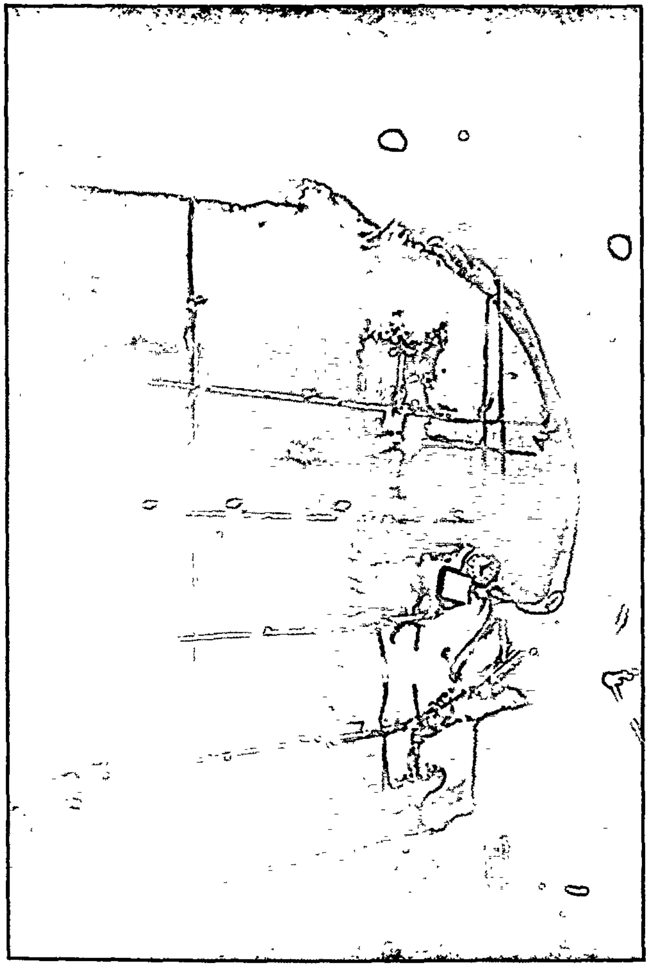


AP-21: Case II, 1m 05s (Plate 23a)

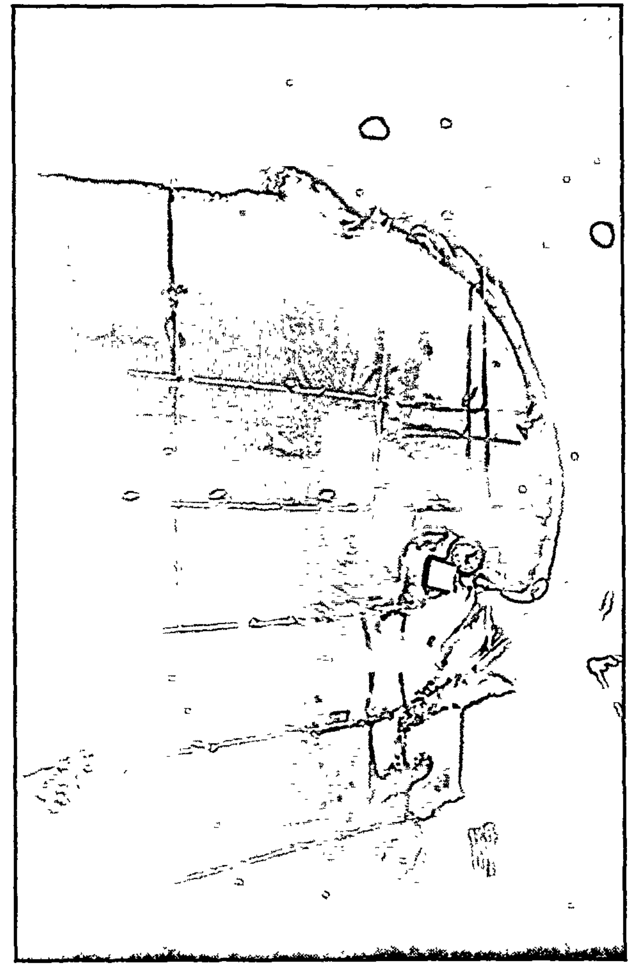
AP-22: Case II, 1m 41s (Plate 24a)

AP-23: Case II, 2m 08s (Plate 24b)

AP-24: Case II, 3m 36s (Plate 24c)



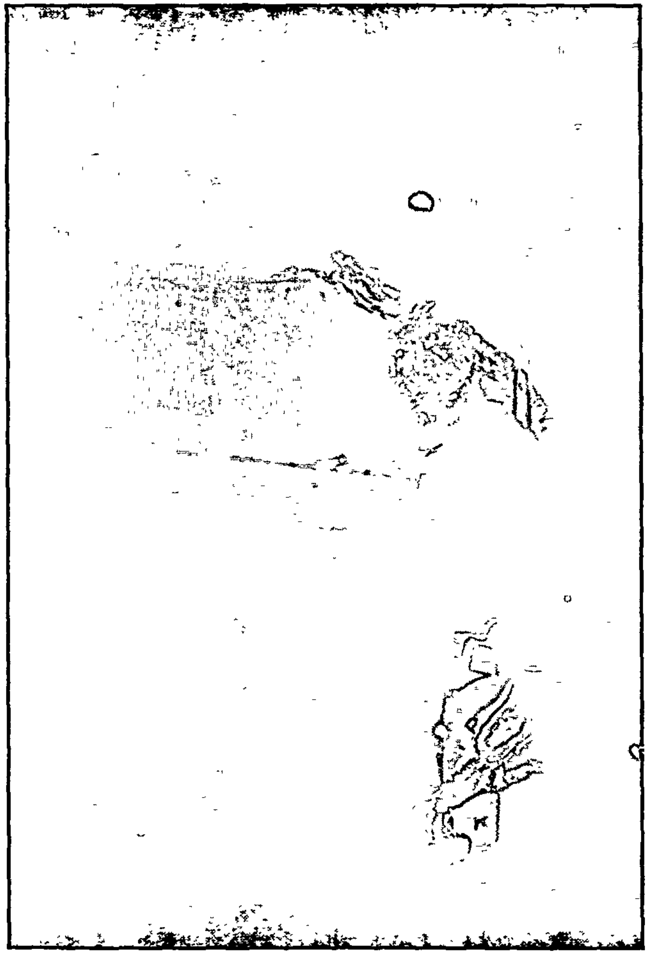
AP-25: Case II, 09s (Plate 31a)



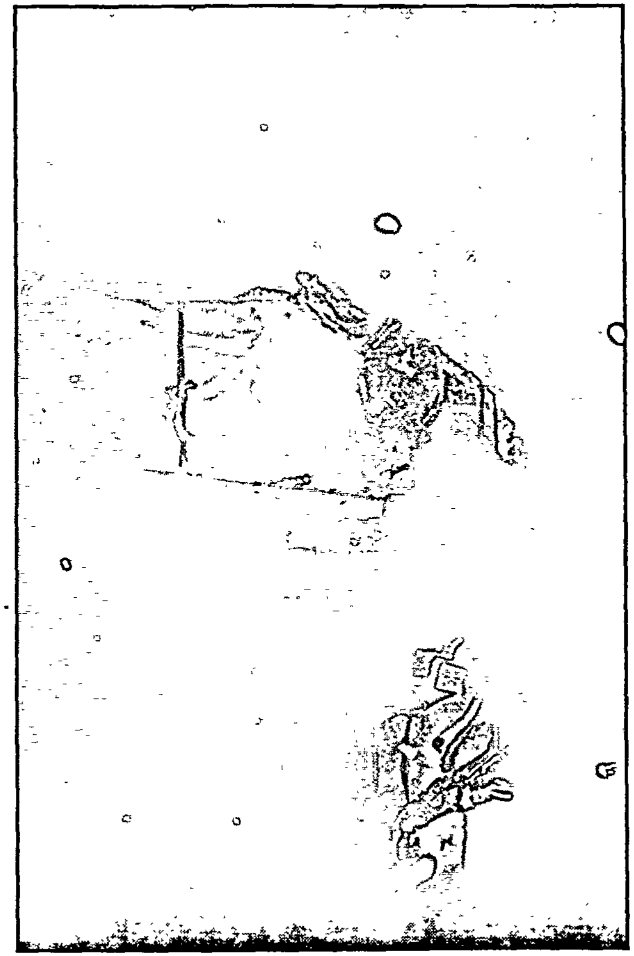
AP-26: Case II, 23s (Plate 32a)

AP-27: Case III, * (Plate 45a)
*Clock stopped

AP-28: Case III, * (Plate 46a)



AP-29: Case III, * (Plate 46b)
*Clock stopped



AP-30: Case III, * (Plate 49a)

AP-31: Case III, * (Plate 49b)
* Clock stopped

AP-32: Case III, * (Plate 49c)

Report Issued: AUG 2 2 1983

Report No. 411-82.270

PACIFIC GAS AND ELECTRIC COMPANY

DEPARTMENT OF ENGINEERING RESEARCH

NPDES MONITORING PROGRAM AND TOXICITY STUDIES AT DIABLO CANYON DURING 1982

Prepared By:

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

During 1982, the self-monitoring program underwent substantial revision, most of which resulted from over 365 hours of public hearing and testimony before the Regional Water Quality Control Board. The evolution of these requirements is described. During 1982 also, the Department of Engineering Research (DER) maintained responsibility for part of the monitoring and assumed joint responsibility with Nuclear Plant Operations staff (NPO) for routine report coordination and preparation. Primary power plant discharge activity during the year was limited to the operation of auxiliary saltwater pumps.

NPDES permit (Order No. 76-11) expired in June 1981. Application for reissuance of the permit was completed June 26, 1981. Public hearings were held by the Regional Board to hear public and Board cross examination of PGandE technical experts and consultants on the new permit. No decision had been reached by the end of 1981. A new permit (Order No. 82-24) was adopted on January 14, 1982. Two additional hearings were held to modify this order. A summary of revisions found in amended Order 82-24 and the ensuing Regional Board hearing of September 10, 1982, are presented. The new requirement to conduct an insitu bioassay is being met by PGandE's participation in the California State Water Resources Board "Mussel Watch" program. Several additional studies were required, and are described. A summarization of toxicity studies conducted in 1982 is presented.

INTRODUCTION

The creation and evolution of the National Pollutant Discharge Elimination System (NPDES) permit process for Diablo Canyon Power Plant (DCPP) is described in Behrens (1978b, 1981a and b, 1982a and b).

During 1982, the self monitoring program underwent substantial revision, most of which resulted from over 365 hours of public hearing and testimony (see Warrick 1983 for details of the NPDES permit reissuance hearings). The evolution of these requirements is described below.

During 1982 also, the Department of Engineering Research (DER) maintained responsibility for part of the monitoring and assumed joint responsibility with the Nuclear Plant Operations staff (NPO) for routine report coordination and preparation. Primary power plant activity during the year was limited to the operation of auxiliary saltwater pumps (September 24, 1980 to present).

NPDES PERMIT

NPDES permit (Order No. 76-11) expired in June 1981. Application for the permit was completed June 26, 1981. Public hearings were held by the California Water Quality Control Board, Central Coast Region (September 11 and 24; October 9, 29, and 30; November 13 and 14, 1981; and January 14, 1982) to hear public and Board cross examination of PGandE technical experts and consultants on the new permit. No decision had been reached by the end of 1981. A new permit (Order No. 82-24) was adopted on January 14, 1982. Two additional hearings (May 14 and June

11, 1982) were held to modify this order.

Revision of the self-monitoring program was publicly discussed by the Board on September 10, 1982.

Amended Order 82-24 contains the fourth revision to the DCPP monitoring and reporting program since the first permit (see Behrens 1978b). A summary of revisions found in amended Order 82-24 and the ensuing Regional Board hearing of September 10, 1982, are presented in Table 1. Although several new chemical constituents are to be sampled under the list, the primary modification consisted of an increased sampling frequency (annually to quarterly and quarterly to monthly) for most trace constituents and an increase in reporting frequency, quarterly to monthly. The new requirement to conduct an insitu bioassay is being met by PGandE's participation in the California State Water Resources Board "Mussel Watch" program. This program involves periodic collection of California mussels, <u>Mytilis</u> <u>californicus</u>, to be analyzed for accumulation of various trace metals and petro-chemicals.

Required in the provisions of the order rather than in the monitoring and reporting program itself, were several additional studies. The Thermal Effects Monitoring Program (TEMP) is not a new requirement but rather a continuation of the previously required 316(a) Demonstration Program. Two technical reports required in Order 82-24, provision D.2, were to be submitted to the Board prior to April 1, 1982. One, an evaluation of alternatives to reduce the heat and volume of the cooling water discharge was entitled "Assessment of Alternatives to the Existing Cooling Water System" (PGandE, 1982a). The second report "The Thermal Discharge Assessment Report" (PGandE, 1982b) was a synthesis of laboratory thermal effects data and population distribution information

TABLE 1

Revisions to Monitoring and Reporting Requirements

	Order 82-24	September 82 Revision
Influent Monitoring		
Turbidity	Added - Monthly measurement	
Grease and oil	Quarterly to Monthly	
Settleable solids	Deleted	
Effluent Monitoring		
pH		Daily grab to monitor continuously
Turbidity	Added for 001 - Monthly measurement	
Grease and oil 001 + 001F	Weekly to Monthly	
Grease and oil 001C, D, G, H, I, J, K, L	Monthly to Quarterly	
Grease and oil 005	Added - Quarterly measurement	
Total Non-Filtrable Res. 001C, D, F, G, H, J, K, L	Quarterly to Monthly	
Arsenic		Annually to Quarterly
Cadmuim		Annually to Quarterly
Total Chromium		Quarterly to Monthly
Copper 001D, F, I, L	Weekly to Only during metal cleaning	
Lead		Annually to Quarterly

Table 1 (Cont.)

	Order 82-24	September 82 Revision
Mercury		Annually to Quarterly
Nickel		Quarterly to Monthly
Silver		Annually to Quarterly
Cyanide		Annually to Quarterly
Phenolic Compounds		Annually to Quarterly
Total Chlorine Residual	Weekly to Twice during each cycle	
Chlorine used (lbs)	Daily to Monthly	
Amonia (as N)		Quarterly to Monthly
Toxicity Concentration	Twice Annually to Quarterly	Quarterly to Monthly
Chlorinated Pesticides and PCB	Added - Annual measurement	Annually to Quarterly
Iron	Weekly to only during metal cleaning	
Titanium	Added - Quarterly measurement	Quarterly to Monthly
Boron, 001	Added - Quarterly measurement	Quarterly to Monthly
Dissolved Oxygen	Weekly to Quarterly	Quarterly to Monthly
Lithium, 001D		Quarterly to when discharging
Hydrazine, 001	Added - Quarterly measurement	Quarterly to Monthly
Hydrazine, 001D		Added - When discharging
Boron, 001D		Added - When discharging

Table 1 (con't)

	Order 82-24	September 82 Revision
Cadmium, chronium, lead, copper, mercury, nickel, silver, zinc - OOF	Added - Quarterly measurement	
Detergent (lbs.)	Deleted	
Settleable Solids 001, 002	Deleted	
Receiving Water Monitoring		
Sediment samples	Added - Sampled annually at two stations	
Radiological Monitoring	Monthly seawater and bull kelp added. Two additional stations added for black and red abalone, perch, and rockfish.	Radiochemical analysis of California mussels sampled quarterly at Avila Beach added
Insitu Bioassay	Added	
Reporting Frequency		Quarterly to Monthly

Other Requirements
(see text for further explanation)

Thermal Effects Monitoring Program required in lieu of a 316(a) demonstration study.

Alternate Cooling Study to be completed prior to April 1, 1982.

Thermal Discharge Assessment to be completed prior to April 1, 1982.

Heat Treatment Optimization Program added to order (report to Board prior to commercial operation of Unit II).

for animals living in the area of the power plant discharge with relation to power plant effluent flow and temperature isotherms. A study to optimize and, therefore, reduce the potential effects of heat treatment has also been required by the Board. This study, initially proposed in four phases, must be completed prior to commercial operation of Unit II (see Regional Board Order 82-54). In the interim, during discharge of heat treatment effluent from Unit I, Unit II's circulating water pumps must be operated at full flow with no heat load.

The monitoring and reporting program included in Order 82-24 is presented in Appendix 1. The revised requirements discussed on September 10, 1982 and adopted October 7, 1982 are presented in Appendix II.

Quarterly (through September 1982) and subsequently monthly, reports were submitted to the Executive Officer of the Central Coast Regional Board according to schedule. The annual summary report of the monitoring and reporting program for 1982 (excluding appendix 3 - Thermal Effects Monitoring Program, 1982 Annual Report), submitted to the board on January 30, 1983, is presented in Appendix III of this report.

BIOASSAYS STUDIES

Toxicity bioassays required under the NPDES permit are conducted at Pacific Gas and Electric Company's on-site Biological Research Laboratory (Behrens 1978a, 1981a and b, and 1982a and b). Order 82-24 increased the frequency of toxicity bioassays from twice annually to

quarterly. Beginning in September, bioassays were required monthly under the new self-monitoring program. The results of these assays are reported monthly to the regional board on the State of California Form Q-2 (Table 2). Supporting data is included in the reports to the regional board. Several research bioassays were also conducted (Table 2).

TABLE 2

Toxicity Studies Conducted During 1982
at Diablo Canyon Biological Research Laboratory

Bioassay No.	Date	Material Tested	Duration (hr.)	FW* SW	Static (S) or Cont. Flow (CF)	Disposition of Final Data or Report
81-N	1/25	Disch 001	96	SW	S	Waste Discharge Report April 2, 1982
82-N	4/12	Disch 001	96	SW	S	Waste Discharge Report July 20, 1982
83-N	7/28	Disch 001	96	SW	S	Waste Discharge Report October 20, 1982
84-S	5/28	Disch 001 (Unit I)	96	SW	S	Appendix IV
84-R	8/9	Radiator Water/ Ethylene glycol disch	96	FW	S	DER Report 411-82.284
85-S	6/5	Disch 001 (Unit II)	96	SW	S	Waste Discharge Report July 2, 1982
85-R	8/16	Radiator Water/ Ethylene glycol	96	FW	S	DER Report 411-82.284
86-R	8/16	Ethylene glycol	96	FW	S	DER Report 411-82.284
87-R	9/9	Disch 001-B	96	SW	S	Appendix IV
88-S	9/9	Disch 001-B	7-day	SW	CF	Terminated due to equip problems.
89-S	9/13	Disch 001-B	7-day	SW	CF	Terminated due to equip problems.
90-S	9/15	Disch 001-B	7-day	SW	CF	Terminated due to equip problems.

Table 2 (Cont.)

91-N	10/18	Disch 001-B	96	SW	S	Waste Discharge Report January 20, 1983
92-N	11/15	Disch 001-B	96	SW	S	Waste Discharge Report January 20, 1983
93-N	12/13	Disch 001-B	96	SW	S	Waste Discharge Report January 20, 1983

*FW = Freshwater; SW = Salt Water

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Warrick, J. W. 1983. Introduction and Historical Overview. In Environmental Investigations at Diablo Canyon, 1982.

APPENDIX I

Revised

Self-monitoring Program

Contained in

NPDES Order 82-24

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

MONITORING AND REPORTING PROGRAM NO. 82-24
FOR
PACIFIC GAS & ELECTRIC COMPANY
DIABLO CANYON NUCLEAR POWER PLANT
SAN LUIS OBISPO COUNTY

Influent Monitoring

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

Parameter	Units	Type of Sample	Minimum Frequency of Analysis
Temperature	°F	Metered	Continuously
Turbidity	NTU	Grab	Monthly
pH	-	Grab	Monthly
Grease & Oil	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Total Non-Filtrable Residue* (Suspended Solids)	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Arsenic	mg/l	Grab	Annually (Oct.)
Cadmium	mg/l	Grab	Annually (Oct.)
Total Chromium	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Copper	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Lead	mg/l	Grab	Annually (Oct.)
Mercury	mg/l	Grab	Annually (Oct.)
Nickel	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Silver	mg/l	Grab	Annually (Oct.)
Zinc	mg/l	Grab	Annually (Oct.)
Cyanide	mg/l	Grab	Annually (Oct.)
Phenolic Compounds	mg/l	Grab	Annually (Oct.)
Ammonia (as N)	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)

Effluent Monitoring

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

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Temperature	°F	001	Metered	Continuously
Flow	MGD	001	Recorded from pump operating data.	Daily
pH	pH Units	001	Grab	Daily when effluent from chemical cleaning is discharged otherwise Monthly.

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Turbidity	NTU	001	Grab	Monthly
Grease & Oil	mg/l	001 & 001F	Grab	Monthly
Grease & Oil	mg/l	001C,001D,001G, 001H,001I,001J, 001K,001L,002,& 005	Grab	Qtrly(Jan,Apr,July,Oct)
Total Non-Filtrable Residue* (Suspended Solids)	mg/l	001&001I	Grab	Monthly
Total Non-Filtrable Residue (Suspended Solids)	mg/l	001C,001D,001F, 001G,001H,001J, 001K&001L	Grab	Monthly
Arsenic	mg/l	001	Grab	Annually (Oct.)
Cadmium	mg/l	001	Grab	Annually (Oct.)
Total Chromium	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Copper	mg/l	001	Grab	Monthly
Copper	mg/l	001D,001F, 001I,&001L	24-Hr. Composite	During metal cleaning operations
Lead	mg/l	001	Grab	Annually (Oct.)
Mercury	mg/l	001	Grab	Annually (Oct.)
Nickel	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Silver	mg/l	001	Grab	Annually (Oct.)
Zinc	mg/l	001	Grab	Monthly
Cyanide	mg/l	001	Grab	Annually (Oct.)
Phenolic Compounds	mg/l	001	Grab	Annually (Oct.)
Total Chlorine Residual	mg/l	001	Grab	At least twice during each chlorination cycle
Chlorine Used	lbs/day	001	Record of Actual amount used.	Monthly
Ammonia (as N)	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Toxicity Concentration**	tu	001	Grab	Qtrly(Jan,Apr,July,Oct)
Total Chlorinated Pesticides & PCB's***	mg/l	001	Grab	Annually (Oct.)
Iron	mg/l	001D,001F 001I&001L	24-Hr. Composite	During metal cleaning operations
Titanium	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Boron	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Dissolved Oxygen	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Lithium	mg/l	001D	Grab	Qtrly(Jan,Apr,July,Oct)
Hydrazine	mg/l	001	Grab	Qtrly. when discharging hydrazine into 001.
Cadmium, chromium, copper, lead, mercury, nickel silver, and zinc	mg/l	001D, 001H & 001L	Quarterly Composite	Qtrly(Jan,Apr,July,Oct)
Cadmium, chromium, lead, copper, mercury, nickel, silver, and zinc	mg/l	001F	Weekly Composite	Qtrly(Jan,Apr,July,Oct)

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

*The total non-filtrable residue (suspended solids) analyses of brine waste streams shall be modified as follows: after determination of the suspended matter by the Standard Methods Technique, a second determination using the identical procedure shall be made of the suspended matter in the filtrate. Both the first and second determinations as well as the difference between the two amounts shall be reported. The calculated difference shall be considered the concentration of non-filtrable residue in the effluent.

**Static bioassays (96-hr. TLm) using species indigenous to Diablo Cove (including red abalone and blue rock fish, when available), but obtained elsewhere, shall be conducted using water being discharged to Diablo Cove. Accumulation of materials in the tissue of bioassay-tested animals shall be measured, as directed by the Executive Officer.

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

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

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

**Total chlorinated pesticides and PCB's shall be measured by summing the individual concentrations of DDT, DDD, DDE, aldrin, BHC, chlordane, endrin, heptachlor, lindane, dieldrin, and polychlorinated biphenyls.

Receiving Water Monitoring

Receiving Water Monitoring shall be conducted as outlined below:

1. Ecological studies as approved by the Executive Officer shall be continued in order to evaluate changes of the marine plant and animal distribution and abundance within the vicinity of the discharge. These studies will be designed in cooperation with the Department of Fish and Game.

2. Sediment samples shall be analyzed annually at two stations inside and two stations adjacent to Diablo Cove for constituents listed in paragraph B.6. on page 9 of Order No. 81-76.

3. Aerial photographs of the existing kelp beds from Pecho Rock to Point Buchon shall be taken three times per year, during February, June and October, for a period of at least two years after commercial operation begins.

4. Surface water temperatures shall be determined at two-month intervals from Point Buchon to Pecho Rock for at least two years after commercial operation begins. Isotherms shall be determined in 2°F intervals.

5. Water temperatures shall be measured at one meter intervals from the surface to the bottom at twelve stations inside and adjacent to Diablo Cove. Measurements shall be taken in February, June and October after commercial operation begins. Precision of measurements shall be within ± 0.2°F.

6. pH and dissolved oxygen content of the receiving water in February, June, and October (including Pacific Gas & Electric stations 3a through c, 4a through c, 5a through c, as well as three stations in Diablo Cove). Dissolved oxygen and pH samples shall be grab samples.

7. Incident light measurements shall be taken at three meter intervals from the surface to the bottom at 6 stations approved by the Executive Officer. Measurements shall be taken on a monthly basis after commercial operation begins and during times of discharge. Measurement shall be with a photometer cell.

8. Radiological monitoring of seawater and bull kelp at stations located at the middle and immediately north and south of Diablo Cove shall be conducted monthly. Radiological monitoring of the following animals shall be conducted quarterly at the same locations:

   Black Abalone
   Red Abalone
   Perch
   Rockfish

9. An in situ bioassay monitoring program approved by the Executive Officer shall be instituted.

Reporting

The following information shall be reported to the Board:

1. Results of Influent, Effluent and Receiving Water Monitoring.

2. Details of any bypass or damage of the 5 micron filters in the liquid radwaste system.

3. The occurrence of any incident causing the release of toxic materials in concentration detrimental to human, plant, bird, or aquatic life shall be reported orally within 12 hours after its occurrence and its cause, effect, and corrective action shall be described in detail in the next regular report submitted to the Regional Board.

4. Daily radiological concentrations and total quantity of radioactive materials in the discharge. Violations of radioactivity limitations shall be reported to the Board immediately.

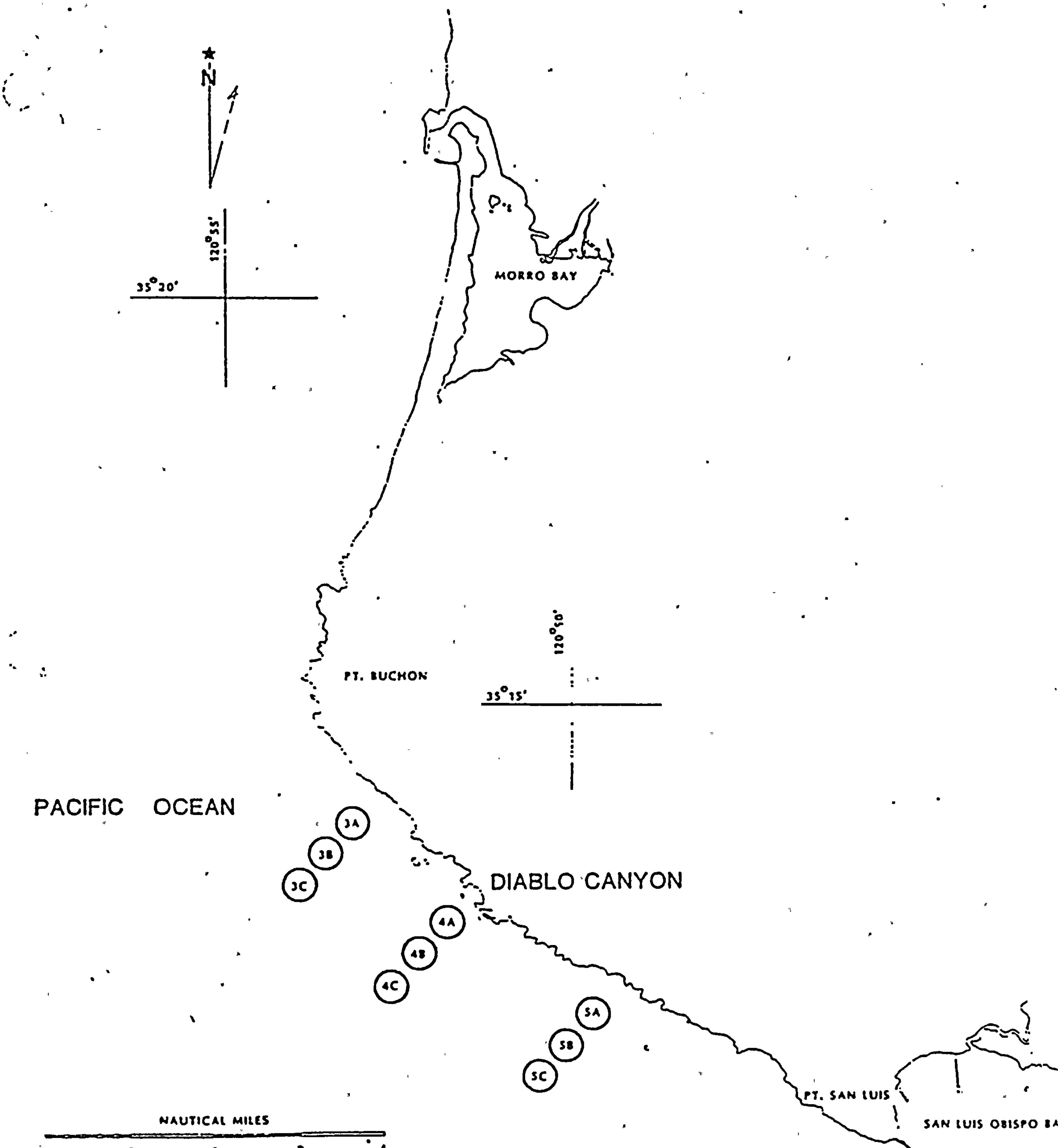
5. A copy of information contained in reports to the Nuclear Regulatory Commission and/or the California Department of Health Services related to the marine environment.

6. Progress reports regarding studies required in Provision D.4., above, shall be submitted every year.

Routine monitoring reports containing information pertinent to the calendar quarter shall be submitted by the 20th day of the following month (i.e. information obtained for the period Jan. 1 to March 31 shall be submitted by April 20th).

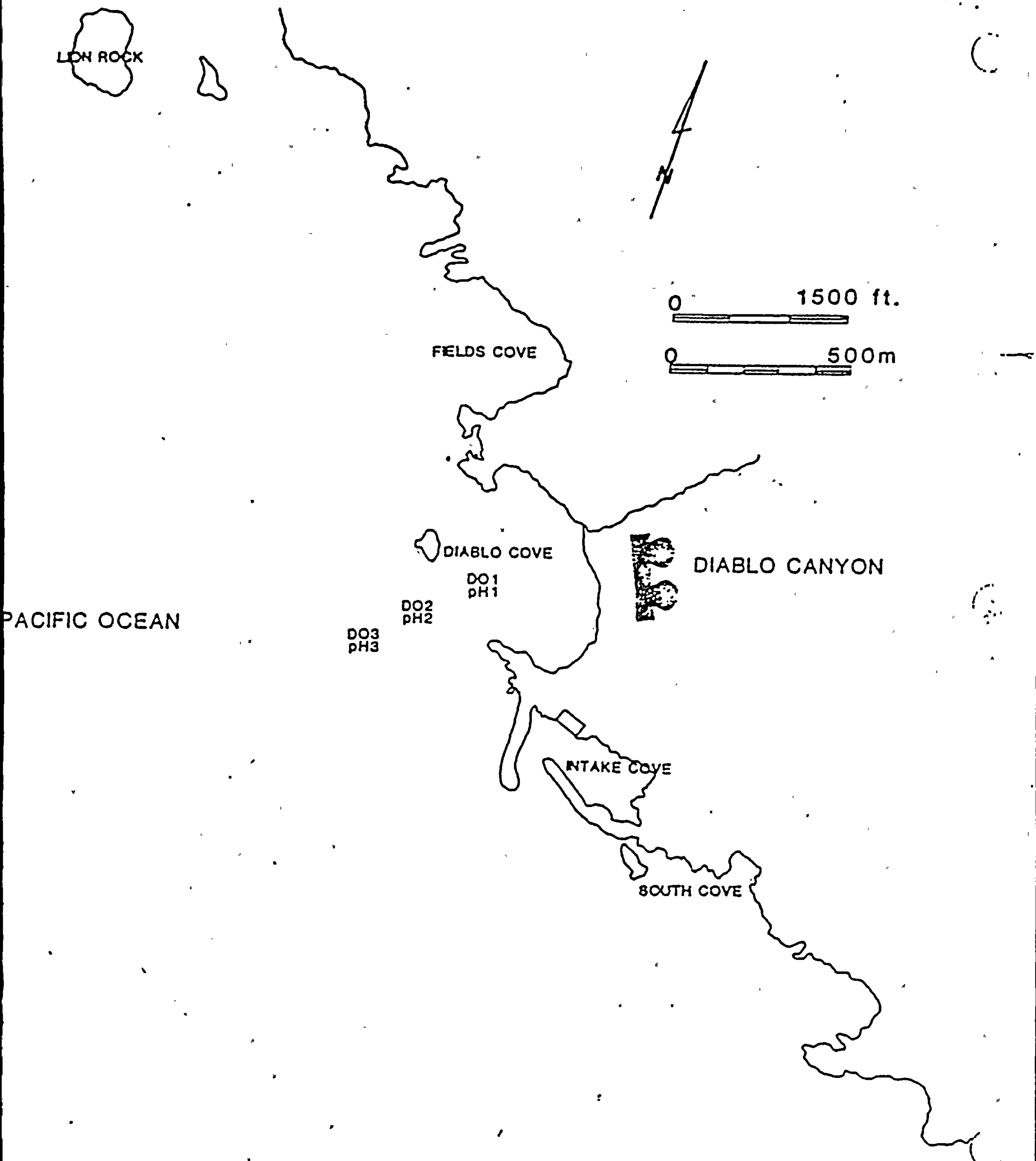
ORDERED BY ____________________
Executive Officer

January 14, 1982
Date



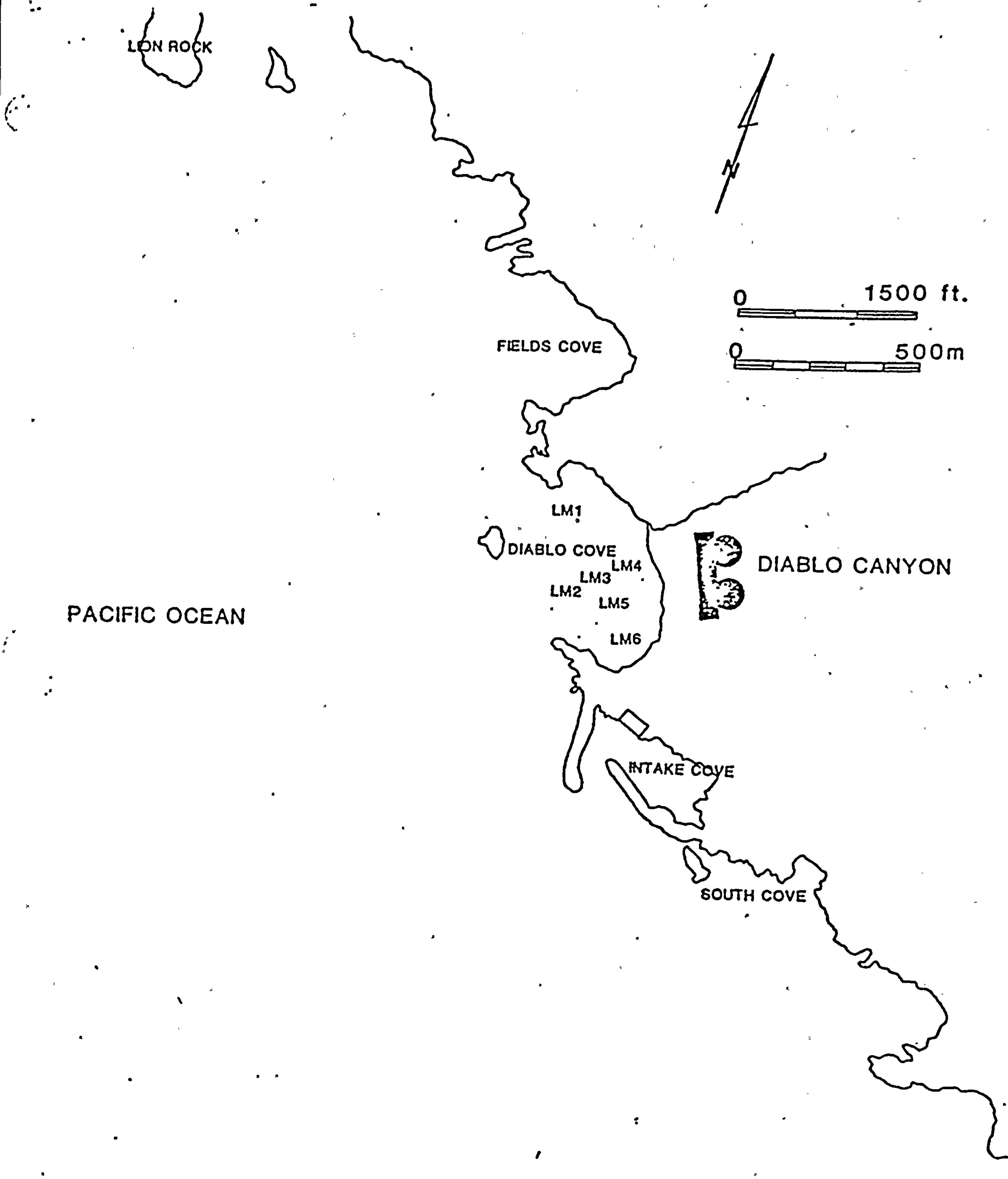
OCEANOGRAPHIC STATIONS

FIGURE 1



DISSOLVED OXYGEN and pH MONITORING STATIONS

FIGURE 2



LIGHT METER LOCATIONS

FIGURE 3

APPENDIX II

Revised Self-monitoring Program

(Adopted October 7, 1982)

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION

MONITORING AND REPORTING PROGRAM NO. 82-24
FOR
PACIFIC GAS & ELECTRIC COMPANY
DIABLO CANYON NUCLEAR POWER PLANT
SAN LUIS OBISPO COUNTY

Influent Monitoring

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

Parameter	Units	Type of Sample	Minimum Frequency of Analysis
Temperature	°F	Metered	Continuously
Turbidity	NTU	Grab	Monthly
pH	-	Grab	Monthly
Grease & Oil	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Total Non-Filtrable Residue* (Suspended Solids)	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Arsenic	mg/l	Grab	Annually (Oct.)
Cadmium	mg/l	Grab	Annually (Oct.)
Total Chromium	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Copper	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Lead	mg/l	Grab	Annually (Oct.)
Mercury	mg/l	Grab	Annually (Oct.)
Nickel	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)
Silver	mg/l	Grab	Annually (Oct.)
Zinc	mg/l	Grab	Annually (Oct.)
Cyanide	mg/l	Grab	Annually (Oct.)
Phenolic Compounds	mg/l	Grab	Annually (Oct.)
Ammonia (as N)	mg/l	Grab	Qtrly(Jan,Apr,July,Oct)

Effluent Monitoring

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

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Temperature	°F	001	Metered	Continuously
Flow	MGD	001	Recorded from pump operating data.	Daily
pH	-	001	Continuously	Daily when discharging from 001 C, D, H, I, J and/or K, otherwise Monthly grab sample.

Parameter	Units	Discharge	Type of Sample	Minimum Frequency of Analysis
Turbidity	NTU	001	Grab	Monthly
Grease & Oil	mg/l	001 & 001F	Grab	Monthly
Grease & Oil	mg/l	001C,001D,001G, 001H,001I,001J, 001K,001L,002,& 005	Grab	Qtrly(Jan,Apr,July,Oct)
Total Non-Filtrable Residue* (Suspended Solids)	mg/l	001&001I	Grab	Monthly
Total Non-Filtrable Residue (Suspended Solids)	mg/l	001C,001D,001F, 001G,001H,001J, 001K&001L	Grab	Monthly
Arsenic	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Cadmium	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Total Chromium	mg/l	001	Grab	Monthly
Copper	mg/l	001	Grab	Monthly
Copper	mg/l	001D,001F, 001I,&001L	24-Hr. Composite	During metal cleaning operations
Lead	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Mercury	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Nickel	mg/l	001	Grab	Monthly
Silver	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Zinc	mg/l	001	Grab	Monthly
Cyanide	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Phenolic Compounds	mg/l	001	Grab	Qtrly(Jan,Apr,July,Oct)
Total Chlorine Residual	mg/l	001	Grab	At least twice during each chlorination cycle
Chlorine Used	lbs/day	001	Record of Actual amount used.	Monthly
Ammonia (as N)	mg/l	001	Grab	Monthly
Toxicity Concentration**	tu	001	Grab	Monthly
Total Chlorinated Pesticides***	mg/l	001,005	Grab	Qtrly(Jan,Apr,July,Oct)
PCB's	mg/l	001,005	Grab	Qtrly(Jan,Apr,July,Oct)
Iron	mg/l	001D,001F 001I&001L	24-Hr. Composite	During metal cleaning operations
Titanium	mg/l	001	Grab	Monthly
Boron	mg/l	001	Grab	Monthly
Dissolved Oxygen	mg/l	001	Grab	Monthly
Lithium, Boron, Hydrazine	mg/l	001D	Grab	When discharging into 001
Hydrazine	mg/l	001	Grab	Monthly when discharging Hydrazine into 001.
Cadmium, chromium, copper, lead, mercury, nickel silver, and zinc	mg/l	001D, 001H & 001L	Quarterly Composite	Qtrly(Jan,Apr,July,Oct)
Cadmium, chromium, lead, copper, mercury, nickel, silver, and zinc	mg/l	001F	Weekly Composite	Qtrly(Jan,Apr,July,Oct)

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

*The total non-filtrable residue (suspended solids) analyses of brine waste streams shall be modified as follows: after determination of the suspended matter by the Standard Methods Technique, a second determination using the identical procedure shall be made of the suspended matter in the filtrate. Both the first and second determinations as well as the difference between the two amounts shall be reported. The calculated difference shall be considered the concentration of non-filtrable residue in the effluent.

**Static bioassays (96-hr. TLm) using species indigenous to Diablo Cove (including red abalone and blue rock fish, when available), but obtained elsewhere, shall be conducted using water being discharged to Diablo Cove. Accumulation of materials in the tissue of bioassay-tested animals shall be measured, as directed by the Executive Officer.

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

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

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

***Total chlorinated pesticides shall be measured by summing the individual concentrations of DDT, DDD, DDE, aldrin, BHC, chlordane, endrin, heptachlor, lindane, and dieldrin.

Receiving Water Monitoring

Receiving Water Monitoring shall be conducted as outlined below:

1. Ecological studies as approved by the Executive Officer shall be continued in order to evaluate changes of the marine plant and animal distribution and abundance within the vicinity of the discharge. These studies will be designed in cooperation with the Department of Fish and Game.

2. Sediment samples shall be analyzed annually at two stations approved by the Executive Officer inside and two stations adjacent to Diablo Cove for constituents listed in paragraph B.1.b. on page 12 of Order No. 82-24.

3. Aerial photographs of the existing kelp beds from Pecho Rock to Point Buchon shall be taken three times per year, during February, June and October, for a period of at least two years after commercial operation begins.

4. Surface water temperature measurements during normal operation and during heat treatment shall be determined at two-month intervals from Point Buchon to Pecho Rock for at least two years after commercial operation begins. Isotherms shall be determined in 2°F intervals.

5. Water temperatures shall be measured at one meter intervals from the surface to the bottom at twelve stations inside and adjacent to Diablo Cove. Measurements shall be taken in February, June and October after commercial operation begins. Precision of measurements shall be within ± 0.2°F.

6. pH and dissolved oxygen content of the receiving water in February, June, and October (including Pacific Gas & Electric stations 3a through c, 4a through c, 5a through c, as well as three stations in Diablo Cove). Dissolved oxygen and pH samples shall be grab samples.

7. Incident light measurements shall be taken at three meter intervals from the surface to the bottom at 6 stations approved by the Executive Officer. Measurements shall be taken on a monthly basis after commercial operation begins if one or more circulating water pumps is operating. Measurement shall be with a photometer cell.

8. Radiological monitoring of seawater and brown algae at stations located at the middle and immediately north and south of Diablo Cove shall be conducted monthly. Radiological monitoring of the following animals shall be conducted quarterly at the same locations:

Black Abalone	Rockfish
Red Abalone	Mussels
Perch	

In addition, radiological monitoring of Mussels shall be conducted quarterly at Avila Beach.

Each of the above radiological monitoring tasks shall begin after commercial operation begins.

9. An in situ bioassay monitoring program approved by the Executive Officer shall be instituted.

Reporting

The following information shall be reported to the Board:

1. Results of Influent, Effluent and Receiving Water Monitoring.

2. Details of any bypass or damage of the 5 micron filters in the liquid radwaste system shall be reported to the Executive Officer immediately.

3. The occurrence of any incident causing the release of toxic materials in concentration detrimental to human, plant, bird, or aquatic life shall be reported orally immediately after its occurrence and its cause, effect, and corrective action shall be described in detail in the next regular report submitted to the Regional Board.

4. Daily radiological concentrations and total quantity of radioactive materials in the discharge. Violations of radioactivity limitations shall be reported to the Board immediately.

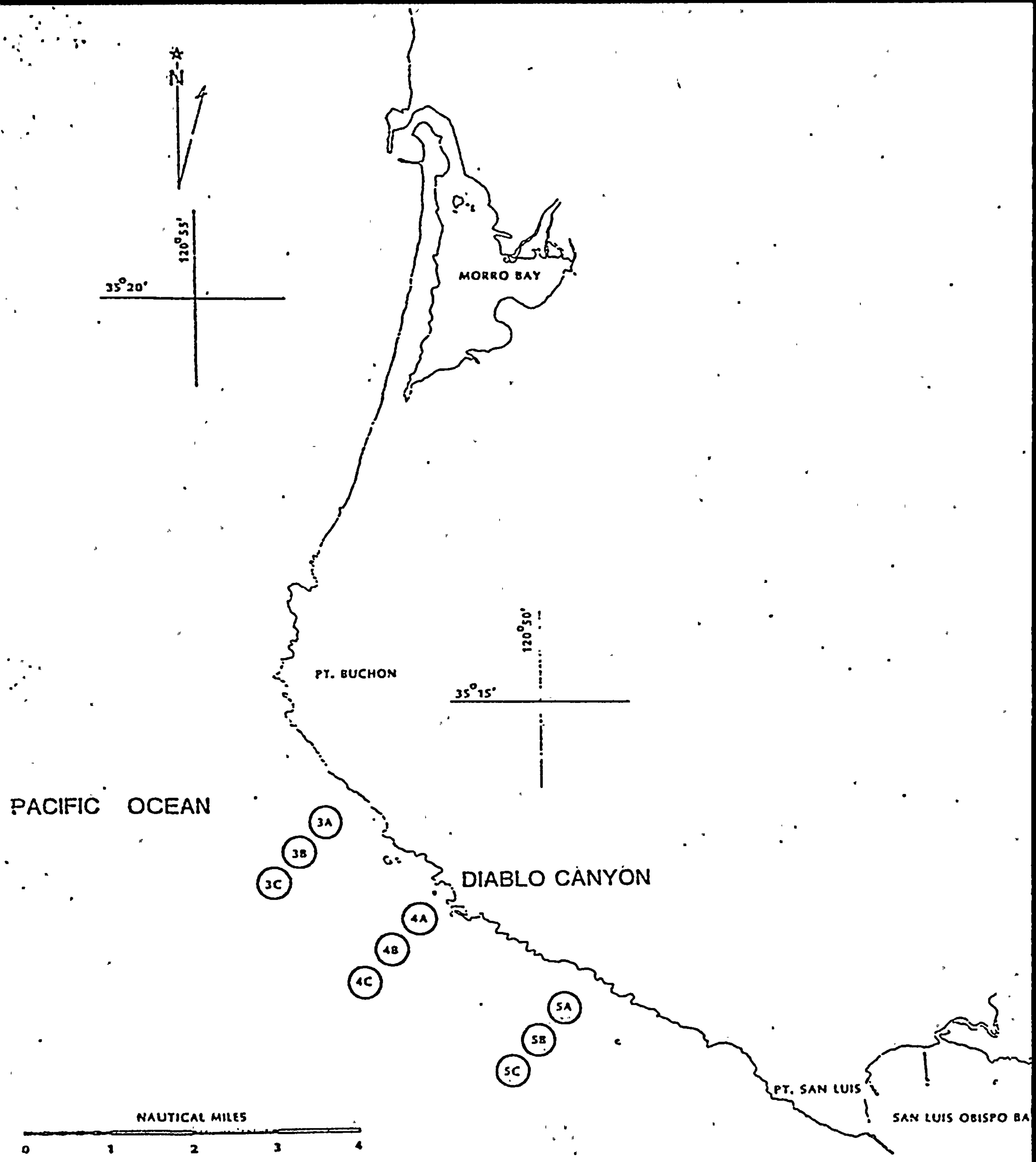
5. A copy of information contained in reports to the Nuclear Regulatory Commission and/or the California Department of Health Services related to the marine environment.

6. Progress reports regarding studies required in Provision D.6. and D.7., above, shall be submitted every year.

Monthly monitoring reports shall be submitted by the 20th day of the following month.

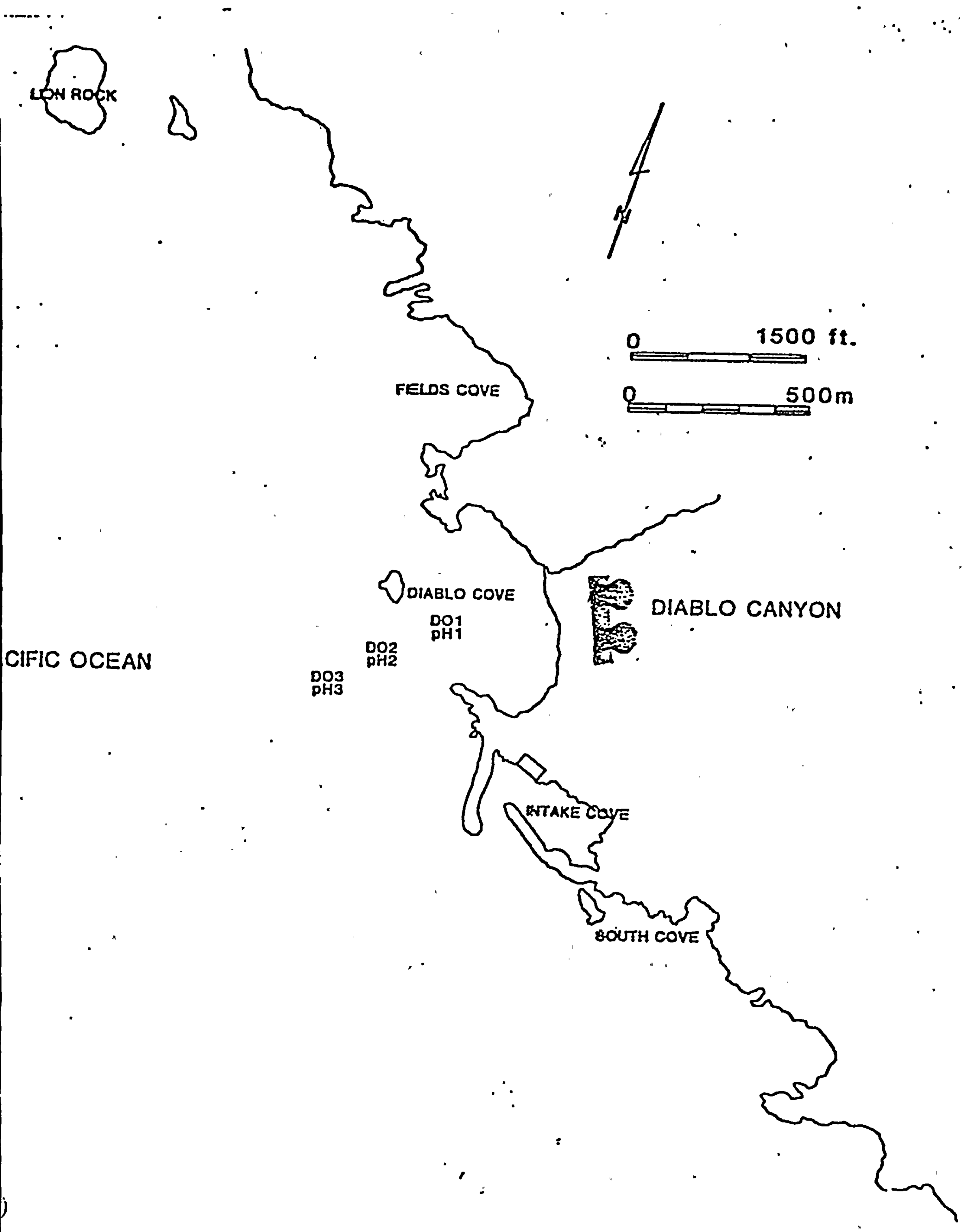
ORDERED BY [signature]
Executive Officer

October 7, 1982
Date

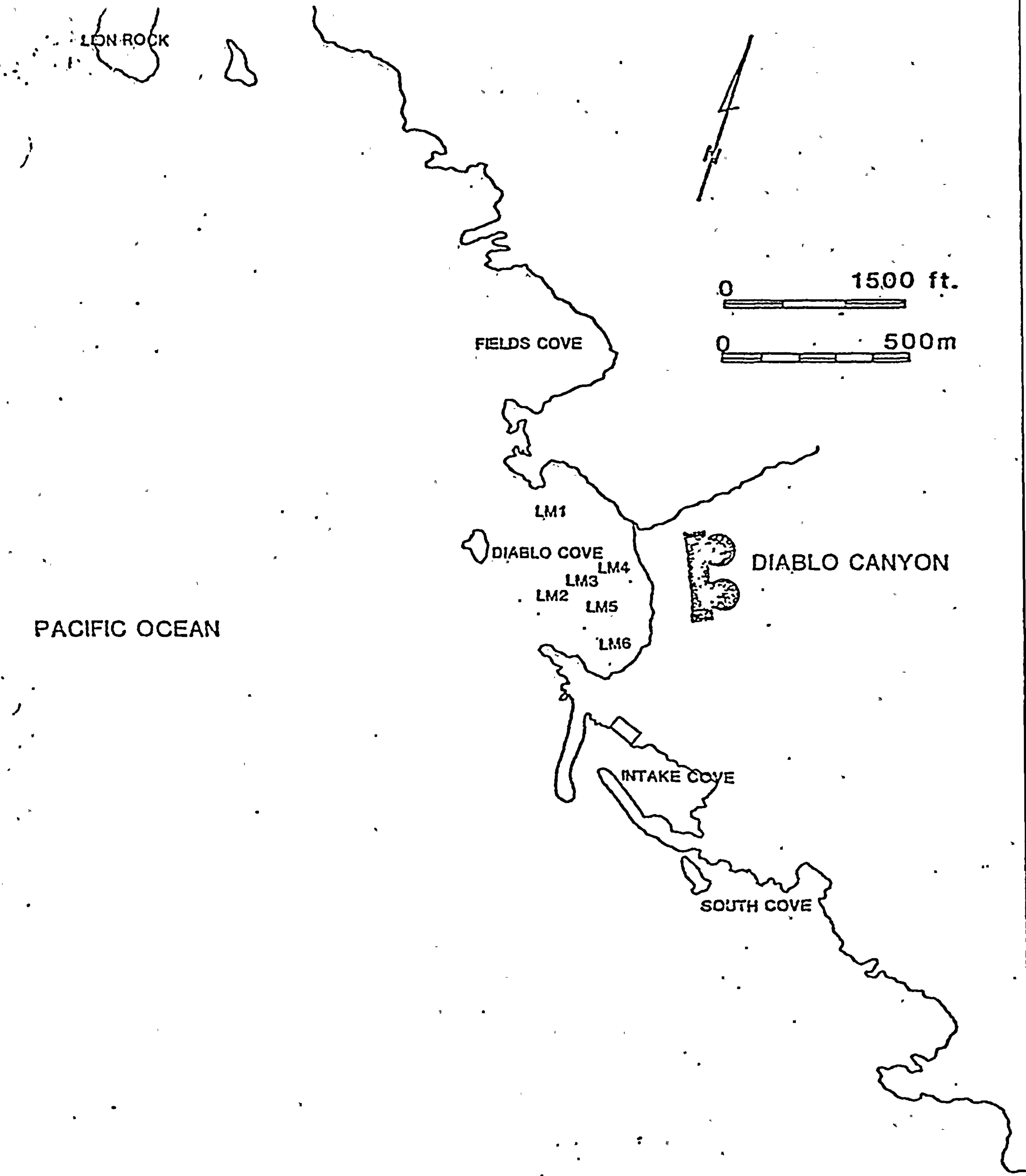


OCEANOGRAPHIC STATIONS

FIGURE 1



DISSOLVED OXYGEN and pH MONITORING STATIONS



LIGHT METER LOCATIONS

FIGURE 3

APPENDIX III

Annual Summary Report of the
Monitoring and Reporting Program at
Diablo Canyon Power Plant During 1982
(excluding the TEMP 1982 Annual Report)

PACIFIC GAS AND ELECTRIC COMPANY

PG and E

DIABLO CANYON POWER PLANT
P.O. Box 56 • Avila Beach. California 93424 • (805) 595-7351

R.C. THORNBERRY
PLANT MANAGER

January 28, 1983

Mr. Kenneth R. Jones
Executive Officer
California Regional Water Quality
Control Board
Central Coast Region
1102-A Laurel Lane
San Luis Obispo, CA 93401

Dear Mr. Jones:

Monitoring and Reporting Program
Diablo Canyon Power Plant

The annual summary report, for the period January 1 through December 31, 1982, of the Diablo Canyon Power Plant Monitoring and Reporting Program and the first annual report of the Thermal Effects Monitoring Program (Provision D.7) are enclosed in accordance with amended Order 82-24 NPDES No. CA0003751.

I certify under penalty of law that I have personally examined and am familiar with the information submitted in the attached document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Sincerely,

R. C. Thornberry

R. C. THORNBERRY

RCT:ct

Enclosure

cc Marine Resources Region
California Department of Fish and Game
350 Golden Shore
Long Beach, CA 90802

Regional Administrator
Attention: Water Division, CA Br.
Environmental Protection Agency, Region IX
215 Fremont Street
San Francisco, CA 94105

Regional Administrator
U. S. Nuclear Regulatory Commission
Region 5
1450 Maria Lane, Suite 210
Walnut Creek, CA 94596

Dr. Thomas D. Cain
Environmental Engineering Branch
Division of Engineering
Office of Nuclear Reactor Reg.
U. S. Nuclear Regulatory Commission
Washington, DC 20535

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Chief Marine Resources Branch
California Department of Fish and Game
Resources Building
1419 Ninth Street
Sacramento, CA 95814

JWWarrick/DWBehrens(69-1771):ct

bcc WHBarr/TGCasebolt
DWBehrens
JVBoots/WAO'Hara
RFCayot/JRAdams
PACrane
MJDoyle/VLWyman
RDEtzler
JBGibson/DJWilliamson
HMHowe/JFMcKenzie/CPWalton
BSLew/RLKelmenson
JDShiffer/RWLorenz/KMGodfrey
HKMcCluer
JWWarrick
BFWaters
RMS

PACIFIC GAS AND ELECTRIC COMPANY

NUCLEAR PLANT OPERATIONS

ANNUAL SUMMARY REPORT ON MONITORING AND REPORTING PROGRAM AT DIABLO CANYON POWER PLANT DURING 1982

TABLE OF CONTENTS

OVERVIEW

Due to revisions in the monitoring and reporting program, adopted January 14, 1982 and amended October 7, 1982, both the reporting frequency and the chemical constituents monitored have changed. Results of our monitoring were reported quarterly for the first three quarters of 1982, and monthly since October. This annual summary report will follow the new format used in the recent monthly monitoring reports.

During 1982 discharges were made from all discharge paths except 001-G, 001-H, 001-I, 001-J, 001-K, 001-L.

Appendix 1 contains a list of non-routine reports sent to staff during 1982.

SUMMARY OF MONITORING PROGRAM RESULTS

A. Monitoring of Plant Influent and Effluent

Appendix 2 contains a summary of the monthly volumes from discharge pathways and both tabular and graphical summaries of the monitoring results previously reported in quarterly and monthly reports.

B. Monitoring of Receiving Waters

1. Ecological Studies at Diablo Canyon

Studies in accordance with the Thermal Effects Monitoring Program (Provision D.7) and studies by the California Department of Fish and Game continue. A periodic report by the California Department of Fish and Game for the period January 1, 1979 - June 30, 1980 was submitted in the first quarterly report of 1982. The annual report of the TEMP program is submitted with this package (Appendix 3).

2. Sediment Analysis

Annual sediment samples were collected on October 28, 1982. Results of analysis were presented in the December report.

3. Aerial Photography of Kelp Beds

Aerial photography (infrared film type 2443) of kelp beds in the vicinity of Diablo Canyon were taken February 18, July 1 and September 20, 1982. Color transparencies of the photos were submitted to staff in the respective quarterly and monthly reports.

4. Surface Water Temperature

These measurements are not scheduled for monitoring until after plant thermal operation begins.

5. Stratified Water Temperatures

These measurements are not scheduled for monitoring until after plant thermal operation begins.

6. pH and Dissolved Oxygen of Receiving Waters

Results of pH and Dissolved Oxygen monitoring in the receiving waters were submitted to staff in the routine quarterly and monthly reports.

7. Incident Light Measurements

Subsurface light measurements were not made this year since the main circulating water pumps were operated only for the purposes of effluent mixing dye tests.

8. Environmental Radiological Monitoring Program

Monthly radiological determinations (gamma isotopic) on seawater and bullkelp, and quarterly samples on black abalone, red abalone, perch and rockfish continued, and results are contained in the routine reports.

9. In situ Bioassay

Results of Mussel Watch will be reported to the Board in the California Department of Fish and Game periodic report for this program. Two periodic samplings of mussels occurred in 1982, June 28 and December 14.

APPENDIX 1

Non-Routine Reports

DEPARTMENT OF NUCLEAR PLANT OPERATIONS
DIABLO CANYON POWER PLANT

Non-Routine Reports Sent to California Regional Water Quality Control Board - Central Coast Region

Date	Subject
April 12, 1982	Visible oil in ocean from malfuncion of oily water separator
June 11, 1982	Elevated chromium analysis result from discharge 001
June 15, 1982	Leachfield overflow into ocean
July 29, 1982	Clarifier sludge pond overflow into Diablo Creek
August 16, 1982	Condensate demineralizer sump overflow into Diablo Creek
September 13, 1982	Elevated copper concentration in discharge 001
October 26, 1982	Visible oil slick in ocean near intake cove breakwater
December 1, 1982	Follow up report on elevated copper concentration in discharge 001

APPENDIX 2

Summaries of Influent and Effluent Monitoring

DIABLO CANYON POWER PLANT

MONTHLY LIQUID DISCHARGE PATHWAY FLOW SUMMARY

	001 Once Thru Cooling Wtr*	001A Fire Water Flush	001B Aux Salt Water	001C Mu Water Waste	001D Liq Rad Waste	001E Service Colling Wtr	001F TB Sump OWS	001G R.O. Blowdown
1982	$x10^6$ gal	$x10^3$ gal	$x10^6$ gal	$x10^3$ gal	$x10^3$ gal	$x10^6$ gal	$x10^3$ gal	$x10^3$ gal
JAN	Ø	Ø	491.66	23.8	43.30	Ø	406.45	Ø
FEB	Ø	175.00	444.36	23.0	49.04	Ø	531.04	Ø
MARCH	Ø	Ø	487.01	167.7	59.30	0.35	139.51	Ø
APRIL	Ø	52.8	463.50	201.9	65.17	Ø	313.48	Ø
MAY	1342.78	Ø	470.25	97.9	60.43	0.35	348.48	Ø
JUNE	451.84	Ø	460.68	Ø	42.55	Ø	437.01	Ø
JULY	Ø	77.5	386.26	163.2	53.90	Ø	230.16	Ø
AUG	Ø	Ø	419.74	126.4	45.46	Ø	65:33	Ø
SEPT	Ø	92.0	452.10	46.2	26.08	11.94	141.14	Ø
OCT	Ø	80.0	118.42	Ø	62.95	Ø	25.56	Ø
NOV	Ø	Ø	161.40	Ø	13.13	Ø	26.00	Ø
DEC	Ø	Ø	426.87	Ø	55.60	.23	73.58	Ø

*Main Circ Only

1982	001H Cond Sea Wtr Demin	001I Sea Evap Blowdown	001J Cond Pump Disch	001K Cond Tube Leak Det	00L Steam Gen Blowdown	002 Intake Sump	003 Screen Wash Intake	004 Thermal Effects Lab	005 Yard Storm Drains
	x10³ gal	x10³ gal	x10³ gal	x10³ gal	x10³ gal	x10³ gal	x10³ gal	x10⁶ gal	x10³ gal
JAN	Ø	Ø	Ø	Ø	Ø	85.5	Ø	25.00	Ø
FEB	Ø	Ø	Ø	Ø	Ø	37.8	9.48	22.58	Ø
MARCH	Ø	Ø	Ø	Ø	Ø	49.5	10.88	25.00	Ø
APRIL	67.90	Ø	Ø	Ø	Ø	144.3	8.66	24.19	YES
MAY	Ø	Ø	Ø	Ø	Ø	212.5	10.18	25.00	Ø
JUNE	Ø	Ø	Ø	Ø	Ø	206.1	Ø	24.19	YES
JULY	Ø	Ø	Ø	Ø	Ø	33.6	43.68	25.00	Ø
AUG	Ø	Ø	Ø	Ø	Ø	16.8	0.05	25.00	YES
SEPT	Ø	Ø	Ø	Ø	Ø	14.7	58.50	24.19	YES
OCT	Ø	Ø	Ø	Ø	Ø	20.4	0.20	25.00	YES
NOV	Ø	Ø	Ø	Ø	Ø	33.3	0.05	24.19	YES
DEC	Ø	Ø	Ø	Ø	Ø	67.6	8.28	25.00	Ø

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

INTAKE COVE SEAWATER INTAKE

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Intake Cove

Parameter:	pH	Turbidity			
High Limit:					
Low Limit:					
Units:		NTU			
1/25/82 11:11	8.00	.20			
2/ 5/82 09:40	8.00	.45			
3/10/82 09:30	7.80	.46			
4/ 1/82 09:18	8.00	.75			
5/ 5/82 09:50	7.84	.65			
6/ 2/82 10:15	7.90	.95			
7/ 1/82 09:05	7.99	.31			
8/ 2/82 09:00	7.91	.22			
9/ 1/82 08:30	7.83	1.00			
10/ 8/82 08:52	7.90	1.00			
10/29/82 21:40	7.80				
10/30/82 15:16	8.10				
11/ 1/82 09:12	8.00	.45			
11/ 3/82 23:11	7.76				
11/12/82 19:01	7.70				
11/15/82 19:02	7.80				
11/16/82 19:10	7.80				
11/23/82 00:18	7.90				
12/ 1/82 19:25	8.00	16.00			
12/ 4/82 12:57	7.81				
12/ 7/82 22:20	7.74				
12/11/82 12:05	8.13				
12/14/82 20:54	7.95				
12/15/82 20:40	7.96				
12/18/82 00:36	8.12				
12/20/82 19:05	7.74				
12/20/82 20:04	7.74				

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

INTAKE COVE SEAWATER INTAKE

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Intake Cove

Parameter:	NonFiltRes	Grease/Oil			
High Limit:		10.00			
Low Limit:					
Units:	mg/l	mg/l			
1/ 4/82 08:27		< 5.00			
1/ 6/82 08:35	3.00				
1/ 8/82 08:31		< 3.00			
1/18/82 08:40		< 3.00			
1/25/82 11:11	2.00	< 3.00			
2/ 5/82 09:40	1.00	< 3.00			
3/10/82 09:30	1.00	< 3.00			
4/ 1/82 09:18	6.00	< 3.00			
5/ 5/82 09:50		< 3.00			
5/ 6/82 09:01	< 1.00	< 3.00			
6/ 2/82 10:15	17.30	< 3.00			
7/ 1/82 09:05	< 1.00	< 3.00			
8/ 2/82 09:00	1.10	< 3.00			
9/ 1/82 08:30	2.60	< 3.00			
10/ 8/82 08:52	< 1.00	< 3.00			
11/ 1/82 09:12	< 1.00	< 3.00			
12/ 1/82 19:25	4.00	< 3.00			

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Intake Cove

Parameter:	NH3 as N	Cyanide				
High Limit:	.100	.005				
Low Limit:						
Units:	mg/l	mg/l				
4/ 1/82 09:18	.041					
4/ 1/82 09:18	.041					
7/ 1/92 09:05	.062					
10/ 8/82 08:52	.054	< .020				OOS
11/ 1/82 09:12	.070					
[illegible] 19:25	.061					

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

INTAKE COVE SEAWATER INTAKE

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Intake Cove

Parameter: High Limit: Low Limit: Units:		Cu mg/l	Total Cr mg/l	Cadmium mg/l	Lead mg/l	
1/25/82	11:11	< .001				
2/ 2/82	09:30		.002			
2/ 9/82	09:00			< .001	.003	
2/ 9/82	09:00	< .001				
3/10/82	09:30	< .001				
3/27/82	13:00		.004			
3/29/82	09:32		.003			
4/ 1/82	09:18		.001	.001	.009	
4/ 1/82	09:18	.001	.001			
5/ 5/82	09:50	.002			.005	
6/ 2/82	10:15	.002				
7/ 1/82	09:05	.001	.007	< .001	.002	
7/26/82	08:56		< .001			
8/ 2/82	09:00	.001	< .001			
8/12/82	08:33		< .001			
8/20/82	09:00		< .001			
9/ 1/82	08:30	.001	< .001	< .001	.008	
10/ 9/82	08:52	.001	< .001	.001	.001	
11/ 1/82	09:12	.001	< .001			
12/ 1/82	19:25	.001	< .001			

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

INTAKE COVE SEAWATER INTAKE

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Intake Cove

Parameter:		Mercury	Silver	Zn	Ni	
High Limit:						
Low Limit:						
Units:		mg/l	mg/l	mg/l	mg/l	
1/25/82	11:11			.003		
2/ 9/82	09:00				.001	
2/ 9/82	09:00			.004		
3/10/82	09:30			.014	.002	
4/ 1/82	09:18				.001	
4/ 1/82	09:18			.004	.001	
5/ 5/82	09:50			.005	.001	
6/ 2/82	10:15			.007		
7/ 1/82	09:05			.007	.002	
8/ 2/82	09:00			.001		
9/ 1/82	08:30			.004	.001	
10/ 8/82	08:52	< .00020	< .00200	.012	.001	
11/ 1/82	09:12			.009	< .001	
12/ 1/82	19:25			.037	.002	

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 - ONCE THROUGH COOLING WATER DISCHARGE

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	pH	Turbidity			
High Limit:	9.00				
Low Limit:	6.00				
Units:		NTU			
1/25/82 11:20	8.00	2.30			
2/ 5/82 09:49	8.10	.45			
3/10/82 09:39	7.90	.45			
4/ 1/82 09:27	8.00	.78			
5/ 5/82 09:59	7.89	.61			
6/ 2/82 10:25	7.90	.58			
7/ 1/82 09:14	8.01	.44			
8/ 2/82 09:09	7.91	.27			
9/ 1/82 08:39	7.95	.60			
10/ 8/82 09:01	7.90	1.20			
11/ 1/82 10:45	8.03	.90			
11/ 3/82 23:40	7.78				
11/12/82 19:01	7.70				
11/15/82 19:02	7.80				
11/16/82 19:10	7.80				
12/ 1/82 19:31	8.00	16.00			
12/ 4/82 13:04	7.94				
12/ 7/82 22:28	7.62				
12/11/82 12:10	8.12				
12/14/82 21:02	7.96				
12/15/82 20:45	7.91				
12/18/82 00:36	8.12				
12/20/82 19:12	7.74				
12/20/82 20:11	7.76				

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 - ONCE THROUGH COOLING WATER DISCHARGE

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	NonFil Res	Grease/Oil			
High Limit:		10.0			
Low Limit:					
Units:	mg/l	mg/l			
1/25/82 11:20	21.00	< 3.0			
2/ 5/82 09:49	2.00	4.0			
3/10/82 09:39	2.00	< 3.0			
4/ 1/82 09:27	1.00	< 3.0			
4/ 8/82 11:55		3.0			
5/ 5/82 09:59		< 3.0			
5/ 6/82 09:10	1.50	< 3.0			
6/ 2/82 10:25	6.30	< 3.0			
6/11/82 09:00	< 1.00				
7/ 1/82 09:14	< 1.00	< 3.0			
8/ 2/82 09:09	1.00	< 3.0			
9/ 1/82 08:39	2.00	< 3.0			
10/ 8/82 09:01	3.00	< 3.0			
11/ 1/82 10:45	< 1.00	3.0			
12/ 1/82 19:31	10.00	< 3.0			

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	Hydrazine	Dissolve O	B		
High Limit:					
Low Limit:					
Units:	mg/l	mg/l	mg/l		
1/26/82 08:59		8.8	8.8		
2/ 9/82 09:09			1.2		
3/29/82 09:41			4.7		
4/ 1/82 09:27		8.6	4.7		
7/ 1/82 09:14	< .001	8.6	4.9		
7/15/82 09:55	< .003				
10/ 8/82 09:01	< .002	8.1	4.5		
11/ 1/82 10:45	< .002	7.4	6.2		
12/ 1/82 19:31	.012	10.0	6.9		

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY
DISCHARGE 001 - ONCE THROUGH COOLING WATER DISCHARGE

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	Cu	Total Cr	Cadmium	Lead		
High Limit:	.020	.002	.003	.008		
Low Limit:						
Units:	mg/l	mg/l	mg/l	mg/l		
1/25/82 11:20	.001					
1/26/82 08:59		.001	< .001	.004		
2/ 2/82 09:39		.001				
2/ 9/82 09:09			< .001	.003		
2/ 9/82 09:09	< .001					
3/10/82 09:39	< .001					
3/27/82 13:09		.011				OOS
3/29/82 09:41		.003				OOS
4/ 1/82 09:27	.001	< .001	.002	.009		OOS
5/ 5/82 09:59	.001			.005		
5/28/82 11:13	.014	.001		.006		
5/28/82 11:15	.034	.001		.002		OOS
5/28/82 11:18	.008	.002		< .001		
5/28/82 11:23	.006	< .001		< .001		
5/28/82 11:31	.023			< .001		OOS
5/28/82 11:43	.001	< .001		< .001		
5/28/82 12:13	.001	< .001		< .001		
5/28/82 12:31	.002			.001		
6/ 2/82 10:25	.001					
6/ 5/82 17:45	.015	< .001	.001	.001		
6/ 5/82 17:50	.019	.013	.001	.005		OOS
6/ 5/82 18:00	.003	.006	< .001	.001		OOS
6/ 5/82 18:15	.003	.004	.001	.001		OOS
6/ 5/82 18:42	.038	.031	.001	.003		OOS
6/ 5/82 18:47	.002	.004	.002	< .001		OOS
6/ 5/82 18:57	.001	.006	.001	< .001		OOS
6/ 5/82 19:12		.001				
6/ 5/82 22:18	.001	.007	.003	.002		OOS
6/ 5/82 22:23	.003	.003	< .001	< .001		OOS
6/ 5/82 22:33	.001	< .001	< .001	< .001		
6/ 5/82 22:48	.001	< .001	< .001	.001		
7/ 1/82 09:14	.001	.005	< .001	.001		OOS
8/ 2/82 09:09	< .001	< .001				
8/12/82 08:41		< .001				
8/20/82 09:09		< .001				
9/ 1/82 08:39	.018	< .001	< .001	.001		
9/ 7/82 09:11	.026					OOS
9/ 8/82 08:45	.020					
9/ 9/82 09:04	.018					
9/10/82 09:03	.019					
9/13/82 08:52	.016					
9/14/82 08:39	.022					OOS
9/15/82 09:15	.020					
9/16/82 09:11	.016					
9/17/82 08:34	.015					
9/18/82 10:39	.014					
9/20/82 09:19	.014					
9/21/82 09:05	.001					
9/22/82 08:39	.002					
9/23/82 14:20	.002					
9/26/82 05:05	.001					
9/27/82 05:31	.002					
9/28/82 05:51	.002					
9/29/82 05:49	.002					
10/ 8/82 09:01	.001	.001	.001	.001		
11/ 1/82 10:45	.001	.001				
12/ 1/82 19:31	.001	< .001				

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	ClPest/PCB	Cyanide	NH3 as N			
High Limit:	.002	.005	.100			
Low Limit:						
Units:	mg/l	mg/l	mg/l			
1/26/82 08:59			.050			
4/ 1/82 09:27			.078			
7/ 1/82 09:14			.056			
10/ 8/82 09:01	< .001	< .020	< .020			OOS
11/ 1/82 10:45			.079			
[illegible]			[illegible]			

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 - ONCE THROUGH COOLING WATER DISCHARGE

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	Ni	Zn	Mercury	Silver		
High Limit:	.080	.080	.00056	.00045		
Low Limit:						
Units:	mg/l	mg/l	mg/l	mg/l		
1/25/82 11:20		.005				
1/26/82 08:59	.001					
2/ 9/82 09:09	.001					
2/ 9/82 09:09		.009				
3/10/82 09:39	.001					
3/10/82 09:39		.008				
4/ 1/82 09:27	.002	.005				
5/ 5/82 09:59	.001	.002				
5/28/82 11:13	.017	.029				
5/28/82 11:15	.011	.029				
5/28/82 11:18	.005	.016				
5/28/82 11:23	.002	.004				
5/28/82 11:31	.004	.008				
5/28/82 11:43	.001	.004				
5/28/82 12:13	.001	.002				
5/28/82 12:31	.001	.007				
6/ 2/82 10:25		.003				
6/ 5/82 17:45	.021	.012				
6/ 5/82 17:50	.014	.010				
6/ 5/82 18:00	.003	.002				
6/ 5/82 18:15	.001	.003				
6/ 5/82 18:42	.070	.047				
6/ 5/82 18:47	.003	.003				
6/ 5/82 18:57	.002	.006				
6/ 5/82 22:18	.002	.003				
6/ 5/82 22:23	.003	.002				
6/ 5/82 22:33	.001	.002				
6/ 5/82 22:48	.001	.002				
7/ 1/82 09:14	.001	.002				
8/ 2/82 09:09		< .001				
9/ 1/82 08:39	.003	.007				
10/ 8/82 09:01	.001	.004	.00020	< .00050		OOS
11/ 1/82 10:45	.001	.006				
12/ 1/82 19:31	.002	.011				

END LIST

SYSTEM: Outfall
UNIT: Common System
POINT: Discharge 001

Parameter:	Arsenic	Titanium			
High Limit:	.008				
Low Limit:					
Units:	mg/l	mg/l			
4/ 1/82 09:27		< .010			
[illegible] 8/82 09:01	< .001	< .010			

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001C - MAKE UP WATER SYSTEM WASTE

SYSTEM: Make Up Demineralizer
UNIT: Common System
POINT: Regenerant Discharge 001C

Parameter:	Grease/Oil	NonFiltRes			
High Limit:	15.00	100.00			
Low Limit:					
Units:	mg/l	mg/l			
1/11/82 18:03	< 3.00				
1/12/82 18:00	< 3.00				
1/17/82 13:37	< 3.00				
2/18/82 15:15	< 3.00	24.00			
2/19/82 12:35	< 3.00	4.00			
3/ 8/82 03:35	< 3.00	24.00			
3/15/82 13:00	< 3.00	3.00			
3/16/82 04:52	< 3.00	2.00			
4/ 2/82 20:00	< 3.00	2.00			
4/ 7/82 13:30	< 3.00	< 1.00			
4/29/82 14:41	< 3.00				
5/ 2/82 10:20	< 3.00				
5/ 3/82 08:50	< 3.00				
5/ 5/82 10:30	< 3.00	10.00			
5/ 8/82 20:35	12.60	1.50			
6/25/82 09:45	< 3.00	44.00			
6/25/82 16:30		< 1.00			
6/26/82 06:40	< 3.00	23.00			
7/ 3/82 11:52	< 3.00	44.00			
7/ 5/82 03:45		3.00			
7/ 6/82 09:00	< 3.00				
7/21/82 11:30		72.00			
7/21/82 13:00		2.00			
7/23/82 02:00	< 3.00	< 1.00			
7/23/82 22:15	< 3.00	51.00			
7/27/82 12:08	< 3.00	2.60			
8/ 9/82 11:15		< 1.00			
8/10/82 01:00	< 3.00	28.00			
8/10/82 20:00	< 3.00	21.00			
8/11/82 13:30	< 3.00	21.00			
9/ 2/82 03:23	< 3.00	2.40			

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001D - LIQUID RADWASTE SYSTEM

SYSTEM: NPDES
UNIT: Common System
POINT: 001D LRW

Parameter:	NONFILTRES	GREASE/OIL			
High Limit:	30.0	15.0			
Low Limit:					
Units:	MG/L	MG/L			
1/25/82 03:40	16.0	< 3.0			
2/18/82 00:00	4.0				
3/29/82 00:00	8.0	3.0			
4/22/82 00:00	3.0	< 3.0			
5/14/82 00:00	6.0				
6/23/82 13:05	3.0	< 3.0			
7/ 2/82 06:25	5.0	3.0			
7/20/82 09:30	1.0	< 3.0			
8/ 2/82 08:50		< 3.0			
8/ 5/82 17:30	8.0	< 3.0			
9/24/82 02:10	6.0				
10/ 5/82 08:40	4.0				
10/ 6/82 08:22		< 3.0			
10/19/82 09:25	4.0	< 3.0			
11/29/82 11:00	3.0	< 3.0			
12/ 1/82 00:00	3.0				
12/23/82 08:10	22.0				

DISCHARGE 001D - LIQUID RADWASTE
COMPOSITE DATA

SYSTEM: NPDES
UNIT: Common System
POINT: 001D LRW

Parameter:	CADMIUM	CHROMIUM	Copper	LEAD	
High Limit:					
Low Limit:					
Units:	MG/L	MG/L	MG/L	MG/L	
4/21/82 00:00	.002	.006	.012	.035	
7/14/82 00:00	.002	.006	.049	.020	
10/ 2/82 00:00	.004	.116	.030	.007	
12/31/82 00:00	.003	.006	.013	.013	

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 D - LIQUID RADWASTE SYSTEM COMPOSITE

SYSTEM: NPDES
UNIT: Common System
POINT: 001D LRW

Parameter: High Limit: Low Limit: Units:	MERCURY MG/L	NICKEL MG/L	ZINC MG/L	SILVER MG/L	
4/21/82 00:00	.0270	.026	.349	.0340	
7/14/82 00:00	.0590	.043	.332	< .0010	
10/ 2 82 00:00	.0230	.091	.042	.0070	
12/31/82 00:00	.0050	.019	.532	.0080	

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 D - LIQUID RADWASTE SYSTEM COMPOSITE

SYSTEM: NPDES
UNIT: Common System
POINT: 001D LRW

Parameter: / High Limit: / Low Limit: / Units:	LITHIUM MG/L	BORON MG/L	HYDRAZINE MG/L		
1/25/82 03:40	.025				
4/22/82 00:00	< .001				
6/23/82 13:05	.013				
7/20/82 09:30	.001				
8/ 2/82 08:50	.009				
10/ 5/82 08:40	.005				
10/19/82 09:25	.007				
10/28/82 10:12	.002	2,065.000	< .002		
10/30/82 05:00	.005	2.800	.007		
11/ 3/82 00:50	.008	.500	.006		
11/ 6/82 06:34	.005	23.000	.026		
11/12/82 12:50	.007	90.000	.200		
11/15/82 16:32	.014	54.000	.020		
11/16/82 08:20	.008	< .500	.014		
11/19/82 15:30	.007	12.000	.050		
11/24/82 11:30	.005	88.000	.065		
11/24/82 22:45	.003	24.000	4.000		
11/29/82 08:30	.004	3.500	.013		
11/29/82 11:00	.001	325.000	.009		
11/30/82 18:30	.006	58.000	.003		
12/ 1/82 08:20	.012	98.000	.023		
12/ 3/82 22:15	.006	62.000	.032		
12/ 4/82 18:15	.004	1,593.000	.006		
12/ 6/82 06:15	.006	2,058.000	.005		
12/ 8/82 09:45	.012	8.000	.005		
12/13/82 15:30	.004	75.000	.170		
12/15/82 09:00	.004	900.000	.006		
12/16/82 04:48	.005	64.000	< .002		
12/17/82 14:00	.006	2.000	< .002		
12/20/82 11:30	.003	31.000	.010		
12/23/82 08:10	.009	255.000	.010		
12/29/82 08:24	.008	41.000	.004		
12/29/82 08:31	.011	80.000	.240		

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 D - TURB. BLDG SUMP - OILY WATER SEPARATOR

SYSTEM: Waste Pond and O.W.S.-Turbine Bld. Sump 001F
UNIT: Common System
POINT: O.W.S./Turb. Bld. Sump 001F

Parameter:		NonFiltRes	Grease/Oil				
High Limit:		30.00	15.00				
Low Limit:							
Units:		mg/l	mg/l				
1/ 7/82	14:30		< 3.00				
1/21/82	08:20		5.00				
1/25/82	08:20	5.00	5.00				
1/26/82	08:30	14.00	12.00				
1/28/82	08:30	18.00	4.00				
2/17/82	09:00	24.00	12.00				
2/24/82	09:00		< 3.00				
3/11/82	10:00	11.00	< 3.00				
3/25/82	08:30	7.00	3.00				
4/ 1/82	11:00		14.00				
4/ 1/82	11:01		12.00				
4/ 2/82	13:00	34.00	48.00				OOS
4/19/82	08:35		< 3.00				
4/19/82	17:03		< 3.00				
4/20/82	15:00		< 3.00				
4/21/82	06:03		4.00				
4/21/82	08:20	22.00	5.00				
4/22/82	14:11	15.00	< 3.00				
4/26/82	08:20	11.00	< 3.00				
4/28/82	16:42	5.00	5.00				
4/29/82	11:12	15.00	< 3.00				
4/29/82	23:46	11.00					
5/ 1/82	18:30	19.00	3.00				
5/ 5/82	09:00	9.00	< 3.00				
5/ 6/82	08:30	8.00	< 3.00				
5/ 7/82	18:10		< 3.00				
5/20/82	08:25	6.00	< 3.00				
6/10/82	13:00	29.00	12.00				
6/16/82	13:59	17.00	< 3.00				
7/ 3/82	17:00	4.90	< 3.00				
7/10/82	20:30	8.60	< 3.00				
8/ 5/82	09:15	4.00	< 3.00				
11/ 1/82	09:05	15.00	3.00				
11/15/82	08:55	15.00	5.00				
12/ 6/82	11:40	6.10	< 3.00				

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 001 D - TURB. BLDG SUMP - OILY WATER SEPARATOR

SYSTEM: Waste Pond and O.W.S.-Turbine Bld. Sump 001F
UNIT: Common System
POINT: O.W.S./Turb. Bld. Sump 001F

Parameter:	Hg	Ni	Ag	Zn	
High Limit:					
Low Limit:					
Units:	mg/l	mg/l	mg/l	mg/l	
1/29/82 09:16		.004		.014	
4/ 2/82 15:00	.02500	.012	< .001	.066	
7/ 2/82 11:15	< .00020	.003	< .001	.073	
11/ 5/82 09:00	< .00020	.028	< .001	.390	

SYSTEM: Waste Pond and O.W.S.-Turbine Bld. Sump 001F
UNIT: Common System
POINT: O.W.S./Turb. Bld. Sump 001F

Parameter:	Cd	Cr	Pb	Cu	
High Limit:				1.000	
Low Limit:					
Units:	mg/l	mg/l	mg/l	mg/l	
1/29/82 09:16	.001	.008	.006	.032	
2/ 5/82 00:00		.003			
4/ 2/82 15:00	.002	.001	.017	.063	
7/ 2/82 11:15	.002	.004	.001	.005	
11/ 5/82 09:00	.008	.018	.175	.020	

DIABLO CANYON POWER PLANT
NPDES DATA: ANNUAL SUMMARY

DISCHARGE 002 - INTAKE BLDG DRAINS

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Intake Building Floor Drain 002

Parameter:	Grease&Oil				
High Limit:	15.0				
Low Limit:					
Units:	mg/l				
1/ 7/82 08:30	4.0				
1/14/82 09:00	< 3.0				
1/21/82 14:00	< 3.0				
1/28/82 09:40	< 3.0				
2/ 3/82 14:00	< 3.0				
4/ 1/82 09:10	< 3.0				
4/22/82 20:50	< 3.0				
5/18/82 08:50	< 3.0				
6/ 2/82 17:45	< 3.0				
7/ 1/82 09:40	< 3.0				
10/19/82 13:00	< 3.0				

DISCHARGE 005 - YARD STORM DRAIN RUNOFF

SYSTEM: Intake/Drains
UNIT: Common System
POINT: Yard Storm Drains 005

Parameter:	Grease/Oil					
High Limit:	5.00					
Low Limit:						
Units:	mg/l					
4/22/82 14:10	< 3.00					
6/29/82 16:45	3.00					
8/27/82 22:30	8.00					OOS
9/15/82 20:00	6.00					OOS
10/26/82 09:45	< 3.00					
10/30/82 12:10	< 3.00					
11/ 9/82 18:10	3.00					

INTERTIDAL COMMUNITY STRUCTURE ANALYSIS:

An Evaluation of the Performance of Selected Subsets of Diablo Cove Intertidal Data Analyzed by Reciprocal Averaging

Richard A. Pimentel

Rosemary C. Bowker

July, 1982

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

This report describes the evaluation of a multivariate statistical technique on separated data sets comprised of presence and absence data. The data sets used were intertidal plant, animal, and substrate data collected by the Wheeler J. North study team during 1978-1980. This evaluation, which was requested by Pacific Gas and Electric Company, was to determine the applicability and demonstrate the utility and understandability of reciprocal averaging as an analysis technique for the reduction of fourteen years of preoperational intertidal and subtidal, presence absence data. Also, in reference to the analytical technique, the appropriateness of plant, animal, and/or substrate data are examined.

The findings reported here concern the analysis technique only and purposely avoid biological interpretation of this pre-operational data base.

INTRODUCTION

Statistical studies of community structure (an expression of the composition, abundance, spacing, and other attributes of plants in a community, Hanson, 1962) are few for marine environments (Pimentel, 1979b; Bowker, 1979; Benech et al, 1979; Pimentel and Bowker, 1980). Community structure herein pertains to defining an ecological gradient in terms of quadrats and of plants, animals, and substrates. Our purpose is to evaluate various components of such data derived from four surveys of a band transect extending from high into low intertidal. We shall apply reciprocal averaging, also called correspondence analysis, a statistical method to obtain quadrat and species scores; the

analysis of variance of quadrat scores; and a graphical analysis of results to compare the effectiveness of plant, animal, and substrate data in both defining the structure of a community at a given point in time and in describing changes in a community through time.

The acquisition of data can be costly if counts of each species in each quadrat are required. Also, owing to the distribution of organisms along transects, either counts or simple presence-absence data for entire transects conform to nonlinear distributions. Orloci (1975, 1979) reviewed the problems of nonlinear ecological data and demonstrated why nonlinear, nonparametric statistical methods are preferred. Further details of potential data problems were considered by Noy-Meir et al. (1975) and Noy-Meir (1979). Reciprocal averaging was proposed for ecological analysis by Hill (1973, 1974) owing to its excellent performance on ecological data and the fact that presence-absence data performed as well as counts. Gauch et al. (1977) and Fasham (1977) applied Monte Carlo studies that further emphasized the excellent performance of reciprocal averaging. Even though 'worst cases' were tested the method never failed to obtain the correct sequence of quadrats from the various simulations of gradients. Recently, Gauch (1982) summarizes by stating, "When a community data set is structured by a single or at least a predominating gradient the RA 1st axis scores will display this gradient effectively." The details of the method and its performance are described in Pimentel (1979a).

Reciprocal averaging (RA) also conforms to EPA accepted

methodology of using ordination techniques for the assessment of disturbances and evaluation of relationships between species and environmental factors (Gonor and Kemp, 1978). However, RA possesses none of the problems encountered when principal component analysis, principal coordinate analysis, and (when presence-absence data are used) nonlinear mapping or nonmetric multidimensional scaling are used with nonlinear data (Pimentel, 1981). Also, RA does not require knowing quadrats that define ends of a gradient as does polar ordination. RA is the only proven method that requires no *a priori* knowledge of any gradient under study.

RECIPROCAL AVERAGING

RA obtains quadrat scores from species present and species scores from the quadrats in which they occur (Pimentel, 1979a). As applied here, the standard procedure of scaling quadrat and species scores to have a minimum value of zero (lowest intertidal) and maximum value of 100 (highest intertidal) is followed. Such scaling merely establishes the range of scores. It fixes neither the value of the mean nor variance. Gauch and Whittaker (1972) review the literature on the nature of species and quadrat distributions along gradients as a preamble to simulating both distributions for Monte Carlo studies. The consistent findings of authors they quote is that individual species and quadrat distributions are not significantly different from normal. Nonlinearity becomes a difficulty only in determining a set of scores for all species or all quadrats in a transect. RA will provide the scores. Also, once obtained, such

scores can be made suitable for parametric statistical analysis by normalizing them to deviation scores.

RA scores reflect the distribution of species and quadrats along a gradient within a community. First axis quadrat scores can be graphed sequentially to construct a 'profile' of the gradient, the community structure, shown by each analysis of a transect. If species are then ordered by species scores (highest to lowest), the distributions of species over each profile can be examined to identify those species that serve as environmental indicators and thus explain the observed 'community profile'.

A hypothetical case where five species are found over a nine quadrat transect is shown in Figure 1. Since both this hypothetical case and the present study pertain to a single transect over a well defined environmental gradient, first axis quadrat scores summarize the single dimensional gradient that is present. Data for these five species and nine quadrats were submitted to analysis by RA. The first axis quadrat scores were used to construct a community profile (the histogram) to allow a visual inspection of the structure defined by the ordination procedure. Species were then sequenced by their first axis species scores (shown by an asterisk in Figure 1). Dashed lines indicate the quadrat distribution (by quadrat scores) of each species and the 100-0 horizontal axis, the first axis species scores. Graphing mechanics are indicated by the 'conifer' (species 1) being designated by an asterisk and no dashed line because the three quadrats in which it occurs (1-3) have very high, near identical quadrat scores.

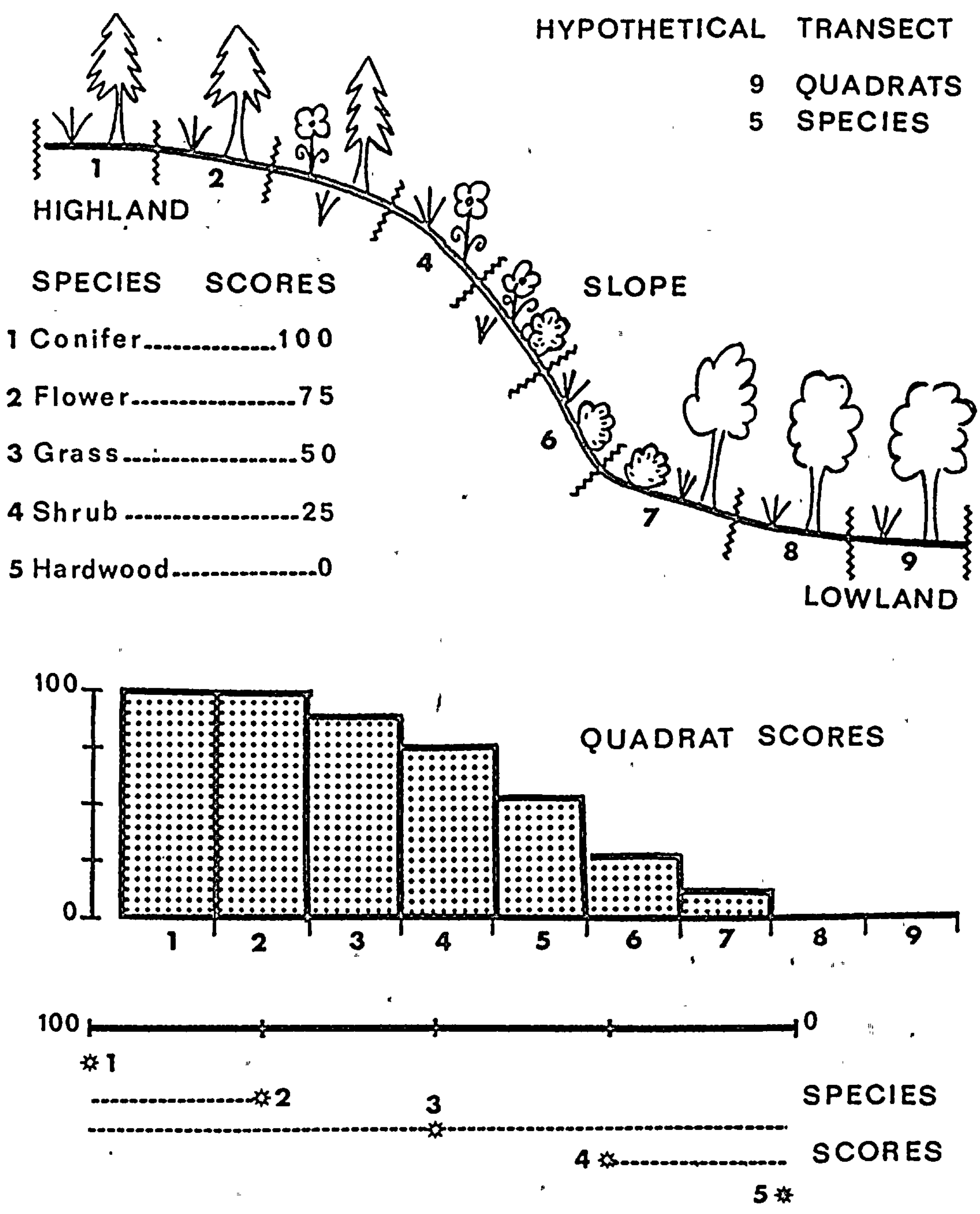


Figure 1. Reciprocal Averaging first axis quadrat scores and first axis species scores for a hypothetical nine quadrat transect with five species present.

The species scores graph stresses species characteristic of the general study area (found throughout the transect) and species restricted within portions of the study area (found in part of the transect). For the hypothetical case, species one, a 'conifer', restricted to the upper three quadrats, is an indicator of the high end of the gradient. Species five, a 'hardwood' only in the lower three quadrats, is an indicator of the low end of the gradient. Species three, a 'grass' found in all quadrats, is representative of the entire study area.

Such an approach is unnecessary when dealing with only five species having discrete distributions over a short transect characterized by a continuous gradient. However, real plants and animals are unlikely to show such simple, discrete distributions. Some species, while always demonstrating a particular environmental preference, may never be particularly abundant. Other species may be commonly found within a particular region of a study area while additional species may show a broad distribution over the entire study area. Moreover, a band transect often reflects an environmental mosaic, so quadrats do not fit sequentially into the community gradient. Therefore, a graphical summarization of the information proves most useful. As the number of species and quadrats increase, both may assume mosaic distributions across a complex gradient. Use of an analytical method like RA regularly becomes mandatory. Even in simple cases, RA provides quantitative measures, scores, that are valuable for statistical comparisons of surveys over time.

To allow an appreciation of both the environmental preference and the abundance of each species in the present

study, the following legend is used to plot species distributions on species scores graphs:

An asterisk indicates the first axis species score for a given species.

A heavy solid line indicates a species with a nearly continuous distribution throughout a set of quadrats resequenced according to the gradient represented. Such a species would be a very good indicator of the part of the gradient in which it is found.

A heavy broken line indicates a species that is abundant but discontinuously distributed throughout the resequenced quadrats. Such a species could still be considered an indicator of the part of the gradient in which it is found.

A light dashed line indicates a species found occasionally in those resequenced quadrats shown and may or may not indicate an environmental preference.

An unbroken light line indicates a species incidental or rare to those quadrats shown.

Use of such a scheme allows the visual demonstration of differences among surveys in the distributions and incidence of the species considered and thus allows an interpretation of the bases for differences in community structure shown to exist by an analysis of variance.

ANALYTICAL METHODS

While our studies further verify the excellent performance of reciprocal averaging for marine data, RA performance is not belabored here. Our present purpose is to evaluate the performance of the type of data submitted to analysis by RA. We will examine four data sets: plant and animal data separately, combined, and the combination plus substrate data. We will describe and evaluate the community structure implied by each.

Data to be analyzed conform to the experimental design of a

four surveys x four data sets with 38 quadrats per sample analysis of variance. The 1m x 1m quadrats are from a permanent band transect at the south end of Diablo Cove, San Luis Obispo County, California. The data consist of presence-absence records of species and substrates in each quadrat. The four complete data sets were derived from station SDIX (North et al., 1978) and represent their data sets WIS378, WISC78, WISC79, and WISC80, March (3) or December (C) data from the 1978, 1979, and 1980 surveys of the W. J. North Ecological Transect Studies of Diablo Cove. In further discussions of surveys, their WIS prefixes are eliminated.

Data are examined for the same 38 quadrats (North's quadrats 4 through 41) for each analysis. The original data included the first 41 to 45 quadrats. When substrate data are removed, the upper three quadrats contain no information for some surveys. Since it is mandatory that sample sizes are equal and the same sources of data are maintained for all surveys, the sample size of 38 quadrats is used.

The 16 RA analyses were performed and each set of first axis RA quadrat scores was then normalized to deviation scores in preparation for the following analyses:

1. One way anova of four surveys using plant data only.
2. One way anova of four surveys using animal data only.
3. One way anova of four surveys using plant and animal data.
4. Two way anova of four surveys by the four complete data sets (plants, animals, and substrates data).

Prior to each anova, Bartlett's and F-max tests of equality of population variances lead to the following conclusions:

1. Equality of variances based upon plant data only.
2. Equality of variances based upon animal data only.

3. Inequality of variances based upon plant plus animal data.
4. Inequality of variances based upon all data.

RESULTS

Owing to known robustness of the analysis of variance when inequality of variances exists for such data, an analysis of variance was performed on all four data sets. As expected, the results of analyses 3 and 4 are consistent with the conclusions of 1 and 2 where analysis of variance assumptions were verified. Also, since every significant F-value was inordinately large, there is no reason to question further the reliability of significant results where variance inequality was indicated (Table 1). The Bartlett's tests were made primarily to evaluate properties of data sets.

Table 1 also includes the results of multiple range tests for each significant F-test. However, not included is the F-value for surveys x data interaction for all data, F = 8.325 with 9 and 592 degrees of freedom. The nature of the interaction is shown in Figure 2.

Table 1. Results of Analysis of Variance and Multiple Range Tests. Significant subsets (groupings) are sequenced from high to low intertidal. Alphanumeric combinations signify surveys, ALL all data, NOS plant and animal data combined, ANI animal data only, and PLT plant data only. Degrees of freedom for numerator and denominator are segregated by a comma.

analysis	F-value	d.f.	groupings
plants	23.662	3,148	(378,C78) (C80) (C79)
animals	29.314	3,148	(C80) (378) (C78) (C79)
species	42.729	3,148	(378) (C80) (C78) (C79)
all surveys	27.090	3,592	(378) (C78,C80) (C79)
all data	71.730	3,592	(ALL) (NOS,PLT) (ANI)

The multiple range tests (Table 1 and Figure 2) are helpful in defining the nature of the significant interaction. The tests demonstrate three data groups: all data emphasizing higher intertidal structure, plants and plants + animals a more intermediate intertidal, and animals the lowest structure. This is also shown in the graph where larger numbers pertain to higher intertidal structure and vice versa. Surveys also fall into three groups where 378 had significantly higher, C78 and C80 intermediate (or balanced) and C79 lower intertidal scores. However, the graph discloses clear exceptions of survey x data subclasses that cause the significant interaction, e.g., plant plus animal interaction data do not provide results intermediate between plants alone and animals except in C78. Also, Table 2 demonstrates significant interaction in the discrepancies between survey mean values for individual and combined data sets.

Comparison of results denies the generality that animals are merely community influents that reflect plants. In addition to animal structure being significantly different for all surveys, the ordering of structure (Table 1) differs from that for plants.

Table 2. Survey means provided by data sets and by surveys x data interaction

	378	C78	C79	C80
animal data	53.74	47.18	40.60	58.48
interaction	48.31	41.75	35.17	53.08
plant data	57.97	56.95	39.82	45.24
interaction	57.78	56.75	39.62	45.06
plant-animal	59.22	45.10	40.56	55.11
interaction	59.58	45.45	40.91	55.46
all data	55.27	50.35	44.57	49.80
interaction	65.07	55.45	46.52	54.05

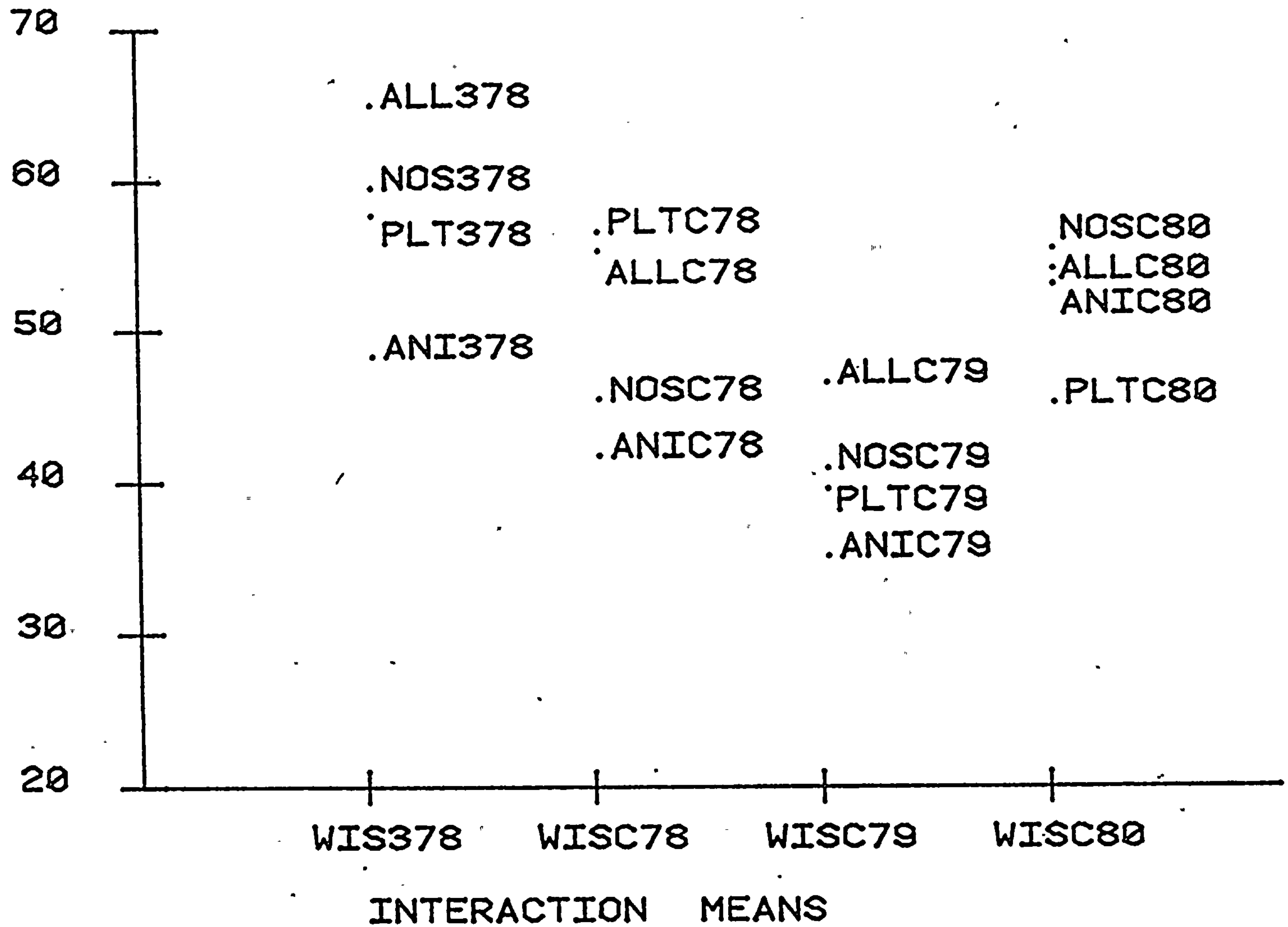


Figure 2. Data x survey interaction means. ALL = Plant, Animal and Substrate data, NOS = Plant and animal data, ANI = Animal data, and PLT = Plant data.

In animals, the highest intertidal structure is emphasized by C80 data whereas highest plant structure is shared by the two 1978 data sets. As one might expect, in combining plant and animal data, an intermediate condition weighted somewhat more heavily by plants might result. This is indicated by the test of significance in the analysis of all data: there is no significant difference between the plant vs. plant-animal data sets. However, this is not always the case and note that all data also provide unique results for surveys. The basis for this is shown by all data segregating, in toto, from the three other data sets (Table 1). Finally, note the uniqueness of C79. Each of the four data sets displays the lowest intertidal structure for this survey.

Since the foregoing provide only a general picture that ignores the specifics of results, each analysis will be considered in further detail in the sequence of plants, animals, plants and animals, and the latter plus substrates.

For purposes of further discussion of the degree to which community profiles describe higher, middle, and lower regions of the intertidal, arbitrary break points have been selected:

High - quadrats with scores greater than 66 (stippled regions in community profile graphs).

Mid - quadrats with 34-66 scores (solid regions in graphs).

Low - quadrats with scores less than 34 (striped regions in graphs).

The same break points shall be applied to species scores.

Plant Data

The community profiles that result when plant data only are

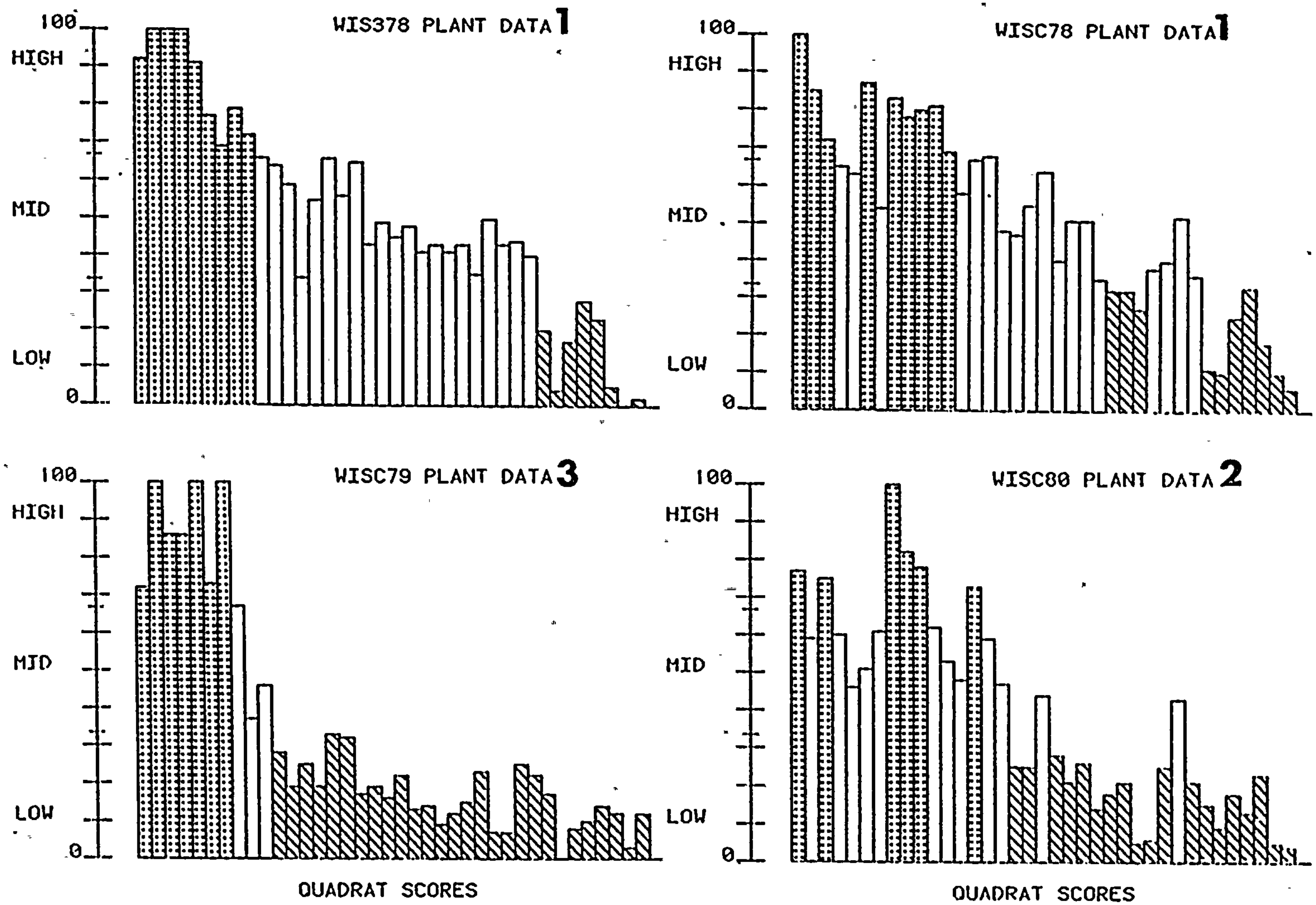


Figure 8. First axis quadrat scores for plant data. Bold numbers indicate non-significant subsets shown by the Multiple Range Tests.

examined are shown in Figure 3. The bold numbers indicate the subsets derived from multiple range tests and are numbered in the sequence as presented in Table 1. The clearest definition of high, mid, and low zones is in 378 and the next best in C78. In contrast, C79 provides poor definition of mid. C80 is not much better. Although otherwise quite different, the profiles for C78 and especially C80 suggest more variation in relief across the transect, perhaps owing to movement of boulders, rocks, and cobble during the winter months. Such movement of plant substrates was discussed by North and Anderson (1973) in their description of this south Diablo Cove transect.

Species scores and their distributions for all surveys are shown in Figure 4. Since biological interpretation is not of concern in this report, in Figure 4, species acronmyns are omitted owing to space constraints. C80 had 23 species; 378, 21; C78, 20; and C79, 18. Species fitting the previously discussed criteria for indicators are labeled in Figures 5a and 5b. There are typical south Diablo Cove indicators, such as Gigartina papillata, Petrocelis, and Pseudolithophyllum neofarlowianum over all surveys. Hildenbrandia was common to the study area during the C78 and C80 surveys. The fewest species (18) are found in C79 and only seven show any type of abundant or common distribution. The other surveys show less overlap in species distributions and more species characteristic of particular areas along the transect.

The 378 and C78 plant scores describe a similar pattern (Figure 5a). The higher intertidal is identified by a blue-green algal zone (Callothrix) and the presence of other species. In

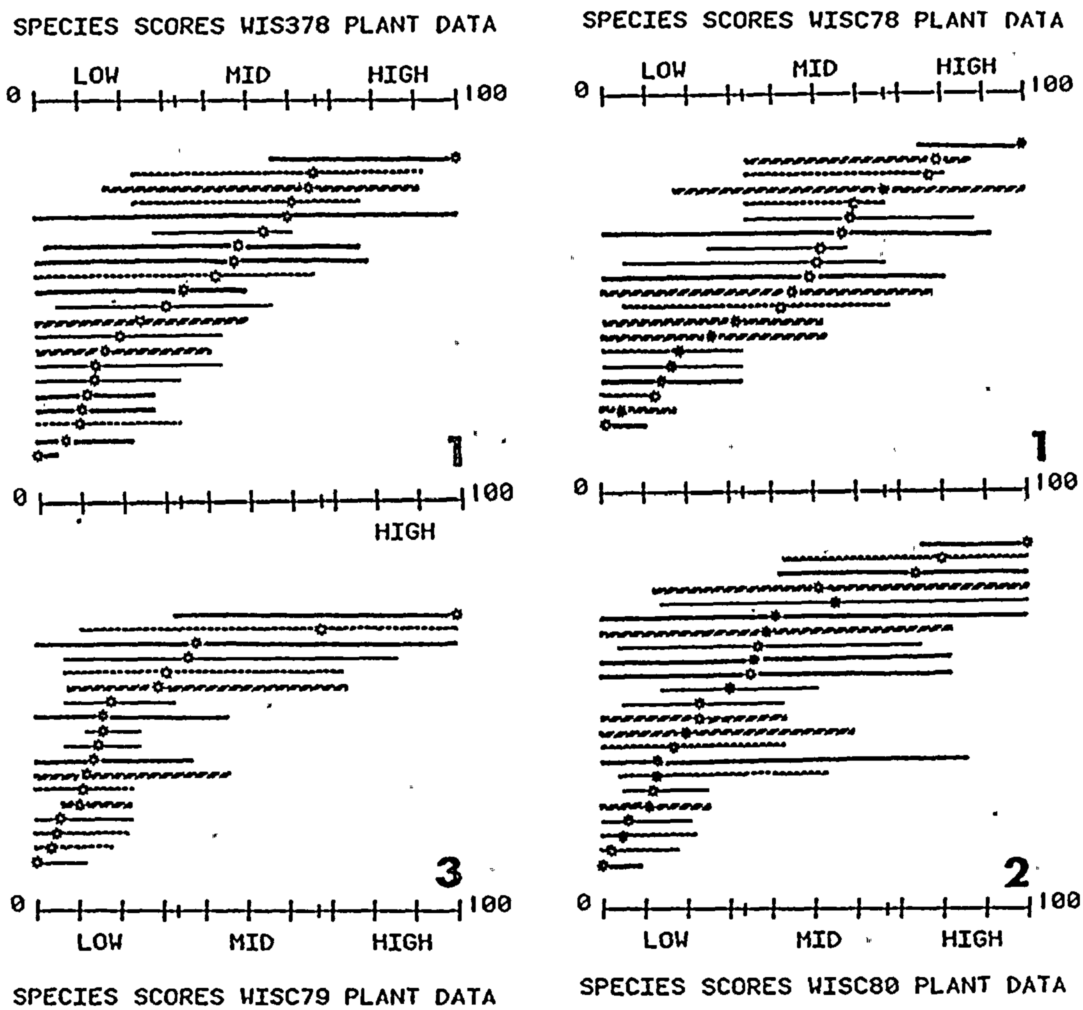


Figure 4. First axis species scores, shown by asterisk, and species distributions for plant data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

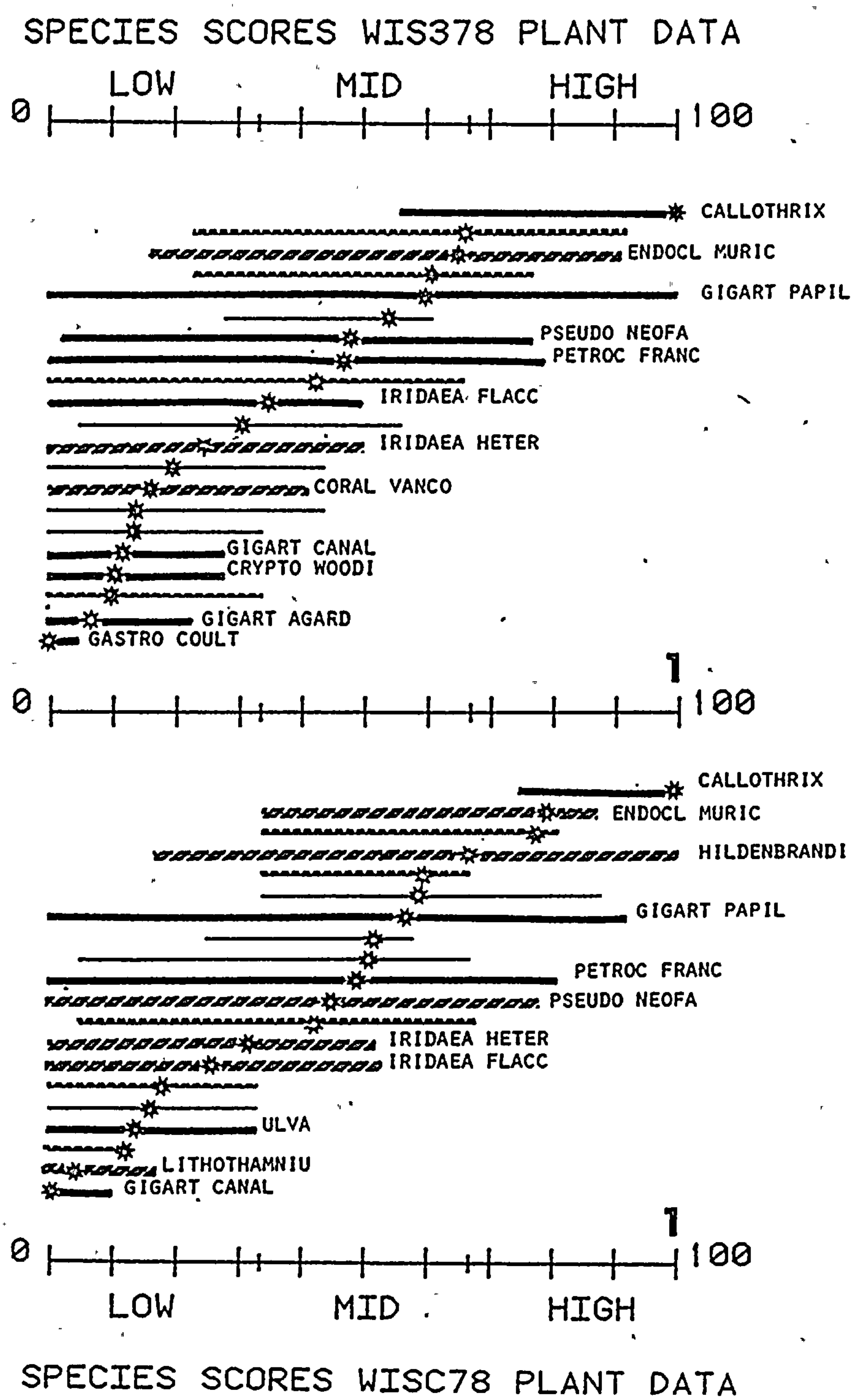


Figure 5a. Species scores, shown by asterisk, and species distributions for 378 and C78 plant data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

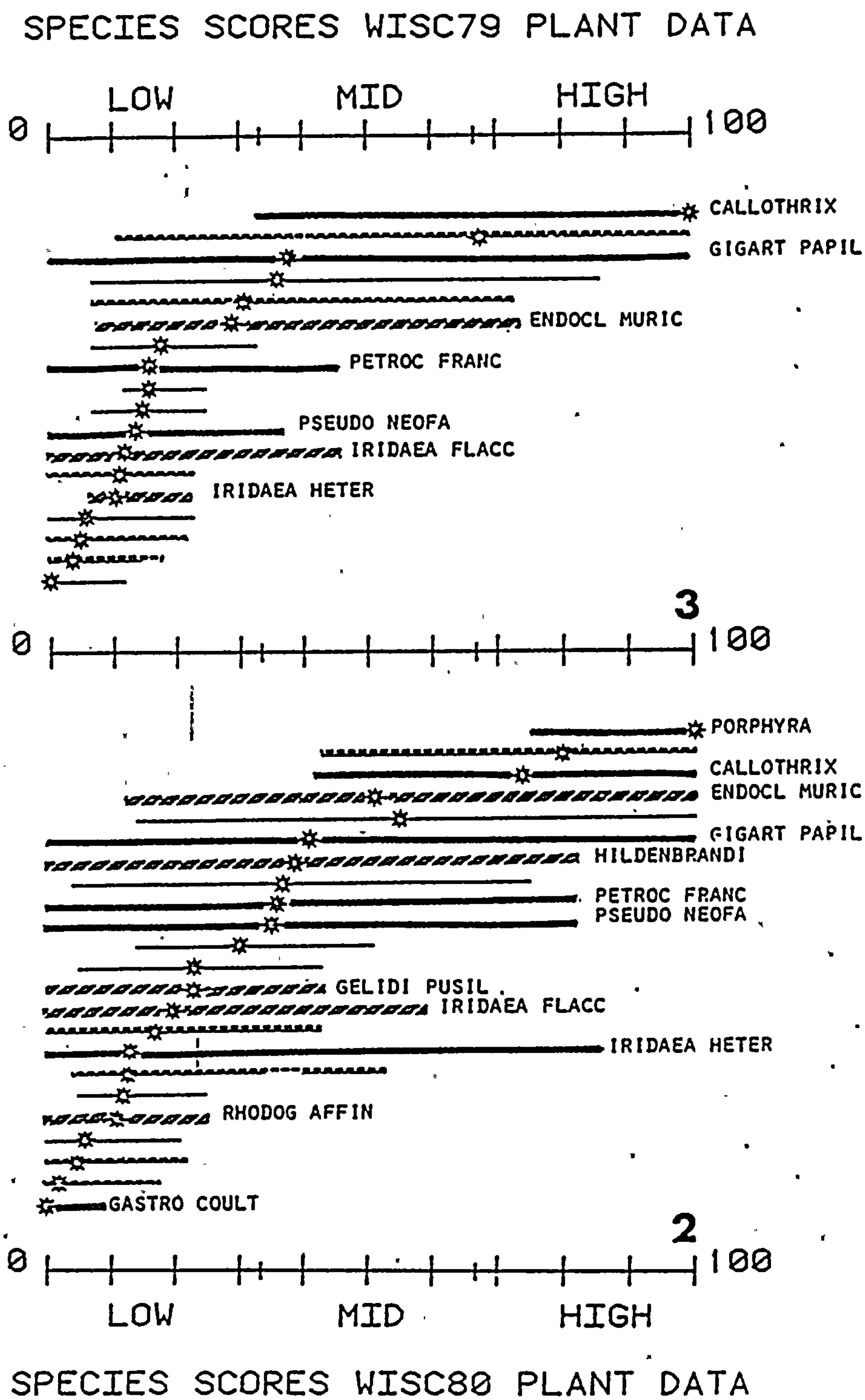


Figure 5b. Species scores, shown by asterisks, and species distributions for C79 and C80 plant data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

lower quadrats, species scores and distributions indicate an increasing diversity. Gigartina canaliculata is shared as a low indicator. The middle intertidal is not clearly defined by indicator species. The community profiles (Figure 3) also are similar, each presenting a good identification of upper, middle, and lower portions of the intertidal gradient.

The C79 plant data (Figure 5b) do not enable clear identification of the middle intertidal. Overall, there are noticeably fewer good indicators and the overall distribution of species is more sporadic. Several lower intertidal species (Gastroclonium, Lithothamnium, Cryptosiphonia woodii) were absent during this survey. Those species with an abundant distribution, such as Gigartina papillata and Petrocelis, are more representative of the study area in general than of any particular region within the transect. Endocladia and Iridae flaccida were in over half of the quadrats sampled.

In contrast, half of the C80 plants are good indicators. Certain species show a more extensive distribution than C79. While the middle intertidal is not as well defined as by 378 and C78, the lower portion of the gradient is again represented by species found in lower quadrats only.

Animal Data

The animal data sets are the smallest examined (16 species for 378 and C79, 18 for C78 and C80), but the analysis of variance indicates a distinct difference among all four surveys. Community profiles (Figure 6) show more lower quadrat scores than seen in plant data. This reflects the nature of intertidal animals. There are progressively fewer animals in increasingly

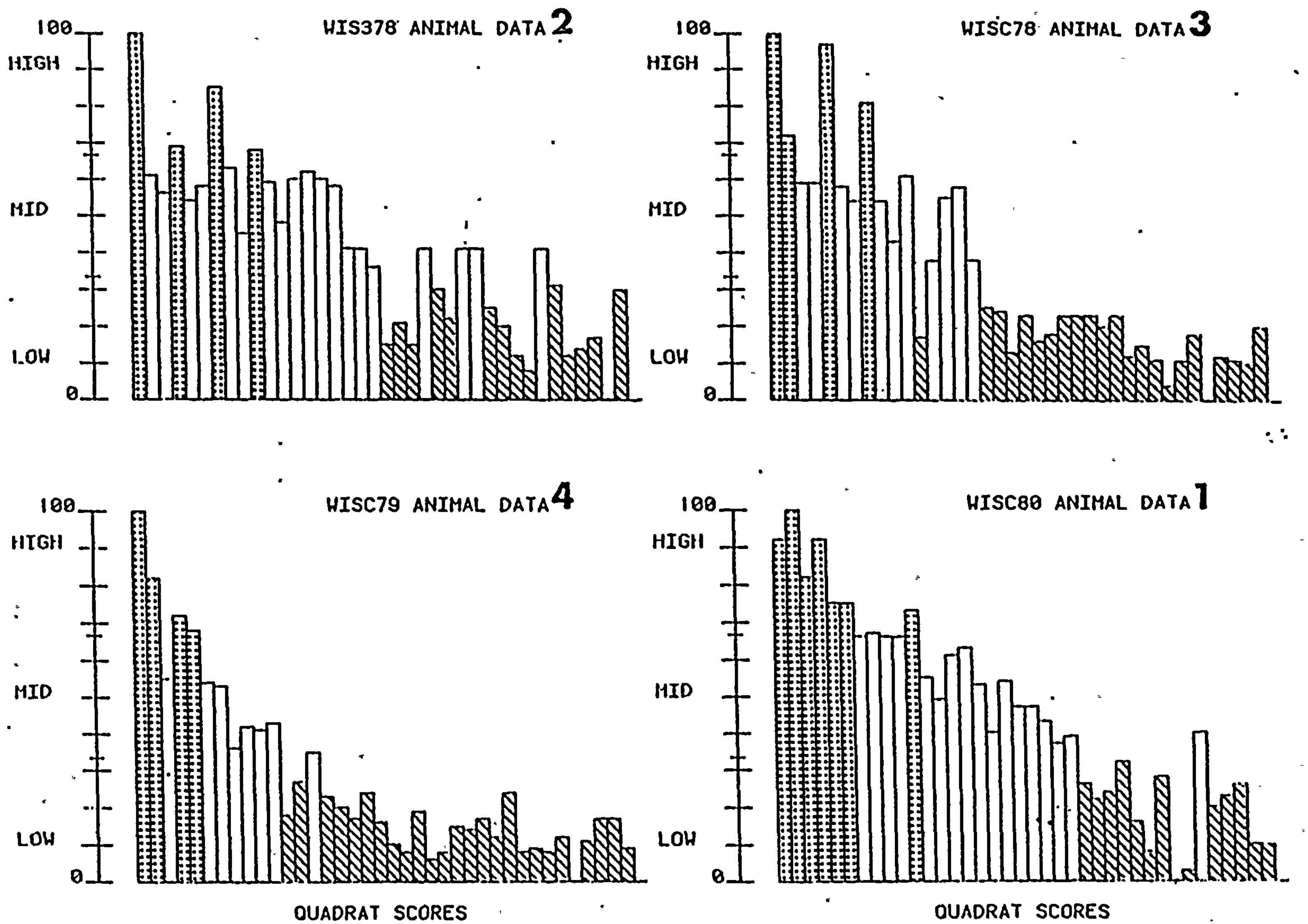


Figure 6. First axis quadrat scores for animal data. Bold numbers indicate non-significant subsets shown by the Multiple Range Tests.

higher quadrats where exposure to dessication increases. However, these low diversity upper quadrats are more 'unique' than lower quadrats which are characterized by higher diversity. In C80, animals had a significantly higher profile than did plants.

As with the plant data, C79 has the lowest community profile. In contrast with the 378 and C78 plant data, the highest and best balanced animal profile is from the C80 data. Intermediate situations are shown by 378 and C78 animal data with 378 having more emphasis on mid through high than does C78.

The animal distributions (Figure 7) are more discontinuous than those for plants. This again reflects the nature of the animals. The plants are all sessile. Plant attachment to substrate and lack of movement except by movement of their substrate lead to a more stable and continuous distribution. While some animals are sessile, mobile ones move in reference to predation pressure, stimuli to search for prey or forage, exposure, and/or other environmental conditions. The sessile, smaller, and more numerous animals are more likely to show a continuous distribution within particular areas of the gradient. Larger and motile animals, such as Patiria miniata, are more likely to be patchy in distribution.

The low C79 community profile is caused by the patchy or discontinuous distribution of species and is associated with a reduced number of species (Figure 8b). There are no good indicators of the lower portion of the gradient. Consequently, the analysis makes no sharp distinction between lower and middle quadrats along the transect.

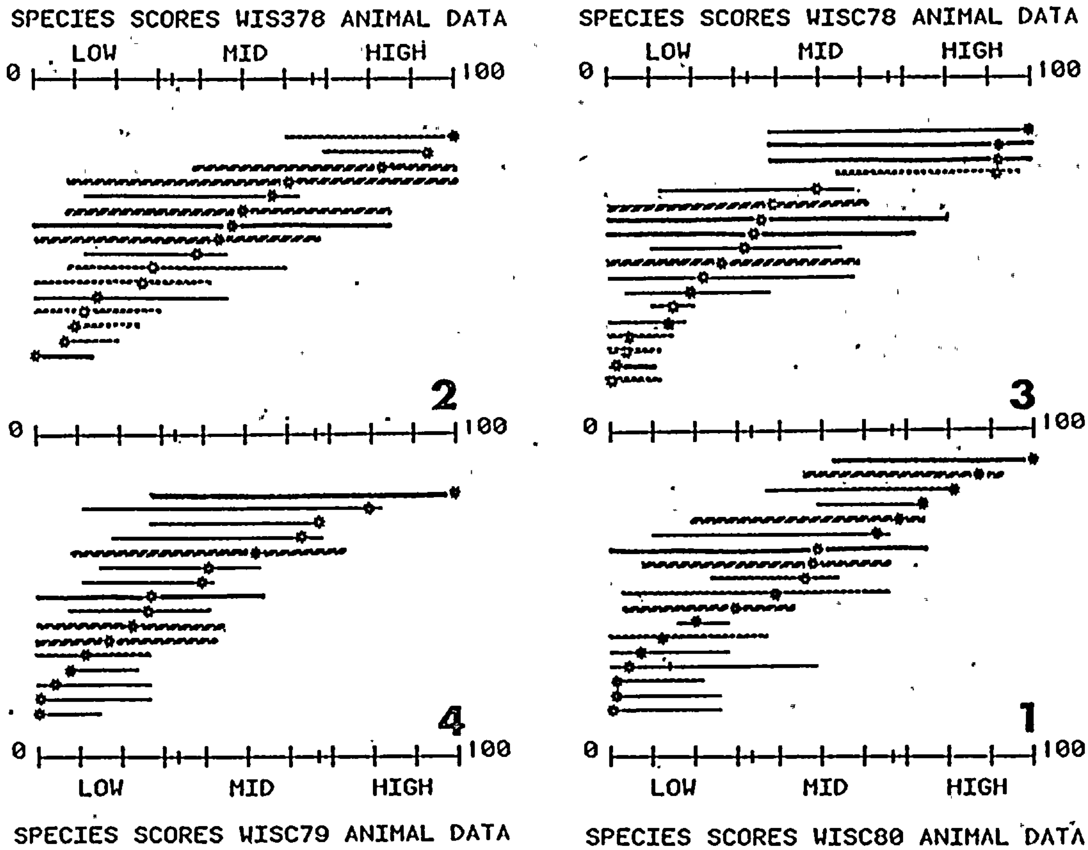


Figure 7. First axis species scores, shown by asterisks, and species distributions for animal data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

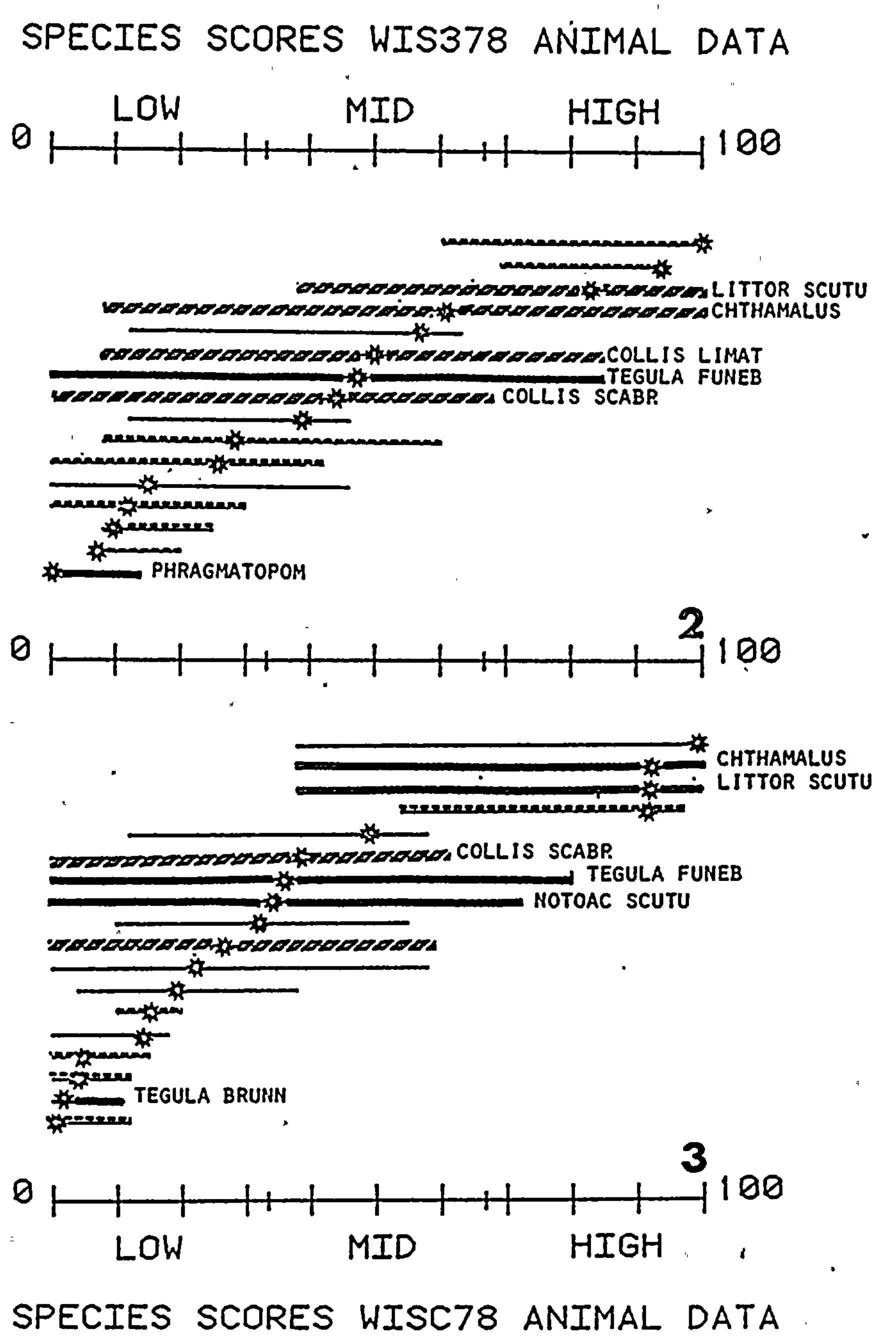


Figure 8a. Species scores, shown by asterisks, and species distributions for 378 and C78 animal data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

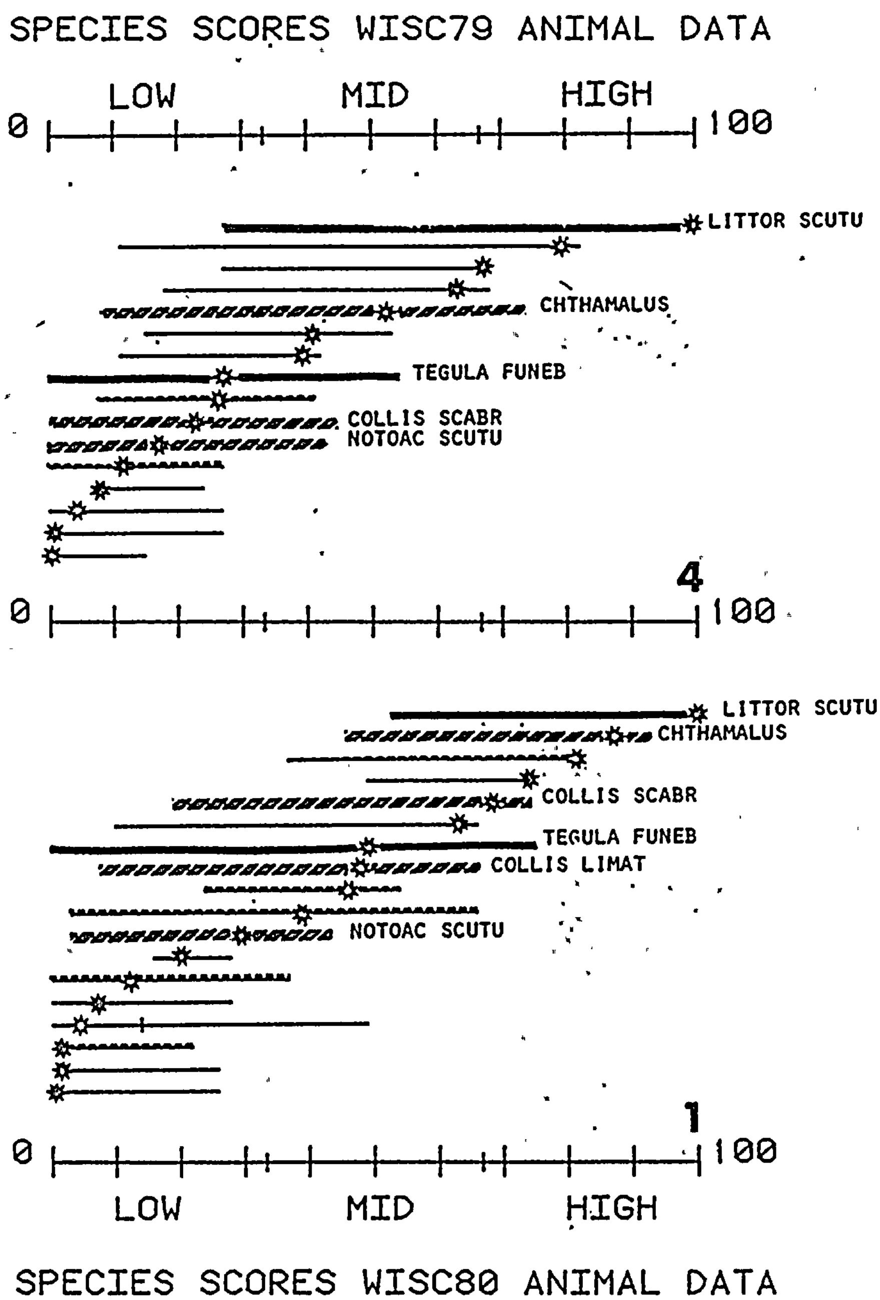


Figure 8b. Species scores, shown by asterisks, and species distributions for C79 and C80 animal data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

Both the 378 and C78 surveys show animal species restricted to the upper intertidal (Figure 8a). However, the distribution of animal species is not as continuous during the 378 survey. The asterisks show that certain species have lower C78 scores than 378. Chthamalus and littorines are better indicators of the upper intertidal and C78 better defines the lower intertidal.

The greatest difference in animal community structure is between C79 and C80. The C80 animal data provide much better definition of zones than C79. Chthamalus and littorines define the upper intertidal and acmaeids the middle. Although poorly defined (in comparison to the plant data), lower quadrats had more restricted distributions than did C79. C79 animal distributions are more sporadic (Figure 8b). Nine of the sixteen species were incidental to the study area. Tegula was not found in upper quadrats. Also, several species were in both lower and middle quadrats. As a result, the middle intertidal is undefined.

Plant and Animal Data Combined

When plant and animal data are joined, the analysis of variance follows animal data findings of each survey having a unique community structure. C79 continues to have the lowest profile (Figure 9). It also has the fewest species (18 plants, 16 animals). The 378 survey (22 plants, 16 animals) gives the best mid and total definitions. C80 (23 plants, 18 animals) displays a mid compression but defines both high and low. In C78 (20 plants, 18 animals), like C79, the upper intertidal is poorly defined. Although C79 had the fewest species, number of species is not clearly related to how well profiles are defined.

Indicators of high, mid, and low are best shown in 378 and

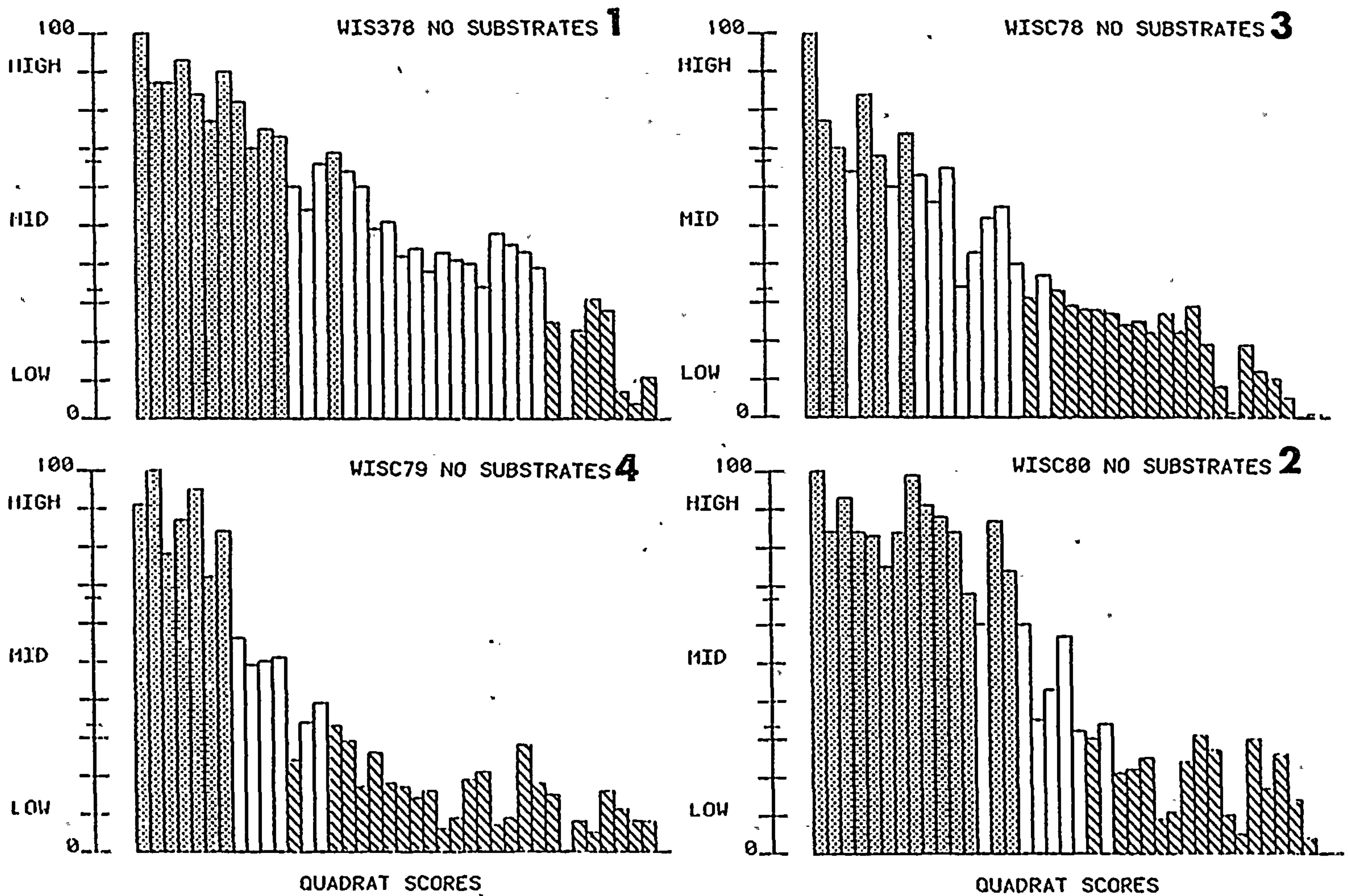


Figure 9. First axis quadrat scores for combined plant and animal data. Bold numbers indicate non-significant subsets shown by the Multiple Range Tests.

poorest in C79 (Figure 10). C78 and C80 have more low indicators but they differ in mid species distributions. Approximately half of the thirty-seven species of survey 378 are good indicators (Figure 11a). Plants are consistently better indicators than are animals. Low is well defined by algae. A blue-green algae/littorine zone identifies high. Acmaeids and Endocladia represent middle quadrats and several species are representative of the study area.

During C78, certain abundant species such as Gigartina papillata, Tegula, and Petrocelis were absent in higher quadrats (Figure 11b). Blue-green algae, barnacles, and littorines identify the upper end of the gradient. Good indicators, mostly algae, are again seen in the lower intertidal. The mid-intertidal is represented by species of incidental distribution absent in upper and lower quadrats.

The basis for the poor C79 profile is shown in Figure 11c. There are no high or low indicators. The absence of mid definition and the resultant abundance of low-scoring quadrats are due to the discontinuous distribution of species in lower quadrats and to many species common to both lower and middle quadrats.

C80 (Figure 11d) had the most species (41). Good indicators exist for high, low, and the study area. Mid had more species with a confined but infrequent occurrence. Porphyra, blue-green algae, and littorines define the upper zone. Endocladia and acmaeids extend from the high through the middle portions of the gradient. Algae and some invertebrates represent the lower intertidal. Gigartina papillata, Petrocelis, Tegula, and

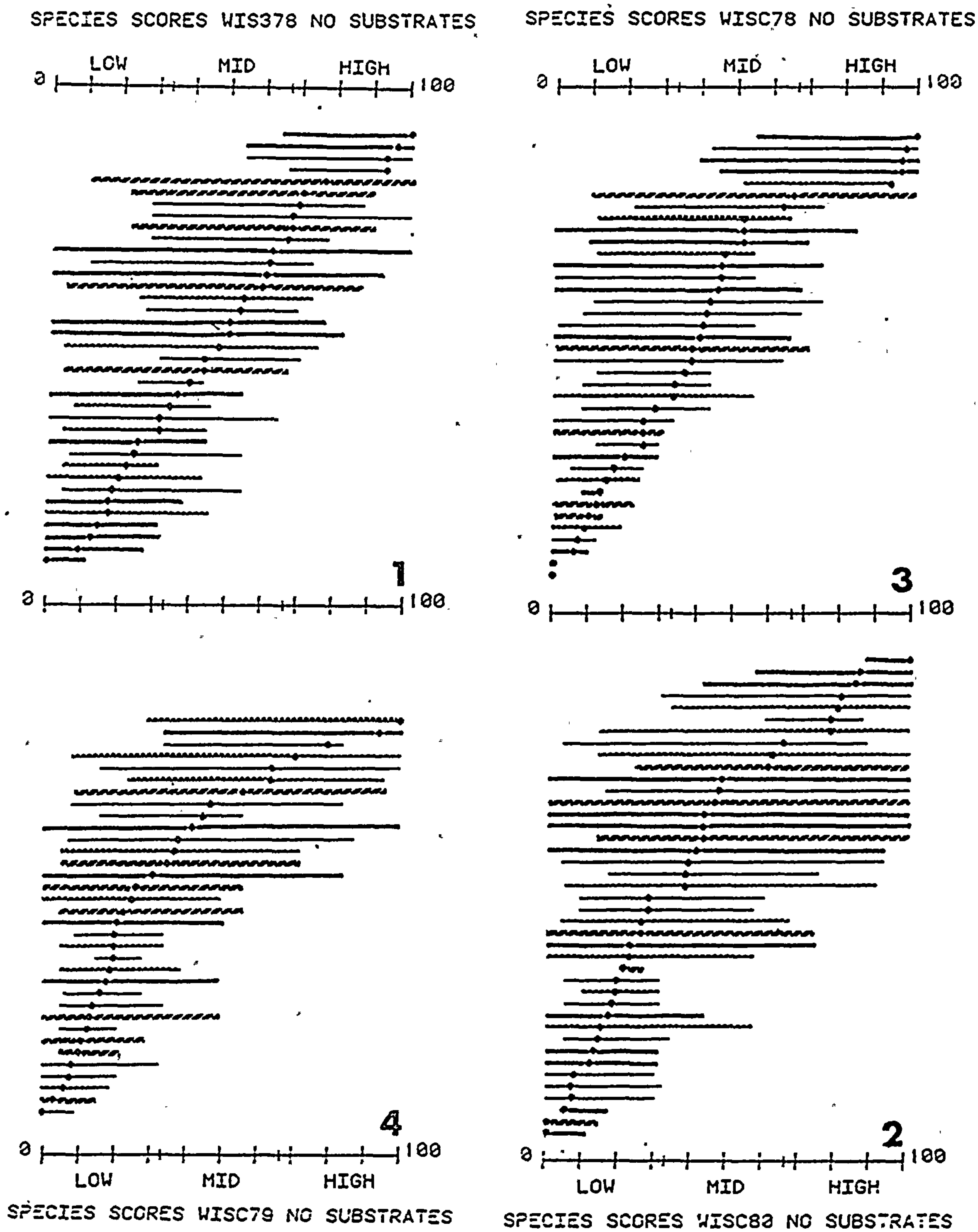
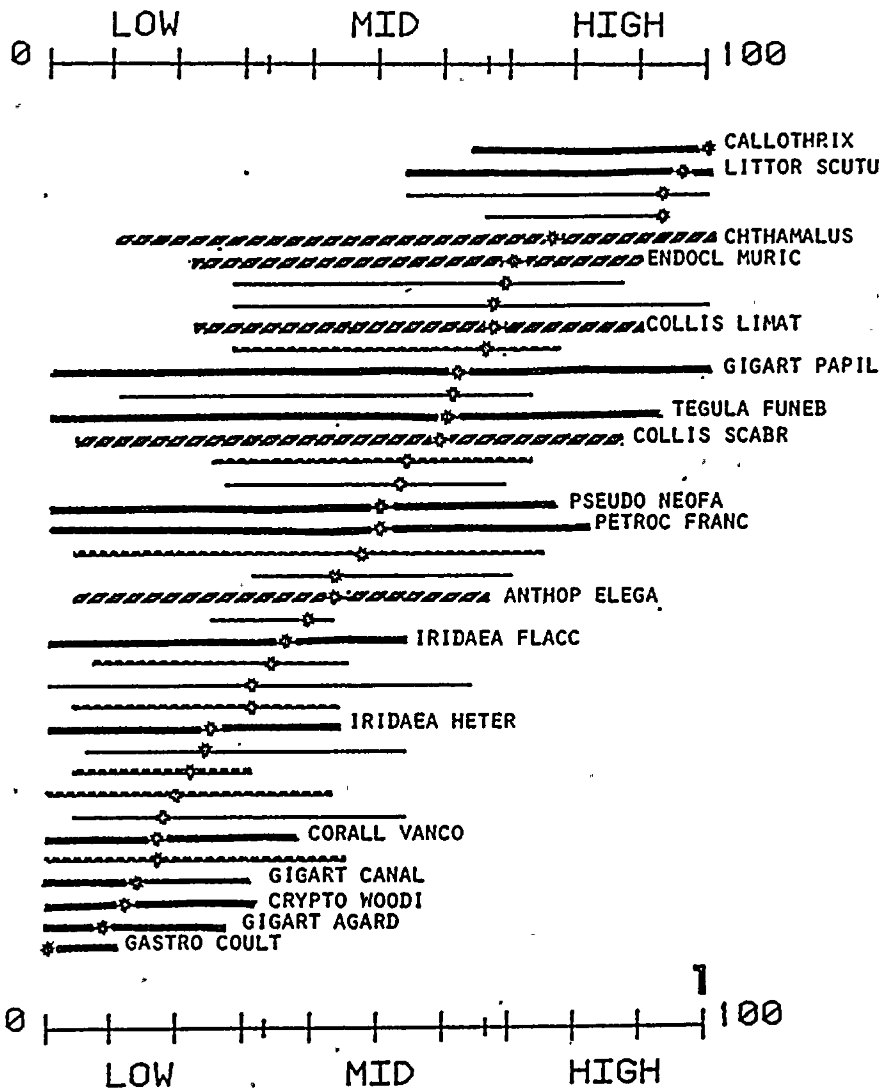
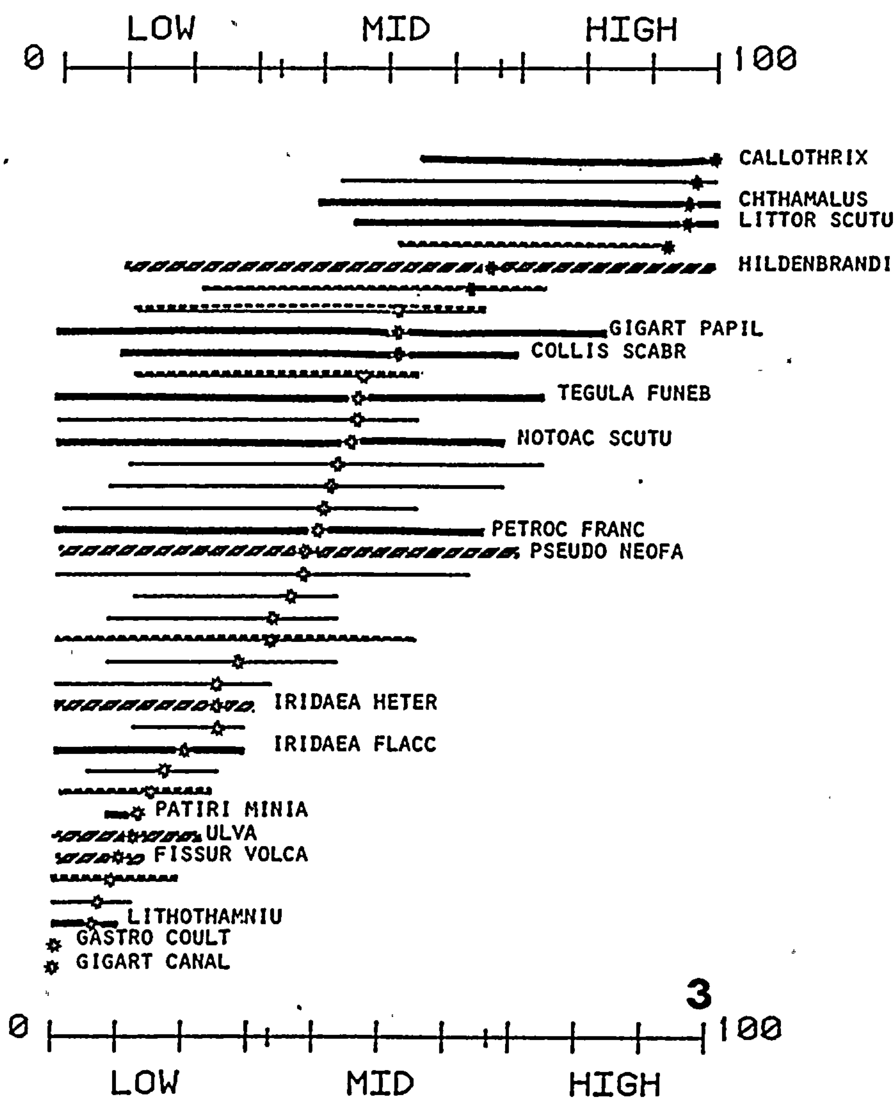


Figure 10 First axis species scores, shown by asterisks, and species distributions for combined plant and animal data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.



SPECIES SCORES WIS378 NO SUBSTRATES

Figure 11a. Species scores and species distributions for 378 combined plant and animal data.



SPECIES SCORES WISC78 NO SUBSTRATES

Figure 11b. Species scores and species distributions for C78 combined plant and animal data.

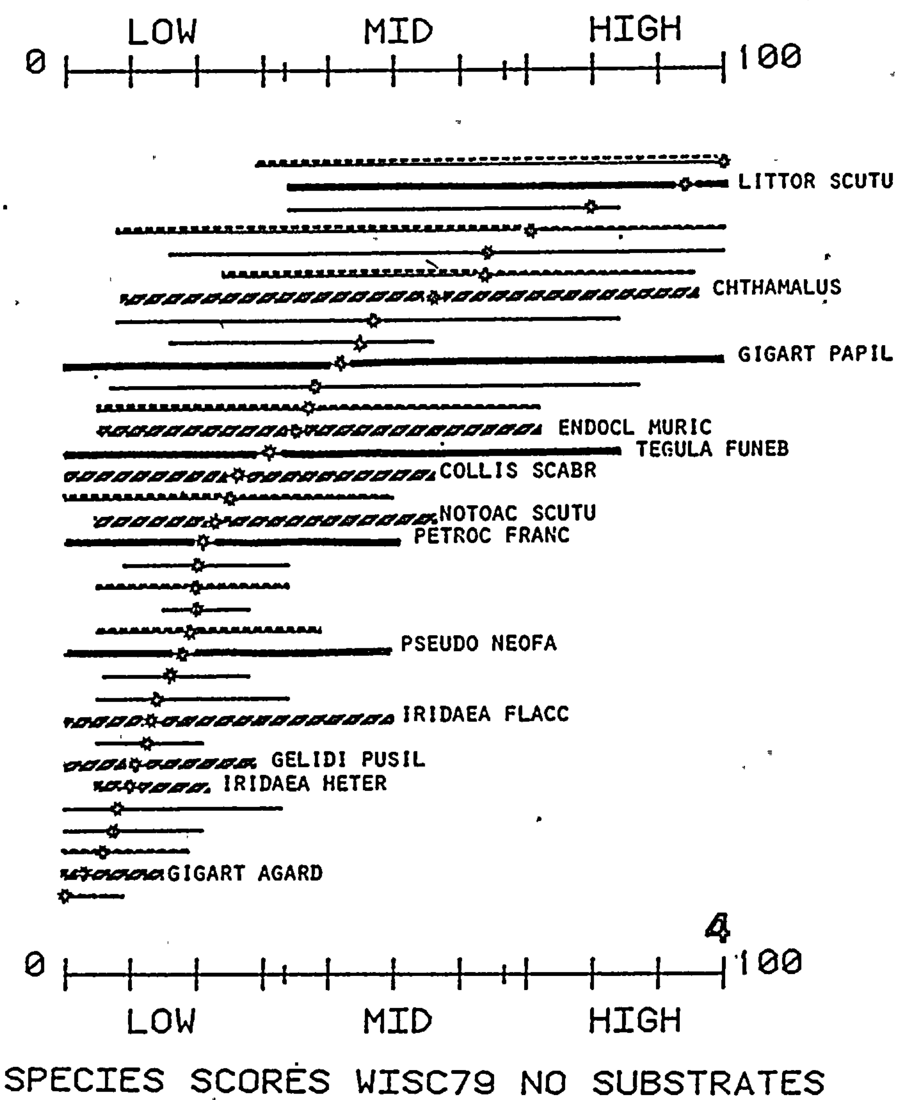


Figure 11c. Species scores and species distributions for C79 combined plant and animal data.

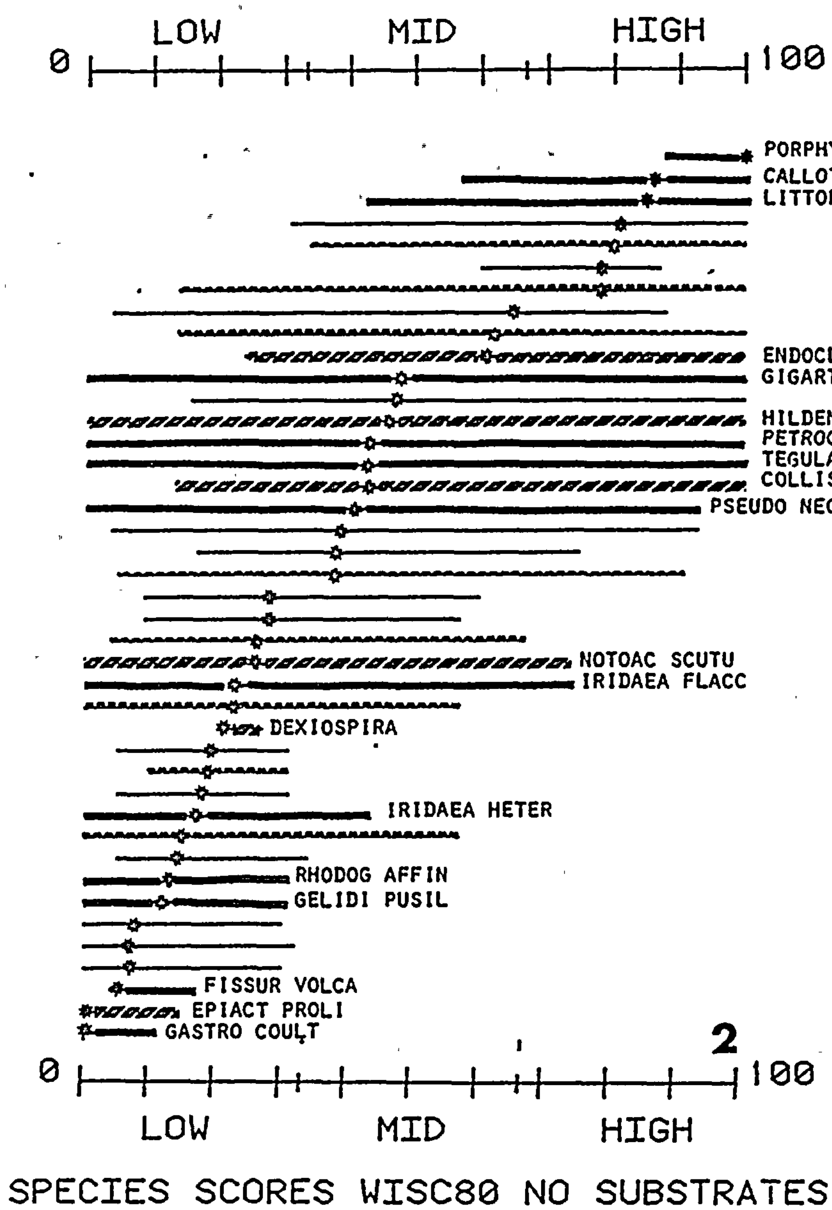


Figure 11d. Species scores and species distributions for C80 combined plant and animal data.

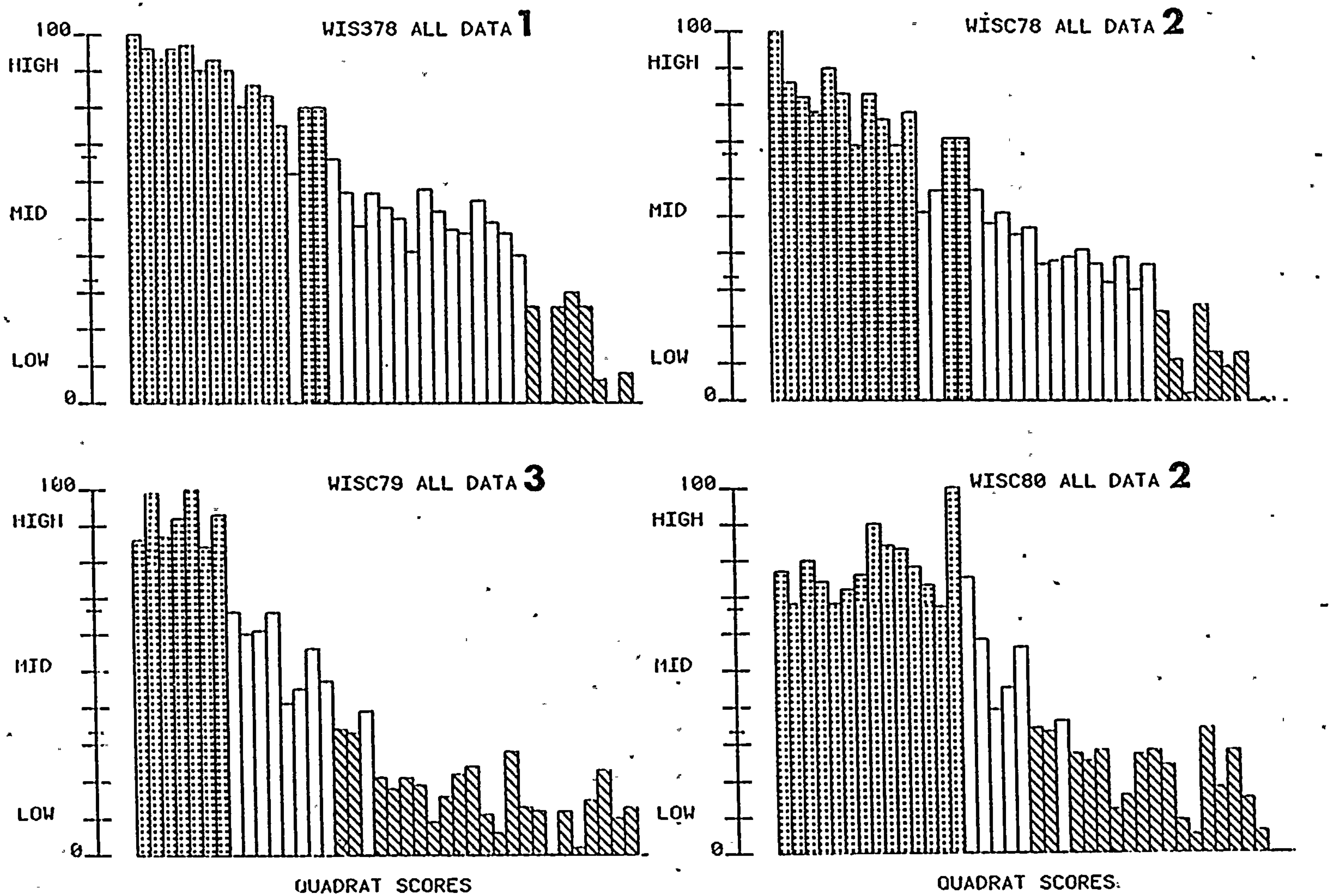


Figure 12. First axis quadrat scores for combined plant, animal and substrate data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.

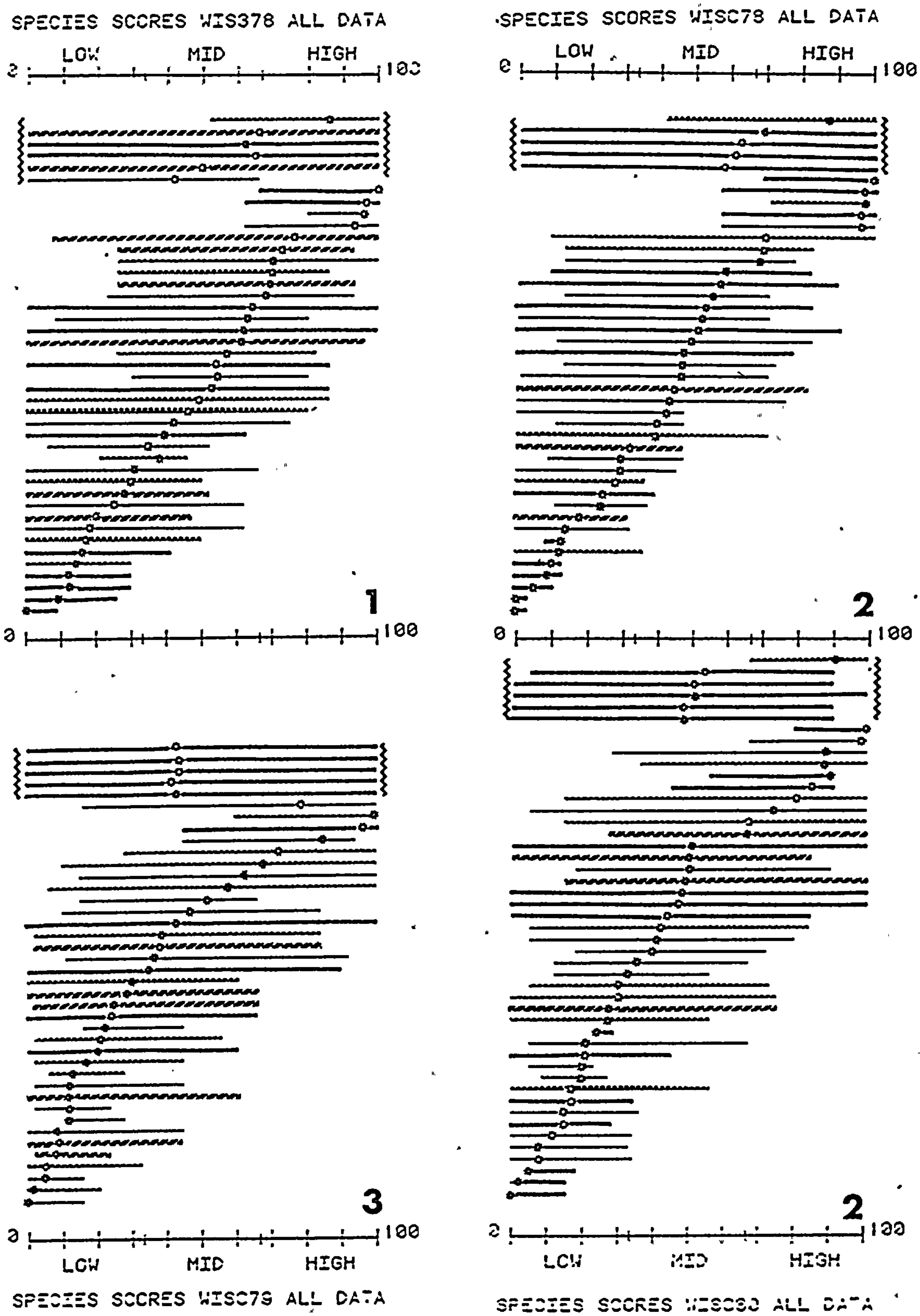
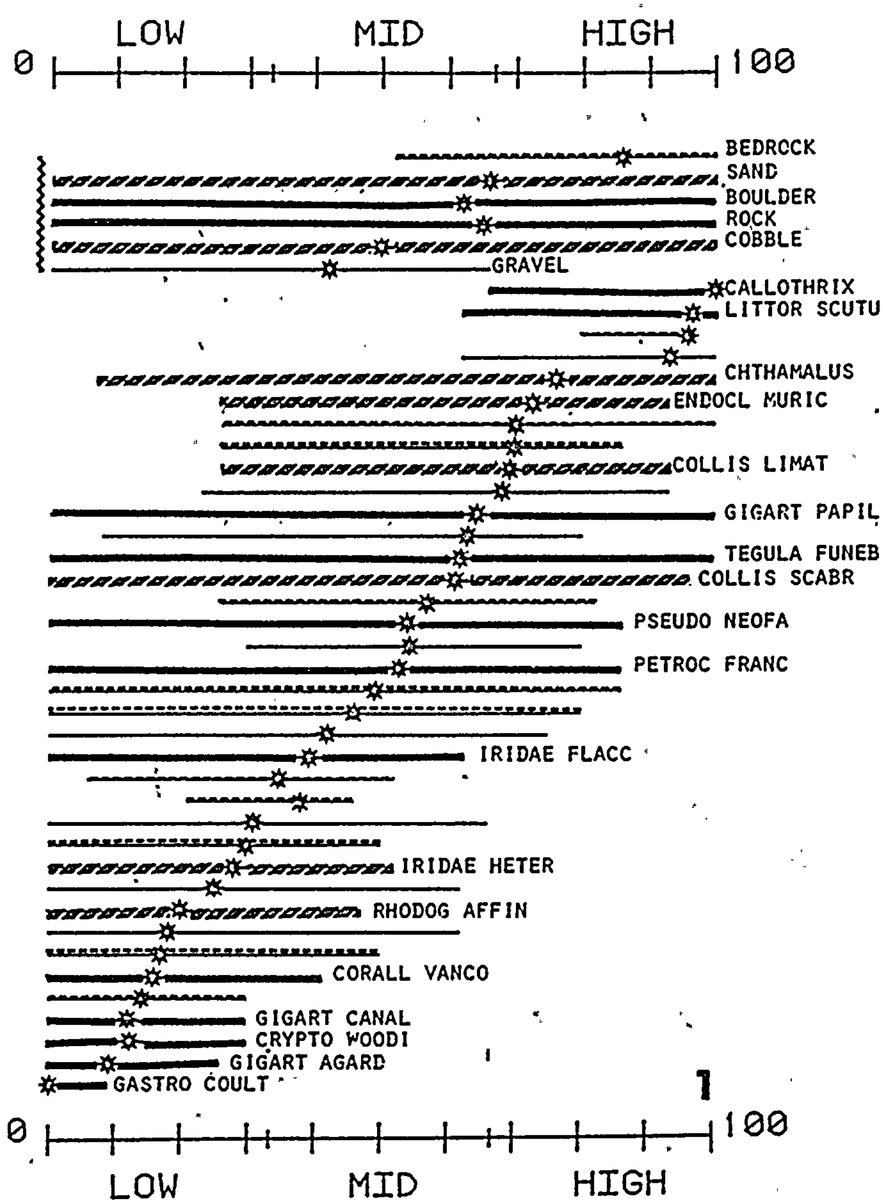


Figure 13. First axis species scores, shown by asterisks, and species distributions for combined plant, animal and substrate data. Bold numbers indicate non-significant subsets shown by Multiple Range Tests.



SPECIES SCORES WIS378 ALL DATA

Figure 14a. Species scores and species distributions for 378 combined plant, animal and substrate data.

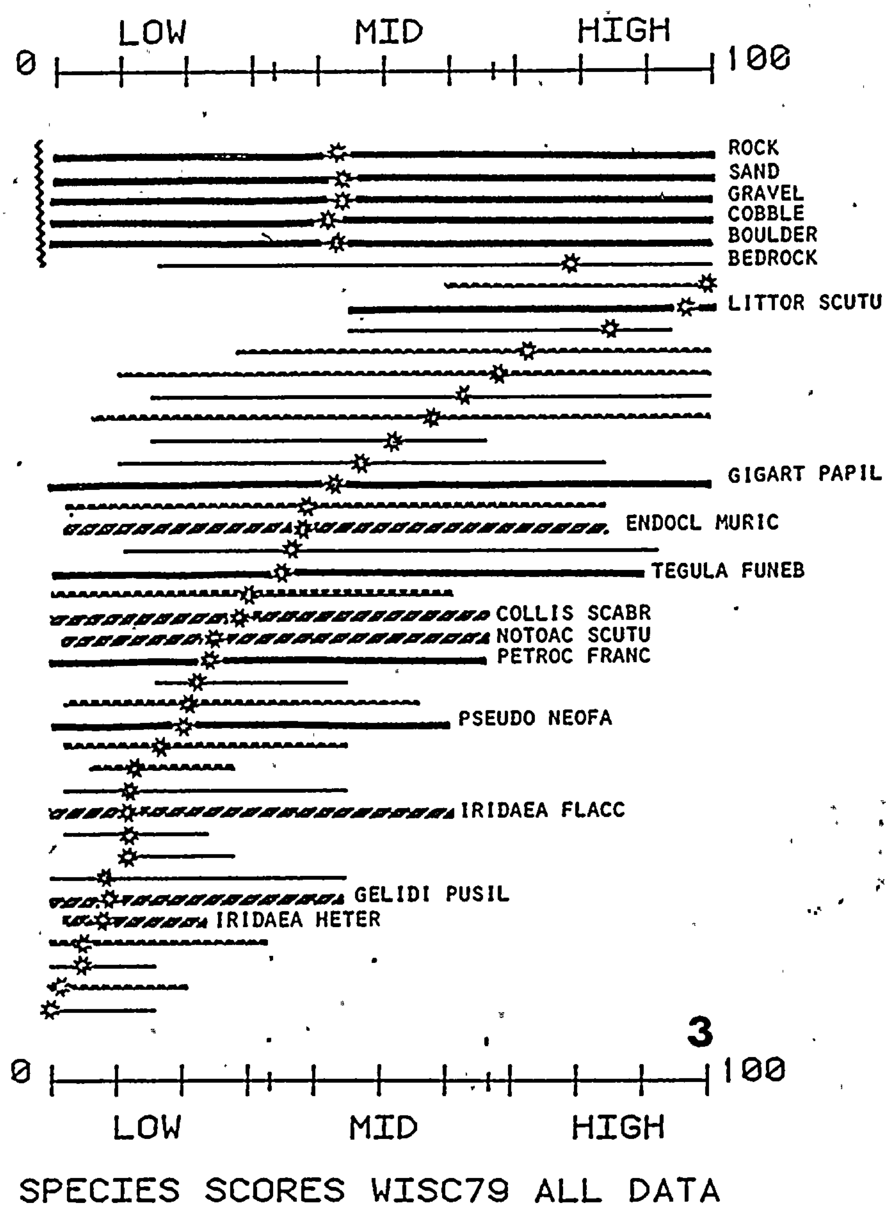
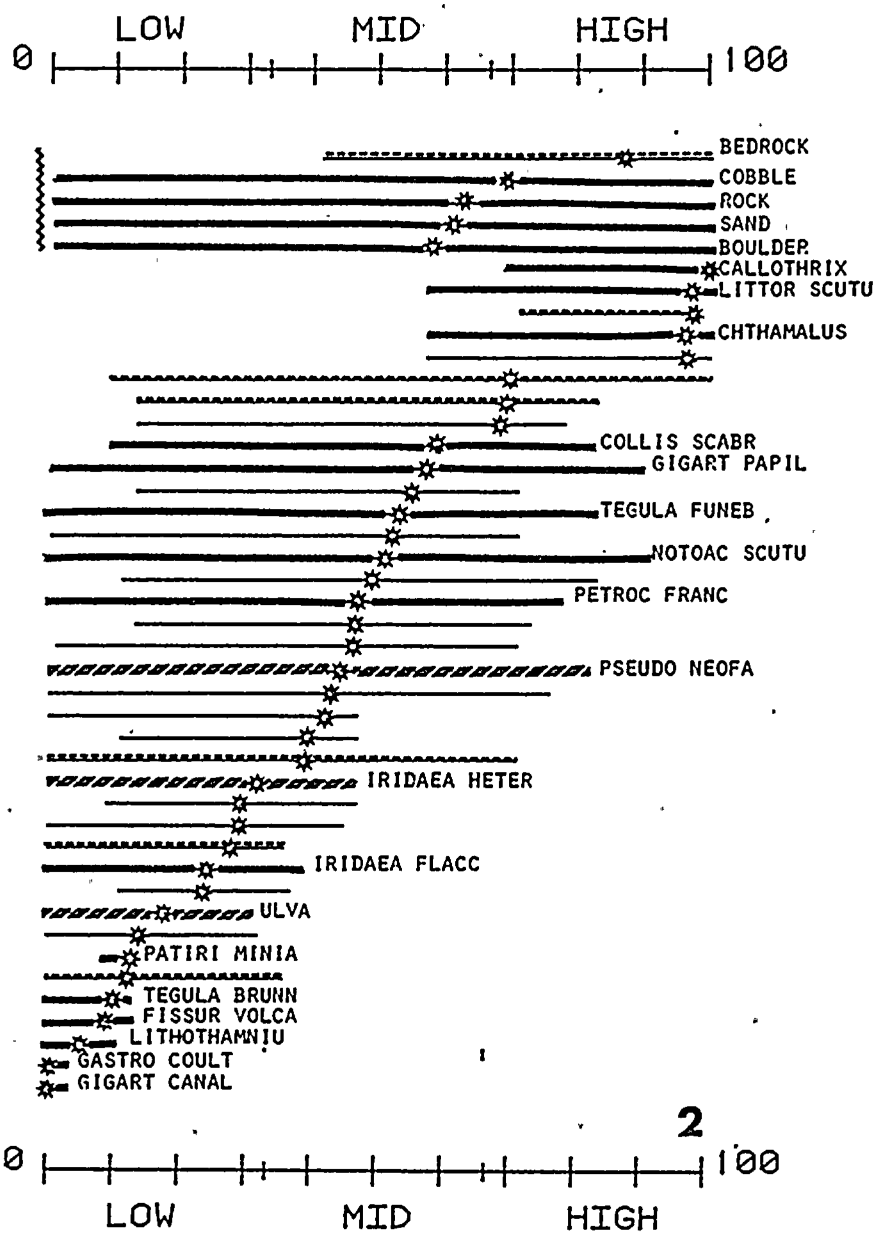


Figure 14b. Species scores and species distributions for C79 combined plant, animal and substrate data.



SPECIES SCORES WISC78 ALL DATA

Figure 14c. Species scores and species distributions for C78 combined plant, animal and substrate data.

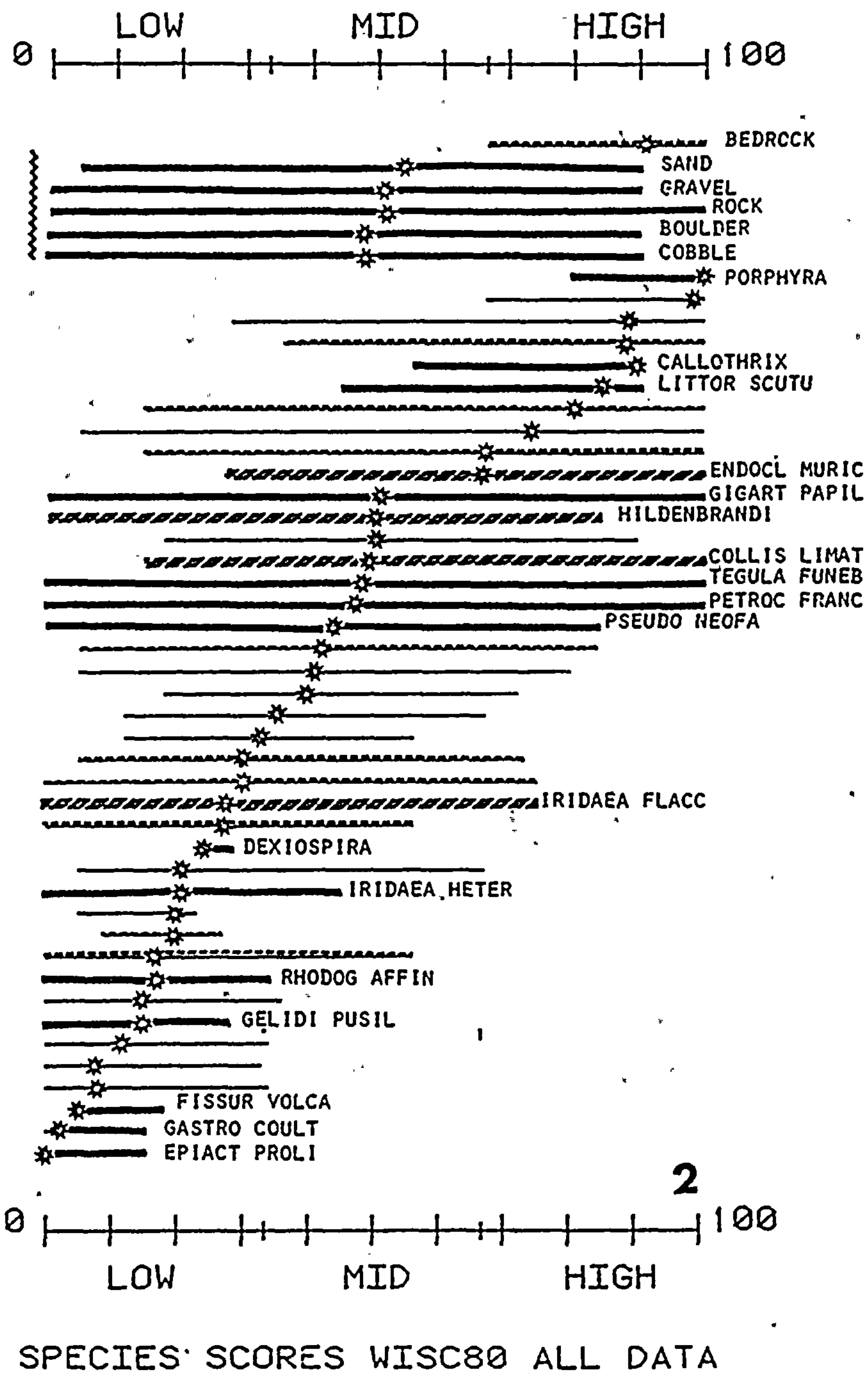


Figure 14d. Species scores and species distributions for C80 combined plant, animal and substrate data.

Hildenbrandia are found throughout the study area.

Plant, Animal, and Substrate Data

When all data are used, the analysis of variance again indicates that 378 has the highest community profile and C79 the lowest (Figure 12). However, the inclusion of substrate data eliminates the significant difference between C78 and C80 by increasing the similarity among quadrats. On the other hand, the general pattern shown by the distributions of plants and animals (Figure 13) is not changed by the inclusion of substrate information.

Looser substrates, such as sand and cobble, were not found in all 378 quadrats (Figure 14a). Gravel was found only in lower quadrats and exposed bedrock only in some upper quadrats. Looser substrates were found in all quadrats in C79 (Figure 14b). Exposed bedrock was infrequent and not restricted to upper quadrats. While cobble and sand also occur in all C78 quadrats, gravel did not (Figure 14c). Exposed bedrock was found only in the upper intertidal. The only substrates present in the highest scoring C80 quadrats were rock and exposed bedrock. Cobble, gravel, and sand were found throughout the study area (Figure 14c).

DISCUSSION

The four data sets provide both similar and different conclusions. All four sets provide lowest profiles for C79 (Figure 15). Although C79 has the fewest plant species and shares the fewest animal species (with 378), elsewhere number of species is not closely related to how well a profile is defined.

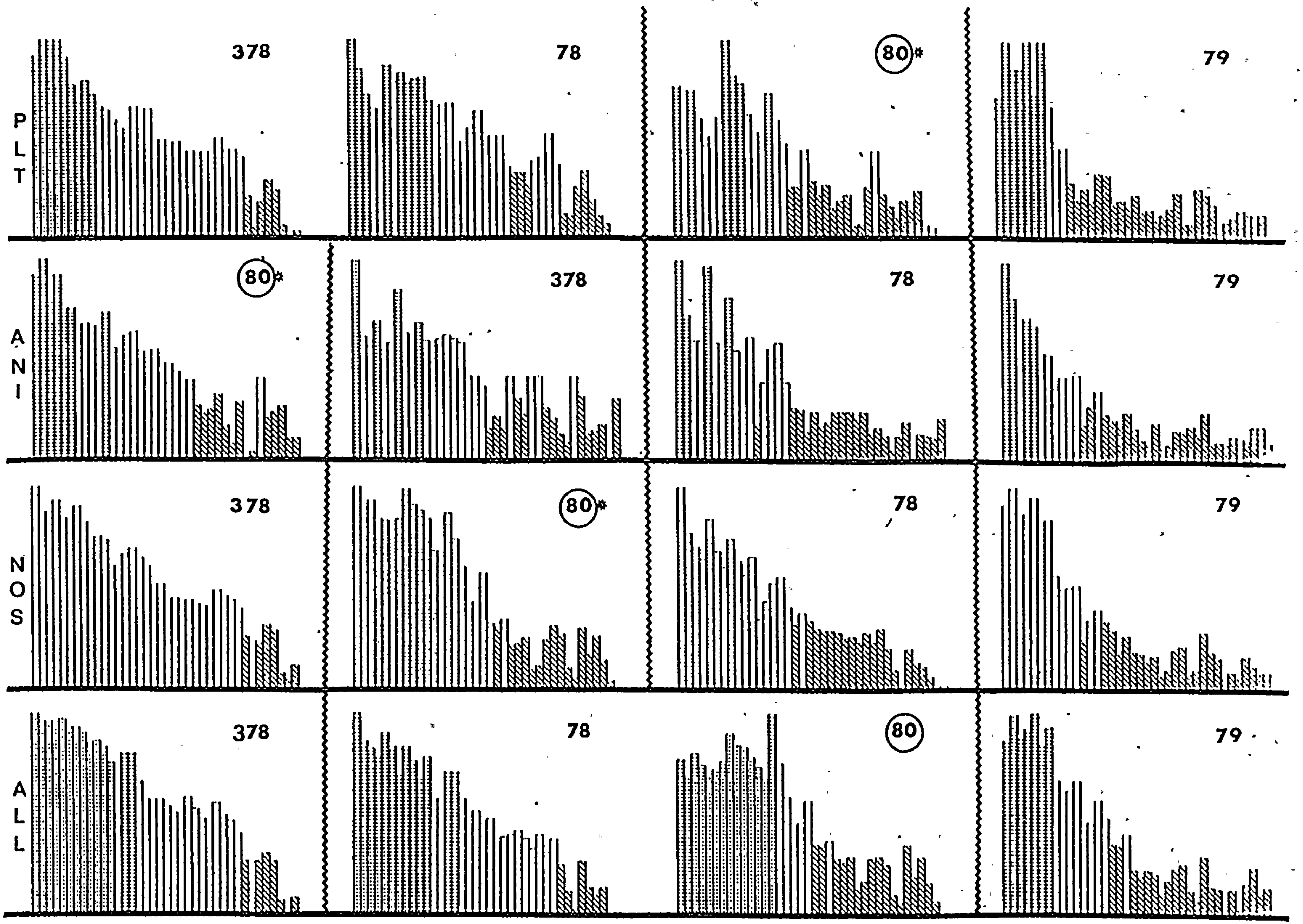


Figure 15. First axis quadrat scores for all data sets and all surveys: Vertical lines indicate non-significant subsets shown by Multiple Range Tests for each type of data.

Well defined profiles are associated with well defined indicators.

The different C80 community profiles shown by the four data sets stress the different plant and animal distributions. For animals, the smoothest gradient transition occurs where the high community profile stems from well defined high and mid intertidal. In contrast, C80 plants do not define high and mid as well as they did for 378 and C78. When these low community profile plants are combined with these higher profile animals, the resultant profile is intermediate.

Each data set has unique properties. Plants alone function as better indicator species, define the gradient better, and indicate fewer differences among surveys than animals do alone. The greater changes in animal profiles suggests that they respond more quickly to environmental extremes, perhaps merely by entering retreats where they are not recorded. In any event, animals contribute a poorer picture of the integrity of the community structure. Animals were concentrated in the lower intertidal but some served as good indicators of the higher. Sessile animals made better indicators than did motile animals. Smaller, more numerous animals often showed continuous distributions and served as better indicators than did larger, less frequent animals. The gradient distribution of certain animals may be related to food preference, e.g., the concurrent distribution of certain grazers and certain algae, but there is a significant difference between the two data sets. However, when plants and animals are combined, the gradient is better defined and more indicators result. If there is a shortcoming to the

combination it exists in greater structural changes being implied than with plants alone. The addition of substrates causes quadrats to appear more similar.

Statistically, the data sets fall into two groups. The plant alone and animal alone sets passed Bartlett's test of homogeneity of variances and the other two sets did not. Passage of Bartlett's test also indicates that plants alone and animals alone provide sets of quadrat scores that follow the normal distribution. Rejection of equality of variances can be due to lack of normality or inequality of variances. Since both lead to the same conclusion, the alternatives need not concern us. In either case, the individual subsets, plants and animals, are different variables, so different that their resultant structures are distinctly unlike through time. This is the source of not passing Bartlett's test, a source probably involving both unequal variances and non-normality.

In our past studies of Diablo Cove (Pimentel, 1979b; Pimentel and Bowker, 1980), combined plant, animal, and substrate data were involved and Bartlett's test was passed. The reason for rejection of the present data set and acceptance of the other stems from data differences. The latter differed from the present data in also including underrock organisms, more stations, and more surveys. Also, quadrats extended neither as high nor as low into the intertidal. Most likely, attenuation of quadrats, high and low, resulted in plants, animals, and substrates appearing as an integrated unit in the other studies. The recurring problem in the present data set is the lowermost

quadrats.

Present analyses further demonstrate known robustness of the analysis of variance when assumptions are not satisfied for data such as used here. Most definitely, the analysis of variance in pinpointing the basis for rejecting Bartlett's test 'overcame' unsatisfied assumptions to do so. For that reason, we seek other reasons to make data recommendations. To do this, we assume that what was found to be the case in this and our past studies (since they are consistent with ecological principles), can be generalzed.

If one wishes to view a community as a stable entity, plant data alone are the choice. They provide the smallest F-value and segregate fewer subsets than do any other data set. If one wishes to observe structural changes, animal data alone are the choice.

If only a single data set is to be examined, that of combined plants and animals seems best. The indicator status of individual data sets and, obviously, the quadrat distributions of plant and animal species are preserved. Although somewhat clearer when plants and animals are treated separately, in combined data, plant or animal structural changes over surveys remain discernable. The only shortcomings arise from statistical analysis of the combined data profiles. Entirely different statistical results can occur in profile comparisons and results can be misleading. For example, no significant difference could arise between a combined profile where plants and animals alone have identical profiles and a combined profile where plants stress one end and animals the other end of a

gradient. One must weigh such potential pitfalls against the merits of combining plant and animal data. We believe that consideration of the total community is more important and realistic than considering any single component, plant or animal. Obviously, the ideal solution would be three analyses, plants, animals, and their combination.

The value of substrate data are debatable. If one ignores substrate information, resultant species scores graphs are no more complex than those for plants and animals combined. However, profiles definitely are altered statistically beyond those provided by combined organisms. Substrates in causing quadrats to appear more similar make it more difficult to evaluate plant and/or animal contributions to profiles. Moreover, we doubt if substrates add useful information.

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Microgeographic Variation in <u>Collisella</u> <u>digitalis</u>: The Use of Shell Morphometrics as a Possible Indicator of Thermal Impact

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Table of Contents

List of Tables

List of Figures

ABSTRACT

A study was conducted to investigate the natural variation occuring in the intertidal limpet, Collisella digitalis, in the vicinity of Diablo Cove, near San Luis Obispo, California. A large number of limpets were collected at several different locations, all at the same approximate tidal height. A final analysis was carried out on 32 individuals from 3 stations within Diablo Cove, and one station in Field's Cove, just north of Diablo Cove. Univariate analyses of variance on 8 measured morphometric characters all yielded significant differences between stations. The multivariate methods of principal component analysis (PCA) and discriminant analysis (DA) were used to examine morphometric patterns of variation at the four stations. Although the ordinations of both the PCA and DA were similar, the PCA tended to emphasize shell characters, whereas the DA ordination emphasized morphological characters. The major patterns of variation observed and the differences between stations appears to be related to differences in exposure to wave shock. Predictions on the effects of thermal impact are made in light of the results discussed.

INTRODUCTION

A study was carried out to investigate morphological variation occurring in the intertidal limpet, Collisella digitalis (Rathke, 1833), in Diablo Cove near San Luis Obispo, California. Diablo Cove is the cooling water discharge site for Pacific Gas and Electric Company's (PG and E) Diablo Canyon Power Plant (DCPP).

Collisella digitalis, along with its congeneric C. scabra (Gould, 1846), are the most conspicuous limpets found in the upper intertidal and splash zones of central California. C. digitalis is recorded as ranging from southwestern Alaska to Cabo San Lucas, Baja California Sur, Mexico (Lindberg, 1981). Within its range it is a highly variable species, and is commonly confused with other species in the genus, when shell characteristics alone are considered. When found co-occurring with the stalked barnacle, Pollicipes polymerus, C. digitalis may exhibit shell characteristics resembling the tergal and scutal plates of the barnacle (Giesel, 1970; Lindberg, 1981). Other species of limpets have also been observed to exhibit habitat-related shell morphs (Test, 1945; Lindberg, 1981).

Studies on geographic variation usually examine variation

over á wide range. Examination of intralocality variation is often limited to a single sample from a locality. Inadequate knowledge of the range of variation in a given species has given rise to classifications with numerous species and subspecies (e.g. Phillips, et al., 1973). Detailed examination within a limited area could contribute towards the understanding of the causes of variation observed throughout the range of a species. In an analysis of shell characteristics of the ring cowry, Cypraea annulus, from Zanzibar, Orr (1959) was able to describe habitat related morphs that were similar to all described subspecies.

A multivariate approach, using the techniques of principal component analysis (PCA), and discriminant analysis (DA) was used in this study. Studies of geographic variation, being analyses of total form, are inherently multivariate in nature. Techniques used in this report have been used successfully in many studies. Their use in studies of geographic variation are reviewed by Gould and Johnston (1972), and Thorpe (1976).

This analysis will examine variation in morphometric data of limpets collected at a number of sites in the vicinity of Diablo Cove. Variation at each sampling site will be discussed in reference to physical factors present at the individual stations. An attempt will be made to predict which variables

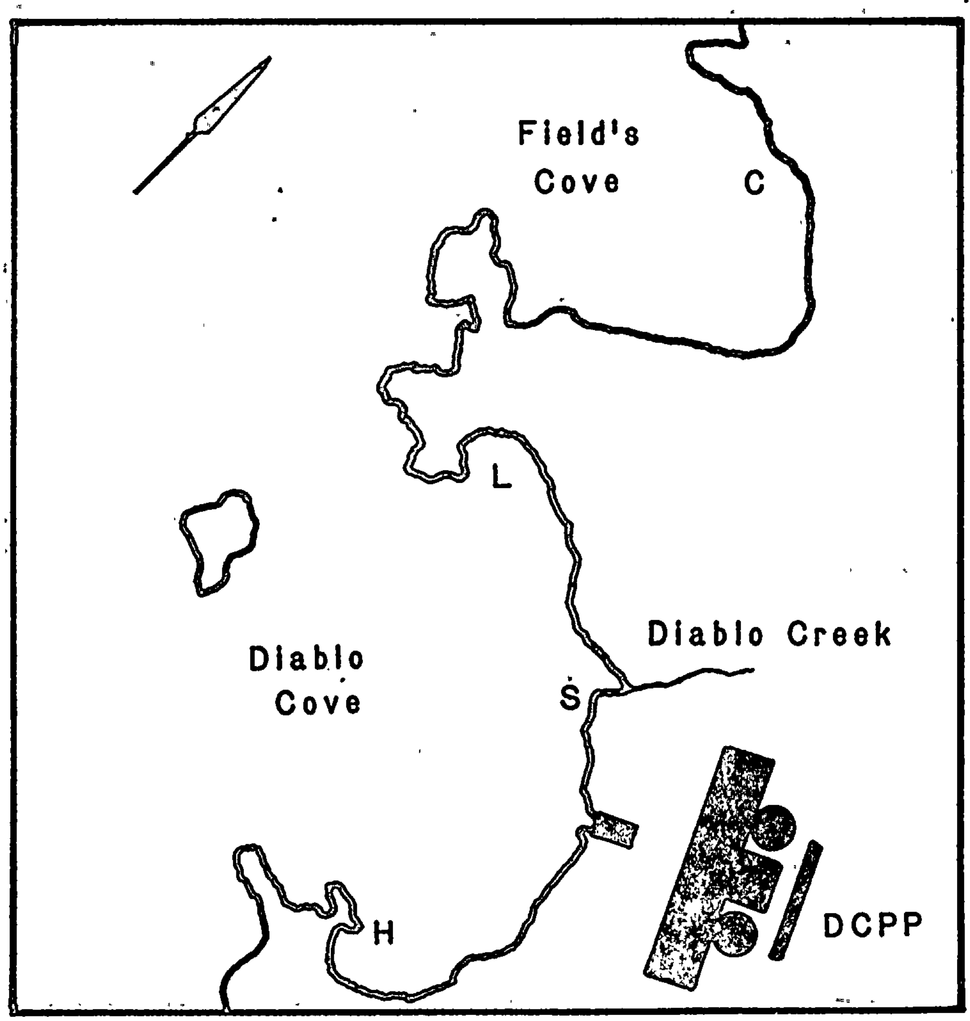
will change with increasing temperature. Following commercial operation of DCPP, and given enough time for limpet settlement and growth, stations could be resampled, and the effects of the thermal discharge on limpet morphometrics assessed.

MATERIALS AND METHODS

Specimens of Collisella digitalis were obtained from four stations in the vicinity of Diablo Cove (stations C, H, L, S; see Figure 1). These stations were selected because they occurred in areas of different anticipated thermal impact (PG and E, 1982), and they were adjacent to PG and E's Intertidal Fish field stations (Pimentel and Bowker, 1980). Description of stations C, H and L are given in Pimentel and Bowker (1980). Station S, not a PG and E station, is directly south of Diablo Creek. Approximately 50 specimens were collected at each station at comparable tidal heights. After elimination of damaged specimens, each sample was reduced to 32 individuals. Before collection, each station was photographed so that densities of individuals could be calculated.

Eight morphological variables were derived to outline the form of the shell and to measure the relative size of different components of the body (Figure 2). In addition, variables were

Figure 1. Map of station locations in the Diablo Cove area.

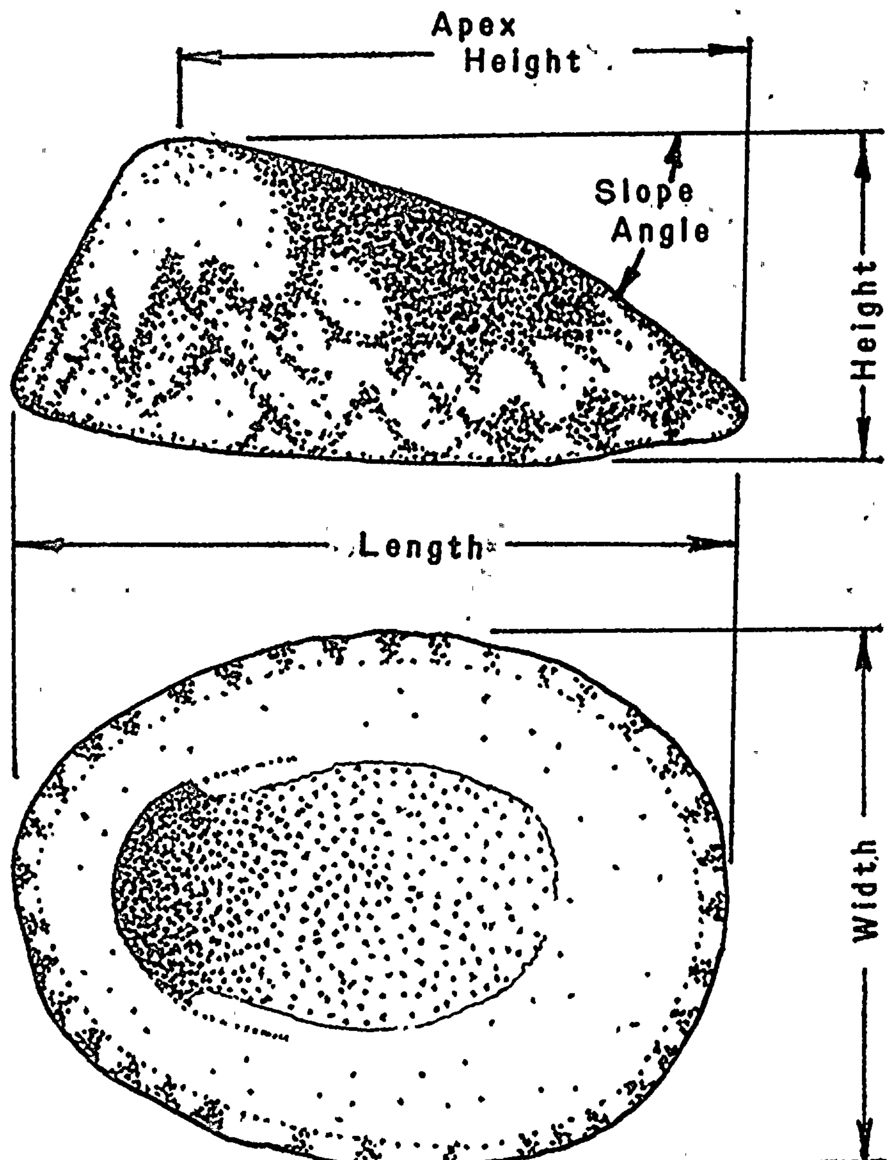


chosen to describe anticipated changes in shell shape due to differential wave exposure as outlined by Test (1945). All linear shell measurements were made using calipers or a plastic ruler. The anterior shell angle was measured by orienting a ruler mounted on a piece of wood tangentially to the anterior slope of the shell. The angle between the ruler and the board was then measured with a protractor. All weights were taken using an electronic scale (Sartorius model 3704).

The data were analyzed using a combination of univariate and multivariate analyses. These analytical methods fully exploit the information content of the data, as well as provide different methods for interpretation. Univariate methods consisted of an analysis of variance (ANOVA) between samples, and a Student-Newman-Keuls multiple range test for each variable. A one-way analysis of variance was performed on each variable to determine if significant differences exist between samples. Significantly different variables were analyzed further using a Student-Newman-Keuls multiple range test to separate samples into homogeneous subsets for each variable.

A multivariate analysis of variance (MANOVA) was performed to determine if significant differences exist between group (sample) mean centroids. This is done as a prerequisite for multigroup principal component analysis (MPCA), and canonical

Figure 2. Morphometric variables used to summarize the shape and form of <u>Collisella</u> <u>digitalis</u>.



analysis of discriminance (CAD). The assumptions of MANOVA are the multivariate extensions of those neccessary for a univariate analysis of variance, therefore Bartlett's Test was used to test for equality of group dispersions (homoscedasticity). When group dispersions are equal only principal components derived from the group dispersion matrix need be analyzed. When group dispersions are unequal, differences between group components can be expected. By comparing angles or correlations between components for groups, and components from dispersion, differences in variation can be examined (Pimentel, 1979).

Patterns of variation occurring within and between samples were examined using principal component analysis (PCA). PCA consists of transforming original variable axes to new axes which describe successively larger partitions of the variation described by all variables (Blackith, 1960). This is accomplished by extracting eigenvalues and eigenvectors from a variance-covariance or correlation matrix. New axes, defined by eigenvalues and eigenvectors, represent independent, linear patterns of variation attributable to differences in size and shape (Jolicoeur and Mosimann, 1962). Because variables in this study had different units of measurement, the data were transformed to z-scores (Sokal and Rohlf, 1969) prior to analysis by PCA.

Variation within samples was examined using MPCA. This technique involves the comparison of angles (Pimentel, 1979), or correlations (Rummel, 1970) between principal components from each group and their pooled within group dispersion. Sample components that display significant correlations with those of pooled dispersion estimate similar intralocality variation.

In a second analysis of variation between samples, data were examined using the canonical analysis of discriminance (CAD). CAD is analogous to PCA in that it involves an eigenvalue-eigenvector solution to a matrix of variances and covariances (i.e. the dispersion matrix). However, CAD involves an analysis of the between sample dispersion matrix multiplied by the inverse of the within sample dispersion matrix. In essence this transformation amounts to maximizing between group differences by minimizing within group differences. In studies of geographic variation, CAD is theoretically preferred as within group differences (primarily sexual dimorphism and habitat variation) frequently obscure between group differences - geographic variation.

RESULTS

Means, standard deviations of morphological variables and

densities for each station are presented in Table 1. A one-way analysis of variance on the raw data found significant differences between stations (all p < .05). Results of Student-Newman-Keuls a posteriori tests (Table 2) show that for three of the eight variables, width, height, and slope angle, all stations are significantly different from one another (p < .05). Stations C and H form the only non-significant grouping for the other five variables.

Significant differences between group mean centroids were detected by MANOVA, while Bartlett's Test showed group dispersions to be unequal (both p < .05). Interpretation of the results from MANOVA are not affected by unequal dispersions, since populations with unequal dispersions are different, even if centroids are equal (Pimentel, 1979). In this study univariate tests confirm the results of MANOVA: individuals at station S are larger and more variable than individuals at the other stations (Tables 1 and 2). This single difference is the likely cause of significant heterogeneous dispersions and is best explored by MPCA.

Results of the separate PCA's for each station and the pooled dispersion matrix are presented in Tables 3-7. Results for the first three principal components are presented as these accounted for greater than 95% of the total variation within

Table 1. Means and standard deviations of morphological variables, and densities of individuals at four stations. Weights are in grams, slope angle in degrees, all other variables in millimeters.

	Stat. C		Stat. H		Stat. L		Stat. S	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Length	12.20	1.87	13.50	1.46	16.90	1.35	23.90	4.91
Width	9.50	1.51	10.80	1.29	14.10	1.38	18.50	3.46
Height	3.50	0.64	4.30	0.65	5.90	0.94	8.20	2.40
Apex height	11.30	1.83	11.40	1.67	15.50	2.25	20.50	4.25
Slope angle	75.00	8.1	65.00	5.4	71.00	8.7	59.00	4.3
Shell weight	0.15	0.06	0.19	0.08	0.51	0.18	1.04	0.73
Foot weight	0.04	0.02	0.05	0.02	0.09	0.08	0.30	0.17
Visceral weight	0.05	0.02	0.06	0.03	0.13	0.04	0.34	0.19
Density (# per 1/4 m.)	151		65		37		45	

Table 2. Results of Student-Newman-Keuls multiple range test. Lines connecting stations represent non-significant ($p < .05$) groupings.

	Stat. C	Stat. H	Stat. L	Stat. S
Length	------------------		----	----
Width	----	----	----	----
Height	----	----	----	----
Apex height	------------------		----	----
Slope angle	----	----	----	----
Shell weight	------------------		----	----
Foot weight	------------------		----	----
Visceral weight	------------------		----	----

each sample. Correlations between station components and pooled dispersion components are presented in Table 8. At a significance level of p=.05, the first component for stations H and S are not significantly different from pooled dispersion, while stations L and C possess unique first components. Significant correlation (r=0.98, p<0.01) of the first dispersion component with a theoretical isometric component (one with equal eigenvector coefficients for all variables) show that this component describes variation in magnitude for all variables, i.e. general size of individuals. Unique size variation at stations C and L can be attributed to differences in the magnitude of slope angle and shell weight (Tables 3 and 5). The first component for stations C and L are strongly correlated with the second pooled dispersion component (Table 8), one contrasting variation in slope angle with size of body components (Table 7). Station H has a similar second component (Tables 4 and 8).

The third pooled dispersion component appears to describe variation due largely to station S, or perhaps to a compounded pattern of variation resulting from the interplay of stations. This component contrasts variation in shell weight and shell size (not height). Third components for all stations, except S, are not correlated with this component (Table 8). Rather, they describe variation unique to each station.

Table 3. Percentage of the variance explained and eigenvectors for principal components from station C.

	Component 1	Component 2	Component 3
% Variance	68.3	27.6	1.3
Length	-.224	-.431	-.473
Width	-.249	-.453	-.139
Height	-.172	-.323	.868
Apex height	-.279	-.453	-.020
Slope angle	-.870	.491	-.001
Shell weight	-.085	-.152	-.021
Foot weight	-.097	-.156	-.038
Visceral weight	-.079	-.097	.041

Table 4. Percentage of variance explained and eigenvectors for principal components from Station H.

	Component 1	Component 2	Component 3
% Variance	65.6	24.4	4.9
Length	-.287	.342	.167
Width	-.333	.410	.198
Height	-.326	.124	.459
Apex height	-.387	.289	-.833
Slope angle	-.669	-.722	.008
Shell weight	-.197	.134	-.102
Foot weight	-.110	.160	.082
Visceral weight	-.228	.229	.107

Table 5. Percentage of variance explained and eigenvectors for principal components from Station L.

	Component 1	Component 2	Component 3
% Variance	72.3	13.0	8.2
Length	-.119	.404	.076
Width	-.157	.562	.108
Height	-.251	-.019	.680
Apex height	-.322	.407	-.588
Slope angle	-.822	-.460	-.155
Shell weight	-.262	.225	.257
Foot weight	-.153	.294	.031
Visceral weight	-.162	.076	.290

Table 6. Percentage of variance explained and eigenvectors for principal components from Station S.

	Component 1	Component 2	Component 3
% Variance	89.9	3.9	2.3
Length	-.312	.280	-.065
Width	-.284	.260	.154
Height	-.350	.222	.587
Apex height	-.314	.238	-.155
Slope angle	-.067	.387	-.724
Shell weight	-.472	-.758	-.245
Foot weight	-.426	-.087	.080
Visceral weight	-.439	.125	-.114

Table 7. Percentage of variance explained and eigenvectors for principal components derived from the pooled within station dispersion matrix.

	Component 1	Component 2	Component 3
% Variance	73.1	16.3	4.0
Length	-.321	.062	.378
Width	-.308	.043	.494
Height	-.356	.013	-.003
Apex height	-.347	-.091	.435
Slope angle	-.190	-.962	-.131
Shell weight	-.444	.145	-.585
Foot weight	-.394	.159	-.118
Visceral weight	-.408	.123	-.227

Table 8. Correlations between principal components for four stations and their pooled dispersion.

		Pooled Dispersion		
		Component 1	Component 2	Component 3
Station C	1	0.58	0.80**	0.13
	2	0.62	-0.54	-0.52
	3	-0.10	-0.02	-0.25
Station H	1	0.80**	0.57	-0.17
	2	-0.46	0.78**	0.40
	3	-0.11	0.13	-0.30
Station L	1	0.69	0.72**	0.05
	2	-0.60	0.540	0.48
	3	-0.31	0.30	-0.38
Station S	1	0.99**	-0.31	0.04
	2	-0.08	-0.47	0.71**
	3	0.08	0.68	0.24

** - r significant at p <= 0.05

That little variation is shared by all groups indicates significant morphological divergence of stations. With such a result it is apparent why there is significant heterogeneity between group dispersions. Although unequal dispersions violate assumptions of CAD, robustness of the methodology allows us to proceed (Pimentel, 1979). In addition, we now have some foundation for understanding differences in variability between stations.

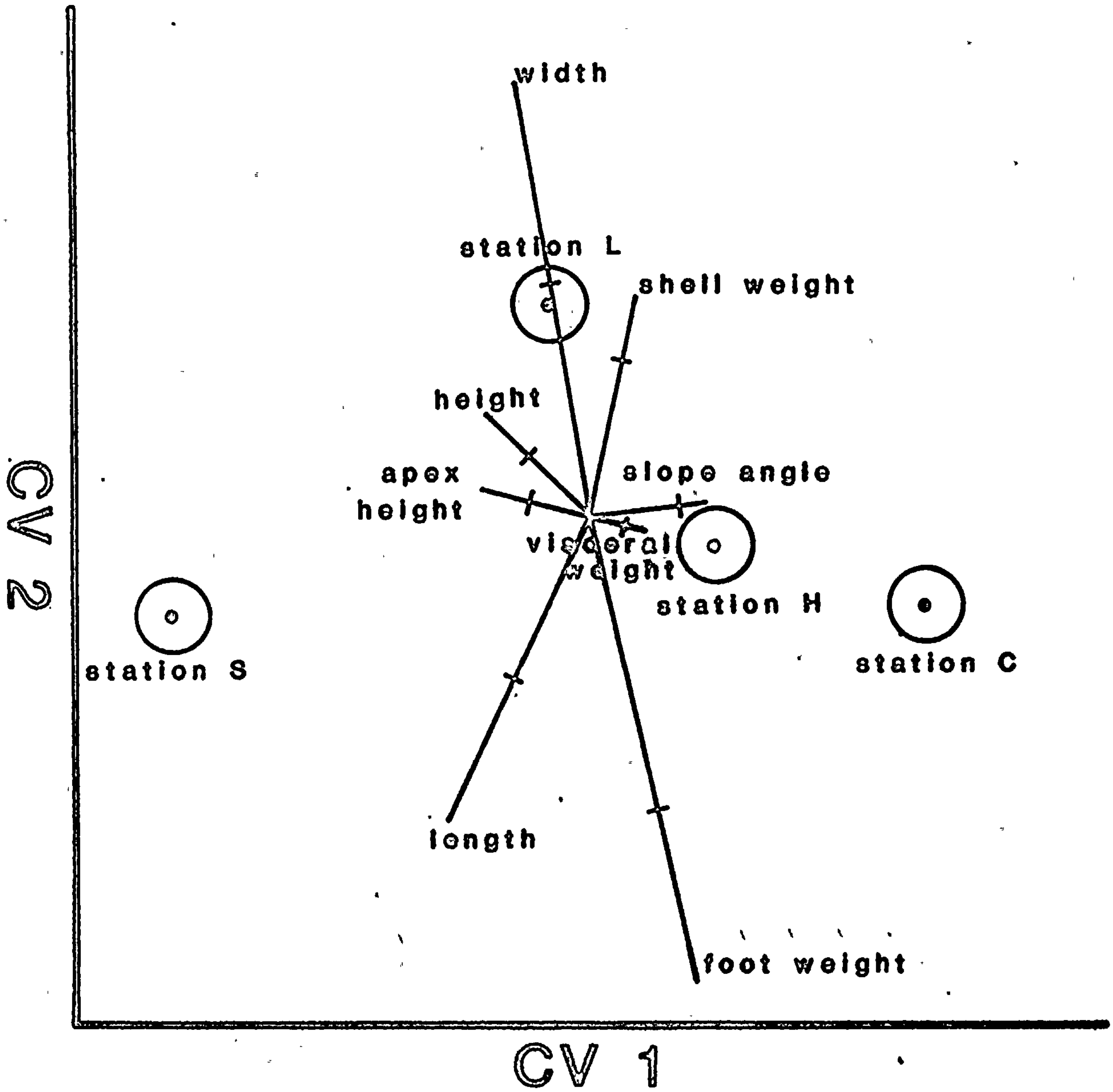
Results of CAD are presented in Table 9 and Figure 3. The first two canonical axes describe 80% and 16%, respectively, of the total differences between groups. A variables importance in discriminating between stations is assessed using both absolute and standardized variable vectors (Figure 3), and the normalized canonical vector coefficients (Table 9). The vector coefficients describe a variables contribution in the calculation of the canonical vector, and therefore take into consideration the simultaneous contributions of all other variables. The normalized coefficients are simply bivariate correlations between a vector and that variable, and therefore are not directly affected by other variables (Klecka, 1980).

The first canonical axis separates groups on the basis of differences in shell size and slope angle relative to weight of body components. Normalized vector coefficients indicate that

Table 9. Normalized canonical vector coefficients for two canonical axes.

	CV 1	CV 2
Length	-.508	-.409
Width	-.283	.583
Height	-.376	.131
Apex height	-.389	.036
Slope angle	.411	.021
Shell weight	.155	.298
Foot weight	.372	-.621
Visceral weight	.194	-.018
Percent Variance	79.7	16.5

Figure 3. Relationships of Collisell digitalis stations based on two canonical axes. Circles indicate 95% confidence radii of stations. Absolute and standardized (tick marks) variable vectors are graphed.



all variables have similar values, and therefore contribute equally to discrimination between groups, either by their individual contributions, or by shared contribution between highly correlated variables (Klecka, 1980). The first canonical axis is significantly correlated with the third pooled dispersion principal component axis ($r=0.73$, $p<0.05$) and subsequently describes 78-100% of differences between station S and the other stations. In addition, this axis explains 50-80% of the differences between stations L, H, and C.

The second canonical axis contrasts station L with the other stations. From Figure 3 and Table 9, we conclude that foot weight, shell length and width, and shell weight are important variables on this axis. Limpets at station L are unique in their relatively small foot, and small, narrow, and heavy shell.

DISCUSSION

Multivariate analysis reveals considerable morphological variation in Collisella digitalis between stations in the vicinity of Diablo Cove. Undoubtably, this is a result of the high intertidal habitat, and variable morphological response of limpets (Test, 1945; Vermeij, 1972,1973). In order to measure

the effects of power plant thermal discharge on limpet morphology, preoperational patterns of morphological variation in the vicinity of the discharge must be examined. By determining which environmental factors influence shell morphology, predictions on the effects of the thermal discharge can be made in relation to natural variation.

Overall, the analyses suggest a unique pattern of morphological variation at station S. Results of MPCA indicate both shared, and unique patterns of morphological variation are present at each site. Isometric variation in size at stations H and S indicates that both large and small individuals at thes stations have similar shell forms. In contrast to these two stations, the larger limpets at station C are relatively lower in shell height, and steeper in shell angle than the smaller individuals, while at station L, the limpets become steeper and thicker with an increase in size. It is apparent that fundamentally different patterns of growth and selection pressures exist between stations.

Another noteworthy pattern of variation present at all stations except station S, involves size independent variation, which can most likely be related to variability in response to environmental stimuli (Blackith, 1965). This pattern of variation primarily contrasts a sloping shell (apex less

eccentric, and more central) with a steep shell (apex projecting anteriorly). At all stations except S, sloping shells are associated with a larger foot weight, visceral weight, and thicker shell. In contrast, steeper shells have relatively smaller body components (Table 7, second principal component).

At station S a different morphological response is evident. Limpets with smaller sloping shells have smaller body components than the larger limpets with steeper shells. A third component of variation at station S (Table 6, third principal component) contrasts slope angle, shell weight, and shell height, and is correlated with variation discriminating station S from the other stations. Station S is unique not only in overall size and variability (Table 6).

Test (1945) discusses several factors that are felt to be important determinants of limpet shell morphology: wave shock, dessication, density of individuals, and availability of food. All of these factors differ between stations in this study. Response to these variables is known to occur either by changes in shell morphology (Test, 1945), or through differential mortality of individuals (Hartwick, 1981; Test, 1945; Vermeij, 1972). For example, an elevated shell form, by producing a smaller aperture, represents an adaptation to dessication, while increasing drag and making the shell more prone to dislodgement

by waves (Branch and Marsh, 1978; Warburton, 1976). Similarly, a low steep shell, oriented into oncoming waves, represents an adaptation to wave shock, but at the cost of shell volume. The range of morphological variation present at a locality is a compromise between physical factors (Test, 1945; Vermeij, 1972, 1973), predators (Hartwick, 1981), and food availability.

The stations where collections were made differ with respect to degree of exposure to wave shock. Station C, located 1 km north of Diablo Cove, in Field's Cove, is subject to considerably more wave shock than stations within Diablo Cove (winter 1981-1982, personal obsevations). Within Diablo Cove, station H, in north Diablo Cove receives considerably more wave shock than station L in south Diablo Cove. Station S is the most protected site, not only due to its position within Diablo Cove, but also by the presence of numerous rock outcrops located seaward of the limpets' habitat.

Other environmental factors also contribute to differences between stations. Station S, located adjacent to Diablo Creek, is subject to periodic freshwater exposure. In addition, limpets at station S occupy a smooth, west facing rock surface covered with a green algal film. The other stations are subject to little freshwater, are located on irregular rock surfaces with no algal mat, and face either east or north, out of direct solar

exposure. Given these differences it is apparent why each station displays unique morphological variation.

In CAD, the first canonical axis shows a direct correspondence between mean CAD scores and rank of exposure to wave shock (C > H > L > S, Figure 3). Limpets respond to this environmental gradient by having larger, more sloping, thinner shells, and smaller body components in wave protected areas (Table 9; first canonical axis). This morphological response is additionally correlated with a significant increase in density of individuals in exposed areas (Table 1). Thus, alternatively, variation of limpets on the first CAD axis may be a response to density, which is in turn a function (perhaps indirect) of wave shock. additionally, substrate, food availability, fresh water, and solar exposure may be correlated with this response. Based on the results of this study a distinction cannot be made between these alternative hypotheses, although one could be made experimentally.

Thermal tolerance experiments on <u>Collisella digitalis</u> indicate no mortality of individuals at temperatures up to 27 C (PG and E, 1982). Based on temperature data generated by tests of a physical, hydraulic model of Diablo Cove, PG and E (1982) predict maximum temperatures of 24-25 C in Diablo Cove during commercial operation of DCPP. Therefore, no mortality of <u>C</u>.

digitalis should occur at any stations during normal operation of the power plant. Contour maps of temperature distributions in Diablo Cove (PG and E, 1982, Figure 4-1) predict the following levels of impact to C. digitalis stations: S > H > L > C.

Based on our results and prior work done by Test (1945) and Vermeij (1973) we predict that limpets recruited into and living under an elevated temperature regime in Diablo Cove should become smaller and thicker, with steeper and higher shells. In addition, density of individuals could likely increase as a result of increased algal productivity. Therefore, we anticipate that morphological relationships of stations as portrayed in this study should change by: 1) a change in shell form for station S, where limpets at station S would more closely resemble those at station C, and/or, 2) the establishment of a new pattern of morphological variation in response to an elevated temperature regime.

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CHAPTER 10

W. J. NORTH MARINE ECOLOGICAL TRANSECTS: 1982

By

Dr. W. J. North, F. A. Chapman, and E. K. Anderson

Table of Contents

CHAPTER 10

W. J. NORTH MARINE ECOLOGICAL STUDIES: 1982

10.1 INTRODUCTION:

As in previous years, our studies have consisted of periodic surveys along fixed transects. Our studies now represent examinations of precisely located areas across a span of thirteen years. Four intertidal and one subtidal samplings were conducted for the year of 1982. These samplings are summarized in the included tables (at the end of the text section). Details of sampling methods are presented in Section 10.3 and in North and Anderson, 1973: Anticipated Biological Effects from Heated Effluents at Diablo Cove (PGandE).

The primary goal of the surveys is to record the various species that are present and their approximate locations or ranges within the transect. We anticipate that stenothermal (cold-loving) species will be influenced most strongly by any heated effluent. If the influence causes them to disappear, they will be replaced by eurythermal (warm-tolerant) species. We believe that this type of change will be detected easily and reliably by our survey methods.

We have frequently observed short term localized changes along our intertidal transects, caused by phenomena such as severe storms, sedimentation, boulder movements, etc. Over the long term, however, we have found our study areas to be quite stable in terms of the

dominant fauna and flora occurring at the sites, as well as distributions of the dominants along the transects. Although small scale catastrophic changes do occur in the intertidal, shifts from the normal condition are temporary and the usual biotic coverage returns after a period of recovery. Any permanent changes after effluent discharge commences should thus be easily detected in the intertidal, particularly if such changes involve substantial reductions in abundances of stenothermal species.

Contrasting strongly with the long term stability displayed by the intertidal areas, a very significant change occurred in subtidal communities of the entire region due to the reappearance of sea otters about 8 to 9 years ago. Otters eliminated the dense and widespread populations of urchins that were constantly observed throughout the region by us from 1966 to 1974. This removal of urchins allowed proliferation of seaweeds and associated organisms so that relatively barren rocky surfaces became covered with foliage. These changes involved alterations primarily in species abundances rather than compositions. The large canopy-forming brown alga, bull kelp (Nereocystis leutkeana), became a temporary dominant in Diablo Cove. It was gradually crowded out by two palm kelps (Laminaria dentigera and Pterygophora californica). Bull kelp presently exists as a relatively minor component of the flora within the cove although substantial stands occur nearby but outside the cove. Dominance by palm kelps has now lasted for a half dozen years or so. It appears that this shrub-based community will be the prevailing association in Diablo Cove unless some major catastrophe rips out existing vegetation and a subclimax community of bull kelp forms temporarily.

Our level of effort at Diablo Canyon has remained approximately constant since 1977 when we changed our intertidal sampling at three stations from once a year to three times a year. For 1982 three additional efforts were conducted: (1) a new intertidal station was added; (2) a subtidal palm kelp population estimate study was begun; and (3) an intertidal shorewalk along the perimeter of Diablo Cove was done.

10.1.1 New station

A new intertidal station (CDIX) was located, marked, and sampled for

the first time during December 1982. CDIX is situated in Diablo Cove, approximately 70 meters NNW from the mouth of Diablo Creek. The transect line is about 41 meters long.

Our other two transect lines within Diablo Cove, SDIX and NDIX, were established prior to 1970 when existing plume models predicted that elevated water temperatures might occupy the entire surface of the cove. The sites of NDIX and SDIX were presumed as lying near the boundaries of the areas to be covered by diluted effluent. These two transects were thus expected to define the approximate limits of any ecological changes. More recent plume models predict a reduced coverage by warm water north of the discharge line. It now appears that NDIX should be well beyond the area where ecological changes might occur. Data from NDIX will thus probably be more representative of a non-impacted ('control') area rather than the assumed transitional area. Furthermore, it now appears that SDIX will become an impacted, rather than a transitional site. While these projected alterations do not necessitate moving our sampling locations, we still wish to have some data available from a transect in a transitional zone. CDIX's location was chosen to be as close to the revised model's predicted transitional zone as possible while also having a biota similar to NDIX and SDIX. The predicted northerly transitional zone is now somewhere in the area between the mouth of Diablo Creek and about 50 meters north of the discharge line. This area was not selected for the new station since the biota in most of this area is sparse, with bare cobble, bare rock, and bare boulders predominant.

10.1.2 Subtidal kelp study

Because of the persistence of the palm kelps (Laminaria dentigera and Pterygophora californica) over the past several years, and because both kelps are considered as stenothermal varieties, we initiated a new study in which the abundances of these two species along the three subtidal transects were estimated in December of 1982. The locations for this study were chosen based on anticipated effluent distribution for the several stations.

DCSX: The shallow end of DCSX lies at about 3 meter depth, directly offshore from the mouth of the discharge structure. The plume will probably lift from the bottom somewhere along the first few meters of

DCSX and communities here may receive significant exposure to warm water, especially during low tides. We thus presumed that this portion of DCSX was a critical location and selected it for assessment of the palm kelp abundances. The outer end of DCSX (ca. 9 meter deep) should lie well below the plume. This was chosen as a sampling site that would demonstrate lack of effect and prove that the plume was behaving as predicted.

<u>DRSX</u>: The transect origin at DRSX lies in the intertidal zone but is difficult to sample because it is vertical and swept by vigorous wave surge. We expect some exposure to diluted effluent here, probably at depths no greater than 3 meters. We selected the shallowest flat bottom here (6 to 7 meters) for measuring palm kelp abundances, as well as a deep area (10 to 11 meters). We expect these will demonstrate possibly mild effects in shallow water and no effect in deep water.

<u>LRSX</u>: The shallowest flat bottom at LRSX (3 meters) was too exposed to surge to permit sampling except on extremely calm days. We therefore sampled the nearest deeper flat rocky bottom (11 to 12 meters) at this station.

10.1.3 Diablo Cove shorewalk

The shorewalk conducted in December 1982 is an activity that was undertaken in the early phases of our studies in Diablo Cove but allowed to lapse in favor of intense sampling along permanent transect lines.

The shorewalk study evaluates the biota and substrates in the general Diablo Cove area. This evaluation could be helpful in determining catastrophic changes (such as the affects of heavy wave action) or smaller changes (seasonal substrate movement or possibly due to heated effluent), that may not substantially affect our permanent transects.

This study consists of evaluating the dominant organisms along the entire Diablo Cove shoreline.

10.2 ACTIVITIES

New sampling methods were added to both our intertidal and subtidal effort, and a new transect was added to our intertidal stations.

10.2.1 Intertidal sampling activities

In addition to our permanent intertidal transect studies, we located and marked a new intertidal station (CDIX) in the mid portion of Diablo Cove, and conducted a shorewalk along the entire shore of Diablo Cove.

Intertidal stations, SDIX, NDIX, and LCIX were sampled four times in 1982 (January, April, September, and December). Our new intertidal transect CDIX, was sampled once, in late December of 1982 and early Janurary 1983.

Transects were sampled throughout their length from quadrat 1 (the highest point on the transect) to the water's level at the time of sampling. Variable numbers of quadrats were sampled for each station at each time because tidal heights on the sampling dates were different. Table 1 lists the activities for each sampling date and Table 5 lists the status of the photographs taken for the December 1982 sampling period.

A shorewalk along the entire perimeter of Diablo Cove was conducted on 30 December 1982. The last time this activity was conducted was on 2 December 1967.

10.2.2 Subtidal sampling activities

In addition to our normal sampling at subtidal transects, an estimation of abundances of two dominant stenothermal kelp species along the transects was conducted.

Subtidal stations were visited once during 1982 (29 to 31 December).

No detailed work was accomplished within the top 3 meters of the DRSX transect and the top 2 meters of the LRSX transect, because of strong

wave surge. We obtained "grab samples" from the upper part of DRSX and sighted a few species as we swept back and forth in the wave surge. Water motion was even stronger at LRSX. We could not scrutinize substrates shallower than 4 to 5 meters but we could catch glimpses of the larger organisms. Since the LRSX transect starts at a depth of 3 meters, close inspection and collections were omitted only from the uppermost 1 to 2 meters of the line. Underwater visibility was fair at all stations allowing moderately good observation of fishlife. The dense stands of seaweeds currently existing at all our stations, however, provide abundant cover for fishes, interfering with detection and identification of shy individuals.

Table 2 summarizes dates of sampling, distances examined along each line, and personnel involved. Table 10 summarizes the field conditions during the dives.

10.2.3 Data entry activities:

NO activity has occurred for our data entry task.

For current entry status for all data from permanent transects see Table 6.

10.2.3.1 New programming and planning

NO programming has been done for the entry programs for 'subtidal' data or for 'laboratory identification' data.

10.3 SUMMARY OF SAMPLING METHODS

With the exception of our shorewalk study, detailed accounts of our survey methods have been given in previous annual reports. In brief, the intertidal and subtidal transects are approximately straight lines ranging in length from about 20 meters to 100 meters. Station CDIX, the new intertidal station, is an exception to our straight line approach. This station has a dog-leg of about 40 degrees at meter 27. The exact distance and number of quadrats along any transect that can

be sampled on a given date varies with circumstances at the time (tidal height, sea conditions, underwater visibility, etc.).

A transect line that is marked at 1 meter intervals is normally strung from the transect origin to the farthest distance possible along the transect. Permanently emplaced markers or chains assist personnel in the positioning of the lines. For subtidal stations some deviations from this description occur, as noted under the subtidal transect methods section.

Sampling of the biota along transect lines is then conducted as outlined under intertidal or subtidal transect methods.

10.3.1 Intertidal methods

Our sampling methods for the intertidal area now includes those for our permanent intertidal transects as well as shorewalk observations.

10.3.1.1 Intertidal transect methods

The highest and lowest points accessible on our permanent intertidal transects are not uniform, so that the range of tidal heights sampled within a the tide series varies. Three of the intertidal transects (SDIX, CDIX, and NDIX) are situated within the boundaries of Diablo Cove and extend the full width of the intertidal from approximately the + 2 meter level (MLLW) to the water's edge at the time of sampling. The other transect (LCIX, on the open coast) extends from approximately the + 6 meter level (MLLW) to about the + 0.5 meter level (MLLW) with a dip in the center of the transect that is at about the - 0.5 meter level (MLLW). The outer end of LCIX stops at an almost vertical rock face that drops to the water's edge, thence to an unknown depth.

After installing the transect line and fastening it to permanent tie down points, a one meter square quadrat is laid successively along the transect line so that corners of the square quadrat are beneath the marks for each meter of the line. We tally all macroscopic plant and animal taxa accessible to 'feel' or to any angle of view within the boundaries of the quadrat.

Percent cover of each plant species is estimated (insofar as possible, estimates are made by the same observer - WJN). Numbers of each animal species are counted or estimated for very numerous taxa, or noted as present for other taxa.

To avoid disturbance, rocks are not moved except that small boulders or cobbles which can be easily overturned are occasionally lifted, organisms tallied, and the rock replaced. Taxonomic information from this under rock habitat is noted as 'U' for under rock.

Each intertidal quadrat is photographed during the winter survey.

10.3.1.2 Intertidal shorewalk methods

This activity consisted of examining the entire intertidal shoreline of Diablo Cove, from North Diablo Cove Point to the base of South Diablo Cove Point, that was readily accessible by foot, without wading or swimming. Observations were directed primarily toward evaluating coverage by dominant organisms, particularly the two stenothermal algae Gastroclonium and Iridaea.

The rocky shoreline was subdivided according to the principal type of substrate present (large boulders, flat pavement rock, ridges, etc.). Notations were recorded as to location, substrate type, and dominant organisms at the various tidal levels.

Three people (W. J. North, F. A. Chapman, and E. K. Anderson) conducted the study which occupied about 1.5 hours during daylight hours (1525 to 1654) on 30 December 1982. The predicted low tide was -0.5 meters (MLLW) at 1626.

10.3.2 Subtidal methods

Two of the subtidal transects extend from the surface to 10 meter depths (DRSX and LRSX). The third transect, DCSX, extends from about 3 meters to 10 meters depth, underlying the path of the future discharge plume and situated approximately along the plume's mid axis.

10.3.2.1 Subtidal transect methods

At subtidal transects at shallow locations, transect lines cannot be laid if wave surge is great. For these circumstances, permanent topographic features such as large boulders, pinnacles and ravines are used as location aids for the transect.

Large plant and animal taxa lying along the transect are tallied out to the limits of underwater visibility on either side of the transect. Small taxa are tallied if they occur within a meter of either side of the transect. Dominant plants are noted, as well as general distributions of the populations along the line.

10.3.2.2 Palm kelp methods

The special study to estimate abundances of the two dominant palm kelps (Laminaria and Pterygophora) along all three of our subtidal transects was started in 1982.

The palm kelp forests were quite dense in the sampling areas so that use of a conventional rigid square quadrat would be difficult. Instead we employed a technique designed for efficiently delineating an area in situations where kelp canopies and stipes interfere with positioning a conventional quadrat. This alternative method utilized a small weight attached to the end of a line marked at one meter. The weight was positioned on the bottom by blind casting. A full circle was swung around the weight with the line, delineating a circular quadrat 2 meters in diameter (ca. 3.1 square meters). All kelp plants lying within 1 meter of the weight were identified and counted. Tallies from a quadrat were recorded and the weight cast again, until 9 to 11 replicates had been taken.

Areas at each station were selected for quadrat cast sampling based on the following criteria:

1. Area must be observable during moderate wave surge. (This excluded most areas shallower than 3 meter depth.)

2. Substrate primarily rock or boulder. For mixed substrate areas (sediment and rock) sample rocky portions only.

3. At a transect that might be exposed to warm water, choose a minimum impact area and a maximum impact area.

General areas at each station finally selected were:

Station DCSX: An area at the shallow inner end at about 3 meters depth, directly offshore from the mouth of the discharge structure Communities here may receive significant exposure to warm water.

An area at the deeper outer end at about 9 meters depth. Communities here should not receive exposure to warm water.

Station DRSX: An area at a depth of 6 to 7 meters. Communities here may receive a mild exposure to warm water.

An area at a depth of 10 to 11 meters. Communities here should not receive exposure to warm water.

Station LRSX: The station was too exposed to allow the selection of an area above 10 meters depth.

An area at a depth of 11 to 12 meters was selected where the bottom consisted of boulders and ridges projecting up out of the surrounding sandy bottom. Casts were restricted to rocky portions of the bottom. No communities at the entire station should receive exposure to warm water.

10.4 SUMMARY OF RESULTS

Sampling dates, stations, transect lengths, and personnel are included at the end of the text in Tables 1 to 5.

Transect sampling species lists and total number of species per major taxonomic category are included at the end of the text in Tables 7a to 7c for intertidal and 8a to 8c for subtidal data.

Palm kelp quadrat count data are included as Table 11.

Transcribed shorewalk observations are included as Appendix 1.

Transcribed subtidal general field notes are included as Appendix 2.

10.4.1 Intertidal results

The intertidal information that we usually report has been supplemented this year by the results of our shorewalk.

10.4.1.1 Intertidal transect results

As in previous years we found diverse and healthy assemblages of plants and animals at all our intertidal stations during 1982. Variations in total number of species observed (Tables 7c) from one survey to the next were considered to be normal fluctuations resulting primarily from seasonal changes or because of differences in numbers of quadrats examined (a function of low tide level on the survey date). We detected no obvious differences in distributional patterns of the major species characteristic of each station. We have not yet undertaken a detailed comparison between the 1982 data and information from previous years, but preliminary review suggests that the dominant organisms were present in their usual abundances as compared to earlier surveys at each station.

Dominant stenothermal plants at our transects within Diablo Cove continued to consist of Gastroclonium coulteri, Gigartina agardhii, Gigartina papillata, Iridaea flaccida, Iridaea heterocarpa, Iridaea cordata, Laurencia spectabilis, and Prionitis lanceolata.

A stenothermal alga, Laminaria dentigera, does not occur as a dominant at our transects but forms an extensive belt just subtidally within most of the central part of the cove.

Dominant stenothermal animals included only one species, the low-intertidal gastropod Tegula brunnea. Thus the flora seem to offer the greatest potential for detecting effects of heated effuluent, even though floral species are usually outnumbered by the fauna, especially within Diablo Cove. There are, of course, numerous other non-dominant stenothermic species occurring along our transects. We have yet to analyze their persistence at the stations, but expect that many will prove useful as indicator organisms.

10.4.1.2 Shorewalk results

The shoreline of Diablo Cove consists of eight major topographical subdivisions whose substrates differ significantly compared to each other. Transistions from one subdivision to the next are usually rather abrupt so that well-defined borders exist. Character of the biota is often influenced by the type of substrate. Hence it is necessary to recognize and classify these geographical entities in any description of the biological status quo. We will henceforth call these entities the intertidal subhabitats. The eight subhabitats were defined as follows (proceeding clockwise from the northwest end of the cove as in Figure 1):

A. Boulders, intermediate sizes

B. Pavement bedrock, flat with sand in basins

C. Boulders, large sizes

D. Boulders, small sizes with cobble (mouth of Diablo Creek)

E. Ridged bedrock, high relief with boulder-cobble mix between

F. Pavement bedrock, flat with small ridges, narrow backshore of boulder-cobble mix

G. Pavement bedrock, flat with small ridges, some sand in basins, broad backshore of boulder-cobble mix

H. Boulder-pavement bedrock, boulder-cobble-sand narrow backshore of sand-cobble mix

These subhabitats were present at the time of our first beach walk in 1966 at approximately the same locations and with similar stucture.

Our primary algal indicator species (Iridaea and Gastroclonium in the intertidal and Laminaria at the lower edge of the intertidal) occurred throughout most of the cove. Their coverages varied from one subhabitat to the next. Gastroclonium was probably distributed most uniformly, followed by Iridaea. A large dense bed of Laminaria,

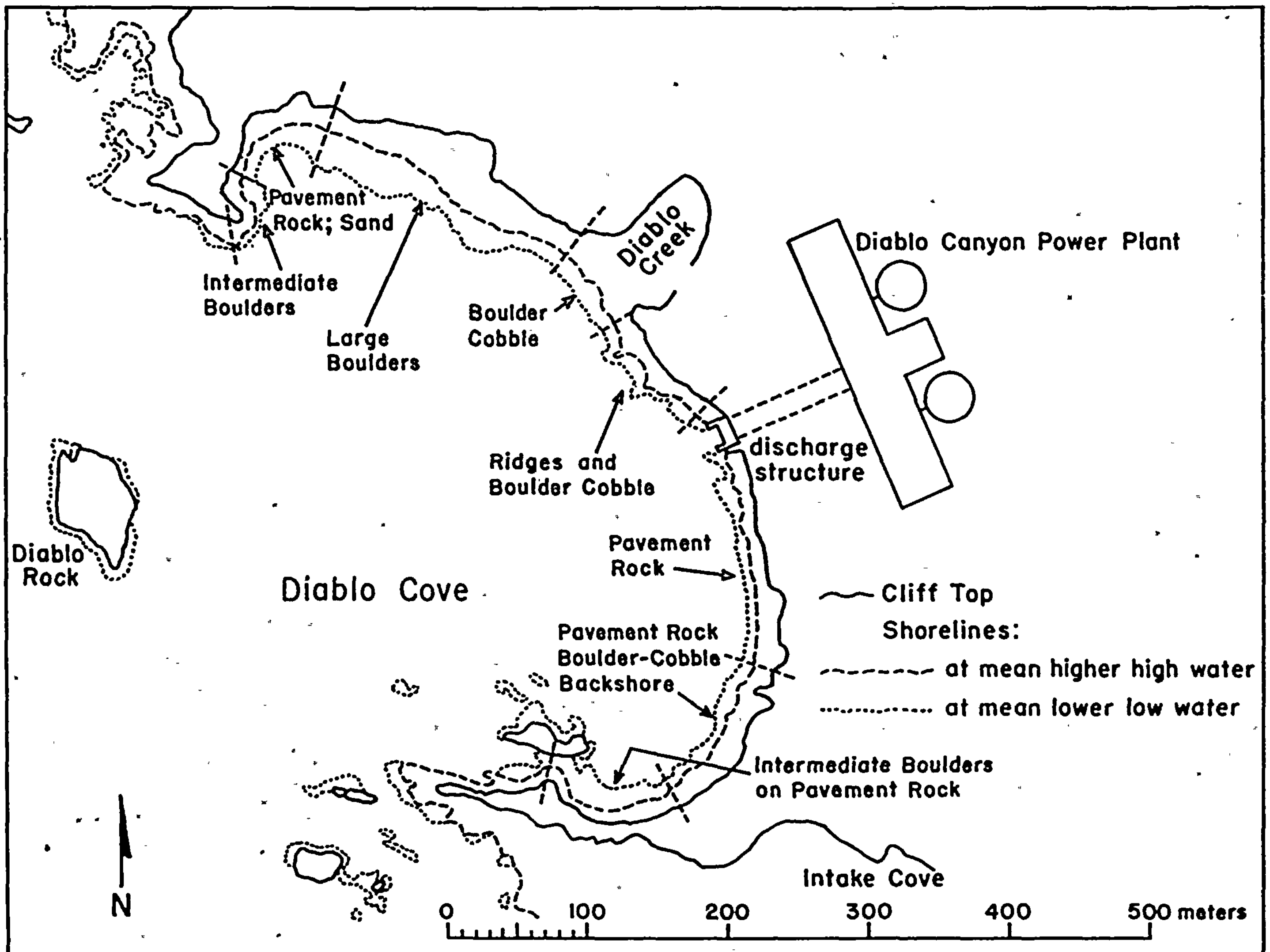


Fig. 10-1 Chart of Diablo Cove showing locations of geological subhabitats.

ca. 150 meters long, was centered just north of the discharge structure. Concentrations of this kelp thinned in both directions away from the central bed.

Haliotis cracherodii and H. rufescens formerly occurred conspicuously in the ridge-boulder environment just south of Diablo Creek (subhabitat E in our list). We did not observe any of these animals exposed in this location on 30 December 1982. Possibly the population was depleted by sea otter predation. Considerable damage from storm-scour was noted in subhabitat G, in the vicinity of a huge pinnacle that dominates the southeastern shoreline in the cove. Pavement rock here was almost barren of algal cover. The substrate had supported a substantial and moderately diverse flora a few months earlier.

When the biota were considered as well as topography, the number of distinct divisions along the shoreline rose to 14 (Figure 2). To distinguish them from the eight major geographical subhabitats, we will refer to them as biotic habitats. We referenced the locations of these biotic habitats to existing survey stations or to major physical features within the cove. DC TEMP program stations (DCT #) were considered as existing survey stations.

Boundaries of the biotic habitats were:

1. NDIX: North Diablo Cove Point to mid DCT 7;
2. DCT 7: mid DCT 7 to just past eastern end of DCT 7;
3. DCT 8: eastern end of DCT 7 to mid DCT 8;
4. DCT 9: mid DCT 8 to mid DCT 9;
5. DER fish: mid DCT 9 to 1st rocky point NNW of CDIX;
6. CDIX: point NNW of CDIX to ca. 30 m SSW of CDIX;
7. CDIX-Creek: 30 m SSW of CDIX to NNW of Diablo Creek;
8. Creek: mouth of Diablo Creek, ca. 40 m wide;

9. NNW Discharge: SSE of Diablo Creek to just NNW of discharge;

10. Discharge: structure; NNW of discharge to SSE of discharge

11. NNW DCT 10: SSE of discharge to DCT 10;

12. South DCT 10: DCT 10 to pinnacle just NNE of DCT 11;

13. DCT 11: Pinnacle to DCT 12;

14. SDIX: DCT 12 to surge channel west of SDIX.

Detailed notes for each biotic habitat are included as part of Appendix 1. In this appendix, substrates and upper shore substrate types are listed by order of dominance, but the major plant taxa are NOT listed in order of abundance.

10.4.2 Subtidal results

The survey in 1982 occurred under fairly favorable sea and swell conditions. Our detailed impressions of the status quo at our subtidal stations in 1982 are recorded in the subtidal field notes (see Appendix 2). Dates, times, and physical conditions during the subtidal studies are listed in Table 10.

10.4.2.1 Subtidal transect results

The two Macrocystis patches within Diablo Cove, first noted during our October 1981 survey, have persisted in the lee of Diablo Rock. The large populations of Macrocystis formerly situated between Lion Rock, Pup Rock, and the mainland, were diminished at the time for our 1982 visit. We noted only scattered and isolated plants here intermixed with occasional Nereocystis plants.

We continued to find a vigorous and diverse biota at all stations. As in the previous six years, algal biomass everywhere was massive. We spent 3.5 hours total time underwater at the various stations (Table 10) and never observed a single urchin while diving (one tiny animal

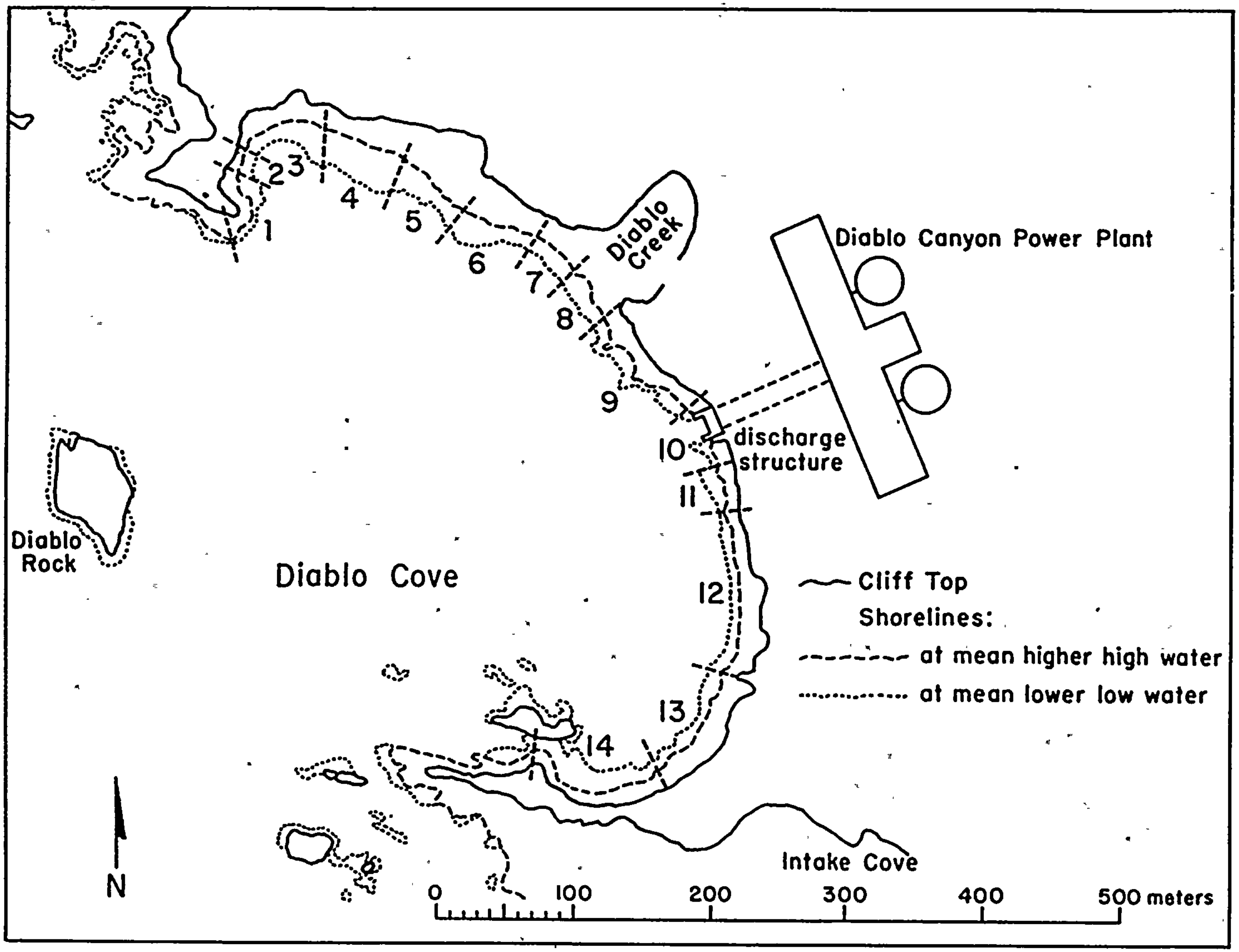


Fig. 10-2 Chart of Diablo Cove showing locations of biotic habitats, numbered as described in the text.

was recovered in the laboratory from an algal collection from station LRSX). Otters were observed in the waters near Pup Rock during our intertidal survey at LCIX in December. Thus it appears that otters continue to control populations of urchins very strongly throughout the region. Absence of adult urchins explains the lush coverage by seaweeds we observed.

Species observed at the subtidal stations on the various survey dates are listed as Tables 8a and 8b. Summation of species by phylum or class is presented for the three stations in Table 8c. The data in the tables substantiate our belief that all subtidal areas examined continued to support diverse flora and fauna whose compositions were characteristic for the region.

10.4.2.2 Palm kelp study results

The individual quadrat counts for the abundances of the two palm kelps (Laminaria dentigera and Pterygophora californica) from the three subtidal stations are given in Table 11. Two other kelps, Cystoseira and Nereocystis occured at the deep portion of station DRSX and these data are also included in the table.

Mean abundances of Laminaria ranged from 0.3 per sq. meter at LRSX to 10.2 per sq. meter in deep water at DRSX (Table 11). The range for Pterygophora was 0.4 per sq. meter in shallow water at DCSX and DRSX to 6.2 per sq. meter for the deep sampling area at DRSX.

In general, Laminaria was more abundant than Pterygophora at shallow depths (3 to 7 meters) whereas the reverse was usually true at depths of 10 meters or more. The deep level at DRSX was an exception (10.2 per sq. meter for Laminaria versus 6.2 per sq. meter for Pterygophora, values which are probably not significantly different from each other). This anomalous finding may have arisen because of recruitment of juvenile plants of both species a few months before our sampling occurred. A third to a half of the populations at DRSX deep were young adults. Nearly all the plants from our other areas were large mature adults.

Numbers of individuals within each quadrat were quite variable. Local topography seemed to influence the distributions profoundly. Firm

projecting rocky surfaces supported denser stands of kelp. Depressions and basins where cobble, gravel, and sand might accumulate, or small moveable boulders seemed not preferred as attachment sites. The variability in numbers of individuals per quadrat probably arose primarily as a reflection of a heterogenous bottom. In consequence, the data in Table 11 are probably not representative of normal distributions. Non-parametric statistics should be utilized for comparative analyses of results. We plan to compare these data with results from similar future surveys to detect any change in abundances of these stenothermal species after the power plant becomes operational.

10.5 DATA ENTRY SYSTEM

All data entry and verification of the data are done under program control on a micro-computer. When data are finally verified, transfer will occur to main computer storage at PG & E's facility. Implementation of this data entry system is not complete.

Table 1: W. J. North intertidal station sampling summary for the Diablo Canyon Site, San Luis Obispo Co., for 1982.

Station	Dates	(Times)	Quadrats	Personnel
SDIX	7 Jan	(1508-1834)	1 to 51	WJN, FAC, eka
	25 Apr	(0409-0912)	1 to 46	FAC, eka
	15 Sep	(0350-0610)	1 to 43	WJN, FAC, eka
	29 Dec	(1616-1927)	1 to 45	WJN, FAC, eka
NDIX	7 Jan	(1253-1440)	21 to 33	WJN, FAC, eka
	8 Jan	(1139-1306)	1 to 20	WJN, FAC, eka
	26 Apr	(0509-0729)	19 to 32	FAC, eka
	26 Apr	(1516-1615)	1 to 10	FAC, eka
	28 Apr	(0721-0829)	11 to 18	FAC, eka
	15 Sep	(0156-0222)	14 to 25	WJN, FAC, eka
	15 Sep	(1436-1533)	1 to 13	WJN, FAC, eka
	29 Dec	(1436-1556)	19 to 29	WJN, FAC, eka
	30 Dec	(1442-1815)	1 to 18	WJN, FAC, eka
LCIX	8 Jan	(1431-1725)	1 to 24	WJN, FAC, eka
	27 Apr	(0547-0845)	1 to 20	FAC, eka
	16 Sep	(0326-0545)	1 to 16	WJN, FAC, MH, eka
	31 Dec	(1442-1740)	1 to 21	WJN, FAC, SK, eka
CDIX	28 Dec	(1424-1630)	28 to 41	FAC, eka
	1 Jan	(1445-1830)	1 to 27	FAC, eka (1983)

All times Pacific Standard

Table 2: W. J. North subtidal station sampling summary for the Diablo Canyon Site, San Luis Obispo Co., for 1982.

Station	Date	(Times)	Meter Range	Personnel
DCSX	29 Dec	(0930-1042)	0 to 100	WJN, RRM
DRSX	29 Dec	(1200-1245)	3 to 7	WJN, RRM
	30 Dec	(0840-0945)	7 to 20	WJN, RRM
LRSX	31 Dec	(0840-0935)	1 to 20 quad casts	WJN, RRM
DCSX, DRSX	31 Dec	(0950-1100)	quad casts	WJN, RRM

All times Pacific Standard

Table 3: Surveys of permanent intertidal and subtidal transects in and near Diablo Cove, San Luis Obispo County by W. J. North. 1972 to 1982.

Date — Total / Outermost quadrats sampled for transects

Month	year	Intertidal SDIX	transects NDIX	LCIX	CDIX	Subtidal transects DRSX	DCSX	LRSX	Notes
Jan	69	6/46*	7/31*	2/21*					* #1
Jun	69			25/25		-/ 9	-/100	-/ 8	
Feb	70	11/35	11/24	25/25					
Nov	70	47/47	32/32*	23/23					* #1
Apr	72					-/12	-/100	-/10	
Dec	72	6/46*	7/31*	2/21*					* #1
Dec	74					-/36	-/100	-/36	
Jan	75	45/45	26/26*	20/20					* #1
Dec	75					-/28	-/100	-/16	
Apr	76	51/51	32/32	16/16					
Jun	76					-/30	-/100	-/30	
Feb	77	40/40	27/27	19/19					
Oct	77	43/43	15/15	16/16					#2
Nov	77	3/46	17/32	4/21		-/24	-/100	-/30	
Mar	78	41/41*	25/25	20/20					* #1
May	78	55/55	33/33	22/22					
Oct	78	39/39	27/27	13/13					
Dec	78	43/43	32/32	22/22					
Jan	79					-/15	-/100	-/20	
May	79	44/44	27/27	20/20					
Sep	79	41/41	23/23	20/20					
Dec	79	45/45	28/28	13/13		-/10	-/100	-/20	
May	80	43/43	23/23	13/13					
Aug	80	46/46	27/27	20/20					
Dec	80	45/45	28/28	17/17					
Jan	81					-/38	-/100	-/38	
May	81	51/51	32/32	20/20					
Oct	81	44/44	25/25	21/21		-/38	-/100	-/38	
		surveys covered in this report							
Jan	82	51/51	33/33	24/24					
Apr	82	46/46	32/32	20/20					
Sep	82	45/45	25/25	16/16					
Dec	82	45/45	29/29	21/21	41/41	-/ 20	-/100	-/ 20	

Note #1: items that were incorrect in our 1979 annual report
Note #2: October 1977 surveys were continued in November of 1977

Table 4: Personnel involved in our sampling effort at Diablo Cove. Names, initials as used in this report, and affiliation are listed.

Initials	Name	Affiliation
KW	Katie Wright	Cal Poly
MH	Mike Haberland	Cal Poly
JD	Joseph Devinney	Caltech
JH	Joyce Hsiao	Caltech
PK	Peter Kirkwood	Caltech
WJN	Wheeler J. North	Caltech
EKA	Einar K. Anderson	Independent
FAC	Faylla A. Chapman	Independent
JK	James Kelley	P. G. & E
BBL	Brita B. Larsson	P. G. & E.
DB	David Behrens	P. G. & E.
DP	Donald Price	P. G. & E.
JRA	James R. Adams	P. G. & E.
JWW	John W. Warrick	P. G. & E.
SK	Sally Kren	P. G. & E.
TH	Ted Holenbeck	P. G. & E.
BT	Brian Tissot	P. G. & E. (cal poly)
DO	Denise Overman	P. G. & E. (cal poly)
LB	Linda Britsky	P. G. & E. (cal poly)
RB	Rosemary Bowker	P. G. & E. (cal poly)
CW	Charles Wert	TERA

Table 5. Listing of intertidal transect quadrat photographs taken during 1982 for W. J. North's intertidal transect studies. Photos have not yet been cataloged.

Month and Station		Quadrat Number of Photos	Comments
January	SDIX	taken (1 to 45)	not cataloged
	NDIX	taken (1 to 29)	not cataloged
Feburary	LCIX	taken (1 to 21)	not cataloged
December	SDIX	taken (1 to 43)	not cataloged
	NDIX	taken (1 to 24)	not cataloged
	LCIX	taken (1 to 22)	not cataloged
	CDIX	taken (1 to 41)	not cataloged

Table 6: Status of data entry to computer readable format for W. J. North transect studies at Diablo Cove, San Luis Obispo County through December 1982. 'S' = subtidal, 'I' = intertidal, and 'L' = laboratory identifications

Year	STATUS Entry	Verif-ied	Final	Trans-ferred	Comments
1969	SIL	SIL	SIL	SIL	
1970	IL	IL	IL	IL	no subtidal
1971					no surveys
1972	SIL	SIL	SIL	SIL	
1973					no surveys
1974	SIL	SIL	SIL	SIL	
1975	I	I			verified (in part)
1976	I	I			verified (in part)
1977	I	I			verified (in part)
1978	I	I			verified (in part)
1979	I	I			verified (in part)
1980	I	I			verified (in part)
1981	I				through October 1981
1982					

Transferred indicates the data is stored at PG & E's computer facility.

Table 7a: Species of marine plants observed and/or collected near Diablo Cove during intertidal station sampling for January, April, September, December of 1982. Station location and identification are listed in Table 9. Taxa names followed by an '+' were identified by I. A. Abbott or by F. A. Chapman.

Intertidal Plant Taxa for 1982		STATIONS												
		SDIX				NDIX				LCIX				CDIX
(MONTH)		J	A	S	D	J	A	S	D	J	A	S	D	D
CYANOPHYTA & CHRYSOPHYTA														
Callothrix sp.		x	x	x	x	x	x	x	x	x	x	x	x	x
Unid. diatoms				x			x							
CHLOROPHYTA														
Cladophora sp.		x	x	x	x	x	x	x	x	x	x	x	x	x
Codium setchellii						x	x	x	x		x			x
Spongomorpha sp.		x		x										
Ulva sp.		x	x	x	x	x	x	x	x	x	x	x	x	x
Unicellular green algae (on rocks)		x	x	x	x	x	x	x	x	x	x	x	x	x
PHAEOPHYTA														
Analipus japonicus									x			x	x	x
Colpomenia sp.				x	x									
Cylindrocarpus rugosus											x			x
Cystoseira osmundacea		x												
Desmarestia ligulata											x	x	x	
Egregia menziesii		x	x				x	x	x	x			x	
Fucus distichus		x	x	x	x	x	x	x						
Hesperophycus harveyanus		x	x	x	x	x	x	x	x					
Laminaria dentigera		x			x					x	x		x	x
Pelvetia fastigiata		x	x	x	x	x	x	x	x	x	x	x		x
Ralfsia sp.		x	x	x	x									x
RHODOPHYTA														
Bangia fusco-purperascens		x	x											
Bossiella plumosa						x								
Bossiella sp.		x	x	x	x	x	x	x	x	x	x	x	x	x
Botryoglossum farlowianum		x	x	x	x	x	x	x	x	x	x	x	x	
Calliarthron sp.		x	x	x	x	x		x	x	x	x	x	x	x
Callithamnion acutum	+												x	
Callithamnion pikeanum	+					x	x		x	x	x		x	x
Callithamnion rupicolum	+					x	x		x	x	x	x	x	x
Callophyllis firma	+						x					x	x	
Callophyllis flabellulata	+									x				
Callophyllis violacea						x				x			x	
Callophyllis sp.		x												
Centroceras sp.													x	

Table 7a: Continued. Intertidal Marine Plants for 1982.

Intertidal Plant Taxa (MONTH)		SDIX J	SDIX A	SDIX S	SDIX D	NDIX J	NDIX A	NDIX S	NDIX D	LCIX J	LCIX A	LCIX S	LCIX D	CDIX D
Ceramium sp.							x				x	x		
Corallina officinalis		x			x	x	x	x	x	x		x	x	x
Corallina vancouveriensis		x	x	x	x	x	x	x	x	x	x	x	x	x
Corallina sp. (juv.)		x	x											
Cryptopleura lobulifera												x		x
Cryptopleura violacea		x	x	x	x	x	x	x	x	x	x	x	x	x
Cryptosiphonia woodii		x	x	x	x	x	x							
Cumagloia andersonii						x	x	x						x
Endocladia muricata		x	x	x	x	x	x	x	x	x	x	x	x	x
Erythrophyllum delesserioides							x			x	x		x	
Farlowia mollis		x												
Gastroclonium coulteri		x	x	x	x	x	x	x	x	x	x	x	x	x
Gelidium coulteri		x	x	x	x	x	x	x	x	x	x	x	x	x
Gelidium pusillum		x	x	x	x	x	x	x	x	x	x		x	x
Gelidium robustum										x				x
Gelidium purpurascens	+	x												
Gigartina agardhii		x	x	x	x	x	x	x	x	x	x	x	x	x
Gigartina canaliculata		x	x	x	x	x	x	x	x	x	x	x	x	x
Gigartina corymbifera			x				x				x			x
Gigartina exasperata		x	x		x	x	x	x	x	x	x	x	x	x
Gigartina leptorhynchos		x	x	x	x									x
Gigartina papillata		x	x	x	x	x	x	x	x	x	x	x	x	x
Grateloupia doryphora	+		x			x								
Griffithsia pacifica	+												x	
Gymnogongrus platyphllus	+									x				
Halosaccion glandiforme			x	x				x			x	x	x	
Halymenia schizymenioides		x	x			x	x				x	x		
Herposiphonia verticillata	+									x	x			
Hildenbrandia sp.		x	x	x	x	x	x	x	x	x	x	x	x	x
Hymenena flabelligera										x	x		x	
Hymenena multiloba										x	x	x	x	
Iridaea cordata		x	x	x		x	x	x	x	x	x		x	
Iridaea flaccida		x	x	x	x	x	x	x	x	x	x	x	x	x
Iridaea heterocarpa		x	x	x	x	x	x	x	x	x	x	x	x	x
Iridaea lineare										x				
Laurencia blinksii										x	x		x	
Laurencia spectabilis		x	x	x	x	x	x	x	x	x			x	x
Lithophyllum sp.		x	x	x	x	x	x	x	x	x	x		x	x
Lithothamnium sp.		x	x		x	x	x	x	x	x	x		x	x
Melobesia sp.		x	x	x	x	x	x	x	x					x
Mesophyllum conchatum	+									x			x	
Mesophyllum lamellatum		x	x	x	x	x	x	x	x	x	x	x	x	x
Microcladia borealis				x						x	x	x		

Table 7a: Continued. Intertidal Marine Plants for 1982.

Intertidal Plant Taxa		STATIONS												
		SDIX				NDIX				LCIX				CDIX
(MONTH)		J	A	S	D	J	A	S	D	J	A	S	D	D
Microcladia coulteri		x	x	x	x	x	x	x	x	x		x		x
Neoagardhiella gaudichaudi		x	x	x	x	x	x	x	x	x	x	x		x
Neoptilota densa				x						x				
Petrocelis franciscana		x	x	x	x	x	x	x	x	x	x	x	x	x
Peyssonellia meridionalis		x		x	x	x				x		x	x	x
Peyssonellia sp.		x		x		x	x	x	x					
Pikea californica										x				
Plocamium violaceum										x		x		x
Polyneura latissima														x
Polysiphonia sp.										x	x			
Porphyra sp.		x		x	x	x	x	x	x	x	x	x	x	x
Prionitis lanceolata	+	x	x	x	x	x	x	x	x	x	x	x	x	x
Pseudolithophyllum neofarlowii		x	x	x	x	x	x	x	x	x	x	x	x	x
Pterosiphonia baileyi										x	x		x	
Pterosiphonia dendroidea											x			x
Rhodochorton purpureum												x	x	
Rhodoglossum affine	+	x	x	x	x	x	x	x	x	x	x		x	x
Rhodoglossum californicum	+	x				x			x					
Rhodoglossum roseum	+				x		x				x			x
Rhodomela larix										x	x			
Rhodymenia californica	+	x												
Rhodymenia pacifica	+					x	x			x				
Schizymenia pacifica			x											
Smithora naiadum		x	x	x	x	x	x	x	x					
SPERMATOPHYTA														
Phyllospadix scouleri		x	x	x	x	x	x	x	x	x	x	x	x	x
LICHEN														
Unid. lichens		x	x	x	x									

Table 7b: Species of marine animals observed and/or collected near Diablo Cove during intertidal station sampling for January, April, September, and December of 1982. Station location and identification are listed in Table 9. Animal taxa followed by a 'W' were laboratory identified by W. J. North.

Intertidal Animal Taxa for 1982		STATIONS												
		SDIX				NDIX				LCIX				CDIX
(MONTH)		J	A	S	D	J	A	S	D	J	A	S	D	D
PROTISTA														
Gromia sp.		x												
PORIFERA														
Esperiopsis orignalis	W					x								
Gellius textapatina	W					x								
Halichondra panicea	W									x				
Haliclona permollis			x			x								
Leucilla nuttingi										x			x	
Leuconia heathi	W								x	x				
Leucosolenia eleanor		x									x			
Leucosolenia nautila	W									x				
Lissodencoryx noxiosa	W									x			x	
Microciona sp.													x	
Plocamia sp.		x			x	x			x	x		x	x	
Unid. sponges			x	x			x		x	x	x	x	x	x
CNIDARIA														
Aglaophenia sp.										x	x		x	
Anthopleura elegantissima		x	x	x	x	x	x	x	x	x	x	x	x	x
Anthopleura xanthogrammica		x	x	x	x	x	x	x	x	x	x	x	x	
Corynactis californica										x	x	x	x	
Epiactis prolifera			x	x	x	x	x		x	x	x			x
Metridium senile											x			
Sertularia sp										x				
Unid. actinaria				x				x				x		
Unid. hydroid													x	
PLATYHELMINTHES														
Unid. polyclad		x		x	x									
NEMERTINEA														
Unid. nemertean			x			x		x	x	x	x	x	x	x
BRYOZOA														
Eurystomella bilabiata		x	x	x	x	x	x		x			x		x
Flustrella sp.										x				
Rhynchozoon sp.		x	x	x	x	x	x		x					x
Victorella sp.	W									x		x		
Unid. bryozoans, erect		x				x	x			x		x		
Unid. bryozoans, encrust.				x	x	x		x	x		x	x	x	x
Unid. Ectoprocts										x				x

Table 7b: Continued. Intertidal Marine Animals for 1982.

Animal Taxa for 1982 (MONTH)	SDIX				NDIX				LCIX				CDIX
	J	A	S	D	J	A	S	D	J	A	S	D	D
MOLLUSCA													
Acanthina sp.	x	x	x	x	x	x		x					
Acmaea mitra	x	x		x	x	x	x	x				x	x
Amphissa sp.	x												
Astraea gibberosa	x			x									
Barleeia sp.	x				x								
Bittium sp.	x	x	x					x					x
Calliostoma canaliculatum									x				
Calliostoma ligatum	x					x		x				x	
Calliostoma sp.	x				x								
Collisella asmi	x	x	x	x	x		x	x					x
Collisella digitalis	x	x	x	x	x	x	x	x	x	x	x	x	x
Collisella limatula	x	x	x	x	x	x	x	x	x	x	x	x	x
Collisella pelta	x	x	x	x	x	x	x	x	x	x	x	x	x
Collisella scabra	x	x	x	x	x	x	x	x	x	x	x	x	x
Conus californicus	x	x											
Crepidula sp.	x	x	x	x	x	x	x	x					x
Cyanoplax sp.	x	x	x	x	x	x	x	x		x			x
Diodora sp.								x					
Epitonium sp.			x										
Fissurella volcano	x	x	x	x	x	x	x	x				x	x
Haliotis cracherodii	x	x	x	x	x	x	x	x	x	x	x	x	x
Hermissenda sp.			x					x					
Hiatella sp.					x								
Homalopoma sp.	x	x		x	x	x	x	x					x
Katharina tunicata								x				x	
Lacuna sp.	x		x	x	x	x	x	x	x	x			x
Littorina planaxis	x	x	x	x	x	x	x	x	x	x	x	x	x
Littorina scutulata	x	x	x	x	x	x	x	x	x	x	x	x	x
Lottia gigantea								x	x	x		x	x
Megatebennius sp.								x					
Mitra idae	x												
Mitrella carinata	x		x	x	x	x	x	x					x
Mitrella sp.	x		x		x	x	x	x			x		x
Mopalia sp.	x		x	x	x		x			x			x
Mytilus californianus	x	x						x	x	x	x	x	x
Notoacmea incessa	x							x					x
Notoacmea palacea						x							
Notoacmea persona					x			x					
Notoacmea scutum	x	x	x	x	x	x	x	x	x	x	x	x	x
Nucella sp.									x	x		x	
Nuttallina sp.	x	x	x	x	x				x	x	x	x	x
Ocenebra circumtexta	x	x	x	x	x	x	x	x				x	x
Ocenebra interfossa	x	x		x		x							

Table 7b: Continued. Intertidal Marine Animals for 1982.

Animal Taxa for 1982	SDIX				NDIX				LCIX				CDIX
(MONTH)	J	A	S	D	J	A	S	D	J	A	S	D	D
MOLLUSCA (Continued)													
Ocenebra lurida							x						
Onchidella sp.					x			x					
Phidiana niger	x												
Rostanga pulchra								x					
Serpulorbis squamigerus	x				x	x	x	x	x	x	x	x	
Tegula brunnea	x	x	x	x	x	x	x	x	x	x		x	x
Tegula funebralis	x	x	x	x	x	x	x	x	x	x	x	x	x
Tonicella lineata					x	x		x	x	x		x	
Tricolia sp.			x		x		x		x				x
Unid. acmaeids	x	x	x	x	x	x	x	x	x	x	x	x	x
Unid. aeolid nudibranch			x										
Unid. chiton	x		x	x	x	x	x	x	x			x	x
Unid. ischnochitonid	x	x	x	x	x	x		x		x	x	x	x
Unid. dorid nudibranch						x							
Unid. pholad									x		x		
SIPUNCULIDA													
Phascolosma sp.			x										
ANNELIDA													
Diopatra ornata (tube)	x			x									
Dodecaceria sp.					x				x	x	x	x	x
Phragmatopoma/*Sabellaria* sp.	x	x	x	x	x	x	x	x	x	x	x	x	x
Platynereis sp.			x					x					
Pista sp.	x	x	x	x	x	x				x	x	x	x
Salmacina sp.			x		x		x	x	x	x	x	x	x
Spiriobranchis sp. (tube)	x	x		x	x		x	x	x	x		x	x
Telepsavus sp. (tube)					x		x	x					x
Unid. nereid				x									x
Unid. sabellid	x												x
Unid. serpulid	x	x						x	x			x	x
Unid. spirorbids	x	x	x	x	x	x	x	x	x	x	x	x	x
ARTHROPODA													
Balanus nubilis										x			
Balanus sp.			x		x	x		x	x	x	x	x	x
"BIG bright red mites"		x			x	x		x	x		x		x
Cancer antennarius			x			x					x		
Cancer sp.	x		x						x				
Chthamalus sp.	x	x	x	x	x	x	x	x	x	x	x	x	x
Crangon sp.				x									
Hemigrapsus sp.	x	x	x	x	x	x	x	x					x
Heptacarpus (*Spirontocaris*) sp.			x	x	x		x	x					x
Idotea sp.	x					x			x		x		

Table 7b: Continued. Intertidal Marine Animals for 1982.

Animal Taxa for 1982	SDIX				NDIX				LCIX				CDIX
(MONTH)	J	A	S	D	J	A	S	D	J	A	S	D	D
ARTHROPODA (Continued)													
Ligia sp.								x					x
Pachygrapsus crassipes	x	x		x		x	x	x	x	x	x	x	x
Petrolisthes sp.	x	x	x	x	x	x				x	x	x	
Pollicipes polymerus									x	x	x	x	x
Pugettia producta	x	x	x	x	x	x	x	x	x	x	x	x	x
Pugettia richi	x		x		x			x					
Tetraclita rubescens	x	x	x	x	x	x	x	x	x	x	x	x	x
Tigriopus sp.					x				x			x	x
Unid. copepods											x		
Unid. gammarids	x	x	x	x	x	x	x	x	x	x	x	x	x
Unid. grapsoids (brachyuran)		x		x		x	x	x		x			x
Unid. majids, juvenile						x	x				x		
Unid. pagurids	x	x	x	x	x	x	x	x					x
Unid. pinixids									x				
Unid. pycnogonids													x
Unid. sphaeromid isopods	x												
ECHINODERMATA													
Henricia sp.						x					x	x	x
Leptasterias sp.	x	x		x	x	x	x	x	x	x	x	x	x
Patiria miniata	x	x		x	x	x	x	x					
Pisaster ochraceus	x	x			x				x	x	x	x	x
Pycnopodia helianthoides	x				x			x					x
Strongylocentrotus purpuratus	x	x			x	x			x	x	x	x	x
Unid. ophiuroid				x									
TUNICATA													
Clavelina huntsmani		x	x			x	x			x			
Cystodytes sp.					x								
Didemnum sp.					x								
Eudistoma sp.		x			x				x	x	x	x	x
Euherdmania sp.									x	x			
Metandrocarpa sp.					x								
Polyclinum planum									x			x	
Pyura haustor	x		x		x		x		x	x	x	x	
Styela sp.									x			x	
Unid. colonial tunicates	x	x	x	x	x	x	x	x	x		x	x	x
VERTEBRATA													
Unid. cottid			x		x		x	x				x	
Unid. gobiesocid		x											
Unid. stichaeid	x				x	x	x				x		

Table 7c: Number of species (or taxa) grouped according to major taxa for intertidal station sampling from January, April, September, and December, 1982. Station location and identification are as listed in Table 9.

MAJOR TAXA	STATIONS																	
	SDIX				NDIX				LCIX				CDIX	TOTAL				
(MONTH)	J	A	S	D	J	A	S	D	J	A	S	D	D	J	A	S	D	ALL
Plants																		
Misc. Plants*	1	1	2	1	1	2	1	1	1	1	1	1	1	1	2	2	1	2
Chlorophyta	4	3	4	3	4	4	4	4	3	4	3	3	4	5	4	5	4	5
Phaeophyta	7	5	5	6	3	4	4	4	3	4	3	4	5	7	8	8	9	11
Rhodophyta	43	38	35	34	43	42	34	35	51	43	34	43	40	67	58	47	59	80
"Lichen"	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Spermatophyta	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total Plants	57	49	48	46	52	53	44	45	59	53	42	52	51	82	74	64	75	100
Animals																		
Porifera	2	2	1	1	4	1	0	3	7	2	2	5	1	11	3	2	5	12
Cnidaria	2	3	4	3	3	3	3	3	6	6	4	5	2	6	6	5	6	9
Misc. Phyla**	2	1	2	1	1	0	1	1	1	1	1	1	1	3	1	3	2	4
Bryozoa	3	2	3	3	4	3	1	3	4	1	4	1	4	7	4	5	4	7
Annelida	7	5	5	6	7	3	5	7	6	6	5	7	10	10	7	8	12	12
Mollusca	39	25	29	27	34	29	26	38	22	21	16	24	30	47	35	35	43	58
Arthropoda	12	10	12	11	12	14	10	13	12	10	13	9	15	17	16	19	18	26
Echinodermata	5	4	0	3	5	4	2	3	3	3	4	4	5	5	5	5	7	7
Tunicata	2	3	3	1	6	2	3	1	6	4	3	5	2	9	5	4	5	10
Vertebrata	1	1	1	0	2	1	2	1	0	0	1	1	0	2	2	2	1	3
Total Animals	75	56	60	56	78	60	53	73	67	54	53	62	70	117	84	88	103	148
Total Plants & Animals	132	105	108	102	130	113	97	118	126	107	95	114	121	199	158	152	178	248
Taxa ID'ed in Lab only	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	2
Quadrats Sampled:	51	46	43	45	33	32	25	29	24	20	16	21	41	108	98	84	136	426

* Misc. Plants — Includes Cyanophyta and Chrysophyta

** Misc. Phyla — Includes Protozoa, Platyhelminthes, Nemertina, and Sipunculida

Table 8a: Species of marine plants observed and/or collected near Diablo Cove during subtidal station sampling for December of 1982. Station location and identification are listed in Table 9. Plant taxa followed by an '+' were identified by F. A. Chapman.

Subtidal Plant Taxa for 1981 (MONTH)		STATIONS DCSX D	DRSX D	LRSX D
PHAEOPHYTA				
Cystoseira osmundacea		x	x	x
Desmarestia ligulata			x	x
Dictyoneurum californicum	+	x	x	x
Laminaria dentigera		x	x	x
Macrocystis sp.				x
Nereocystis luetkeana			x	
Pterygophora californica		x	x	x
RHODOPHYTA				
Antithamnion defectum	+		x	
Bossiella sp.			x	
Botryoglossum farlowianum	+	x	x	x
Calliarthron cheilosporioides		x	x	x
Callithamnion acutum	+		x	
Callophyllis flabellulata	+		x	x
Callophyllis violacea		x	x	x
Callophyllis sp.	+		x	x
Corallina officinalis		x		
Gelidium robustum			x	
Gigartina corymbifera		x		x
Gigartina exasperata		x	x	x
Gymnogonrus platyphyllus				x
Halymenia sp.			x	x
Iridaea flaccida	+			x
Lithothamnium sp.		x	x	x
Neoptilota densa	+	x	x	
Opuntiella californica	+	x	x	x
Peyssonellia sp.		x	x	x
Polyneura latissima	+	x		x
Prionitis angusta	+	x	x	x
Prionitis australis		x		
Rhodymenia californica		x		x
Rhodymenia pacifica	+	x	x	x
Schizymenia pacifica	+			x
Weeksia reticulata	+	x	x	x

Table 8b: Species of marine animals observed and/or collected near Diablo Cove during subtidal station sampling for December of 1982. Station location and identification are listed in Table 9. Animal taxa names followed by a 'W' were lab identified by W. J. North.

Subtidal Animal Taxa for 1981 (MONTH)		STATIONS DCSX D	DRSX D	LRSX D
PORIFERA				
Astylinifer arndti		x		
Cliona celata	W			x
Halichondria panicea		x	x	x
Haliclona ecbasis	W		x	
Haliclona lunisimilis	W	x		x
Hymenamphiastra cyanocrypta			x	x
Isociona lithophoenix			x	x
Leucilla nuttingi		x	x	x
Leuconia heathi		x	x	x
Leucosolenia eleanor				x
Plocamia karykina	W	x	x	
Prianos problematicus	W		x	x
Speciospongia confoederata	W		x	
Tethya aurantia		x		x
CNIDARIA				
Aglaophenia sp.			x	
Anthopleura elegantissima		x	x	x
Anthopleura xanthogrammica			x	x
Astrangia sp.				x
Balanophyllia elegans		x	x	x
Corynactis californica			x	x
Metridium senile		x		
Paracyathus stearnsi			x	x
"*Rivularia*" sp.		x		
Tealia sp.				x
Unid. hydroid		x	x	x
BRYOZOA				
Costazia robertsoniae	W	x	x	x
Crisia sp.			x	x
Diaperoecia sp.		x	x	x
Hippodiplosia insculpta	W	x		x
Hippoporina californica	W		x	x
Hippothoa hyalina	W	x	x	
Membranipora sp.		x	x	x
Microporella californica	W		x	x
Parasmittina californica	W		x	x
Phidolopora pacifica			x	x
Rhynchozoon rostratum			x	x
Victorella sp.	W	x		

Table 8b: (Continued) Subtidal Marine Animals for 1982.

Subtidal Animal Taxa (MONTH)	STATIONS DCSX D	DRSX D	LRSX D
MOLLUSCA			
Acanthodoris sp.		x	
Acmaea mitra	x	x	
Anisodoris nobilis		x	x
Astraea gibberosa		x	x
Calliostoma annulatum	x	x	x
Calliostoma canaliculatum		x	x
Calliostoma ligatum		x	x
Doriopsilla albopunctata	x		x
Flabellinopsis iodinea			x
Hinnites multirugosus		x	x
Mitra idae	x		x
Pteropurpura sp.			x
Serpulorbis squamigerus	x	x	x
Tegula brunnea	x	x	
Tegula montereyi		x	x
Tonicella lineata	x	x	x
Unid. chiton		x	
ANNELIDA			
"*Dexiospira*" sp.	x	x	x
Diopatra ornata (tubes)	x	x	x
Dodecaceria sp.		x	x
Eudistylia polymorpha	x	x	x
Phragmatopoma/Sabellaria sp.	x	x	
Salmacina sp.	x	x	x
Telepsavus costarum			x
Unid. sabellid		x	x
Unid. serpulid	x	x	
ARTHROPODA			
Balanus nubilis		x	
Balanus tintinnabulum	x	x	
Cancer sp.			x
Alpheus sp.	x		
Pandalus sp.			x
Pugettia producta		x	
Scyra acutifrons	x		x
Unid. pagurids	x	x	x

Table 8b: (Continued) Subtidal Marine Animals for 1982.

Subtidal Animal Taxa (MONTH)	STATIONS DCSX D	DRSX D	LRSX D
ECHINODERMATA			
Henricia leviuscula	x		
Leptasterias sp.	x	x	
Ophiothrix spiculata		x	
Orthasterias koehleri			x
Parastichopus sp.			x
Patiria miniata	x	x	x
Pisaster brevispinus			x
Pisaster giganteus	x	x	x
Pisaster ochraceus	x	x	
Pycnopodia helianthoides		x	
Strongylocentrotus sp. juvenile			x
TUNICATA			
Archidistoma (Eudistoma) sp.	x	x	
Boltenia villosa	x	x	x
Cnemidocarpa finmarkiensis			x
Cystodites lobatus	x		x
Didemnum carnulentum	x	x	x
Pyura haustor	x	x	x
Styela montereyensis	x	x	x
Unid. colonial tunicates	x	x	
VERTEBRATA			
Coryphopterus nicholsi			x
Embiotoca jacksonii		x	x
Embiotoca lateralis	x	x	
Heterostichus rostratus			x
Hexagrammos decagrammus			x
Hypsurus caryi			x
Ophiodon elongatus	x		x
Orthanopeus triacis	x	x	x
Oxylebius pictus	x	x	x
Rachochilus toxotes			x
Scorpaenichthes marmoratus		x	
Sebastes atrovirens			x
Sebastes chrysomelas		x	x
Sebastes melanops		x	x
Sebastes mystinus			x
Zaolophus californianus			x
Unid. cottidae	x	x	x

Table 8c: Number of species (or taxa) grouped according to major taxa for subtidal station sampling for December of 1982.
Station location and identification are as listed in Table 9.

MAJOR TAXA	STATIONS				
	DCSX	DRSX	LCSX	TOTAL	
(MONTH)	D	D	D	D	ALL
Plants					
Chlorophyta	0	0	0	0	0
Phaeophyta	4	6	6	7	7
Rhodophyta	16	18	19	26	26
Total Plants	20	24	25	33	33
Animals					
Porifera	7	8	10	14	14
Cnidaria	5	7	8	11	11
Bryozoa	6	11	10	12	12
Annelida	6	8	7	9	9
Mollusca	7	14	13	17	17
Arthropoda	4	4	4	8	8
Echinodermata	5	5	6	11	11
Tunicata	7	6	6	8	8
Vertebrata	5	8	15	17	17
Total Animals	52	71	79	107	107
Total Plants & Animals	72	95	104	140	140
ID'ed Only in LAB	2	4	3	6	6
Meter Range sampled	0 100	3 20	1 20		

Table 9: W. J. North permanent Diablo Canyon transect locations:

Station	Type	Location
SDIX	Intertidal	in Diablo Cove, in southeastern corner
CDIX	Intertidal	in Diablo Cove, just northwest of Diablo Creek. First sampled in December 1982.
NDIX	Intertidal	in Diablo Cove, in northwestern corner
LCIX	Intertidal	on 'open' coast, on mainland, inshore from Pup Rock, and in the lee of Lion Rock
DRSX	Subtidal	beginning on inshore eastern side of Diablo Rock and extending easterly into Diablo Cove
DCSX	Subtidal	beginning near the discharge structure and extending towards Diablo Rock
LRSX	Subtidal	beginning on the eastern side of Pup Rock and extending to the southeast

Table 10: Summary of physical data for three stations visited in the Diablo Canyon Region 29 to 31 December 1982. On these days wave periods were from 10 to 16 seconds and wave heights were estimated at one to four feet (0.3 to 1.2 m).

Station Location	Date and Time	Time up	Total Time Min.	Temperature Surf. F.	Temperature Bot. F	UW visibility Surf. Feet	UW visibility Bot. Feet	Depth Feet
A. DCSX Diablo Cove	12/29 0930	1042	72	60	60	10	10	10-30
B. DRSX Diablo Rock	12/29 1200	1225	25	60	60	10	5-15	5-20
	12/30 0840	0942	62	59	59	15	15	20-30
C. LRSX Pup Rock	12/31 0844	0935	51	58	58	10	15	50

Table 11: Numbers of Laminaria and Pterygophora plants tallied within 3.14 sq. meter quadrats positioned by blind casting at the indicated subtidal stations near Diablo Canyon on the indicated dates. We also tallied numbers of Cystoseira and Nereocystis occuring in the quadrats at DRSX on 31 December 1982. Sedimentary bottom was avoided and the samples represent only rocky substrate.

Date MM/dd	Station	Depth feet	Species	No. per quadrat											Mean /sq. m
12/29	DCSX	10	L.	26	26	20	10	18	9	57	15	38	9		7.3
			P.	0	0	4	2	0	1	0	3	0	3		0.4
12/31	DCSX	30	L.	5	8	5	11	1	0	12	14	11	13	13	2.7
			P.	17	16	13	16	13	12	19	4	11	20	6	4.3
12/30	DRSX	19-24	L.	18	29	32	22	14	12	47	87	26	31		10.1
			P.	5	1	3	0	0	0	2	0	0	1		0.4
12/31	DRSX	34-38	L.	39	27	26	36	33	32	24	24	47			10.2
			P.	5	12	13	31	18	43	23	22	8			6.2
			C.	4	3	2	1	2	1	3	9	4			1.0
			N.	3	0	0	0	0	0	0	0	0			0.1
12/31	LRSX	35-40	L.	0	0	0	2	2	4	0	0	0	1	3	0.3
			P.	16	20	52	26	8	22	14	9	14	18	5	5.9

Appendix 1: Shorewalk Notes for December 1982

WJN Diablo Cove, Shorewalk Notes for Dec 1982: Page 1

Introduction:

Observations of major plant communities were made along the shore line of Diablo Cove, San Luis Obispo County, on 30 December 1982, from North Diablo Cove Point to South Diablo Cove Point by W. J. North, F. A. Chapman, and E. K. Anderson.

The observations were made from 1525 to 1654. Low tide was at 1626, -0.52 m (-1.7 ft) MLLW.

Height distributions were very rough estimates of the location of the taxa relative to the water level at the time of the observation. All of the heights reported as 'MLLW', are the field estimates minus 0.5 m.

Notes were made of major plant species, their estimated tidal range, and the major substrate component for areas around the Cove. Similarity to existing WJN station biotic types were noted where applicable.

Location of the areas were referenced to existing stations or to major physical features within the Cove. DC TEMP program stations are noted as DCT #xx. Fourteen distinct areas were noted, based on plant communities and substrate types, as follows:

1. NDIX Area: North Diablo Cove Point to mid DCT # 7;
2. DCT # 7 Area: mid DCT # 7 to just past east end of DCT # 7;
3. DCT # 8 Area: east end DCT #7 to mid DCT # 8;
4. DCT # 9 Area: mid DCT # 8 to mid DCT # 9;
5. DER Fish Area: mid DCT # 9 to 1st rocky point NNW of CDIX;
6. CDIX Area: point NNW of CDIX to about 30 m SSW of CDIX;
7. CDIX-Creek Area: about 30 m SSW of CDIX to NNW of Diablo Creek;
8. Creek Area: mouth of Diablo creek, width about 40 m.;
9. Creek-Discharge Area: SSE of Diablo Creek to NNW of discharge;
10. Discharge Area: NNW of discharge to just SSE of structure;
11. NNW DCT #10 Area: SSE of discharge to DCT #10;
12. South DCT #10 Area: DCT #10 to Pinnacle just NNE of DCT #11;
13. DCT #11 Area: pinnacle to DCT #12;
14. SDIX Area: DCT #12 to surge channel W of SDIX;

See Figure 2, in the text, for a rough sketch of the above areas identified by number.

Species list and definitions

Taxa were identified only to genus in the text. The following list gives the species name if applicable:

Plants

a. Analipus japonicus
b. Bossiella spp.
c. Calliarthron spp.
d. Corallina spp. (mainly vancouveriensis)
e. Cystoseira osmundacea
f. Dictyoneurum californicum
g. Egregia menziesis
h. Gastroclonium coulteri
i. Iridaea flaccida
j. Laminaria dentigera
k. Phyllospadix scouleri (not positively identified)
l. Rhodomela larix
m. Ulva spp.

Animals

a. Chthamalus spp.
b. Pista pacifica (not positively identified)

Substrate Definitions

a. sand - less than 0.3 cm
b. gravel - less than 6.5 cm and > sand
c. cobble - less than 25.6 cm and > gravel
d. boulder - greater than 26 cm, but probably NOT bedrock
e. bedrock - appears to be solid rock

Area Notes

In the following section, substrates and upper shore substrate type are listed by order of dominant types. Major plant taxa do NOT necessarily reflect order of abundance.

NDIX Area: Time: 1525 to 1535

Location: North Diablo Cove Point to mid DC TEMP Station # 7
Substrate: Boulder field grading from large (> 1 m diam.), high relief, to small, fairly well stabilized
Uppershore: boulders, bedrock

Major Plants: Egregia, Laminaria, Dictoyneurum, Phyllospadix, Gastroclonium, Gigartina exasperata, Gigartina canaliculata, and Iridaea

Egregia occuring as scattered clumps at -0.2m to +0.3m MLLW, nowhere extensive

Laminaria occuring as scattered plants at <-0.5m to -0.2m MLLW

Dictyoneurum occuring in bands on boulder sides at <-0.5m to -0.5m MLLW

Gastroclonium occuring on upper surfaces of boulders typical of NDIX area

Iridaea occuring in similar areas as Gastroclonium

Gigartina exasperata occuring as clumps at <-0.5m to -0.1m MLLW

Neoagardhiella occuring in scattered clumps at -0.2 to +0.0m MLLW, typically in more sheltered portions of boulder field

Phyllospadix occuring in scattered mats mixed with some Pista; at lower elevations

DCT #7 Area: Time: 1535 to 1537

Location: mid DC TEMP Station # 7 extending about 15 m along Cove shore
Substrate: sand, gravel, and cobble field, with some isolated, fairly stable boulders scattered throughout area
Uppershore: boulder, cobble, bedrock

Major Plants: Phyllospadix, Gastroclonium, and Iridaea

Similar to NDIX Area with added notes as follow:

Phyllospadix - Pista beds occuring mixed with sand, gravel, cobble at <-0.5m to -0.1m MLLW

Iridaea in a reduced belt compared to NDIX Area

Gastroclonium on upper parts of scattered boulders

DCT # 8 Area: Time: 1538 to 1542

Location: from the eastern end of DC TEMP Station #7 to mid DC TEMP Station # 8
Substrate: scoured bedrock, sand; gravel, very few boulders
Uppershore: cobble, sand

Major Plants: Phyllospadix, Gastroclonium, erect corallines, and Polysiphonia

Phyllospadix - sand - Pista mat extensive at lower elevations (<-0.5m to -0.1m MLLW)

Erect corallines locally dense in scattered areas

Gastroclonium in small patches on higher parts

Anthopleura elegantissima forming dense patches; up to 1 m^2 at about the +0.1m MLLW elevation

Polysiphonia - sand mat locally dense

Laminaria occuring as scattered single plants at <-0:5m to -0.3m MLLW

DCT #9 Area: Time: 1543 to 1549

Location: mid DC TEMP Station # 8 to mid DC TEMP Station # 9
Substrate: larger boulders (> 2 m diam.) with some bedrock
Uppershore: boulder, cobble, bedrock

Major Plants: Phyllospadix, Gastroclonium, Iridaea, Gigartina canaliculata, and Laminaria

Similar to NDIX Area with added notes as follow:

Boulders typically larger than NDIX with more bedrock areas

Egregia as scattered plants extending up into boulder field to +0.0m MLLW

Phyllospadix also extending up into boulder field to about +0:1m MLLW, associated Pista more abundant than in NDIX Area, less than DCT #8 Area

Laminaria more common than for DCT #8 Area, at <-0.5m to -0.2m MLLW

Dictyoneurum not noted as being present

DER Fish Area: Time: 1550 to 1556

Location: mid DC TEMP Station # 9 to first rocky point NNW of WJN CDIX
Substrate: larger boulders (> 2 m diam.) with more bedrock
Uppershore: cobble, boulder, bedrock

Major Plants: Phyllospadix, Gastroclonium, Iridaea, Gigartina canaliculata, and Laminaria

Similar to NDIX Area with added notes as follow:

Gastroclonium belt becoming compressed, with clumps extending farther up into boulder field at -0.2m to +0.7m MLLW

Iridaea typically on back sides of boulders (some on tops) at +0.1m to +0.9m MLLW

Laminaria slightly more abundant at <-0.5m to -0.1m MLLW

Egregia sparse, some well up into boulder field at about +0.5m MLLW

Dictyoneurum not noted as being present

CDIX Area: Time: 1557 to 1604

Location: point NNW of CDIX to about 30 m SSE of CDIX
Substrate: flat bedrock ridges, large boulders (> 2 m diam.), some smaller boulders and cobble
Uppershore: cobble, boulder, bedrock

Major Plants: Phyllospadix, Gastroclonium, Iridaea, Gigartina canaliculata, Dictyoneurum, and Laminaria

Similar to NDIX Area with added notes as follow:

Bedrock more extensive in wide ridges

Iridaea dominant coverage on bedrock and large boulders in higher portions of area at +0.0m to +1.3m MLLW

Gastroclonium forming fairly large mats below Iridaea at -0.3m to +0.2m MLLW

Phyllospadix locally heavy cover at <-0.5m to +0.0m MLLW

Dictyoneurum forming heavy belts on sides of bedrock formations and boulders at <-0.5m to -0.2m MLLW

CDIX-Creek Area: Time: 1605 to 1607

Location: 30 m SSE of CDIX to NNW of Diablo Creek mouth
Substrate: fairly flat bedrock, scattered cobble and boulder
Uppershore: boulder, bedrock, cobble

Major Plants: Phyllospadix, Gastroclonium, Iridaea, and, Laminaria

Phyllospadix probably the dominant plant at <-0.5m to +0.2m MLLW

Gastroclonium forming a thin belt above Phyllospadix area at +0.1m to +0.5m MLLW

Iridaea in small local patches at higher elevations

Laminaria present at <-0.5m to -0.4m MLLW

Diablo Creek Area: Time: 1608 to 1609

Location: mouth of Diablo creek, width about 40 m
Substrate: cobble and boulders (overlaying bedrock ??)
Uppershore: cobble, sand, gravel

Major Plants: Phyllospadix, Rhodomela, Analipus, and, Laminaria

Elevation notes NOT taken

Phyllospadix dominant plant as for CDIX-Creek Area

Rhodomela, Analipus and Chthamalus common

Iridaea and Gastroclonium sparse scattered plants

Laminaria present

Creek-Discharge Area: Time: 1610 to 1615

Location: SSE of Diablo Creek to just NNW of discharge structure
Substrate: sand, gravel, cobble, boulders, large bedrock ridges
Uppershore: bedrock, cobble, sand

Major Plants: Phyllospadix and Laminaria, some Egregia,

Boulders in some cases hugh

Bedrock ridges with high relief (approx. 3 to 4 m)

Laminaria becoming locally dense (up to about 10 per m^2) at <-0.5m to -0.2m MLLW

Phyllospadix as sparse patches at <-0.5m to +0.5m MLLW

Egregia sparse

Gastroclonium and Iridaea almost non-existent

Discharge Area: Time: 1616 to 1625

Location: NNW of discharge structure to just SSE of structure
Substrate: bedrock with some scattered boulders
Uppershore: bedrock, discharge structure

Major Plants: Phyllospadix and Laminaria, some Egregia, Gastroclonium, Cystoseira, and Corallina

Laminaria dense (probably up to as many as 30 per m^2) at <-0.5m to -0.1m MLLW

Phyllospadix - Pista mat at <-0.5m to +0.0m MLLW

Cystoseira as large local patches at <-0.5m to -0.3m MLLW

Corallina locally dense patches

Gastroclonium forming dense patches on bedrock at SSE end of area at about +0.2m MLLW

Iridaea and Rhodomela sparse

NNW DCT #10 Area: Time: 1626 to 1632

Location: SSE of discharge structure to start of DC TEMP Station #10
Substrate: bedrock with few scattered boulders
Uppershore: bedrock, cobble

Major Plants: Phyllospadix and Laminaria, some Egregia, Gastroclonium, Cystoseira, Ulva, and Corallina

Similar to Discharge Area with added notes as follow:

Phyllospadix - Pista mat at -0.2m to -0.1m MLLW

Gastroclonium forming extensive patches at +0.0m to +0.1m MLLW

Egregia more common, mainly as young plants at -0.1m to +0.0m MLLW

Ulva - Corallina mat extensive, slightly lower than Gastroclonium

Calliarthron, Bossiella and Prionitis lanceolata in pools

Laminaria still in dense stands of about 10 to 30 per m^2 at <-0.5m to -0.5m MLLW

South DCT #10 Area: Time: 1633 to 1640

Location: DC TEMP Station #10 to pinnacle just NNE of DC TEMP Station #11
Substrate: boulder - cobble field, some bedrock
Uppershore: cobble, boulder, bedrock

Major Plants: Phyllospadix, some Laminaria, some Egregia, Gastroclonium, Cystoseira, Rhodomela

Phyllospadix - Pista belt dominant at <-0.5m to +0.1m MLLW, "belt" becomes thinner as progress south

Gastroclonium mixed in with Phyllospadix and locally dense at -0.1m to +0.2m MLLW

Rhodomela in patches at +0.0m to +0.2m MLLW

Iridaea, Egregia and Cystoseira sparse

DCT #11 Area: Time: 1641 to 1644

Location: pinnacle just NNE of DC TEMP Station #11 to start of DC TEMP Station #12
Substrate: bedrock with some boulders
Uppershore: bedrock, cobble, sand

Major Plants: Phyllospadix, some Egregia, some Gastroclonium, Rhodomela

In general this area looks as if it has been beat to hell

Phyllospadix dominant at <-0.5m to +0.0m MLLW

Iridaea almost none

Egregia, erect corallines, Rhodomela, and Gastroclonium present

SDIX Area: Time: 1645 to 1654

Location: start of DC TEMP Station #12 to surge channel at southern point of Diablo Cove
Substrate: boulders (to 2 m), cobble, with some bedrock
Uppershore: cobble, boulder, bedrock

Major Plants: Phyllospadix, some Egregia, Iridaea, Gastroclonium, Rhodomela, Calliarthron in surge channel

Phyllospadix - Pista mat at -0.5m to -0.1m MLLW, Pista less dense

Rhodomela fairly common in ESE part at +0.1m to +0.2m MLLW

Gastroclonium locally common up to +0.1m MLLW

Iridaea locally common up to +0.2m MLLW

Laminaria sparse below water's edge

Appendix 2: Subtidal Field Notes

DCSX: 29 December 1982. Sky clear, no current, wave height 1 to 4 feet (0.3 to 1.2 m), period ca. 10 sec. Communities looked healthy. Tops of most Laminaria and Pterygophora plants were tattered, often stubs were all that remained. Foliaceous turf algae were fairly sparse and consisted of only a few species. The dominant subcanopy alga was Calliarthron which formed thick mats throughout the shallow parts of DCSX and on pinnacle tops in the deeper parts of the transect. Pinnacle tops also suported fair quantities of Prionitis angusta, P. australis, and Callophyllis violacea. Patches of Dictyoneurum and Neoptilota occurred on pinnacle tops in the mid-transect region. Opuntiella and tattered Polyneura tended to occur down in the channels and on the vertical sides of pinnacles. There were many Tegula on kelp stipes along the shallow parts of the transect but not in the deeper areas. No urchins were observed anywhere.

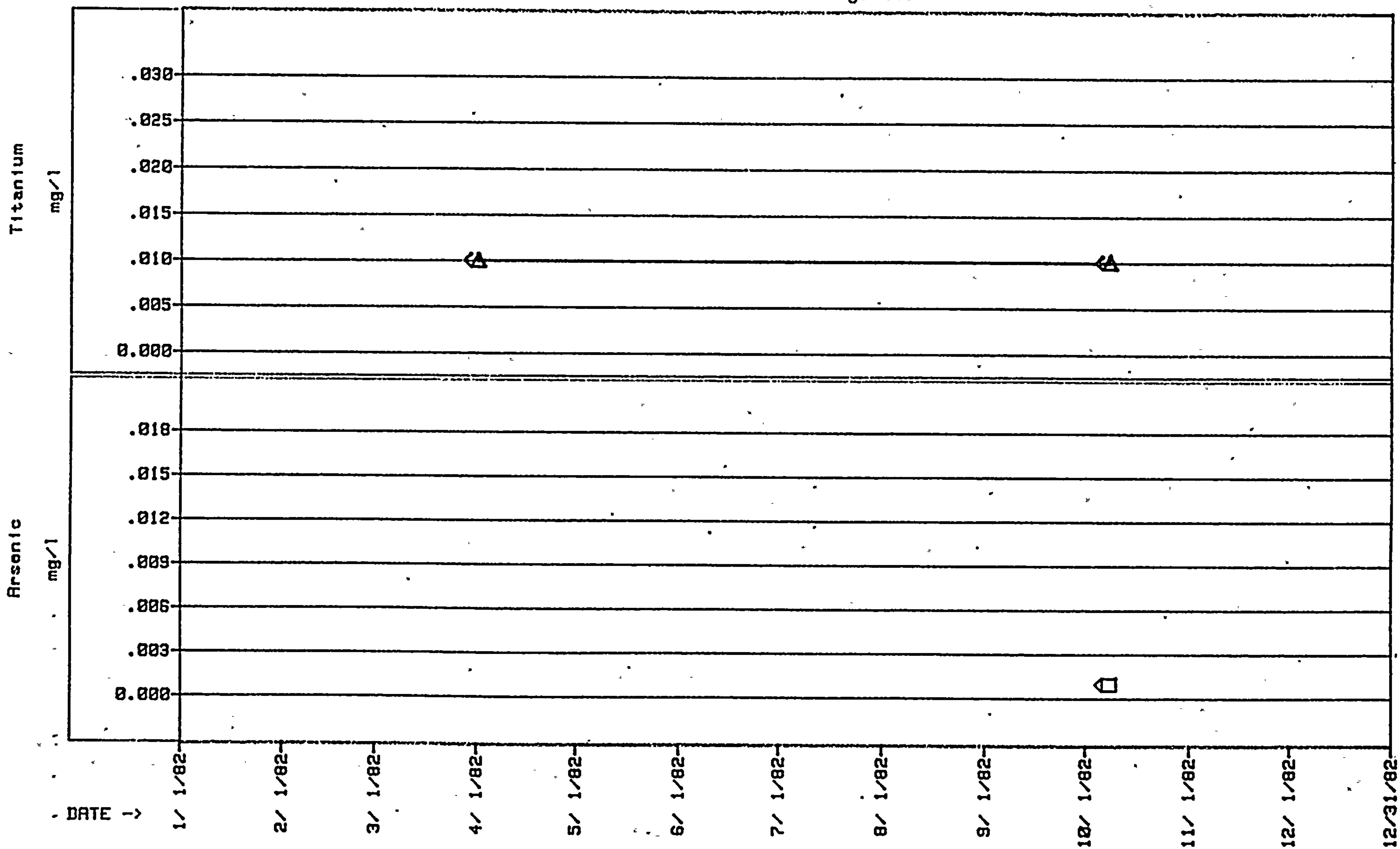
DRSX: 29 and 31 December 1982. Sky clear, ca. 5 knot offshore wind. Very healthy community: Visibility reduced so fishes were difficult to observe. Algal cover probably densest we have ever seen here. Invertebrate turf seems slightly reduced and crowded out by proliferation of flora. Callophyllis violacea, Gigartina exasperata, and Opuntiella were the commonest plants on the lower cliff face and transitional region to flat bottom. Calliarthron was dominant at shallow levels of the cliff. While throwing quadrats on 31 December in the deeper flatland, encountered large aggregate of drift algae in a deep basin. Many of the Laminaria and Pterygophora at this deep level were juvenile plants (ca. six months old). There were no urchins anywhere.

IRSX: 31 December 1982. Sky clear, no current, glassy sea, wave height 1 to 2 feet (0.3 to 0.6 m), period 16 sec. Algal cover on the vertical cliff face was as dense as ever observed here. Also a well-developed invertebrate turf present on the cliff. The Diopatra colony in the sand at the base of the cliff seemed to be of normal density. The shelf at the top of the cliff was difficult to study because of surge, but could observe dense algal cover. Dominant alga on the shelf was Calliarthron but flora was very diverse (more so than at DRSX). Saw no urchins anywhere, but we accidentally collected one tiny juvenile Strongylocentrotus sp. in picking up algal specimens. Out on flat bottom at the cliff base we encountered freshly uncovered boulders with fine sand around the bottoms. Boulders displayed dead coralline crusts. Polyneura abundant and some Gigartina exasperata. Saw occasional patches of Weeksia and infrequent groups of Porphyra-like blades. There was not the usual proliferation of Halymenia. Observed one moderately large aggregate of drift with a huge Nereocystis in it. The Macrocystis holdfasts were sometimes reminiscent of M. angustifolia as it occurs in the Santa Barbara region.

PG&E

NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Outfall - Discharge 001



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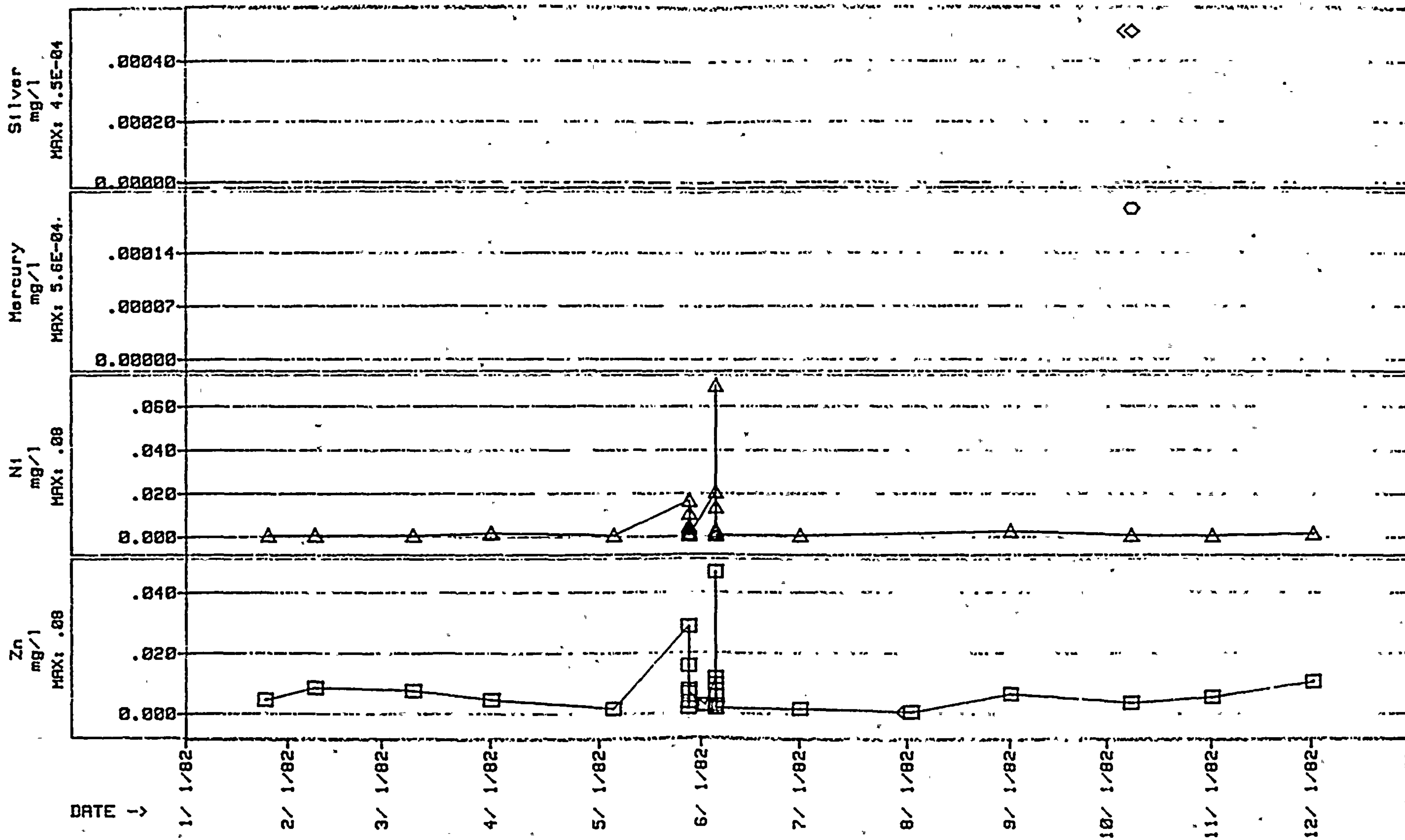
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Outfall - Discharge 001



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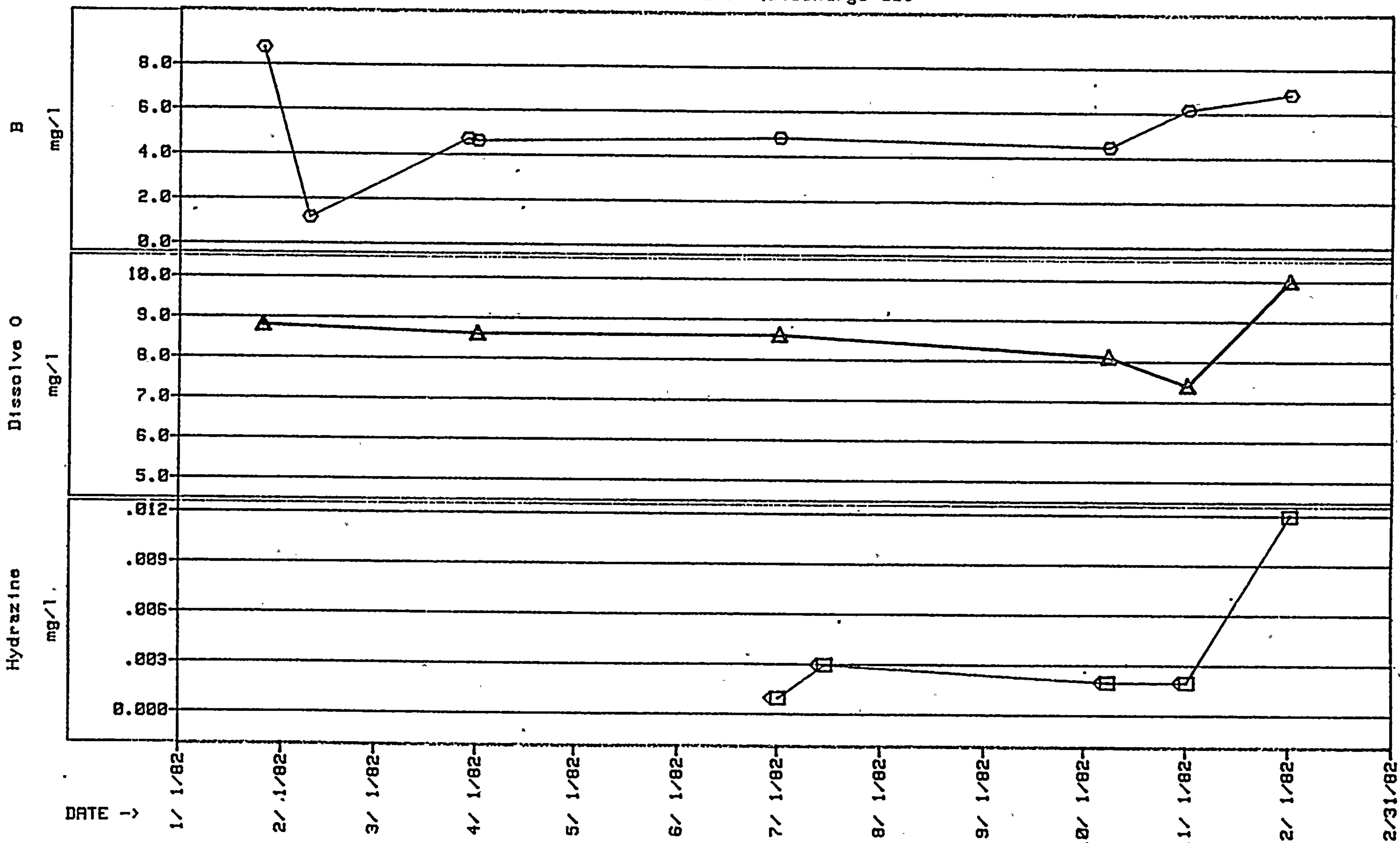
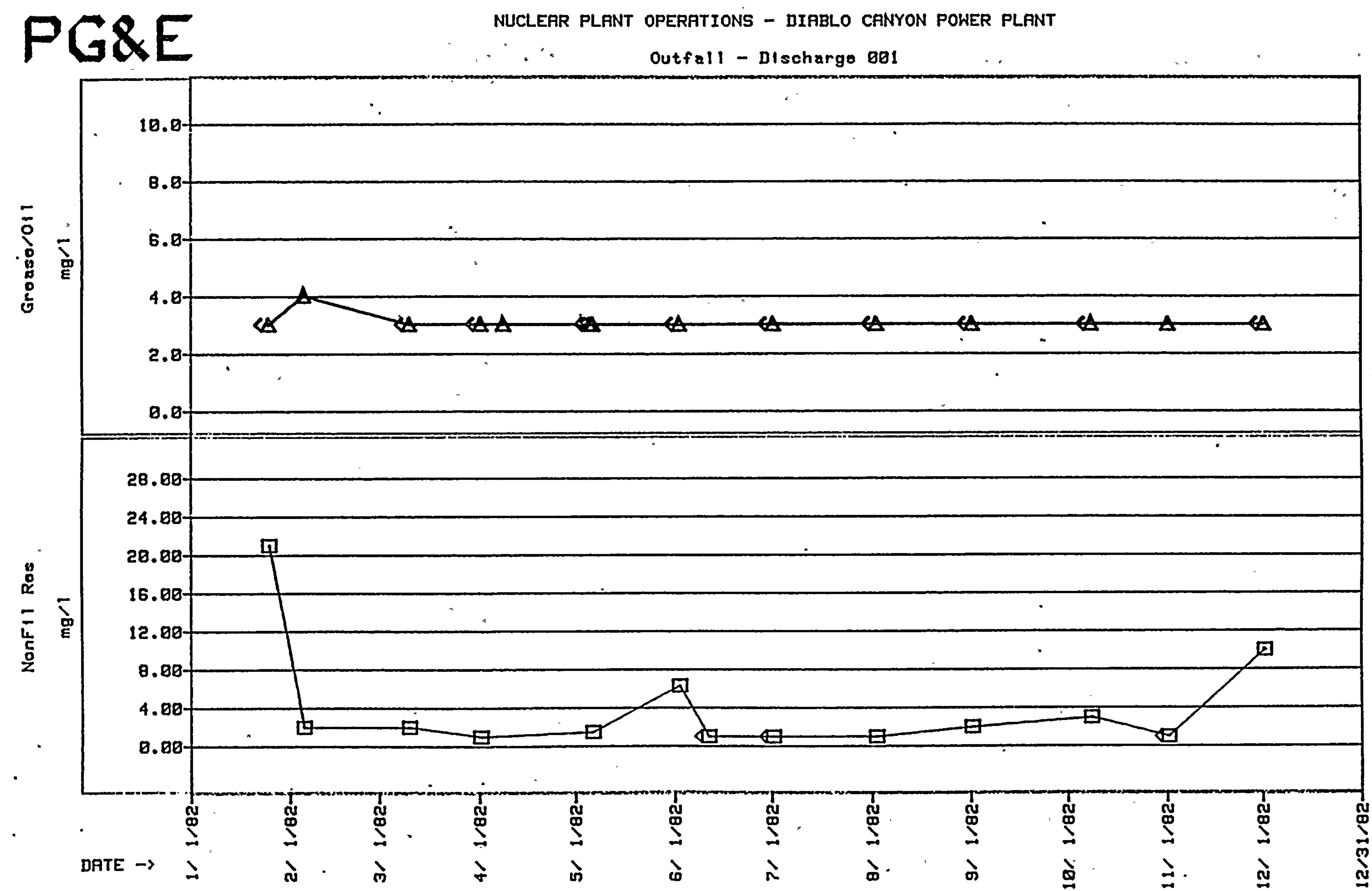
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Outfall - Discharge 001




PG&E
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT
Outfall - Discharge 001
Grease/Oil mg/l
10.0
8.0
6.0
4.0
2.0
0.0
NonFil Res mg/l
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00
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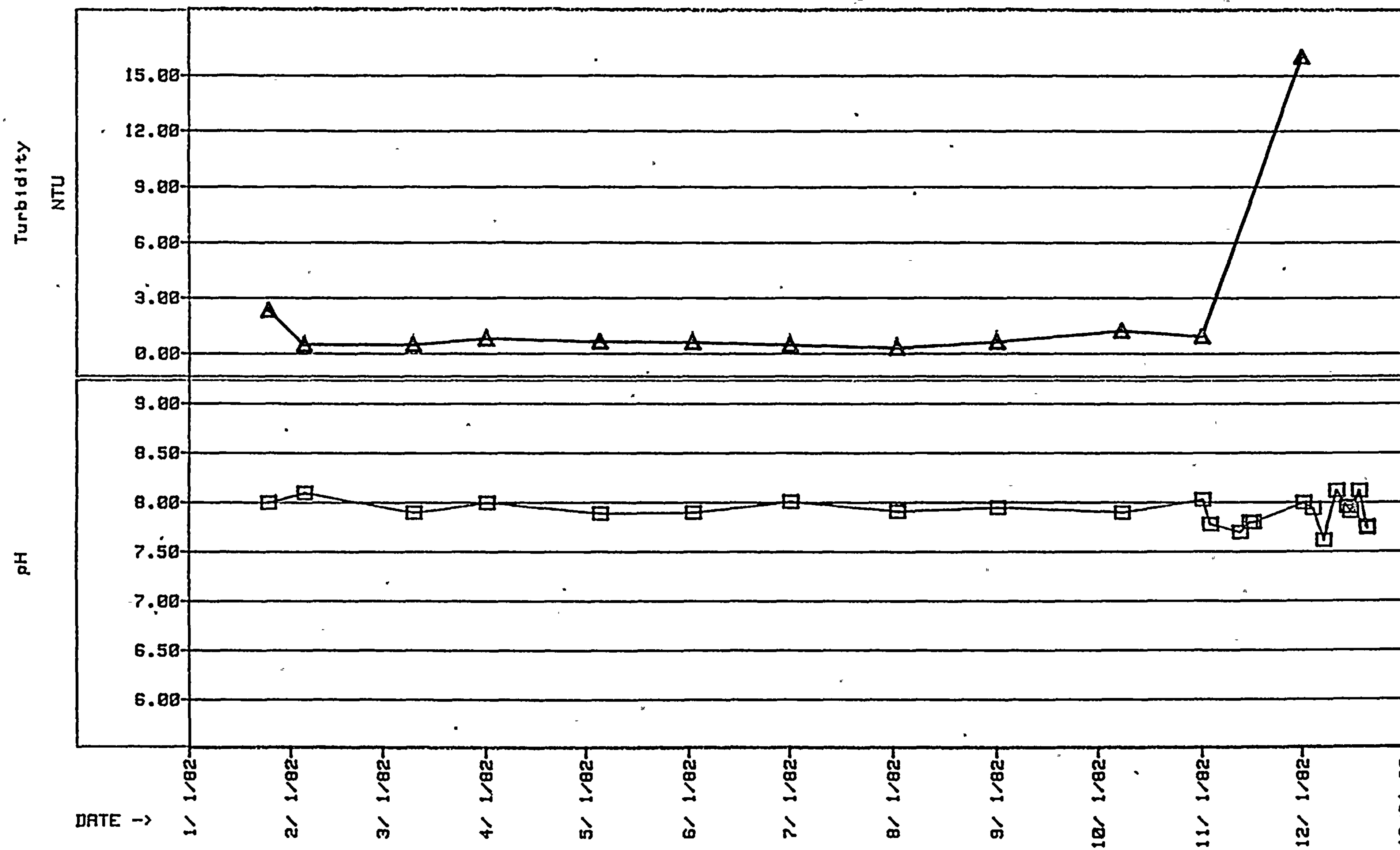
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Outfall - Discharge 001



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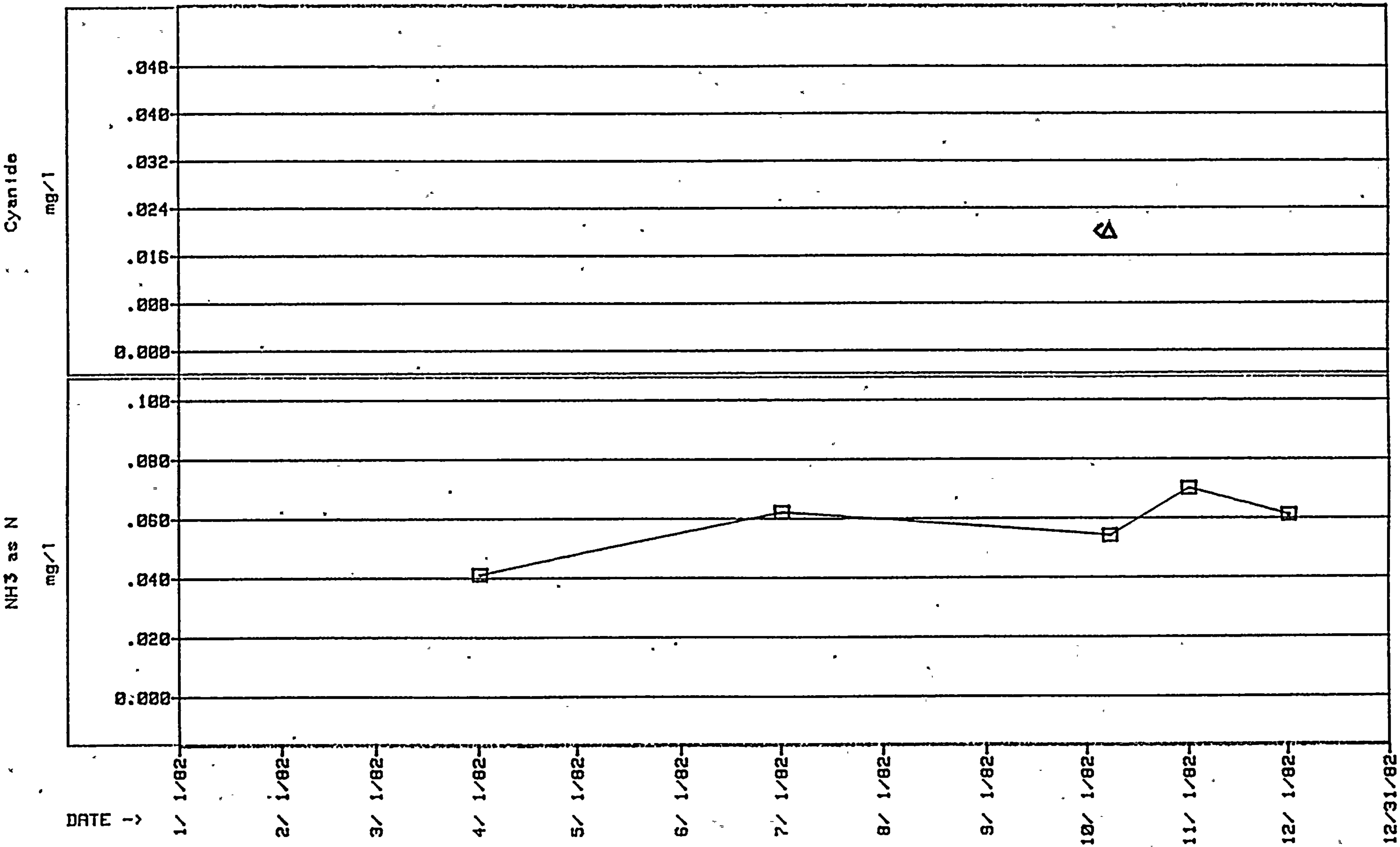
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Intake Cove



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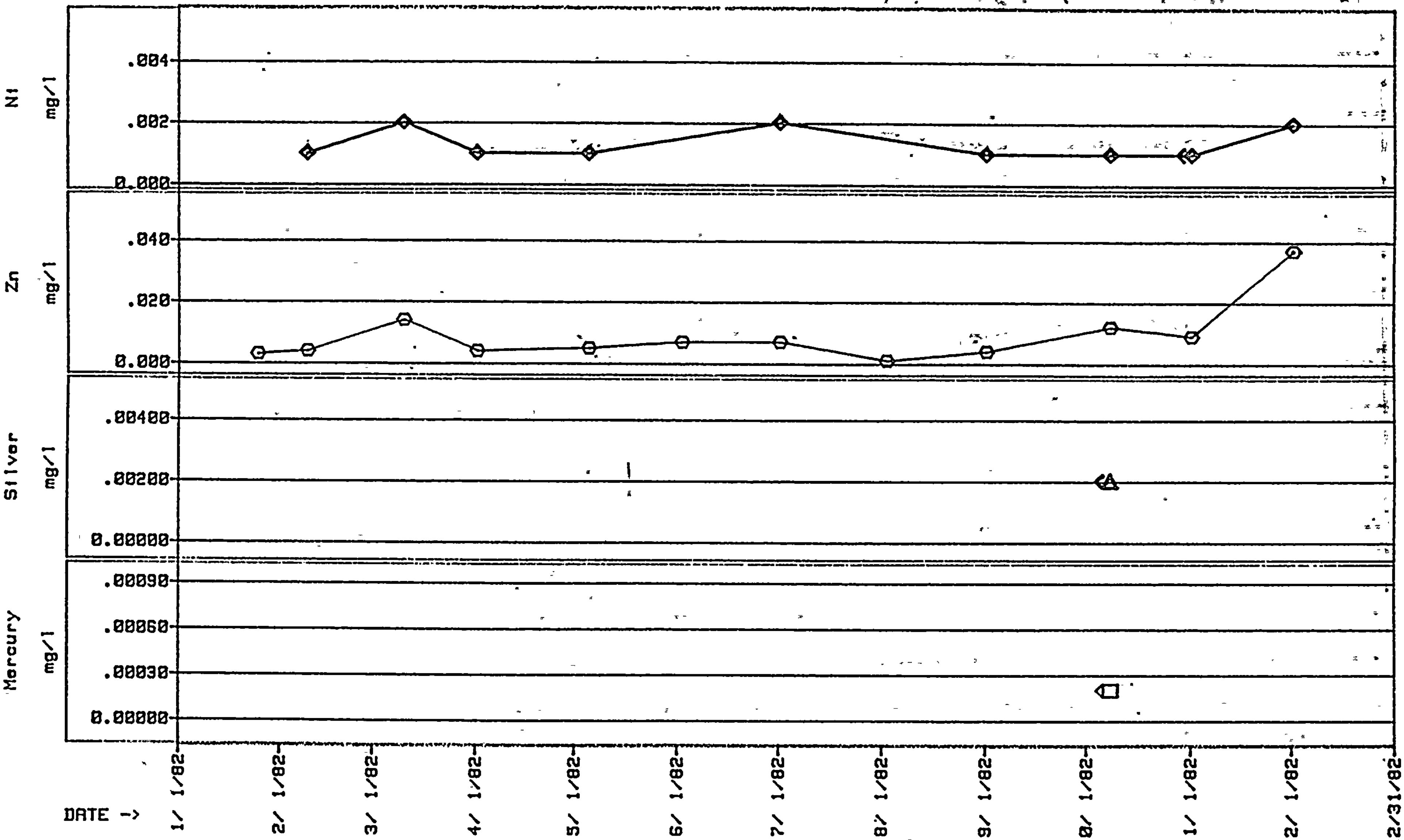
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Intake Cove



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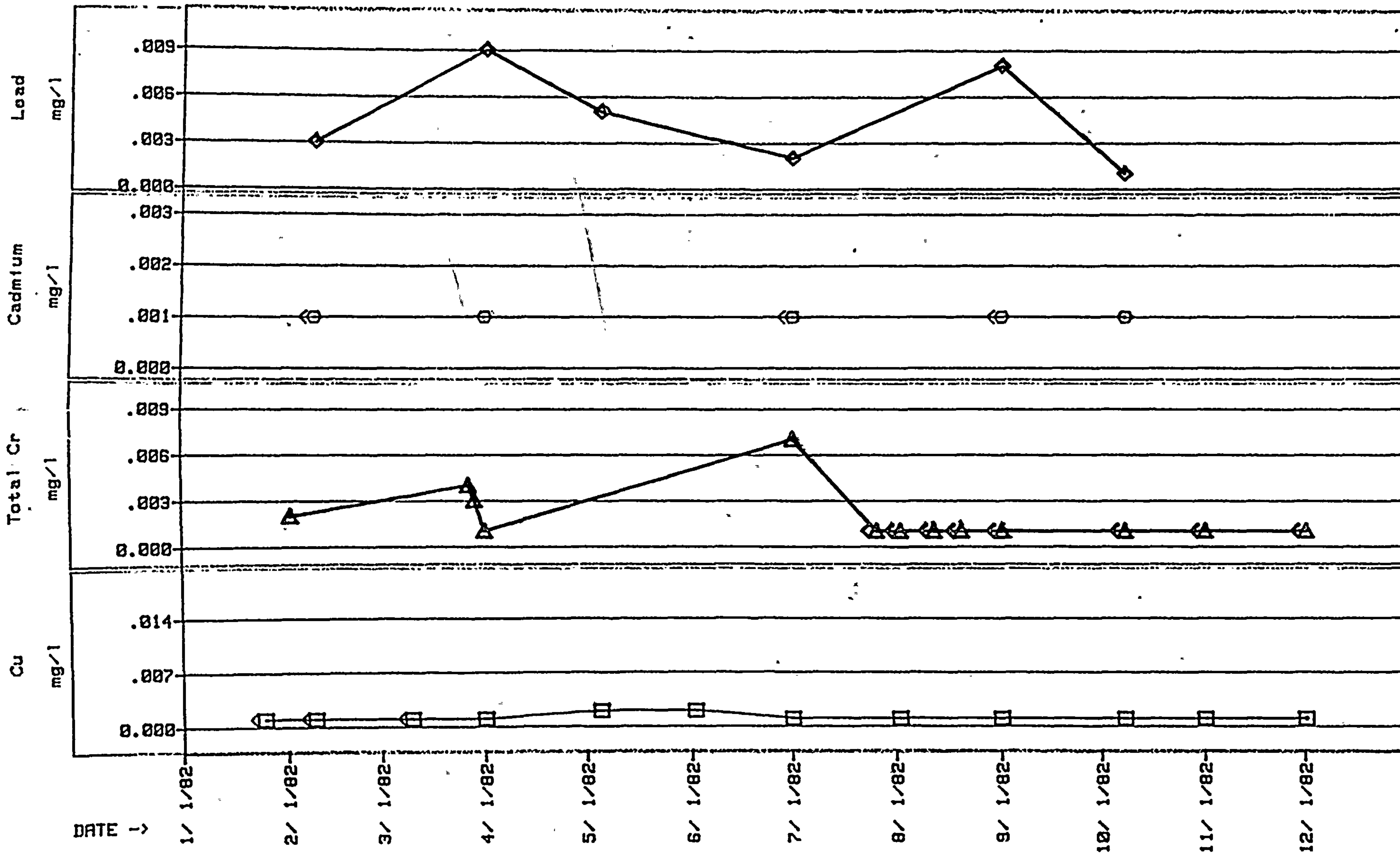
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Intake Cove



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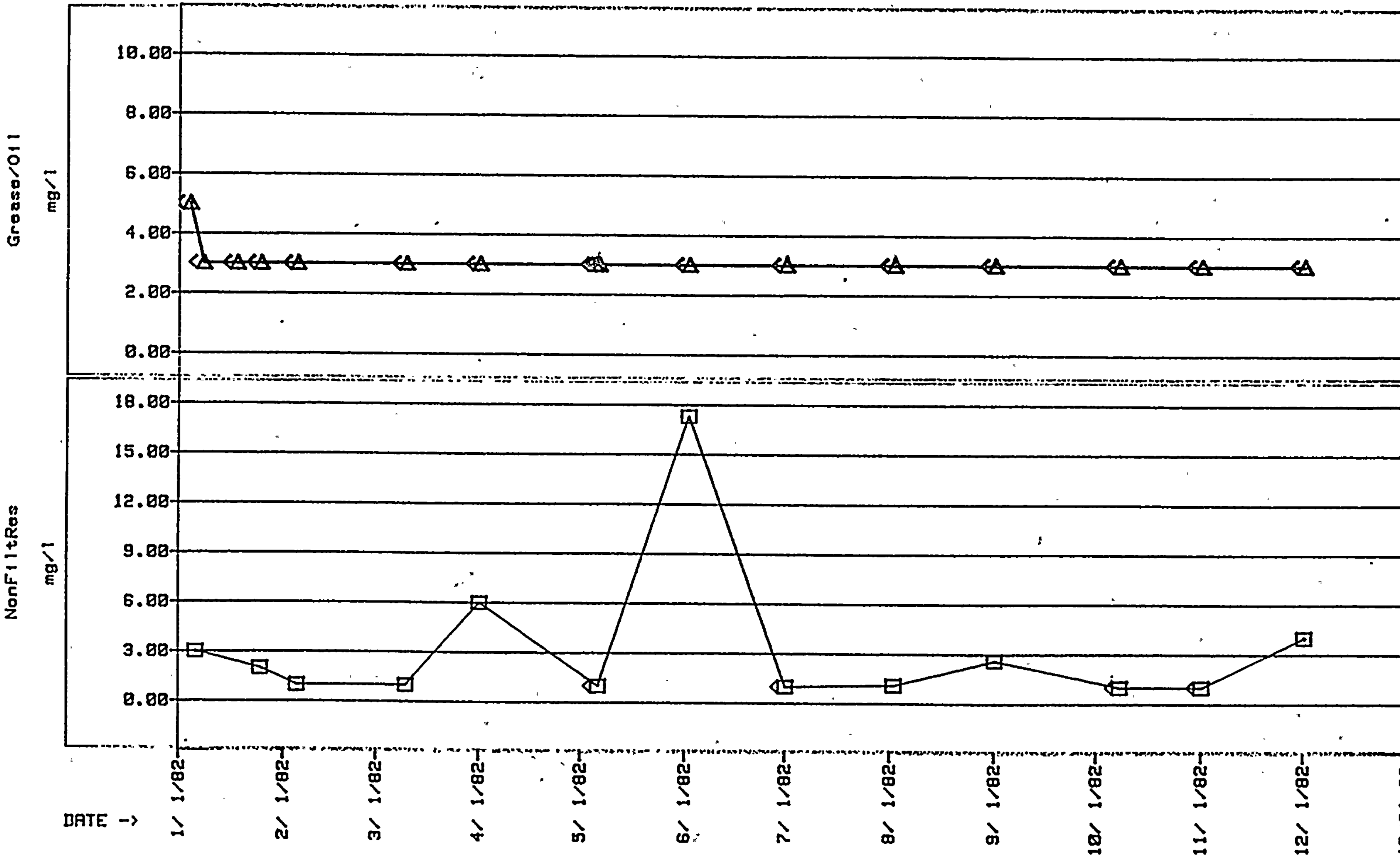
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Intake Cove



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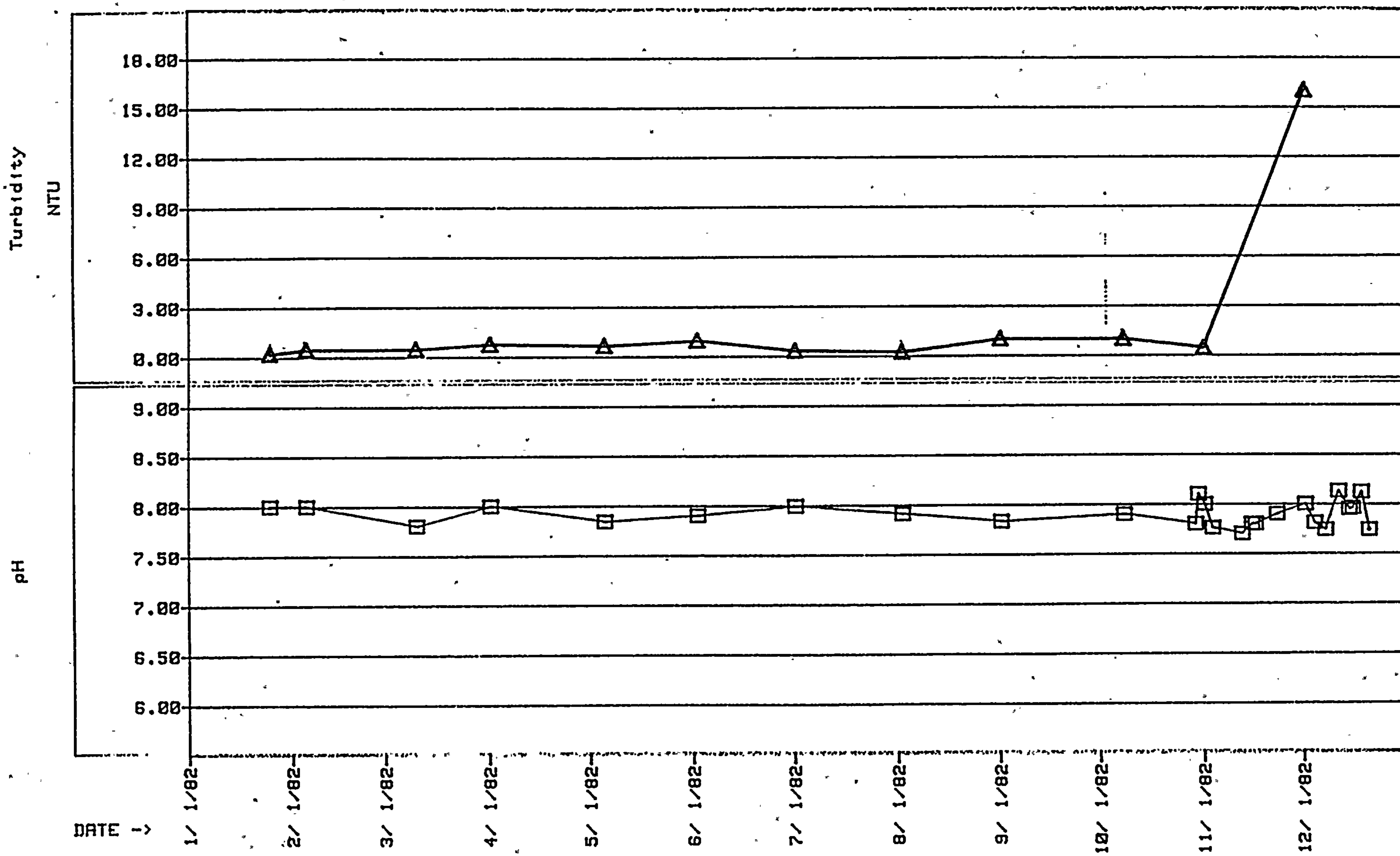
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Intake Cove



PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH
DIABLO CANYON BIOLOGICAL RESEARCH LABORATORY

Bioassay Chemical Data Sheet

ASSAY NO.: 87-R DATE / TIME SAMPLED 9 Sept. '82/0900 hrs.

CHEMICAL ANALYSIS BY: WAO'H

TYPE DISCHARGE (give full description of material and source): Water - Diablo Canyon Discharge 001 - ASW

CONCENTRATION OF SPECIFIED TOXICANTS AT TIME OF COLLECTION: ______

TEST CON'C	TEST								START			
	HARDNESS $CaCO_3$	ALKALINITY $CaCO_3$	SPECIFIED						TOXICANTS ppb			
			Cu	Ni	Fe	Zn	Pb	Cr				
100%			13	3	13	6	2	<1				
56%			6	2	8	5	2	<1				
32%			4	1	15	5	1	<1				
18%			4	1	—	5	3	<1				
10%			2	2	8	5	<1	<1				
CONTROL			2	4	6	8	3	<1				

TEST CON'C	96 HR.		SPECIFIED						TOXICANTS ppb	
	Cu	Ni	Fe	Zn	Pb	Cr				
100%	8	3	7	12	7	<1				
56%	4	9	7	11	12	<1				
32%	4	3	16	9	11	<1				
18%	3	1	7	11	12	<1				
10%	2	1	7	11	10	<1				
CONTROL	2	5	8	28	8	<1				

SALINITY ______

PACIFIC GAS & ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH
DIABLO CANYON BIOLOGICAL LABORATORY
STATIC BIOASSAY REPORT SHEET

ASSAY NO. 87-R

TEST ORGANISM DATA

TEST SPECIES: Red Abalone
SOURCE: Estero Bay Mariculture Lab
AVERAGE LENGTH: 41 mm RANGE: 35-49 mm
ACCLIMATION TIME: ≥1 yr TEMPERATURE: Ambient
WATER SOURCE: South Cove/Diablo Cyn.

TEST SOLUTION DATA

SOURCE OF TEST SOLUTION: Diablo Canyon Discharge 001 - ASW

DATE/TIME SAMPLED: 9 Sept. '82 / 0900 hrs

DATE STARTED: 9 Sept '82
TIME STARTED: 0935 HRS.
VOLUME/DEPTH OF TEST SOLUTION: 19 L / 18 cm
RENEWAL OF TEST SOLUTION AT: NA HR. INTERVALS
TYPE OF AERATION: Condé
NUMBER OF ORGANISMS PER CONCENTRATION: 10
DILUTION WATER SOURCE: South Cove/Diablo Cyn.

TEST CONCENTRATIONS

	100%	56%	32%	18%	10%	CONTROL
0 HOURS						
TEMP.	14.5	14.5	14.5	14.5	14.5	14.5
D.O.	7.0	6.7	6.2	6.2	6.6	5.8
pH	7.1	7.7	7.7	7.7	7.7	7.6
SALINITY/HARDNESS						
24 HOURS						
ORGANISMS SURVIVING	10	10	10	10	10	10
% SURVIVL	100%	100%	100%	100%	100%	100%
TEMP.	15.2	15.2	15.2	15.2	15.2	15.2
D.O.	6.8	7.0	6.6	6.5	6.8	6.1
pH	7.7	7.7	7.6	7.6	7.6	7.5
48 HOURS						
ORGANISMS SURVIVING						
% SURVIVAL						
TEMP.						
D.O.						
pH						
72 HOURS						
ORGANISMS SURVIVING						
% SURVIVAL.						
TEMP.						
D.O.						
pH						
96 HOURS						
ORGANISMS SURVIVING	10	10	10	10	10	10
% SURVIVAL	100%	100%	100%	100%	100%	100%
TEMP.	15.5	15.5	15.5	15.5	15.5	15.5
D.O.	6.9	6.9	6.8	6.7	6.8	5.9
pH	7.0	7.7	7.7	7.7	7.7	7.5
SALINITY/HARDNESS						

TU: No Mortality

PACIFIC GAS AND ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH
DIABLO CANYON BIOLOGICAL RESEARCH LABORATORY

Bioassay Chemical Data Sheet

ASSAY NO.: 84-S DATE / TIME SAMPLED 28 My '82 / 1100 hrs.

CHEMICAL ANALYSIS BY: WAO'H

TYPE DISCHARGE (give full description of material and source): Water- Unit 1 Circ pump

CONCENTRATION OF SPECIFIED TOXICANTS AT TIME OF COLLECTION:

TEST CON'C	TEST START		SPECIFIED TOXICANTS ppb									
	HARDNESS $CaCO_3$	ALKALINITY $CaCO_3$	Cu	Ni	Fe	Zn	Pb	Cr	Cd			
100%			11	13	171	19	2	6	1			
56%			15	10	146	16	6	3	<1			
32%			7	7	130	12	2	3	<1			
18%			6	8	13	9	<1	1	1			
10%			5	4	14	11	1	1	1			
CONTROL			1	4	3	1	1	<1	<1			

TEST CON'C	96 HR. SPECIFIED TOXICANTS ppb									
	Cu	Ni	Fe	Zn	Pb	Cr	Cd			
100%	3	4	11	6	2	1	<1			
56%	9	3	16	12	1	1	1			
32%	6	2	3	2	1	5	<1			
18%	5	4	9	10	1	1	1			
10%	4	1	20	10	4	1	2			
CONTROL	5	1	8	7	3	1	1			

SALINITY ______

PACIFIC GAS & ELECTRIC COMPANY
DEPARTMENT OF ENGINEERING RESEARCH
DIABLO CANYON BIOLOGICAL LABORATORY
STATIC BIOASSAY REPORT SHEET

ASSAY NO. 84-S

TEST ORGANISM DATA

TEST SPECIES: Red Abalone

SOURCE: Estero Bay Mariculture Lab

AVERAGE LENGTH: 38mm RANGE: 36-42 mm

ACCLIMATION TIME: ≥1yr TEMPERATURE: Amb.

WATER SOURCE: Seawater pump

TEST SOLUTION DATA

SOURCE OF TEST SOLUTION: Unit 1 Circ-pump Start-up

DATE/TIME SAMPLED: 28 May '82 / 1100 hrs

DATE STARTED: 28 May '82

TIME STARTED: 1130 HRS.

VOLUME/DEPTH OF TEST SOLUTION: 19 L /20cm.

RENEWAL OF TEST SOLUTION AT: NA HR. INTERVALS

TYPE OF AERATION: Condé

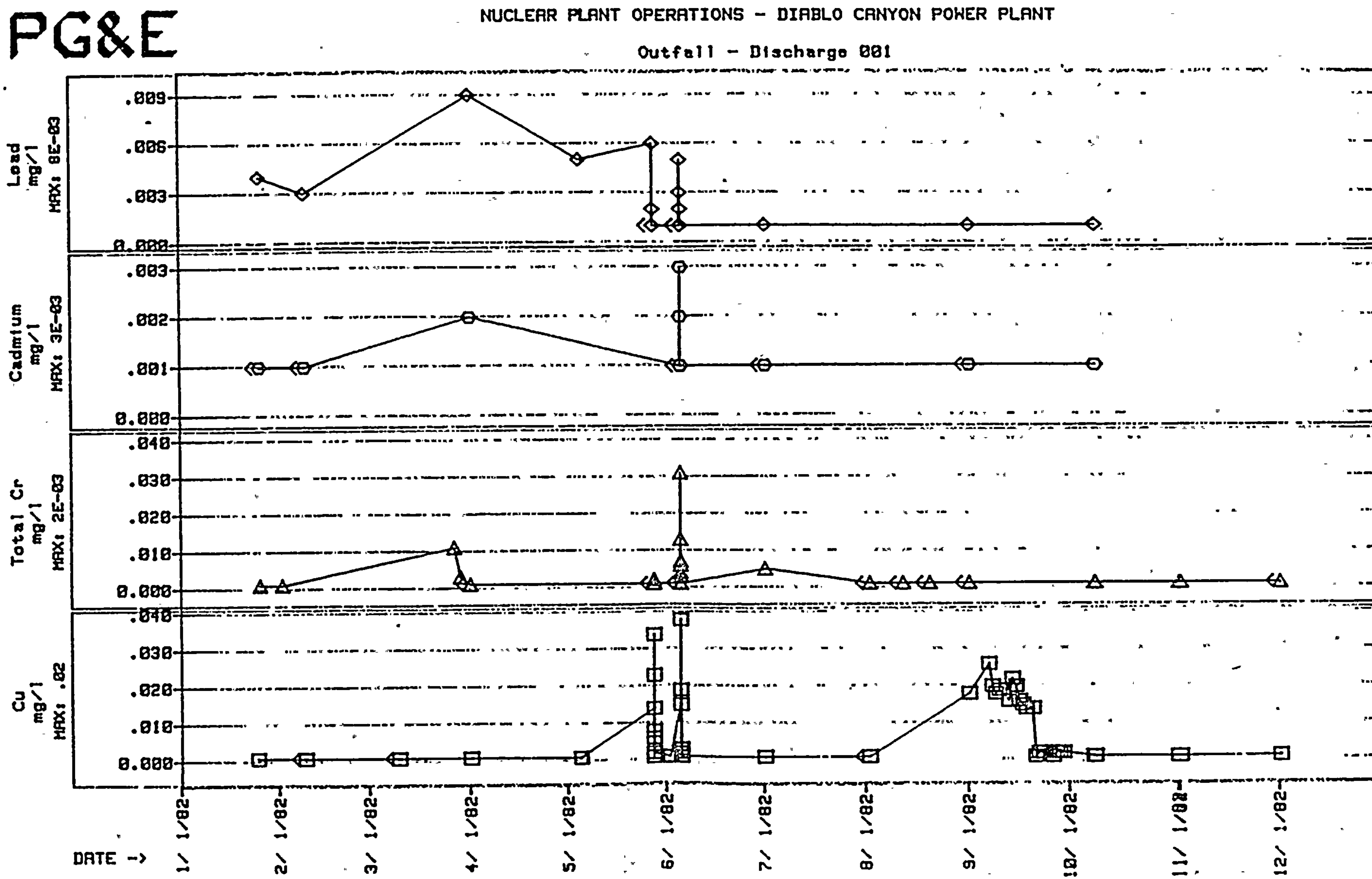
NUMBER OF ORGANISMS PER CONCENTRATION: 10

DILUTION WATER SOURCE: Seawater pump

TEST CONCENTRATIONS

	100%	56%	32%	18%	10%	CONTROL
0 HOURS						
TEMP.	13.5	13.5	13.4	13.3	13.3	13.3
D.O.	7.0	7.6	7.8	7.8	7.8	8.4
pH	8.1	8.1	8.1	8.1	8.1	8.1
SALINITY/HARDNESS						
24 HOURS						
ORGANISMS SURVIVING	10	10	10	10	10	10
% SURVIVL	100%	100%	100%	100%	100%	100%
TEMP.	13.0	13.0	13.0	13.0	13.0	13.0
D.O.						
pH						
48 HOURS						
ORGANISMS SURVIVING	10	10	10	10	10	10
% SURVIVAL	100%	100%	100%	100%	100%	100%
TEMP.	12.8	12.8	12.8	12.8	12.8	12.8
D.O.						
pH						
72 HOURS						
ORGANISMS SURVIVING	10	10	10	10	10	10
% SURVIVAL	100%	100%	100%	100%	100%	100%
TEMP.	13.0	13.0	13.0	13.0	13.0	13.0
D.O.						
pH						
96 HOURS						
ORGANISMS SURVIVING	10	10	10	10	10	10
% SURVIVAL	100%	100%	100%	100%	100%	100%
TEMP.	13.0	13.0	13.0	13.0	13.0	13.0
D.O.	6.0	6.0	3.4	3.0	5.2	5.4
pH	8.1	8.1	8.1	8.1	8.1	8.1
SALINITY/HARDNESS						

TU: No Mortality



PG&E
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT
Outfall - Discharge 001
Lead mg/l MAX: 8E-03
.009
.006
.003
0.000
Cadmium mg/l MAX: 3E-03
.003
.002
.001
0.000
Total Cr mg/l MAX: 2E-03
.040
.030
.020
.010
0.000
Cu mg/l MAX: .02
.040
.030
.020
.010
0.000
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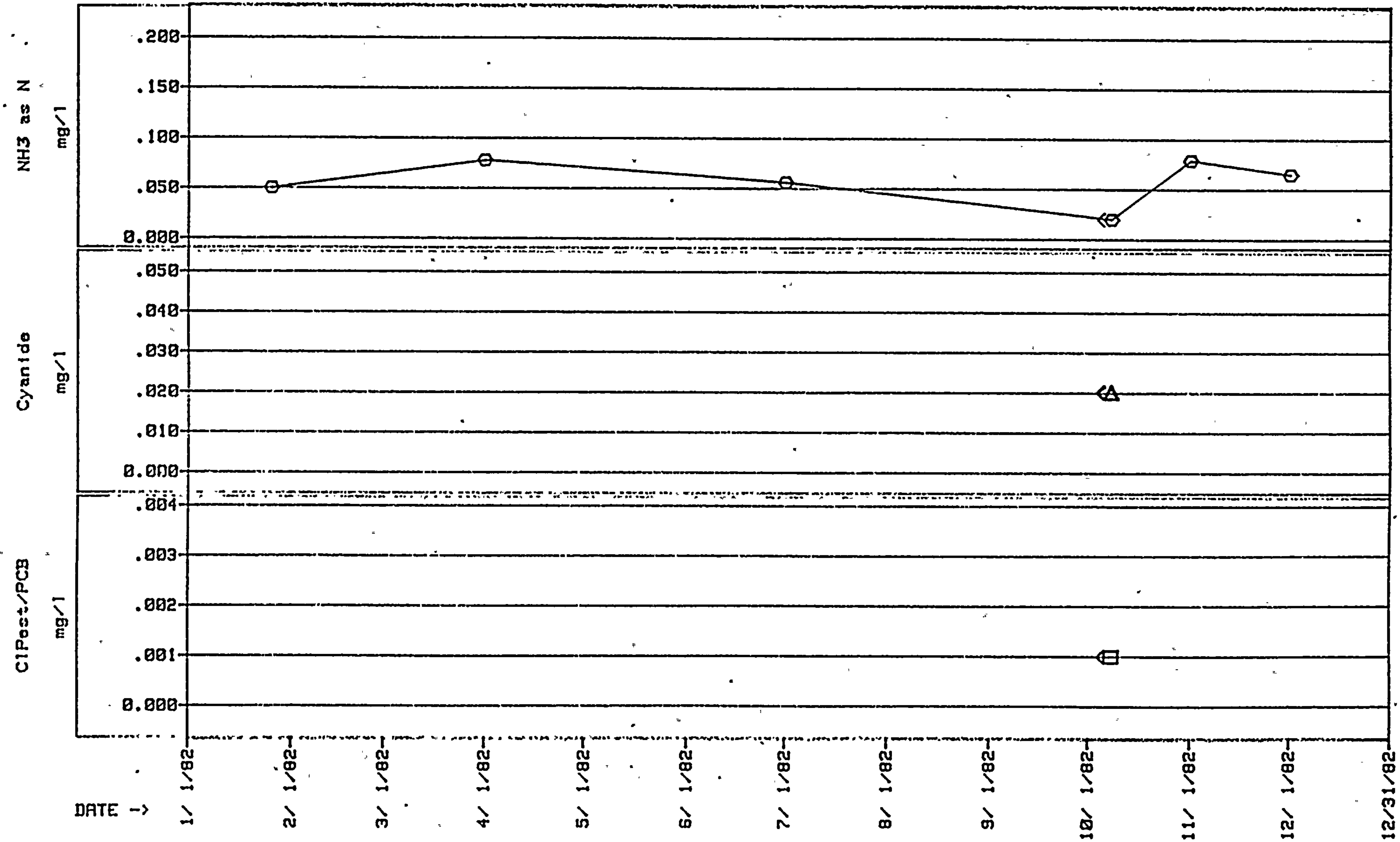
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Outfall - Discharge 001



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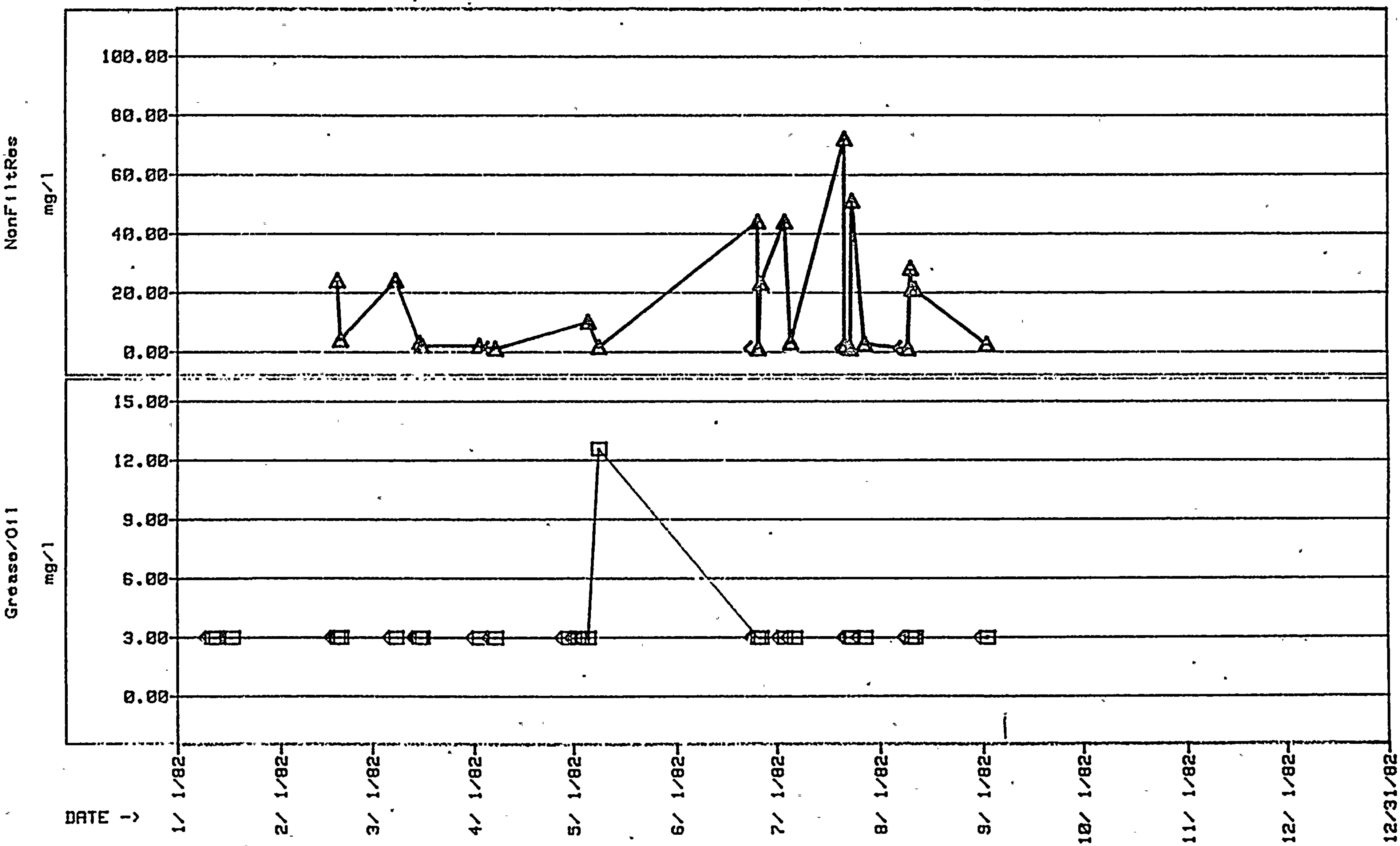
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Make Up Demineralizer - Regenerant Discharge 001C



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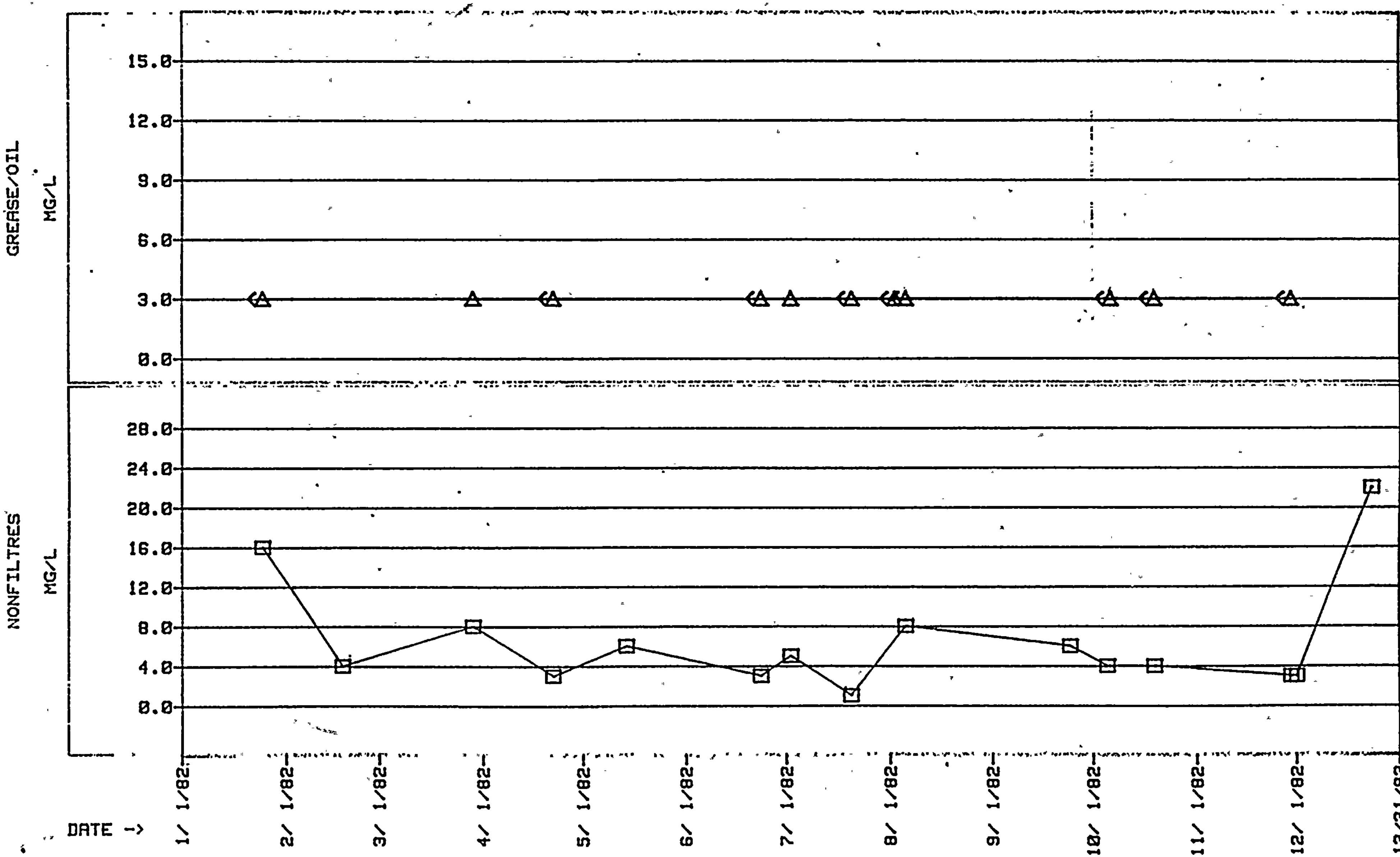
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

NPDES - 001D LRW



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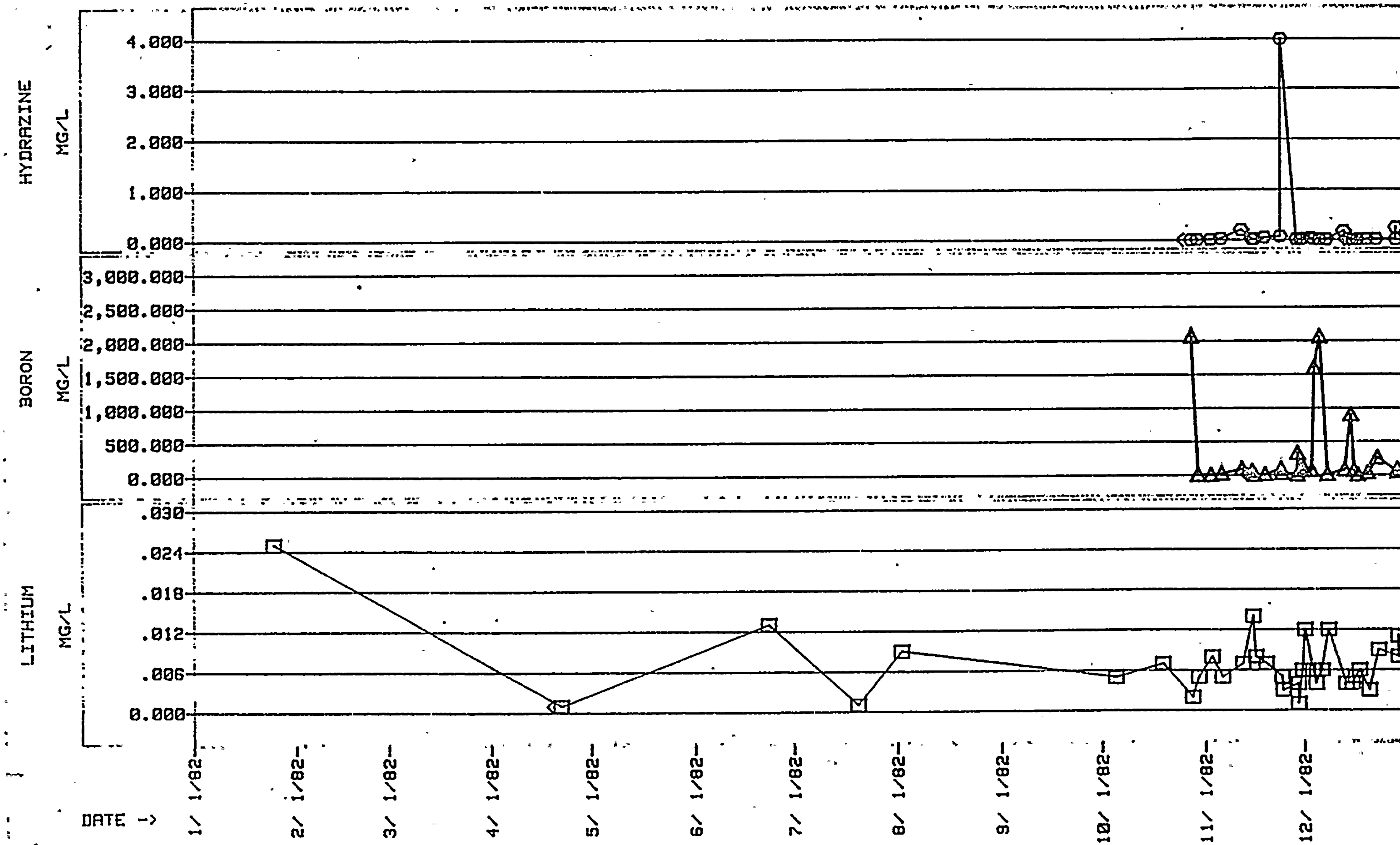
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

NPDES - 001D LRW



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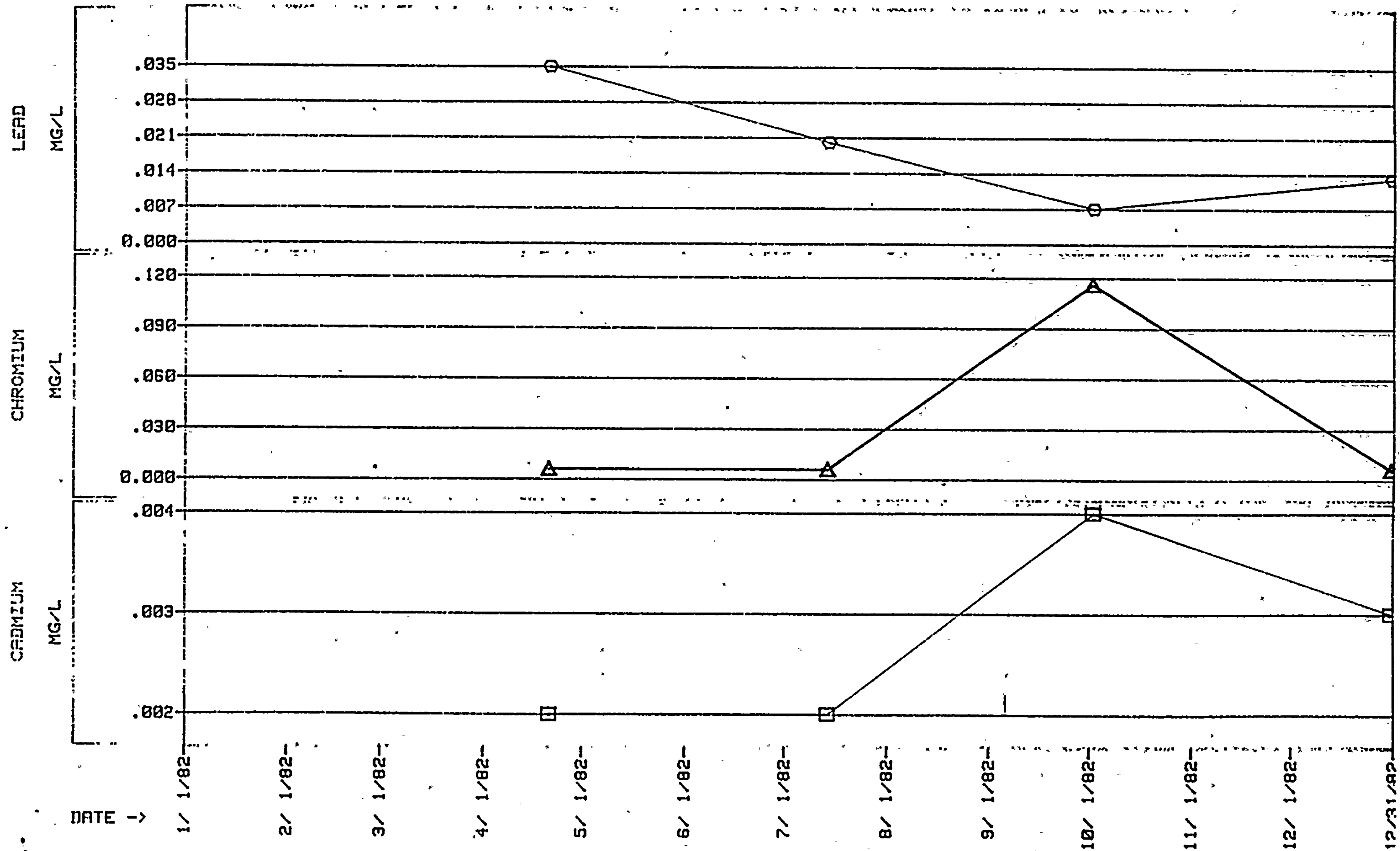
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

NPDES - 001D LRW



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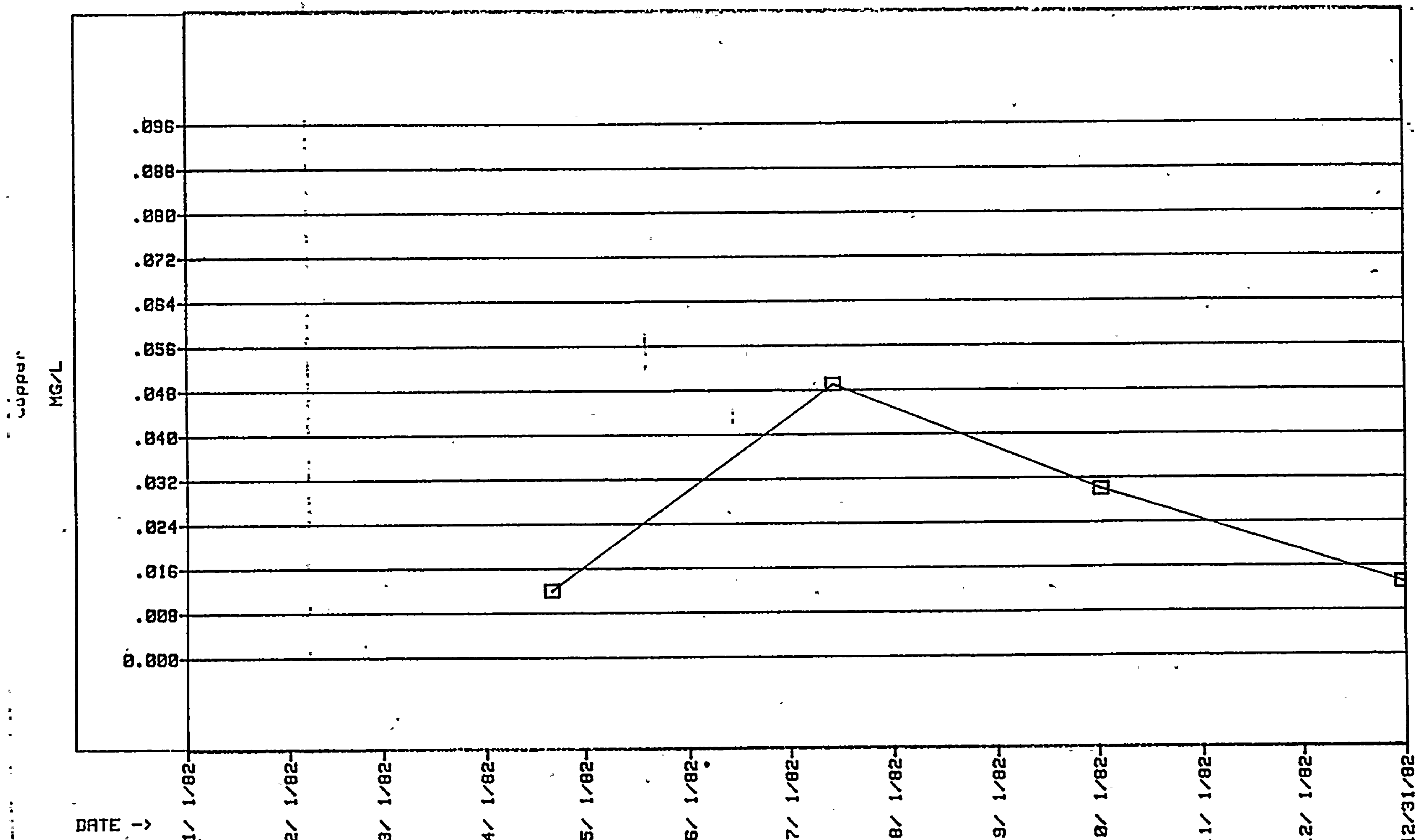
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

NPDES - 001D LRW



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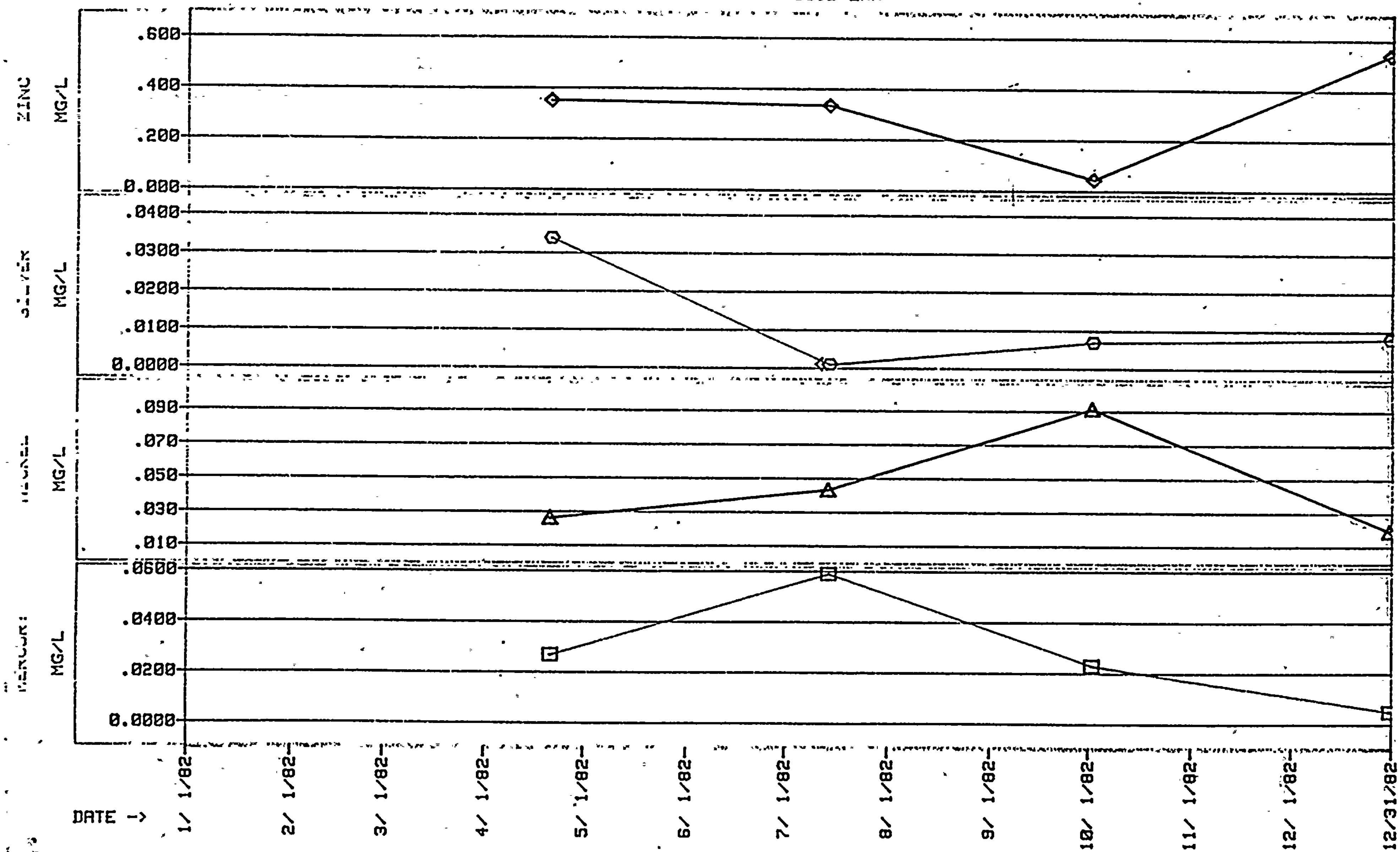
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

NPDES - 001D LRW



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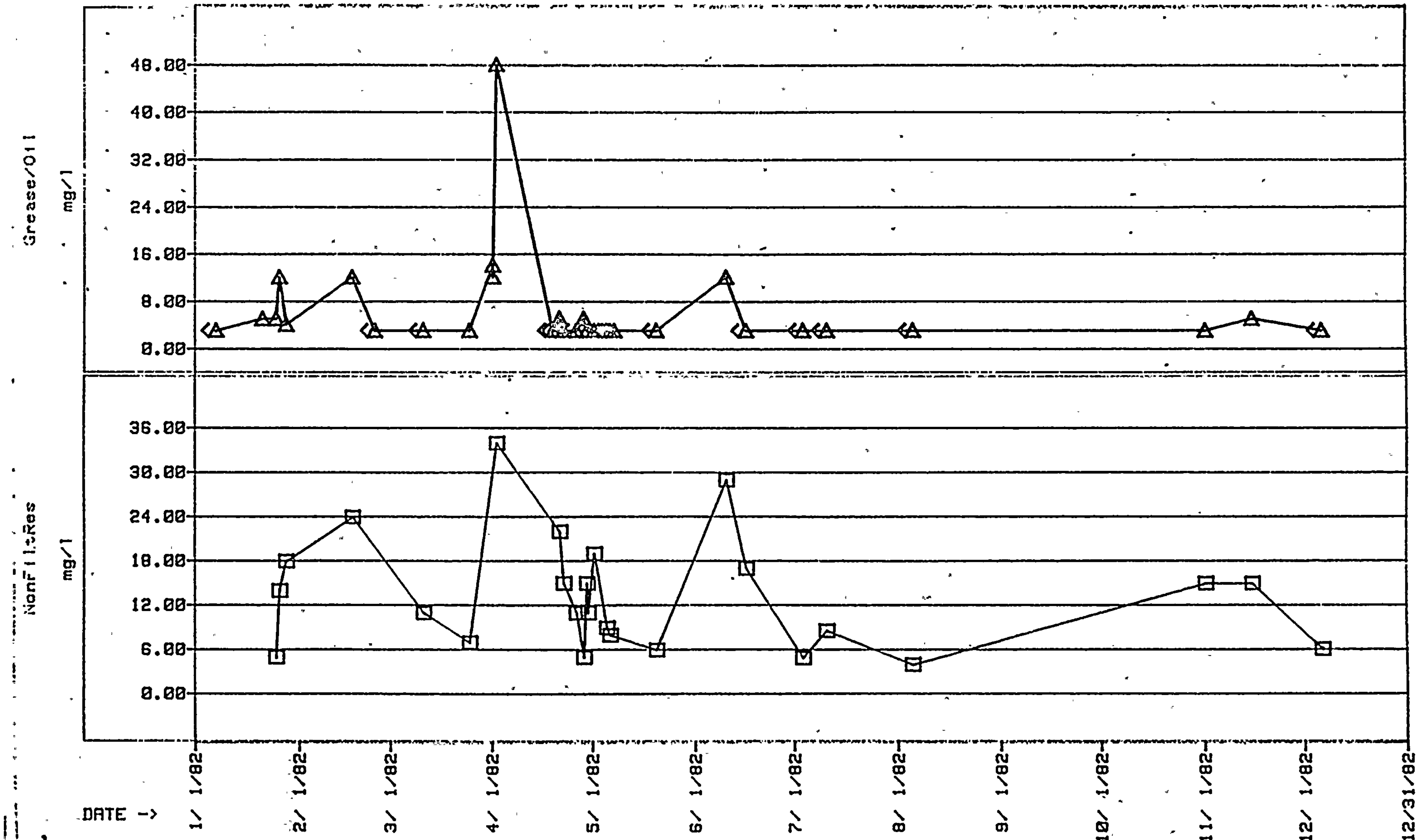
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Waste Pond and O.W.S.-Turbine Bld. Sump 001F - O.W.S./Turb. Bld. Sump 001F



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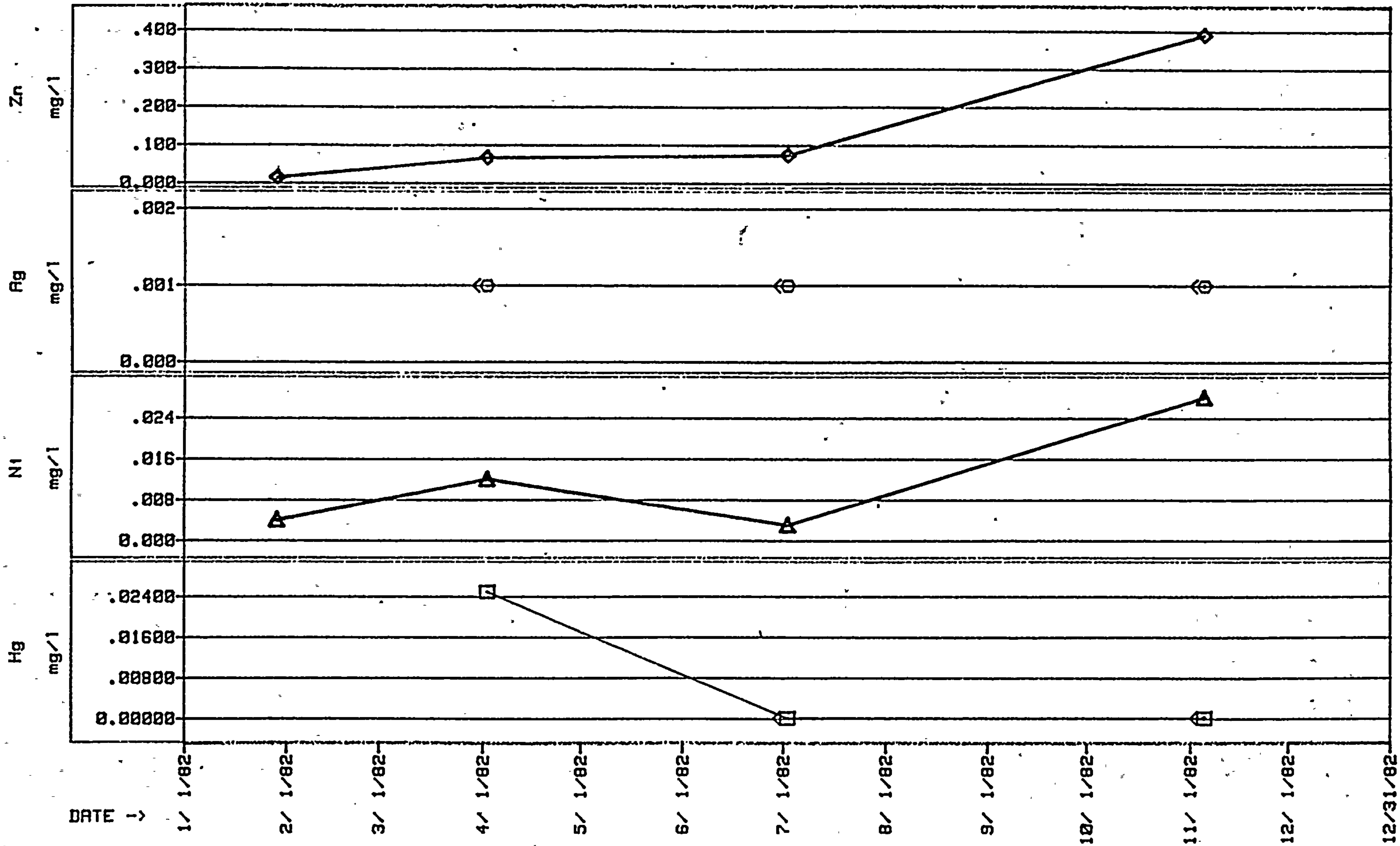
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Waste Pond and O.W.S.-Turbine Bld. Sump 001F - O.W.S./Turb. Bld. Sump 001F



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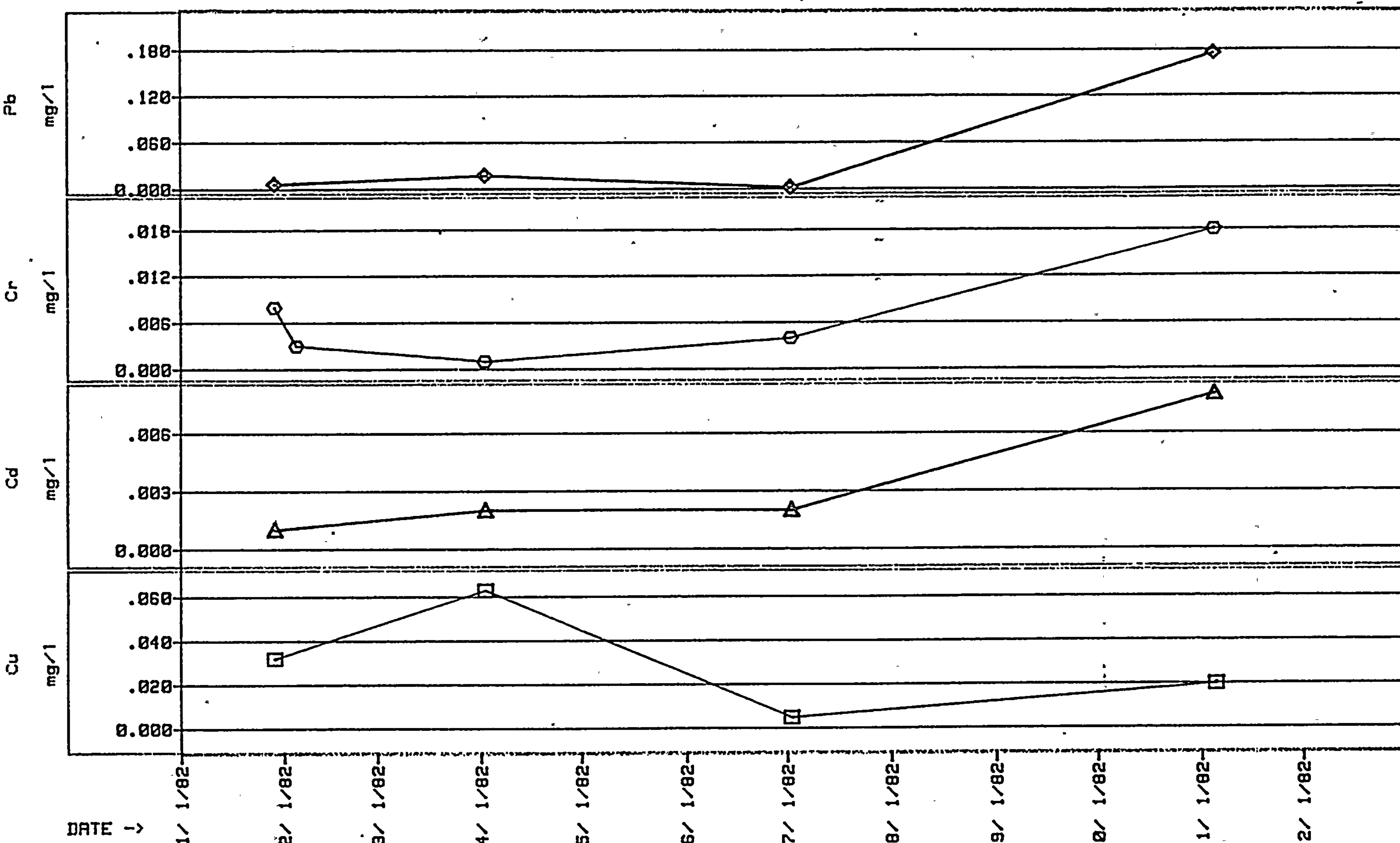
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Waste Pond and O.W.S.-Turbine Bld. Sump 001F - O.W.S./Turb. Bld. Sump 001F



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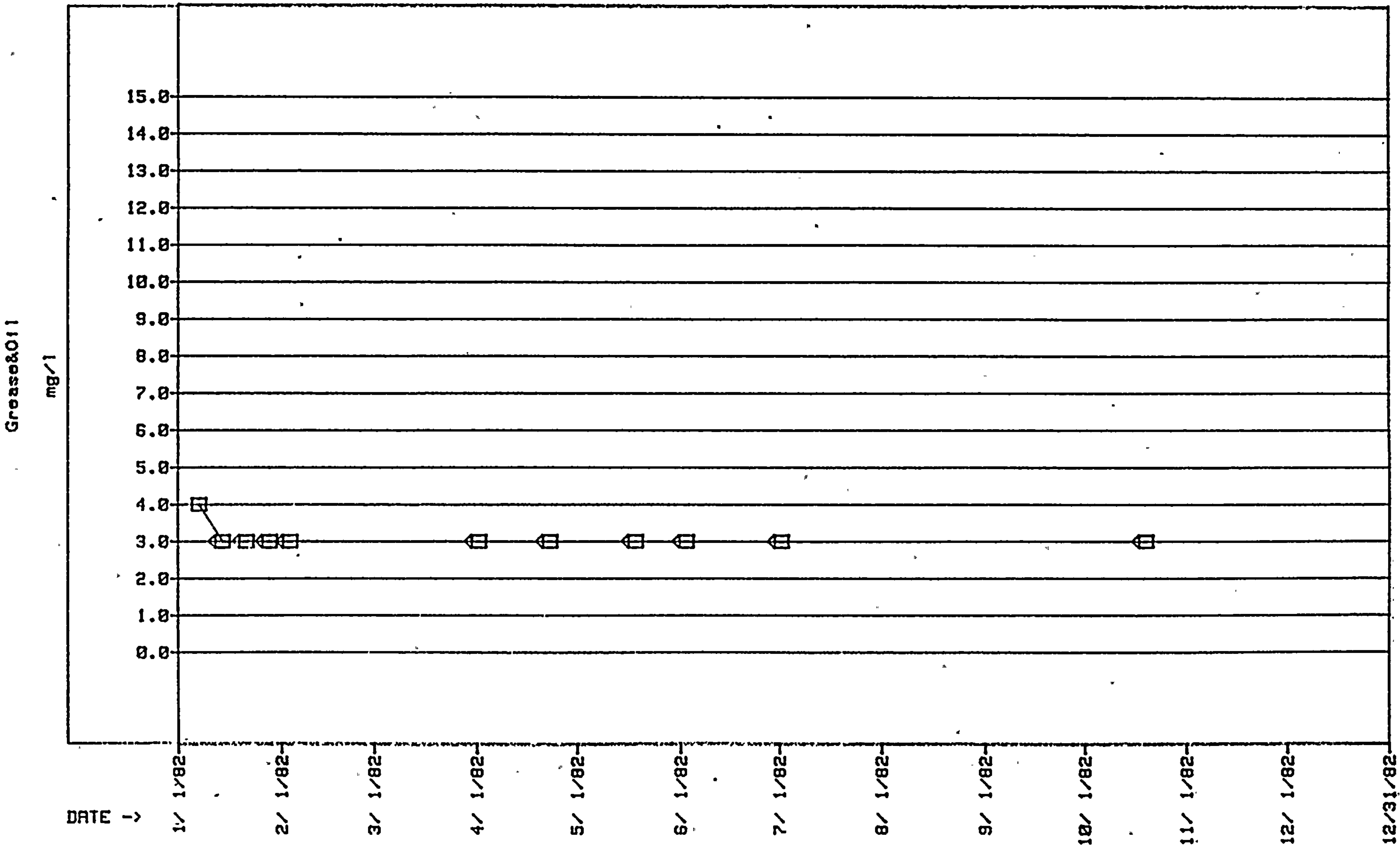
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Intake Building Floor Drain 002



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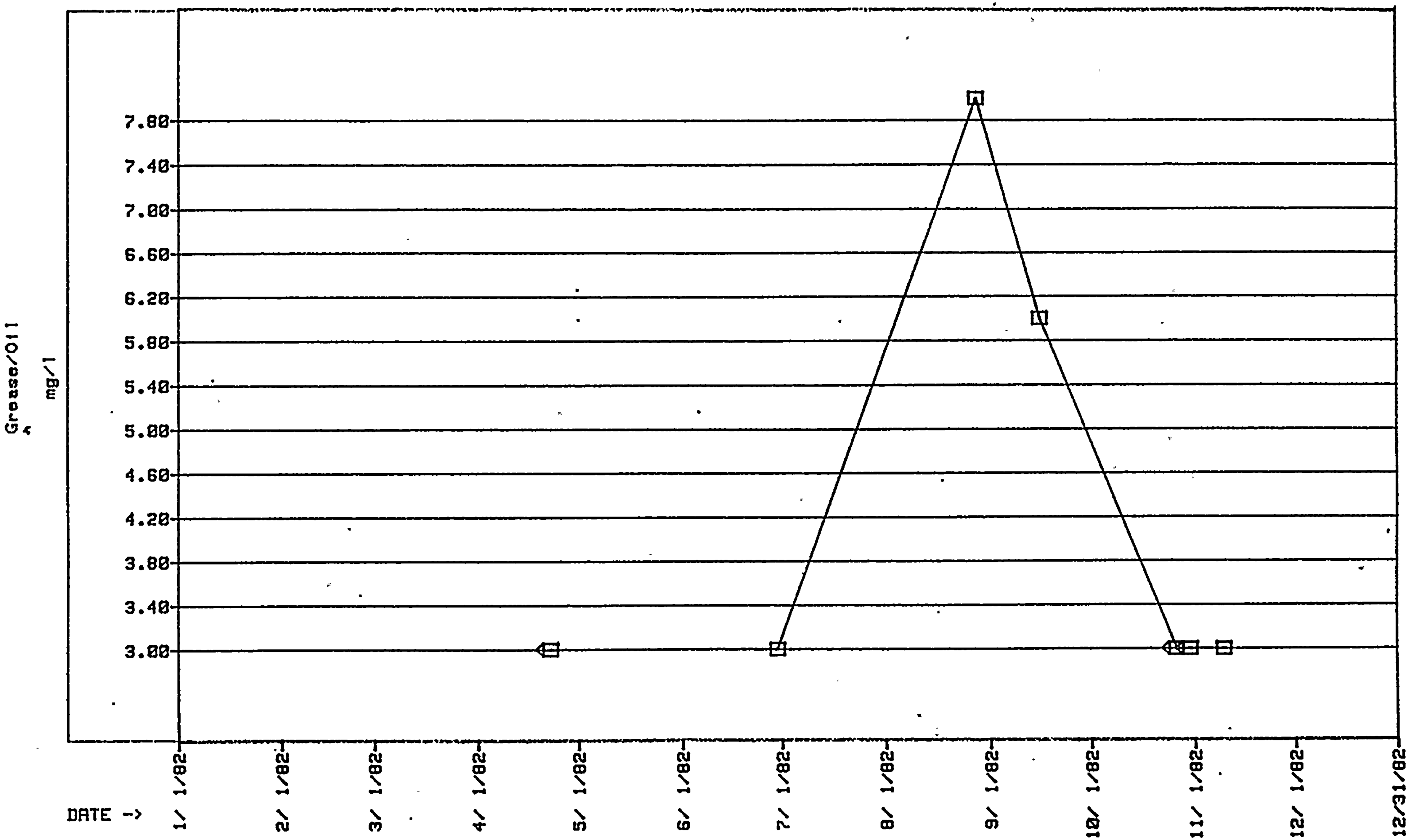
NUCLEAR PLANT OPERATIONS - DIABLO CANYON POWER PLANT

Intake/Drains - Yard Storm Drains 005



APPENDIX IV

Bioassay Results

(Not Reported Elsewhere)

Assay 84-S Unit 1, Disch 001, Pump Start-up

Assay 87-R Unit 1, Disch 001-B, Elevated Copper

OBSERVATIONS OF THE SEA OTTER

Enhydra lutris

POPULATION

Between Point Buchon and Rattlesnake Creek

San Luis Obispo, California

January through December 1982

By

Suzanne V. Benech

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

Sea otter numbers, rafting sites and incidental feeding activities were recorded twice a month from January through December, 1982. Subtidal sea urchin and abalone density surveys, tagged sea otter and night activity observations were also conducted. The overall sea otter population in the study area has continued to stabilize although seasonal fluctuations still occur. Females and pups represented approximately 80% of the population throughout most of the year, while males represented a larger proportion of the population (50%) in the late fall and early winter. Feeding observations indicated that abalone is no longer the most predominant prey species as it was out ranked for the first time by crab and "others" food categories representing 16, 65 and 19% respectively. Sea urchin densities were detectable (1/300 m^2) for the first time since 1978. Abalone densities decreased to 1/100 m^2. Tagged sea otter observations indicated that a major influx of animals came from the San Simeon area approximately 30 miles north of the study area. Night observations continued to confirm that sea otters actively forage after dark.

Introduction

Sea otter (Enhydra lutris) activities along the Buchon headland in San Luis Obispo County, California have been monitored since 1973 when they were first sighted along this portion of the coast. The 1982 Sea Otter Report represents the tenth annual summary of sea otter behavior and population dynamics within the vicinity of Pacific Gas and Electric Company's (PG&E) Diablo Canyon Nuclear Power Plant (DCNPP). These studies represent ten years of sea otter observations prior to power plant operation. The annual sea otter reports generally document the reestablishment of this area as part of the sea otter's southernmost range. These observations in conjunction with other environmental studies funded by PG & E, continue to contribute to the understanding of both sea otter population dynamics and the interrelationships of this species with sublittoral community structure within the DCNPP vicinity.

Objectives:

The 1982 observations of sea otter activities within the vicinity of the Diablo Canyon Nuclear Power Plant were accomplished by:

1. Sea otter counts
2. Recording sea otter distributions
3. Observing sea otter feeding habits
4. Surveying sea urchin densities

5. Recording tagged sea otters
6. Observing sea otters night behavior

Study Area:

The study area is located along 15 kms of coastline off the Buchon headland in San Luis Obispo County, California (Figure 1). To provide a standardized reference, the area from Point Buchon to Rattlesnake Creek has been divided into 5 major zones based on known sea otter resting sites (Figure 2). In addition, these zones are further subdivided as an aid in mapping and tracking sea otter activities (Figure 3).

Procedures:

Survey procedures remain unchanged from those of 1981. Observations of sea otter numbers, locations, distributions, movements and feeding behavior were bi-weekly. Counts and activity scans were accomplished by using both 7 x 50 binoculars and a high resolution (60-80x) field telescope from various points along the coastline providing a relatively clear and overlapping view of each zone. Incidental behavior, and sea otter distributions were made during these counts.

A subtidal survey, using scuba, was conducted in the Pecho Rock area. This is a continuation of the sea urchin and abalone density documentation begun in 1974 to aid in the understanding of sea otter foraging effects. The sampling

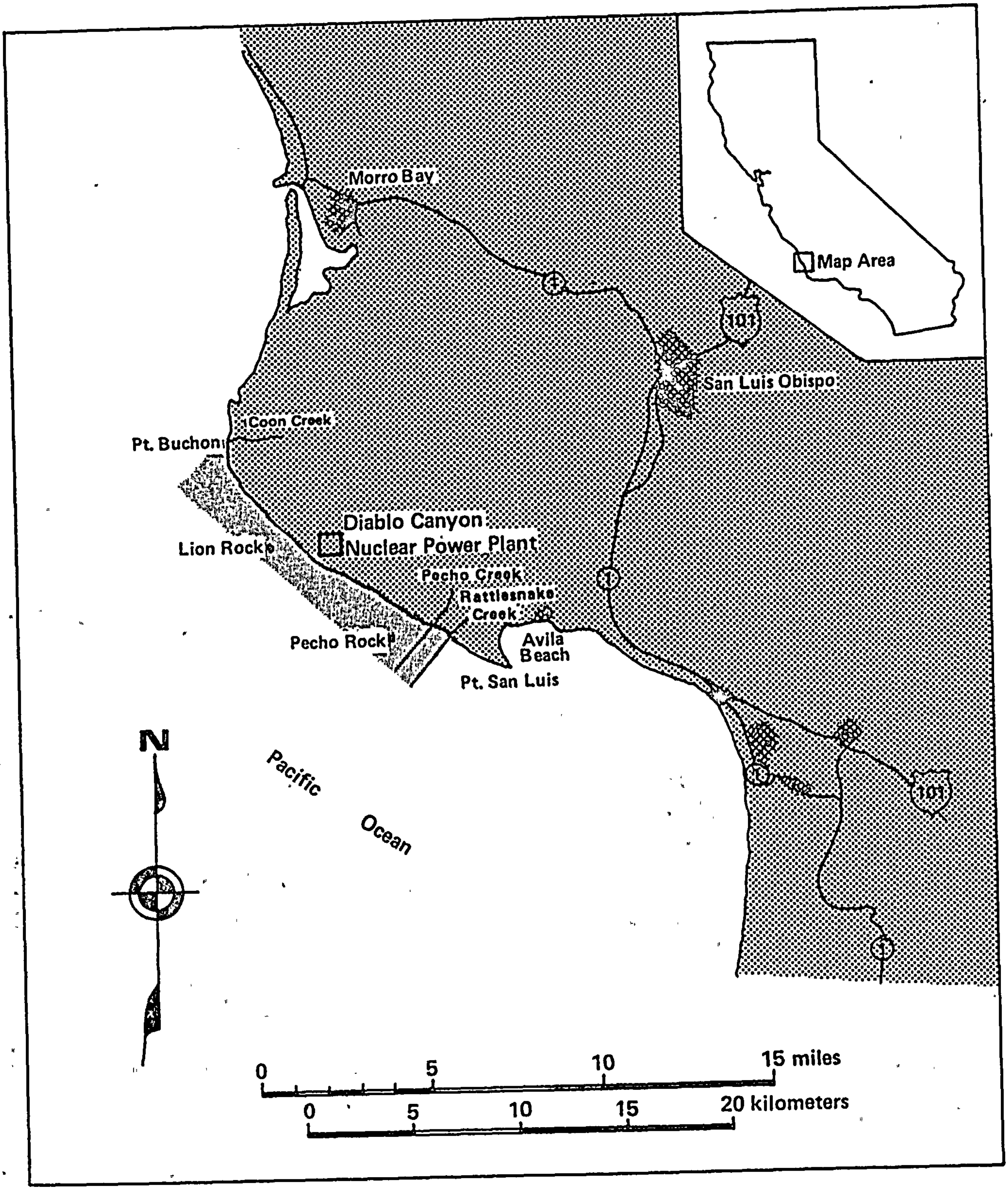


FIGURE 1

STUDY AREA

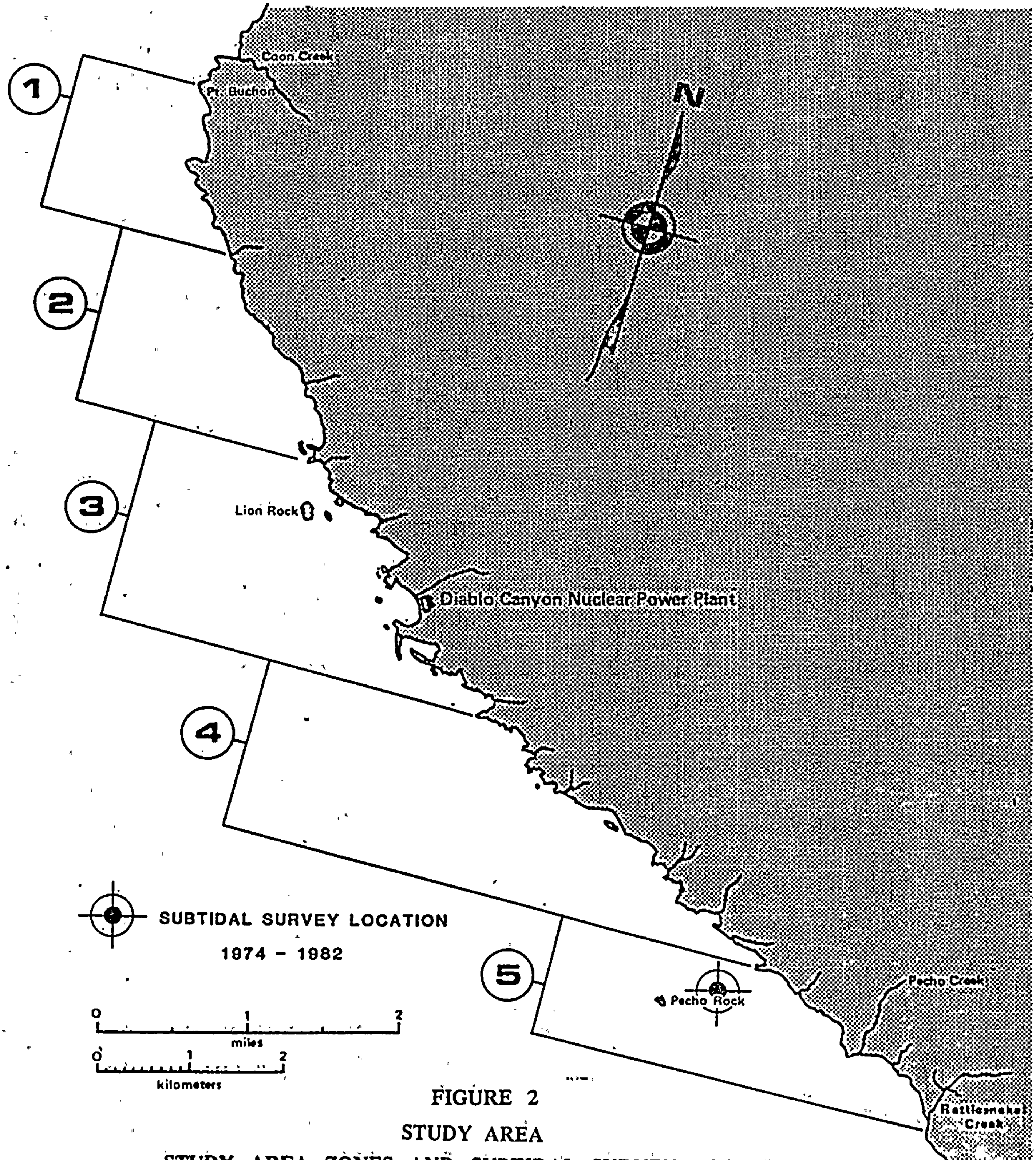


FIGURE 2
STUDY AREA
STUDY AREA ZONES AND SUBTIDAL SURVEY LOCATION

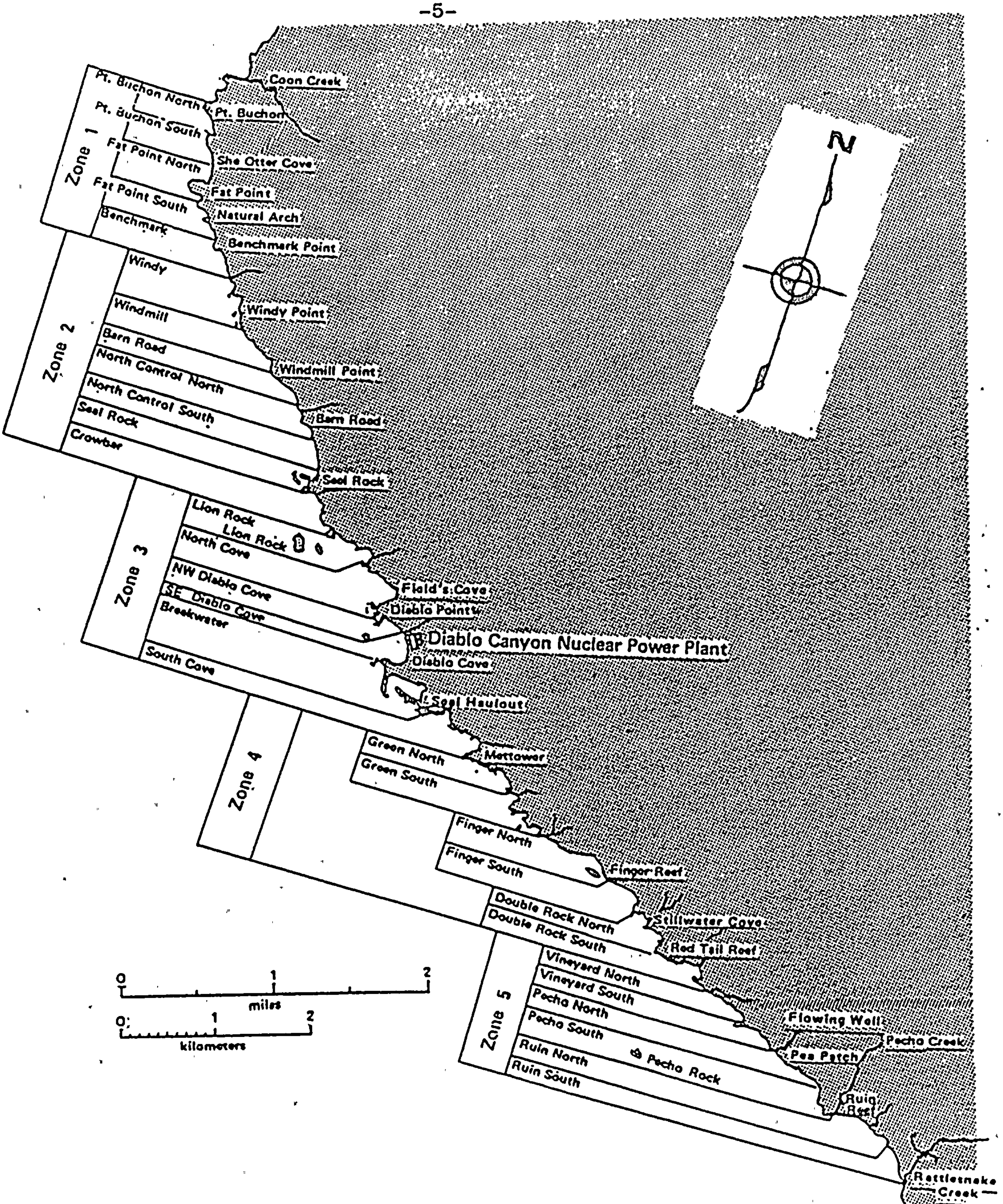


FIGURE 3

STUDY ZONE SUBDIVISIONS

techniques are the same as in previous years, using 10 randomly placed 30 square meter circular transects within a fixed 0.5 square kilometer kelp bed area near Pecho Rock (Figure 2). Sea urchin (Strongylocentrotus franciscanus) and abalone (Haliotis rufescens) counts remain restricted to macroscopic animals (>2cm). As is previous studies, a 500 mm night scope was used to document nocturnal sea otter activities. Hourly observations were made on a female raft of sea otters from dusk to dawn.

Results:

Population size

A large consolidated raft of predominately male sea otters which typically occurred in the study area from 1973-1979 has not been observed within these boundaries for 46 months.

The area between Point Buchon and Rattlesnake Creek remains dominated by females and pups which generally accounted for about 80% of the overall resident population (Table 1). Although total area counts continue to fluctuate seasonally, the influx is not as large as in the past. Consistent with previous years, sea otter counts are generally higher in the winter and spring and low in the summer and fall (Figure 4). The 1982 seasonal average from January through June was 29, dropping to 23 for July through December. The winter/spring average is similar to that of 1981 (21), while the summer/fall average was higher and somewhat more stabilized

TABLE 1

MONTHLY SEA OTTER COUNTS

1982

MONTH	COUNT	MEAN	S. D.	MINIMUM PROBABLE ADULT FEMALES		MAXIMUM NO. OF PUPS OBSERVED		MAXIMUM PROBABLE ADULT MALES	
				NO.	% OF POP.	NO.	% OF POP.	NO.	% OF POP.
JANUARY	13, 5	9	5.7	8	89	1	11	5	56
FEBRUARY	19, 20	20	0.7	11	55	5	25	4	20
MARCH	34, 24	29	7.1	18	62	7	24	4	14
APRIL	30, 43	37	9.2	25	68	8	22	4	11
MAY	37 30	34	5.0	20	59	8	24	6	18
JUNE	38, 33	36	3.5	22	61	10	28	5	14
JULY	32, 26	29	4.2	20	69	5	17	4	14
AUGUST	24			19	79	4	17	1	4
SEPTEMBER	NO. OBSERV.								
OCTOBER	16, 25	21	6.4	14	65	2	10	5	24
NOVEMBER	21, 20	21	0.7	19	90	6	29	6	29
DECEMBER	15, 23	19	5.7	5	26	2	11	12	63

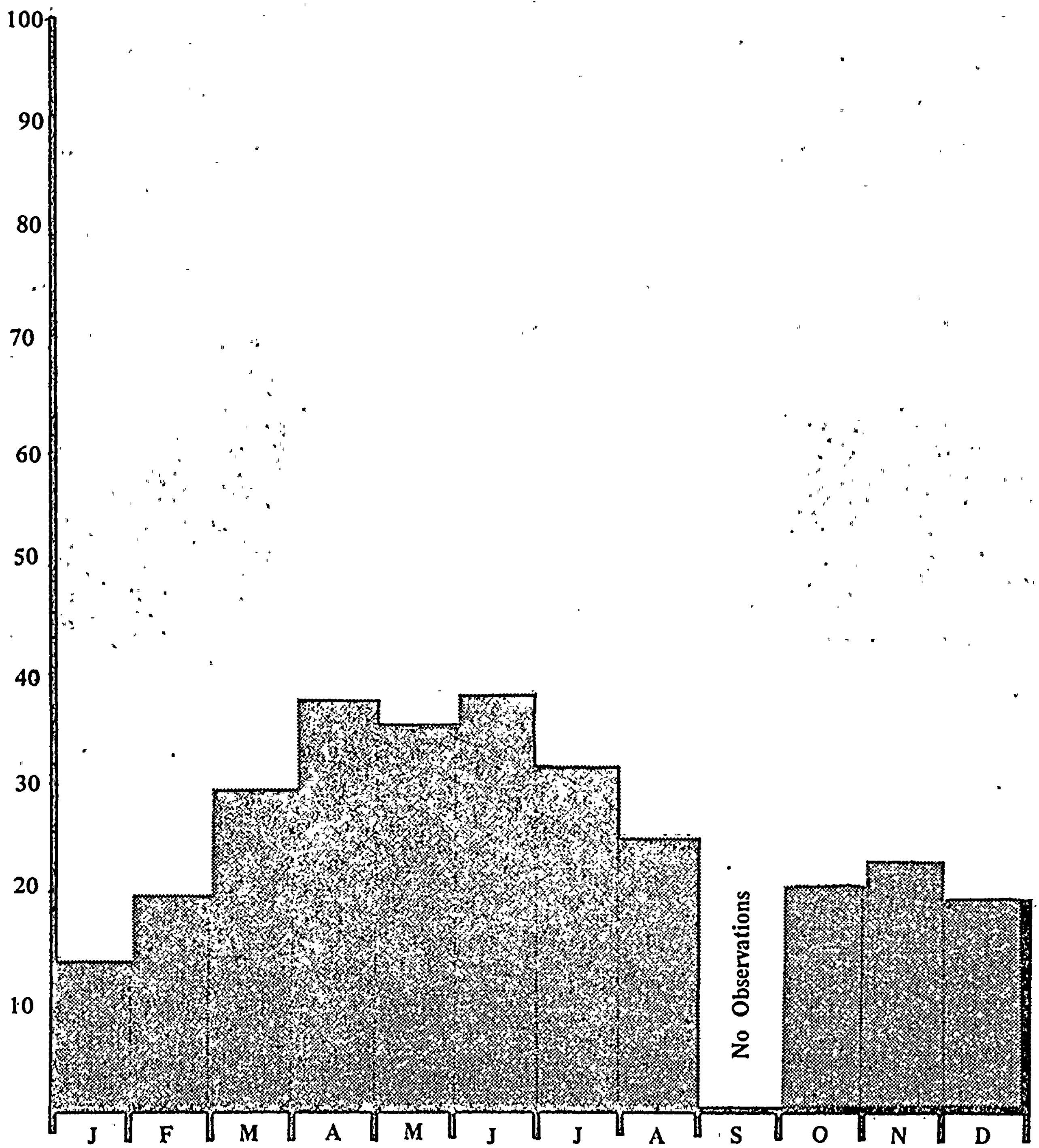


Figure 4

AVERAGE MONTHLY COUNTS

OF SEA OTTERS IN THE STUDY AREA

1982

than the average (16) of the previous year. This years, like 1980 and 1981, displays a significant reduction in population size since the southern front no longer resides within the study area.

The highest single count in 1982 occurred in April and totaled 43 individuals. Although the lowest counts traditionally occur in the fall, both this year and in 1981 the low count has been recorded in January, with totals of 14 and 7 respectively.

Population Distribution and Composition:

Male and female sea otters were observed throughout the study area and in all zones (Table 2). Males were generally found scattered individually within zones 1 through 4 and in a small group ranging from 2 to 9 animals in zone 5. It is likely that the solitary males were territorial, although the exact boundaries of each were unknown. Apparently, two of these "territorial" males resided near the power plant site (zone 3), a third was regularly found near Fat Point in zone 1 and a fourth near Finger Reef in zone 4. Zone 5 remained predominately male territory. The total numbers of animals located in zones 4 and 5 are notably lower than in the remainder of the study area (Figure 5). December was the only month when a male raft of any size (9) was present.

Female raft sizes ranged from 2 to 31 animals and were generally larger than male rafts in the study area. There

TABLE 2
SEA OTTER COUNTS

DATE	January 18	January 31	February 27	February 28	March 7	March 20	April 17	April 30
ZONE 1								
Point Buchon							1	
Fat Point North								
Fat Point South					1			
Benchmark Point	6		10		1	1		
ZONE 2								
Windy Point			1 + 1	2	9 + 1		4	4 + 1
Windmill			1	4 + 1	1 + 1	3		2 + 2
Barn Road		1		1 + 1		3	2	
North Control N.		1				3 + 3		
North Control S.			1	2 + 1	1 + 1		1	
Seal Rock				2				
Crowbar				2				
ZONE 3								
Lion Rock		2 + 1	1	2 + 2	11 + 4	2 + 1	14 + 4	26 + 5
North Cove							1	
N.W. Diablo Cove			1					
S.E. Diablo Cove					1	3 + 1	1	
Breakwater			1					
South Cove								
ZONE 4								
Green North								1
Green South								1
Finger North						1		1
Finger South								
Double Rock N.	2					1		
Double Rock S.							1	
ZONE 5								
Vineyard North								
Vineyard South								
Pecho North								
Pecho South	1		1				1	
Ruin North	3							
Ruin South	1		1		1	2		
Rattlesnake					1			
TOTALS	13	4 + 1	18 + 1	15 + 5	27 + 7	19 + 5	26 + 4	35 + 8

* + = Pups

TABLE 2

SEA OTTER COUNTS
continued

DATE	May 7	May 14	June 3	June 17	July 4	July 24	August 15	
ZONE 1								
Point Buchon				1	1	1		
Fat Point North	1						2	
Fat Point South	3 + 1	1 + 1		1	1			
Benchmark Point	4	1 + 1		4 + 4	10 + 3	9		
ZONE 2								
Windy Point	1	3	9 + 3	11 + 3	6	6	14 + 1	
Windmill		8 + 5	1				2 + 2	
Barn Road	1				3	1		
North Control N.						3		
North Control S.								
Seal Rock			1					
Crowbar	2							
ZONE 3								
Lion Rock	10 + 3	4 + 1	10 + 6	3 + 1	2 + 2	2 + 1	1 + 1	
North Cove	1			1				
N.W. Diablo Cove	2 + 1		1 + 1			1		
S.E. Diablo Cove							1	
Breakwater	1		3		3			
South Cove	1							
ZONE 4								
Green North								
Green South								
Finger North								
Finger South								
Double Rock N.								
Double Rock S.	1							
ZONE 5								
Vineyard North								
Vineyard South								
Pecho North								
Pecho South	3	4	3	3	1	2		
Ruin North								
Ruin South	1							
Rattlesnake		1		1				
TOTALS	32 + 5	22 + 8	28 + 10	25 + 8	27 + 5	25 + 1	20 + 4	

* + = Pups

TABLE 2
SEA OTTER COUNTS
continued

DATE	September		October		November		December	
	No observations		11	19	7	17	6	20
ZONE 1								
Point Buchon			1					
Fat Point North			1			1		
Fat Point South			1		1 + 1	1		
Benchmark Point			8 + 1	14 + 1	6 + 2	8 + 2	3 + 1	7
ZONE 2								
Windy Point			1 + 1	2	1		1	2
Windmill						1	1 + 1	1
Barn Road				1	1			
North Control N.								
North Control S.								
Seal Rock								
Crowbar								
ZONE 3					1 + 1			
Lion Rock							3	
North Cove				1	1		1	1
N.W. Diablo Cove				2	2 + 2	1		
S.E. Diablo Cove								
Breakwater					1			
South Cove								
ZONE 4								
Green North						1		
Green South								
Finger North			2	3 + 1		2		1
Finger South								
Double Rock N.								
Double Rock S.								
ZONE 5								
Vineyard North								
Vineyard South								
Pecho North								2
Pecho South					1	3	4	9
Ruin North								
Ruin South								
Rattlesnake								
TOTALS			14 + 2	24 + 1	15 + 6	18 + 2	13 + 2	23

* + = Pups

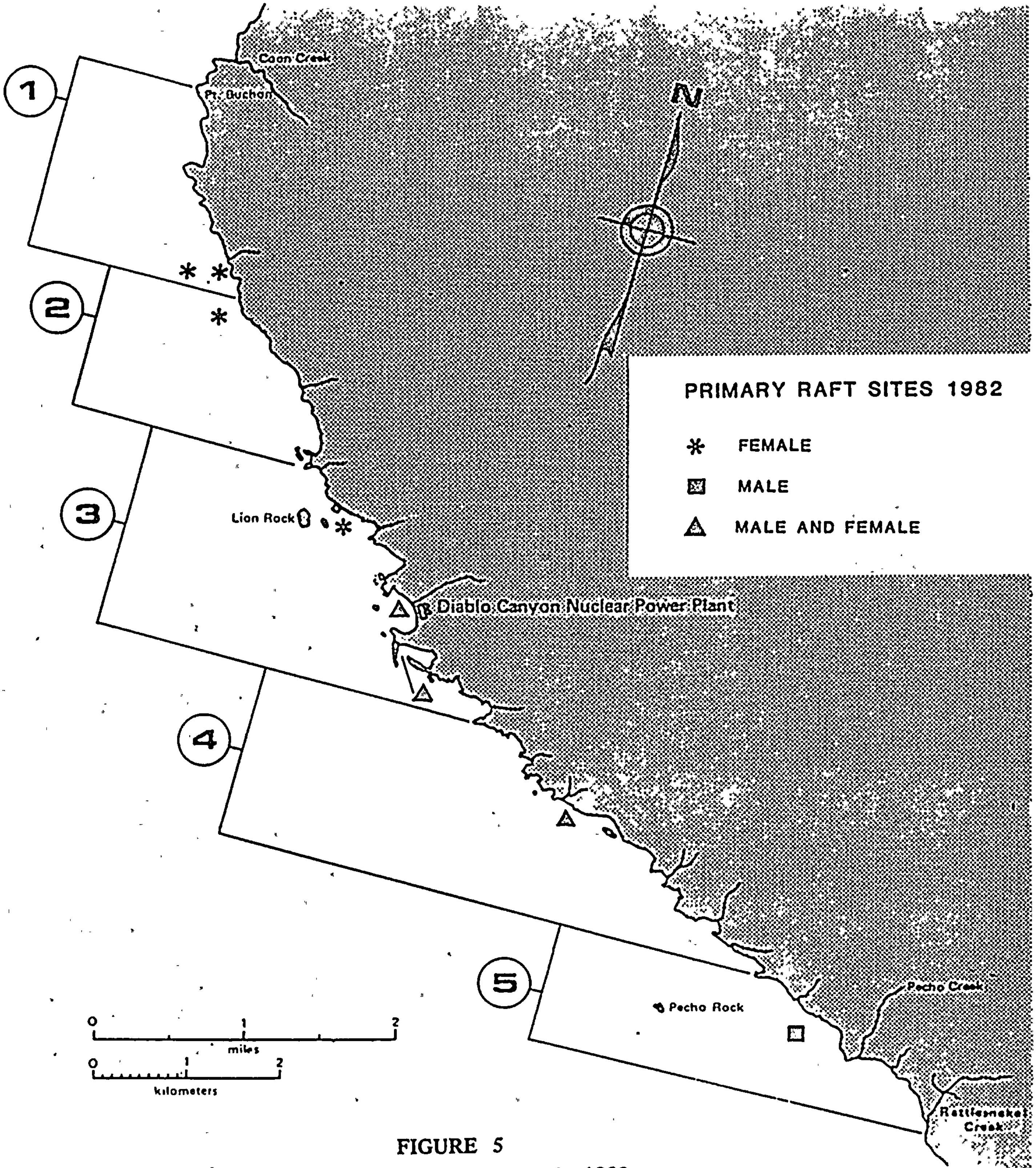


FIGURE 5
SEA OTTER RAFT LOCATIONS 1982

were 4 major female raft sites; 3 near Windy Point at the border of zones 1 and 2 and one in Lion Rock Cove in zone 3 (Figure 5). These locales are historically and currently the preferred female rafting areas. The 3 northernmost raft sites were all within 1 kilometer of each other. Two were located off Benchmark, and were probably occupied at different times by the same animals. The offshore location was occupied from January to December. In December, the offshore _Macrocystis_ kelp bed was abandoned and the inshore _Nereocystis_ kelp bed was occupied. The Windy Point _Macrocystis_ kelp bed was also a popular female rafting area which was occupied by small numbers of animals throughout the year.

Historically, Lion Rock Cove has been the most consistently occupied female raft site. This year, however, it was only used as a popular resting site from March through June. The females continue to be quite variable in their specific choice of raft sites as evidenced by the constant fluctuation of total animals at each of the preferred rafting locales.

Although females with pups were observed as far south as Finger reef in zone 4, there were no consolidated rafts of females beyond zone 3.

Unlike previous years (1980 and 1981), male and female raft sizes increased and decreased with a different seasonal pattern. The largest female raft sizes were in April, May

and June. The only notable increase in the male raft size was in December.

Although female sea otters still prefer to raft in Macrocystis, some rafting sites in zone 4 and zone 1 were located in Nereocystis kelp beds.

Since 1980, females have outnumbered males in the study area. The ratio of males to females and dependent pups varied with season. From March to July, ratios of 6 females to 1 male were common. In January and February and again in October and November, ratios of 3 to 1 were observed. By December, the ratios had reversed, males outnumbered females 2 to 1.

The largest number of pups observed in the area during a single count was 10, recorded in June. On the average, pups represented nearly 20% of the total population and ranged from a low of 7% to a high of 29% in November.

It should be noted that the males generally remained solitary and scattered throughout all zones but associated with female rafting sites. Unlike last year, some males did occupy a distinct raft in zone 5. This raft reached its maximum size of 9 sea otters in December.

Feeding Observations:

Crabs (Cancer spp. and Pugettia sp.). were the most commonly observed food items representing 65% of all the

prey species being consumed by sea otters. The category of composite molluscs which include species of mussels, clams and turban snails remains an important part of the sea otter's diet at 19% of the total observed food items. Abalone (Haliotis spp.) prey item observations were significantly lower than in the past, accounting for only 16% of the total. Sea urchins (Strongylocentrotus spp.), a preferred but now scarce food item, was not recorded during these incidental feeding observations (Figure 6).

Abalone, (for the first time since sea otters reestablished themselves off this portion of coastline in 1973), has dropped below that of crab and "others" species in frequency of occurrence.

Crab species dominate all other food categories, followed by the mollusc group. Abalone, a historically preferred item, is no longer the single most commonly observed prey. Sea urchins, a historically preferred food source, do not represent an important food source at this time in the study area.

The total number of feeding observations within each zone generally reflects the proximity of rafting sites (Table 3). Zone 2 accounted for about 32% of the total feeding observations, followed by zone 3 with 26% and zone 5 with 19%. The area within zone 2 is bordered by the two most constantly occupied raft sites and was continuously used by animals from both sites as a foraging area. Zone 3 was

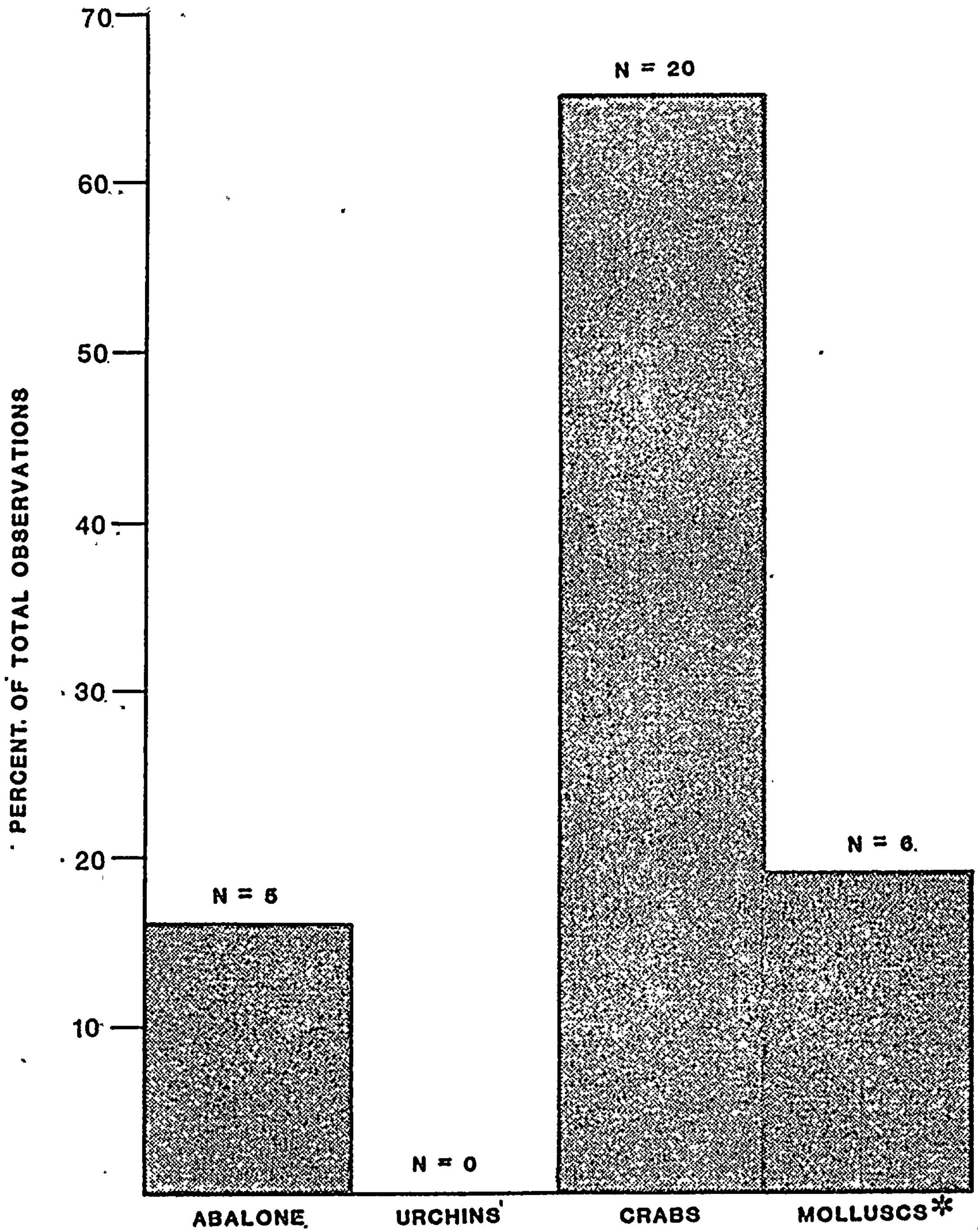


FIGURE 6

FOOD ITEM SUMMARY

TOTAL FEEDING OBSERVATIONS

1982

* MUSSELS, CLAMS, TURBAN SNAILS

TABLE 3

SUMMARY OF SEA OTTER FEEDING OBSERVATIONS

1982

		AB	U	C	S	TOTAL
ZONE 1	OBSERVED	0	0	1	2	3
	% TOTAL	0	0	33	67	
ZONE 2	OBSERVED	1	0	8	1	10
	% TOTAL	10	0	80	10	
ZONE 3	OBSERVED	1	0	4	3	8
	% TOTAL	13	0	50	38	
ZONE 4	OBSERVED	2	0	2	0	4
	% TOTAL	50	0	50	0	
ZONE 5	OBSERVED	1	0	5	0	6
	% TOTAL	17	0	83	0	

AB = ABALONE

U = URCHIN

C = CRAB

S = SHELLED MOLLUSCS

occupied by a female raft at Lion Rock and the nearby Diablo area was actively foraged by territorial males, as well as females and pups.

Crabs were the only food category observed being consumed in all zones. Observations of sea otters feeding on sea urchins were absent at all zones.

Observed feeding activity within the most heavily foraged area, zone 2, seemed to be divided between the Windy Point and Barn Road sections of the coastline. Feeding activity in zone 3 seemed to be more concentrated at its northern end near the large female raft at Lion Rock (Table 4). The majority of all the observed feeding activity remains in the shallow subtidal and low intertidal zones (less than 7 meters).

Subtidal Survey

For the first time since 1978, a sea urchin was found within one of the ten subtidal stations. Thus, sea urchin densities within the Pecho Rock study area have apparently increased from non-detectable levels to 1 per 300 m^2. The sea urchin test diameter was approximately one inch, which suggests that the animal was in its first year of growth and a new recruit to the area. Abalone densities have decreased from from those of 1980 and 1981. This year densities of 1 per 100 m^2 were recorded. Each of the 3 animals observed were adults between 5 and 7 inches in length and well hidden

TABLE 4

FEEDING OBSERVATIONS

ZONE	LOCATION	UNID AB	BLCK AB	RED AB	CANC CRAB	KELP CRAB	MOLLUSC	TEG TURB
1	Buchon							
	Lover's							
	She Otter							
	Fat Point						1	
	Natural Arch				1			
	Benchmark							1
2	Windy Point			1	2		1	
	Windmill							
	Windmill South							
	Barn Road				3	1		
	North Control					2		
3	Lion Rock				1	2	1	
	Diablo		1		1		2	
	Seal Haulout							
	South Cove							
4	Met. Tower							
	Green Peak							
	Finger			1	1			
	Redtail							
	Double Rock			1	1			
5	Pecho							
	Wash Rock							
	Flowing Well							
	Pea Patch In				4	1		
	Pea Patch Out							
	Ruin Reef	1						
	Rattlesnake							
	TOTALS	1	1	3	14	6	5	1
	GRAND TOTAL	31						

Percent Representation Abalone 16 Urchins 0 Crabs 65 Others 19

UNID AB: Unidentified Abalone (Shell-less)

BLCK AB: Black Abalone *(Haliotis cracherodii)*

RED AB: Red Abalone *(Haliotis rufescens)*

CANC. CRAB: Crab *(Cancer antennarius)*

KELP CRAB: *(Pugettia producta)*

MOLLUSC: Mussel or Clam

TEG TURB: Turban Snail *(Tegula spp.)*

in narrow crevices and under rocks (Table 5).

There was no evidence of sea otters foraging for sea urchins in the area as there were no characteristically broken tests found. Although 11 broken abalone shells were found during the survey, the shells looked very old and did not appear to have been the result of recent sea otter foraging behavior. Several (4) scallop shells were also among the shell debris which had characteristic and relatively recent sea otter foraging marks.

In addition to the lush stands of algal turf (predominantly _Cryptopluera_, spp. _Hymenena_ sp. and _Botryoglossum_ sp. mix), the bat star (_Pateria_ sp.), sponges, and a variety of tunicates and boring clams (Pholadidae) dominated the bottom fauna.

Tagged Sea Otter Observations:

During 1982 a total of 11 tagged sea otter observations were recorded within the study area (Table 6). When the tag codes were keyed to the tag information provided by the California Department of Fish and Game and the U.S. Fish and Wildlife Service, it was found that all of the observed animals were originally captured and tagged off San Simeon approximately 30 miles up coast of the study area (Figure 7).

The tags identified 2 adult males and 3 adult females. Both males were observed in June, one in zone 1, and the other in

TABLE 5
SUBTIDAL SURVEY
PECHO ROCK AREA
1982

STATION	DEPTH	LIVE URCHIN COUNT	LIVE ABALONE
1	25	0	0
2	20	0	2
3	30	0	0
4	30	0	0
5	32	0	0
6	28	0	0
7	25	0	0
8	22	0	0
9	28	0	1
10	28	1*	0

LITTER OBSERVED AND COLLECTED WITH CHARACTERISTIC OTTER FORAGING MARKS IN THE STATION LOCALES

Mytilus californianus

Haliotis rufescens

PHOLADIDAE

Hinnites giganteus

*Approximately 1 inch *Strongylocentrotus franciscanus*

TABLE 6
TAGGED SEA OTTER OBSERVATIONS
1982

DATE	OBSERVED TIME (PST)	STUDY ZONE	TAGGED LOCALE*	RIGHT HIND COLOR POSITION	LEFT HIND COLOR POSITION	SEX	WEIGHT * (lbs)
3/7/82	1100	3	SAN SIMEON	DRK. BL. 1/2	RED.4/5	F+PUP	54
3/20/82	1100	3	SAN SIMEON	DRK. BL. 1/2	RED 4/5	F+PUP	54
4/17/82	1215	3	SAN SIMEON	DRK. BL. 1/2	RED 4/5	F+PUP	54
4/30/82	1300	3	SAN SIMEON	DRK. BL. 1/2	RED 4/5	F+PUP	54
5/7/82	1200	3	SAN SIMEON	DRK. BL. 1/2	RED 4/5	F+PUP	54
5/7/82	1200	3	SAN SIMEON	DRK. BL. 1/2	YELW. 4/5	F	
6/3/82	1030	3	SAN SIMEON	DRK. BL. 1/2	RED 4/5	F+PUP	54
6/17/82	0923	5	SAN SIMEON	WHITE 4/5	DRK. GRN 4/5	M	60
6/17/82	1130	3	SAN SIMEON	DRK. BL. 1/2	TEAR 1/2	F	
6/16/82	1223	1	SAN SIMEON	WHITE 4/5	YELW. 4/5	M	58
7/24/82	1700	3	SAN SIMEON	DRK. BL. 1/2	RED 4/5	F+PUP	54

* CDF & G and USF & W TAGGING INFORMATION

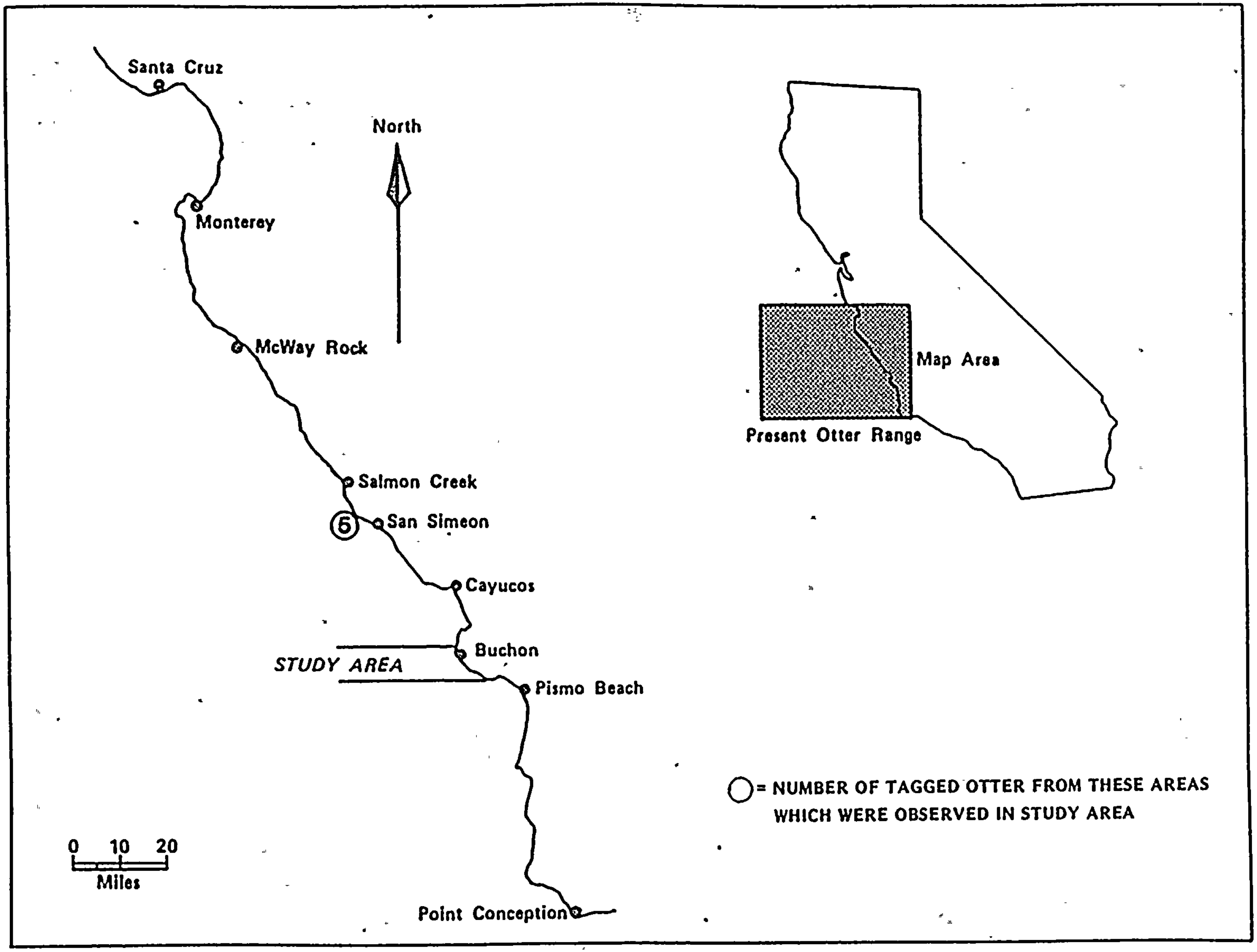


FIGURE 7

TAG OBSERVATION SUMMARY MAP

1982

zone 5. All of the females were observed in zone 3 at the raft site at Lion Rock. Observations of tagged females began in March and ended in July. The most continuously observed animal was a female who was seen with a woolly pup in early March and periodically sighted in the area with her pup in Diablo Cove and within the general area between these two raft sites.

Night Observations:

One night observation in zone 3 was conducted in May (Table 7). The raft of female sea otters and pups at Lion Rock Cove was observed on an hourly basis and an activity scan was made of the sea otters within the raft locale. Consistent with previous years, the females and pups actively foraged, traveled and groomed after dark. Movement of animals in and out of the raft site occurred throughout the night, but it appeared that the greatest numbers of sea otters were active between 2000 and 2300 hours.

General Behavior:

Table 8 presents a list of selected behavioral observations. In addition to the "normal" behavioral observations, two separate incidents of "abnormal" conditions of behavior were monitored (as a part of a separate study). The first incident was that of a small diesel oil spill, and since sea otters can die if their pelts become excessively oiled, observations of hauling out, excessive grooming activities

TABLE 7

NIGHT OBSERVATIONS

LION ROCK COVE

MAY 14-15

1982

TIME	NOTES	NO. OF OTTERS	ACTIVITY
1915	USING NIGHT SCOPE	5 ADULTS 3 PUPS	1 GROOMING 5 AT REST 2 TRAVELING
1930		6 ADULTS 3 PUPS	7 AT REST 2 FORAGING
2000		4 ADULTS 1 PUP	AT REST
2100		4 ADULTS 1 PUP	AT REST
2200		8 ADULTS 1 PUP	1 FORAGING 2 GROOMING 6 AT REST
2300		9 ADULTS 2 PUPS	2 TRAVELING 1 GROOMING 8 AT REST
0000		9 ADULTS 2 PUPS	AT REST PUP CRYING
0100		10 ADULTS	AT REST
0200		7 ADULTS	AT REST
0300		10 ADULTS 2 PUPS	ALL SCATTERED BUT AT REST
0400		10 ADULTS 2 PUPS	ALL SCATTERED IN CLUMPS AT REST
0430	SUNRISE		
0500		12 ADULTS 4 PUPS	AT REST
0600	USING SPOTTING SCOPE	12 ADULTS 7 PUPS	GROOMING
0700		12 ADULTS 7 PUPS	ALL AT REST

TABLE 8

GENERAL BEHAVIORAL OBSERVATIONS

1982

OBSERVATION	DATE	TIME (PST)	LOCATION (ZONE)	ACTIVITY
1	1/18/82	0945	5	FORAGING OTTER DEFECATED COLOR WAS RED-ORANGE
2	1/18/82	1015	4	PAIR MATING
3	1/18/82	1420	3	MOM AND YOUNG PUP AVOIDED MALE'S APPROACH
4	2/27/82	1230	3	SILVERHEADED MALE FORAGING IN UPPER INTERTIDAL (+2 MLLW) EATING BLACK ABALONE
5	2/28/82	1000	3	FEMALE LOOKS PREGNANT
6	2/28/82	1030	3	OLDER PUP INSPECTS YOUNG PUP ON MOM'S BELLY. MOM NIPS AT OLD PUP. OTHER FEMALE INSPECTS YOUNG PUP AND MOM NIPS BOTH. FEMALE AND OLD PUP LEAVE MOM AND YOUNG PUP ALONE.
7	3/7/82	1100	3	VERY PREGNANT FEMALE JUST OUTSIDE MAIN RAFT AT LION ROCK
8	4/30/82	1230	3	PAIR MATING. MALE LOCKS ARMS AND GRABS NOSE FROM BEHIND. MALE THEN PULLS FEMALE'S HEAD BACK, TURNS AND HOLDS HER UNDERWATER MOST OF THE TIME ALLOWING HER HEAD TO RISE FOR A BREATH DURING SLOW ROLLS. THEY SPEND MOST OF THEIR TIME SIDE TO SIDE
9	5/14/82	1125	3	MOM AND VERY YOUNG PUP
10	10/11/82	1000	5	3 HARBOR SEALS RAFTED AND WRAPPED IN KELP LIKE A SEA OTTER WOULD
11	10/11/82	1050	4	OTTER PAIR MATING
12	10/19/82	1210	1	NEWBORN PUP SPOTTED APPROXIMATELY 50 METERS N.W. OF MAIN RAFT. PUP VERY WET AND NOT MOVING. MOM GROOMS PUP FOR 25 MIN. AND PUP BECOMES MORE LIVELY

TABLE 8

GENERAL BEHAVIORAL OBSERVATIONS

CONTINUED

OBSERVATION	DATE	TIME (PST)	LOCATION (ZONE)	ACTIVITY
13	11/7/82	1200	3	SILVER HEADED MALE IN INTAKE COVE SHIVERING AS IF ILL
14	11/7/82	1345	1	CARCASS FLOATING OFFSHORE BENCHMARK. IT WAS BLOATE BUT THE COLOR AND SIZE OF AN OTTER

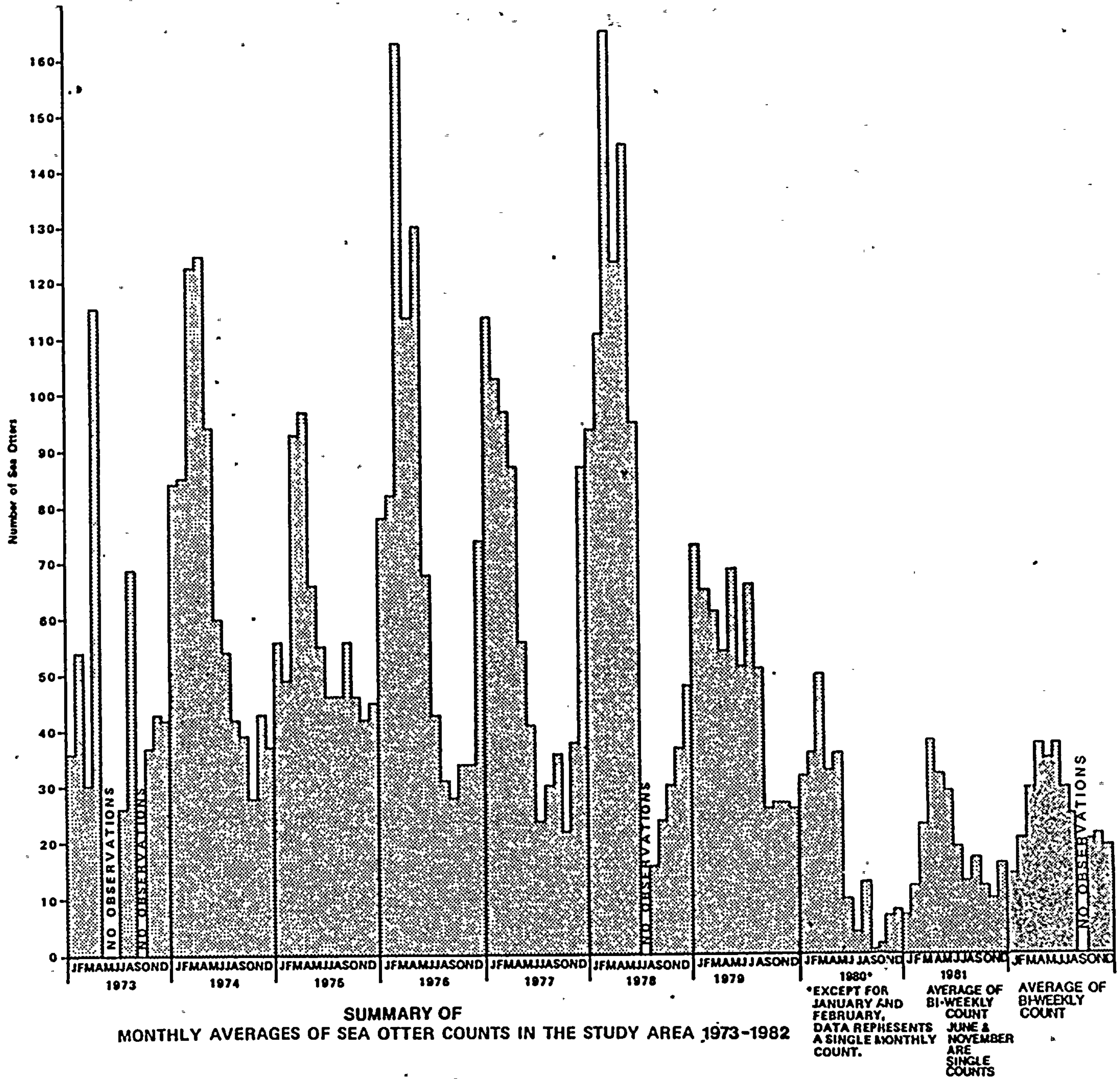
or unhealthy animals were searched for within the vicinity of the slick, but not found. The slick generally remained offshore and was never observed to be in any direct contact with any sea otters. A male otter which spent much of his time near the site of the slick was never observed directly within it and appeared normal throughout the observation period.

The second incident occurred approximately two weeks after the first. In this case the male sea otter which commonly rested in the Diablo intake cove appeared to be ill. While at rest he shivered and was not easily disturbed by human harassment. While feeding he did not travel far and used the very shallow intertidal as his major foraging area. Once the sea otter died, a necropsy was performed and the cause of death was due to massive chest infection, caused by a puncture would in the shoulder (personal communication Dr. C. Woodhouse, Santa Barbara Musuem of Natural History.

DISCUSSION

Population Size:

The maximum number of sea otters observed in the area remains low when compared to pre-1980 data (Figure 8). The seasonal fluctuation of animals in the study area is continuing to stabilize. This area although not the southernmost boundary of the sea otter's range, is



SUMMARY OF
MONTHLY AVERAGES OF SEA OTTER COUNTS IN THE STUDY AREA 1973-1982

FIGURE 8

influenced by its proximity to that boundary. This area represents the southernmost extension of "established" female raft sites. This "boundary effect" is reflected in the count variability. If the southern front and established females continue to extend southward, the study area total population counts should continue to stabilize.

Population Distribution and Composition:

Although it was unexpected, zone 5 changed from a transition area occupied, but not dominated by, either male or female sea otters, to a male dominated area. Although small when compared to previous male rafts in the area, a consolidated group of males did reestablish themselves by December of this year. It is even possible that the presently dispersed southern male front may reestablish themselves within the southern portion of the study area. This would not be surprising since the southern portion of the study area does not have a dense resident group of sea otters and it is still somewhat male dominated. This reestablishment is also possible because the southern front does not necessarily move to its southernmost boundary every year (Personal connumication Fred Wendell CDF & G).

The area seems to be rather stabilized due to the fact that the females have established specific and relatively unvarying raft sites. However, the obvious changes in ratios of females to males in the study area from 6 to 1, to 1 to 2 respectively seems to indicate that the area is

still very transitional. Although the number of sea otters in the area do not vary as they did in the past, the specific individuals may.

Feeding Observations:

When comparing the annual food item summarys (Figure 9), it looks as if urchins continue to be an insignificant food source. Abalone, for the first time in ten years of observations, no longer dominates the list of prey items. In fact, "others" which represents a wide spectrum of small molluscs and echinoderms, were observed being consumed in greater frequency than the more preferred abalone. Crab increased in frequency as an observed prey item, representing 65% of the total incidental feeding observations. This year, not only is the total number of sea otters within the study area reduced compared to pre-1980 levels, but the sea otters feeding preferences have apparently changed. These preferences seem to now more closely resemble those of sea otters residing within older, more established portions of the range where feeding strategies have changed to match the scarcity of sea urchins and abalone, (the two most preferred and heavily foraged prey species found in recently occupied rocky bottom habitat within the study area).

It must be noted that although no sea urchins were observed being consumed during normal incidental feeding observations, sea urchins were observed being consumed on

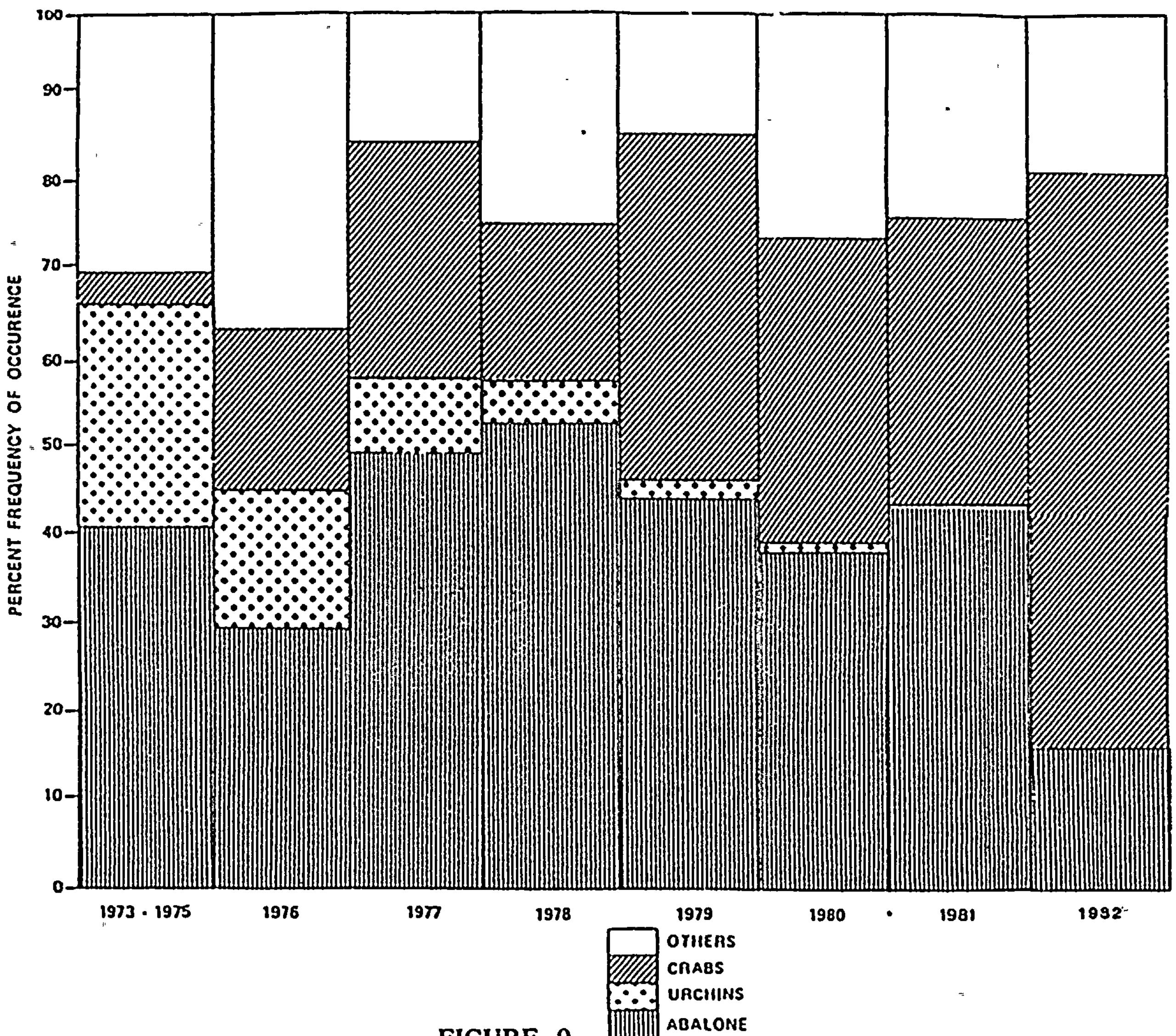


FIGURE 9

FOOD ITEM SUMMARY

FREQUENCY OF OCCURRANCE

two occasions during the continuous observation of a single sea otter (during a separate study in the area). During a series of observations, an adult male sea otter, which resided in the Diablo intake cove, consumed 36 urchins, one black abalone, and 5 cancer crabs. In addition, all but one of these urchins were Strongylocentrotus purpuratus and all ranged from approximately 1 to 3 inches in diameter. These urchins were all taken in the upper intertidal zone (+1 to +2 MMLW) during relatively high water conditions. During a second series of observations of the same sea otter but while he was ill, the animal consumed 20 urchins and 2 cancer crabs. All the urchins were located in the upper intertidal zone and were very small.

Even though the observational techniques were different (continuous observation vs. activity scan) and are not directly comparable, there may be a bias against sea urchins using this activity scan technique since this food item is small and quickly consumed. These observations could also be biased in the opposite direction by the specific preference, age and overall condition of the animal. Old or sick animals may tend to forage in the upper intertidal, reducing the diving effort involved, but compromising food preference.

It seems that activity scan may be subject to less bias than continuous observations of a single animal when overall foraging trends are being considered.

Subtidal Surveys:

Sea otter predation of sea urchins as evidenced by feeding observations and subtidal density counts, continues to maintain the red sea urchin population within the Pecho Rock area at low levels. Sea urchin densities in relation to the maximum number of sea otters observed within the Pecho Rock area from 1974 through 1982 are summarized in Figure 10. Even though 1982 marks the first detectable levels of sea urchins in the area since 1978, it is assumed that since this was a historically preferred sea otter prey item, they will perpetually remain at very low levels as long as sea otters continue to inhabit the study area.

Tagged Sea Otter Observations:

This year all tagged sea otter observed in the study area were originally captured and tagged in the San Simeon area. The tagged animals included both males and females. One of the three females had a dependent pup. This general information suggests two things. One, that the study area remains an area of transition with a substantial amount of seasonal transients. Two, that seasonal movements of individuals within the range are not exclusively male, nor limited to males and non-breeding females, but include (although the proportions are not known) young, old, male and female animals.

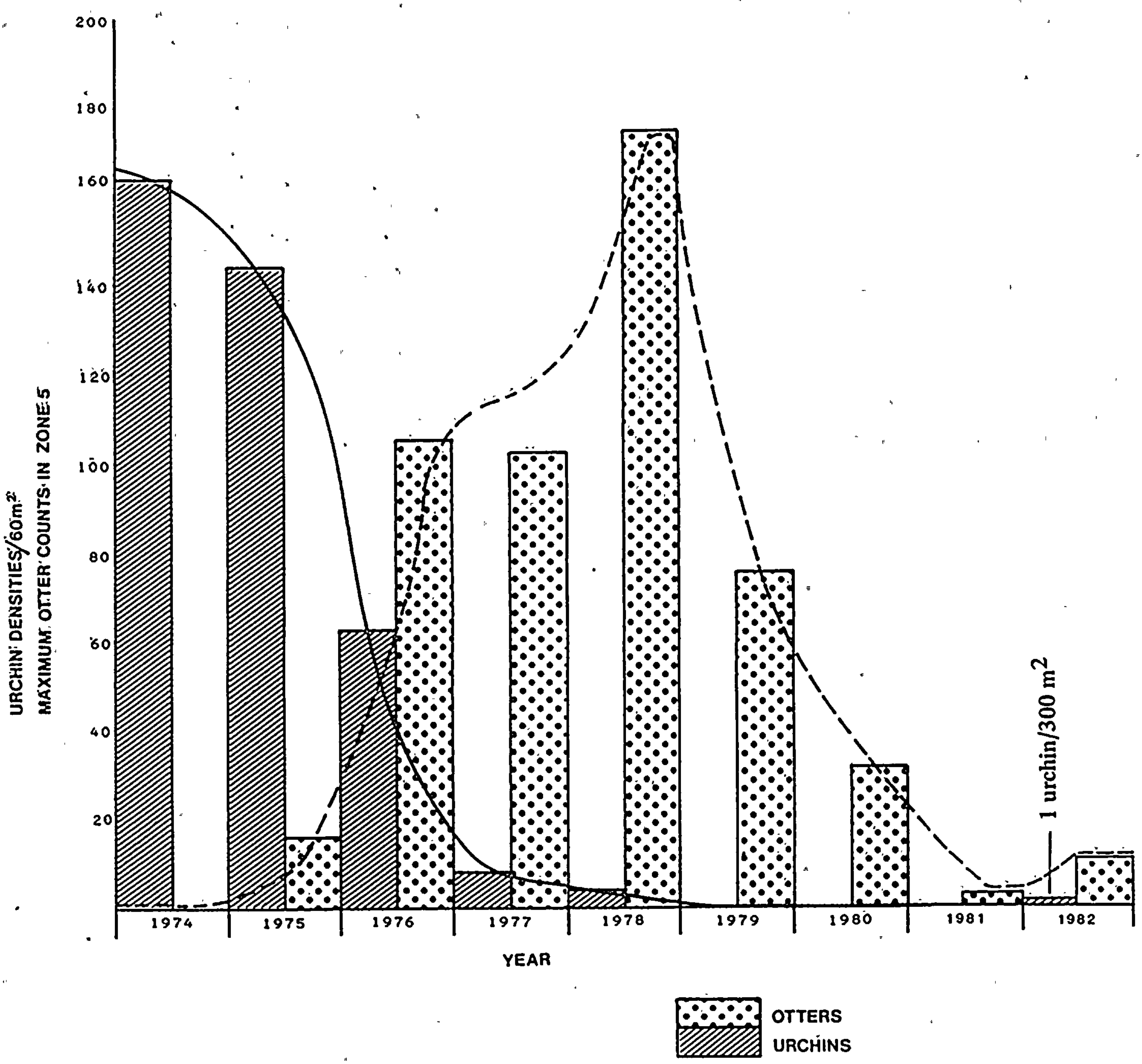


FIGURE 10
A SUMMARY OF SEA URCHIN
DENSITIES AT PECHO IN RELATION TO
OTTER NUMBERS 1974-1982

Night Observations:

This year's data remains consistent with those of previous night observations. Normal "daily" activities continue after dark which include resting, grooming and foraging among males, females and pups.

General Behavior:

Mating behavior was observed throughout the year and pupping seemed to occur generally in the spring and again in the fall.

Sea otters continued to use the high intertidal as an important foraging area.

PEREGRINE FALCON OBSERVATIONS

1982 Diàblo Canyon

by

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SCPBRG - Peregrine Falcon Observations - 1982 Diablo Canyon

INTRODUCTION

The peregrine falcon is a year-round resident and primary predator in the Diablo Canyon region. They nest at Diablo Rock, a small offshore rock approximately 1500 feet west of the Diablo Canyon Nuclear Generating Station. Peregrines eat small to medium-sized birds they catch in the air. At Diablo, this often includes phalaropes, grebes, swallows, blackbirds, and feral pigeons. There are nearby pairs approximately ten miles north at Morro Rock and ten miles southeast at Shell Beach. Other than six pairs on the coast of Monterey County, these are the only pairs existing on the west coast of the United States other than two pairs near the tip of the Olympic Peninsula in Washington.

The peregrine once was a common nester along the California coast (at approximately ten-mile intervals) and throughout the temperate areas of the state. It is one of only five cosmopolitan species, and is represented by 22 races (Falco peregrinus anatum in California). Throughout the world severe declines have occurred as a result of the effects of accumulation of DDT (in the form of the metabolite DDE) in the falcon's fat reserves. DDT-induced eggshell thinning (as in the bald eagle, brown pelican, and others) causes accidental breakage of eggs by incubating adults and increased embryonic mortality. Hence, since application of DDT began in the 1940s eggshell thinning has increased mortality while decreasing productivity and recruitment. The California population has decreased from a historic population, pre-1950, of in excess of 200 pairs (with average eggshell thickness of 0.356 mm) to only two known pairs in 1970 (with average eggshell thickness of less than 0.300 mm, a reduction of over 15% in thickness).

Beginning in the late 1970s, management to increase productivity was initiated. Since that time young have been fostered in remnant

central coast nests and hacked in areas of extinction. The central coast population has increased from one pair in the early 1970s to over ten pair at present as a result of management, DDT restriction, regulation, and habitat preservation.

Arnold and Martin, Tolman, Cameron, and others visited Diablo Canyon in the mid-1960s. Peregrines were absent by that time. Walton visited Diablo Canyon regularly in the 1970s and peregrines continued to be absent (with the exception of a few sightings considered to be foraging birds from Morro Rock).

Construction of the Diablo Canyon Nuclear Generating Station (NGS) involved the removal of one historic nesting cliff, but preserved in a security zone around the NGS, excellent peregrine falcon nesting and foraging habitat, including at least one historic nest site (Diablo Rock). Just to the north of the NGS is a second, more commonly used historic nest site, Lion Rock. Private landowners as well as Pacific Gas and Electric Company (PGandE) have created a refuge-like atmosphere which has preserved ideal peregrine falcon habitat and as a result, beginning in 1980, peregrine observations increased, peregrines became resident, and in 1982, peregrine falcons successfully nested and produced young. The following report describes activities of the peregrines and observers in 1982.

METHODS

Beginning in 1980, Young, Warrick, Krenn, and others began making increased numbers of sightings of peregrines in Diablo Cove. An adult male and immature female were observed in 1981. PGandE biologists continued their observations - these were also supplemented by monthly visits by SCPBRG biologists and beginning in 1982, a full-time nest-site attendant to record breeding behavior and document nesting success and any impacts on the falcons by activities in the area. Birds were

observed from boats with binoculars or the naked eye and from land with spotting scopes and binoculars, largely from the southern point in Diablo Cove, a distance of over 300 yards.

RESULTS AND DISCUSSION

The pair of falcons at Diablo Rock have been found to be remarkably tolerant of human activity in close proximity to their nest ledge and within area normally considered the defended territory for peregrines. Most of the human activity in this pair's territory is within 2000 feet of the nest; outside a 2000-foot core the pair's range is largely undeveloped (see Figure 1). Major construction of the NGS and associated facilities has continued from before the occupation of Diablo Rock through the 1982 nesting season.

The falcons are not banded. Falcons released in San Luis Obispo County before 1981 were usually unbanded. It is likely however, that these birds were originally fledged from Morro Rock. The female was observed in 1981 in immature plumage, hence she was born in 1980. The male was first seen in adult plumage, hence he was born in 1979 or earlier. The birds did not nest in 1981 (the female was sexually immature), but did nest in 1982.

Two falcons were observed by SCPBRG personnel on every monthly visit to Diablo Rock from May 1981 to December 1982. Occasionally birds were foraging and roosting at Lion Rock; during most visits the birds were closely associated with Diablo Rock. Figure 2 describes Diablo Rock, including perches most commonly used and nest ledge location. The nest ledge is approximately two-thirds of the way up from the water level on the rock and has a southwest orientation. The actual scrape is approximately 21" X 15". The rock itself protrudes approximately 55 feet from the water.

Observations of the nesting season with a full-time attendant were conducted from 16 March to 31 July 1982. The female was breeding for the first time. Egg production from experienced females in San Luis Obispo County could be expected approximately 15-21 March. Incubation began approximately 23-24 April in 1982 and would be expected to be earlier in subsequent years. Young hatched approximately 23-24 May and fledging occurred starting 4 July 1982. A chronology of important dates is provided as Table 1.

Prey species were recorded and potential prey species and other members of the avian community were listed and provided here as Table 2a and 2b. Avenues utilized by foraging adults are shown on Figure 1.

Eggshell quality

All of the falcons in central coastal California remain affected by DDT by accumulation of residues from prey species that have wintered in Latin America where DDT is still used or from prey species that obtain residual DDE in local sediments and sinks. Eggshells were collected from Diablo Rock by Felton, Blanchard, and PGandE staff, and measured by Kiff and Sumida of the Western Foundation of Vertebrate Zoology. Twenty fragments, unfortunately dirty and weathered, measured a mean thickness of 0.212 mm compared to historic pre-DDT eggshell data from this region of 0.356 mm (Table 3). Eggshells were unlikely this thin from a first-year breeding two-year-old female, but it is likely they were at least 10% thin based on measurements of eggs from two other two-year-olds in the region, and failure could occur in subsequent years with current rate of accumulation and thinning.

Potential impacts

Several activities occurred in 1982 that might have been considered as potential impacts on the falcons.

Occasional close passes by helicopters and other aircraft - While no negative impact resulted, and birds were never seen to react more than

to briefly leave their perch and fly, inappropriate timing of such an event (while incubation is occurring) could have significant effects (egg breakage) and these aircraft flights should be eliminated.

Testing of pumps - No negative impact resulted. Falcons flew to vicinity of human activity and discharge of pumps and then left the area or went back to their perch on Diablo Rock.

Sampling by biologists - Activities in small boats around Diablo Rock were tolerated. If boats approached the base of the rock the falcons occasionally vocalized. Direct approaches could result in vocalizations and the falcons flying to the opposite side of the rock or in some cases to Lion Rock. This close approach by sampling boats should be avoided or minimized from March to July.

Nuclear demonstration - A flotilla of boats and helicopters (fortunately not during the breeding season) was tolerated by the falcons. During demonstrations, Walton observed the falcons largely on Diablo Rock with brief visits to Lion Rock and inland foraging areas.

Construction on reactor - Constant noise seems to be tolerated. Sudden abrupt loud noises, explosions, falling beams, etc. are observed by the falcons, but rarely resulted in flushing or vocalizations except during fledging period when birds vocalized regularly.

Construction on breakwater - Construction using heavy equipment, explosives, and a great deal of movement of rocks and debris by trucks and cranes commenced after fledging of young. A large crane was 1500 feet away and visible from Diablo Rock. Vocalizations were occasionally made by adults, particularly when fledgling male flew into area of construction and observer. The adult falcons notice this activity as they notice construction activity at reactor site. The falcons are observed

to orient their gaze in the direction of noises and activity. However, no major disturbance or stress was noted. There was essentially no visible change in the falcon behavior before or after construction began or no noticeable change in behavior between the Diablo Canyon pair and other pairs under observation by SCPBRG that were not subjected to such activity in the territory.

Sensitive times for disturbance in falcon behavior are during courtship from February to March (30-day period), egg laying from March to April (15-day period), and fledging from June to July (10-day period). Avoidance of new, sudden, unusual, or loud activities during these times will reduce the impact on behavior and lessen chances of reproductive failure.

Peregrines are unlikely to abandon a territory for any reason once eggs have been laid. Negative impacts can cause increased chances of embryonic or juvenile mortality by causing egg or young chilling or overheating, reduction of foraging success, or changing behavior in adults (if defending territory instead of foraging). If disturbance is high or falcons are unsuccessful, they will often move to an alternate nest ledge the following year. In this case the birds would be expected to move to Lion Rock.

A continued potential impact is activity by public in Diablo Cove. A large-scale demonstration during the nesting season could be a severe threat to the nesting success. Demonstrators must be kept away from Diablo Rock, and especially demonstrators and fishermen must be kept off of Diablo Rock.

RECOMMENDATIONS

1 - Continue to monitor territory monthly; continue full-time breeding season observations.

2 - Increase the number of attendants to allow a rotating schedule (1 to 2).

3 - Provide a wind shelter for attendants.

4 - Continue to minimize the potential for disturbance to the falcons, particularly from mid-February to mid-July (specifically the courtship, egg laying, and fledging periods).

5 - Evaluate behavior and impacts on an individual-pair basis, not applying generalizations from other peregrine nesting territories.

6 - Insure fledging by captive incubating eggs and fostering young into nests.

PERSONNEL

Carrie Bennett initiated full-time observations (from 16 March to 11 May). She conducted observations through egg laying. Carrie was a student at the University of Wyoming and is currently at the University of Indiana. Dean Thompson continued observations through hatching and fledging period and made observations after fledging to document impacts, if any, of the breakwater construction and repair on the nesting falcons (11 May to 31 July). Dean was a student at California Polytechnic State University, San Luis Obispo.

Brian Walton verified observations and compiled a report. Gary Guliasi, Brian Hatfield, Merlyn Felton, and Brian Walton provided supplemental observations.

The multitude of observations by PGandE, the California Department of Fish and Game, and other people active in the territory support the information provided here - no discrepancies between observers have been noted. PGandE staff helped in all phases of the project and associated meetings.

CONCLUSIONS

The peregrine falcons currently at Diablo Canyon have occupied a previously abandoned historic nesting territory. Since the earlier abandonment in the 1960s, the territory has been altered significantly - one ledge and cliff was removed and a nuclear generating station was built in what would be the defended area within the territory. In spite of this, and while construction was progressing, the falcons found the territory suitable, in fact so suitable that they became residents, matured, and produced two young - probably from three eggs - a normal reproductive season for peregrines. Unfortunately one young drowned on its first flight - something unrelated to this specific territory, but a part of natural selection affecting peregrine survival. This may reflect selection of a poor nest site by a young female peregrine, or possibly some inherent behavioral problem in the young, or just as well, sheer coincidence. The remaining young fledged and dispersed normally.

PGandE provided funds to do appropriate work to monitor territory, and adjusted its construction schedule to meet demands of the peregrines regarding reduced disturbance during the sensitive period in the nesting cycle (fledging of young). No negative impacts of construction effort were documented. Continued work of this nature, with a contingency plan for manipulation of eggs should thinning of eggs continue, should be sufficient to maintain an active territory with normal productivity within the Diablo Canyon NGS area.

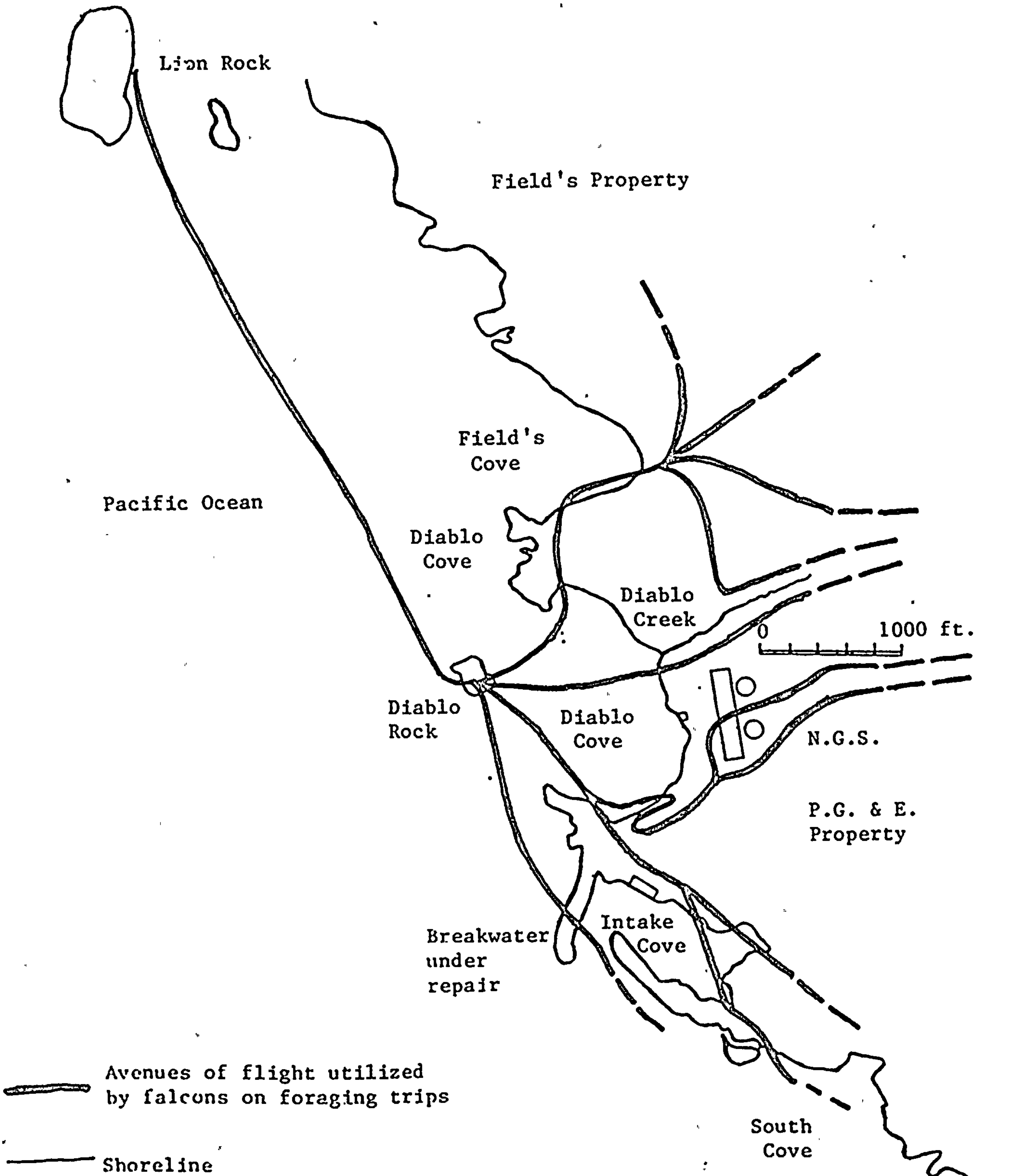


Figure 1. Location of Diablo Rock and avenues utilized by falcons on foraging trips.

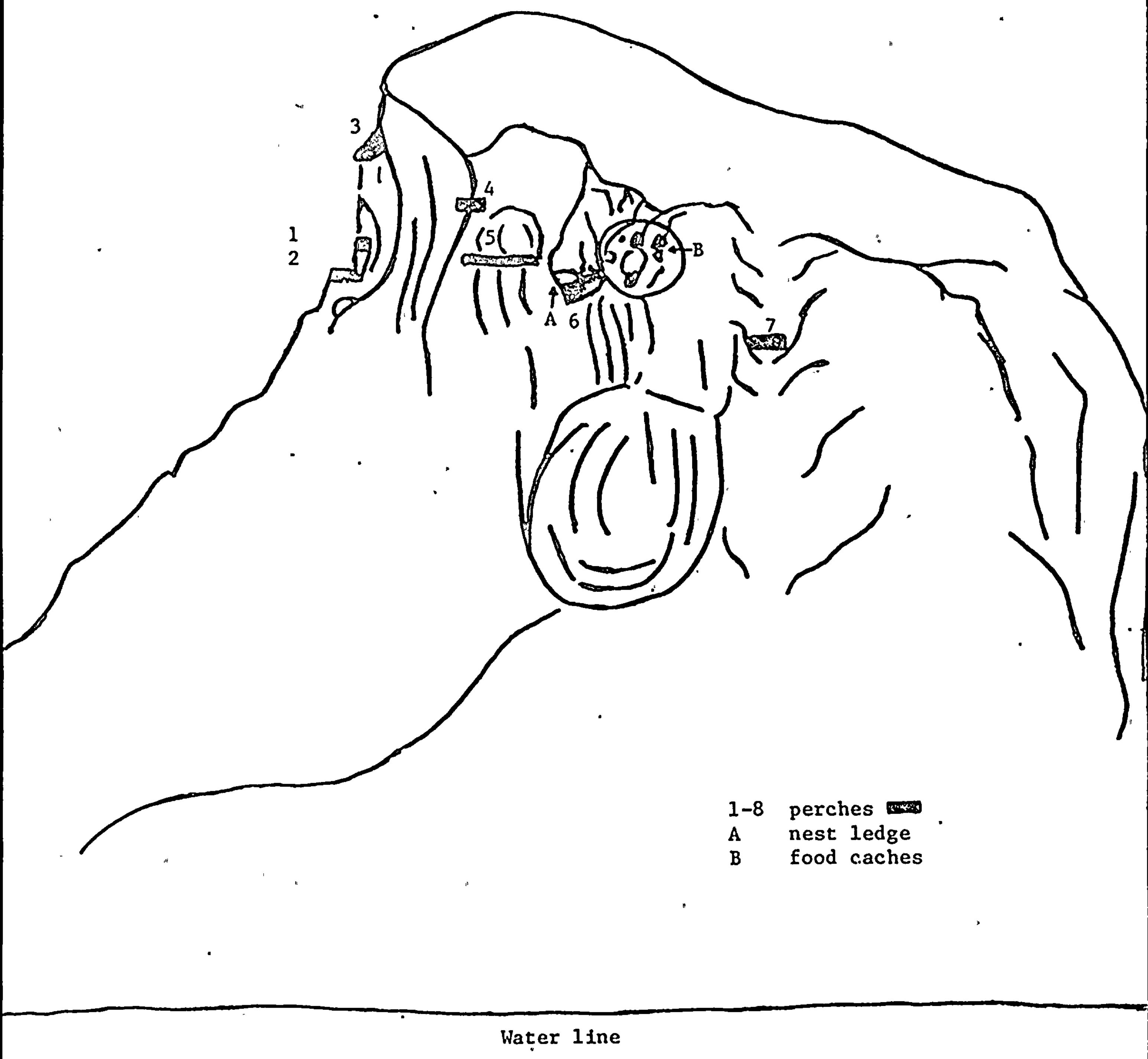


Figure 2. Diablo Rock - favorite falcon perches and nest site location.

Table 1. Chronology of important dates and activities for 1982 breeding season.

Date	Activity
March 16	Observations begin by Bennett
April 1	Adult falcon courtship and copulation intensifies
April 23-24	Behavior suggests incubation has begun (known incubation period is 33.5 days)
May 11	Bennett leaves and Thompson begins observations
May 23-24	Behavior suggests hatching of at least one egg
June 7	Brooding of hatchlings decreases
June 9	Nestling vocalizations heard
June 28	Nestling seen
June 29	Second nestling confirmed
July 4	Male nestling fledges (normal fledging age is 42 days)
July 7	Crane barge arrives to repair breakwater
July 8	Female nestling fledges and is lost on far side of rock. Female may have hatched later. Females occasionally take longer than 42 days to fledge; they are slower to develop than males.
July 9-10	Female fledgling confirmed dead
July 13	Male fledgling conducts aerial food exchange with adult male
July 15	Male fledgling observed grabbing a western gull chick and eating it
July 21	Observations decrease; fledgling doing well - harrasses red-tailed hawk
August 2	Adult male seen for only six minutes -- last observation

Table 2a. Identified prey items.

Black oystercatcher	(Haematopus bachmani)
Phalarope	sp.
*Western gull (chick)	(Larus occidentalis)
*Rock dove	(Columba livia)
Mourning dove	(Zenaidura macroura)
*Barn swallow	(Hirundo rustica)
*Cliff swallow	(Petrochelidon pyrrhonota)
Starling	(Sturnus vulgaris)
Red-winged blackbird	(Agelaius phoeniceus)
Eared grebe	(Podiceps caspicus)

*The gull chick was taken by the male peregrine fledgling. The swallows were taken by the adult male. The rock doves were taken by the adult female.

Table 2b. Avian species recorded at Diablo Canyon (*rare or occasional).

Common loon	(Gavia immer)
Eared grebe	(Podiceps caspicus)
Brown pelican	(Pelecanus occidentalis)
Brandt's cormorant	(Phalacrocorax penicillatus)
Pelagic cormorant	(Phalacrocorax pelagicus)
Turkey vulture	(Cathartes aura)
White-tailed kite	(Elanus leucurus)
Cooper's hawk	(Accipiter cooperii)
*Marsh hawk	(Circus cyaneus)
Red-tailed hawk	(Buteo jamaicensis)
*Osprey	(Pandion haliaetus)
*Golden eagle	(Aquila chrysaetos)
American kestrel	(Falco sparverius)
California quail	(Lophortyx californicus)
Great blue heron	(Ardea herodias)
Black oystercatcher	(Haematopus bachmani)
Killdeer	(Charadrius vociferus)
Willet	(Catoptrophorus semipalmatus)
Phalarope	spp.
Western gull	(Larus occidentalis)
Ring-billed gull	(Larus delawarensis)
Heermann's gull	(Larus heermanni)
Bonaparte's gull	(Larus philadelphia)
*Least tern	(Sterna albifrons)
Caspian tern	(Hydroprogne caspia)
Pigeon guillemot	(Cepphus columba)
Rock dove	(Columba livia)
Mourning dove	(Zenaidura macroura)
Roadrunner	(Geococcyx californianus)
Great horned owl	(Bubo virginianus)
White-throated swift	(Aeronautes saxatalis)
Anna's hummingbird	(Calypte anna)
Belted kingfisher	(Megaceryle alcyon)
Common flicker	(Colaptes auratus)
Black phoebe	(Sayornis nigricans)
Barn swallow	(Hirundo rustica)
Cliff swallow	(Petrochelidon pyrrhonota)
Scrub jay	(Aphelocoma coerulescens)
Chestnut-backed chickadee	(Parus rufescens)
Wrentit	(Chamaea fasciata)
Bewick's wren	(Thryomanes bewickii)
California thrasher	(Toxostoma redivivum)
Robin	(Turdus migratorius)
Starling	(Sturnus vulgaris)
House sparrow	(Passer domesticus)
Western meadowlark	(Sturnella neglecta)
Red-winged blackbird	(Agelaius phoeniceus)
Brewer's blackbird	(Euphagus cyanocephalus)
House finch	(Carpodacus mexicanus)
Brown towhee	(Pipilo fuscus)
White-crowned sparrow	(Zonotrichia leucophrys)

Table 3. Eggshell thicknesses of 1982 Diablo Rock peregrine falcon eggshell fragments.

1 - 0.204 mm	11 - 0.230 mm
2 - 0.210 mm	12 - 0.230 mm
3 - 0.225 mm	13 - 0.242 mm
4 - 0.202 mm	14 - 0.221 mm
5 - 0.217 mm	15 - 0.217 mm
6 - 0.201 mm	16 - 0.200 mm
7 - 0.190 mm	17 - 0.237 mm
8 - 0.200 mm	18 - 0.197 mm
9 - 0.202 mm	19 - 0.192 mm
10 - 0.218 mm	20 - 0.210 mm

Historic thickness for this region	0.356 mm
Mean 1982 thickness	0.212 mm
% thinning	—

These measurements are not considered real due to weathering of and sediments found on the egg samples.

Measurements were done by Kiff and Sumida of Western Foundation of Vertebrate Zoology and collections were made by Felton and Blanchard of SCPBRG.

Observations of the Gray Whale Migration in the Vicinity of Diablo Canyon: 1981-82 Migration

By

David W. Behrens

Biologist

May 1983

Table of Contents

List of Tables

List of Figures

Abstract

A census of the California gray whale, Eschrichtius robustus was conducted offshore of the Diablo Canyon Power Plant to determine the number of animals passing through the anticipated area of the thermal plume, their time of passage, distance from shore and behavior while in migration. A total of 98.25 hours on 30 days were spent collecting data. A study corridor 1830m (6000 ft) wide was used based on discharge plume predictions. During the 1981-82 migration, southbound whales passed the plant between November 18, 1981 and February 8, 1982. North-bound whales passed between February 8 and June 3, 1982. Numbers passing within the 1830m corridor reached ten whales per hour (WPH) during the southerly leg and 22.5 WPH during the northerly movement. The largest pod contained seven individuals. Mean pod size was 1.8 during southerly movement and 1.7 during the northerly movement. Mating behavior was observed during the northern migration. Based on 98.25 hrs of counts an estimated 9840 whales passed through the 1830m corridor on the southerly migration, while 12,068 whales passed through on the northerly migration.

Introduction

Concern over population size and health of the California gray whale, <u>Eschrichtius robustus</u> (Lilljeborg) has been forefront in the minds of environmentalists and government agencies since 1937 when the hunting of gray whales was forbidden by international agreement due to the species near extinction in the late 19th century. More recently the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 have provided full protection for this species.

In October 1979, the U.S. Fish and Wildlife Service (USFWS) Acting Regional Director in Portland, Oregon, contacted the U.S. Nuclear Regulatory Commission (NRC) Acting Chief of Environmental Projects in Washington D.C. and expressed concern over possible power plant impacts to five endangered species: the California brown pelican, American peregrine falcon, California least tern, southern sea otter, and the gray whale (Warrick 1982). USFWS requested a formal consultation with NRC representatives as stipulated in Section 7 of the Endangered Species Act. In January 1980, the consultation meeting was held in the USFWS offices in Sacramento, California, and included representatives of USFWS, NRC and the California Department of Fish and Game (CDF&G). During the meeting, the status of the Diablo Canyon project and potential impacts of the power plant were reviewed by NRC personnel for the benefit of the

USFWS and CDF&G attendees.

Following the meeting the NRC formally requested USFWS to render a determination pursuant to Section 7 of the Endangered Species Act, Public Law 95-632, as to the effects of the operation of Diablo Canyon Power Plant on the five endangered species, and to prepare an opinion, "whether the plant operation would result in any effect on critical habitat or would jeopardize the continued existance of the five species". Jurisdiction over the gray whale was determined to be the responsibility of the National Marine Fisheries Service (NMFS), and hence, the Regional Director of this agency responded to the NRC request. The NMFS Regional Director's letter to NRC concluded that "the operation of the nuclear generating station at Diablo Canyon, California is not likely to jeopardize the continued existance of any of the threatened or endangered species under the purview of the National Marine Fisheries Service". The gray whale was mentioned specifically as were the more pelagic humpback whale, sperm whale, right whale, blue whale, fin whale and sei whale.

Although no action was required on the part of PGandE regarding interaction with the NRC or USFWS or surveillance of possible plant impacts on whale activities, concern has been expressed by various environmental intervenors, in such arenas as the NPDES permit renewal hearings held by the

California Water Quality Control Board, Cental Coast Region. Because of these concerns, a gray whale census was conducted at Diablo Canyon during the 1981-82 migration to determine the number of whales migrating close enough to shore to pass through the thermal discharge plume once the power plant begins operations. Study objectives included documentation of time of passage, distance from shore and behavior exhibited while the whales were in the area of predicted plume coverage.

Methods

Based on thermal plume dispersion predictions resulting from studies conducted at the University of California, Berkeley, physical hydraulic model of Diablo Cove and the adjacent shoreline, a corridor 1830m (6000 ft) wide was chosen for study (Figure 1). This corridor not only includes the extent of the predicted 2.0^{0}C surface isotherm, but approximates the limits of visual acuity and reliability under weather conditions expected during the migration season. In order to view the corridor entirely from a single location, a land-based observation site at an altitude of about 279m (915 ft) was chosen. This site was approximately 305m (1000 ft) from the shoreline (Lat. 35^{0}, 12',45"N; Long. 120^{0},51'10"W) (Figure 2). A 45^{0} viewing arc

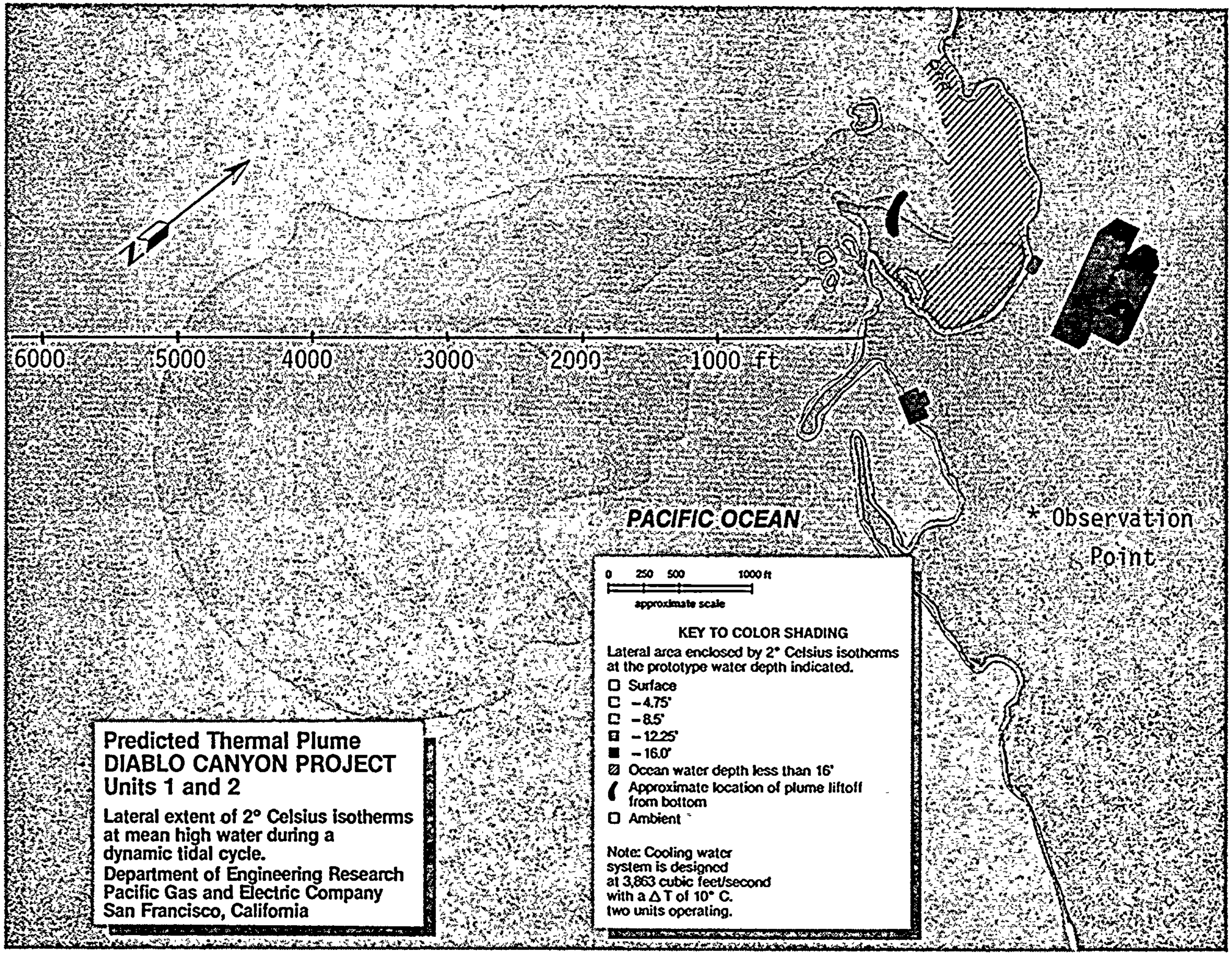
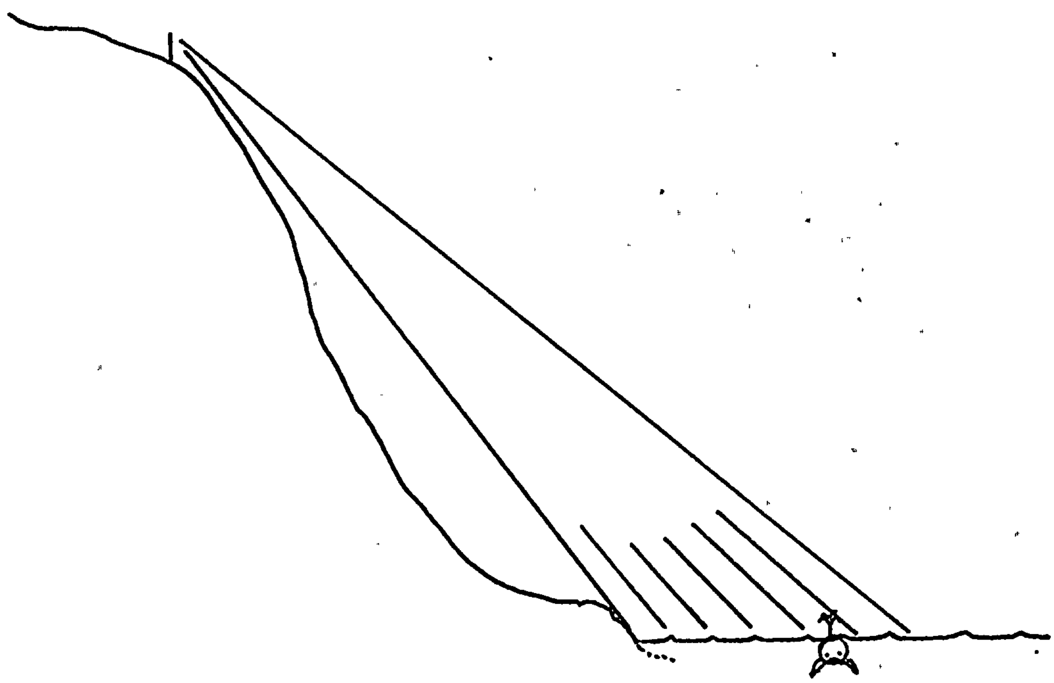

6000
5000
4000
3000
2000
1000 ft
PACIFIC OCEAN
* Observation Point
0 250 500 1000 ft
approximate scale
KEY TO COLOR SHADING
Lateral area enclosed by 2° Celsius isotherms at the prototype water depth indicated.
Surface
−4.75'
−8.5'
−12.25'
−16.0'
Ocean water depth less than 16'
Approximate location of plume liftoff from bottom
Ambient
Note: Cooling water system is designed at 3,863 cubic feet/second with a Δ T of 10° C. two units operating.
Predicted Thermal Plume
DIABLO CANYON PROJECT
Units 1 and 2
Lateral extent of 2° Celsius isotherms at mean high water during a dynamic tidal cycle.
Department of Engineering Research
Pacific Gas and Electric Company
San Francisco, California

Figure 1

Figure 2

Elevational view of observation site.

(not to scale)



(185-230^{0}) delineated the northern and southern boundaries of the study corridor.

Whale counts were limited to days when weather conditions permitted clear vision of the entire study corridor. Counts varied from one to five hours in duration and occurred during early daylight hours in order to avoid interference from sun reflection and glare off the ocean surface.

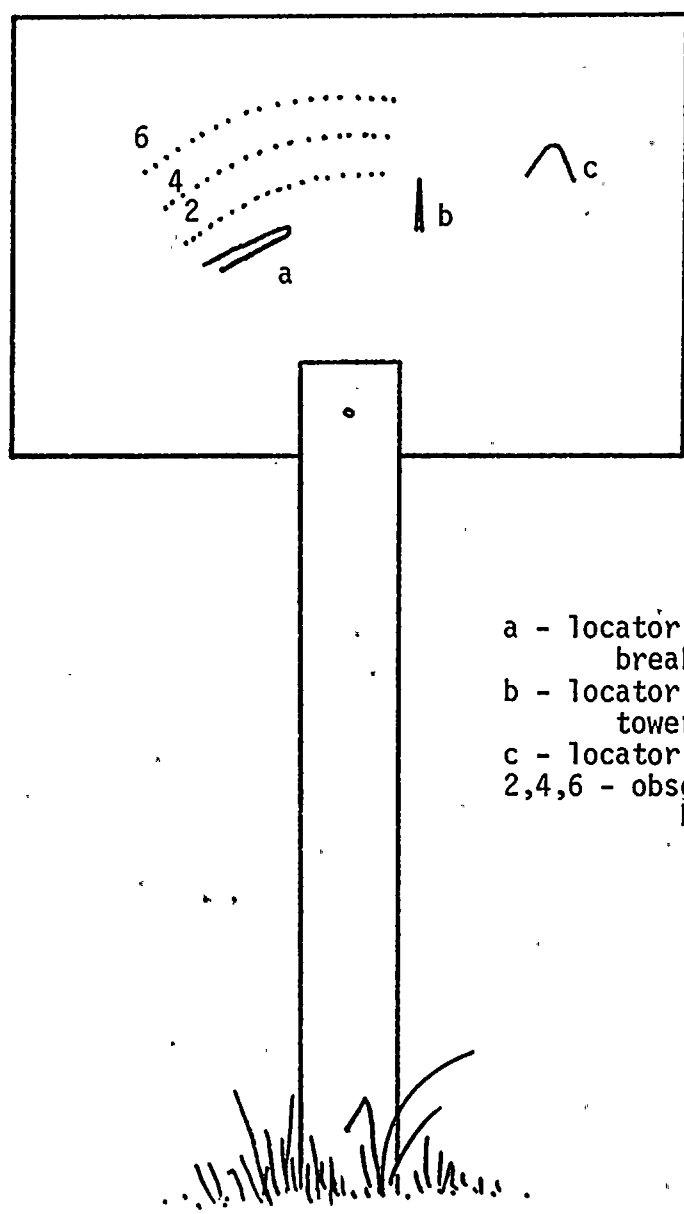
Whales were spotted by naked eye or using 7X50 binoculars and their position monitored until they entered the study corridor. Individuals passing outside of the 1830m corridor were noted in a log book, but were not used in our analysis. Once within the corridor, the animals distance from shore was determined using a custom designed viewing/rangefinder window (Figure 3). The window consisted of a transparent plexiglass sheet mounted on a permanent fixed post. Points of visual reference were drawn on the sheet for the purpose of positioning the observer's eyes at a fixed distance behind the window. Also drawn on the window were a series of lines dividing the corridor into 610m (2000 ft) lanes (at 610, 1219 & 1830m; 2000, 4000 & 6000 ft, respectively). The precise location of these lanes were established by sighting in on a research vessel whose position was located by range-finding radar at specific points throughout the desired corridor.

Once a whale entered the corridor its position was recorded by zone, which were numbered relative to their distance from shore (zone 1 = 0-305m (0-1000 ft); zone 2 = 305-610m (1000-2000 ft); zone 3 = 610-914m (2000-3000 ft), etc.). Each whale or pod of whales was assigned a unique sample number for identification. Table 1 lists ecological and environmental data collected on each whale or pod of whales at the time it passed through the study corridor. Meteorological data was recorded hourly to document changes during a single observation period. All data were recorded in the field on preprinted keypunch compatable data forms. Data were stored and maintained, prior to analysis, on disk file. All permanent data were stored on mag tape. Data reduction and analysis was accomplished by means of the Statistical Analysis System (SAS) which is supported on PG&E's IBM 370 computer system. Custom SAS programs were developed for the whale survey data. Program output consists of statistical analysis and report ready graphics.

Figure 3

Whale viewing/rangefinder window

(not to scale)



a - locator for east breakwater
b - locator for met tower
c - locator for Diablo Rock
2,4,6 - observation corridor boundary

Table 1

Data Collected During Whale Observations

Date
Number of whales in pod
Direction of travel
Behavior type*
Behavior frequency
Behavior duration
Atmospheric visibility
Swell height
Wind speed
Surf conditions

---

*Behavioral Types Identified

Spy hopping
Breaching
Pectorial fin extention
Fluke extention
Kelp scraping
Playing
Mating
Feeding

Results

Study Effort

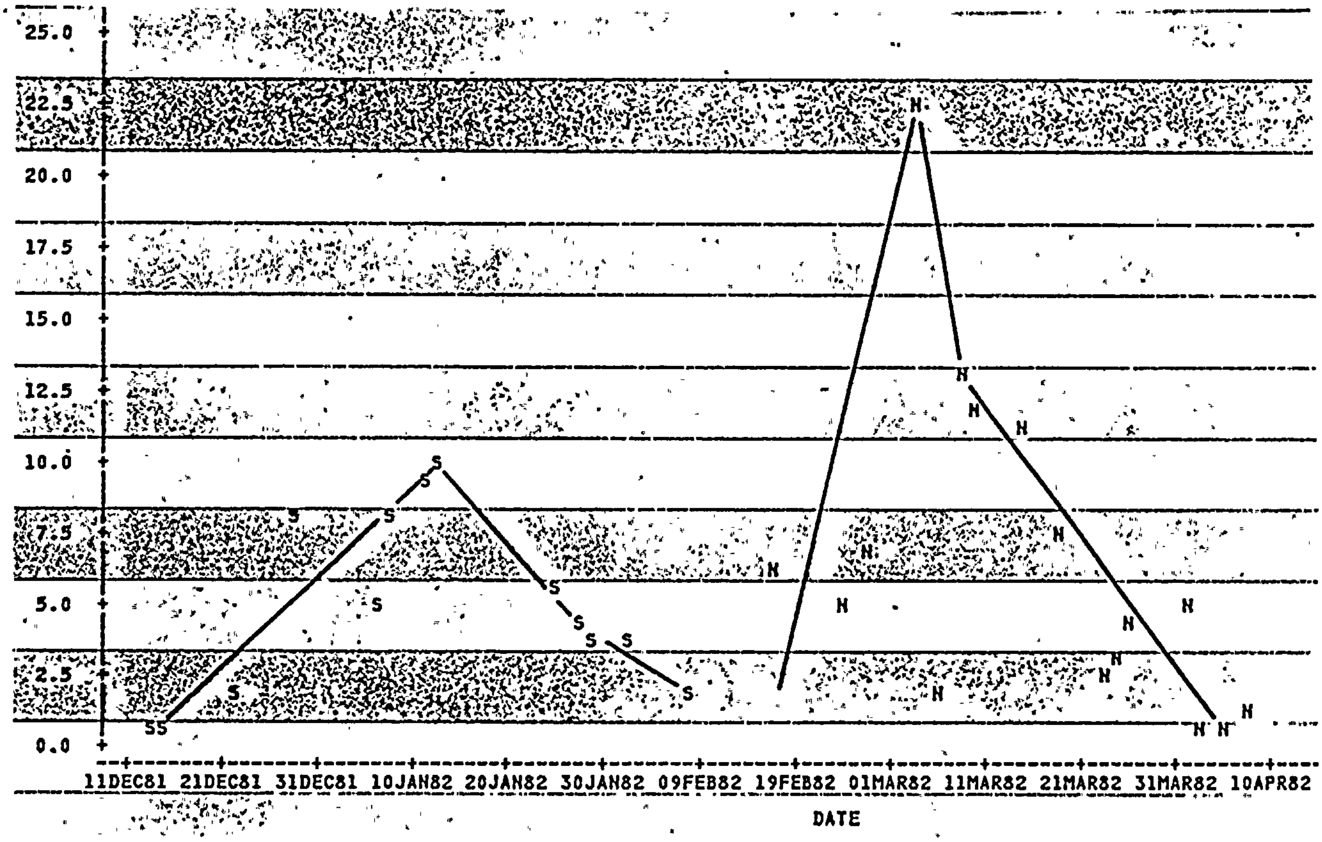
The first confirmed sighting of a southerly migrating whale occurred on November 18, 1981. Formal observations began December 21, 1981. By this date whale numbers had reached one whale per hour. A total of 98.25 hours on 30 separate days were spent collecting data. No whales where observed on four observation days, during 10.25 hours of observation. Poor weather conditions caused cancelation of whale counts of three observation days. Formal counts were terminated on May 12, 1982 when counts dropped below 0.5 whales per hour. Appendix 1 contains the daily observation data.

Migration

The first southerly migrating whale was observed on November 18, 1981. The southern migration reached a peak in abundance in mid-January when the mean hourly counts reached 10 whales per hour (WPH) within the 1830m corridor (Figure 4). The last individual migrating south was observed on February 8, 1982. Thus, in the vicinity of Diablo Cove, southbound whales passed for approximately 83 days during the 1981-82 migration.

Figure 4
Mean Number of Whales Observed Per Hour
During North and South Migrations

(Line plotted to describe general trends)



NOTE: 15 OBS HAD MISSING VALUES

The first northerly migrating whale was observed on February 8, 1982 also. The peak in whale abundance occurred in March, when the highest mean hourly count reached 22.5 WPH in the study corridor (Figure 4). This value is much higher than other counts during that same week, which ranged from 12-13.5 WPH. Although counts were terminated on May 12, 1982, individual sightings were noted until June 3, 1982. Based on our observations, whales passed Diablo Cove in a northerly direction for approximately 116 days.

Table 2 presents total daily counts per observation day and cumulative frequencies by migratory direction. A total of 205 whales were observed to pass within 1830m of shore during 41.5 hours of southern migration. A total of 313 whales were observed within the corridor during 56.75 hours of northerly return observations.

Pod Size

The largest pods observed within the study corridor contained seven individuals and were observed during the southern leg of migration. Mean pod size was 1.8 during southern migration and 1.7 during the northern return. Figures 5 and 6 present frequency distributions of pod size by migration direction. In zones 1-5 (0-5000ft), pods of one or two whales accounted for greater than 85% of the sitings, while in zone 6 (5000-6000ft) this sized pod

Table 2

Totals and Cumulative Frequencies of Whales per Day by Direction

MIGRATION DIRECTION=S

DATE	FREQUENCY	CUM FREQ	PERCENT	CUM PERCENT
14DEC81	1	1	0.488	0.488
15DEC81	2	3	0.976	1.463
22DEC81	6	9	2.927	4.390
28DEC81	21	30	10.244	14.634
06JAN82	26	56	12.683	27.317
07JAN82	28	84	13.659	40.976
11JAN82	32	116	15.610	56.585
13JAN82	40	156	19.512	76.098
25JAN82	17	173	8.293	84.390
27JAN82	13	186	6.341	90.732
29JAN82	11	197	5.366	96.098
01FEB82	7	204	3.415	99.512
08FEB82	1	205	0.488	100.000

MIGRATION DIRECTION=N

DATE	FREQUENCY	CUM FREQ	PERCENT	CUM PERCENT
08FEB82	3	3	0.962	0.962
17FEB82	6	9	1.923	2.885
24FEB82	21	30	6.731	9.615
27FEB82	20	50	6.410	16.026
03MAR82	67	117	21.474	37.500
06MAR82	5	122	1.603	39.103
08MAR82	53	175	16.987	56.090
10MAR82	36	211	11.538	67.628
15MAR82	31	242	9.936	77.564
19MAR82	23	265	7.372	84.936
23MAR82	11	276	3.526	88.462
25MAR82	9	285	2.885	91.346
26MAR82	16	301	5.128	96.474
01APR82	5	306	1.603	98.077
02APR82	2	308	0.641	98.718
05APR82	1	309	0.321	99.038
08APR82	3	312	0.962	100.000

Figure 5

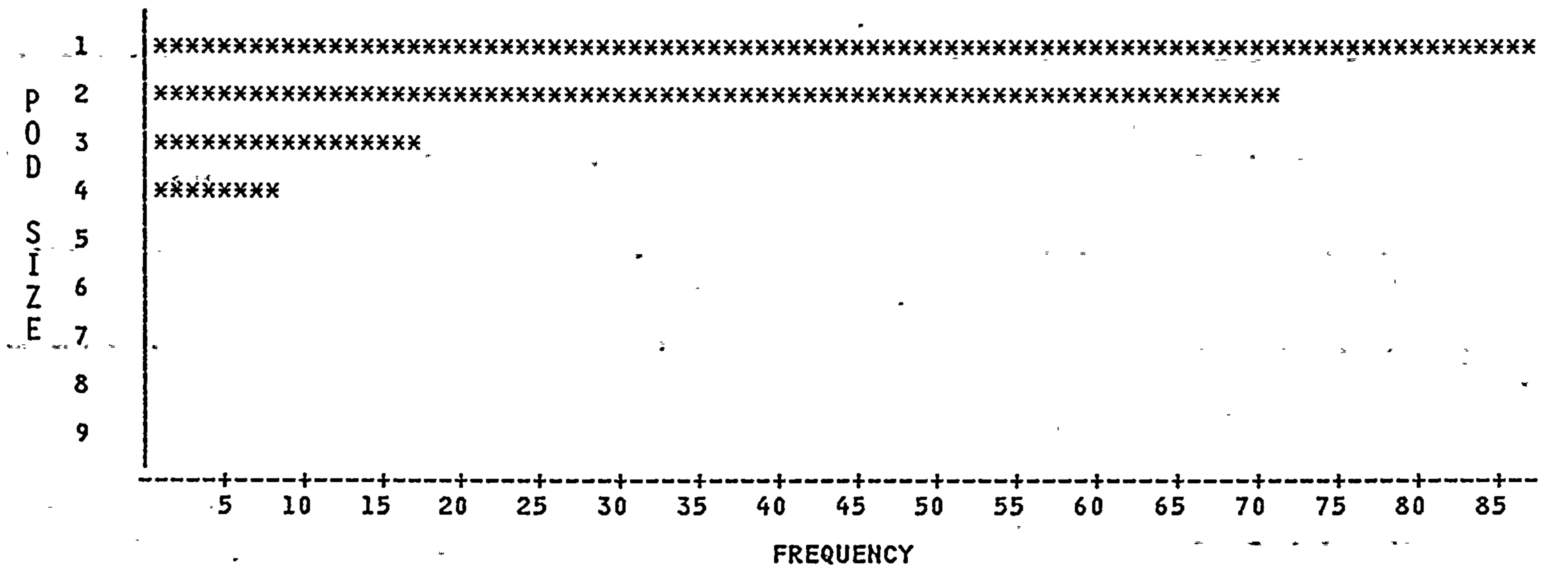
Frequency of Occurrence of Pod Sizes During Southerly Migration

```
                                   FREQUENCY BAR CHART

                                                                          FREQ  CUM.  PERCENT    CUM.
                                                                                FREQ            PERCENT
      1 |********************************************************    56    56    49.12    49.12
      2 |****************************************                    40    96    35.09    84.21
P     3 |***********                                                 11   107     9.65    93.86
O     4 |***                                                          3   110     2.63    96.49
D     5 |*                                                            1   111     0.88    97.37
      6 |**                                                           2   113     1.75    99.12
S     7 |*                                                            1   114     0.88   100.00
I     8 |                                                             0   114     0.00   100.00
Z     9 |                                                             0   114     0.00   100.00
E       |
        -----+----+----+----+----+----+----+----+----+----+----+-
             5   10   15   20   25   30   35   40   45   50   55

                               FREQUENCY
```

Figure 6

Frequency of Occurrence of Pod Sizes During Northerly Migration

FREQUENCY BAR CHART



POD SIZE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	87	87	47.54	47.54
2	71	158	38.80	86.34
3	17	175	9.29	95.63
4	8	183	4.37	100.00
5	0	183	0.00	100.00
6	0	183	0.00	100.00
7	0	183	0.00	100.00
8	0	183	0.00	100.00
9	0	183	0.00	100.00

accounted for 78%. Appendix 2 contains frequency distributions of pod size by zone.

Distribution

Tables 3 and 4 present a breakdown of numbers of whales by zone for each observation day and each migratory direction, respectively. Figure 7 presents the percent composition of the six zones for each direction of migration. During the southern migration 62.5% of the individuals were observed to move through zone 6 (1524-1830m offshore), while during the northern migration 33.5% were observed in this zone. The compliment to this was observed nearshore, where during the southern migration only 7.3% were observed within 610m (Zones 1 & 2) of the shoreline, while during the northerly return 13.8% were observed within 610m of shore.

Behavior

Due to the difficulty in accurately assessing different types of behavior, this portion of the study received reduced emphasis. Only very general observations can be made. Table 5 presents the incidence of various behavior by migratory direction. Normal migratory swimming was the most common behavior observed, with individuals displaying other behaviors accounting for only 12.4% of all behavior noted.

Table 3

Total Number of Whales and Percent of Total in Each Zone

During Southerly Migration

DATE FREQUENCY ROW PCT	ZONE 1	2	3	4	5	6	TOTAL
14DEC81	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1 100.00	1
15DEC81	0 0.00	0 0.00	0 0.00	0 0.00	2 100.00	0 0.00	2
22DEC81	0 0.00	0 0.00	0 0.00	0 0.00	5 83.33	1 16.67	6
28DEC81	0 0.00	1 4.76	0 0.00	2 9.52	6 28.57	12 57.14	21
06JAN82	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	26 100.00	26
07JAN82	0 0.00	0 0.00	0 0.00	0 0.00	2 7.14	26 92.86	28
11JAN82	0 0.00	4 12.50	2 6.25	6 18.75	3 9.38	17 53.13	32
13JAN82	0 0.00	2 5.00	2 5.00	2 5.00	3 7.50	31 77.50	40
25JAN82	0 0.00	0 0.00	1 5.88	2 11.76	6 35.29	8 47.06	17
27JAN82	1 7.69	1 7.69	1 7.69	3 23.08	4 30.77	3 23.08	13
29JAN82	4 36.36	1 9.09	0 0.00	3 27.27	1 9.09	2 18.18	11
01FEB82	0 0.00	0 0.00	2 28.57	3 42.86	1 14.29	1 14.29	7
08FEB82	1 100.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1
TOTAL	6	9	8	21	33	128	205

Table 4

Total Number of Whales and Percent of Total in Each Zone During Northerly Migration

DATE ZONE

FREQUENCY / ROW PCT	1	2	3	4	5	6	TOTAL
08FEB82	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	3 100.00	3
17FEB82	0 0.00	0 0.00	0 0.00	0 0.00	6 100.00	0 0.00	6
24FEB82	0 0.00	0 0.00	4 19.05	4 19.05	3 14.29	10 47.62	21
27FEB82	0 0.00	3 15.00	2 10.00	3 15.00	3 15.00	9 45.00	20
03MAR82	0 0.00	1 1.49	1 1.49	15 22.39	13 19.40	37 55.22	67
06MAR82	2 40.00	0 0.00	0 0.00	2 40.00	1 20.00	0 0.00	5
08MAR82	1 1.89	1 1.89	6 11.32	10 18.87	15 28.30	20 37.74	53
10MAR82	0 0.00	2 5.56	7 19.44	4 11.11	7 19.44	16 44.44	36
15MAR82	0 0.00	6 19.35	6 19.35	8 25.81	8 25.81	3 9.68	31
TOTAL	10	33	39	60	65	105	312

(CONTINUED)

Table 4 (continued)

DATE FREQUENCY ROW PCT	ZONE 1	2	3	4	5	6	TOTAL
19MAR82	1 4.35	1 4.35	1 4.35	9 39.13	5 21.74	6 26.09	23
23MAR82	1 9.09	4 36.36	2 18.18	2 18.18	2 18.18	0 0.00	11
25MAR82	0 0.00	3 33.33	4 44.44	2 22.22	0 0.00	0 0.00	9
26MAR82	2 12.50	9 56.25	5 31.25	0 0.00	0 0.00	0 0.00	16
01APR82	2 40.00	3 60.00	0 0.00	0 0.00	0 0.00	0 0.00	5
02APR82	0 0.00	0 0.00	1 50.00	1 50.00	0 0.00	0 0.00	2
05APR82	1 100.00	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	1
08APR82	0 0.00	0 0.00	0 0.00	0 0.00	2 66.67	1 33.33	3
TOTAL	10	33	39	60	65	105	312

Figure 7

Percent Composition of Whales Within Each Zone, by Direction

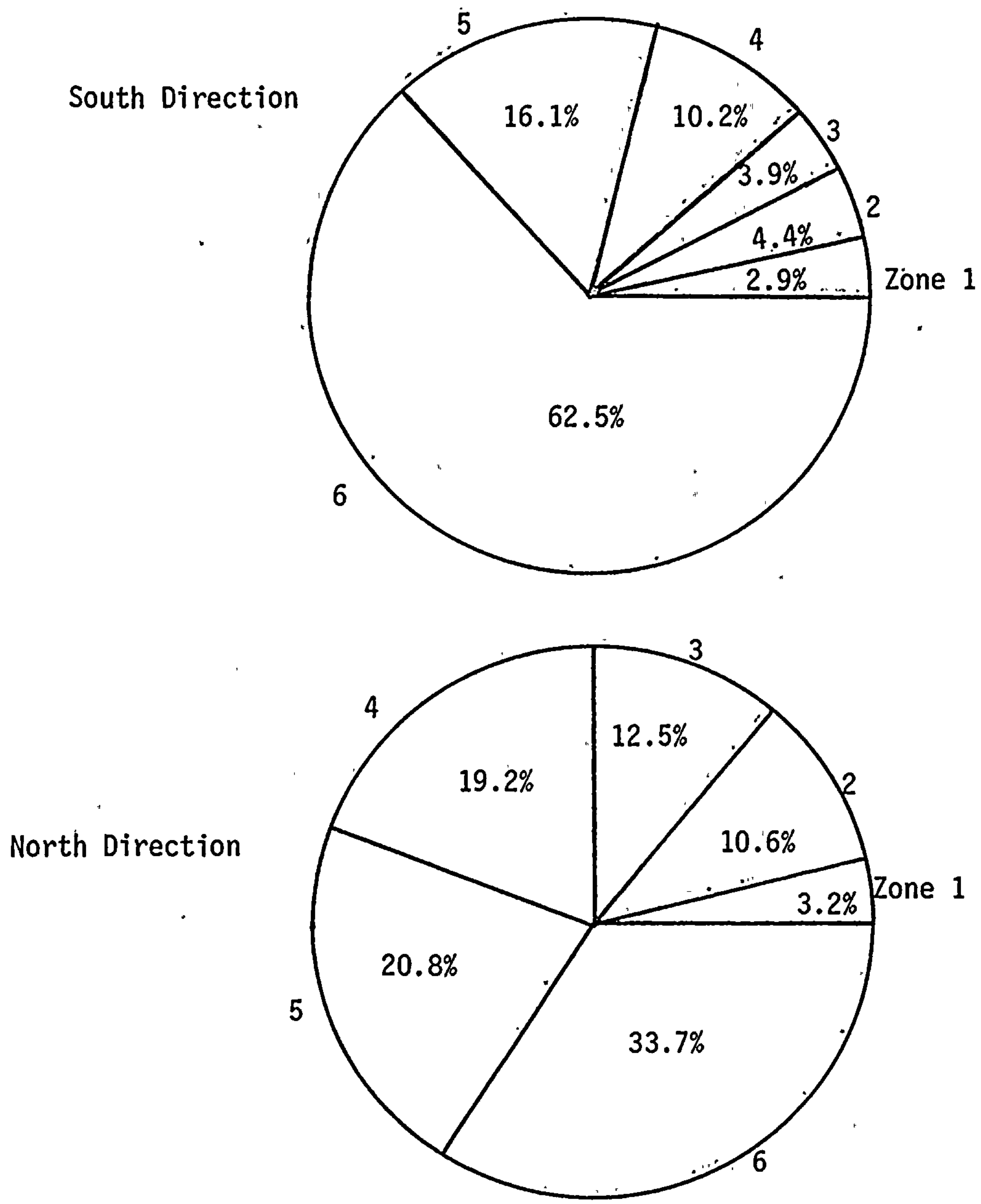


Table 5

Total Number of Whales Exhibiting Various Behavior

By Direction, 1981-82

	Southerly	Northerly
Breaching	2	9
Pectoral Fin Extended	2	2
Fluke Extended	2	0
Unusual Swimming Behavior	4	15
Playing Activity	7	18
Mating - Penis Visible	0	3

Breaching occurred more frequently during the northern migration. Mating behavior, which was defined by lying still in the water and the observation of an erect penis, was noted on three occassions, all during the northern return.

Discussion

Rugh and Braham (1979) reported that a certain degree of variablitiy exists concerning the date on which whales leave the Bering Sea to begin their southerly migration, late October-December. In the 1977 migration, they observed that 11,179 ±878 whales left between November 20 and December 9. Considering the estimated 49 days required to swim from Cape Sarichel, Alaska to Point Loma, California, a distance of 5,056 km, one would surmize that this years migration began much earlier than usual since the first whale sighted at Diablo Cove was on November 18, 1981. The existence of the peak in numbers at Point Loma on January 11, 1978, much further south suggests, however, that for any given year. arrival time at the calving grounds may be more important than departure from the Bering Sea.

During the 1981-82 migration, animals were observed passing the Diablo Canyon Power Plant for 7.5 calendar months. Our 98.25 hours of observation accounted for approximately 2.08% of the time that whales passed Diablo Cove in a southerly direction and 2.04% of the northerly direction. Although the primary goal of the study was to determine how many whales pass through the predicted extent of the thermal plume during the migration, caution must be

exercised in such an extrapolation due to the portion of the population sampled. Assuming no diurnal variation this calculation suggests that 9840 whales passed through our 1830m corridor during the 83 days of southerly migration and that 12,068 whales passed through the corridor during 116 days of northerly migration. The latter estimate excludes the elevated count on March 3, as the inclusion of this days count greatly exaggerates the estimate.

The most recent population estimate (1981-82) made by the USFWS Marine Mammal Laboratory, Seattle, Wash. was 17,500 (14,500-19,000) animals (Marine Mammal Protection Act, Annual Report 1981/82). Our corridor estimate (12,068) compares favorably to this estimate when one considers previously published data on population concentrations and distances from shore.

The difference in numbers between southern and northern migration is not only explained by the obvious addition of newborn calves but also by observations that the whales swim closer to shore during the northern migration (personal communication, Michael Poole, Sonoma State Univ.). This phenomenon, therefore, increases the proportion of the population passing through the 1830m corridor. Our observations found that fewer animals occupied zone 6 while a greater number swam through zones 1, 2 and 3 during the northerly return.

At Unimake Pass, Alaska, 71% of the whales pass within 815m of the shore (Rugh & Braham, 1979). This distance varies with location along the migratory route, coastline characteristics, water depth and weather conditions and becomes greater as the migration proceeds southerly (personal communication, Dr. Thomas Dohl, Univ. of California, Santa Cruz). By Point Loma, only 11% of the population are sighted within 815m. Our data suggests that about 36% pass within 815m of shore.

Pod size was observed to be similar during both directions of the migration and compared with that observed by Rugh and Braham (1979) at Unimak Pass. They reported that there was no apparent change in size through time with the mean pod being 1.95 ±0.07 in 1977. Of 1253 pods, the largest they observed was composed of 9 individuals.

Wilson and Behrens (1981) reported observations of concurrent mating in the vicinity of Diablo Canyon. The three matings observed in this study occurred in the same location as those reported by them. Although highly speculative, the coincidence of this behavior occurring in this same spot annually may be explained by some unknown preference for the presence of a geographical feature such as the subtidal pinnacle and kelp bed which exists at this location.

Acknowledgements

I would like to express many thanks to Mark Couacaud, who designed and initiated this study as his senior thesis at California Polytechnic State University, San Luis Obispo. Special thanks also to Cal Poly Foundation students Debbie Jo (Smeltzer) Sommerville and Paul Dunn, who assisted Marc with the whale counts. Thanks also to David C. Sommerville for developing the custom software used in the data reduction and analysis.

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Appendix 1

Daily Whale Observation Data

APPENDIX 1
DAILY WHALE OBSERVATION DATA

DATE	TIME	POD NUMBER	WHALES	DIRECTION	BEHAVIOR	NUMBER OF PARTICIPANTS	REPETITIONS	DURATION
14DEC81	13:52:00	1	1	S	.	.	.	.
15DEC81	14:02:00	2	2	S	.	.	.	.
22DEC81	10:30:00	3	3	S	.	.	.	.
22DEC81	11:30:00	4	1	S	.	.	.	.
22DEC81	12:45:00	5	2	S	.	.	.	.
28DEC81	10:50:00	6	4	S	7	3	1	40
28DEC81	11:14:00	7	1	S	.	.	.	.
28DEC81	11:25:00	8	4	S	.	.	.	.
28DEC81	11:30:00	9	1	S	.	.	.	.
28DEC81	11:53:00	10	2	S	.	.	.	.
28DEC81	11:53:00	11	2	S	.	.	.	.
28DEC81	12:00:00	12	1	S	.	.	.	.
28DEC81	12:16:00	13	1	S	.	.	.	.
28DEC81	12:25:00	14	1	S	.	.	.	.
28DEC81	12:30:00	15	3	S	.	.	.	.
28DEC81	12:32:00	16	1	S	.	.	.	.
06JAN82	9:45:00	17	1	S	.	.	.	.
06JAN82	9:56:00	18	6	S	.	.	.	.
06JAN82	10:20:00	19	1	S	.	.	.	.
06JAN82	11:27:00	20	3	S	.	.	.	.
06JAN82	11:38:00	21	2	S	.	.	.	.
06JAN82	11:56:00	22	1	S	.	.	.	.
06JAN82	12:08:00	23	2	S	.	.	.	.
06JAN82	12:20:00	24	1	S	.	.	.	.
06JAN82	12:30:00	25	1	S	.	.	.	.
06JAN82	13:20:00	26	1	S	.	.	.	.
06JAN82	13:23:00	27	2	S	.	.	.	.
06JAN82	13:30:00	28	2	S	.	.	.	.
06JAN82	13:54:00	29	3	S	.	.	.	.
07JAN82	11:00:00	30	3	S	.	.	.	.
07JAN82	11:20:00	31	1	S	.	.	.	.
07JAN82	11:50:00	32	3	S	.	.	.	.
07JAN82	12:20:00	33	2	S	4	2	2	1
07JAN82	12:45:00	34	5	S	.	.	.	.
07JAN82	12:50:00	35	2	S	.	.	.	.
07JAN82	13:05:00	36	3	S	.	.	.	.
07JAN82	13:15:00	37	1	S	.	.	.	.
07JAN82	13:30:00	38	1	S	.	.	.	.
07JAN82	13:30:00	39	2	S	.	.	.	.
07JAN82	13:40:00	40	2	S	.	.	.	.
07JAN82	13:40:00	41	3	S	.	.	.	.
11JAN82	11:55:00	42	2	S	.	.	.	.
11JAN82	12:05:00	43	3	S	.	.	.	.
11JAN82	12:55:00	44	1	S	.	.	.	.
11JAN82	13:01:00	45	2	S	.	.	.	.
11JAN82	13:23:00	46	1	S	.	.	.	.
11JAN82	13:31:00	47	2	S	.	.	.	.
11JAN82	13:40:00	48	2	S	.	.	.	.
11JAN82	13:47:00	49	1	S	.	.	.	.
11JAN82	13:54:00	50	2	S	.	.	.	.
11JAN82	14:09:00	51	1	S	.	.	.	.

APPENDIX 1
DAILY WHALE OBSERVATION DATA

DATE	TIME	POD NUMBER	WHALES	DIRECTION	BEHAVIOR	NUMBER OF PARTICIPANTS	REPETITIONS	DURATION
11JAN82	14:19:00	52	2	S	.	.	.	.
11JAN82	14:25:00	53	1	S	.	.	.	.
11JAN82	14:31:00	54	6	S	.	.	.	.
11JAN82	14:33:00	55	2	S	.	.	.	.
11JAN82	14:39:00	56	1	S	.	.	.	.
11JAN82	14:40:00	57	1	S	.	.	.	.
11JAN82	14:40:00	58	1	S	.	.	.	.
11JAN82	15:00:00	59	1	S	.	.	.	.
13JAN82	10:45:00	60	1	S	.	.	.	.
13JAN82	10:49:00	61	2	S	.	.	.	.
13JAN82	11:21:00	62	2	S	.	.	.	.
13JAN82	11:32:00	63	2	S	.	.	.	.
13JAN82	11:33:00	64	2	S	.	.	.	.
13JAN82	11:45:00	65	1	S	.	.	.	.
13JAN82	11:55:00	66	1	S	2	1	3	2
13JAN82	12:23:00	67	2	S	.	.	.	.
13JAN82	12:29:00	68	7	S	.	.	.	.
13JAN82	12:36:00	69	2	S	.	.	.	.
13JAN82	12:37:00	70	1	S	.	.	.	.
13JAN82	13:11:00	71	2	S	.	.	.	.
13JAN82	13:17:00	72	2	S	.	.	.	.
13JAN82	13:27:00	73	2	S	.	.	.	.
13JAN82	13:38:00	74	3	S	.	.	.	.
13JAN82	13:47:00	75	2	S	.	.	.	.
13JAN82	14:01:00	76	2	S	.	.	.	.
13JAN82	14:01:00	77	2	S	.	.	.	.
13JAN82	14:01:00	78	2	S	.	.	.	.
25JAN82	8:05:00	79	1	S	.	.	.	.
25JAN82	8:14:00	80	2	S	.	.	.	.
25JAN82	8:22:00	81	2	S	.	.	.	.
25JAN82	8:42:00	82	1	S	.	.	.	.
25JAN82	8:50:00	83	1	S	.	.	.	.
25JAN82	9:02:00	84	1	S	.	.	.	.
25JAN82	9:15:00	85	1	S	2	1	1	1
25JAN82	9:19:00	86	1	S	.	.	.	.
25JAN82	9:45:00	87	1	S	.	.	.	.
25JAN82	9:59:00	88	1	S	.	.	.	.
25JAN82	10:05:00	89	1	S	.	.	.	.
25JAN82	10:05:00	90	1	S	.	.	.	.
25JAN82	10:15:00	91	1	S	.	.	.	.
25JAN82	10:20:00	92	2	S	.	.	.	.
27JAN82	10:06:00	93	1	S	.	.	.	.
27JAN82	10:30:00	94	1	S	.	.	.	.
27JAN82	10:36:00	95	1	S	.	.	.	.
27JAN82	10:37:00	96	1	S	.	.	.	.
27JAN82	10:42:00	97	1	S	.	.	.	.
27JAN82	10:50:00	98	3	S	7	3	1	20
27JAN82	10:55:00	99	1	S	.	.	.	.
27JAN82	11:05:00	100	1	S	.	.	.	.
27JAN82	12:30:00	101	1	S	.	.	.	.
27JAN82	12:58:00	102	2	S	.	.	.	.

APPENDIX 1
DAILY WHALE OBSERVATION DATA

DATE	TIME	POD NUMBER	WHALES	DIRECTION	BEHAVIOR	NUMBER OF PARTICIPANTS	REPETITIONS	DURATION
29JAN82	11:34:00	103	2	S	.	.	.	.
29JAN82	11:58:00	104	1	S	.	.	.	.
29JAN82	13:23:00	105	2	S	.	.	.	.
29JAN82	13:38:00	106	1	S	.	.	.	.
29JAN82	14:00:00	107	4	S	6	4	1	20
29JAN82	14:00:00	108	1	S	.	.	.	.
01FEB82	10:00:00	109	1	S	.	.	.	.
01FEB82	12:24:00	110	1	S	.	.	.	.
01FEB82	12:55:00	111	2	S	.	.	.	.
01FEB82	13:17:00	112	2	S	3	1	1	1
01FEB82	13:29:00	113	1	S	.	.	.	.
08FEB82	11:34:00	114	1	S	.	.	.	.
08FEB82	12:25:00	115	3	N	.	.	.	.
17FEB82	11:37:00	116	4	N	.	.	.	.
17FEB82	12:25:00	117	2	N	.	.	.	.
24FEB82	10:02:00	118	1	N	.	.	.	.
24FEB82	10:15:00	119	1	N	.	.	.	.
24FEB82	10:30:00	120	2	N	.	.	.	.
24FEB82	10:56:00	121	2	N	.	.	.	.
24FEB82	11:23:00	122	3	N	.	.	.	.
24FEB82	11:49:00	123	2	N	.	.	.	.
24FEB82	12:05:00	124	1	N	.	.	.	.
24FEB82	12:25:00	125	1	N	.	.	.	.
24FEB82	12:57:00	126	2	N	.	.	.	.
24FEB82	13:35:00	127	1	N	.	.	.	.
24FEB82	13:40:00	128	2	N	.	.	.	.
24FEB82	13:55:00	129	2	N	.	.	.	.
24FEB82	13:55:00	130	1	N	.	.	.	.
27FEB82	9:46:00	131	1	N	.	.	.	.
27FEB82	9:54:00	132	1	N	.	.	.	.
27FEB82	10:28:00	133	1	N	.	.	.	.
27FEB82	10:35:00	134	2	N	.	.	.	.
27FEB82	10:45:00	135	2	N	.	.	.	.
27FEB82	11:00:00	136	2	N	.	.	.	.
27FEB82	11:41:00	137	1	N	.	.	.	.
27FEB82	11:55:00	138	2	N	.	.	.	.
27FEB82	12:00:00	139	2	N	.	.	.	.
27FEB82	12:04:00	140	3	N	6	3	1	5
27FEB82	12:17:00	141	2	N	.	.	.	.
27FEB82	12:25:00	142	1	N	.	.	.	.
03MAR82	9:30:00	143	1	N	.	.	.	.
03MAR82	9:35:00	144	1	N	.	.	.	.
03MAR82	9:47:00	145	2	N	.	.	.	.
03MAR82	9:50:00	146	3	N	.	.	.	.
03MAR82	9:54:00	147	1	N	.	.	.	.
03MAR82	9:58:00	148	2	N	.	.	.	.
03MAR82	9:58:00	149	1	N	.	.	.	.
03MAR82	9:59:00	150	2	N	.	.	.	.
03MAR82	10:05:00	151	2	N	.	.	.	.
03MAR82	10:05:00	152	2	N	2	1	1	1
03MAR82	10:07:00	153	4	N	.	.	.	.

APPENDIX 1
DAILY WHALE OBSERVATION DATA

DATE	TIME	POD NUMBER	WHALES	DIRECTION	BEHAVIOR	NUMBER OF PARTICIPANTS	REPETITIONS	DURATION
03MAR82	10:10:00	154	1	N	.	.	.	.
03MAR82	10:17:00	155	1	N	.	.	.	.
03MAR82	10:20:00	156	4	N	.	.	.	.
03MAR82	10:30:00	157	2	N	.	.	.	.
03MAR82	10:30:00	158	1	N	.	.	.	.
03MAR82	10:36:00	159	1	N	.	.	.	.
03MAR82	10:43:00	160	1	N	.	.	.	.
03MAR82	10:45:00	161	1	N	.	.	.	.
03MAR82	10:50:00	162	1	N	.	.	.	.
03MAR82	10:56:00	163	1	N	.	.	.	.
03MAR82	10:59:00	164	2	N	.	.	.	.
03MAR82	11:05:00	165	1	N	.	.	.	.
03MAR82	11:10:00	166	2	N	.	.	.	.
03MAR82	11:20:00	167	2	N	.	.	.	.
03MAR82	11:24:00	168	1	N	.	.	.	.
03MAR82	11:27:00	169	4	N	2	1	4	2
03MAR82	11:31:00	170	2	N	.	.	.	.
03MAR82	11:40:00	171	2	N	.	.	.	.
03MAR82	11:48:00	172	4	N	.	.	.	.
03MAR82	11:50:00	173	2	N	.	.	.	.
03MAR82	11:55:00	174	2	N	.	.	.	.
03MAR82	12:00:00	175	2	N	6	2	1	10
03MAR82	12:05:00	176	3	N	7	3	1	15
03MAR82	12:05:00	177	2	N	.	.	.	.
03MAR82	12:22:00	178	1	N	.	.	.	.
06MAR82	10:05:00	179	1	N	.	.	.	.
06MAR82	10:20:00	180	1	N	.	.	.	.
06MAR82	10:30:00	181	1	N	.	.	.	.
06MAR82	11:26:00	182	1	N	.	.	.	.
06MAR82	11:29:00	183	1	N	.	.	.	.
08MAR82	9:30:00	184	2	N	.	.	.	.
08MAR82	9:32:00	185	1	N	.	.	.	.
08MAR82	9:45:00	186	1	N	.	.	.	.
08MAR82	9:50:00	187	1	N	.	.	.	.
08MAR82	9:50:00	188	3	N	6	2	1	1
08MAR82	10:15:00	189	3	N	6	3	1	1
08MAR82	10:24:00	190	2	N	.	.	.	.
08MAR82	10:45:00	191	3	N	8	3	1	95
08MAR82	10:50:00	192	1	N	.	.	.	.
08MAR82	11:10:00	193	2	N	.	.	.	.
08MAR82	11:15:00	194	3	N	7	3	1	7
08MAR82	11:20:00	195	4	N	7	4	1	2
08MAR82	11:22:00	196	1	N	.	.	.	.
08MAR82	11:27:00	197	3	N	7	3	1	20
08MAR82	11:36:00	198	3	N	7	3	1	10
08MAR82	11:40:00	199	2	N	3	1	1	1
08MAR82	11:56:00	200	2	N	.	.	.	.
08MAR82	12:15:00	201	2	N	.	.	.	.
08MAR82	12:20:00	202	1	N	.	.	.	.
08MAR82	12:39:00	203	2	N	.	.	.	.
08MAR82	12:45:00	204	1	N	.	.	.	.

APPENDIX 1
DAILY WHALE OBSERVATION DATA

DATE	TIME	POD NUMBER	WHALES	DIRECTION	BEHAVIOR	NUMBER OF PARTICIPANTS	REPETITIONS	DURATION
08MAR82	13:00:00	205	2	N	.	.	.	.
08MAR82	13:05:00	206	1	N	.	.	.	.
08MAR82	13:10:00	207	2	N	.	.	.	.
08MAR82	13:26:00	208	1	N	.	.	.	.
08MAR82	13:26:00	209	2	N	.	.	.	.
08MAR82	13:30:00	210	2	N	.	.	.	.
10MAR82	9:30:00	211	1	N	.	.	.	.
10MAR82	9:36:00	212	1	N	2	1	1	1
10MAR82	9:50:00	213	2	N	6	2	1	1
10MAR82	9:50:00	214	1	N	.	.	.	.
10MAR82	9:50:00	215	1	N	.	.	.	.
10MAR82	9:55:00	216	1	N	.	.	.	.
10MAR82	10:02:00	217	2	N	.	.	.	.
10MAR82	10:05:00	218	1	N	.	.	.	.
10MAR82	10:09:00	219	3	N	.	.	.	.
10MAR82	10:15:00	220	2	N	.	.	.	.
10MAR82	10:22:00	221	2	N	.	.	.	.
10MAR82	10:27:00	222	2	N	.	.	.	.
10MAR82	10:28:00	223	2	N	.	.	.	.
10MAR82	10:50:00	224	2	N	.	.	.	.
10MAR82	10:55:00	225	1	N	.	.	.	.
10MAR82	11:52:00	226	3	N	.	.	.	.
10MAR82	11:53:00	227	4	N	.	.	.	.
10MAR82	12:05:00	228	2	N	.	.	.	.
10MAR82	12:07:00	229	2	N	.	.	.	.
10MAR82	12:07:00	230	1	N	.	.	.	.
15MAR82	9:00:00	231	2	N	.	.	.	.
15MAR82	9:05:00	232	1	N	.	.	.	.
15MAR82	9:36:00	233	2	N	.	.	.	.
15MAR82	9:35:00	234	1	N	.	.	.	.
15MAR82	9:42:00	235	1	N	.	.	.	.
15MAR82	9:47:00	236	2	N	.	.	.	.
15MAR82	10:00:00	237	4	N	.	.	.	.
15MAR82	10:05:00	238	1	N	.	.	.	.
15MAR82	10:06:00	239	2	N	.	.	.	.
15MAR82	10:16:00	240	1	N	.	.	.	.
15MAR82	10:45:00	241	2	N	.	.	.	.
15MAR82	10:45:00	242	2	N	.	.	.	.
15MAR82	10:55:00	243	1	N	.	.	.	.
15MAR82	11:00:00	244	2	N	.	.	.	.
15MAR82	11:05:00	245	1	N	.	.	.	.
15MAR82	11:07:00	246	1	N	.	.	.	.
15MAR82	11:16:00	247	1	N	.	.	.	.
15MAR82	11:19:00	248	1	N	.	.	.	.
15MAR82	11:26:00	249	2	N	.	.	.	.
15MAR82	11:31:00	250	1	N	.	.	.	.
19MAR82	11:20:00	251	2	N	.	.	.	.
19MAR82	11:25:00	252	2	N	2	1	5	4
19MAR82	11:29:00	253	2	N	.	.	.	.
19MAR82	11:43:00	254	1	N	.	.	.	.
19MAR82	11:47:00	255	3	N	.	.	.	.

APPENDIX 1
DAILY WHALE OBSERVATION DATA

DATE	TIME	POD NUMBER	WHALES	DIRECTION	BEHAVIOR	NUMBER OF PARTICIPANTS	REPETITIONS	DURATION
19MAR82	11:54:00	256	1	N	.	.	.	.
19MAR82	12:01:00	257	2	N	.	.	.	.
19MAR82	12:01:00	258	1	N	.	.	.	.
19MAR82	12:11:00	259	1	N	.	.	.	.
19MAR82	12:23:00	260	1	N	.	.	.	.
19MAR82	12:45:00	261	2	N	.	.	.	.
19MAR82	12:46:00	262	1	N	.	.	.	.
19MAR82	12:48:00	263	1	N	.	.	.	.
19MAR82	13:02:00	264	1	N	6	1	1	3
19MAR82	13:15:00	265	2	N	.	.	.	.
23MAR82	10:56:00	266	2	N	.	.	.	.
23MAR82	11:54:00	267	1	N	.	.	.	.
23MAR82	12:14:00	268	2	N	.	.	.	.
23MAR82	12:16:00	269	1	N	6	1	1	2
23MAR82	13:29:00	270	1	N	.	.	.	.
23MAR82	14:00:00	271	1	N	.	.	.	.
23MAR82	14:14:00	272	1	N	.	.	.	.
23MAR82	14:15:00	273	1	N	.	.	.	.
23MAR82	14:21:00	274	1	N	.	.	.	.
25MAR82	8:50:00	275	2	N	7	2	1	30
25MAR82	9:30:00	276	1	N	.	.	.	.
25MAR82	9:32:00	277	2	N	.	.	.	.
25MAR82	9:37:00	278	1	N	.	.	.	.
25MAR82	9:40:00	279	2	N	.	.	.	.
25MAR82	11:29:00	280	1	N	.	.	.	.
26MAR82	11:01:00	281	1	N	.	.	.	.
26MAR82	11:02:00	282	1	N	.	.	.	.
26MAR82	11:06:00	283	3	N	.	.	.	.
26MAR82	11:10:00	284	1	N	.	.	.	.
26MAR82	12:41:00	285	2	N	.	.	.	.
26MAR82	12:55:00	286	3	N	.	.	.	.
26MAR82	13:02:00	287	1	N	.	.	.	.
26MAR82	13:10:00	288	2	N	.	.	.	.
26MAR82	13:19:00	289	1	N	.	.	.	.
26MAR82	13:52:00	290	1	N	.	.	.	.
01APR82	10:16:00	291	2	N	.	.	.	.
01APR82	10:45:00	292	3	N	.	.	.	.
02APR82	12:17:00	293	1	N	.	.	.	.
02APR82	12:21:00	294	1	N	.	.	.	.
05APR82	13:00:00	295	1	N	.	.	.	.
08APR82	12:25:00	296	1	N	.	.	.	.
08APR82	12:39:00	297	2	N	.	.	.	.

APPENDIX 1
DAILY ENVIRONMENTAL DATA

DATE	OBSERVER	TIME	VISIBILITY	SWELL HEIGHT	WIND SPEED	SURFACE CONDITIONS
14DEC81	MJC	12:47:00	CL	02-06	8	WC
14DEC81	MJC	13:47:00	CL	02-06	5	HC
15DEC81	MJC	10:40:00	HZ	05-10	5	HC
15DEC81	MJC	11:40:00	HZ	05-10	5	HC
15DEC81	MJC	12:40:00	PC	05-10	10	WC
15DEC81	MJC	13:40:00	CL	10-12	25	HC
17DEC81	DJS	9:50:00	HZ	02-07	5	SM
17DEC81	DJS	10:50:00	CL	05-10	5	SM
17DEC81	DJS	11:50:00	CL	05-10	5	SM
17DEC81	DJS	12:50:00	HZ	05-10	5	SM
17DEC81	DJS	13:50:00	HZ	05-10	5	SM
22DEC81	DJS	9:45:00	HZ	10-15	8	SM
22DEC81	DJS	10:45:00	CL	10-15	8	SM
22DEC81	DJS	11:45:00	CL	10-15	8	SM
22DEC81	DJS	12:45:00	CL	10-15	8	LC
28DEC81	MJC	10:30:00	CL	02-06	1	LC
28DEC81	MJC	11:30:00	CL	02-06	5	LC
28DEC81	MJC	12:30:00	CL	05-10	10	HC
28DEC81	MJC	13:00:00	CL	10-15	15	WC
06JAN82	MJC	9:30:00	CL	04-08	5	LC
06JAN82	MJC	10:30:00	CL	04-08	5	LC
06JAN82	MJC	11:30:00	CL	04-08	5	LC
06JAN82	MJC	12:30:00	CL	04-08	5	LC
06JAN82	MJC	13:30:00	CL	04-08	5	LC
06JAN82	MJC	14:30:00	CL	04-08	10	LC
07JAN82	DJS	10:30:00	CL	03-07	5	SM
07JAN82	DJS	11:30:00	CL	03-05	5	SM
07JAN82	DJS	12:30:00	CL	03-05	5	SM
07JAN82	DJS	13:30:00	CL	03-05	5	SM
11JAN82	MJC	11:45:00	CL	02-06	5	SM
11JAN82	MJC	12:45:00	CL	02-06	5	SM
11JAN82	MJC	13:45:00	CL	02-06	5	SM
11JAN82	MJC	14:45:00	CL	02-06	5	SM
13JAN82	MJC	10:15:00	HZ	01-05	1	LC
13JAN82	MJC	11:15:00	CL	01-05	3	LC
13JAN82	MJC	12:15:00	CL	01-05	1	SM
13JAN82	MJC	13:15:00	CL	01-05	3	SM
13JAN82	MJC	14:15:00	CL	01-05	1	SM
25JAN82	MJC	8:00:00	CL	02-06	10	LC
25JAN82	MJC	9:00:00	CL	02-06	10	LC
25JAN82	MJC	10:00:00	CL	04-08	15	LC
25JAN82	MJC	11:00:00	CL	02-06	10	LC
27JAN82	MJC	10:00:00	HZ	05-10	10	HC
27JAN82	MJC	11:00:00	CL	05-12	10	HC
27JAN82	MJC	12:00:00	CL	05-12	15	HC
27JAN82	MJC	13:00:00	CL	05-12	15	HC
29JAN82	MJC	11:30:00	CL	05-10	25	HC
29JAN82	MJC	12:30:00	CL	05-10	25	HC
29JAN82	MJC	13:30:00	CL	05-10	10	HC
29JAN82	MJC	14:30:00	CL	08-15	15	HC
01FEB82	MJC	10:00:00	HZ	02-05	5	HC

APPENDIX 1
DAILY ENVIRONMENTAL DATA

DATE	OBSERVER	TIME	VISIBILITY	SWELL HEIGHT	WIND SPEED	SURFACE CONDITIONS
01FEB82	MJC	11:00:00	CL	05-08	5	HC
01FEB82	MJC	12:00:00	HZ	05-10	5	WC
01FEB82	MJC	13:00:00	CL	05-08	2	LC
08FEB82	MJC	10:00:00	PC	01-02	1	SM
08FEB82	MJC	11:00:00	HZ	01-03	3	SM
08FEB82	MJC	12:00:00	HZ	01-03	5	SM
17FEB82	MJC	11:30:00	CL	05-10	25	HC
17FEB82	MJC	12:30:00	HZ	10-15	25	WC
24FEB82	MJC	10:00:00	HZ	02-05	5	LC
24FEB82	MJC	11:00:00	HZ	02-05	5	LC
24FEB82	MJC	12:00:00	HZ	02-05	5	LC
24FEB82	MJC	13:00:00	HZ	02-05	5	LC
24FEB82	MJC	14:00:00	HZ	02-05	5	LC
27FEB82	MJC	9:30:00	HZ	01-02	1	SM
27FEB82	MJC	10:30:00	CL	02-04	1	SM
27FEB82	MJC	11:30:00	HZ	02-04	5	SM
27FEB82	MJC	12:30:00	CL	02-04	5	LC
03MAR82	MJC	9:30:00	HZ	02-06	10	HC
03MAR82	MJC	10:30:00	CL	05-08	10	HC
03MAR82	MJC	11:30:00	CL	05-10	10	HC
03MAR82	MJC	12:30:00	CL	05-10	20	WC
06MAR82	MJC	9:30:00	PC	01-04	1	SM
06MAR82	MJC	10:30:00	PC	01-04	1	SM
06MAR82	MJC	11:30:00	CL	01-04	1	SM
06MAR82	MJC	12:30:00	CL	01-04	2	SM
08MAR82	MJC	9:30:00	HZ	02-06	5	LC
08MAR82	MJC	10:30:00	OV	02-06	5	LC
08MAR82	MJC	11:30:00	CL	02-06	5	LC
08MAR82	MJC	12:30:00	PC	02-06	5	LC
10MAR82	MJC	9:30:00	OV	01-02	1	SM
10MAR82	MJC	10:30:00	OV	01-02	5	SM
10MAR82	MJC	11:30:00	OV	02-04	1	SM
10MAR82	MJC	12:30:00	OV	02-04	5	SM
15MAR82	PAD	9:00:00	CL	06-08	5	HC
15MAR82	PAD	10:00:00	CL	06-08	15	HC
15MAR82	PAD	11:00:00	CL	06-08	20	HC
19MAR82	PAD	10:45:00	CL	04-06	5	LC
19MAR82	PAD	11:45:00	CL	04-06	10	HC
19MAR82	PAD	12:45:00	CL	04-06	10	HC
19MAR82	PAD	13:45:00	CL	04-06	20	HC
23MAR82	PAD	10:45:00	HZ	03-06	10	LC
23MAR82	PAD	11:45:00	HZ	03-06	10	LC
23MAR82	PAD	12:45:00	HZ	03-06	10	LC
23MAR82	PAD	13:45:00	HZ	03-06	15	LC
23MAR82	PAD	14:45:00	HZ	03-06	15	LC
25MAR82	PAD	8:30:00	HZ	02-04	0	SM
25MAR82	PAD	9:30:00	OV	03-06	5	SM
25MAR82	PAD	10:30:00	OV	03-06	10	LC
25MAR82	PAD	11:30:00	OV	03-06	15	LC
26MAR82	PAD	10:30:00	OV	03-06	10	SM
26MAR82	PAD	11:30:00	PC	03-06	15	SM

APPENDIX I
DAILY ENVIRONMENTAL DATA

DATE	OBSERVER	TIME	VISIBILITY	SWELL HEIGHT	WIND SPEED	SURFACE CONDITIONS
26MAR82	PAD	12:30:00	PC	03-06	15	SM
26MAR82	PAD	13:30:00	CL	03-06	15	LC
01APR82	MJC	10:00:00	OV	04-08	10	LC
01APR82	MJC	11:00:00	RN	04-08	10	HC
02APR82	PAD	10:10:00	PC	06-08	10	LC
02APR82	PAD	11:10:00	CL	06-08	15	LC
02APR82	PAD	12:10:00	CL	06-08	15	LC
02APR82	PAD	13:10:00	CL	06-08	15	LC
02APR82	PAD	14:10:00	CL	06-08	15	LC
05APR82	PAD	10:30:00	CL	04-06	10	LC
05APR82	PAD	11:30:00	CL	04-08	20	HC
05APR82	PAD	12:30:00	OV	04-08	20	HC
05APR82	PAD	13:30:00	CL	04-08	20	HC
08APR82	MJC	11:00:00	HZ	01-03	1	SM
08APR82	MJC	12:00:00	OV	01-03	1	SM
08APR82	MJC	13:00:00	OV	02-04	10	SM
08APR82	MJC	14:00:00	OV	02-04	10	SM
27APR82	MJC	11:30:00	HZ	01-02	8	WC
27APR82	MJC	12:30:00	HZ	01-02	5	WC
27APR82	MJC	13:30:00	HZ	02-03	8	WC
29APR82	DJS	13:30:00	HZ	03-05	15	HC
29APR82	DJS	14:30:00	HZ	03-05	10	LC
29APR82	DJS	15:30:00	HZ	02-04	10	LC
12MAY82	PAD	10:00:00	CL	03-05	10	LC
12MAY82	PAD	11:00:00	CL	03-05	15	LC
12MAY82	PAD	12:00:00	CL	03-05	20	HC
12MAY82	PAD	13:00:00	CL	03-05	20	HC

Appendix 2

Frequency Distributions of Pod Sizes by Zone

FREQUENCY OF OCCURRENCE OF POD SIZES BY ZONE
NORTH AND SOUTH COMBINED
ZONE=1

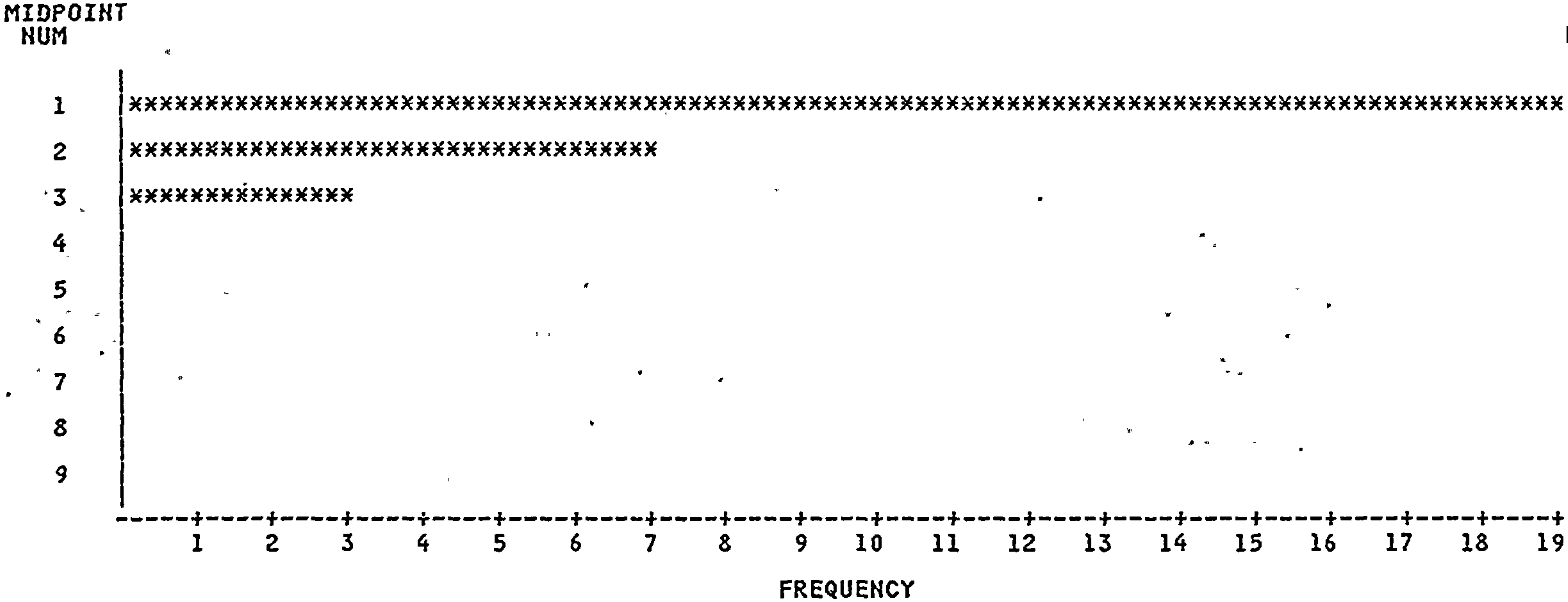
FREQUENCY BAR CHART

```
MIDPOINT
  NUM                                                                 FREQ  CUM.  PERCENT   CUM.
                                                                            FREQ           PERCENT
       |
   1   |**************************************************   10    10    83.33    83.33
       |
   2   |*****                                                 1    11     8.33    91.67
       |
   3   |                                                      0    11     0.00    91.67
       |
   4   |*****                                                 1    12     8.33   100.00
       |
   5   |                                                      0    12     0.00   100.00
       |
   6   |                                                      0    12     0.00   100.00
       |
   7   |                                                      0    12     0.00   100.00
       |
   8   |                                                      0    12     0.00   100.00
       |
   9   |                                                      0    12     0.00   100.00
       |
       ----+----+----+----+----+----+----+----+----+----+
           1    2    3    4    5    6    7    8    9   10

                          FREQUENCY
```

FREQUENCY OF OCCURRENCE OF POD SIZES BY ZONE
NORTH AND SOUTH COMBINED
ZONE=2

FREQUENCY BAR CHART



MIDPOINT NUM	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	19	19	65.52	65.52
2	7	26	24.14	89.66
3	3	29	10.34	100.00
4	0	29	0.00	100.00
5	0	29	0.00	100.00
6	0	29	0.00	100.00
7	0	29	0.00	100.00
8	0	29	0.00	100.00
9	0	29	0.00	100.00

FREQUENCY OF OCCURRENCE OF POD SIZES BY ZONE
NORTH AND SOUTH COMBINED
ZONE=3

FREQUENCY BAR CHART

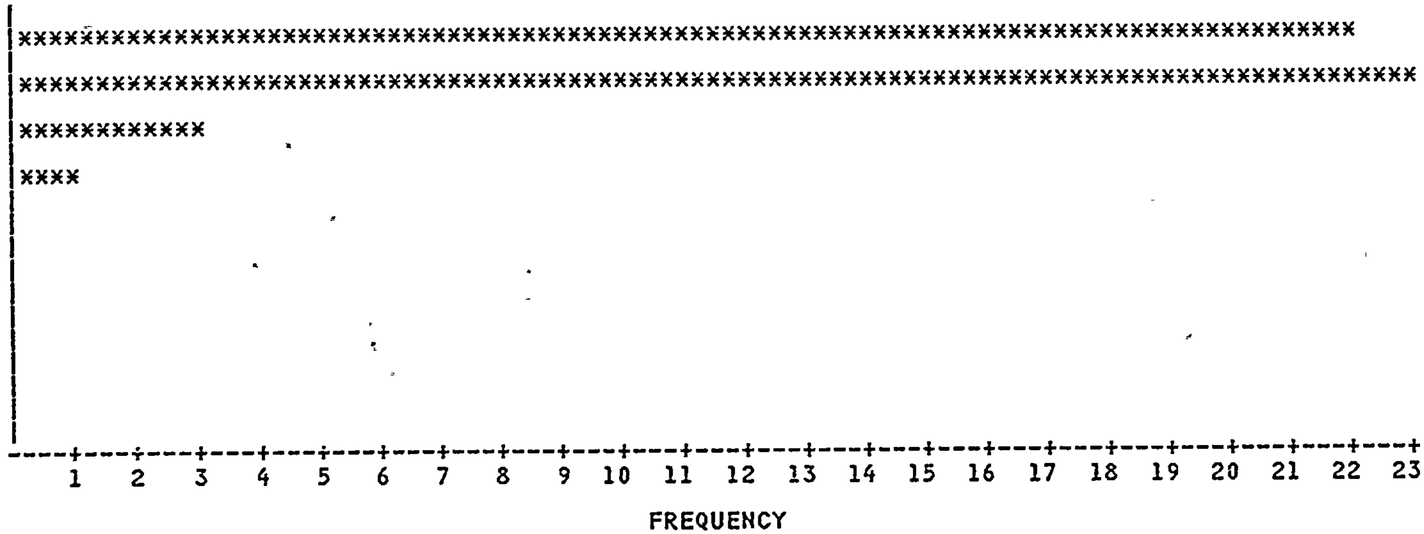
MIDPOINT NUM	FREQUENCY	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	11	11	39.29	39.29
2	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	16	27	57.14	96.43
3		0	27	0.00	96.43
4	xxxxx	1	28	3.57	100.00
5		0	28	0.00	100.00
6		0	28	0.00	100.00
7		0	28	0.00	100.00
8		0	28	0.00	100.00
9		0	28	0.00	100.00

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

FREQUENCY

FREQUENCY OF OCCURRENCE OF POD SIZES BY ZONE
NORTH AND SOUTH COMBINED
ZONE=4

FREQUENCY BAR CHART



MIDPOINT NUM	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	22	22	44.90	44.90
2	23	45	46.94	91.84
3	3	48	6.12	97.96
4	1	49	2.04	100.00
5	0	49	0.00	100.00
6	0	49	0.00	100.00
7	0	49	0.00	100.00
8	0	49	0.00	100.00
9	0	49	0.00	100.00

FREQUENCY OF OCCURRENCE OF POD SIZES BY ZONE
NORTH AND SOUTH COMBINED
ZONE=5

FREQUENCY BAR CHART

```
MIDPOINT
  NUM                                                                                                                     FREQ   CUM.   PERCENT    CUM.
                                                                                                                                 FREQ             PERCENT
         |
    1    |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX      33     33     54.10     54.10
    2    |XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                20     53     32.79     86.89
    3    |XXXXXXXXXXXXXX                                                           7     60     11.48     98.36
    4    |XX                                                                       1     61      1.64    100.00
    5    |                                                                         0     61      0.00    100.00
    6    |                                                                         0     61      0.00    100.00
    7    |                                                                         0     61      0.00    100.00
    8    |                                                                         0     61      0.00    100.00
    9    |                                                                         0     61      0.00    100.00
         |
         ----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---
             2   4   6   8  10  12  14  16  18  20  22  24  26  28  30  32

                                  FREQUENCY
```

FREQUENCY OF OCCURRENCE OF POD SIZES BY ZONE
NORTH AND SOUTH COMBINED
ZONE=6

FREQUENCY BAR CHART

```
MIDPOINT
NUM                                                                                                              FREQ  CUM.   PERCENT    CUM.
                                                                                                                       FREQ             PERCENT

 1  |************************************************************************************************    48     48    40.68    40.68
 2  |****************************************************************************************            44     92    37.29    77.97
 3  |******************************                                                                      15    107    12.71    90.68
 4  |**************                                                                                       7    114     5.93    96.61
 5  |**                                                                                                   1    115     0.85    97.46
 6  |****                                                                                                 2    117     1.69    99.15
 7  |**                                                                                                   1    118     0.85   100.00
 8  |                                                                                                     0    118     0.00   100.00
 9  |                                                                                                     0    118     0.00   100.00
    |
    ----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
        2   4   6   8  10  12  14  16  18  20  22  24  26  28  30  32  34  36  38  40  42  44  46  48

                                               FREQUENCY
```

FISHERIES INVESTIGATIONS AT DIABLO CANYON - 1982

By

David C. Sommerville
and
Sally J. Krenn

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This report presents a summary of the status of fishery investigations conducted by Pacific Gas and Electric Company biologists at the Diablo Canyon Power Plant during 1982.

The present Partyboat Sampling Program began in 1979. The goal of the study is to monitor the sportfishery in the vicinity of Diablo Canyon in order to detect changes which might be attributable to the operation of the power plant. While the overall study design has remained unchanged, specific modifications to the methodology have occurred. Modifications which were affected during 1982 are discussed. Sportfishing catch and effort data are presented and compared with results of previous years. The species composition of the catch is presented and discussed.

INTRODUCTION

This report summarizes the progress of the Partyboat Sampling Program through the end of 1982. Included are a summary of data collected to date, and an account of changes in sampling methodology and study design which occurred during the year.

The present Diablo Canyon Partyboat Sampling Program began in March, 1979, in an effort to provide a detailed preoperational data base regarding the sportfishery in the vicinity of the Diablo Canyon Power Plant. A complete description of the objectives of the program was presented in the 1979 progress report (Sommerville 1982).

The goals of the study are twofold. The primary objective is to monitor, in detail, partyboat sportfishery catch and effort both prior to and during plant operation in order to detect any changes in the fishery which might be attributable to the operation of the power plant. Secondary study objectives are to obtain life history data on the more abundant species in the catch, to aid in evaluating possible relationships between plant operation and shifts in the sportfishery. Catch data and life history data will ultimately be used in the development of population models in an assessment of the effects of entrainment and impingement mortality on adult populations in the receiving water body.

METHODS AND MATERIALS

Study methodology was described in detail in the 1979 annual progress report (Sommerville 1982). Several changes in the study methodology occurred during 1982 but the overall study design was not affected. Changes in study methods are discussed in a later section.

The study area consists of a stretch of coastline which ranges from around Point Buchon in the north to the vicinity of Point San Luis in the south (Figure 1). The Diablo Canyon Power Plant is approximately centered in this region. The study area corresponds roughly to the region fished by partyboats operating out of Port San Luis. Previous experience has shown that boats out of Morro Bay rarely frequent this area. Partyboat skippers rely on local knowledge of fishing sites, returning to productive areas time and again. Location codes were established for fishing locations based on LORAN coordinates and the names used by local boat operators.

Field sampling consisted of a team of two investigators boarding a fishing vessel at the dock and proceeding to the fishing location. On the way to the fishing site, the following information was recorded: date, sea state, wind speed, and the number of anglers on board. Once at the fishing site, the depth, location code, and LORAN coordinates were recorded. The total time spent fishing was measured on a stop watch. Prior to returning to port, all fishes taken were identified and enumerated. Rockfishes (family Scorpaenidae) were identified to species, others were identified to the family level.

Rockfish specimens sampled for life history data were selected and sampled with the permission of the angler. Each fish sampled was assigned a log number, and the standard and total lengths were measured. Scales and otoloiths were taken for aging. The gonads were removed and preserved in buffered formalin-seawater. Gonads were assigned a stage of ripeness in the field. Stages of ripeness were modified from information presented by DeLacy et al. (1964), Moser (1967), and Westrheim (1975).

In the laboratory, fecundity of gravid females was determined gravimetrically, by weighing three counted subsamples of ova and extrapolating to the entire gonad. Age was determined from otoliths and/or scales, by counting concentric annual rings. Otoliths proved to be preferable in most

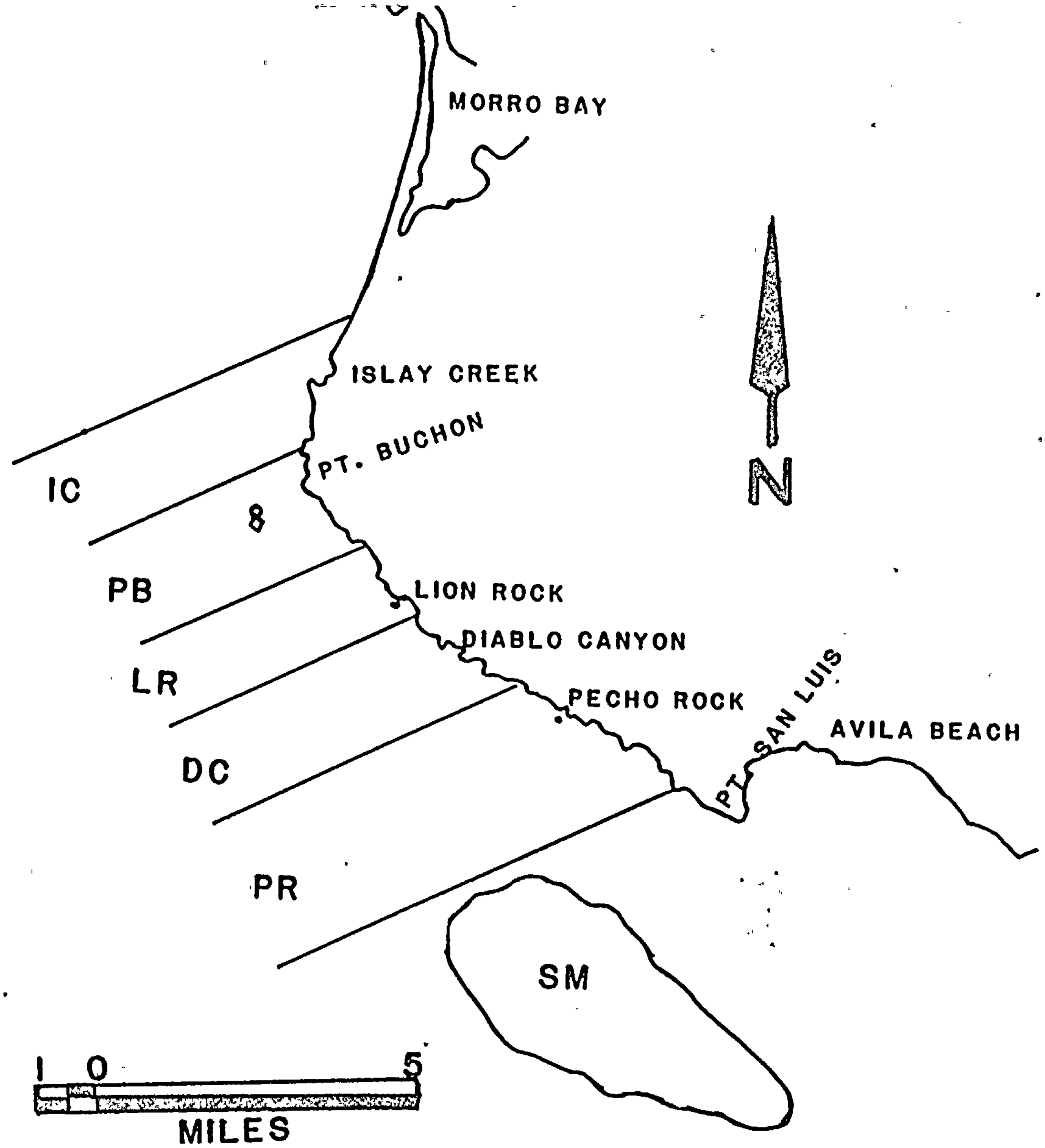


Figure 1: Partyboat Sampling Program Study Area.

cases, since in many Sebastes species scales often provide erroneous age estimates in older fish (Six and Horton 1977, Kimura et al. 1979). Extremely thick otoliths of older specimens which proved difficult to read were sliced on a jeweler's saw and read in cross section.

All data were entered into the PGandE computer system for records management and data processing and analysis. Catch and effort, life history data, and length measurements were maintained in separate datasets.

Program Modifications - 1982

Beginning in mid 1982, two changes were made to the sampling program. Life history sampling of select species was discontinued in June. Life history data for eight select species had been collected for a full year and the data base was judged to be sufficient for analysis.

The second change in the study involved collecting data on the size frequency of each species in the total catch. The total length of each individual in the catch is recorded in the field by making a mark on a styrene measuring slate which is organized by species. The length marks are measured in the laboratory to the nearest millimeter and recorded on preprinted data sheets.

Size composition of the catch will be monitored prior to and during plant operation in an effort to determine possible effects of impingement and entrainment on recruitment. If mortality of larvae and juveniles produces a measureable effect on adult populations, such effects would be manifested as reductions of given year classes in the fishery. Comparison of the age/size composition of the catch before and after plant operation will provide a means of specifically evaluating effects of impingement and entrainment losses on catchable stocks.

Catch and Effort - 1982

During 1982, a total of 44 sampling trips were made to fishing locations in the vicinity of Diablo Canyon (Table 1). The number of anglers per trip ranged from a low of four in the month of May to a high of 48 in the month of August. Fishing pressure was greatest during the late spring and summer months. Catch per unit effort, expressed as the number of fish caught per angler hour, ranged from 2.91 to 13.65.

Catch statistics in the study area have remained relatively constant over the four years of the study (Table 2). Although the mean number of anglers per trip and the mean time spent fishing have varied little among years, the average CPUE during 1982 was notably greater than in previous years. Over the first three years of the study this statistic approximated 5.5 fishes per angler hour, but during 1982, the mean CPUE increased to 6.5. This increase was due to greater catches per effort during the spring months. This period was characterized by unusually calm weather during 1982. The result appears to be increased "catchability" which in turn caused an increase in the annual catch per unit effort.

Species Composition of Catch - 1982

Table 3 summarizes the catch of fishes taken in terms of the number of individuals landed per species and relative frequency of occurrence of each species. A total of 12,153 fishes comprising 29 species were enumerated during 44 sampling efforts. The catch was as in previous years, dominated numerically by blue rockfish which accounted for 64.4% of the catch. The five most abundant species were rockfishes, which accounted for 86% of the total catch.

Blue rockfish and yellowtail rockfish have consistently ranked first and second and have collectively accounted for about 65% of the total catch over the four year period (Table 4). This is in part due to the

TABLE 1 : PARTYBOAT SAMPLING TRIP SUMMARY FOR 1982

TRIP_NO	DATE	AREA	ANGLERS	TIME	CATCH	CPUE
128	08JAN82	1	13	4.02	218	4.17
129	13JAN82	1	13	2.68	218	6.26
130	14JAN82	1	16	2.00	203	6.34
131	25JAN82	1	17	2.40	260	6.37
132	02FEB82	1	23	2.80	412	6.40
133	09FEB82	1	19	2.63	333	6.66
134	18FEB82	1	16	1.87	243	8.12
135	24FEB82	1	24	2.96	337	4.74
136	04MAR82	1	5	2.66	97	7.29
137	11MAR82	1	14	2.42	133	3.93
138	22MAR82	1	17	2.43	297	7.19
139	25MAR82	1	29	2.32	248	3.69
140	07APR82	1	24	2.83	291	4.28
141	09APR82	1	31	2.77	408	4.75
142	15APR82	1	14	2.00	128	4.57
143	23APR82	1	9	1.80	147	9.07
144	05MAY82	1	13	3.17	193	4.68
145	12MAY82	1	4	2.22	37	4.17
146	21MAY82	1	18	2.31	226	5.44
147	25MAY82	1	22	2.13	262	5.59
148	04JUN82	1	6	1.60	117	12.19
149	08JUN82	1	12	3.27	114	2.91
150	21JUN82	1	12	3.20	206	5.36
151	30JUN82	1	36	2.60	454	4.85
152	09JUL82	1	25	3.52	495	5.63
153	14JUL82	1	22	2.36	384	7.40
154	26JUL82	1	19	1.82	343	9.92
155	29JUL82	1	20	1.33	363	13.65
156	04AUG82	1	23	3.83	463	5.26
157	17AUG82	1	36	1.83	585	8.88
158	26AUG82	1	48	2.47	767	6.47
159	08SEP82	1	16	2.17	275	7.92
160	14SEP82	1	12	2.97	162	4.55
161	17SEP82	1	13	3.03	371	9.42
162	23SEP82	1	12	2.63	137	4.34
163	01OCT82	1	15	2.55	333	8.71
164	07OCT82	1	9	2.20	178	8.99
165	14OCT82	1	11	2.18	169	7.05
166	22OCT82	1	28	2.73	567	7.42
167	29OCT82	1	18	2.22	260	6.51
168	05NOV82	1	6	2.42	121	8.33
169	22NOV82	1	15	2.09	140	4.47
170	24NOV82	1	15	2.60	232	5.95
171	07DEC82	1	11	3.00	226	6.85
	TOTAL		781	111.04	12153	- -
	MEAN		18	2.52	276	6.52

Table 2: Summary of Catch Statistics, 1979 - 1982.

	1979	1980	1981	1982
Mean No. of Anglers	23	18	19	18
Mean Time Spent Fishing	2.26	2.05	2.34	2.52
Mean Total Catch	256	169	239	276
Mean CPUE	5.70	5.26	5.61	6.52

Table 3: Numbers and Relative Frequency of Occurrence of Fish Species Taken Aboard Partyboats During 1982

Species	Number	Rel. Freq.
Blue Rockfish	7822	64.3627
Yellowtail Rockfish	990	8.1461
Rosy Rockfish	717	5.8998
Starry Rockfish	480	3.9496
Olive Rockfish	422	3.4724
Gopher Rockfish	298	2.4521
Canary Rockfish	280	2.3040
Copper Rockfish	271	2.2299
Pacific Mackerel	194	1.5963
Vermilion Rockfish	187	1.5387
Greenspotted Rockfish	121	0.9956
Flag Rockfish	74	0.6089
Bocaccio	61	0.5019
Yelloweye Rockfish	46	0.3785
Widow Rockfish	44	0.3621
China Rockfish	40	0.3291
Bothid Flatfish	38	0.3127
Lingcod	21	0.1728
Speckeled Rockfish	15	0.1234
Square Spot Rockfish	9	0.0741
Cabezon	7	0.0576
Greenstriped Rockfish	6	0.0494
Jack Mackerel	4	0.0329
Black and Yellow	1	0.0082
Black Rockfish	1	0.0082
Brown Rockfish	1	0.0082
Croakers	1	0.0082
Pleuronectid Flatfish	1	0.0082
Treefish	1	0.0082
TOTAL	12153	

Table 4: The Five Most Abundant Species in the Catch, Ranked by Percent Composition, 1979 - 1982.

	1979	1980	1981	1982
RANK	SPECIES	SPECIES	SPECIES	SPECIES
1	Blue	Blue	Blue	Blue
2	Yellowtail	Yellowtail	Yellowtail	Yellowtail
3	Canary	Pacific MacKerel	Rosy	Rosy
4	Boccacio	Rosy	Starry	Starry
5	Rosy	Canary	Canary	Olive

tendency of partyboat skippers to help anglers to "limit out" by seeking these more accessable midwater species when fishing for more desireable bottom dwelling species, such as bocaccio and vermilion rockfish, proves unsuccessful.

Life History Sampling - 1982

The number of fishes sampled each month for life history data is presented in Table 5. A total of 875 individuals of 8 species were sampled during the year. Life history sampling was terminated in June, since the data base was judged to be sufficient for describing age/length relationships and annual cycles in reproduction.

Table 5: NUMBER OF EACH SPECIES SAMPLED PER MONTH DURING 1982
YR=82

TABLE OF SPECIES BY MO

SPECIES MO

FREQUENCY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	TOTAL
BLUE ROCKFISH	27	23	22	30	27	129
CANARY ROCKFISH	21	20	17	8	7	73
COPPER ROCKFISH	31	17	26	17	16	107
GOPHER ROCKFISH	29	38	7	36	21	131
OLIVE ROCKFISH	11	38	19	26	26	120
ROSY ROCKFISH	22	21	24	19	16	102
STARRY ROCKFISH	23	24	23	22	23	115
YELLOWTAIL ROCKF	21	22	18	18	19	98
TOTAL	185	203	156	176	155	875

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APPENDIX A

Partyboat Catch and Effort Data - 1982

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

VARIABLES:
ANGLERS= NUMBER OF ANGLERS ON TRIP
TIME= TIME SPENT FISHING, IN HOURS
DEPTH1-5= DEPTHS FISHED AT EACH STOPPING POINT, IN FATHOMS
WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=128

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
08JAN82	13	4.02	1	PR	31					2	1		
												BOTHID FLATFISH	1
												PACIFIC MACKEREL	7
												BLUE ROCKFISH	115
												BOCACCIO	3
												COPPER ROCKFISH	3
												OLIVE ROCKFISH	2
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	9
												STARRY ROCKFISH	35
												GREENSPOTTED ROCKFISH	2
												ROSY ROCKFISH	15
												FLAG ROCKFISH	2
												YELLOWEYE ROCKFISH	4
												CANARY ROCKFISH	10
												VERMILION ROCKFISH	8
												SQUARE SPOT ROCKFISH	1

TRIP_NO=129

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
13JAN82	13	2.68	1	SM	35	45				2	1		
												PACIFIC MACKEREL	9
												BLUE ROCKFISH	72
												BOCACCIO	2
												COPPER ROCKFISH	74
												WIDOW ROCKFISH	1
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	17
												STARRY ROCKFISH	4
												GREENSPOTTED ROCKFISH	2
												ROSY ROCKFISH	18
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	10
												VERMILION ROCKFISH	7

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

VARIABLES:
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DEPTH1-5= DEPTHS FISHED AT EACH STOPPING POINT, IN FATHOMS
WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=130

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
14JAN82	16	2	1	SM	35	39	25			2	2		
												BOTHID FLATFISH	3
												PACIFIC MACKEREL	6
												BLUE ROCKFISH	82
												BOCACCIO	3
												GOPHER ROCKFISH	3
												COPPER ROCKFISH	34
												WIDOW ROCKFISH	1
												YELLOWTAIL ROCKFISH	25
												STARRY ROCKFISH	7
												GREENSPOTTED ROCKFISH	1
												ROSY ROCKFISH	23
												FLAG ROCKFISH	2
												YELLOWEYE ROCKFISH	2
												CANARY ROCKFISH	5
												VERMILION ROCKFISH	4
												SQUARE SPOT ROCKFISH	2

TRIP_NO=131

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
25JAN82	17	2.4	1	SM	35					3	2		
												LINGCOD	1
												PACIFIC MACKEREL	4
												BLUE ROCKFISH	198
												GOPHER ROCKFISH	6
												COPPER ROCKFISH	5
												OLIVE ROCKFISH	16
												BROWN ROCKFISH	1
												CHINA ROCKFISH	1
												STARRY ROCKFISH	8
												ROSY ROCKFISH	7
												FLAG ROCKFISH	2
												CANARY ROCKFISH	5
												VERMILION ROCKFISH	6

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

VARIABLES:
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WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=132

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
02FEB82	23	2.8	1	PR	60	48	44			2	1		
												JACK MACKEREL	4
												PACIFIC MACKEREL	12
												BLUE ROCKFISH	175
												BOCACCIO	10
												COPPER ROCKFISH	18
												OLIVE ROCKFISH	3
												YELLOWTAIL ROCKFISH	12
												STARRY ROCKFISH	13
												GREENSPOTTED ROCKFISH	15
												ROSY ROCKFISH	31
												FLAG ROCKFISH	9
												GREENSTRIPED ROCKFISH	4
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	74
												VERMILION ROCKFISH	31

TRIP_NO=133

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
09FEB82	19	2.63	1	PR	46					1	1		
												BOTHID FLATFISH	6
												BLUE ROCKFISH	159
												BOCACCIO	3
												COPPER ROCKFISH	19
												YELLOWTAIL ROCKFISH	38
												STARRY ROCKFISH	12
												GREENSPOTTED ROCKFISH	21
												ROSY ROCKFISH	17
												FLAG ROCKFISH	9
												YELLOWEYE ROCKFISH	2
												CANARY ROCKFISH	34
												VERMILION ROCKFISH	13

TRIP_NO=134

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
18FEB82	16	1.87	1	PR	42	30				5	3		
												LINGCOD	1
												BLUE ROCKFISH	163
												GOPHER ROCKFISH	3
												OLIVE ROCKFISH	18
												YELLOWTAIL ROCKFISH	37
												STARRY ROCKFISH	3

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

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WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=134

ATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
												ROSY ROCKFISH	9
												FLAG ROCKFISH	1
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	5
												VERMILION ROCKFISH	2

TRIP_NO=135

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
24FEB82	24	2.96	1	PR	37	24				9	6		
												PACIFIC MACKEREL	10
												BLUE ROCKFISH	252
												GOPHER ROCKFISH	2
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	7
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	23
												STARRY ROCKFISH	20
												ROSY ROCKFISH	18
												YELLOWEYE ROCKFISH	2
												CANARY ROCKFISH	1

TRIP_NO=136

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
04MAR82	5	2.66	1	PR	37	35				10	6		
												BOTHID FLATFISH	1
												BLUE ROCKFISH	65
												COPPER ROCKFISH	3
												WIDOW ROCKFISH	1
												YELLOWTAIL ROCKFISH	7
												STARRY ROCKFISH	8
												ROSY ROCKFISH	7
												CANARY ROCKFISH	2
												VERMILION ROCKFISH	2
												SPECKELED ROCKFISH	1

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

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TRIP_NO=137

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
11MAR82	14	2.42	1	PR	30	35				8	2		
												LINGCOD	1
												BLUE ROCKFISH	100
												GOPHER ROCKFISH	6
												OLIVE ROCKFISH	16
												YELLOWTAIL ROCKFISH	6
												STARRY ROCKFISH	1
												ROSY ROCKFISH	3

TRIP_NO=138

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
22MAR82	17	2.43	1	PR	42	42				1	0		
												PACIFIC MACKEREL	1
												BLUE ROCKFISH	177
												BOCACCIO	2
												COPPER ROCKFISH	11
												YELLOWTAIL ROCKFISH	31
												STARRY ROCKFISH	7
												GREENSPOTTED ROCKFISH	5
												ROSY ROCKFISH	30
												FLAG ROCKFISH	10
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	18
												VERMILION ROCKFISH	4

TRIP_NO=139

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
25MAR82	29	2.32	1	DC	35	40	30	10		3	1		
												BOTHID FLATFISH	5
												BLUE ROCKFISH	140
												GOPHER ROCKFISH	2
												COPPER ROCKFISH	16
												OLIVE ROCKFISH	9
												CHINA ROCKFISH	5
												YELLOWTAIL ROCKFISH	10
												STARRY ROCKFISH	11
												GREENSPOTTED ROCKFISH	4
												ROSY ROCKFISH	28
												FLAG ROCKFISH	1
												CANARY ROCKFISH	12
												VERMILION ROCKFISH	5

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

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TRIP_NO=140

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
07APR82	24	2.83	1	PR	30					5	2		
												LINGCOD	1
												BLUE ROCKFISH	207
												BOCACCIO	2
												COPPER ROCKFISH	2
												OLIVE ROCKFISH	11
												YELLOWTAIL ROCKFISH	23
												STARRY ROCKFISH	25
												ROSY ROCKFISH	13
												FLAG ROCKFISH	3
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	3

TRIP_NO=141

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
09APR82	31	2.77	1	PR	33	21				1	1		
												LINGCOD	1
												BLUE ROCKFISH	298
												GOPHER ROCKFISH	10
												COPPER ROCKFISH	3
												OLIVE ROCKFISH	16
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	18
												STARRY ROCKFISH	21
												ROSY ROCKFISH	29
												FLAG ROCKFISH	5
												CANARY ROCKFISH	3
												VERMILION ROCKFISH	3

TRIP_NO=142

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
15APR82	14	2	1	PR	18					5	3		
												BLUE ROCKFISH	115
												GOPHER ROCKFISH	3
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	6
												CHINA ROCKFISH	1
												VERMILION ROCKFISH	2

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

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TRIP_NO=143

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
23APR82	9	1.8	1	PR	22					2	1	BLUE ROCKFISH	109
												GOPHER ROCKFISH	3
												COPPER ROCKFISH	3
												OLIVE ROCKFISH	1
												YELLOWTAIL ROCKFISH	13
												STARRY ROCKFISH	3
												GREENSPOTTED ROCKFISH	2
												ROSY ROCKFISH	2
												FLAG ROCKFISH	4
												CANARY ROCKFISH	3
												VERMILION ROCKFISH	4

TRIP_NO=144

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
05MAY82	13	3.17	1	DC	38	28				1	1	LINGCOD	1
												BLUE ROCKFISH	119
												BOCACCIO	1
												COPPER ROCKFISH	3
												OLIVE ROCKFISH	21
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	10
												STARRY ROCKFISH	18
												ROSY ROCKFISH	9
												FLAG ROCKFISH	1
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	3
												VERMILION ROCKFISH	5

TRIP_NO=145

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
12MAY82	4	2.22	1	DC	42	16	15			6	3	CABEZON	1
												BLUE ROCKFISH	10
												GOPHER ROCKFISH	6
												COPPER ROCKFISH	2
												OLIVE ROCKFISH	4
												YELLOWTAIL ROCKFISH	3
												STARRY ROCKFISH	4
												ROSY ROCKFISH	1
												FLAG ROCKFISH	2

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

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WIND= WIND SPEED, IN KNOTS SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=145

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
												CANARY ROCKFISH	2
												VERMILION ROCKFISH	2

TRIP_NO=146

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
21MAY82	18	2.31	1	SM	40	20				5	3		
												LINGCOD	1
												PACIFIC MACKEREL	2
												BLUE ROCKFISH	138
												GOPHER ROCKFISH	1
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	5
												CHINA ROCKFISH	2
												YELLOWTAIL ROCKFISH	22
												STARRY ROCKFISH	32
												ROSY ROCKFISH	18
												FLAG ROCKFISH	1
												CANARY ROCKFISH	1
												VERMILION ROCKFISH	1
												SPECKELED ROCKFISH	1

TRIP_NO=147

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
25MAY82	22	2.13	1	SM	50	24				1	2		
												BLUE ROCKFISH	204
												GOPHER ROCKFISH	6
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	9
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	15
												STARRY ROCKFISH	11
												ROSY ROCKFISH	8
												FLAG ROCKFISH	2
												CANARY ROCKFISH	3
												VERMILION ROCKFISH	2

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

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TRIP_NO=148

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
04JUN82	6	1.6	1	PR	14					15	4		
												BLUE ROCKFISH	98
												GOPHER ROCKFISH	4
												OLIVE ROCKFISH	12
												CANARY ROCKFISH	1
												VERMILION ROCKFISH	2

TRIP_NO=149

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
08JUN82	12	3.27	1	PR	30	28				10	1		
												BLUE ROCKFISH	54
												GOPHER ROCKFISH	7
												COPPER ROCKFISH	2
												OLIVE ROCKFISH	9
												YELLOWTAIL ROCKFISH	11
												STARRY ROCKFISH	19
												ROSY ROCKFISH	6
												FLAG ROCKFISH	5
												YELLOWEYE ROCKFISH	1

TRIP_NO=150

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
21JUN82	12	3.2	1	PR	42	28				2	1		
												BLUE ROCKFISH	117
												BOCACCIO	2
												GOPHER ROCKFISH	1
												COPPER ROCKFISH	2
												OLIVE ROCKFISH	16
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	10
												STARRY ROCKFISH	20
												ROSY ROCKFISH	20
												FLAG ROCKFISH	4
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	3
												VERMILION ROCKFISH	9

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TRIP_NO=151

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
30JUN82	36	2.6	1	PR	32	21	20	4		8	2		
												CABEZON	3
												LINGCOD	2
												BLUE ROCKFISH	390
												GOPHER ROCKFISH	18
												BLACK AND YELLOW ROCKFISH	1
												OLIVE ROCKFISH	20
												CHINA ROCKFISH	2
												YELLOWTAIL ROCKFISH	7
												ROSY ROCKFISH	7
												CANARY ROCKFISH	1
												VERMILION ROCKFISH	3

TRIP_NO=152

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
09JUL82	25	3.52	1	PR	22	22	28			3	5		
												PACIFIC MACKEREL	1
												BLUE ROCKFISH	381
												GOPHER ROCKFISH	27
												COPPER ROCKFISH	6
												OLIVE ROCKFISH	25
												CHINA ROCKFISH	14
												YELLOWTAIL ROCKFISH	10
												STARRY ROCKFISH	3
												ROSY ROCKFISH	20
												FLAG ROCKFISH	1
												CANARY ROCKFISH	3
												VERMILION ROCKFISH	4

TRIP_NO=153

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
14JUL82	22	2.36	1	PR	18	40				13	7		
												LINGCOD	1
												PLEURONECTID FLATFISH	1
												BLUE ROCKFISH	340
												GOPHER ROCKFISH	12
												OLIVE ROCKFISH	25
												BLACK ROCKFISH	1
												YELLOWTAIL ROCKFISH	3
												VERMILION ROCKFISH	1

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WIND= WIND SPEED, IN KNOTS SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=154

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
26JUL82	19	1.82	1	PR	40	24	10			7	2	CABEZON	1
												PACIFIC MACKEREL	31
												BLUE ROCKFISH	258
												GOPHER ROCKFISH	16
												COPPER ROCKFISH	3
												OLIVE ROCKFISH	8
												YELLOWTAIL ROCKFISH	18
												ROSY ROCKFISH	3
												CANARY ROCKFISH	2
												VERMILION ROCKFISH	3

TRIP_NO=155

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
29JUL82	20	1.33	1	PR	20					17	6	CABEZON	1
												PACIFIC MACKEREL	18
												BLUE ROCKFISH	258
												GOPHER ROCKFISH	3
												OLIVE ROCKFISH	51
												YELLOWTAIL ROCKFISH	13
												STARRY ROCKFISH	1
												ROSY ROCKFISH	17
												VERMILION ROCKFISH	1

TRIP_NO=156

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
04AUG82	23	3.83	1	PR	30	42				4	2	PACIFIC MACKEREL	1
												BLUE ROCKFISH	202
												COPPER ROCKFISH	13
												OLIVE ROCKFISH	3
												CHINA ROCKFISH	2
												YELLOWTAIL ROCKFISH	89
												STARRY ROCKFISH	32
												GREENSPOTTED ROCKFISH	1
												ROSY ROCKFISH	81
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	18
												VERMILION ROCKFISH	20

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WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=157

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
17AUG82	36	1.83	1	PR	24	4	18			16	4		
												LINGCOD	2
												BLUE ROCKFISH	515
												GOPHER ROCKFISH	26
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	23
												YELLOWTAIL ROCKFISH	3
												STARRY ROCKFISH	1
												ROSY ROCKFISH	10
												CANARY ROCKFISH	1
												VERMILION ROCKFISH	3

TRIP_NO=158

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
26AUG82	48	2.47	1	LR	26	15				2	3		
												CABEZON	1
												LINGCOD	1
												BLUE ROCKFISH	616
												GOPHER ROCKFISH	74
												COPPER ROCKFISH	3
												OLIVE ROCKFISH	30
												TREEFISH	1
												CHINA ROCKFISH	2
												YELLOWTAIL ROCKFISH	9
												STARRY ROCKFISH	2
												ROSY ROCKFISH	23
												FLAG ROCKFISH	2
												CANARY ROCKFISH	2
												VERMILION ROCKFISH	1

TRIP_NO=159

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
08SEP82	16	2.17	1	DC	23	27				0	2		
												BLUE ROCKFISH	239
												GOPHER ROCKFISH	3
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	14
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	6
												STARRY ROCKFISH	1
												ROSY ROCKFISH	8
												FLAG ROCKFISH	1

APPENDIX A: PARTYBOAT CATCH AND EFFORT DATA FOR 1982

VARIABLES:
ANGLERS= NUMBER OF ANGLERS ON TRIP
TIME= TIME SPENT FISHING, IN HOURS
DEPTH1-5= DEPTHS FISHED AT EACH STOPPING POINT, IN FATHOMS
WIND= WIND SPEED, IN KNOTS SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=159

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
												VERMILION ROCKFISH	1

TRIP_NO=160

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
14SEP82	12	2.97	1	LR	30	25				4	2		
												LINGCOD	3
												PACIFIC MACKEREL	2
												BLUE ROCKFISH	105
												GOPHER ROCKFISH	30
												COPPER ROCKFISH	1
												OLIVE ROCKFISH	7
												CHINA ROCKFISH	2
												YELLOWTAIL ROCKFISH	2
												ROSY ROCKFISH	8
												VERMILION ROCKFISH	2

TRIP_NO=161

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
17SEP82	13	3.03	1	PR	37					1	1		
												LINGCOD	1
												BLUE ROCKFISH	194
												BOCACCIO	5
												COPPER ROCKFISH	8
												OLIVE ROCKFISH	4
												WIDOW ROCKFISH	3
												YELLOWTAIL ROCKFISH	63
												STARRY ROCKFISH	36
												ROSY ROCKFISH	31
												YELLOWEYE ROCKFISH	4
												CANARY ROCKFISH	7
												VERMILION ROCKFISH	11
												SPECKELED ROCKFISH	4

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WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

-- TRIP_NO=162 --

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
23SEP82	12	2.63	1	PR	40	42	22			1	2	PACIFIC MACKEREL	4
												BLUE ROCKFISH	80
												GOPHER ROCKFISH	13
												COPPER ROCKFISH	5
												OLIVE ROCKFISH	3
												YELLOWTAIL ROCKFISH	16
												STARRY ROCKFISH	5
												ROSY ROCKFISH	11

-- TRIP_NO=163 --

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
01OCT82	15	2.55	1	SM	48					2	2	LINGCOD	1
												PACIFIC MACKEREL	29
												BLUE ROCKFISH	73
												BOCACCIO	7
												COPPER ROCKFISH	1
												WIDOW ROCKFISH	17
												YELLOWTAIL ROCKFISH	139
												STARRY ROCKFISH	13
												GREENSPOTTED ROCKFISH	15
												ROSY ROCKFISH	9
												FLAG ROCKFISH	1
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	8
												VERMILION ROCKFISH	12
												SPECKELED ROCKFISH	7

-- TRIP_NO=164 --

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
07OCT82	9	2.2	1	SM	48	26				10	4	CROAKERS	1
												PACIFIC MACKEREL	4
												BLUE ROCKFISH	111
												GOPHER ROCKFISH	1
												COPPER ROCKFISH	4
												OLIVE ROCKFISH	1
												WIDOW ROCKFISH	2
												CHINA ROCKFISH	1
												YELLOWTAIL ROCKFISH	30
												STARRY ROCKFISH	2

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TRIP_NO=164

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
												ROSY ROCKFISH	18
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	1
												VERMILION ROCKFISH	1

TRIP_NO=165

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
14OCT82	11	2.18	1	PR	42	36				2	2		
												PACIFIC MACKEREL	9
												BLUE ROCKFISH	114
												GOPHER ROCKFISH	6
												COPPER ROCKFISH	2
												OLIVE ROCKFISH	6
												YELLOWTAIL ROCKFISH	20
												STARRY ROCKFISH	2
												ROSY ROCKFISH	6
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	3

TRIP_NO=166

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
22OCT82	28	2.73	1	PR	42	41				3	2		
												BOTHID FLATFISH	5
												BLUE ROCKFISH	325
												BOCACCIO	11
												COPPER ROCKFISH	5
												OLIVE ROCKFISH	14
												WIDOW ROCKFISH	10
												YELLOWTAIL ROCKFISH	64
												STARRY ROCKFISH	50
												ROSY ROCKFISH	64
												FLAG ROCKFISH	2
												YELLOWEYE ROCKFISH	8
												CANARY ROCKFISH	4
												VERMILION ROCKFISH	3
												SQUARE SPOT ROCKFISH	2

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TRIP_NO=167

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
29OCT82	18	2.22	1	LR	57	50	42			5	3		
												BOTHID FLATFISH	7
												PACIFIC MACKEREL	12
												BLUE ROCKFISH	78
												BOCACCIO	5
												COPPER ROCKFISH	4
												WIDOW ROCKFISH	2
												YELLOWTAIL ROCKFISH	72
												STARRY ROCKFISH	12
												GREENSPOTTED ROCKFISH	29
												ROSY ROCKFISH	19
												FLAG ROCKFISH	2
												GREENSTRIPED ROCKFISH	2
												YELLOWEYE ROCKFISH	3
												CANARY ROCKFISH	7
												VERMILION ROCKFISH	5
												SPECKELED ROCKFISH	1

TRIP_NO=168

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
05NOV82	6	2.42	1	SM	48	32				3	1		
												BOTHID FLATFISH	1
												PACIFIC MACKEREL	6
												BLUE ROCKFISH	31
												BOCACCIO	2
												COPPER ROCKFISH	3
												WIDOW ROCKFISH	2
												YELLOWTAIL ROCKFISH	42
												STARRY ROCKFISH	3
												GREENSPOTTED ROCKFISH	12
												ROSY ROCKFISH	9
												YELLOWEYE ROCKFISH	4
												CANARY ROCKFISH	2
												SQUARE SPOT ROCKFISH	4

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TRIP_NO=169

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
22NOV82	15	2.09	1	SM	50	38				8	3	BOTHID FLATFISH	3
												PACIFIC MACKEREL	3
												BLUE ROCKFISH	50
												COPPER ROCKFISH	7
												WIDOW ROCKFISH	5
												YELLOWTAIL ROCKFISH	10
												STARRY ROCKFISH	10
												GREENSPOTTED ROCKFISH	8
												ROSY ROCKFISH	26
												YELLOWEYE ROCKFISH	1
												CANARY ROCKFISH	14
												VERMILION ROCKFISH	2
												SPECKELED ROCKFISH	1

TRIP_NO=170

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
24NOV82	15	2.6	1	DC	48	12	44			5	3	BOTHID FLATFISH	1
												LINGCOD	3
												PACIFIC MACKEREL	23
												BLUE ROCKFISH	168
												BOCACCIO	1
												GOPHER ROCKFISH	6
												OLIVE ROCKFISH	6
												YELLOWTAIL ROCKFISH	13
												STARRY ROCKFISH	5
												GREENSPOTTED ROCKFISH	3
												ROSY ROCKFISH	2
												CANARY ROCKFISH	1

TRIP_NO=171

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
07DEC82	11	3	1	PR	32	40				8	2	BOTHID FLATFISH	5
												BLUE ROCKFISH	127
												BOCACCIO	2
												OLIVE ROCKFISH	1
												YELLOWTAIL ROCKFISH	21
												STARRY ROCKFISH	20
												GREENSPOTTED ROCKFISH	1
												ROSY ROCKFISH	33

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WIND= WIND SPEED, IN KNOTS   SWELL= SWELL HEIGHT, IN FEET

TRIP_NO=171

DATE	ANGLERS	TIME	AREA	LOCATION	DEPTH1	DEPTH2	DEPTH3	DEPTH4	DEPTH5	WIND	SWELL	SPECIES	NUMBER
												FLAG ROCKFISH	2
												YELLOWEYE ROCKFISH	4
												CANARY ROCKFISH	8
												VERMILION ROCKFISH	2

BREAKWATER REPAIR MARINE MONITORING PROGRAM

1982

by

T. C. Wilson
Biologist

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June 1983

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Diablo Canyon Power Plant utilizes two constructed breakwaters to protect the cooling water intake structure and equipment from both wave damage and surge (Figure 1). The breakwaters form a protected embayment. In 1981, the west breakwater sustained extensive damage along 200 feet of the distal end due to intense storm wave activity. In July, 1982, repair of that breakwater was initiated. Work terminated in December, 1982, as a result of intense winter storm wave activity. Biological surveys originally scheduled through January, 1983, were also terminated.

The original breakwater consisted of a mound-type structure of quarried core stone covered by larger two to eight ton stone. Interlocking 21.6 ton concrete tribar structures stabilized the core and a series of 21 X 7 foot (cross section) concrete cap sections protected the top of the breakwater from over-topping waves. Repair specifications defined restoration to be the same configuration as before damage except that 36.8 ton tribars would stabilize the seaward side of the repaired section. Additionally, concrete embedment ribs would be layed to further stabilize tribars on both west and east breakwaters (Figure 2). The breakwater terminates on both the seaward and protected sides in approximately 30 feet of seawater. The seawater bottom substrate is rock reef and sand; the bottom substrate on the protected side is rock reef covered by varying depths of fine clay-like silt. This silt is evident from

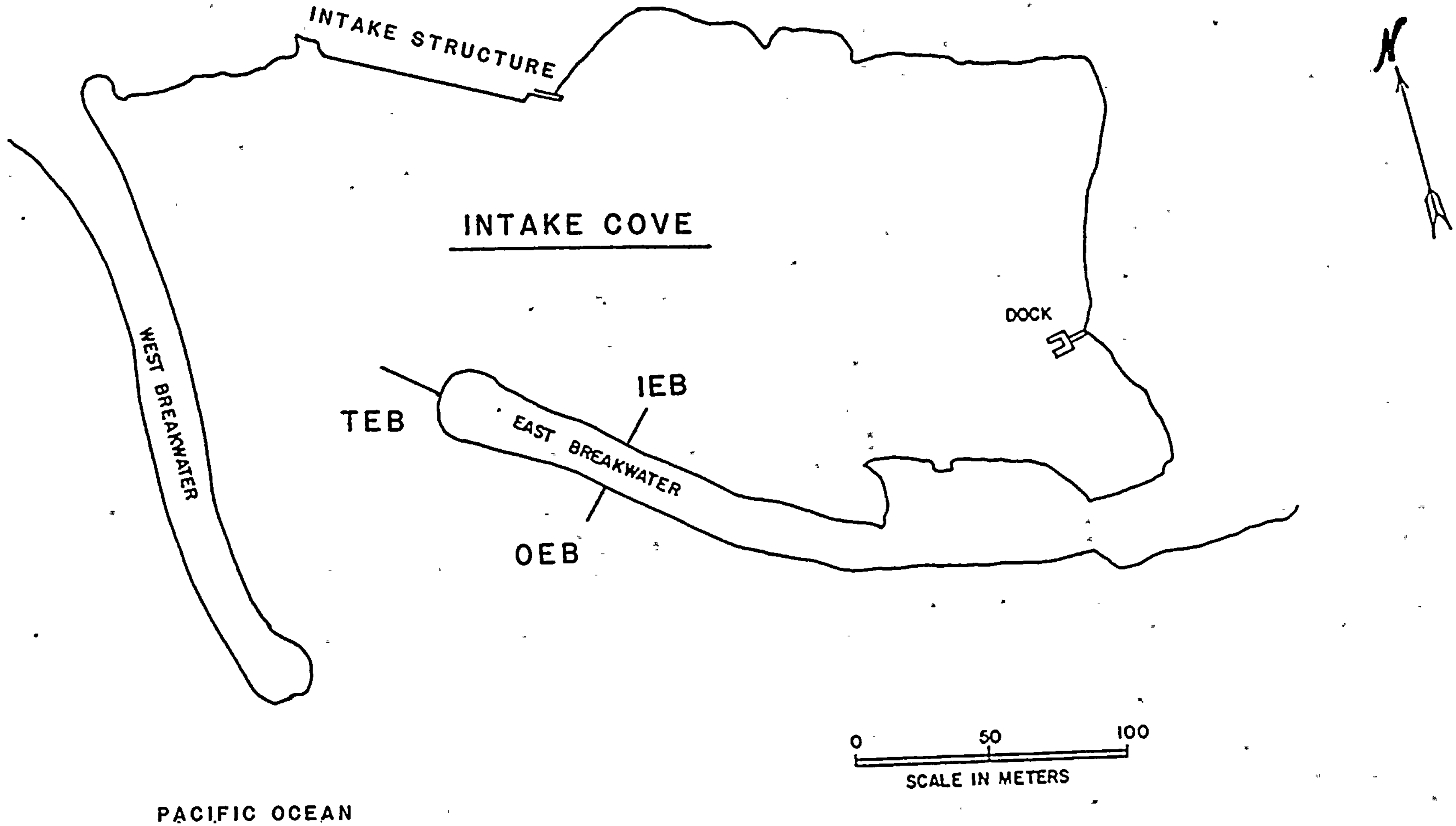

Figure 1.

Location of Marine Monitoring Stations for Breakwater Repair Activities.

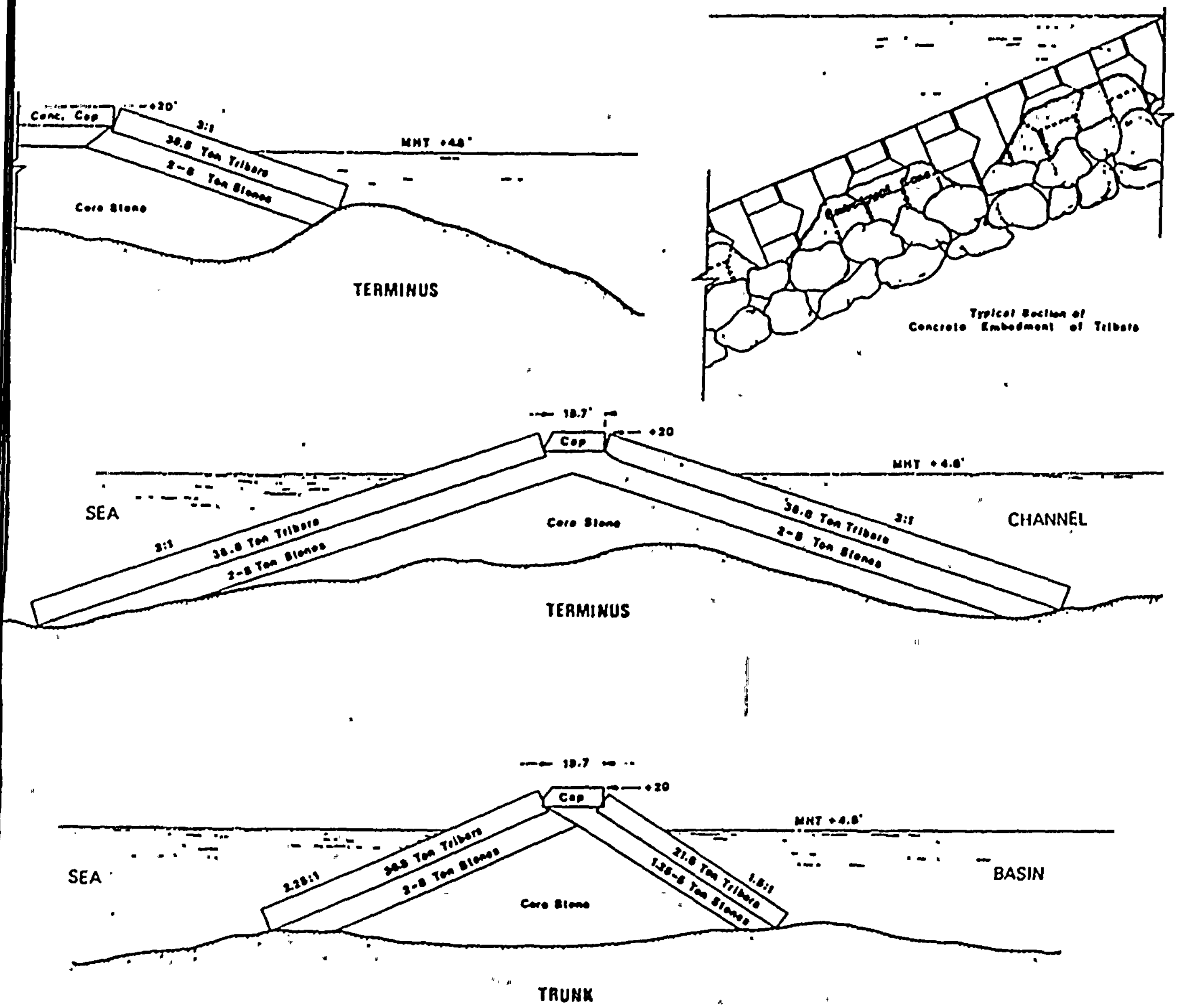

Figure 2

RESTORATION OF WEST BREAKWATER
AND IMPROVEMENTS
AT DIABLO CANYON INTAKE BASIN
SECTIONS

approximately MLLW and increases with depth due to quiescence in the protected cove formed by the breakwaters. The breakwater habitat supports a rich assemblage of plants and animals including species recognized for sport and commercial importance such as three species of abalone. The protected Intake Cove substrate supports a specialized community adapted to the mud bottom of embayments.

Reconstruction plans included removal of core and tribar debris from the Intake Cove channel and reformation of the core primarily with new quarry stone. Construction activities could have ecological significance. Several areas of potential environmental impact were defined:

1. Disruption of breeding cycle of a local nesting pair of peregrine falcons.
2. Loss of abalone resident to the breakwater structure.
3. Suffocation of invertebrates caused by sediment buildup on the bottom.
4. Loss of algae due to the reduction of available light caused by excessive turbidity and siltation.
5. Mortality of fish, mammals, and birds due to underwater blasting.

A program was designed to determine what species were inhabiting the breakwater habitat, minimize impacts to those inhabitants where possible, monitor relative water quality, and define any unusual changes in localized marine communities of plants and animals. This program was developed as a condition of a U. S. Corps of Engineers (COE) Nationwide Permit, under

which construction was authorized. Agency involvement included the California Department of Fish and Game (CDF&G), U.S. Fish and Wildlife Service (USFWS) and the COE. Additionally, assistance in interpreting behavior of peregrine falcons was received from the Santa Cruz Predatory Bird Research Group (SCPBRG).

Studies which began in June, 1982, were terminated in December, 1982, when intense seasonal storms prevented continuation of construction activities. Reconstruction progress was lost through wave activity and an additional 60 feet of intact breakwater was destroyed. Initiation of reconstruction was scheduled to begin in March, 1983. Continued environmental monitoring was scheduled for that time.

METHODS AND MATERIALS

Peregrine Falcons

Peregrine falcon observations by consultant observers from the Santa Cruz Predatory Bird Research Group (SCPBRG) were initiated in March, 1982. Observations were required as a condition of the Nationwide Permit for construction to ensure no contruction related impacts to the peregrines during their breeding cycle. Construction activities were to be curtailed if behavioral changes could be related to those activities. Construction activities relative to observed peregrine behavior were evaluated on a daily basis by the U.S. Fish and Wildlife Service.

Abalone

Removal of abalone from repair sites began in June, prior to construction. Divers surveyed the proposed repair area and removed all accessible abalone. During construction, biologists collected abalone from tribars and stone as it was removed from the damaged section. All abalone were sexed and measured. Surviving abalone were held in Diablo Canyon laboratory seawater tanks for later transplant under direction of the CDF&G.

Sediment and Water Quality

Sediment accretion on the bottom was measured in three areas (Figure 1) using permanently embedded stakes. Divers periodically measured the length of the exposed stake at each station to determine sediment gain or loss.

Relative water quality was determined daily from July 27 through December 16, 1982, in the local construction area and control areas (Figure 3). Activities which could be expected to increase turbidity were core removal and building, and embedment grouting. Ranges and mean values for turbidity and Secchi readings were calculated for each station for turbidity related activities and non-turbidity related activities. On August 12, a seventh station was included one half mile off shore as a more extreme control. Light penetration was estimated using a standard Secchi-disc and turbidity measured with a TURNER Nephelometer using samples collected just below the water surface.

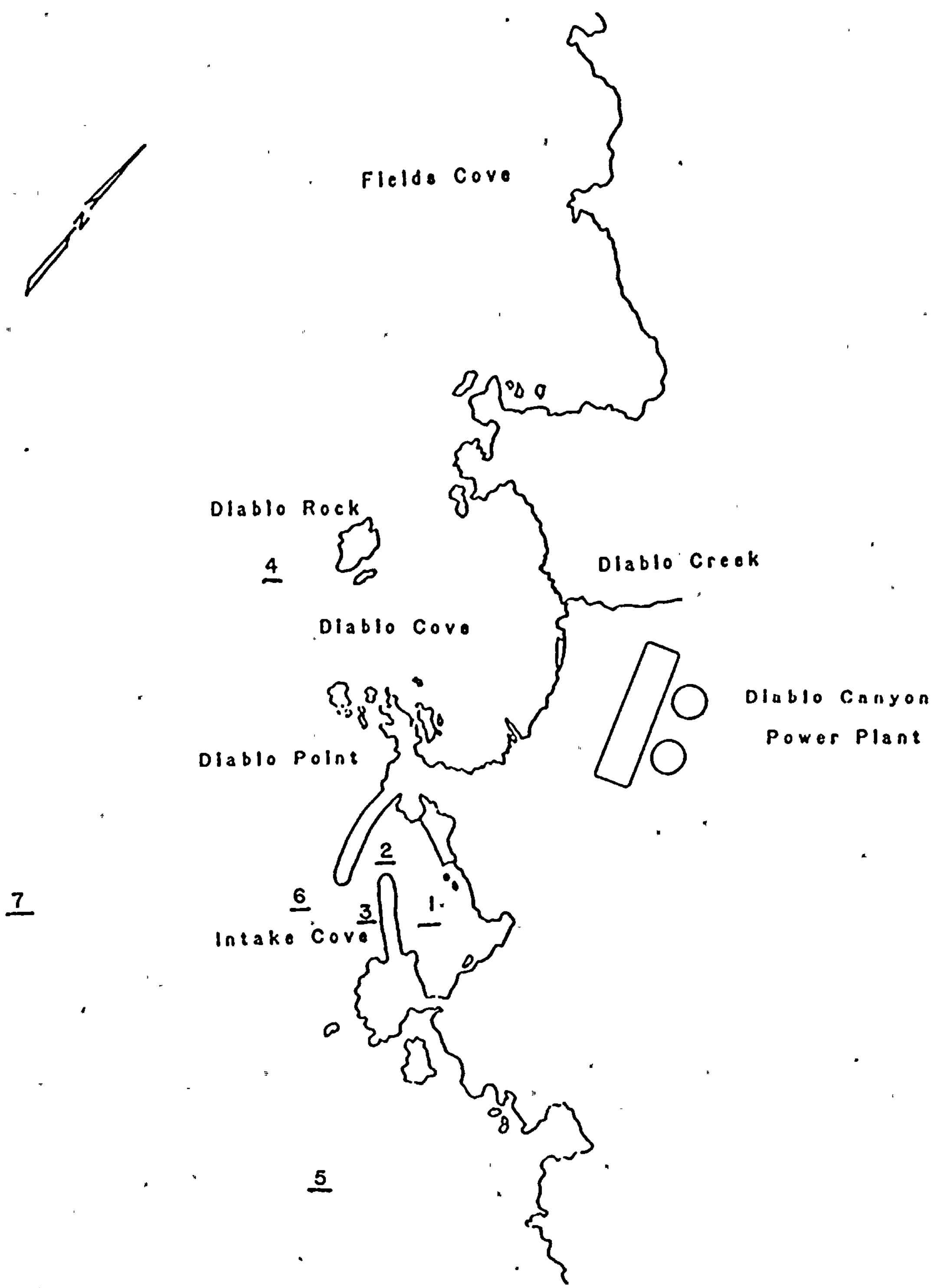

Figure 3.

Location of Seven Water Quality Sampling Stations for Breakwater Repair Activities.

Flora and Fauna

An inventory of species associated with the breakwater habitat was made by diver observations and by collections and identifications made from breakwater material as it was removed during reconstruction activities.

Permanent sampling stations were installed to determine if large unexpected changes occurred in localized algae and invertebrate communities. Markers were drilled into place by divers along three permanent transect chains at approximate MMLW depths of 10-15, 20-30, and greater than 30 feet. Data are reported as presence and absence for algae and invertebrates found in a circular quarter meter quadrat at each permanent marker. Presence and absence data collection was chosen as an indicator of the health of the community. Mobile invertebrates were not reviewed for a determination of potential change, but rather as representative of normal community structure. Quantitative data was not utilized due to the potential for investigator error over such a limited time frame. Small changes in abundances due to estimation errors could lead to biased interpretation in an environment subject to large degrees of natural variation. Each permanent station was assessed through time. Data were collected monthly as weather and construction activity permitted. Additionally, sampling station photographs were taken for each sampling period.

Subtidal Blasting

Subtidal blasting impacts to marine mammals were minimized by maintaining continuous surface observations for thirty minutes prior to each blast. Observations were made from shore and from boats in and around the zone of potential risk. Actual timing of the blasts was coordinated with the mammal observations made by CDF&G personnel, PGandE and contractor staff. In addition, beginning with the second day of blasting, at least two "seal shots" were exploded in the area prior to each primary blast as recommended by the CDF&G. Fish killed or injured during blasting were collected by boat, enumerated, identified, and then given to CDF&G personnel for disposal.

RESULTS

Peregrine Falcons

Results of 1982 peregrine falcon observations at Diablo Canyon are reported in Chapter XII. No impact on the peregrine falcons during construction was noted.

Abalone

Table 1 lists sex and size of abalone species collected prior to and during construction activities. Two hundred and fourteen abalone were collected (97 red, 112 black, 4 pinto and 1 flat).

Sediment and Water Quality

Table 2 reports sediment accretion at the three stations between August 25 and November 3, 1982. An increase of 13 mm

Table 1

Counts and Size of Abalone by Species and Sex
Removed From Breakwater Area
Prior To and During Construction Activities

SPECIES	SEX	COUNT	SIZE (cm.)		
			x	Range	S.D.
Haliotis rufescens	Male	32	17.0	7.6-23.3	3.66
Haliotis rufescens	Female	50	12.5	2.8-20.5	5.45
Haliotis rufescens	Unknown	15	10.7	5.3-21.1	6.95
	Total =	97			
Haliotis cracherodii	Male	50	11.1	6.6-15.6	2.78
Haliotis cracherodii	Female	59	9.6	6.0-19.0	2.29
Haliotis cracherodii	Unknown	3	8.2	2.8-11.1	4.65
	Total =	112			
Haliotis kamschatkana	Unknown	4	2.9	2.2- 3.7	0.78
Haliotis walallensis	Unknown	1	11.8		

Haliotis Total = 214

Table 2

Sediment Accretion at Three East Breakwater Stations as Determined by Measurement at Three Permanent Stakes

Station	Date	Stake Height (cm)	Sediment Gain/Loss (cm)	Net Change
IEB	8/25/82	24.3	--	--
IEB	9/22/82	24.0	+0.3	+0.3
IEB	11/03/82	23.0	+1.0	+1.3
TEB	8/25/82	39.3	--	--
TEB	9/22/82	41.0	-1.7	-1.7
OEB	8/25/82	53.6	--	--
OEB	9/22/82	54.5	-0.9	-0.9
OEB	11/03/82	53.5	+1.0	+0.1

was noted on the Intake Cove side (Station IEB). A 1 mm increase was recorded outside the east breakwater (Station OEB) following a 9 mm decrease at that location. However, a 17 mm decrease in sediment was found at the east breakwater tip (Station TEB) between the August 25 and September 22 measurements. A November measurement was not made at Station 2 due to the damage to the permanent sediment stake resulting from construction activities.

Water quality data are presented in Table 3. Secchi readings indicated no relationship of decreased light penetration during potential turbidity causing activities within stations when compared to non-turbidity causing activities. Similarly, turbidity measurements support this finding.

Flora and Fauna

Eighty-eight algal species, 174 invertebrate, and 54 fish species were observed on or in the vicinity of the breakwater (Appendices A through C).

Table 4 presents data collected in permanently marked quadrats along transect lines. No pattern of invertebrate loss was noted, and presence and absence of most invertebrates was found to be, as expected, a function of the transient nature of mobile invertebrates. Absence of some species of algae was evident in some quadrats through time, but appearance of algal species was also noted. No pattern indicated consistent loss except in the deepest (39 feet) quadrat at the outside east breakwater station in which all three recorded algal species were absent from the November 4 survey.

Table 3

Turbidity and Secchi Disc Measurements For Seven Stations During Breakwater Construction Activites

Turbidity Causing Activities (Tribar Removal, Grouting) | Non-Turbidity Causing Activities (Tribar Placement, no water activity)

TURBIDITY READINGS:

Sta.	n	x	S.D.	Range	n	x	S.D.	Range
1	65	.41	.154	.15-.85	23	.56	.172	.35-1.00
2	65	.40	.142	.15-.90	23	.55	.203	.30-1.10
3	65	.34	.129	.15-.70	23	.49	.219	.20-1.10
4	65	.29	.103	.15-.65	23	.36	.184	.15-.80
5	65	.31	.106	.15-.60	23	.41	.172	.15-.80
6	65	.33	.136	.14-.45	23	.38	.182	.17-.85
7	56	.26	.089	.15-.45	21	.31	.161	.15-.70

SECCHI DISC READINGS:

Sta.	n	x	S.D.	Range	n	x	S.D.	Range
1	65	20.2	4.38	10-28	22	19.1	4.20	11-27
2	65	19.1	4.22	11-27	22	17.4	6.89	5-28
3	65	24.1	7.50	6-43	23	20.2	8.15	5-34
4	65	28.9	7.80	13-50	23	25.2	7.70	14-46
5	65	28.7	7.46	14-45	23	23.9	6.04	16-33
6	65	27.9	8.22	9-50	23	25.1	8.54	14-52
7	56	33.9	9.39	18-55	21	30.3	11.06	16-52

Table 4

1982 Permanent Marine Monitoring Breakwater Stations
Presence and Absence Survey Data for Algae and Invertebrates

TIP EAST BREAKWATER

QUAD: 1 Depth: 14 feet

ALGAE:

	Sept. 30	Nov. 4
Calliarthron sp.	P	P
Callophyllis violacea	P	P
Crustose Coralline Algae	P	P
Callophyllis violacea	P	P
Cystoseira osmundacea	P	P
Cryptopleura lobulifera/violacea	P	A

INVERTEBRATES:

	Sept. 30	Nov. 4
Acmaea mitra	P	P
Anisodoris nobilis	A	P
Astrea gibberosa	A	P
Calliostoma ligatum	A	P
Hermissenda crassicornis	A	P
Pagurus sp.	A	P
Phragmatopoma californica	P	P
Pycnopodia helianthoides	P	A
Serpulorbis squamigerus	P	P
Tonicella lineata	P	P

QUAD: 2 Depth: 25 feet

ALGAE:

	Aug. 24	Sept. 30	Nov. 4
Calliarthron sp.	P	P	P
Botryoglossum/Hymenena	P	P	P
Gigartina exasperata	P	P	P
Microcladia coulteri	P	P	P

TABLE 4 (Cont.) - IEB Quad 2

INVERTEBRATES:

	Aug. 24	Sept. 30	Nov. 4
Amphissa versicolor	P	A	P
Balanophyllia elegans	P	P	P
Calliostoma ligatum	P	A	P
Doriopsilla albopunctata	P	A	A
Lophopanopeus sp.	P	A	A
Pododusmus cepio	P	A	P
Pugettia richii	P	A	A
Strongylocentrotus purpuratus	P	A	P
Styela montereyensis	A	P	P

FISH:

	Aug. 24	Sept. 30	Nov. 4
Gibbonsia sp.	A	A	P

TABLE 4 (Cont.)

OFFSHORE EAST BREAKWATER

QUAD: 2 Depth: 20 feet

ALGAE:

	Aug. 22	Sept. 30	Nov. 4
Botryoglossum/Hymenena	P	P	P
Calliarthron sp.	P	P	P
Callophyllis flabellulata	A	P	P
Callophyllis violacea	P	A	P
Crustose Coralline Algae	P	P	P
Gigartina exasperata	P	P	P
Microcladia coulteri	P	A	A
Prionitis lanceolata	A	P	P
Pterygophora californica	A	P	A

INVERTEBRATES:

	Aug. 22	Sept. 30	Nov. 4
Acmaea mitra	A	P	P
Astrea gibberosa	P	A	A
Balanophilia elegans	P	P	P
Calliostoma ligatum	P	P	A
Corynactis californica	P	P	P
Doriopsilla albopunctata	A	A	P
Epiactis prolifera	A	A	P
Henricia leviuscula	A	A	P
Pagurus sp.	A	A	P
Patiria miniata	A	A	P
Petaloconchus montereyensis	A	P	P
Pugettia richii	P	P	P
Styela montereyensis	P	A	A
Tonicella lineata	A	A	P

FISH:

	Aug. 22	Sept. 30	Nov. 4
Cottid		A	P

TABLE 4 (Cont.) - OEB

QUAD: 3 Depth: 25 feet

ALGAE:

	Aug. 22	Sept. 30	Nov. 4
Calliarthron sp.	P	P	P
Crustose Coralline Algae	A	P	P
Cystoseira osmundacea	A	P	P
Prionitis lanceolata	P	P	P
Pterygophora californica	P	P	A

INVERTEBRATES:

	Aug. 22	Sept. 30	Nov. 4
Acmaea mitra	A	P	P
Balanophllia elegans	P	P	P
Calliostoma ligatum	A	P	P
Corynactis californica	P	P	P
Leptasterias crassicornis	A	A	P
Pagurus sp.	P	A	P
Petaloconchus montereyensis	P	P	P
Pugettia richii	A	A	P
Tonicella lineata	A	A	P

QUAD: 4 Depth: 39 feet

ALGAE:

	Aug. 22	Sept. 30	Nov. 4
Callophyllis flabellulata	P	P	A
Cryptopleura sp.	P	P	A
Neoptilota densa	P	A	A

INVERTEBRATES:

	Aug. 22	Sept. 30	Nov. 4
Astrea gibberosa	P	A	A
Diopatra ornata	P	P	P
Leptosynapta sp.	A	P	A
Ophioroidea	A	P	P
Pagurus sp.	A	P	A
Patiria miniata	A	P	P
Tegula brunnea	P	A	A

TABLE 4 (Cont.)

INSIDE EAST BREAKWATER

QUAD: 1 Depth: 10 feet

ALGAE:

	Aug. 23	Nov. 3
Calliarthon sp.	P	P
Crustose Coralline Algae	P	P
Gigartina exasperata	P	P
Iridaea cordata	P	A
Microcladia coulteri	A	P
Neoagardhiella baileyi	P	P
Prionitis lanceolata	P	P
Ulva sp.	P	P

INVERTEBRATES:

	Aug. 23	Nov. 3
Acmaea mitra	A	P
Calliostoma ligatum	P	P
Homolapoma luridum	P	A
Loxorhynchus sp.	A	P
Patiria miniata	P	A
Pugettia richii	P	P
Serpulorbis squamigerus	P	P
Tonicella liniata	P	P
Tricolia pulloides	P	A

FISH:

Gibbonsia sp.	P	P

QUAD: 2 Depth: 18 feet

ALGAE:

	Aug. 23	Nov. 3
Callithamnion rupicolum	P	P
Gigartina exasperata	P	P
Iridaea heterocarpa	P	P
Neoagardhiella baileyi	P	P

TABLE 4 (Cont.) - IEB Quad 2

INVERTEBRATES:

	Aug. 23	Nov. 3
Cancer sp.	P	A
Mitrella carinata	P	P
Pagurus sp.	A	P
Patiria miniata	A	P
Pugettia producta	P	A
Pugettia richii	P	A

FISH:

Gibbonsia sp.	P	P

QUAD: 3   Depth: 22 feet

ALGAE:

	Aug. 23	Nov. 3
Callithamnion rupicolum	P	P
Gigartina exasperata	P	P
Neoagardhiella baileyi	P	P
Prionitis lanceolata	P	P

INVERTEBRATES:

	Aug. 23	Nov. 3
Cancer antennarius	A	P
Patiria miniata	P	P
Pugettia richii	A	P

FISH:

Hexagrammas decagrammus	P	A

TABLE 4 (Cont.) - IEB

QUAD: 4 Depth: 32 feet

ALGAE:

	Aug. 23	Nov. 3
Callithamnion rupicolum	P	A

INVERTEBRATES:

	Aug. 23	Nov. 3
Patiria miniata	P	P

Subtidal Blasting

Table 5 presents total fish collected (348) following blasting activity and the quantity of explosive used for each blast. Also, total species counts are listed for all blasts. An estimated 15 percent additional fish mortality (52) was observed, but fish could not be recovered or were lost to seagull and pelican predation. The first blast, September 1, killed an adult female California sea lion. Mortality was apparently caused by blast concussion. Adherence to the pre-blasting "warning shot" procedure appeared effective in preventing further marine mammal mortality.

DISCUSSION

Peregrine Falcons

Observation of peregrine falcon behavior during breakwater construction activities is discussed in Chapter XII. Interruption of construction activities during the breeding cycle was not required as activities appeared to have no impact on peregrine behavior.

Abalone

The 214 abalone collected during and prior to breakwater construction were maintained in the Diablo Canyon Power Plant Biological Research Laboratory in a continuous flow seawater system. Abalone were scheduled for transplant in a location to be specified by the California Department of Fish and Game.

Table 5

Fish Collected After Breakwater Construction Blasting
Date and Quantity of Explosives

DATE	TIME	EXPLOSIVE (LBS.)	FISH COLLECTED
9/01/82	1031	154	179
9/02/82	1143	360	103
9/02/82	1515	16	39
9/15/82	1041	20	27
		TOTAL 550	TOTAL 348

TOTAL SPECIES COUNTS FOR ALL BLASTS

Striped Surfperch	170
Blue Rockfish	109
Rubberlip Surfperch	12
Black Surfperch	12
Pile Surfperch	12
Olive Rockfish	10
Gopher Rockfish	7
Kelp Rockfish	5
Kelp Surfperch	4
Grass Rockfish	1
Giant Kelpfish	1
Tubesnout	1
Red Brotula	1

Sediment and Water Quality

The sediment increases and decreases noted were typical for these station locations. Rapid changes would be expected at Station OEB due to wave exposure and associated turbulence. At Station IEB continued build-up occurs naturally due to the quiescence of the protected embayment. Decreases would only be expected in extreme sea conditions when breakwater overtopping occurs. Station TEB experienced increased wave exposure due to the damaged west breakwater and resulting decreases in sediment depths were noted.

Sediment resulting from breakwater activities probably contributed to the natural sediment build-up in the immediate breakwater areas. However, increases are typically offset by decreases resulting from dynamic wave forces and are, therefore, short term. Where wave energies are less (embayments), deposition is generally longer term. However, benthic communities in these low energy environments are adapted to the sediments. The build-up then, unless extremely rapid, would be expected to have no impact. Sediment deposition was not considered unusual or excessive at any station during the period covered by this study.

Average water quality did not appear to be affected by those breakwater activities that would potentially cause turbidity to increase. Water quality generally appeared to lessen during periods when non-turbidity related activities were performed. This observation probably reflects the termination of turbidity causing activities during rougher sea

state conditions. These rougher sea states and associated weather conditions caused an increase in natural turbidity which appeared greater than turbidity related to breakwater activity. Therefore, short term turbidity associated with breakwater construction would be expected to have no measurable impact on the marine community.

Flora and Fauna

The total of 316 species of algae, invertebrates, and fish observed on and around the Diablo Canyon breakwaters indicate a diverse biological community. This community was further described using presence/absence data for dominant representative species.

The intent of the presence/absence study design was to assess the condition of the floral and faunal community in the immediate vicinity of the breakwater construction activities. Algal species were reviewed for loss. Some absences were noted between the first and last surveys but, concurrently, species additions were also observed. Only in the case of one quadrat (TEB-4) was all algae absent in the final survey. This quadrat was located in a sandy-silt bottom predominated by the marine worm *Diopatra ornata*. Attached to the *Diopatra* worm tubes were minimal abundances of three algal species. The disappearance from this marginal algal habitat likely resulted from wave activity and abrasion and probably was not related to breakwater construction activities.

Mobile invertebrates both appeared and disappeared in quadrats, indicating a normal transient pattern within the

community. One sedentary invertebrate, the tunicate *Styela montervensis*, was present in the first survey (Station OEB) and only in one quadrat. This species is a solitary stalked tunicate which would not be affected by minimal sediment deposition. Its loss probably resulted from natural mortality.

No observations or data indicated a measurable negative impact on the biological community in the area surveyed. This finding is consistent with the water quality and sedimentation data collected.

Subtidal Blasting

Fish losses due to blasting were minimal. Less than one fish per pound of explosive was killed. Incidental diver observations were made to determine if any fish sank after the blast. No obvious mortality increase was noted.

Appendix A

List of Algal Species Observed in the Breakwater Habitats at Diablo Canyon Power Plant in 1982
Number of Species = 88

Chlorophyta
- Ulotrichales
  - *Ulva* sp.
- Cladophorales
  - *Chaetomorpha* sp.
  - *Cladophora* sp.
  - *Spongomorpha* sp.
- Codiales
  - *Derbesia marina*

Phaeophyta
- Desmarestiales
  - *Desmarestia ligulata*
- Laminariales
  - *Alaria marginata*
  - *Dictyoneurum californicum*
  - *Egregia menziesii*
  - *Laminaria dentigera*
  - *Macrocystis integrifolia*
  - *Nereocystis luetkeana*
  - *Pterogophora californica*
- Fucales
  - *Cystoseira osmundacea*

Rhodophyta
- Bangiales
  - *Porphyra nereocystis*
  - *Porphyra perforata*
  - *Smithora naiadum*
- Nemaliales
  - *Gelidium coulteri*
  - *Gelidium pusillum*
  - *Gelidium purpurascens*
- Cryptonemiales
  - *Bossiella plumosa*
  - *Calliarthron* sp.
  - *Callophyllis flabellulata*
  - *Callophyllis obtusifolia*
  - *Callophyllis pinnata*
  - *Callophyllis violacea*
  - *Corallina officialis*
  - *Corallina vancouveriensis*
  - *Cryptosiphonia woodii*
  - *Endocladia muricata*
  - *Erythrophyllum delesserioides*
  - *Farlowia compressa*
  - *Halymenia* sp.
  - *Lithophyllum* sp.
  - *Lithothamnium* sp.

Pikea californica
Prionitis californica

Gigartinales

Gigartina agardhii
Gigartina canaliculata
Gigartina corymbifera
Gigartina exasperata
Gigartina harveyana
Gigartina leptorhynchos
Gigartina papillata
Gigartina spinosa
Gymnogongrus platyphyllus
Gymnogongrus sp.
Iridaea cordata
Iridaea flaccida
Iridaea heterocarpa
Iridaea lineare
Neoagardhiella baileyi
Opuntiella californica
Petrocelis fransiscana
Plocamium violaceum
Rhodoglossum affine
Schizymenia pacifica

Rhodomeniales

Fauchea laciniata
Gastroclonium coulteri
Halosaccion glandiforme
Rhodymenia californica
Rhodomenia pacifica
Rhodomenia rhizoides

Ceramiales

Botryoglossum farlowianum
Callithamnion pikeanum
Callithamnion rupicolum
Ceramium eatonianum
Cryptopleura corallinara
Cryptopleura lobulifera
Cryptopleura violacea
Delesseria decipiens
Hymenena cunifolia
Hymenena flabelligera
Janczewskia gardneri
Laurencia splendens
Microcladia coulteri
Microcladia borealis
Neoptilota hypnoides
Neoptilota densa
Phycodrys setchellii
Pleonosporium squarrulosum
Polyneura latissima
Polysiphonia brodiaei
Polysiphonia hendryi
Polysiphonia pacifica
Pterochondria woodii
Ptilota filicina
Rhodomela larix

Appendix B

List of Invertebrate Species
Observed in the Breakwater Habitats
at Diablo Canyon Power Plant in 1982
Number of Species = 174

Porifera
- Demospongiae
  - *Cliona celata*
  - *Tethya aurantia*
- Calcarea
  - *Haliclona* sp.
  - *Leucandra heathi*
  - *Leucilla nuttingi*
  - *Leucosolenia eleanor*

Cnidaria
- Hydrozoa
  - *Abietinaria* sp.
  - *Aglaophenia* sp.
  - *Eudendrium californicum*
  - *Plumularia* sp.
  - *Sertularella* sp.
  - *Sertularia* sp.
  - *Thuiaria* sp.
- Anthozoa
  - *Anthopleura elegantissima*
  - *Anthopleura xanthogrammica*
  - *Balanophyllia elegans*
  - *Corynactis californica*
  - *Epiactis prolifera*
  - *Metridium senile*
  - *Tealia lofotensis*
  - *Tealia piscivora*
- Platyhelminthes
  - *Pseudostylocus burchami*
  - *Stylochus* sp.
- Nemertea
  - *Emplectonema gracile*
  - *Micrura verrilli*
  - *Peranemertes perigrina*
- Sipuncula
  - *Phascolosoma agasizii*
- Annelida
  - Polychaeta
    - *Eulalia aviculiseta*
    - *Eupomatus gracilis*
    - *Halosydna brevisetosa*
    - *Nereis grubei*
    - *Phragmatopoma californica*
    - *Salmacina tribranchiata*
    - *Schizobranchia insignis*
    - *Serpula vermicularis*
- Arthropoda

Crustacea
  Cirripedia
    Balanus cariosus
    Balanus tintinabulum
    Chthamalus sp.
    Polycipes polymerus
    Tetriclita squamosa
  Isopoda
    Cirolana harfordi
    Dynamenella glabra
    Exosphaeroma amplicauda
    Gnorimosphaeroma lutea
    Ianiropsis kincaidi derjugini
    Idotea fewkesi
    Idotea montereyensis
    Idotea resecata
    Idotea stenops
    Idotea urotoma
    Idotea wosnesenskii
  Amphipoda
    Gammarida
      Ampithoe humeralis
      Ampithoe lacertosa
      Ampithoe plumosa
      Ampithoe sp.
      Hyale sp.
      Jassa falcata
      Parallorchestes ochotensis
      Pleusymptes subglaber
    Caprellida
      Caprella penantis
      Metacaprella kennerlyi
  Decapoda
    Natantia
      Alpheus dentipes
      Heptacarpus cristatus
      Heptacarpus brevirostris
      Heptacarpus pictus
      Heptacarpus taylori
      Pandalus danae
    Reptantia
      Cancer antennarius
      Cancer jordani
      Cancer productus
      Haplogaster cauvicauda
      Lophopanopeus leucomanus
      Loxorhynchus crispatus
      Loxorhynchus grandis
      Mimulus foliatus
      Pachycheles rudis
      Pachygrapsus crassipes
      Petrolisthes eriomerus
      Pugettia producta
      Pugettia richii
      Scyra acutifrons
  Pycnogonida
      Phoxichilidium femoratum
Mollusca
  Polyplacophora
      Callistochiton palmatus

Cyanoplax dentiens
Cryptochiton stelleri
Lepidozona mertensii
Mopalia ciliata
Mopalia hindsii
Placophorella vellata
Tonicella lineata

Opisthobranchia

Nudibranchia

Anisodoris nobilis
Archidoris montereyensis
Cadlina flavomaculata
Coryphella trilineata
Cuthona lagunae
Diaulula sandiegensis
Doriopsilla albopunctata
Hermissenda crassicornis

Prosobranchia

Gastropoda

Acmaea mitra
Amphissa versicolor
Astraea gibberosa
Calliostoma annulatum
Calliostoma canaliculata
Calliostoma ligatum
Ceratostoma foliatum
Collisella digitalis
Collisella limatula
Collisella ochracea
Collisella pelta
Collisella strigitella
Crepipetella lingulata
Haliotis cracherodii
Haliotis kamschatkana
Haliotis rufescens
Haliotis walallensis
Homolapoma luridum
Lacuna marmorata
Margurites salmoneus
Marsenina stearnsi
Mitra idae
Ocenebra circumtexta
Ocenebra foveolata
Ocenebra interfossa
Ocenebra lurida
Petaloconchus montereyensis
Pseudomelatoma torosa
Serpulorbis squamigerus
Tegula brunnea
Tegula montereyi
Tegula pulligo

Pulmonata

Williamia peltoides

Bivalvia

Hiatella arctica
Hinnites giganteus
Kellia laperousii
Mytilus californianus
Mytilus edulis
Pododesmus cepio

Echinodermata

Echinoidea

Strongylocentrotus franciscanus
Strongylocentrotus purpuratus

Holothuroidea

Eupentacta quinquesemita
Parastichopus parvimensis

Asteroidea

Dermasterias imbricata
Henricia leviuscula
Leptasterias hexactis
Orthasterias koehleri
Patiria miniata
Pisaster brevispinus
Pisaster giganteus
Pisaster ochraceus
Pycnopodia helianthoides
Stylasterias forreri

Ophioroidea

Ophioplocus esmarki
Ophiothrix spiculata

Ectoprocta

Callopora horrida
Costazia robertsonae
Crisia occidentalis
Diaperoecia californica
Filicrisia sp.
Hippodiplosia insculpta
Phidolopora pacifica
Porella porifera
Tricellaria occidentalis
Tricellaria ternata
Tubellipora tuba

Urochordata

Ascidiacea

Archidistoma ritteri
Ascidia ceretodes
Boltenia villosa
Chelyosoma productum
Cnemidocarpa finmarkiensis
Diplosoma macdonaldi
Halocynthia hilgendorfi igaboja
Pyura hauster
Styela montereyensis
Trididenum opacum

Appendix C

List of Fish Species Observed in the Breakwater Habitats at Diablo Canyon Power plant in 1982 Number of Species = 54

Scientific Name	Common Name
Chondrichthys	
Squantinidae	
Squatina californica	Pacific Angel Shark
Scyliorhinidae	
Cephaloscyllium ventriosum	Swell Shark
Dasyatididae	
Urolopus halleri	Round Stingray
Osteichthys	
Brotulidae	
Brosmophycis marginata	Red Brotula
Gobiesocidae	
Gobiesox maendricus	Northern Clingfish
Rimicola muscarum	Kelp Clingfish
Gasterosteidae	
Aulorhynchus flavidus	Tubesnout
Syngnathidae	
Syngnathus leptorhynchus	Bay Pipefish
Scorpaenidae	
Sebastes atrovirens	Kelp Rockfish
Sebastes auriculatus	Brown Rockfish
Sebastes carnatus	Gopher Rockfish
Sebastes caurinus	Copper Rockfish
Sebastes chrysomelas	Black and Yellow Rockfish
Sebastes melanops	Black Rockfish
Sebastes miniatus	Vermillion Rockfish
Sebastes mystinus	Blue Rockfish
Sebastes paucispinis	Bocaccio
Sebastes pinniger	Canary Rockfish
Sebastes rastrelliger	Grass Rockfish
Sebastes serranoides	Olive Rockfish
Hexagrammidae	
Hexagrammos decagrammus	Kelp Greenling
Ophiodon elongatus	Lingcod
Oxylebius pictus	Painted Greenling
Cottidae	
Artidius corallinus	Coralline Sculpin
Artidius lateralis	Smoothhead Sculpin
Clinocottus recalvus	Bald Scupin
Leptocottus armatus	Staghorn Sculpin
Oligocottus snyderi	Fluffy Sculpin
Orthanopias triacis	Snubnose Sculpin
Scorpaenichthys marmoratus	Cabezon
Agonidae	
Bothragonus swanii	Rockhead

Liparidae	
Liparis mucosus	Slimy Snailfish
Embiotocidae	
Brachyistius frenatus	Kelp Surfperch
Cymatogaster aggregata	Shiner Surfperch
Damalichthys vacca	Pile Surfperch
Embiotoca jacksoni	Black Surfperch
Embiotoca lateralis	Striped Surfperch
Hypsurus caryi	Rainbow Surfperch
Rhacochilus toxotes	Rubberlip Surfperch
Labridae	
Oxijulis californica	Senorita
Pimelometopon pulchrum	California Sheepshead
Bathymasteridae	
Ronquilus jordani	Northern Ronquil
Clinidae	
Gibbonsia elegans	Spotted Kelpfish
Gibbonsia metzi	Striped Kelpfish
Gibbonsia montereyensis	Crevice Kelpfish
Heterostichus rostratus	Giant Kelpfish
Cebidichthyidae	
Cebidichthys violaceus	Monkeyface Eel
Stichaeidae	
Chirolophis nugator	Mosshead Warbonnet
Pholidae	
Apodichthys flavidus	Penpoint Gunnel
Gobiidae	
Coryphopterus nicholsii	Blackeye Goby
Cynoglossidae	
Symphurus atricauda	California Tonguefish
Bothidae	
Citharichthys stigmaeus	Speckled Sanddab
Pleuronectidae	
Isopsetta isolepis	Butter Sole
Parophrys vetulus	English Sole