BIOLOGICAL AND OCEANOGRAPHICAL SURVEY OF THE SANTA BARBARA CHANNEL OIL SPILL 1969—1970

VOLUME II

PHYSICAL, CHEMICAL AND GEOLOGICAL STUDIES

Under the general editorship of

RONALD L. KOLPACK

ALLAN HANCOCK FOUNDATION
UNIVERSITY OF SOUTHERN CALIFORNIA
1971

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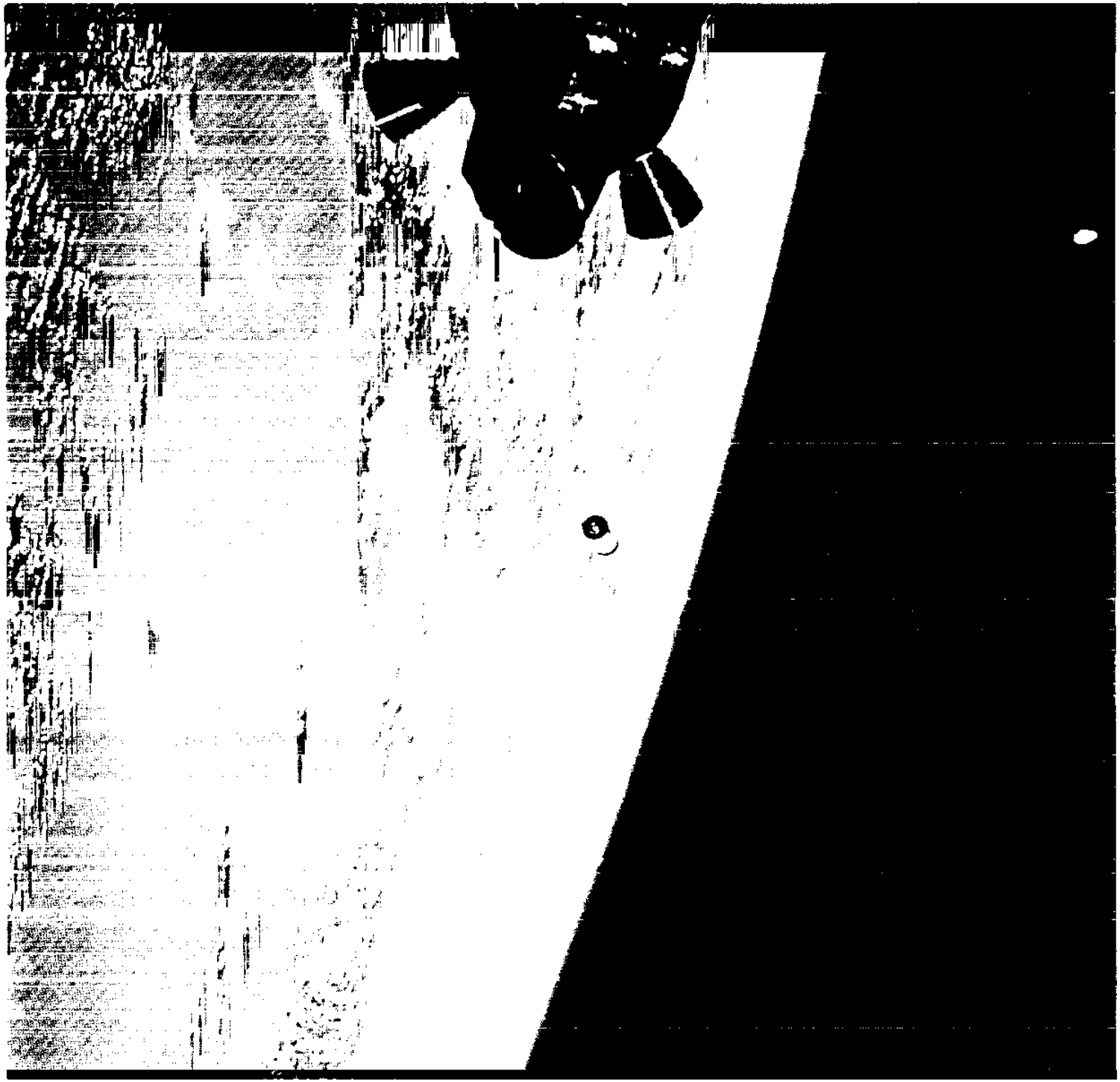
Aerial photograph of Santa Barbara Channel from an altitude of 106 nautical miles. San Miguel Island is in the foreground, followed by Santa Rosa, Santa Cruz and Anacapa Islands. Photograph taken March 9, 1968 from Apollo 9. NASA photograph #AS9-19-2949. Courtesy of Dr. Robert E. Stevenson and NASA.

ERRATA

Page ii	4 th line --- March 9, 1968 should read March 9, 1969
Page 63	3 rd line from bottom --- curculation should read circulation
Page 95	station 13970 west of Oxnard should be station 13370
Page 182	2 nd line --- tranding 290° should read trending 290°
Page 214	2 nd paragraph, 13 th line, 4 th word has should read have
Page 300	13 th line --- concommittant should read concomitant
Page 469	station 13891 should read

Day	Time	Lat.(N)	Long. (W)	Depth (m)
13	1446	34°18'30"	119°54'00"	439



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CHAPTER 1

INTRODUCTION

The sequence of events which influenced the Santa Barbara Channel environment after mid-January, 1969 occurred in a dynamic system. A portion of the oil emanating from an offshore well blowout approximately 6 miles southeast of Santa Barbara spread over large areas of the channel and was deposited on some beaches and at the sediment-water interface. A major flood also occurred at the same time and large quantities of detrital material were introduced into the channel. In addition, active natural seeps existed and hydrocarbons from these sources were introduced into the environment before, during and after peak flow from the well blowout.

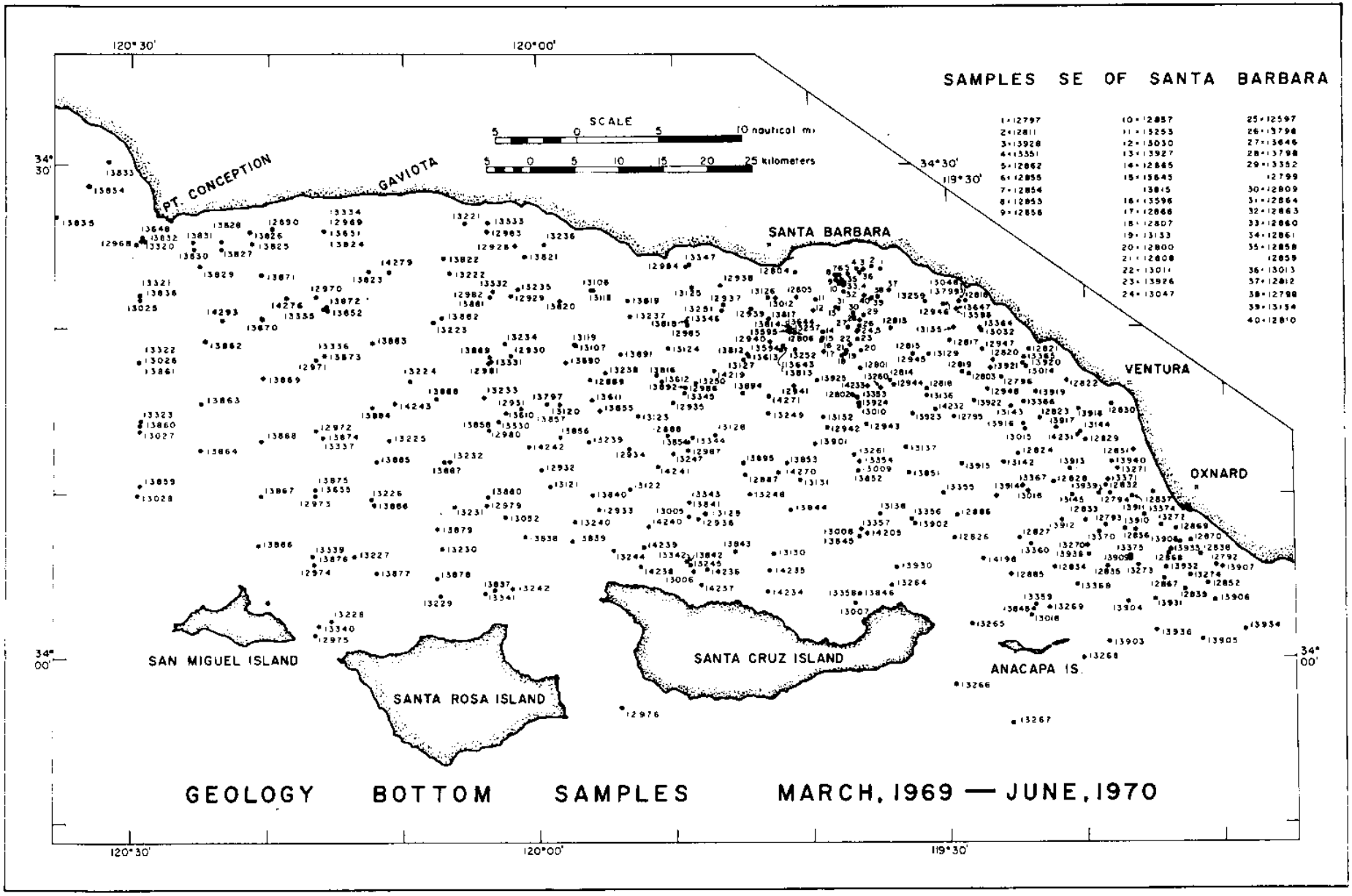
A survey of the area by the University of Southern California formally commenced in late February, 1969 in order to assess the effects of these incidents. The physical, chemical and geological program was established on the premise that the entire Santa Barbara Channel, from the beaches to the central basin, might be affected by oil from the well blowout. A major portion of the effort involved in this study concerned field observations, collection of samples and laboratory analyses. Some of the stations occupied during the course of the offshore work are shown in Figure 1. Additional sample coverage for beach, near-shore and hydrographic studies is shown in other sections of this report.

Our evaluation of the events described previously is based on approximately 45 man days on the beaches, 115 ship days at sea, 30 hours of SCUBA dives and 25 hours of aerial observations. In excess of 250,000 laboratory analyses and field measurements were reduced to about 650 charts and graphs. In addition, more than 1000 color photographs were taken during the field work. From this, we have selected a representative number of illustrations to include in this report. The text of the report has been kept to a minimum, wherever possible, because the illustrations succinctly depict the environmental parameters which were studied.

All of the oceanographic values will be available from the National Oceanographic Data Center, Washington, D.C. The other physical and chemical values will be

available from editorial data centers when the papers resulting from this study are published in referred scientific journals. However, those values which could be difficult to obtain are listed in the appendix. All station locations are also listed in the appendix because they may be helpful to anyone interested in evaluating this report.

Figure 1. Location map of sediment samples collected in Santa Barbara Channel during March, 1969 through June, 1970.


SAMPLES SE OF SANTA BARBARA
1 = 12797
2 = 12811
3 = 13928
4 = 13551
5 = 12862
6 = 12855
7 = 12854
8 = 12853
9 = 12856
10 = 12857
11 = 13253
12 = 13030
13 = 13927
14 = 12865
15 = 13645
13815
16 = 13596
17 = 12866
18 = 12807
19 = 13133
20 = 12800
21 = 12808
22 = 13014
23 = 13926
24 = 13047
25 = 12597
26 = 13798
27 = 13646
28 = 13798
29 = 13352
12799
30 = 12809
31 = 12864
32 = 12863
33 = 12860
34 = 12861
35 = 12858
12859
36 = 13013
37 = 12812
38 = 12798
39 = 13154
40 = 12810
SCALE
5 0 5 10 nautical mi
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
GEOLOGY BOTTOM SAMPLES MARCH, 1969 — JUNE, 1970

ACKNOWLEDGMENTS

This study was made possible by an unrestricted grant from the Western Oil and Gas Association to the University of Southern California.

It is a pleasure to thank the many individuals who provided assistance during the course of this investigation. Dr. Peter Barnes, David Drake, Dr. Donn Gorsline and Mikihiko Oguri served as cruise leaders or participated in most of the cruises aboard the Velero IV. Larry Gatto, Dr. Roderick MacLeod, Glenn Rattmann, students from the Fullerton Junior College Marine Technician Program as well as many other students and research personnel were also members of the scientific crew aboard the Velero IV.

Thanks also go to Captain Fred Ziesenhenne and crew of the Velero IV and Captain Richard Bergeron and crew of the Golden West for navigation, advice and other assistance during shipboard operations. Mr. Walter W. Hoffman kindly operated and provided the use of his vessel Aquarius for SCUBA dives. Dr. David Cook, Taylor Loop, Kendal Robinson and Ronald Zakrzewski made several SCUBA dives. Dr. Carleton Scott arranged for several photographic flights over the channel. Rick Brandt, Ruth Brockmoeller, Scot Cameron, Ginny Dofflemeyer, Larry Doyle, William Jesse, John Kushma, Richard Lamb, Karen Morin, Kendal Robinson Janet Stull, Steven Surface, Celeste Ventura, Robert Young, Ronald Zakrzewski and John Ziegler assisted in the laboratory and the field during various portions of the program. June E. Brown and Susan Shaar typed portions of the appendix and Richard Stauffer drafted some of the figures in the papers on foraminifera. Susie Dimitriou typed the text of this report and assisted in collating the report.

Special thanks go to Scot Cameron, Kendal Robinson, Robert Young and Ronald Zakrzewski for doing much of the laboratory work and for final drafting of the figures. The editor of this volume is particularly grateful to Susie Dimitriou for deciphering an illegible scrawl and for editorial assistance. Drs. Orville Bandy and Donn Gorsline provided invaluable advice and encouragement during the entire course of this investigation.

Ship support was from a National Science Foundation grant (GB-8206) and much of the support for David Drake and Peter Fleisher was from a National Science

Foundation grant (GA- 22842) and an Office of Naval Research contract (N00014-67A-0269-0009). Support for a portion of the last part of this study was from the National Sea Grant Program.

Credit for the work accomplished during the course of this investigation should go to the foregoing individuals and organizations. However, the sole responsibility for everything presented in the physical, chemical and geological reports is assumed by the editor of this volume.

CHAPTER 2

PHYSICAL CHARACTERISTICS OF SANDY BEACHES IN THE SANTA BARBARA CHANNEL AREA

by

Ronald L. Kolpack
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

INTRODUCTION

The presence of oil deposited in the beach environment as a result of a well blowout was considered to be a possible hindrance to the natural movement of beach sand. Oil layers could increase the erosive resistance of beach sand by providing a protective cover or by increasing the cohesiveness of the detrital particles due to cementation. Therefore, a study was initiated to observe the movement of beach sand over a period of one year and to determine if oil deposited in the beach environment altered the normal seasonal transgressive-regressive characteristics. Concomitantly, it was necessary to determine if oil remaining after cleanup operations remained buried after one year. Burial of oil appeared to be a distinct possibility because deposition occurred during the time of the normal maximum regressive stage of the foreshore and backshore beach areas.

Major floods in early 1969 contributed large quantities of material to the beach and nearshore environment, especially in the vicinity of source areas such as the Santa Ynez, Ventura and Santa Clara Rivers. A few smaller streams also contributed material and consequently increased the larger than normal volume of sand present. Initial deposition of this material near source areas resulted in a disequilibrium condition and the reaction expected was an

attempt by the system to restore equilibrium by erosion and redistribution.

Ten mainland beaches (fig. 1) were selected for monthly study after a reconnaissance survey of the coast from Surf to Santa Monica was conducted in February and March, 1969. Selection of the beaches was based on representative geographic spacing as well as an attempt to study a variety of sandy beach environments. Most of the survey transects were located on open stretches of the beach; however, several transects were located near rocky points so that movement of material near promontories could be studied.

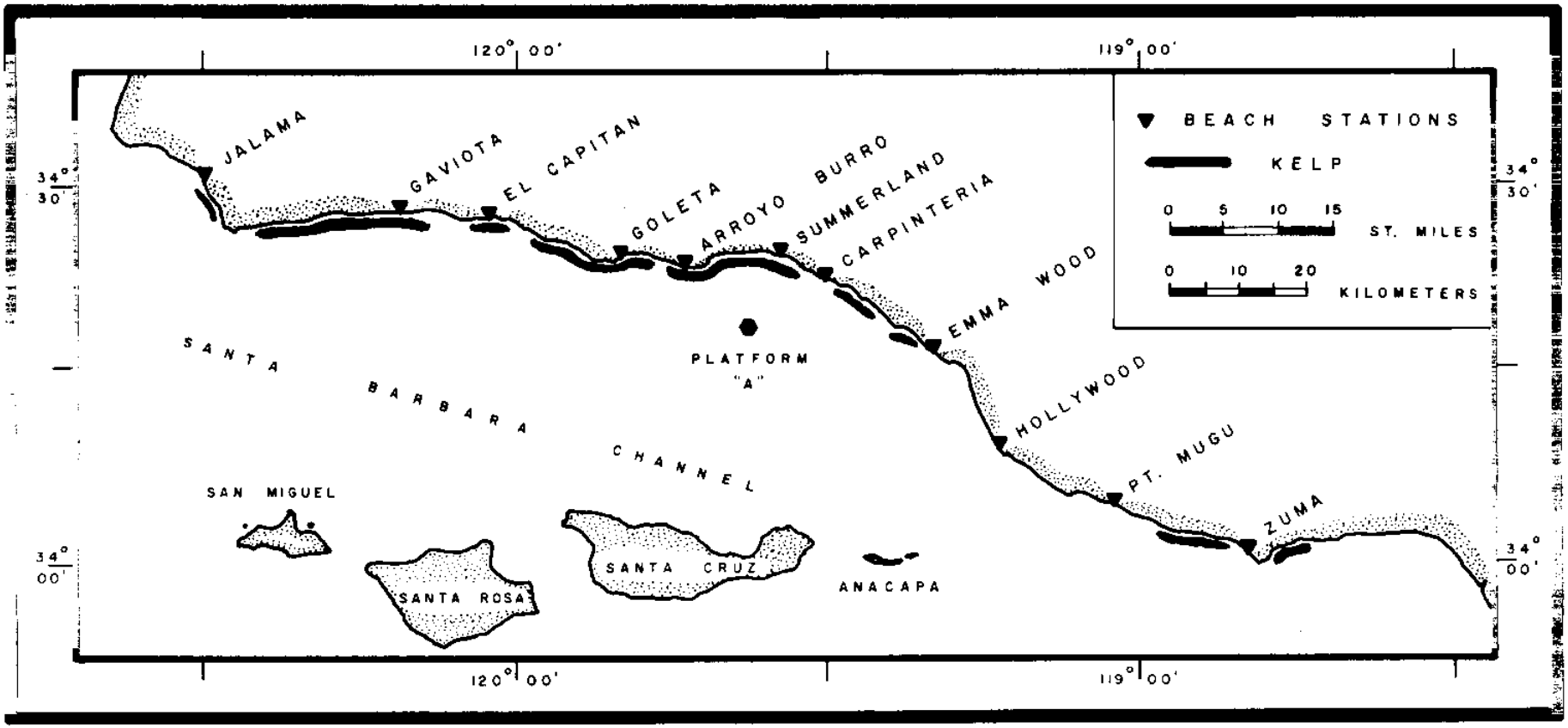
ACKNOWLEDGMENTS

This study was based primarily on field measurements and observations made in an invigorating environment. The writer was fortunate to have had the support of Rick Brandt, William Jessee, Taylor Loop and Kendal Robinson during various phases of the field work and the results of this study are directly attributable to their excellent assistance. The U.S. Army Coastal Engineering Research Center kindly provided data tabulations of the Littoral Environment Observation (LEO) program measurements made at several southern California beaches during 1968 and 1969. Thanks for this information as well as for several stimulating discussions go to Dennis Berg, David Duane and Andre Szuwalski.

PROCEDURES

Gross alterations of seasonal beach processes can be observed merely by recording anomalous conditions. This approach is purely subjective and can not be reduced quantitatively. A more ideal approach involves measurement of beach characteristics on a closely spaced grid at frequent intervals. Such a monitoring procedure involves precise measurement of all physical parameters related to energy conditions and movement of sand. The effort and financial support for a sophisticated field program as well as necessary high precision aerial support were beyond the means of this project and probably would not have been entirely applicable to the objective. Consequently, the program that was established was directed primarily at measurement of beach profiles at monthly intervals.

Figure 1. Location map of Santa Barbara Channel mainland beaches studied during 1969-70.


120° 00'
119° 00'
34° 30'
34° 00'
BEACH STATIONS
KELP
0 5 10 15
ST. MILES
0 10 20
KILOMETERS
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
PT. MUGU
ZUMA
PLATFORM "A"
SANTA BARBARA CHANNEL
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA

Profile measurements were made by the method described by Emery (1961). This technique is based on measurement of the difference in elevation between two 5 foot rods which are marked off in 0.1 foot intervals and are placed 5 feet apart for each measurement. The starting point for each profile is a known base point and the difference in elevation between the two rods (placed 5 feet apart) is determined by an observer using the horizon as a reference to obtain the line of sight difference in elevation between the two points.

Precise measurements to 0.01 feet in a 5 foot linear distance can be routinely accomplished except in a heavy surf. The method has many advantages but there is a disadvantage which on occasion can result in a prematurely terminated profile measurement. The problem encountered in high energy breaker zones is that the distance and elevation of the moving base rod must be maintained. Thus, the length of the profiles depends, to a certain degree, on the stamina and physical skill of the observers. Ideally, profile measurements can be made to a maximum water depth of slightly less than 5 feet.

All profile measurements, except for the months of December and January, were made by the same observer. The readings made in those two months were made by an experienced observer and the reproducibility between the observers, established on duplicate readings over several months, was $\pm$ 0.1 feet in elevation over a linear distance of 150 feet.

Additional measurements were made and sediment and water samples were collected during the course of the monthly profiling study in order to better utilize the field time available. The other observations were: wave period and height (average of 20 measurements), orientation of the shoreline and the approaching waves, water and air temperature, cloud cover, wind speed and direction and longshore drift velocity. An average of 10 sediment samples for grain size characteristics and 2 samples for foraminiferal analysis were collected at each beach each month. Water samples for salinity determinations were also collected during most of the year. Samples from auger holes were taken along a profile near the beach profile at approximately 3 month intervals at beaches where oil deposited in February and March was buried. In addition, at least 4 photographs of each beach were taken monthly. Photograph orientation, with respect to the profile line, was upcoast, downcoast,

toward the ocean and away from the ocean.

PHYSICAL CHARACTERISTICS

Temperature

Surface water temperatures taken in the area seaward of the breaker zone at monthly intervals (fig. 2) show that on an average the lowest water temperature occurs at Jalama Beach (north of Pt. Conception) and the highest temperatures occur at Summerland and Carpinteria beaches. The lower temperatures at Jalama are in all probability a reflection of cold southward flowing nearshore water from north of Pt. Arguello. Higher water temperatures from Santa Barbara (Arroyo Burro) to Carpinteria are a resultant of offshore eddies and entrapment of water between the kelp beds and the shoreline. Hollywood Beach, south of Ventura, is an unprotected, high energy beach and the water temperatures are representative of the offshore surface water.

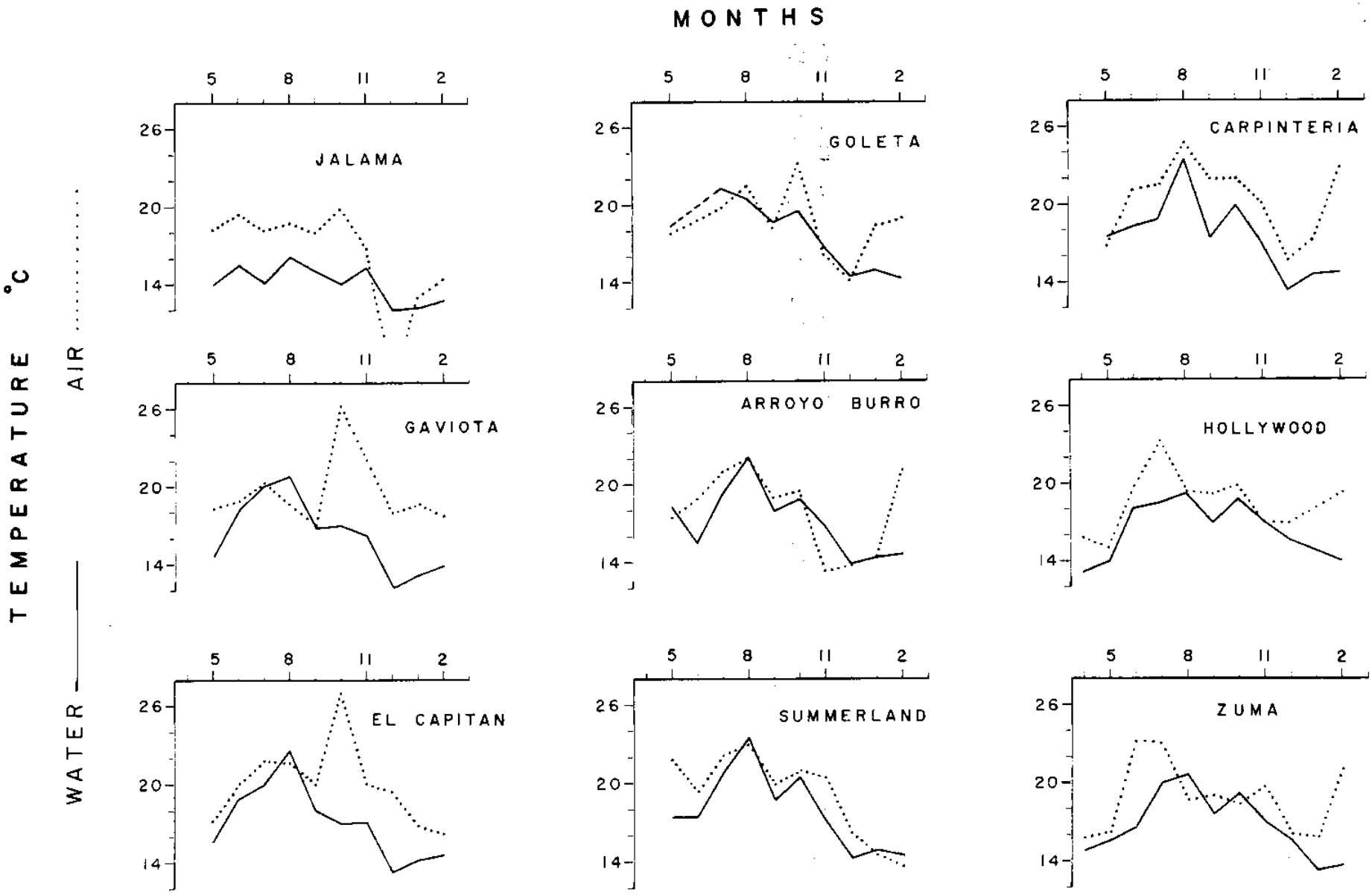
There are a number of inflections in the yearly temperature curves for each beach but the pattern of coldest temperatures occurring in December and warmest temperatures in August is quite evident. One must realize, however, that these measurements were made only once each month. Therefore, values from the Littoral Environment Observation (LEO) program were plotted for 1968 and 1969 (figs. 3-4) to determine if the patterns discussed previously were real. Inspection of the curves for the six beaches in the area from which values were available shows the same pattern, and our values are well within the monthly range of LEO values. The 1968 LEO information is not as complete, but there is evidence to indicate that the highest water temperatures occurred in September.

Air temperatures are less consistent and measurements made at monthly intervals are probably not too meaningful because the values are influenced significantly by existing local conditions at the time of measurement.

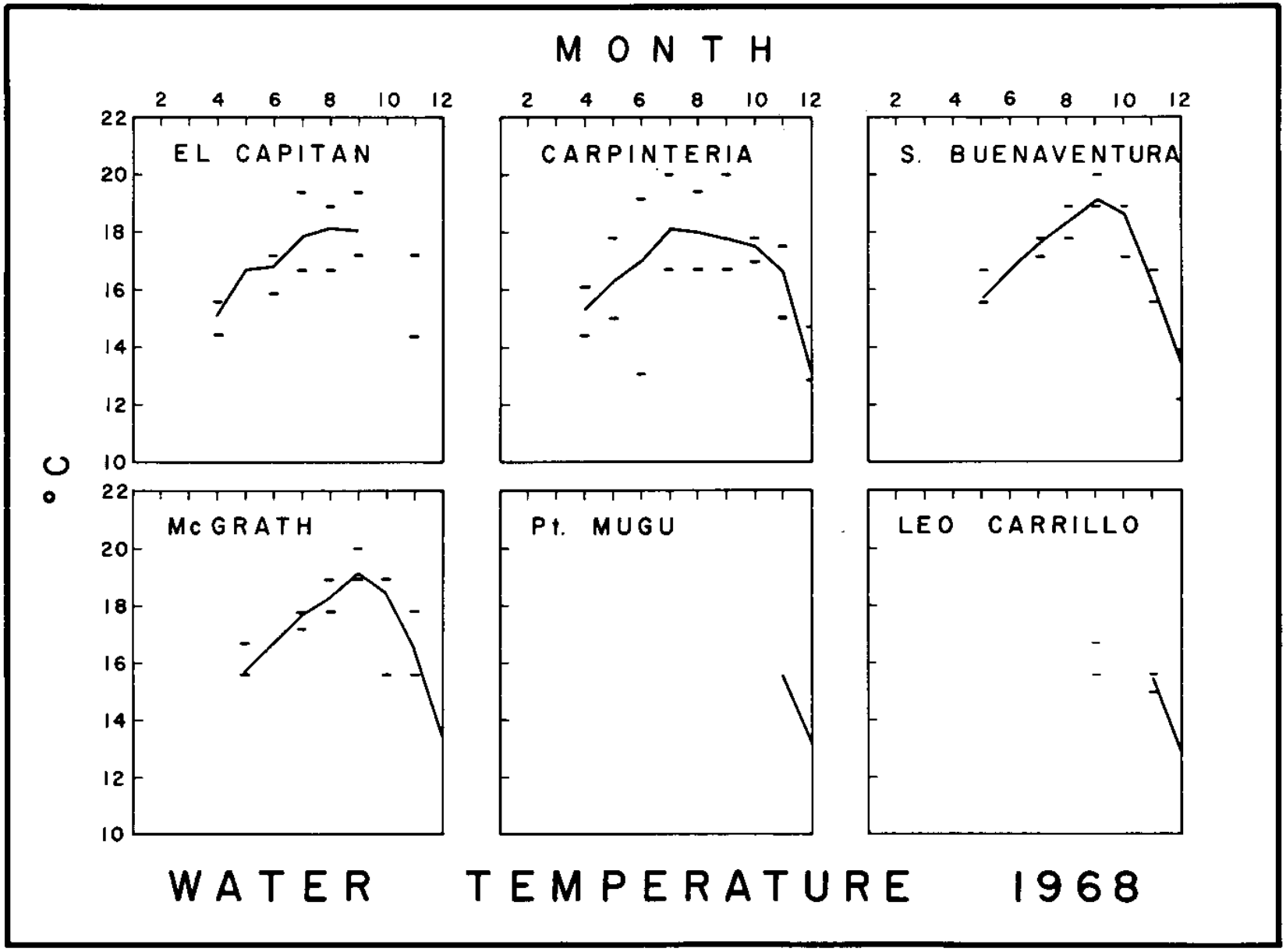
Wave Height and Period

The greatest wave heights in 1969 were recorded at Jalama and Hollywood beaches and these two beaches also had the highest yearly average (fig. 5). Wave height values reflect beach orientation relative to direction of prevailing swell, storm conditions and the amount of offshore protection

Figure 2. Air (.....) and surface water (———) temperatures for the period May, 1969 through February, 1970.


MONTHS
TEMPERATURE °C
AIR .....
WATER ———
JALAMA
GOLETA
CARPINTERIA
GAVIOTA
ARROYO BURRO
HOLLYWOOD
EL CAPITAN
SUMMERLAND
ZUMA
5
8
11
2
26
20
14

Figures 3-4. Water temperatures for six beaches during 1968 and 1969. Values obtained from the Littoral Environmental Observation (LEO) program. Average monthly values are connected by a solid line and the ranges are shown by horizontal dashes.


MONTH
2 4 6 8 10 12
22 20 18 16 14 12 10
°C
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WATER TEMPERATURE 1968

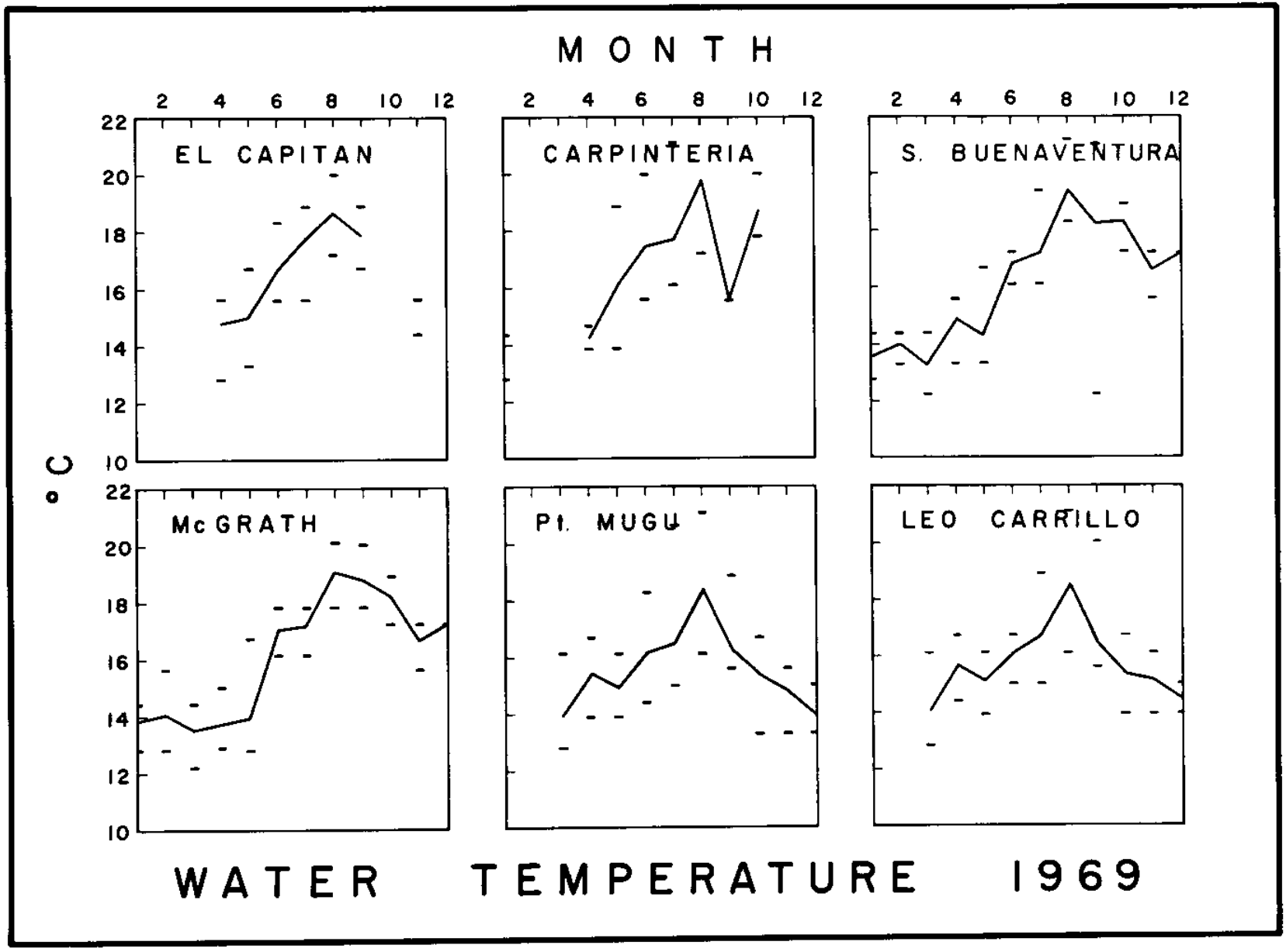
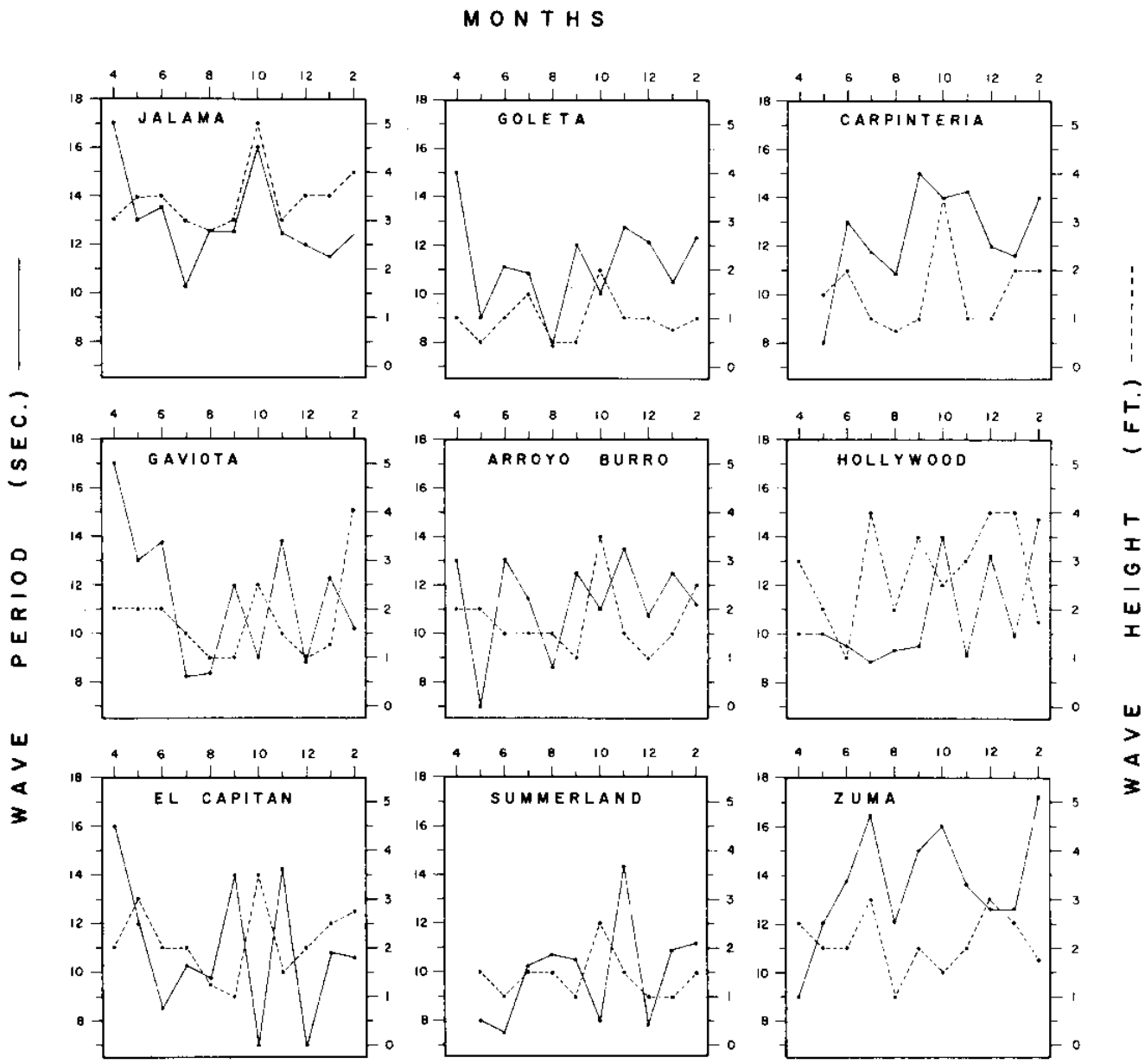

MONTH
2 4 6 8 10 12
22 20 18 16 14 12 10
°C
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WATER TEMPERATURE 1969

Figure 5. Wave period (_____) in seconds and wave height (-----) in feet for the period April, 1969 through February, 1970. Each monthly value is an average of 20 measurements.


MONTHS
WAVE PERIOD (SEC.)
WAVE HEIGHT (FT.)
JALAMA
GOLETA
CARPINTERIA
GAVIOTA
ARROYO BURRO
HOLLYWOOD
EL CAPITAN
SUMMERLAND
ZUMA

provided by kelp. Spring and winter are generally the seasons of greatest wave heights with the summer and fall seasons reflecting calmer conditions (figs. 6-7). Our measurements show a distinct period of high waves in October; however, this appears to be anomalous because the average LEO values for 1969 (fig. 7) do not show this pattern.

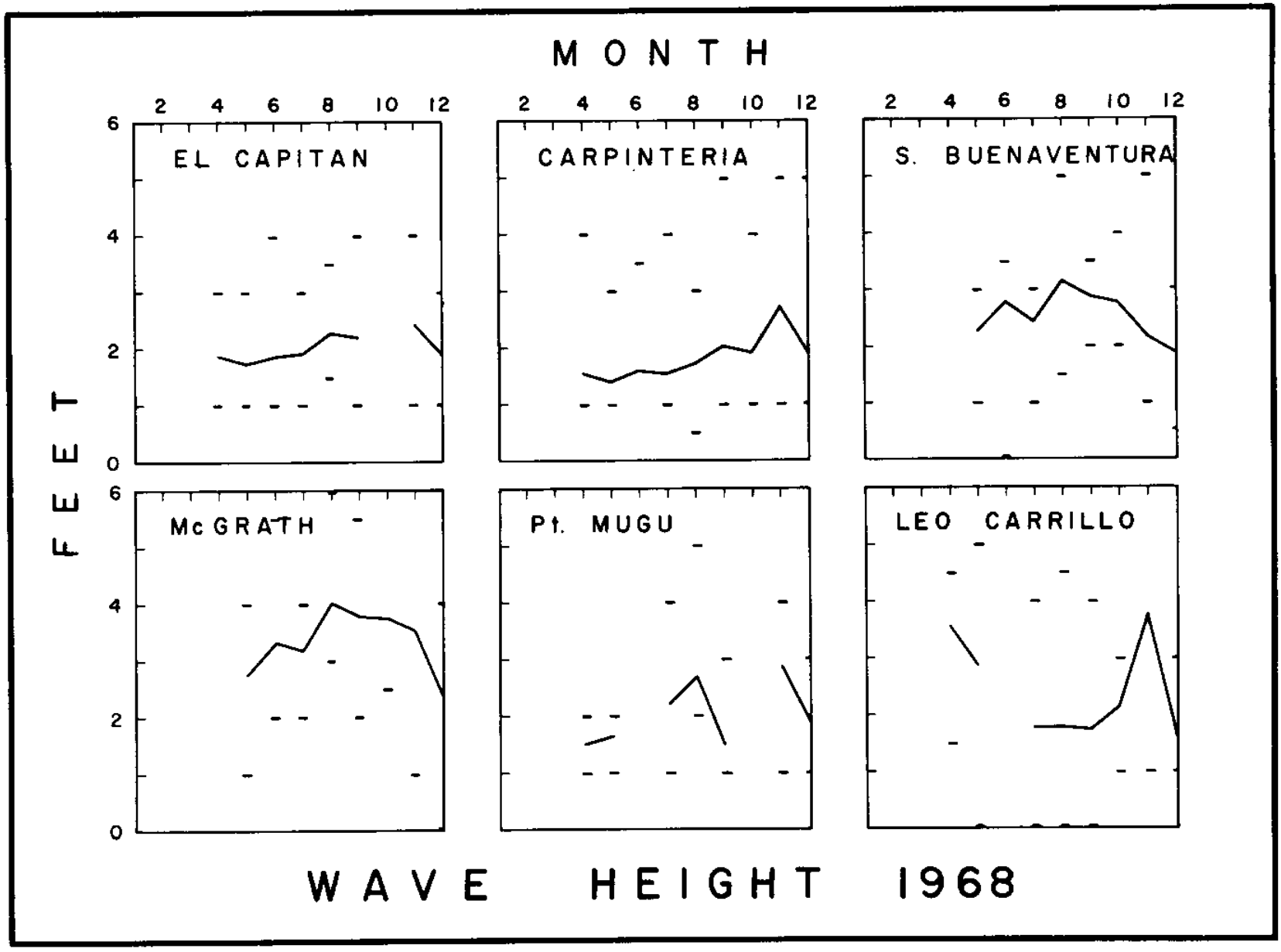
The relationship between beach orientation and direction of prevailing wave approach is evident in the plots of wave period versus time (fig. 5). As an example, one can see a progressive interference pattern develop from Jalama toward the southeast during a time of long period storm swell in April, 1969. This effect is directly related to the protection afforded portions of the mainland coast by the offshore islands. Short term incidents of long wave periods are also present in the daily and weekly LEO plots but are smoothed out in the plots of monthly averages (figs. 8-9).

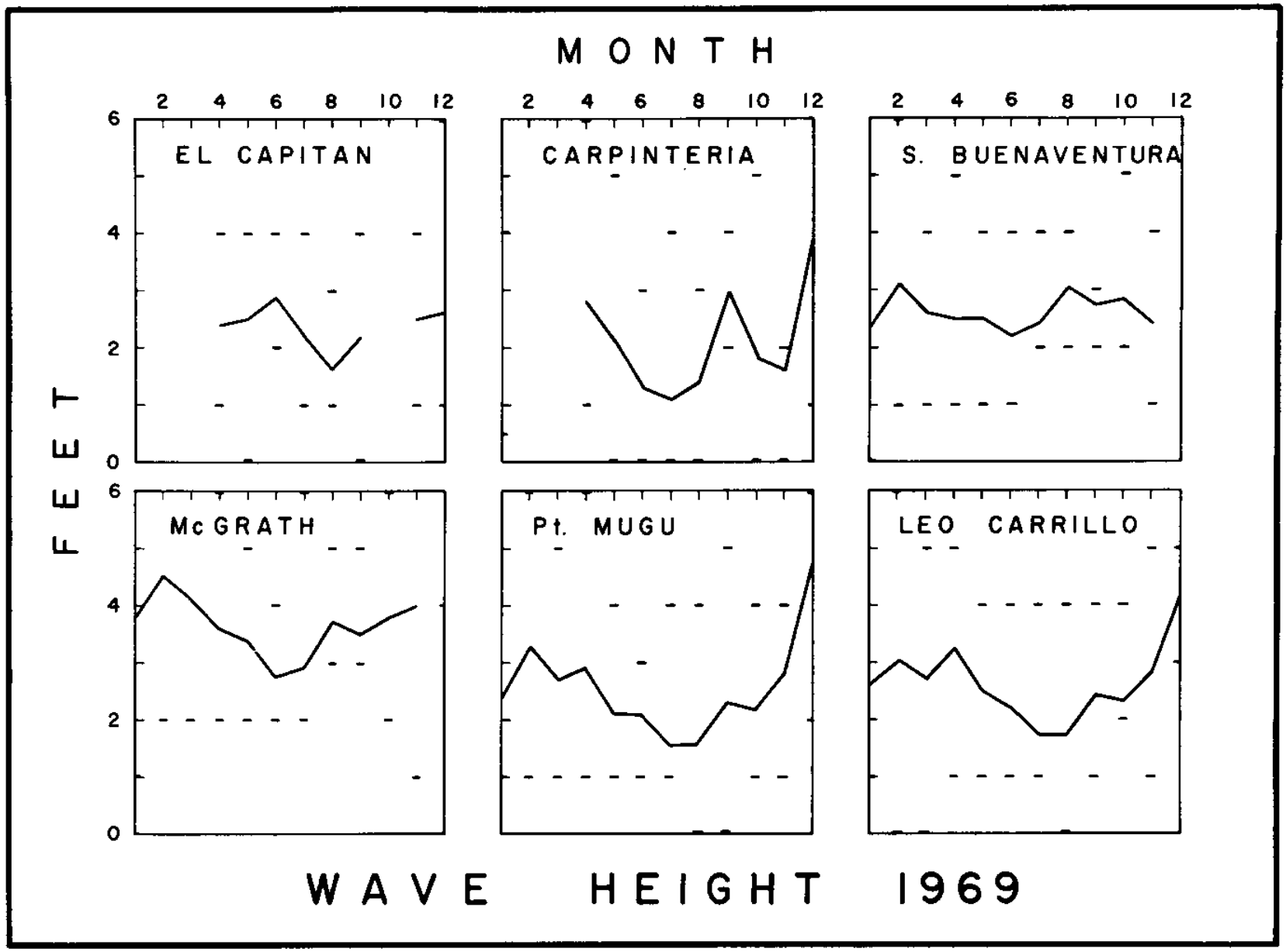
Longshore Drift

Surface water longshore drift velocities were determined at variable distances from the water line by releasing Rhodamine-B dye and measuring the distance of dye patch movement over a time interval of 2-3 minutes. Selection of release distances was based on field observations at the time of each beach survey and are representative of the general longshore drift pattern at the time of wave and wind parameter measurements. An attempt was made to avoid the effects of rip current cells. Duplicate or triplicate sets of dye releases were usually made over an extended period of time whenever rip currents appeared to have influenced the drift velocities or when the dye patch moved in opposite directions within a distance of 25 feet or less. On occasion, large, relatively fixed rip current cells were present during the entire time spent at a beach, particularly Jalama and Zuma beaches, and undoubtedly several of the measurements were influenced by these rip currents.

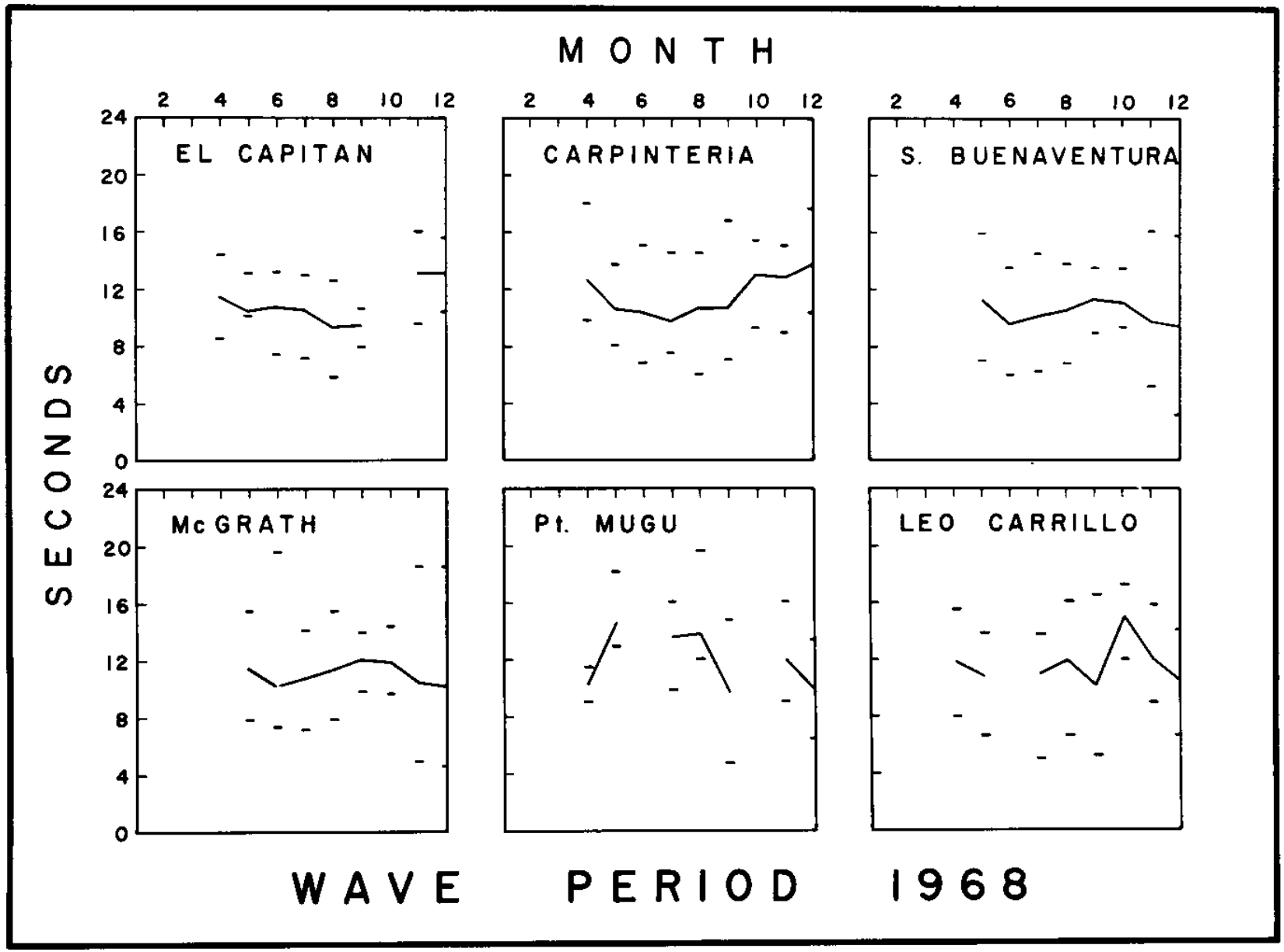
The highest longshore drift velocities (fig. 10) are associated with periods of large wave heights (fig. 5). A plot of the maximum longshore drift velocity versus the average wave height squared multiplied by the cosine of the angle between shoreline trend and wave approach ($h^2 \cos \alpha$) for each beach each month shows a linear relationship for most of the observations (fig. 11). It turns out that wave

Figures 6-7. Wave heights for 6 beaches during 1968 and 1969. Values obtained from the LEO program. Average monthly values are connected by a solid line and the ranges are shown by horizontal values. Each daily wave height value (measured from crest to trough) is an average for the highest third of the observed breakers.


MONTH
2 4 6 8 10 12
FEET
0 2 4 6
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WAVE HEIGHT 1968


MONTH
2 4 6 8 10 12
FEET
0 2 4 6
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WAVE HEIGHT 1969

Figures 8-9. Wave periods for 6 beaches during 1968 and 1969. Values obtained from the LEO program. Average monthly values are connected by a solid line and the ranges are shown by a horizontal dash.


MONTH
2 4 6 8 10 12
24
20
16
12
8
4
0
SECONDS
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WAVE PERIOD 1968

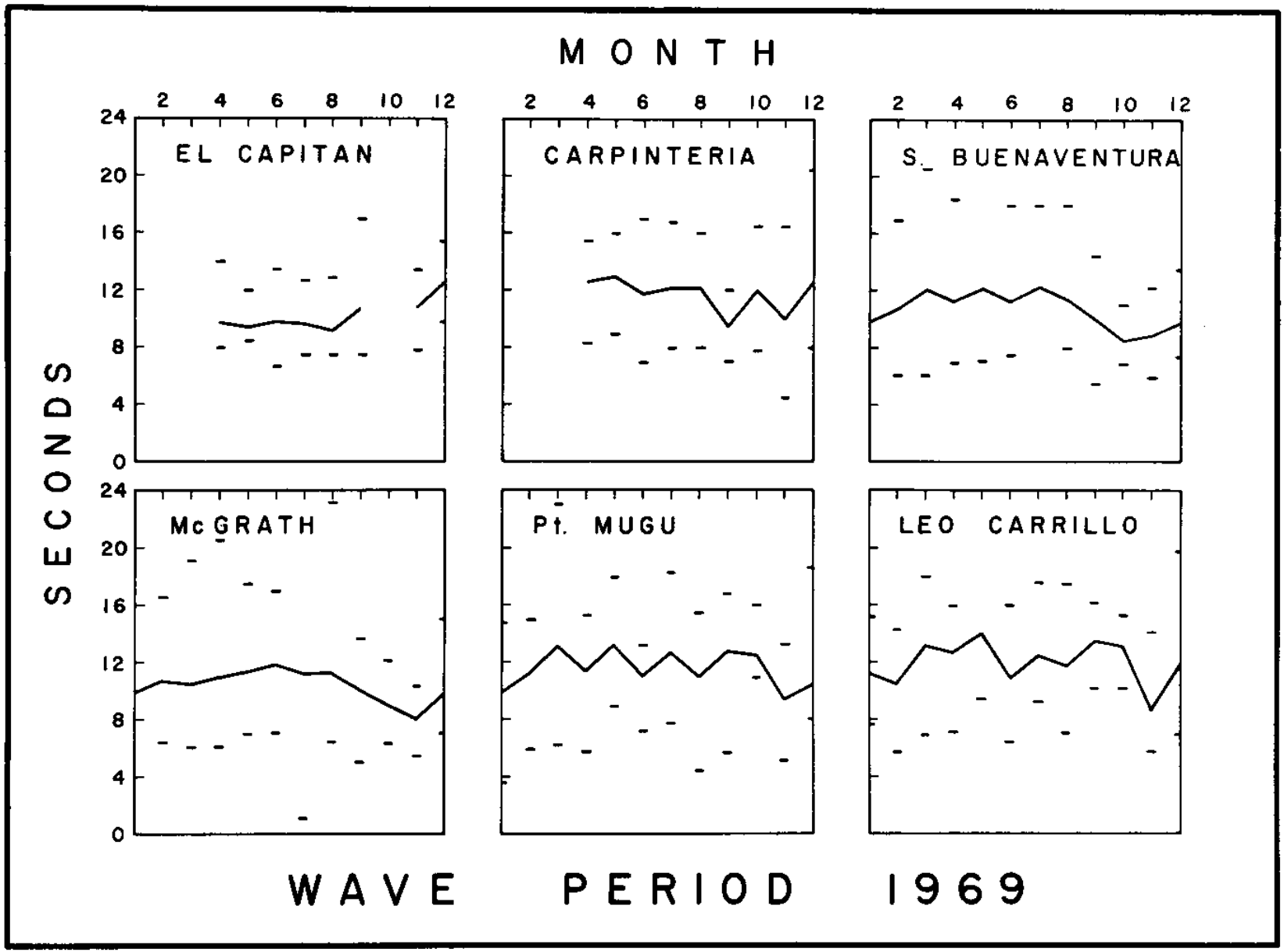

MONTH
2 4 6 8 10 12
24
20
16
12
8
4
0
SECONDS
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WAVE PERIOD 1969

Figure 10. Longshore drift velocities (solid bar) for the period July, 1969 through February, 1970. The length of each bar represents the velocity (ft/sec) and the value at the terminus of each bar is the distance (feet) seaward of the water line for that measurement. The thin solid line connects values of $h^2 \cos \alpha$ where h=average wave height and α =angle between shoreline trend and wave approach.

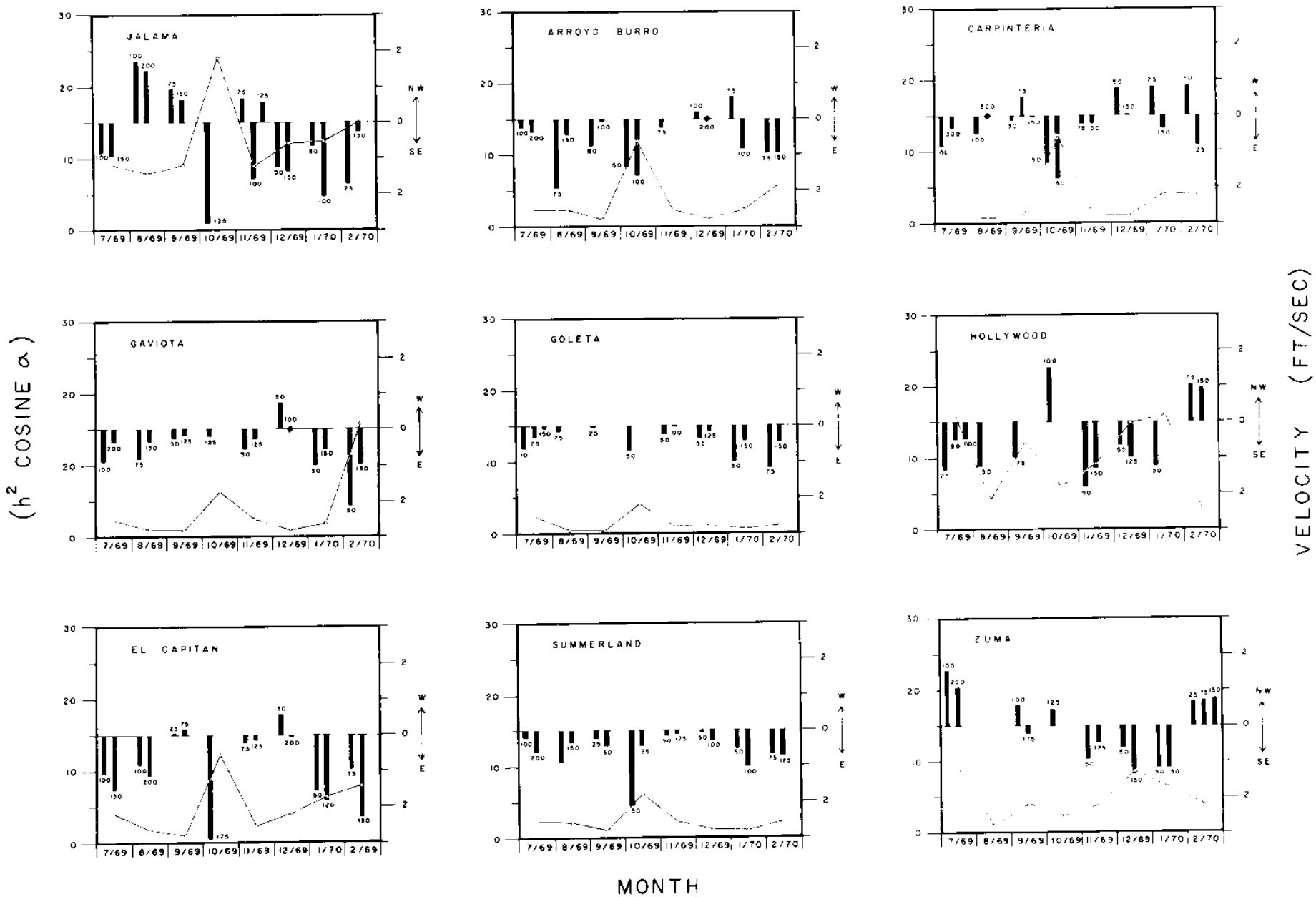
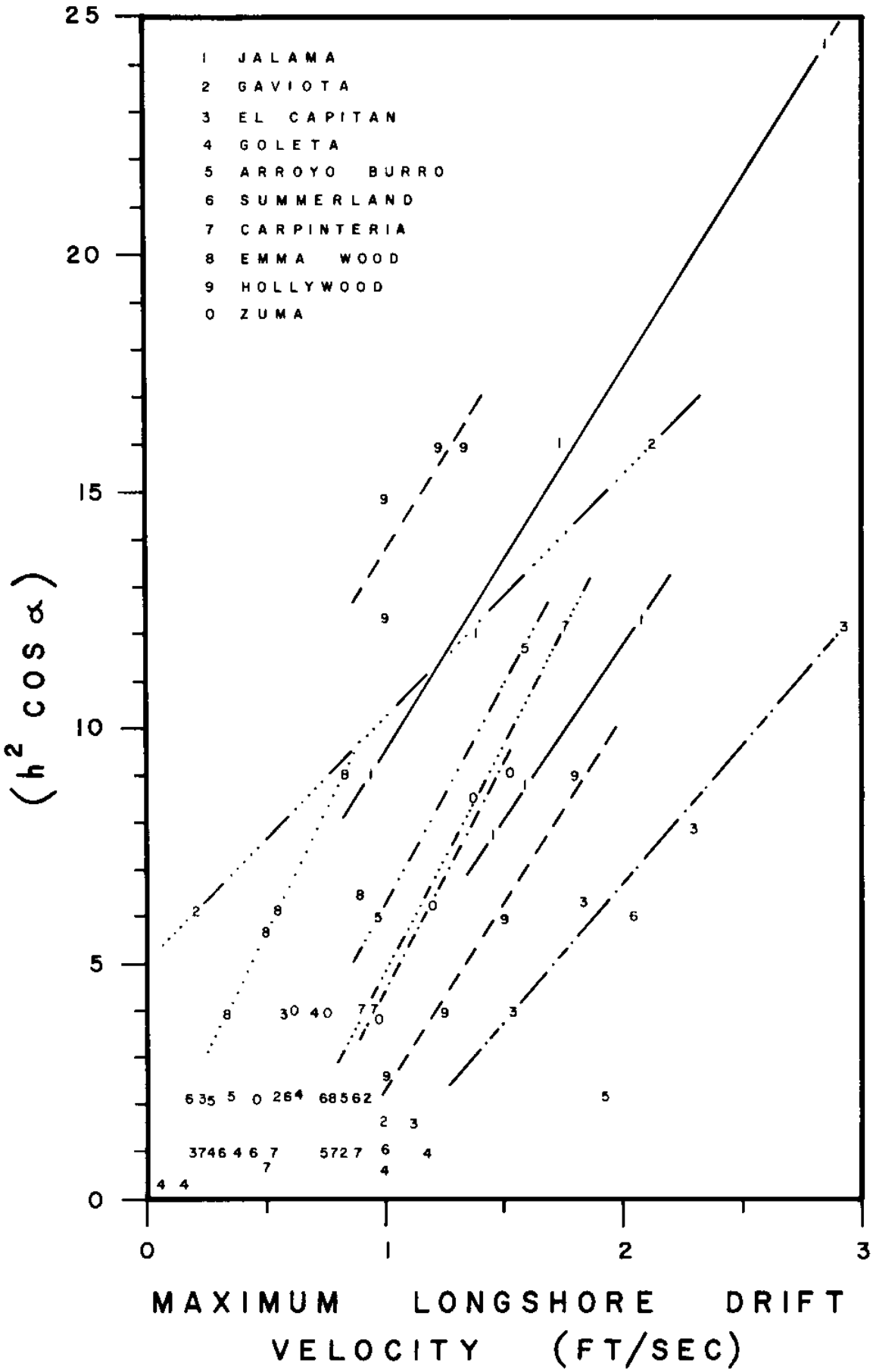

JALAMA
ARROYO BURRO
CARPINTERIA
GAVIOTA
GOLETA
HOLLYWOOD
EL CAPITAN
SUMMERLAND
ZUMA
7/69
8/69
9/69
10/69
11/69
12/69
1/70
2/70
NW
SE
W
E
(h² COSINE α)
VELOCITY (FT/SEC)
MONTH

Figure 11. Maximum longshore drift velocity (ft/sec) versus $h^2 \cos \alpha$ where h=average wave height and α =angle between shoreline trend and wave approach.


1 JALAMA
2 GAVIOTA
3 EL CAPITAN
4 GOLETA
5 ARROYO BURRO
6 SUMMERLAND
7 CARPINTERIA
8 EMMA WOOD
9 HOLLYWOOD
0 ZUMA
$(h^2 \cos \alpha)$
MAXIMUM LONGSHORE DRIFT VELOCITY (FT/SEC)
0
5
10
15
20
25
0
1
2
3

heights of less than 2 feet produced an inconclusive scatter when the results were plotted in this manner and the angle between shoreline trend and wave approach was not significant for wave height values which exceeded 2 feet.

High longshore drift velocities and large wave heights also correlate well with high wind velocities (see appendix) as described by Shepard and Inman (1950), Ingle (1966) and others. Comparison of longshore drift velocities with average wind speeds (figs. 12-13) is not realistic in view of the transient variability of local nearshore winds.

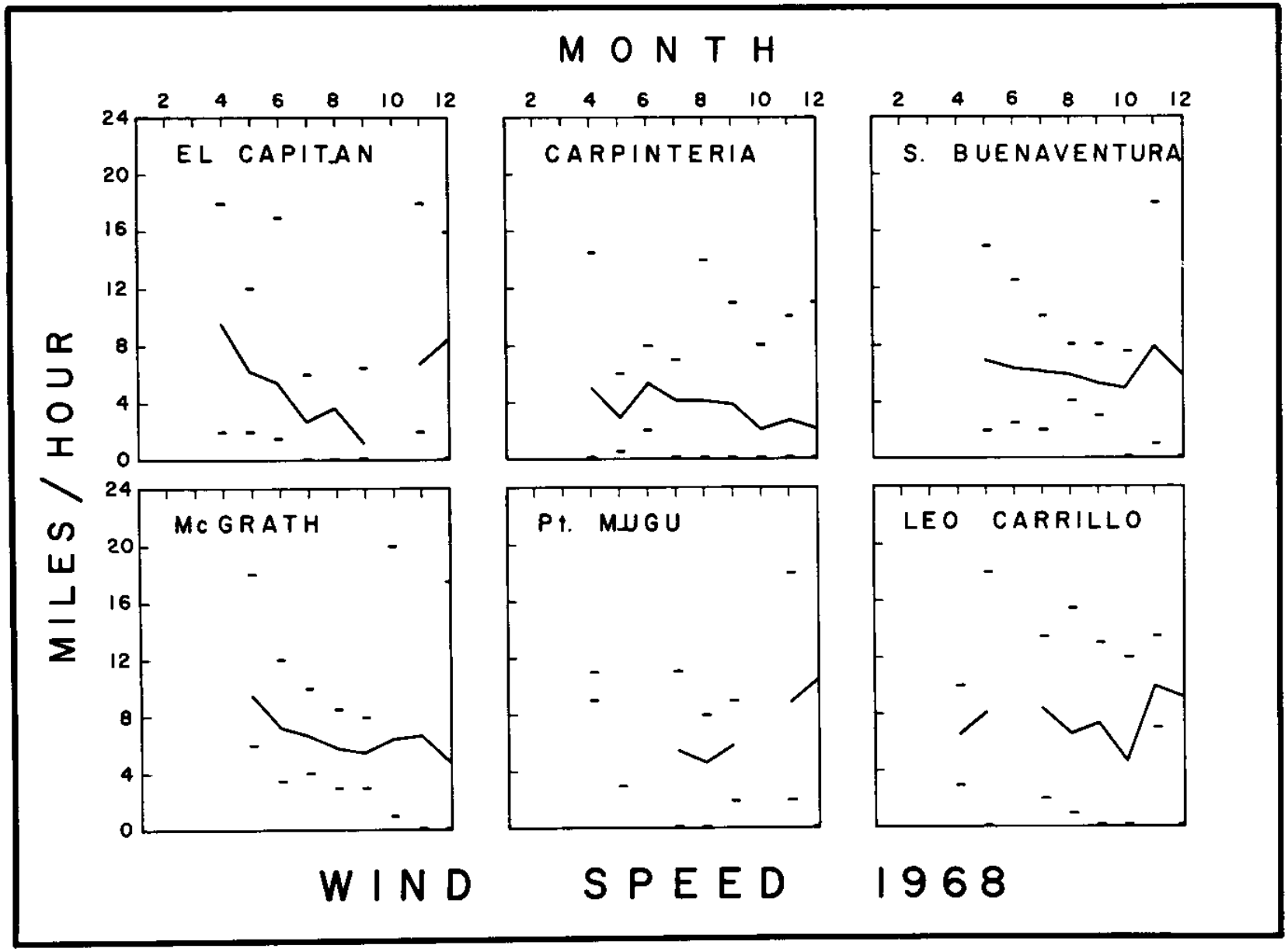
The physical characteristics of the 10 beaches, studied over a period of one year, allow one to classify these beaches in terms of energy conditions. The classification, in order of average high to low energy, is: Jalama, Hollywood, Emma Wood, El Capitan, Arroyo Burro, Zuma, Carpinteria, Gaviota, Summerland and Goleta.

Beach Profiles

Three dominant sources, Santa Ynez, Ventura and Santa Clara Rivers, supply detrital material to the Santa Barbara mainland coast. The largest flood in more than 40 years transported a tremendous quantity of material to the ocean and much of the coarse material was deposited in the beach environment. Erosion and redistribution of the beach sands occurred after February, 1969 and the net relative cross-sectional changes were positive for most of the northwestern beaches through April (table 1). The monthly changes in cut and fill, illustrated in figures 14-34, reveal the interrelationship of supply and demand between adjacent beaches and this pattern is superimposed on a seasonal transgressive-regressive cycle.

The oil spill occurred after the seasonal cycle when most of the foreshore areas were cut back. Consequently, any oil not removed from the beaches was buried by the transgressing sands. However, the beaches southeast of the Ventura and Santa Clara Rivers were exceptions to the preceeding statement. A tremendous quantity of sand was deposited near the mouths of those two rivers during a one month period following peak flooding at the end of January and February, 1969. Large quantities of this sand had been redistributed southward and those beaches were built up to an abnormal extent relative to "normal" conditions. The immediate effect

Figures 12-13. Wind speed for 6 beaches during 1968 and 1969. Values obtained from the LEO program. Average monthly values are connected by a solid line and the ranges are shown by a horizontal dash.


MONTH
2 4 6 8 10 12
MILES / HOUR
0 4 8 12 16 20 24
EL CAPITAN
CARPINTERIA
S. BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WIND SPEED 1968

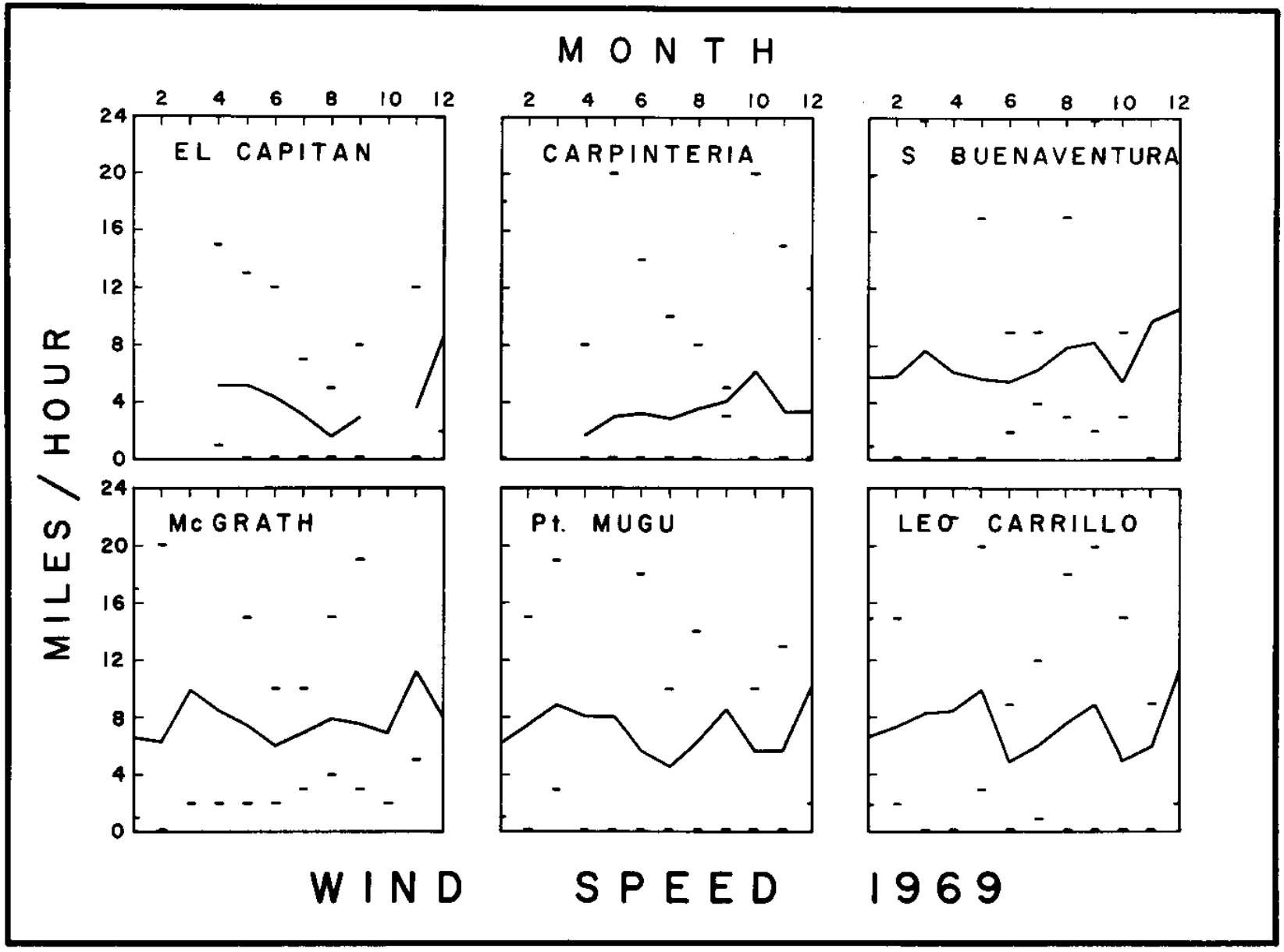

MONTH
2 4 6 8 10 12
24 20 16 12 8 4 0
MILES / HOUR
EL CAPITAN
CARPINTERIA
S BUENAVENTURA
McGRATH
Pt. MUGU
LEO CARRILLO
WIND SPEED 1969

Table 1. Beach profile net relative area changes (ft^2). Changes measured represent cross-sectional areas of cut and fill. A minus sign represents net cut for the entire profile.

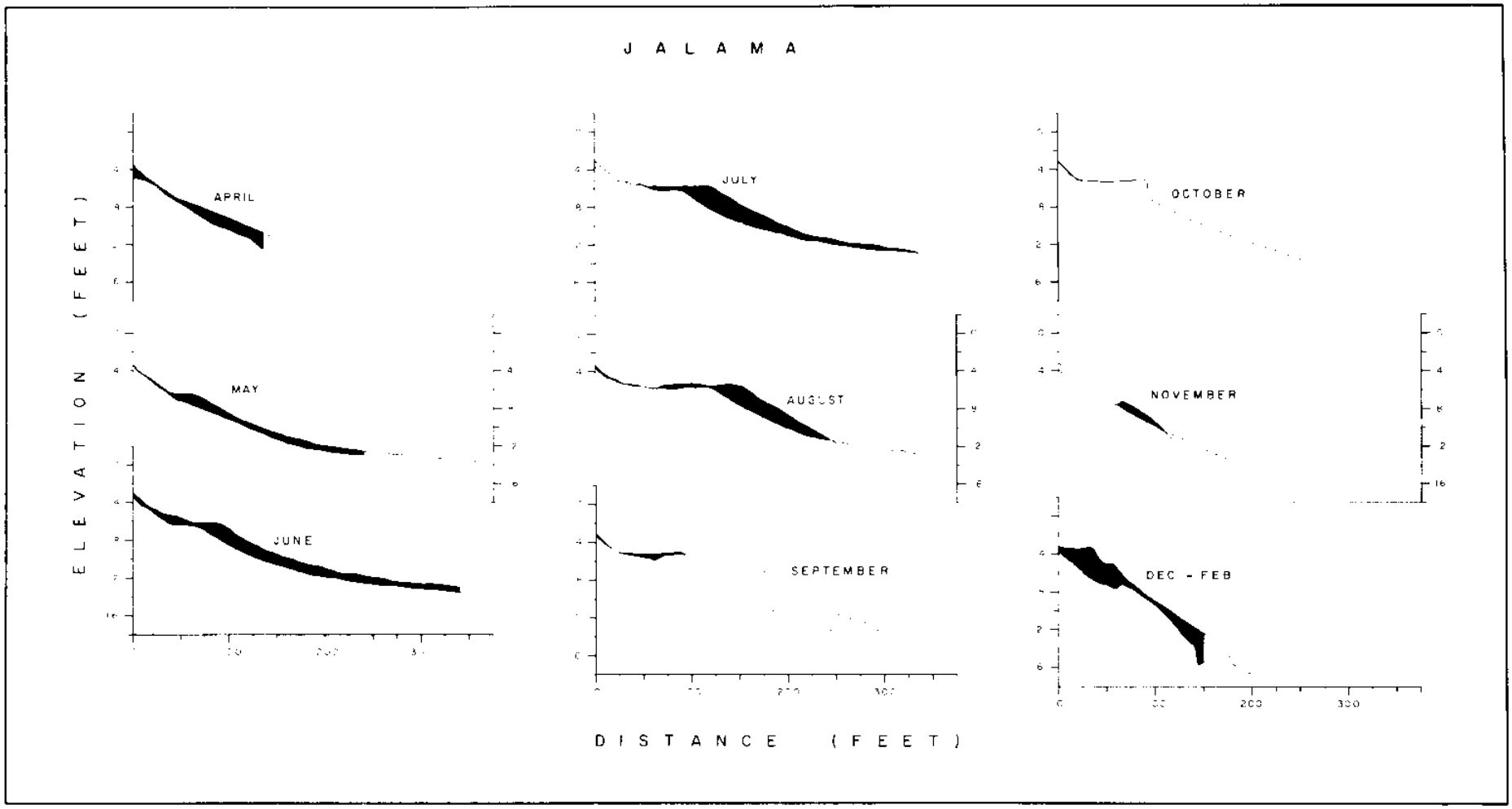
BEACH PROFILE NET RELATIVE AREA CHANGES (FT^2)

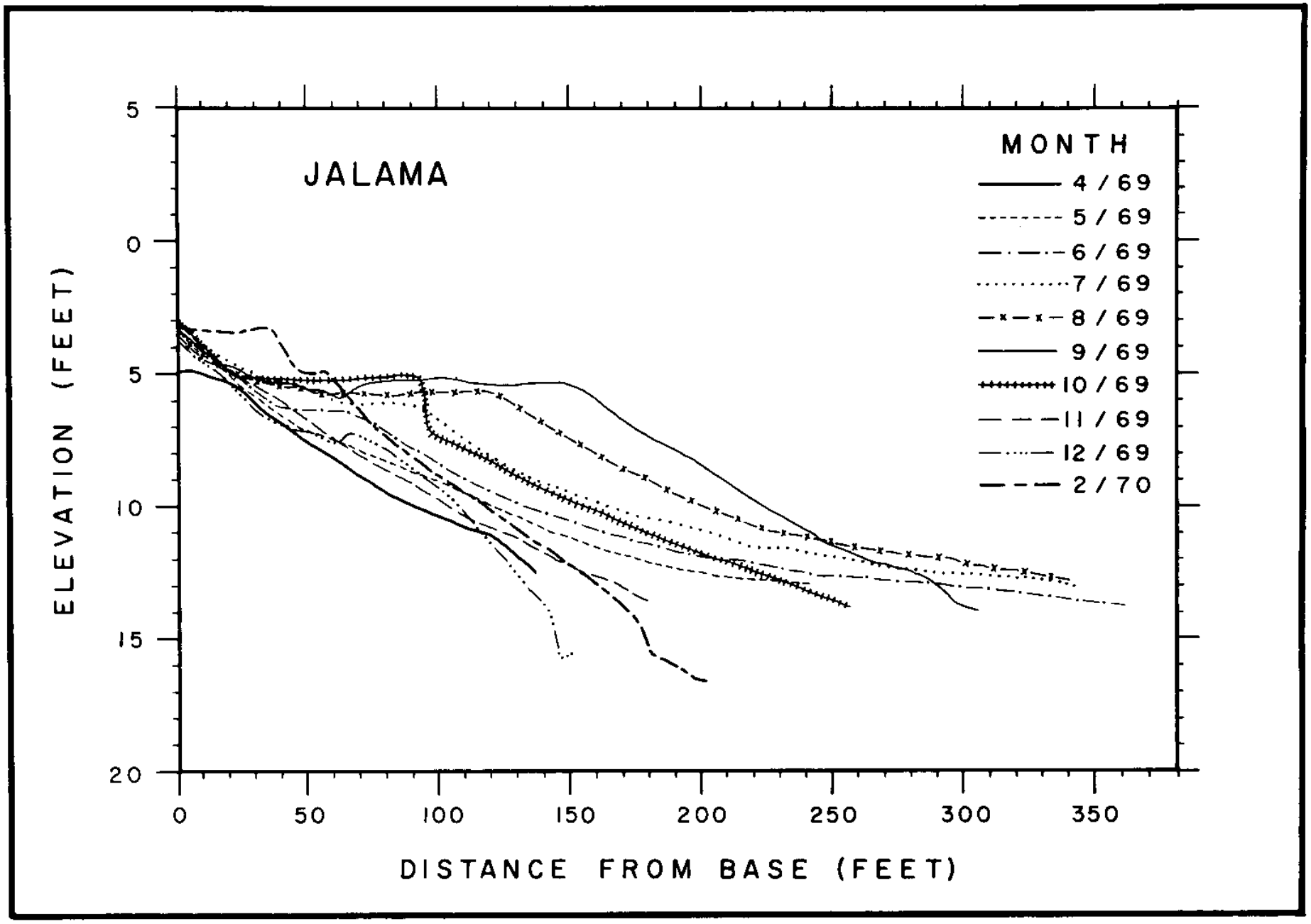
YEAR	MONTH	JALAMA	GAVIOTA	EL CAPITAN	GOLETA	ARROYO BURRO	SUMMERLAND	CARPINTERIA	EMMA WOOD	HOLLYWOOD	PT. MUGU	ZUMA
1969	APR	132	-15	176	337	-1	161	---	---	-147	-235	234
	MAY	112	-42	51	-339	237	-153	225	316	218	279	-143
	JUN	292	156	-38	-79	81	-6	-318	-1	-50	-461	101
	JUL	248	37	121	-87	111	42	148	125	75	684	-22
	AUG	155	-66	-12	-78	220	-135	-12	-57	8	---	77
	SEP	-501	-128	-133	26	-390	59	-147	-326	-40	---	42
	OCT	-356	58	-192	285	199	172	29	73	107	---	-139
	NOV	-68	-170	58	207	-563	-192	-223	---	-5	---	-264
	DEC	---	---	-85	-39	-8	-40	-76	---	-82	---	415
1970	JAN	230*	-172*	2	-119	33	34	-14	---	155	---	-407
	TOTAL	244	-342	-52	114	-81	-58	-388	130	239	267	-106

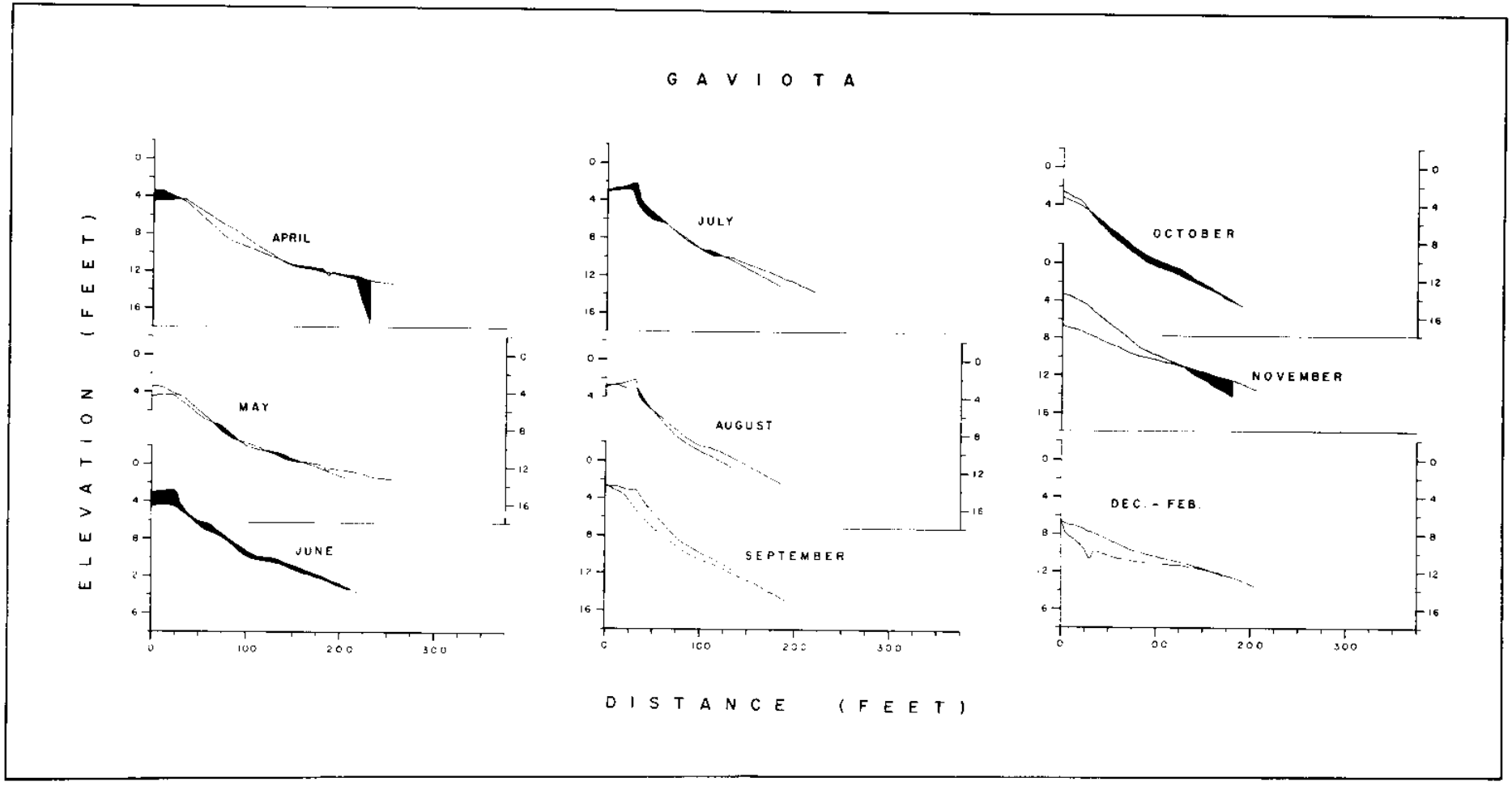
* Represents net change in 2 months

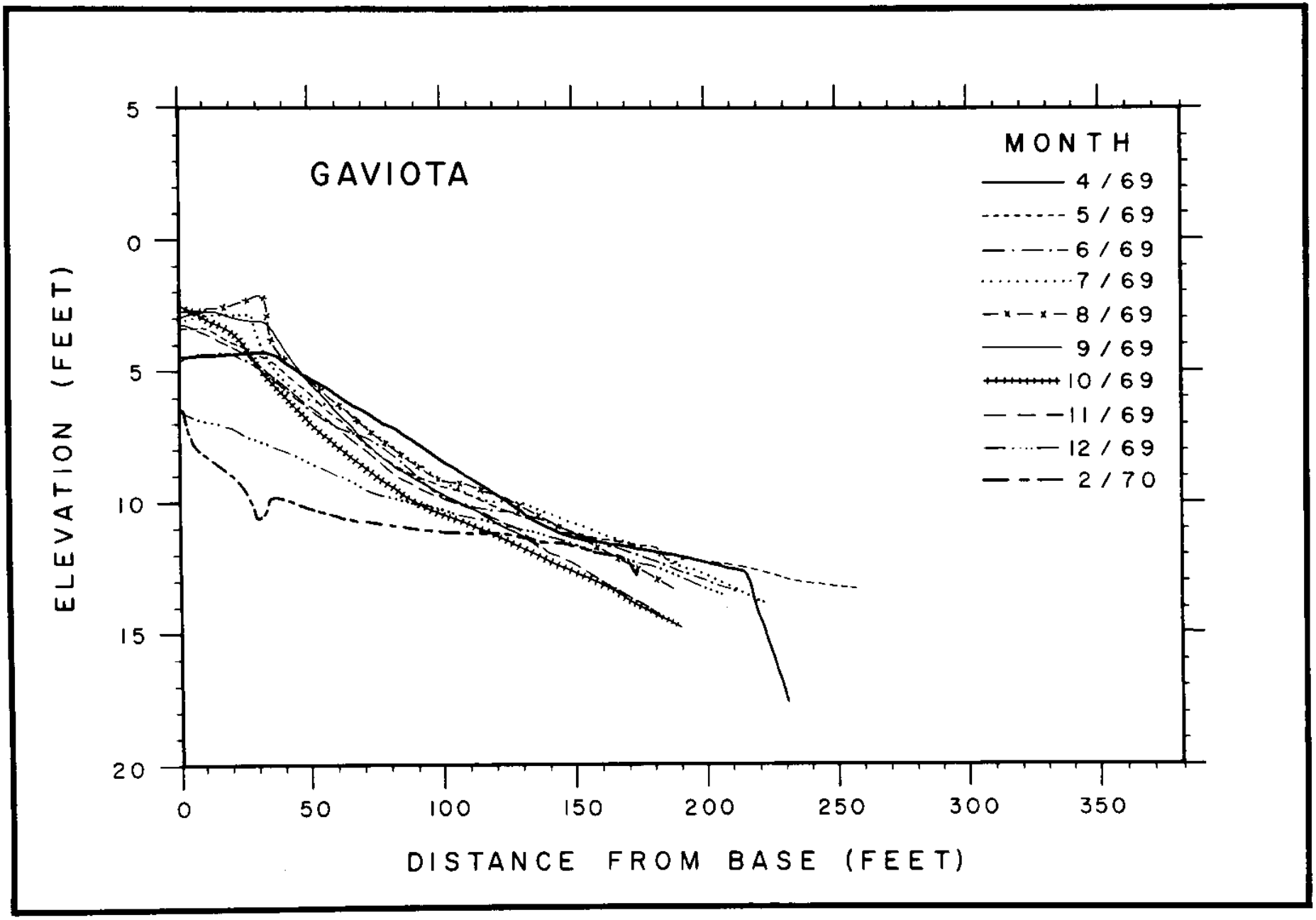
Figures 14-34. Beach profiles. Black area on monthly profiles represents fill. The area of cut or fill was measured from the area between monthly profile lines to the vertical at the end of the shortest profile.

Plates are arranged in order from Jalama (northwest) to Zuma (southeast). A diagram of monthly cut and fill for Pt. Mugu was not included because the composite adequately portrays the sequence of events at that beach.


J A L A M A
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DEC - FEB
200
300
DISTANCE (FEET)


JALAMA
MONTH
4 / 69
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
2 / 70
ELEVATION (FEET)
5
0
5
10
15
20
0
50
100
150
200
250
300
350
DISTANCE FROM BASE (FEET)


GAVIOTA
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DEC. - FEB.
DISTANCE (FEET)


GAVIOTA
MONTH
4 / 69
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
2 / 70
ELEVATION (FEET)
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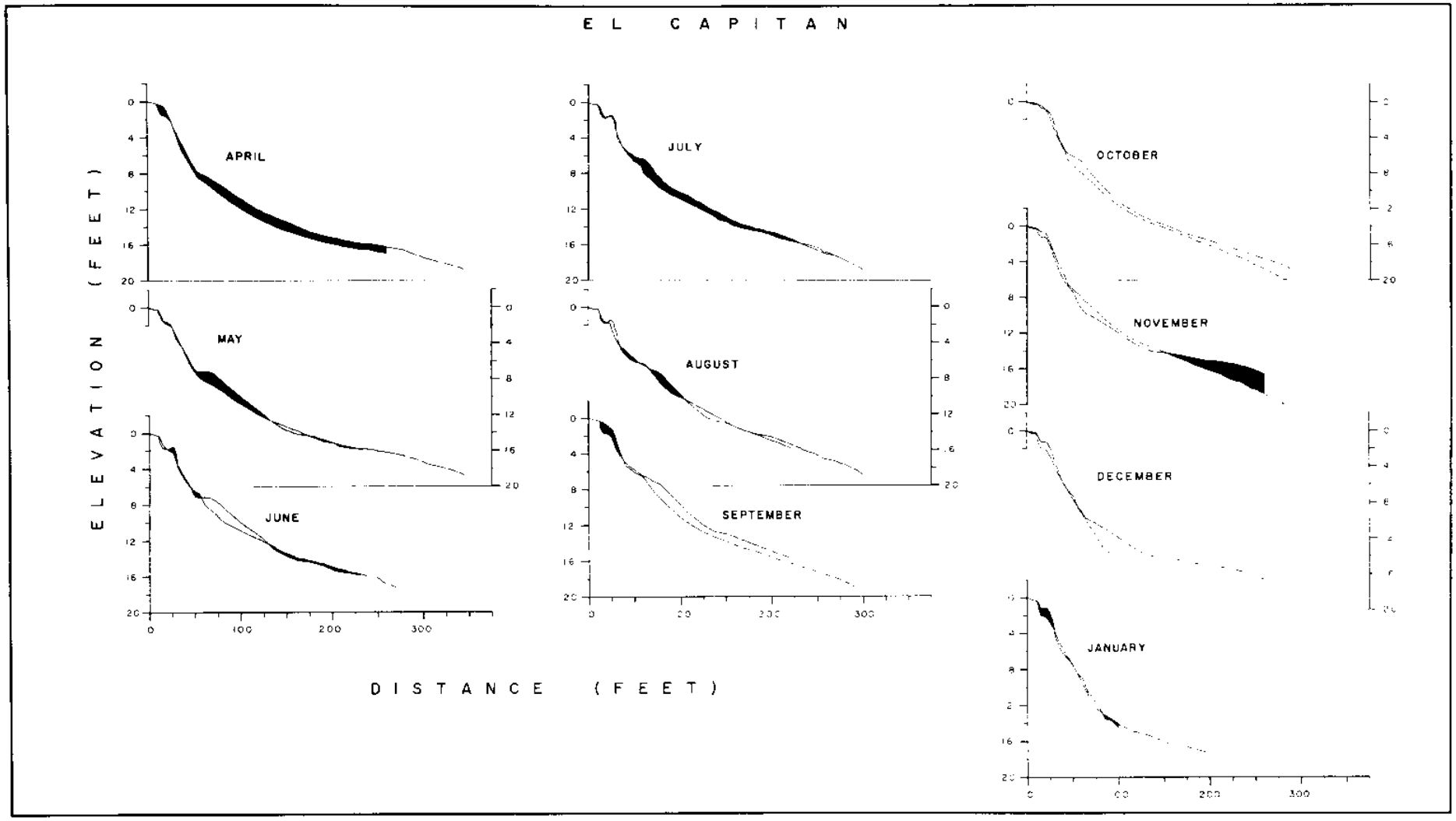
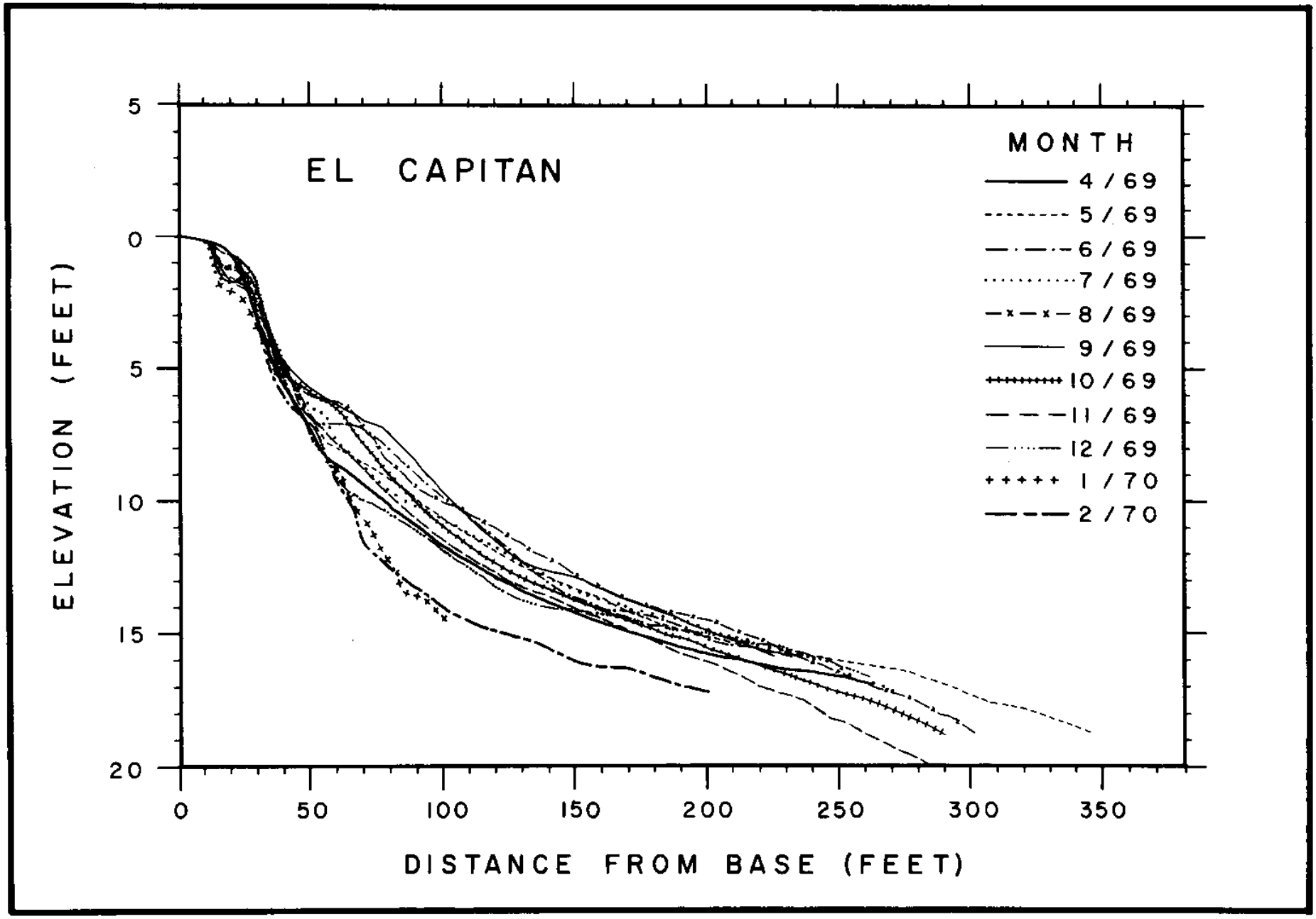
350
DISTANCE FROM BASE (FEET)


EL CAPITAN
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
DISTANCE (FEET)


EL CAPITAN
MONTH
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5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
ELEVATION (FEET)
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200
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300
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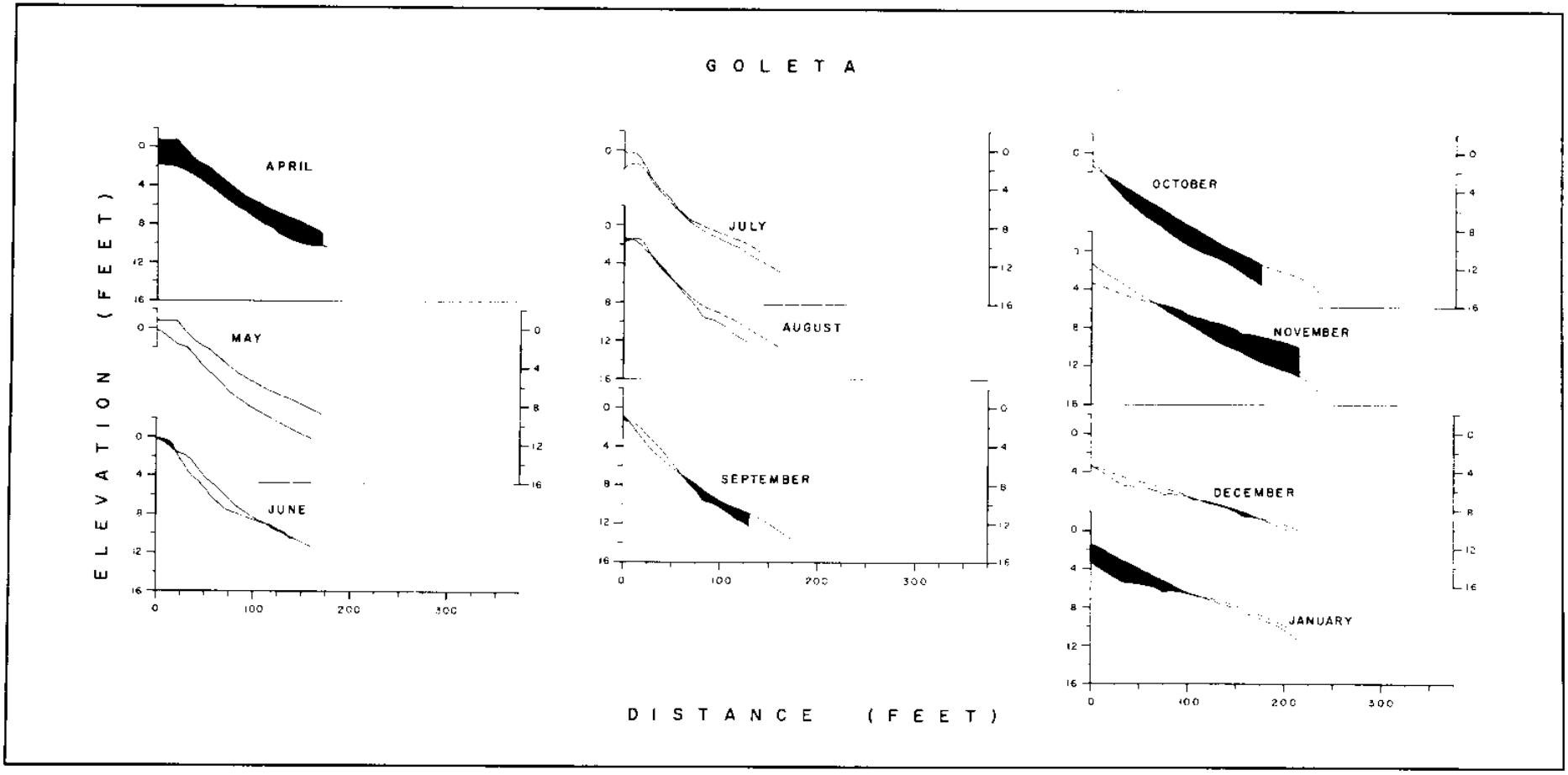
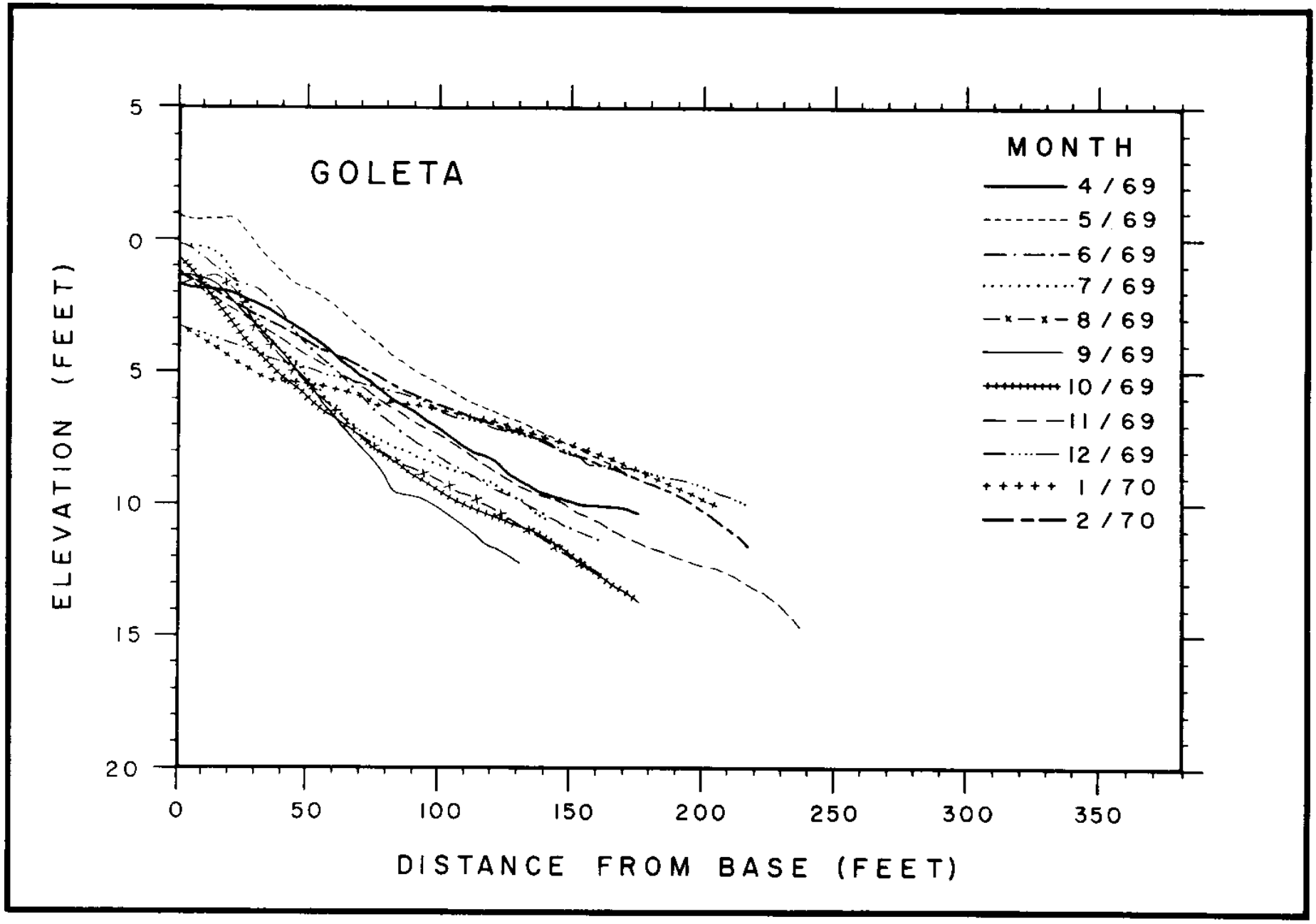
DISTANCE FROM BASE (FEET)


GOLETA
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
0
4
8
12
16
0
100
200
300
DISTANCE (FEET)


GOLETA
MONTH
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7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
ELEVATION (FEET)
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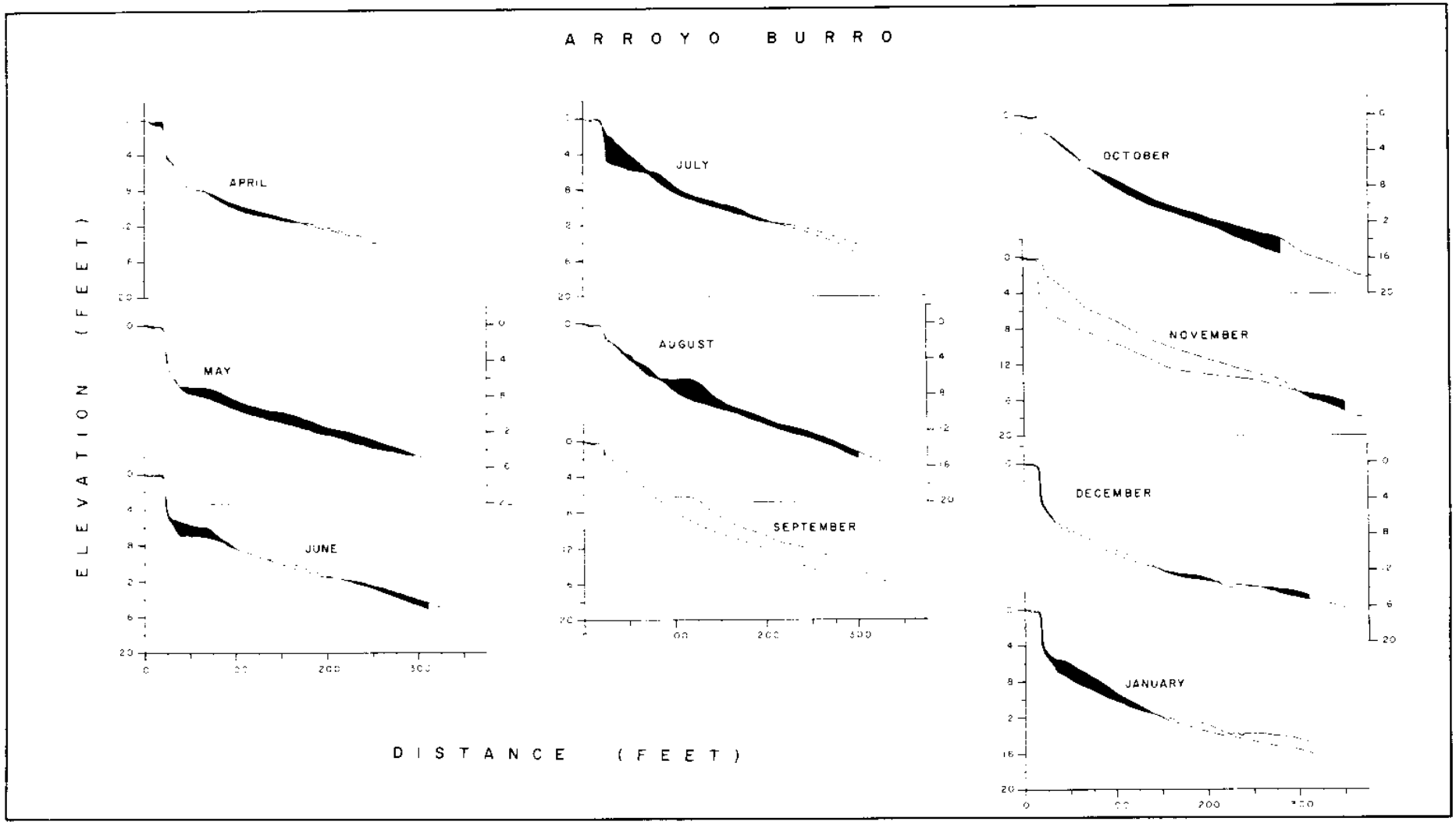
DISTANCE FROM BASE (FEET)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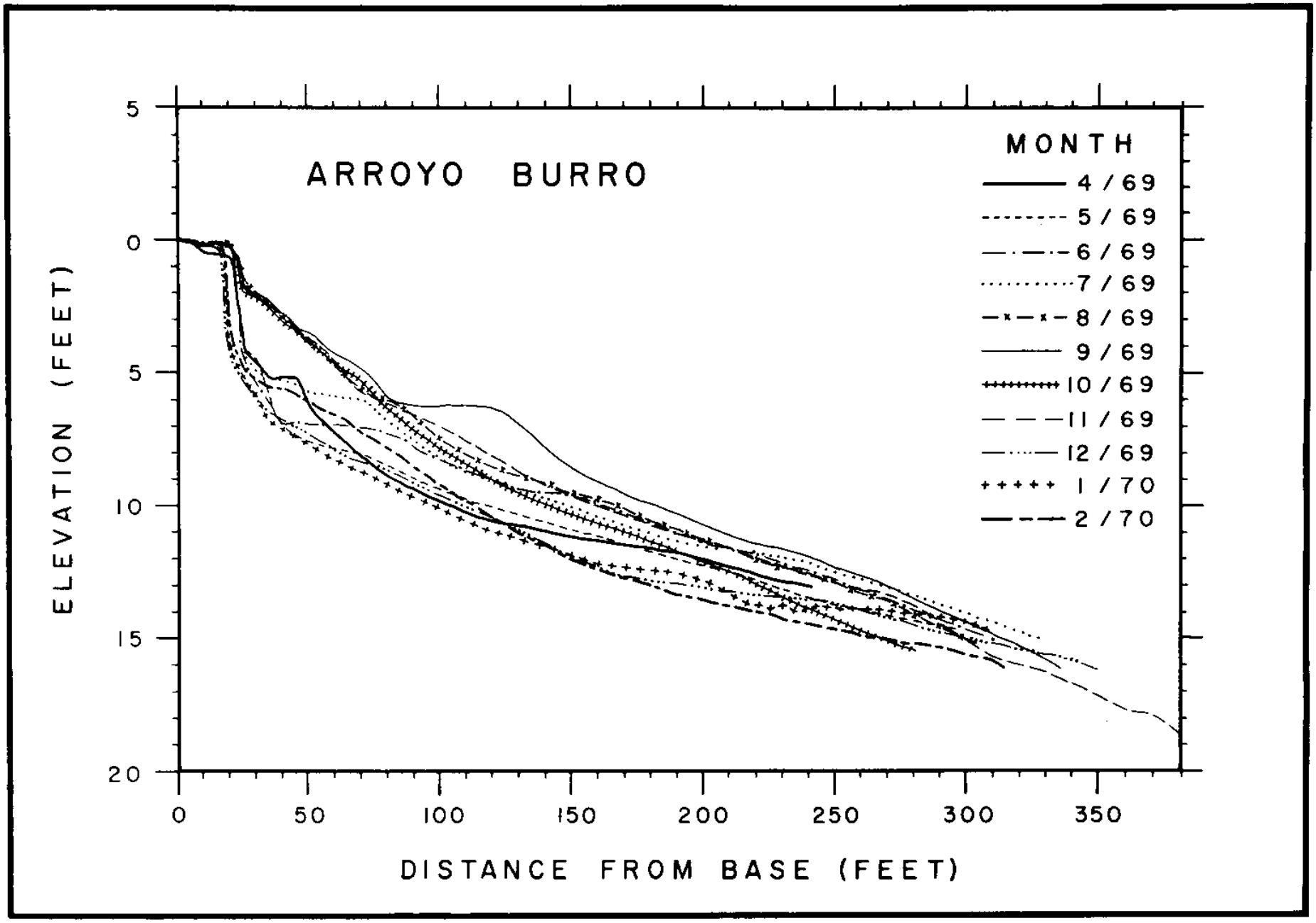
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
DISTANCE (FEET)


ARROYO BURRO
MONTH
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6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
ELEVATION (FEET)
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150
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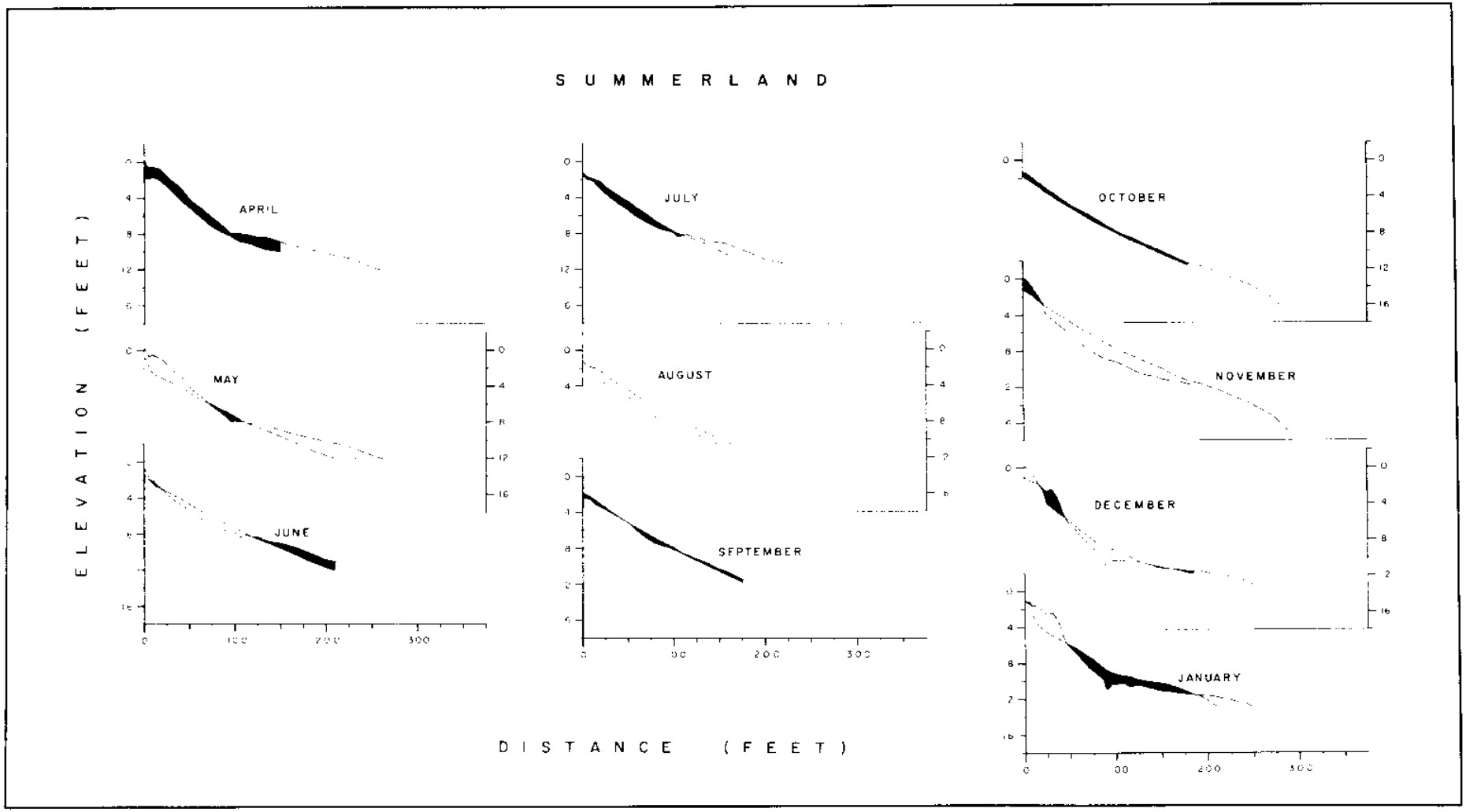
350
DISTANCE FROM BASE (FEET)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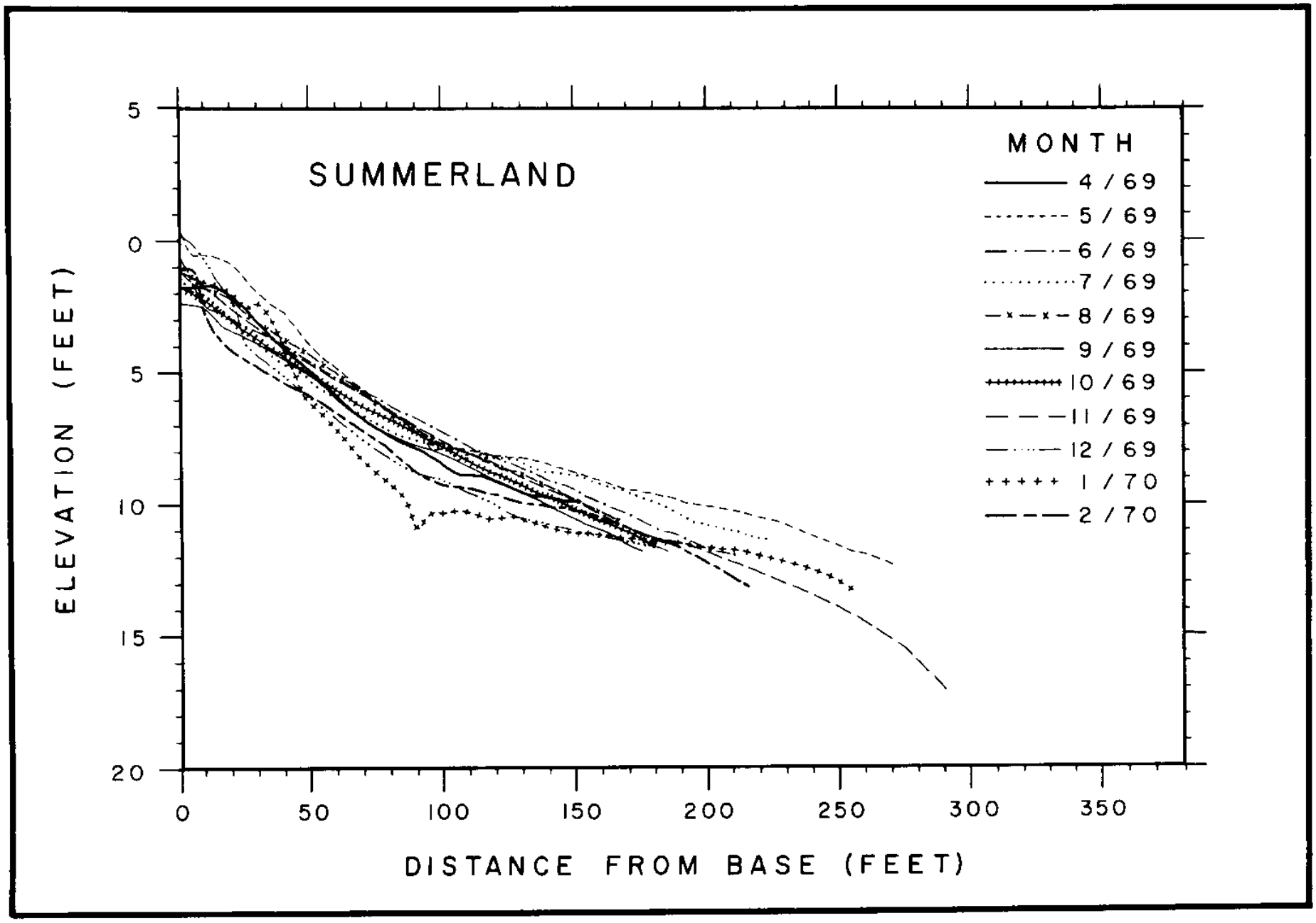
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
DISTANCE (FEET)


SUMMERLAND
MONTH
4 / 69
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
ELEVATION (FEET)
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150
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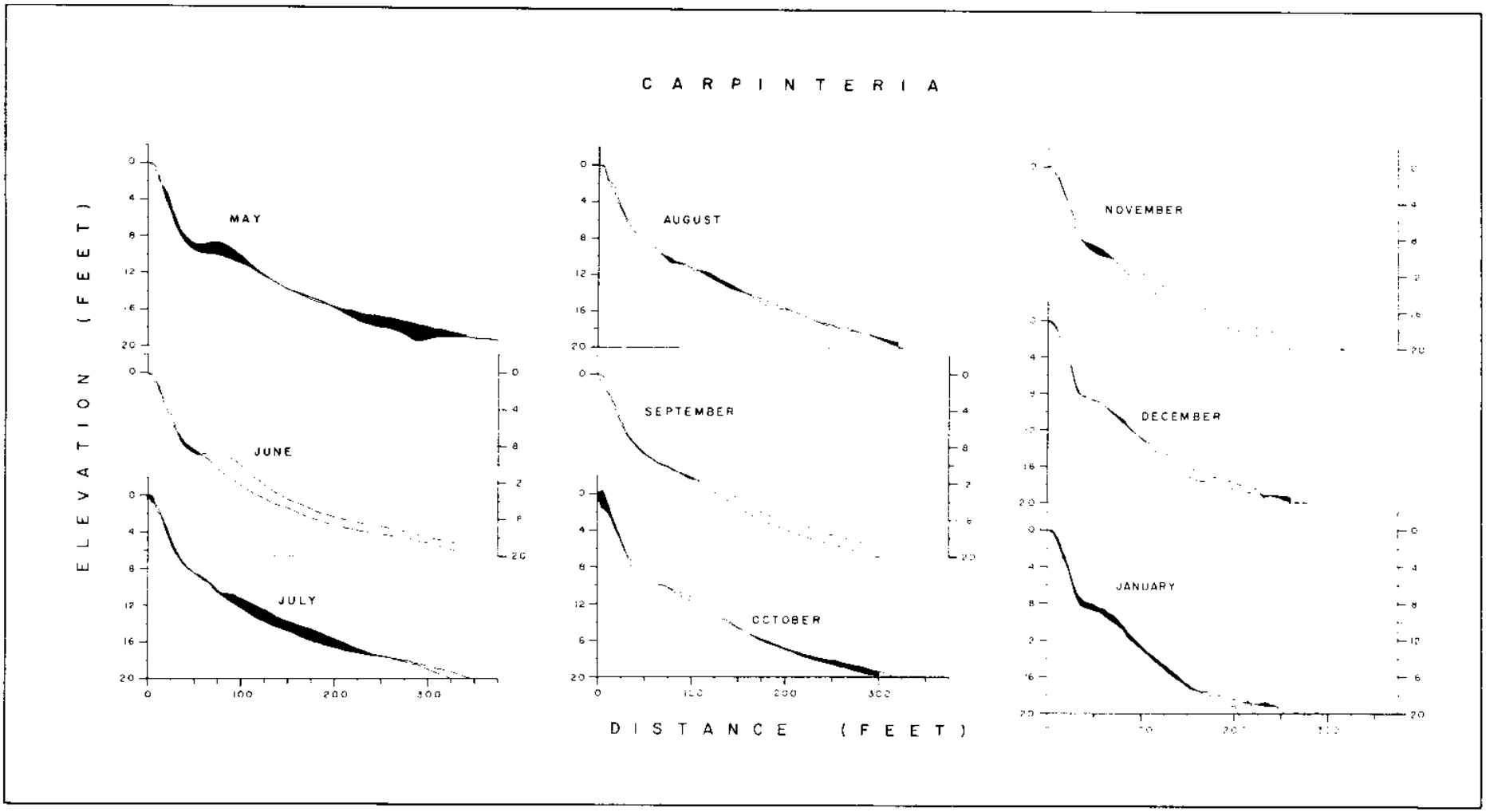
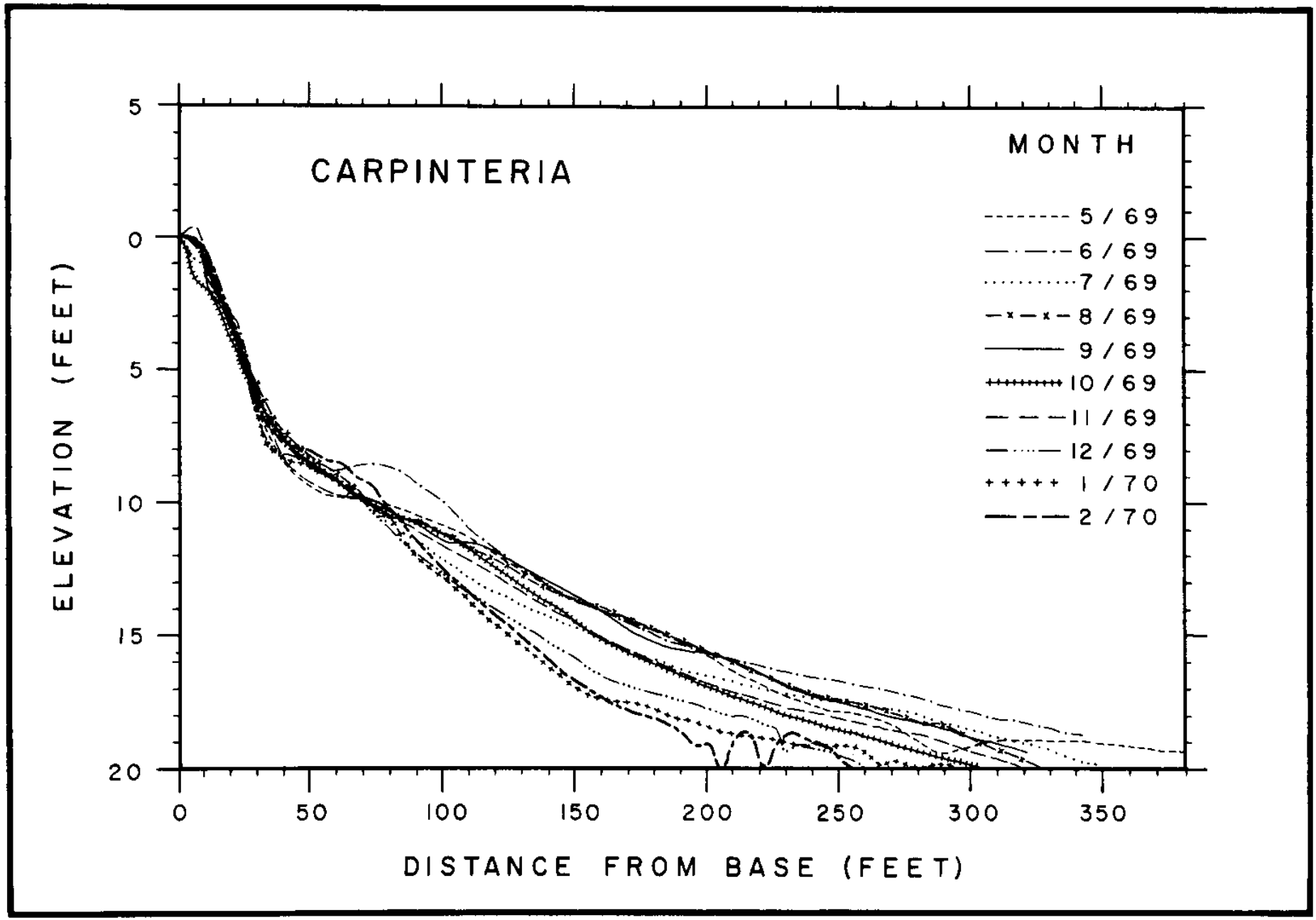
250
300
350
DISTANCE FROM BASE (FEET)


CARPINTERIA
ELEVATION (FEET)
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
DISTANCE (FEET)


CARPINTERIA
MONTH
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
ELEVATION (FEET)
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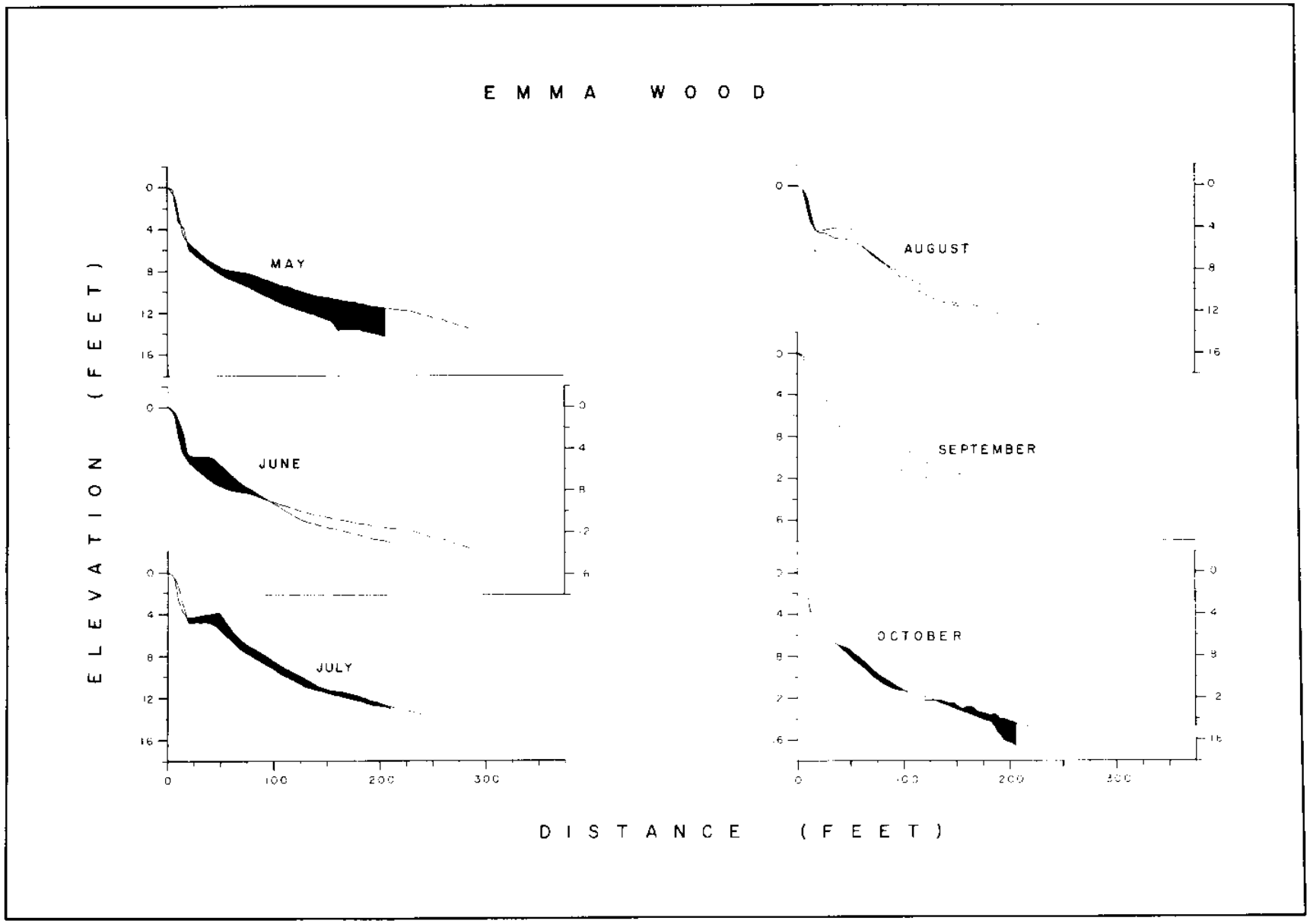
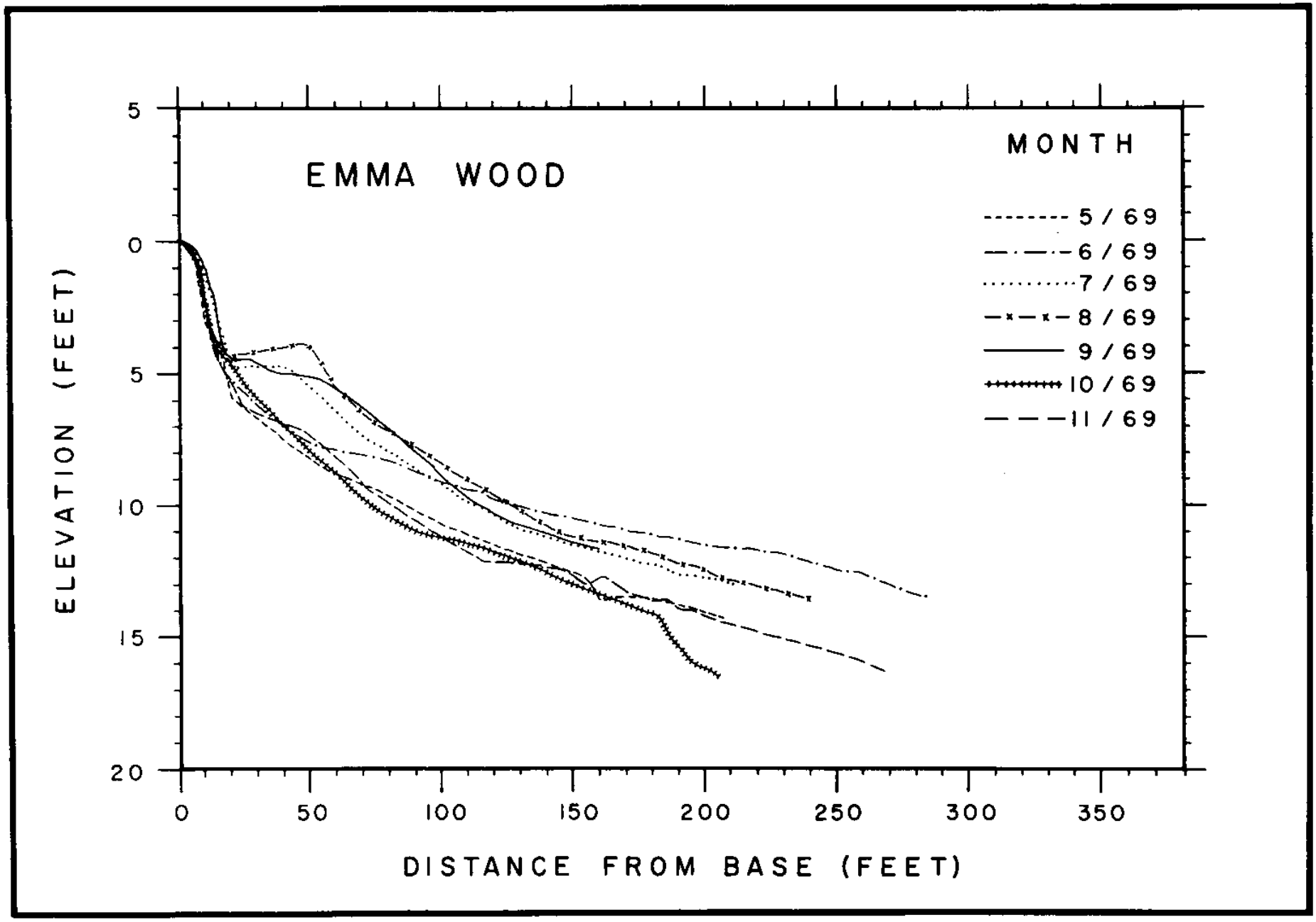
50
100
150
200
250
300
350
DISTANCE FROM BASE (FEET)


EMMA WOOD
ELEVATION (FEET)
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
0
100
200
300
DISTANCE (FEET)


EMMA WOOD
MONTH
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
ELEVATION (FEET)
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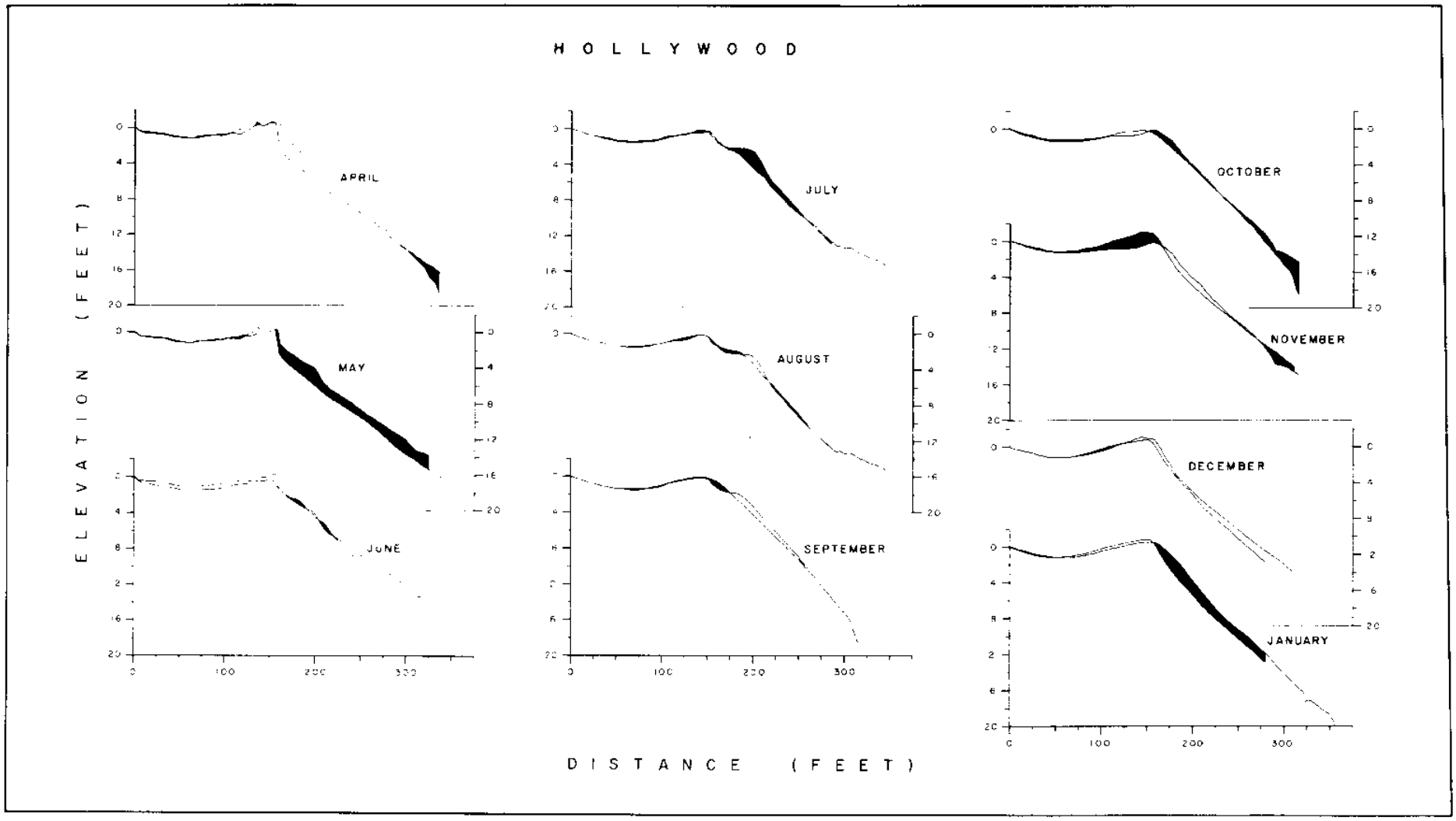
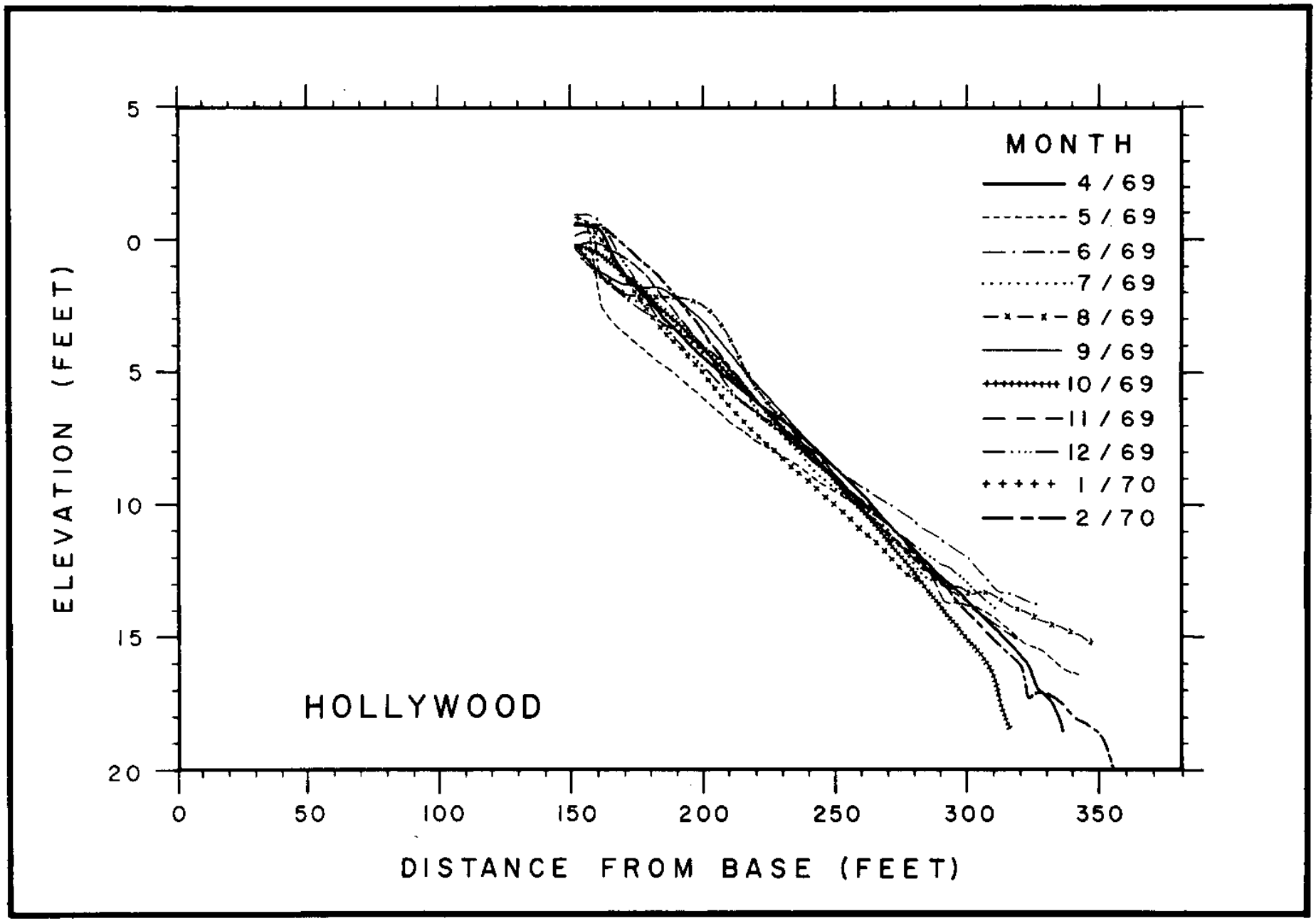
350
DISTANCE FROM BASE (FEET)


HOLLYWOOD
ELEVATION (FEET)
DISTANCE (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY


MONTH
4 / 69
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
HOLLYWOOD
ELEVATION (FEET)
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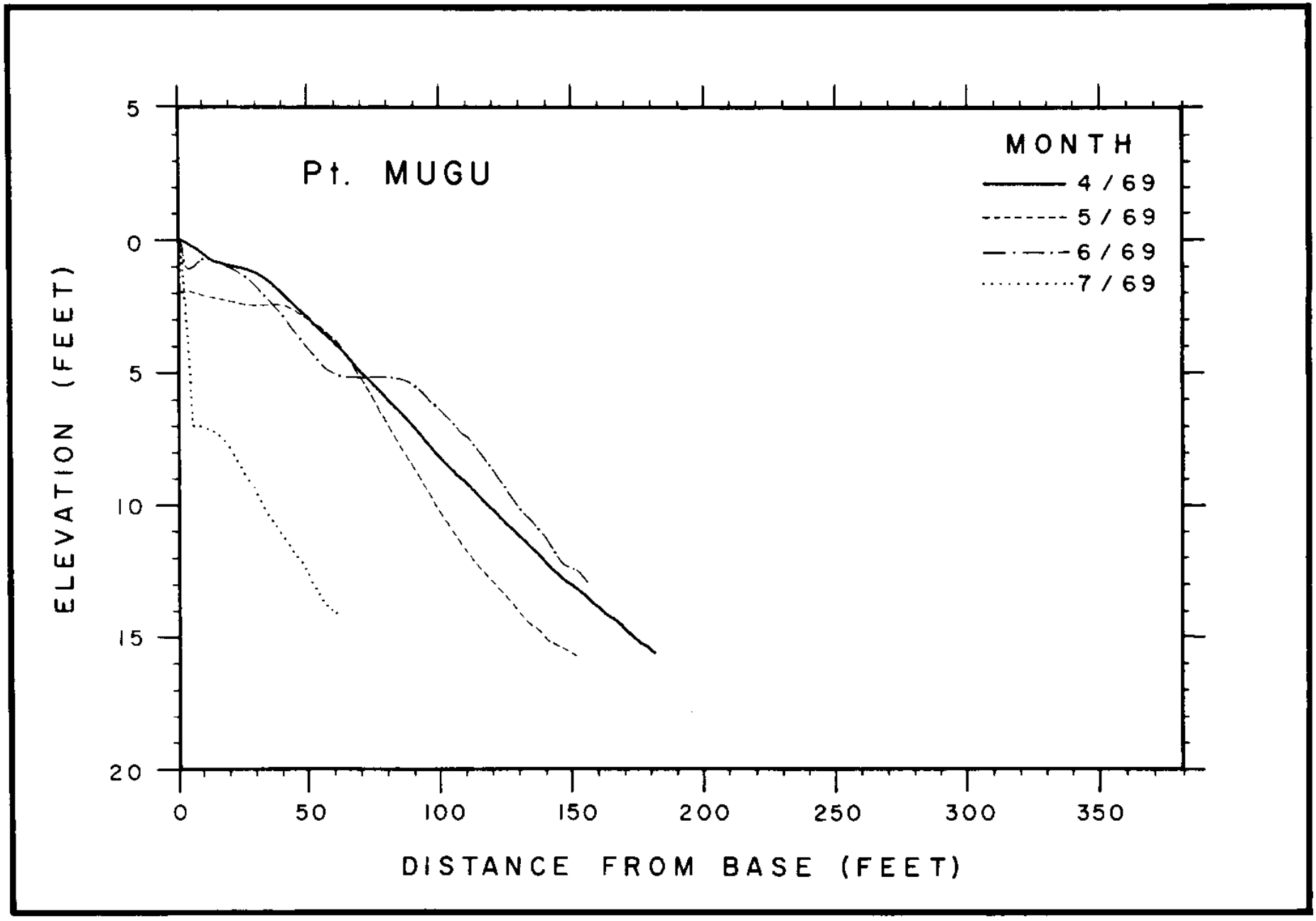
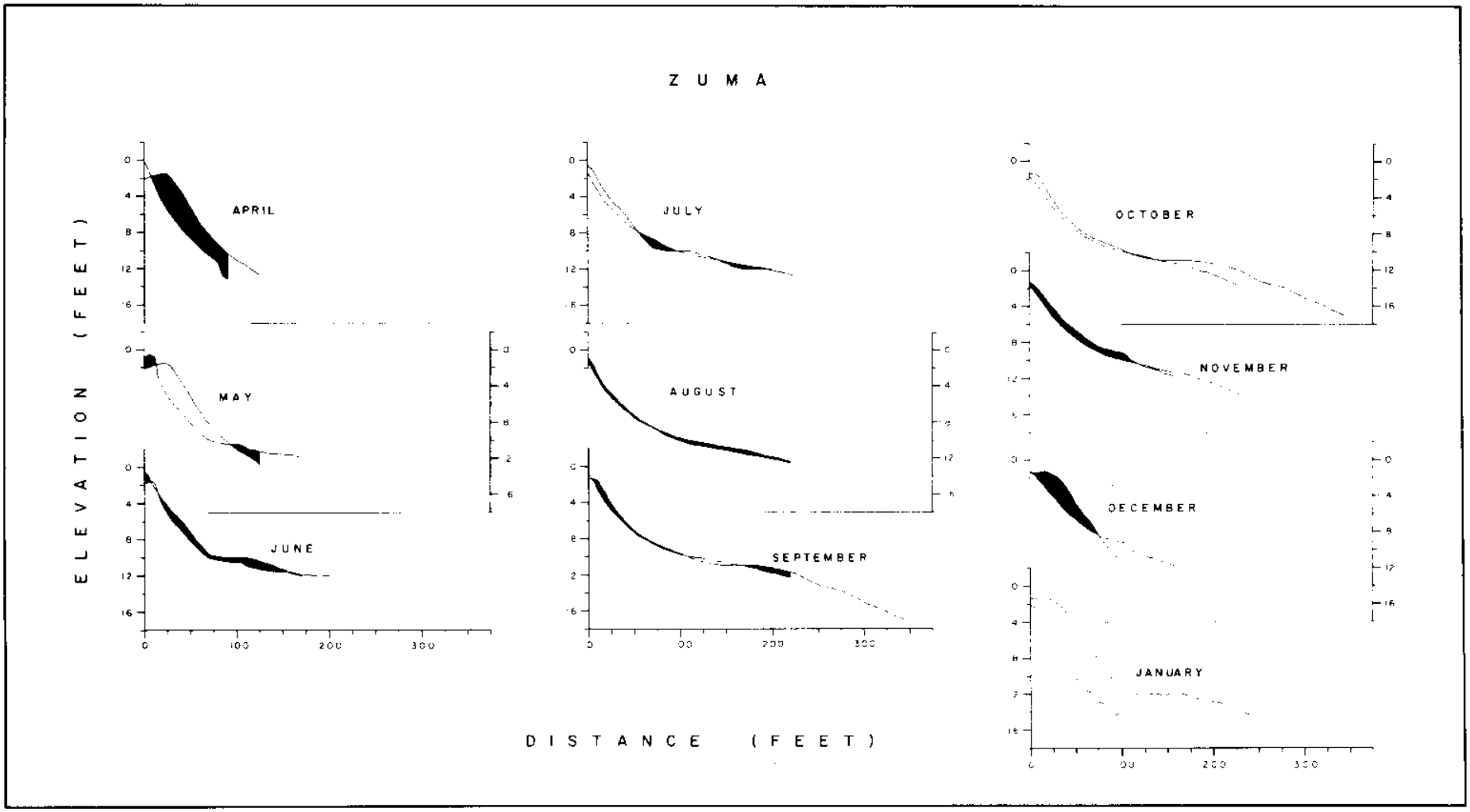
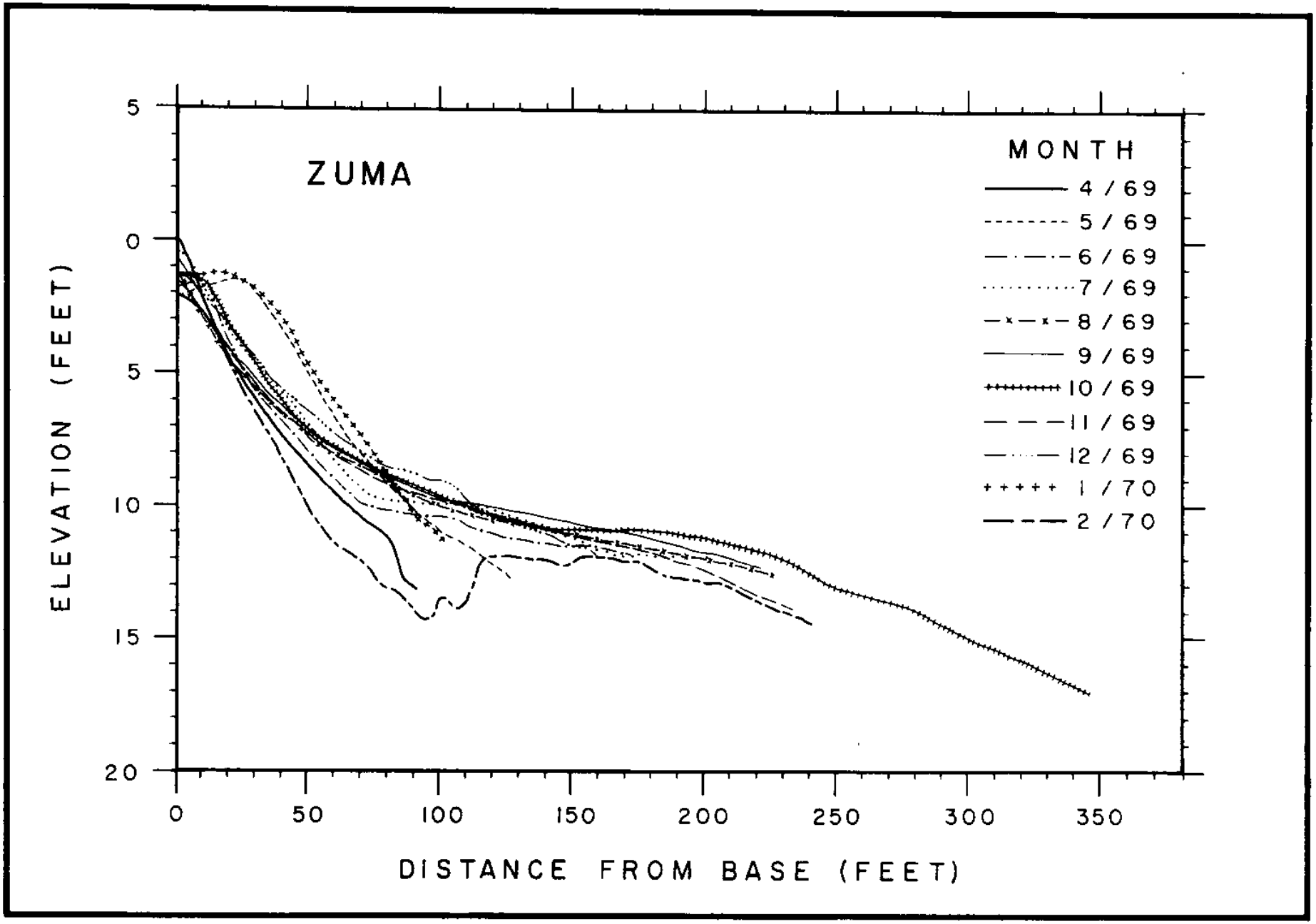
DISTANCE FROM BASE (FEET)


Pt. MUGU
MONTH
4 / 69
5 / 69
6 / 69
7 / 69
ELEVATION (FEET)
5
0
5
10
15
20
0
50
100
150
200
250
300
350
DISTANCE FROM BASE (FEET)


Z U M A
ELEVATION (FEET)
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
DISTANCE (FEET)


ZUMA
MONTH
4 / 69
5 / 69
6 / 69
7 / 69
8 / 69
9 / 69
10 / 69
11 / 69
12 / 69
1 / 70
2 / 70
ELEVATION (FEET)
5
0
5
10
15
20
0
50
100
150
200
250
300
350
DISTANCE FROM BASE (FEET)

of these disequilibrium conditions was for cutting to occur in the areas south of the rivers, as can be seen from the profiles and net areal computations for Hollywood and Pt. Mugu beaches.

The "abnormal" removal of foreshore beach material during this time also resulted in the natural removal of oil deposited in those areas. Only isolated blobs of oil were recovered from auger holes and trenches in the area south of the Ventura River and the field observations and measurements indicate that they were either reworked or most probably deposited after the time of the major oil spill. The largest deposit of buried oil detected during this study was found at Carpinteria Beach and this layer originally consisted of 2-3 inches of sand heavily impregnated with oil. After a period of several months the oil diffused vertically and the sand became less cohesive. This phenomenon has been interpreted as resulting from tidal induced movement of the beach water table whereby some of the oil migrated upward and downward with the moving beach water table. Only isolated remnants of this oil layer remained after the major cut in November, 1969.

Reworking and transportation of tar globules was observed at Arroyo Burro and Summerland beaches during the summer and fall seasons but primarily in September and November. Heavy accumulations of rounded tar fragments were concentrated in the troughs inshore of the primary and secondary breaker lines at Arroyo Burro. At Summerland, there was usually only one breaker line and the tar globules were concentrated in the trough shoreward of that zone.

No attempt was made to determine the fate of these concentrations of tar except to note that the residence time of large fragments appeared to be relatively short owing to the agitation exerted by the breaking waves. The large particles of tar most certainly were broken down to sand size or smaller bits within a period of weeks and the smaller particles then transported offshore.

SUMMARY

The largest flood in southern California in the last 40 years contributed abnormally large quantities of detrital material to the beach environment along the Santa Barbara Channel mainland coast. The primary source areas for this material were the Santa Ynez, Ventura and Santa

Clara Rivers. Oil from a major oil spill in the Santa Barbara Channel was deposited on some beaches during a period when the foreshore areas were cut back as a result of the normal seasonal transgressive-regressive cycle. Subsequently, prograding sand buried some oil not removed by man and this oil remained buried until approximately November, 1969. However, oil deposited near or downcoast from source areas, such as the Ventura and Santa Clara Rivers, was removed from the beach environment within a period of months because sand was being transported away from the areas of initial deposition.

Several factors influence the net transport of beach sand along the Santa Barbara Channel mainland coast. Beach orientation and the direction of prevailing wave approach produce a pattern of progressive movement of material from Jalama toward the southeast. This pattern was altered somewhat during the early part of 1969 as a result of flood sediments deposited near major source areas. The normal transgressive-regressive cycle (fig. 35) was temporarily modified by an overabundance of sand in those areas and the effect of these disequilibrium conditions was to alter the supply and demand requirements imposed on adjacent beaches. It is apparent, however, that the natural cycle of events approached "normality" by the end of 1969.

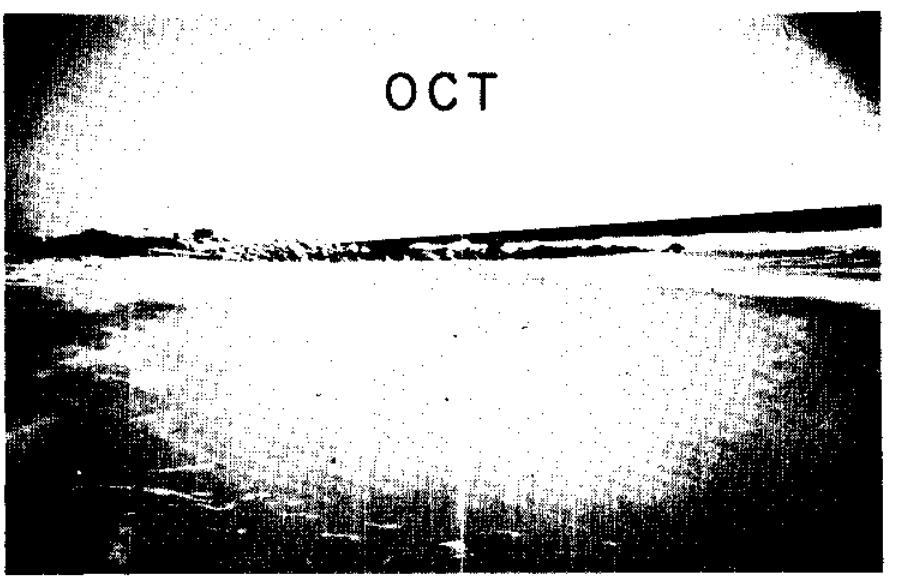
Observation of buried oil layers as well as results of the monthly beach profiling study indicate that only isolated remnants of oil deposited on the beaches in early 1969 remained buried one year later. Deposition of oil on the beaches did not significantly alter the normal movement of beach sand. Tar globules which were removed from the foreshore area, as a result of seasonal cutting of the beaches, accumulated in the troughs just inshore of the breaker line. These tar globules were subjected to intense abrasion by the breaking waves and were physically broken down to small fragments within a period of, at most, weeks. The smaller fragments of tar were probably then transported offshore.

The 10 beaches studied can be classified in order of average energy conditions. The classification, from high to low energy, is: Jalama, Hollywood, Emma Wood, El Capitan, Arroyo Burro, Zuma, Carpinteria, Gaviota, Summerland and Goleta.

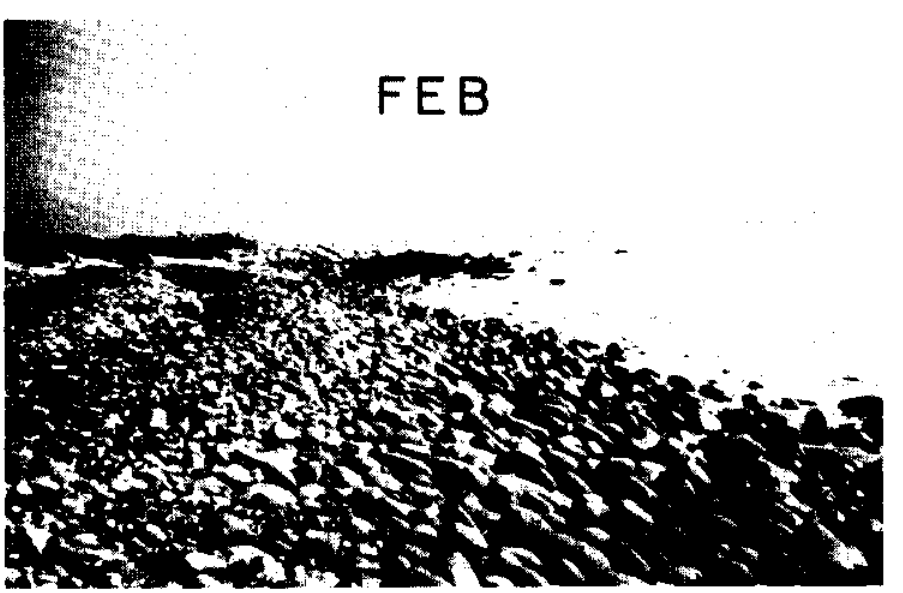
Figure 35. Photographs of seasonal transgressive-regressive cycle at El Capitan Beach. View is toward the east from the beach profile line.

MAY

OCT



FEB



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Ingle, J.C., Jr., 1966, The Movement of Beach Sand: Developments in Sedimentology, V. 5, Elsevier, New York, New York, 221 pp.

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CHAPTER 3

SEASONAL STUDY OF BEACH FORAMINIFERAL POPULATIONS IN THE SANTA BARBARA CHANNEL AREA

by

Ronald W. Morin
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

INTRODUCTION

The purpose of this study was to assess the effects of oil pollution on beach foraminiferal populations from April, 1969 to February, 1970. The study was conducted in conjunction with a study of the physical parameters of the beaches (Kolpack) and interested readers are referred to that chapter for details of water and sand transport characteristics.

LOCATION

The mainland coast of the Santa Barbara Channel region is generally considered to extend from Point Conception on the west to Point Hueneme on the east (Vedder, Wagner, and Schoellhammer, 1969). Samples used in this study were collected from sandy beaches, some of which are slightly beyond these geographic limits (fig. 1). The coastline is approximately 195 km (120 miles) of numerous rocky points and intervening beaches. Most of the points consist of relatively hard rocks which have resisted marine erosion better than the rocks between the promontories. Strata exposed in sea-cliffs of the points and behind some of the beaches have reported (Dibblee, 1950, 1966; Vedder, Wagner and Schoellhammer, 1969) to range from Miocene through Pleistocene in age. More protection from wave action is afforded the beaches northwest of Carpinteria by kelp beds

than beaches to the southeast (fig. 1). Heavy accumulations of kelp were reported by Davies (1958) to cover almost 60 km^2 (23 mi^2) between Point Conception and Carpinteria whereas only about 16 km^2 (6 mi^2) occur from Carpinteria to Zuma Beach. Although the present coastline principally is one of erosion, rivers and streams are the main source of the beach sand which is being transported in a southeasterly direction by longshore drift (Handin, 1951; Trask, 1952; Kolpack, 1970).

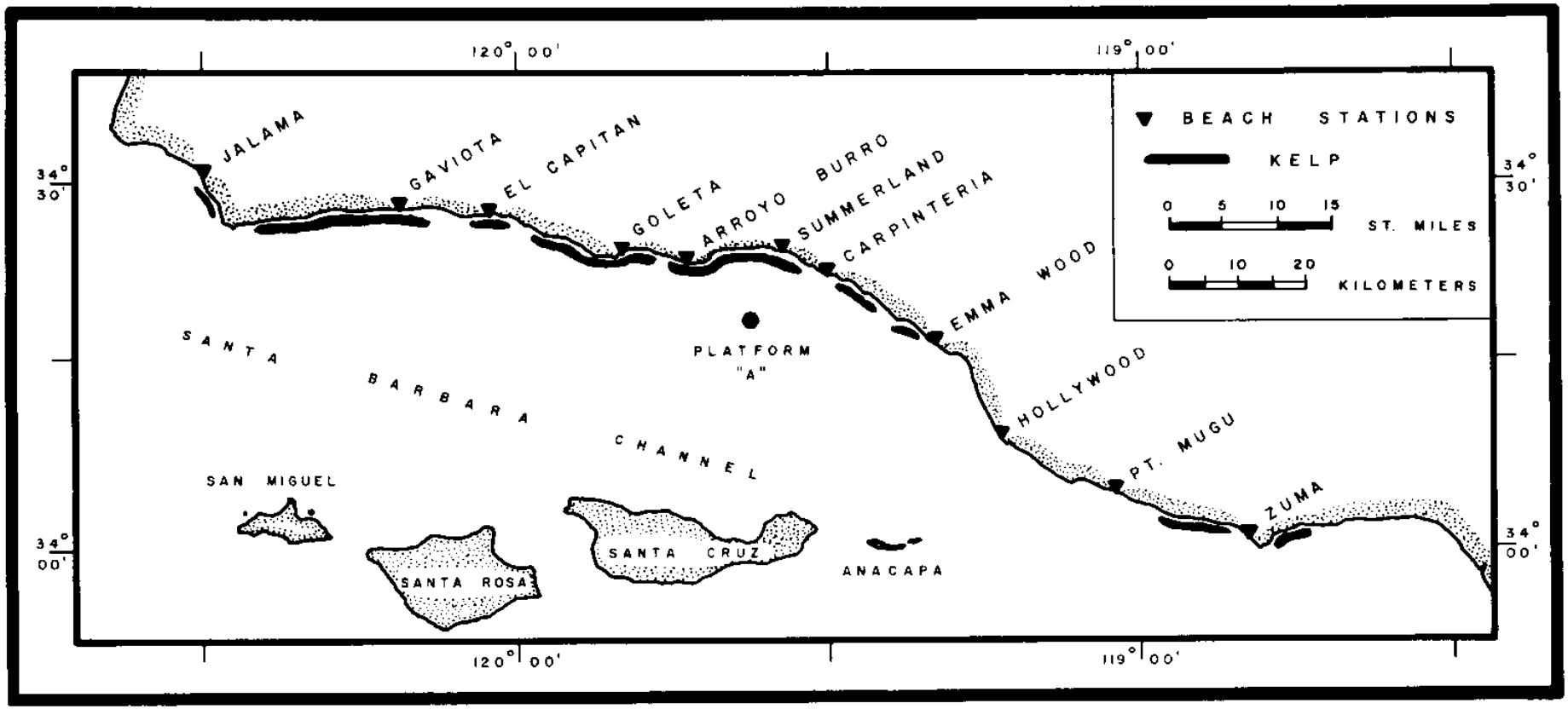
METHODS

Collecting stations were established at 12 sandy beaches in the channel area during the 11 months of this study. A single sample was collected at the beach near Sea Cliff and the station at Point Mugu was abandoned when the beach disappeared after 5 months of sampling. The remaining beaches were sampled from the time a station was chosen, either April or May, 1969, until the end of the study unless local conditions prevented sampling.

Two samples were generally collected at each station. One sample was taken using a quart carton to scoop up the upper centimeter (½ inch) of sand along the swash mark of the last wave. Only surface material was collected to avoid faunas which were incorporated in the sediments under conditions different from those at the time of sampling. A second sample was taken offshore at a water depth of about 1.5 m (5 feet). After each carton was at least three-quarters filled, Rose Bengal, dissolved in water, was added to allow for identification of protoplasm in living foraminiferal species (Walton, 1952). The location of both samples was determined with respect to a permanent point of reference on each beach.

All samples were immediately dried and weighed in the laboratory. They were then washed on a 250 mesh Tyler screen (62 micron openings) to remove excess Rose Bengal and any fine sediment. After washing, foraminiferal tests were concentrated in carbon tetrachloride. The relative abundance of foraminiferal species and the number of specimens per 100 grams of sediment were determined for 54 swash samples and 106 offshore samples. Relatively large numbers of tests in some samples, up to 6,000, required the use of a modified Otto microsplitter to obtain workable, but representative, splits.

Figure 1. Location of collecting stations in the Santa Barbara Channel region, California. Distributions of kelp after Davies (1968).


120° 00'
119° 00'
34° 30'
34° 00'
BEACH STATIONS
KELP
0 5 10 15
ST. MILES
0 10 20
KILOMETERS
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
PT. MUGU
ZUMA
PLATFORM "A"
SANTA BARBARA CHANNEL
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA

Rose Bengal dissolved in fresh water, instead of a preservative, was used to determine living foraminiferal species because living species collected from deep water were found to exhibit a trophic reaction to fresh water. This resulted in a red stain in all but the ultimate chamber. Such a distinct pattern is helpful since individuals not living at the time of collection often had one or more areas of the test stained red due to the presence of protein material. Meyer (personal communication) has found that the majority of the tests with random stain patterns contain bacteria.

ACKNOWLEDGMENTS

Acknowledgment for advice and criticism of this manuscript is due Drs. O.L. Bandy and R.L. Kolpack. Dr. Kolpack also designed the study, supervised the collection of the samples analyzed, and provided both sedimentological and oceanographic data on the sites sampled. The author is indebted to many members of the Department of Geological Sciences for assistance throughout the extent of this study.

REWORKED FAUNAS

Fossil foraminiferal species made up an average of 38 and 46 percent of the fauna in swash and offshore samples, respectively. Their presence is explained by the erosion of marine beds, ranging in age from Miocene to Pleistocene (Dibble, 1950, 1966; Vedder, Wagner and Schoelhammer, 1969), which are exposed in sea-cliffs and submarine outcrops of the Santa Barbara Channel's mainland coast and shelf. The abundance of reworked species with respect to species living in the beach environment resulted from their greater resistance to abrasion. This greater resistance is due to post-depositional changes in the foraminiferal tests, such as filling of tests voids or replacement of test walls by silica.

Although fossil species comprise a large part of the beach fauna, any changes in the fossil constituents were not the result of recent environmental conditions. Thus, only the relative abundance of reworked specimens was noted.

FAUNAL VARIATIONS

Living Populations

The following species occasionally were found to be living at the time of collection: Buccella tenerrima (Bandy), Cibicides fletcheri (Galloway and Wissler), Elphidiella hannai (Cushman and Grant), Rosalina globularis (d'Orbigny), and Rotorbinella lomaensis (Bandy). Elphidiids, miliolids, and several agglutinated species were also found with all but their ultimate chambers stained. This is the same fauna that Cooper (1961) found to be living in a tidepool near El Capitan State Beach.

Less than 1 percent of the individuals in the beach samples analyzed were living when collected, although tests with spotty stains were found in many samples. Low percentages of living specimens are to be expected on the sandy beaches studied in view of the work of Reiter (1959) and Atkinson (1969). Both authors found that foraminiferal communities on exposed shorelines are dependent upon algae for shelter. There also appears to be a dependence on algae for food supply (Sliter, 1965; Atkinson, 1969). Although algae are generally lacking at the sites sampled, any drastic changes in nearby foraminiferal communities, such as high mortality, should be observable since wave action and longshore drift introduce empty tests onto the unprotected beaches.

Beach Foraminiferal Number

One convienent method of estimating the size of foraminiferal populations is to record the number of tests per gram of dry sediment, the foraminiferal number. The relatively low number of specimens in beach samples made it necessary to multiply the number of tests in a beach sample by 100, that is, to calculate the number of tests per 100 grams of sediment. This allows the use of whole numbers instead of fractions (Reiter, 1959). Therefore, the foraminiferal number multiplied by 100 will be called the beach foraminiferal number in this report.

The beach foraminiferal number of samples collected along the swash mark was generally below 40 (fig. 2). The Sea Cliff and Point Mugu samples had values less than 4. Numbers of 40 or more were found periodically at all stations northwest of Carpinteria State Beach except for those near Gaviota and El Capitan State Beaches.

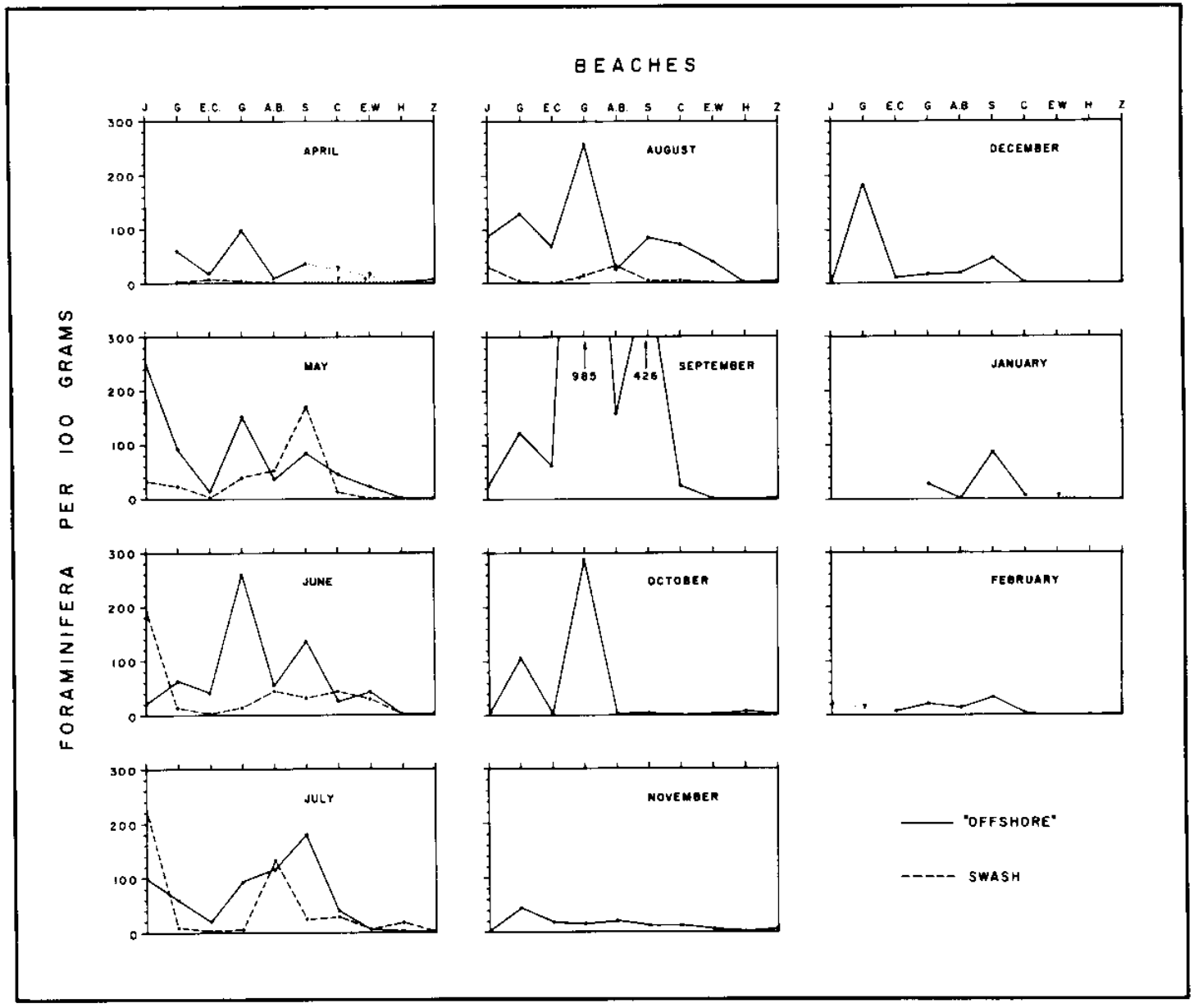
A maximum of 36 tests per 100 grams of sediment was reported for swash samples from unprotected stations at Santa Monica Bay (Reiter, 1959), which is just southeast of Zuma Beach. Reiter (1959) reported more than 8 times as many specimens at beaches protected by both land and kelp beds. This explains the relatively higher values northwest of Carpinteria where partial protection is provided by kelp beds. The similarity between beach foraminiferal numbers of the channel region and of Santa Monica Bay suggests that foraminiferal populations of the channel region's beach environment have not undergone much change in abundance from April to August, 1969.

It became obvious after the first 5 months of this study that the beach foraminiferal number of swash samples were generally much lower than that of offshore samples (fig. 2). Inasmuch as the relative abundance of foraminiferal species was more meaningful in offshore samples owing to the presence of larger populations, analysis of swash samples was discontinued.

The beach foraminiferal number of offshore samples (fig. 2) suggests that the Carpinteria State Beach station marks a change in the beach environment just as the beach foraminiferal number of the swash samples did. Values of less than 100, and often below 50, were found consistently for the Capinteria area and the stations to the southeast. This includes samples from the Sea Cliff and Point Mugu stations, which had less than 4 tests per 100 grams of sediment for all samples collected. The El Capitan State Beach station was the only beach sampled northwest of Carpinteria which never had values in excess of 100 during the entire study. The remaining stations, Jalama to Summerland, had beach foraminiferal numbers ranging from less than 100 to more than 200. The highest values observed in this area occurred from May to October, 1969, with the Goleta Beach station having the largest populations.

More abundant foraminiferan populations northwest of Carpinteria may be the product of either biological or physical factors. Mortality or higher productivity could explain the relatively high number of tests. Another possible cause could be greater shelter from destructive beach processes since the magnitude of the differences in population abundance found in the Santa Barbara Channel region is similar to the difference found between swash samples from protected and unprotected areas in Santa Monica Bay (Reiter, 1959). This hypothesis is supported by the distribution of kelp beds in the channel area.

Figure 2. Beach foraminiferal number for swash (- -) and offshore (——) samples.


BEACHES
FORAMINIFERA PER 100 GRAMS
J G E.C. G A.B. S C E.W H Z
300
200
100
0
APRIL
AUGUST
DECEMBER
MAY
SEPTEMBER
985
426
JANUARY
JUNE
OCTOBER
FEBRUARY
JULY
NOVEMBER
"OFFSHORE"
SWASH

Frequency Distribution of Species

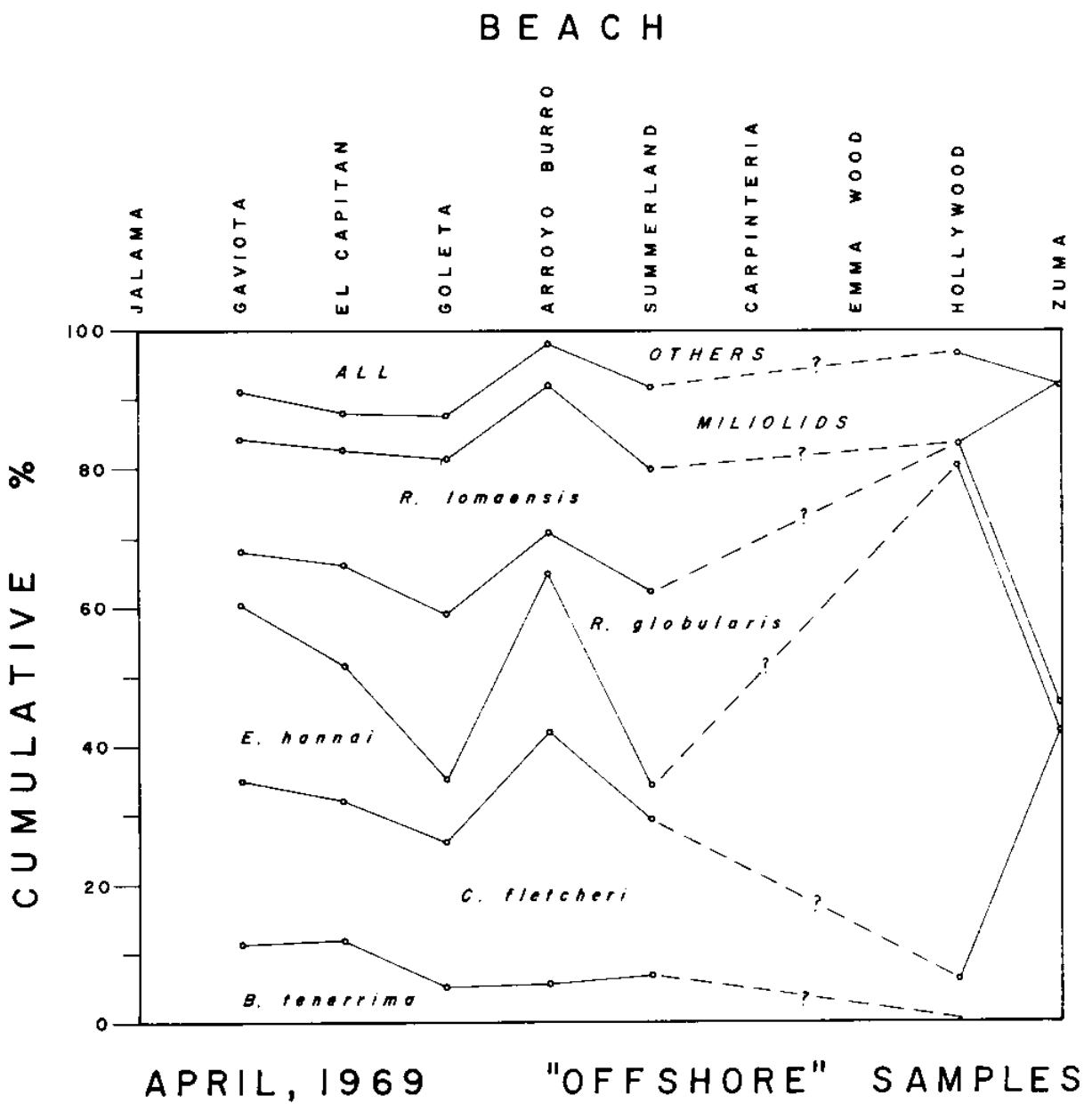
The relatively low number of specimens found in the swash samples analyzed results in a variable, and an unreliable, frequency distribution of foraminiferal species. For this reason, the relative abundance of species collected from the swash mark is not shown. It should be noted, however, that when the beach foraminiferal number was greater than 40, the populations consisted of about 40 to 80 percent *Cibicides fletcheri* and *Elphidiella hannai* and from less than 1 to 12 *Rosalina globularis*. The presence of "*Tretomphalus*," *Rosalina globularis*' gamont (Sliter, 1965), in swash samples from the Goleta, Summerland, Carpinteria, and Zuma stations of August, 1969, indicates that reproduction was occurring at this time.

The relative abundance of dominant benthonic foraminiferal species found to be living in offshore samples indicates that several marked changes in the foraminiferal populations of the channel area occurred during the 11 months of this study (fig. 3). Unfortunately, the populations counted at the Hollywood and Zuma stations never exceeded 20 specimens per sample as compared to the other 8 stations which had counts ranging from about 100 to 300 or more tests per sample. The unreliability of data from these two stations leaves only 2 stations southeast of Carpinteria State Beach for comparison with the 6 to the northwest.

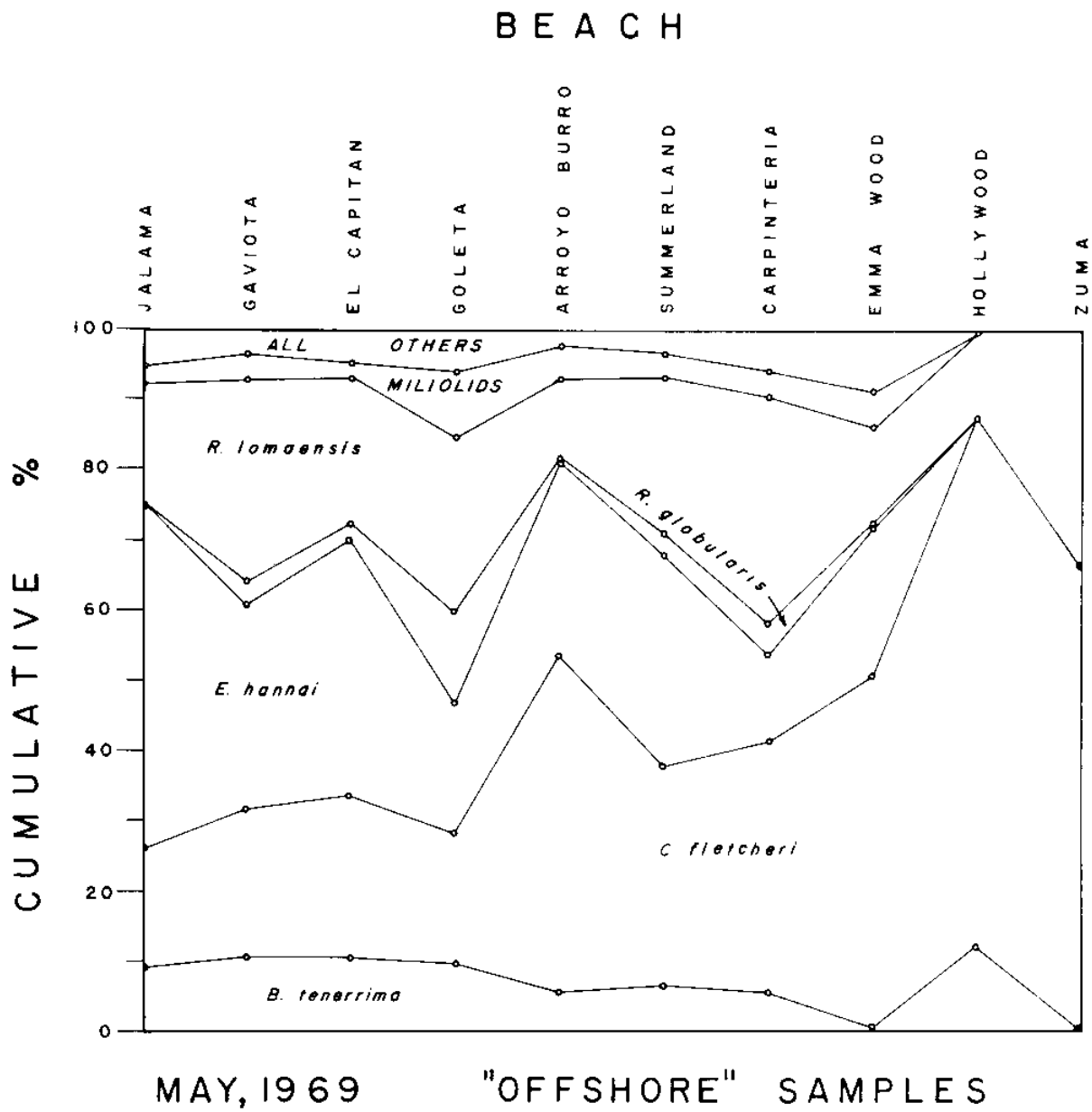
The minor species *Buccella tenerrima* and *Rotorbinella lomaensis* were fairly consistent in relative abundance, making up about 10 to 20 percent of the benthonic fauna, respectively. Whereas, the combination of miliolids and miscellaneous species increase from approximately 20 percent of the foraminiferal population during April to September, 1969, to about 30 percent from October, 1969 to February, 1970.

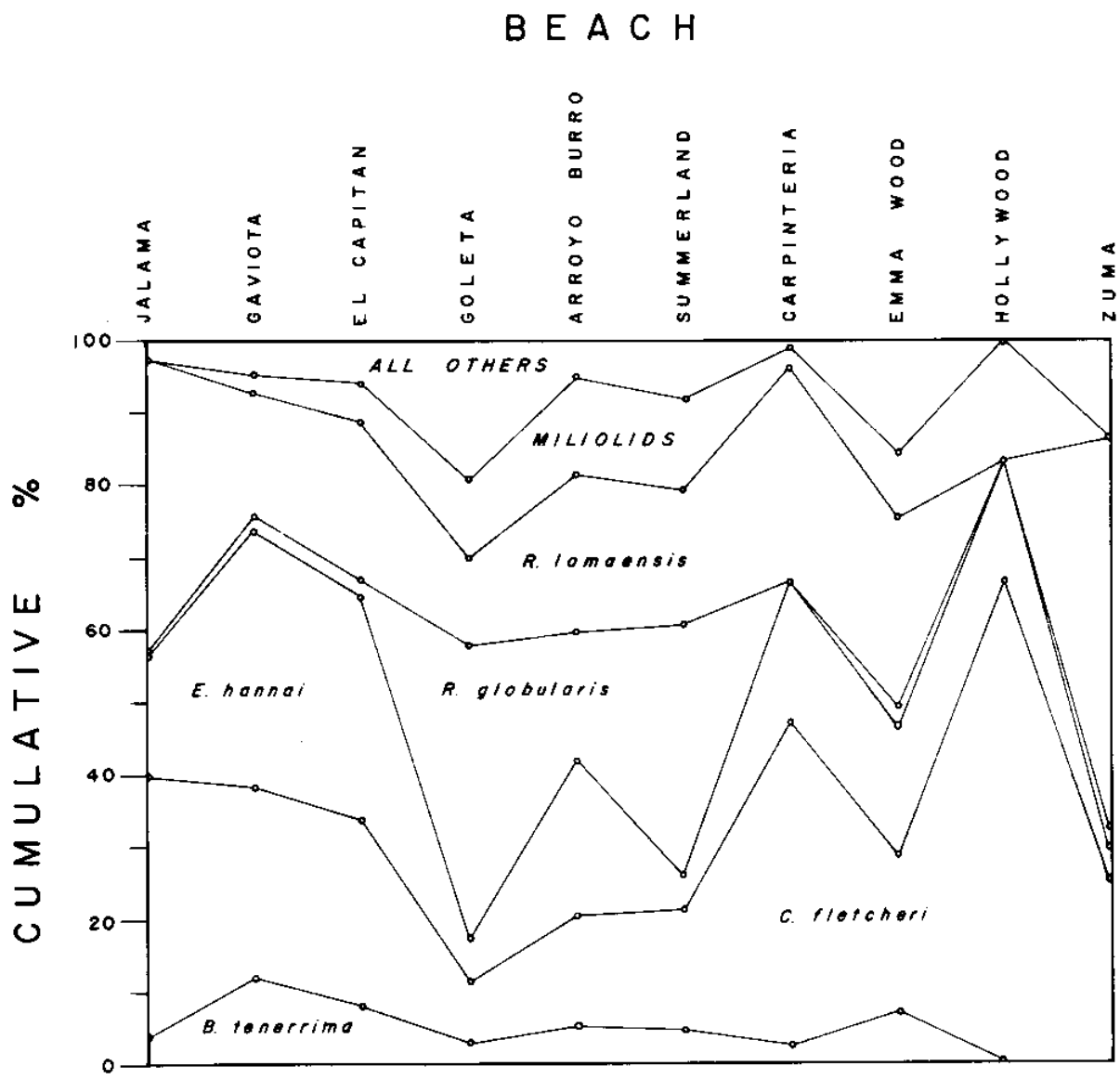
About 50 percent of the benthonic population in all offshore samples analyzed consisted of *Cibicides fletcheri* and *Elphidiella hannai* during April and May, 1969. As these two species decreased in relative abundance from June to August, 1969, *Rosalina globularis* increased between the Gaviota and Carpinteria stations. *Rosalina globularis* became the dominant species at most stations between Gaviota and Carpinteria State Beaches from September to December, 1969. Subsequently, it decreased in abundance during January and February, 1970, as *Cibicides fletcheri* and *Elphidiella hannai* increased slightly.

Figures 3-13. Frequency distribution of dominant foraminiferal species in offshore beach samples.

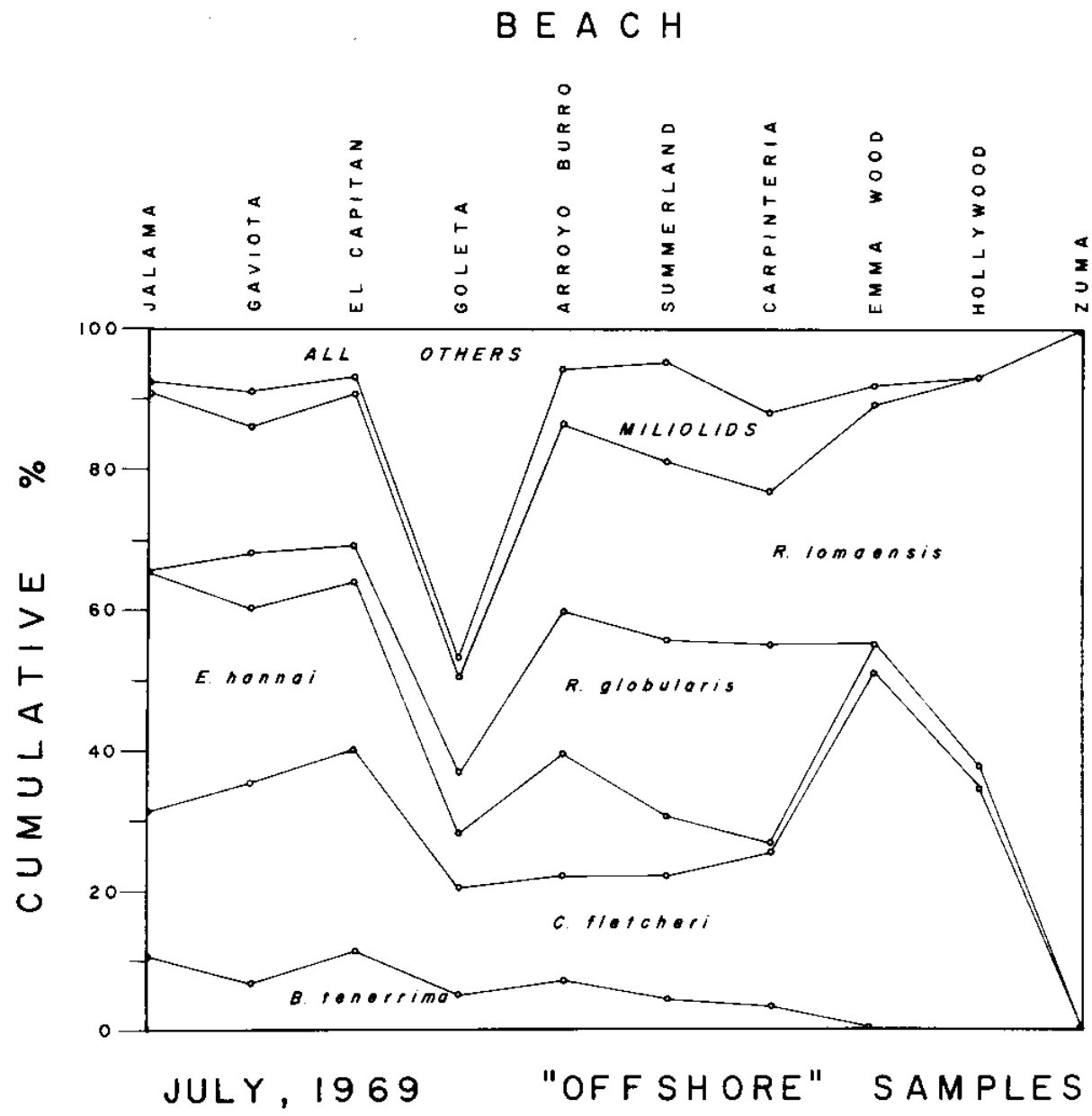


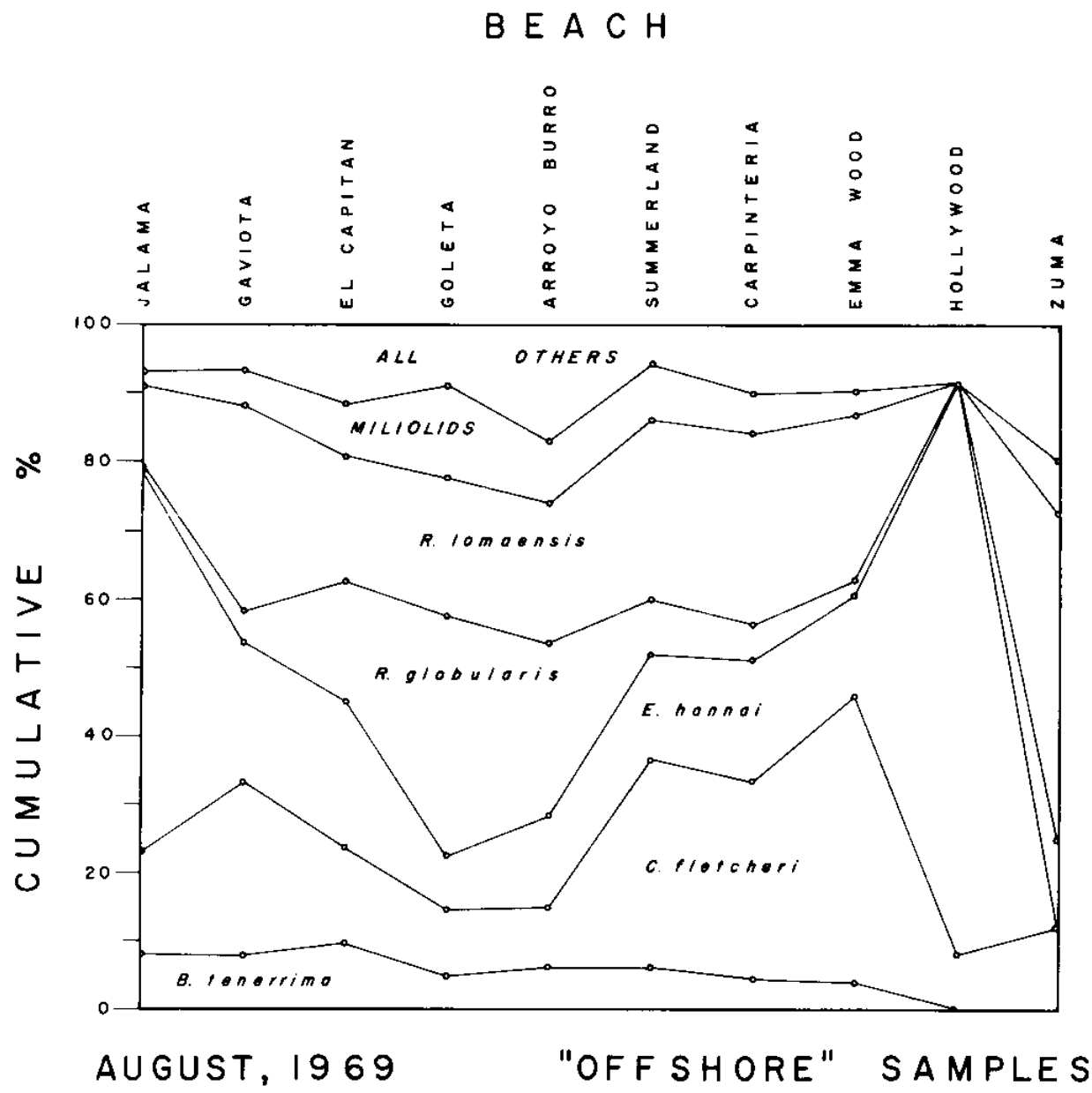
APRIL, 1969 "OFFSHORE" SAMPLES

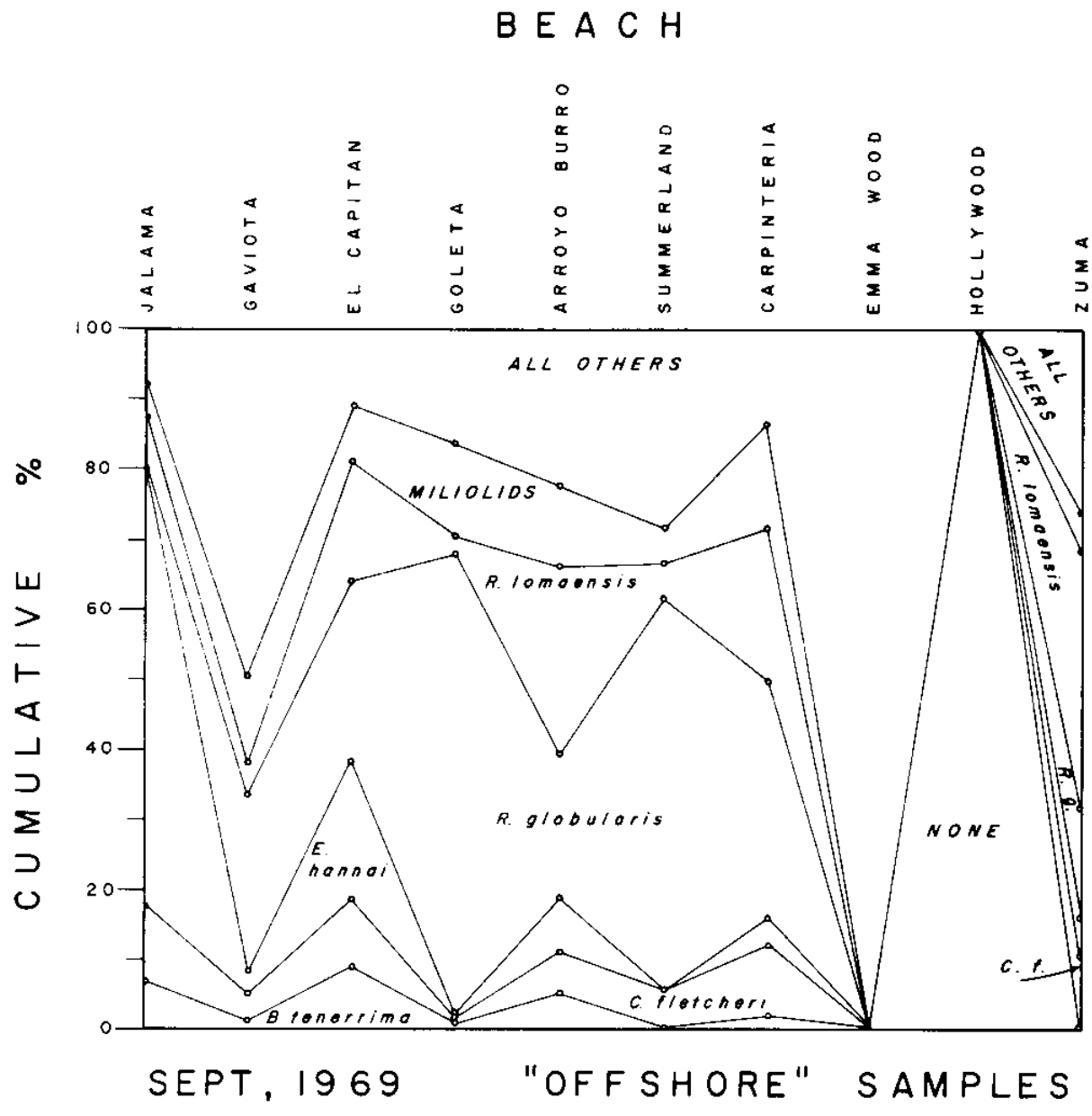

BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
C. fletcheri
B. tenerrima
MAY, 1969 "OFFSHORE" SAMPLES

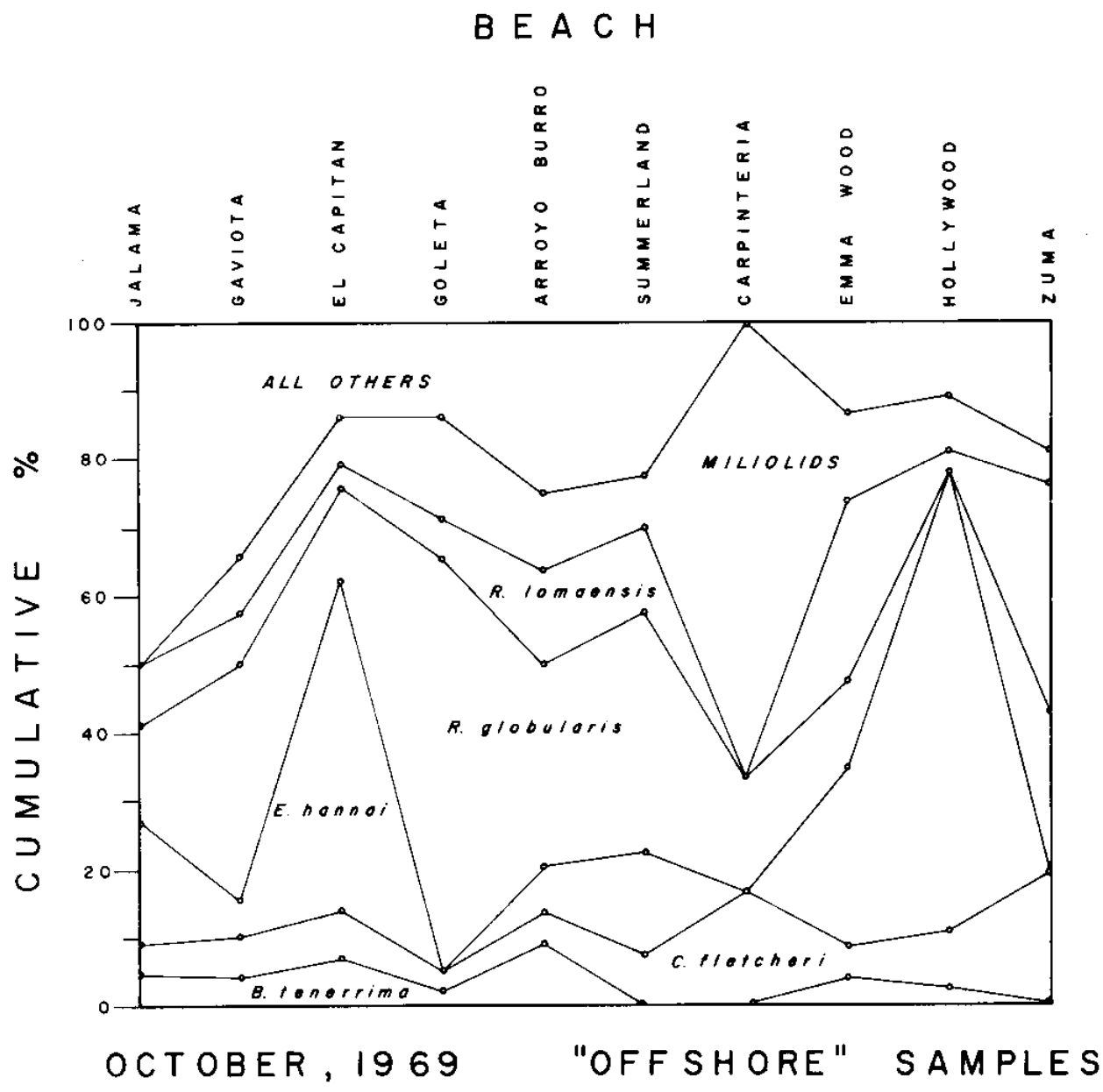


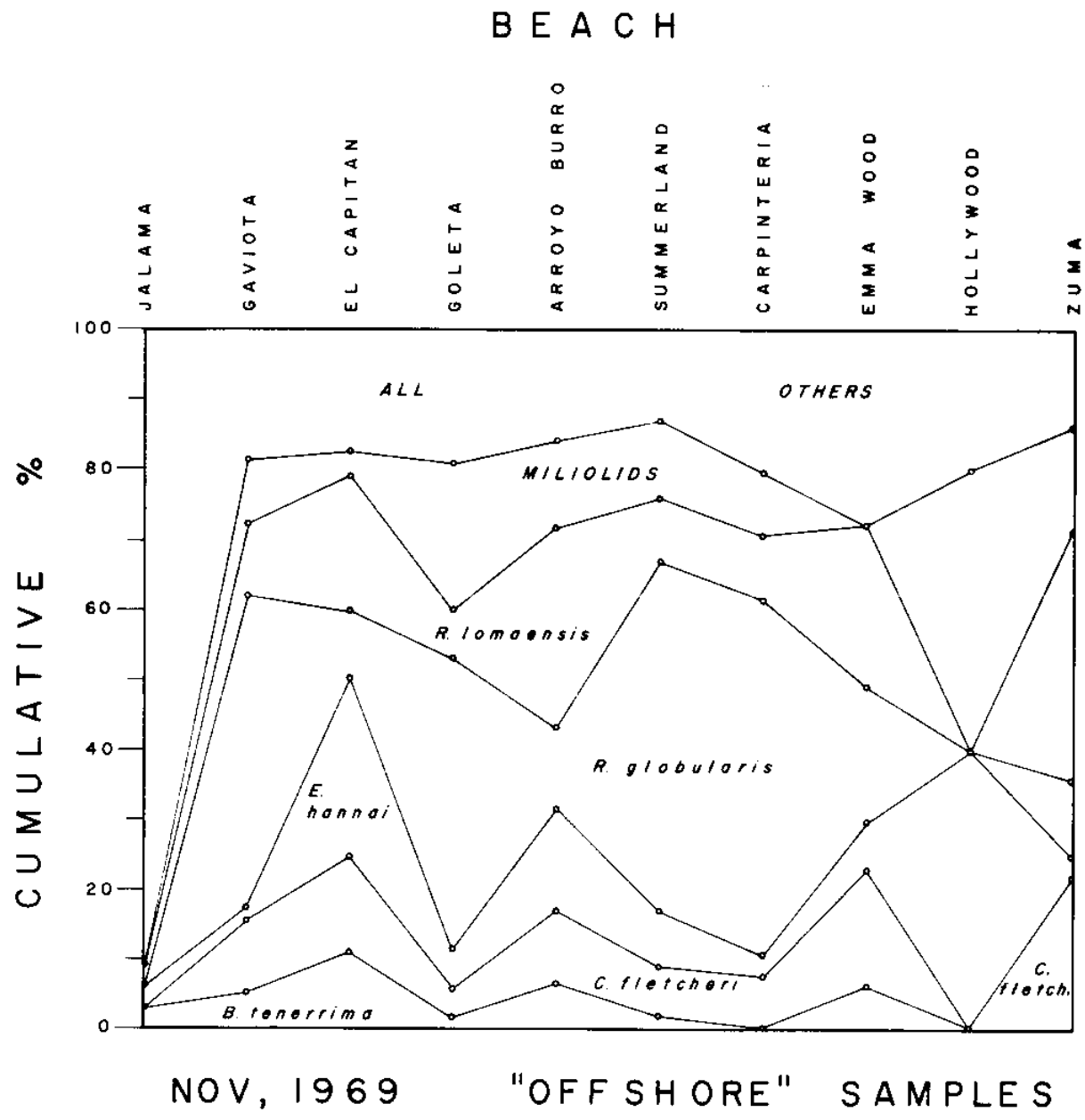
JUNE, 1969 "OFFSHORE" SAMPLES

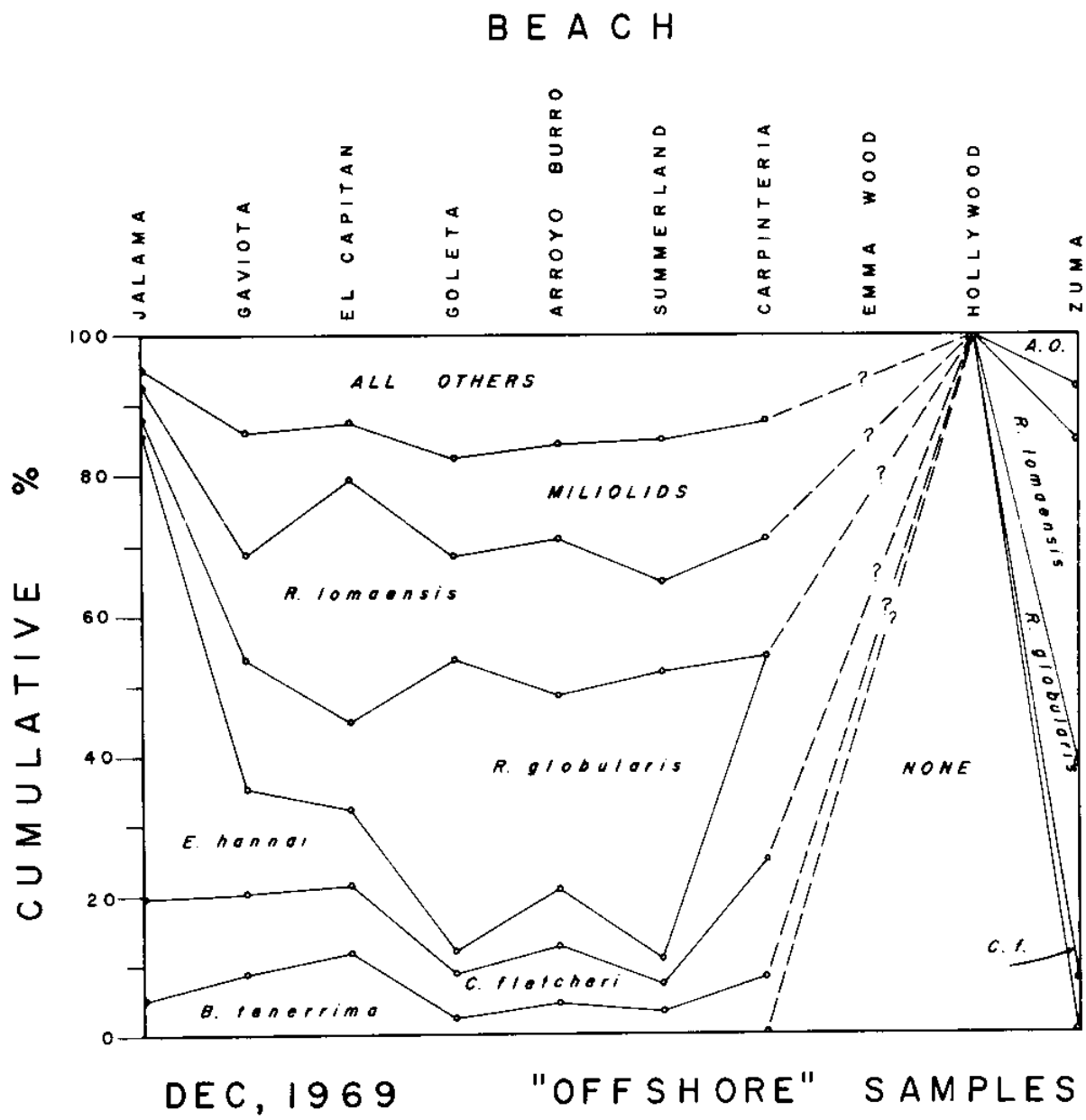

BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
E. hannai
R. globularis
C. fletcheri
B. tenerrima
JULY, 1969 "OFFSHORE" SAMPLES


BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
C. fletcheri
B. tenerrima
AUGUST, 1969 "OFFSHORE" SAMPLES


BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
B tenerrima
C. fletcheri
NONE
ALL OTHERS
R. lomaensis
R. g.
C. f.
SEPT, 1969 "OFFSHORE" SAMPLES


BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
C. fletcheri
B. tenerrima
OCTOBER, 1969 "OFFSHORE" SAMPLES


BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL
OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
C. fletcheri
B. tenerrima
C. fletch.
NOV, 1969 "OFFSHORE" SAMPLES


BEACH
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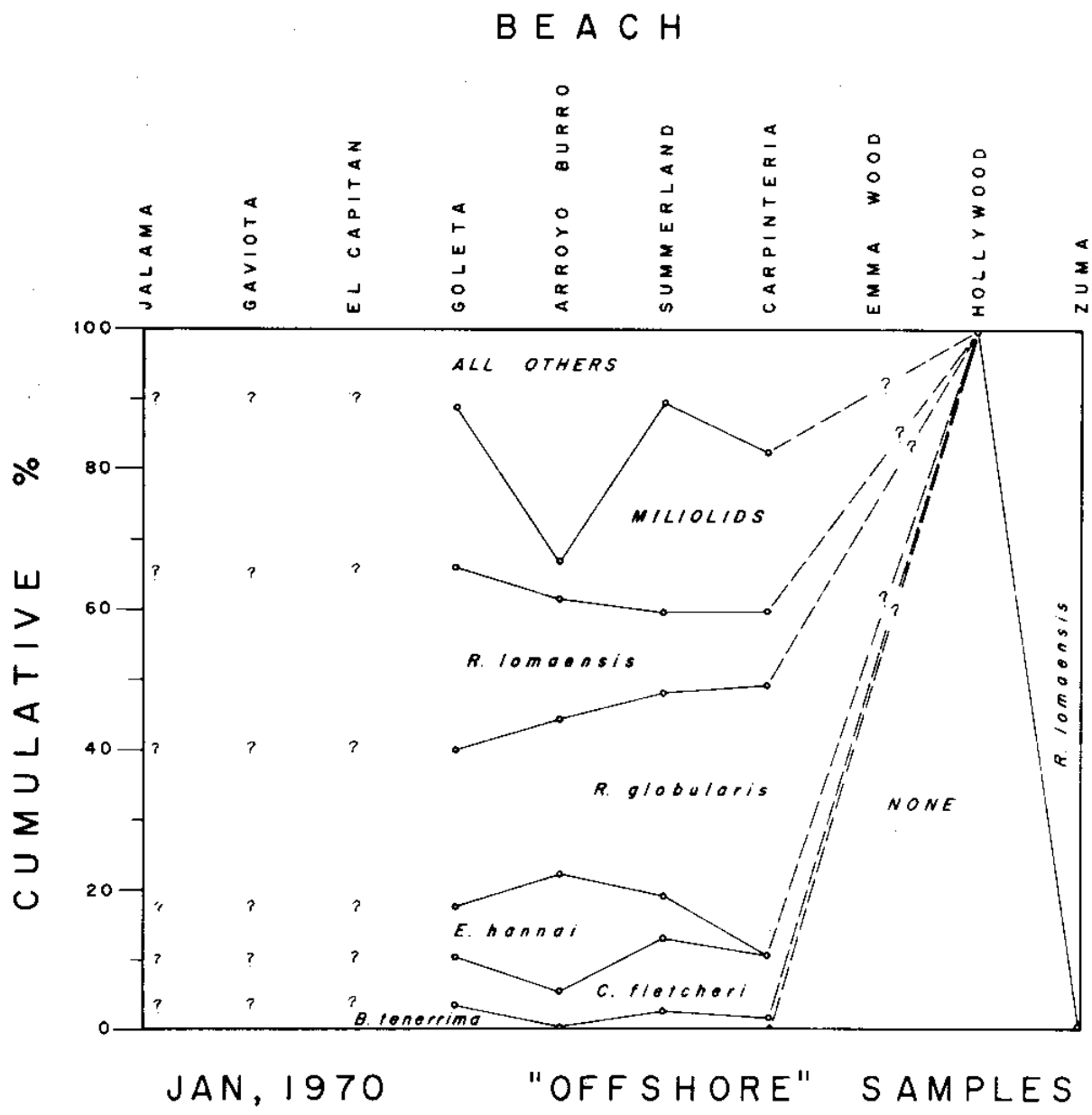
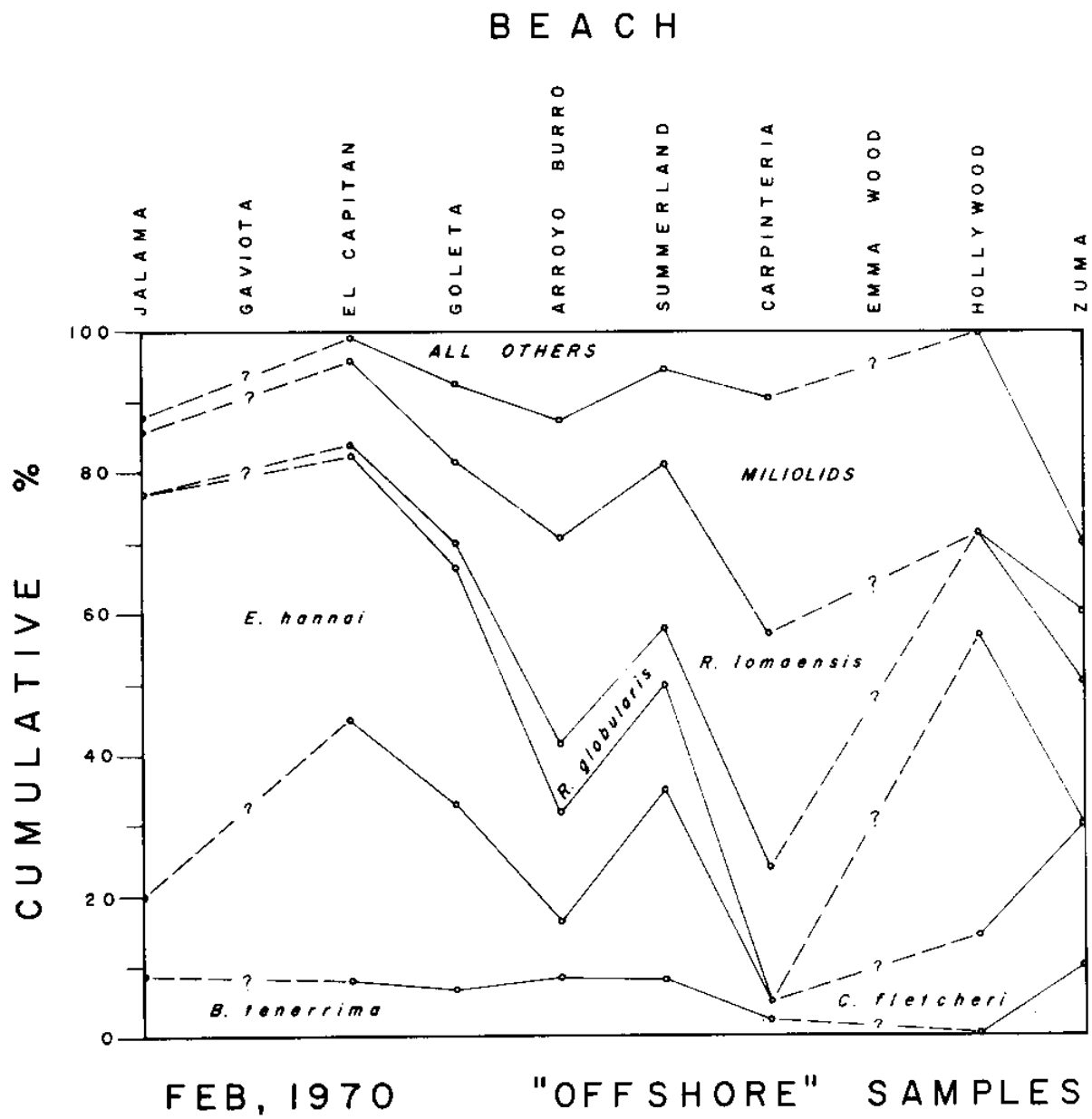
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
B. tenerrima
C. fletcheri
NONE
A.O.
C.f.
DEC, 1969 "OFFSHORE" SAMPLES


BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
R. lomaensis
R. globularis
E. hannai
C. fletcheri
B. tenerrima
NONE
R. lomaensis
JAN, 1970 "OFFSHORE" SAMPLES


BEACH
JALAMA
GAVIOTA
EL CAPITAN
GOLETA
ARROYO BURRO
SUMMERLAND
CARPINTERIA
EMMA WOOD
HOLLYWOOD
ZUMA
CUMULATIVE %
100
80
60
40
20
0
ALL OTHERS
MILIOLIDS
E. hannai
R. lomaensis
R. globularis
B. tenerrima
C. fletcheri
FEB, 1970 "OFFSHORE" SAMPLES

Changes in the relative abundance of dominant species in the offshore samples may be explained in several ways. Either a selective kill-off or a higher productivity of Rosalina globularis could cause the increase in its abundance relative to Cibicides fletcheri and Elphidiella hannai. The decrease of Rosalina globularis relative to the other 2 species in January and February, 1970, suggests that reproduction, not mass mortality, is the cause of the changes. This is further supported by the presence of "Tretomphalus," Rosalina globularis' gamont (Sliter, 1965), in swash samples collected during August, 1969, which indicates that reproduction was occurring because the delicate float chamber of the gamont is quickly destroyed in the beach environment. Instead of biological changes, different degrees in the intensity of destructive beach processes may explain the inverse relationship between the relatively thin-walled Rosalina globularis and the more durable species, Cibicides fletcheri and Elphidiella hannai. This hypothesis is supported by the dominance of Rosalina globularis only at those stations with partial protection by kelp beds.

SUMMARY

The faunal changes observed in the beach environment of the Santa Barbara Channel region from April, 1969, to February, 1970, appear to be the result of seasonal variations. Both the beach foraminiferal number and the relative abundance of Rosalina globularis were relatively low in offshore beach samples for the months of April and May. At stations between Gaviota and Carpinteria State Beaches, the magnitude of both parameters increased during the months of June and August, and reached their maximum values in September and October. The parallel between the two parameters ended in November when Rosalina globularis was still the dominant species whereas the beach foraminiferal number became relatively low. The dominance of Rosalina globularis continued until about December and finally decreased in abundance during February.

The apparent seasonal cycle of population size and species dominance in the area between Gaviota and Carpinteria State Beaches makes the possibility of a kill-off of foraminiferal species unlikely. The remote possibility of a kill-off is also indicated by the similar magnitude of beach foraminiferal numbers for swash samples of the channel region and those previously reported in Santa Monica Bay

(Reiter, 1959). Furthermore, productivity was occurring during the period of increases in both the beach foraminiferal numbers and the relative abundance of Rosalina globularis since the delicate gamont of Rosalina globularis was found in swash samples collected during August, 1969.

The magnitude of the beach foraminiferal number and the relative abundance of Rosalina globularis has been shown in this study to increase as beaches are given more protection from wave action by kelp beds. A general decrease in the intensity of destructive beach processes is, thus, a likely reason for the relative increase in the magnitude of both parameters from June to October, 1969. Increased intensity of these processes can also explain the lower beach foraminiferal numbers from November, 1969, to January, 1970, but not the continued dominance of Rosalina globularis.

Increased productivity could also explain the increase of both parameters. When the beach foraminiferal number decreased in November, 1969, Rosalina globularis still dominated the fauna owing perhaps to production rates high enough to maintain the dominance of this species. Both values were low by February, 1970, because the reproduction rate of Rosalina globularis may have become lower than the minimum rate required to maintain its dominance in the destructive beach environment.

The most logical conclusion that can be drawn is that a combination of seasonal variations in both productivity and the intensity of beach processes, but not a kill-off by oil pollution, caused the changes observed in the beach foraminiferal population of the Santa Barbara Channel region from April, 1969, to February, 1970.

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CHAPTER 4

OCEANOGRAPHY OF THE SANTA BARBARA CHANNEL

by

Ronald L. Kolpack
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

INTRODUCTION

Interpretation of the processes affecting a marine environment must be based on oceanography because the oceanographic characteristics define the environment. The spatial variations of the conservative and non-conservative properties of a nearshore area, such as the Santa Barbara Channel, are influenced by origin of the water, bottom topography, biological activity, weather and geography.

Most of the physical, chemical and geological studies undertaken in an attempt to assess the effects of an oil spill in Santa Barbara Channel required more than a cursory knowledge of the oceanographic parameters in that area. In addition, an oceanographic study was considered to be of merit to some of the biological studies that were being conducted simultaneously.

A review of available published oceanographic information (Emery, 1960; California Cooperative Oceanic Fisheries Investigations (CALCOFI) Progress Reports and various reports by the Allan Hancock Foundation staff) provided a valuable insight into the general oceanographic conditions existing in the area. However, answers for some of the questions posed for this study were not available because most of the previous work was lacking in either

geographic or seasonal detail.

The initial phase of this oceanographic study was concentrated on an evaluation of available values from previous studies. CALCOFI temperature, salinity and oxygen values from stations in the Santa Barbara Channel for the last 15 years were plotted in order to establish "normal" conditions. These values show that there are three distinct seasons (fig. 1) in the area. Our hydrographic program was then based, within the limits of ship scheduling and funding, on three cruises in order to observe the water characteristics during 1969. A representative grid of approximately 40 stations (fig. 2) was established and these stations were occupied in May, August and December.

At each station, a continuous record of temperature and salinity versus depth (fig. 3) was obtained with a Bissett-Berman model 9060 STD and water samples, for nutrient analysis, from standard depths were obtained with Teflon lined Nansen bottles equiped with reversing thermometers. Nutrient analyses were by the methods described in Strickland and Parsons (1968).

Surface current patterns were derived essentially from a drift card survey but other information such as distribution of surface water isotherms and turbidity were utilized whenever possible.

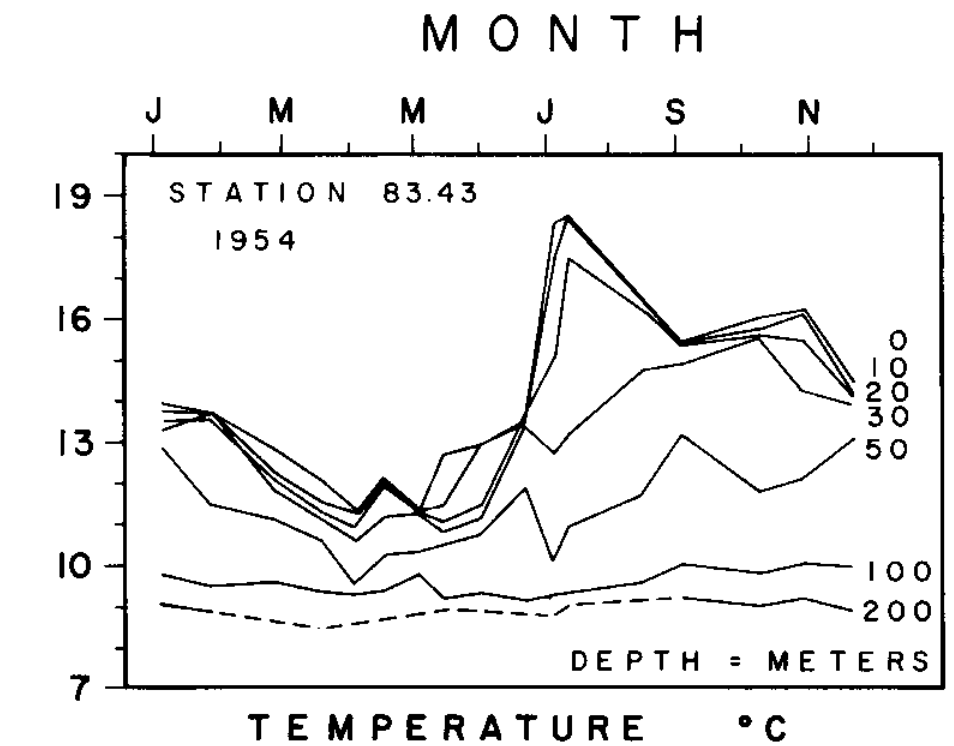
ACKNOWLEDGMENTS

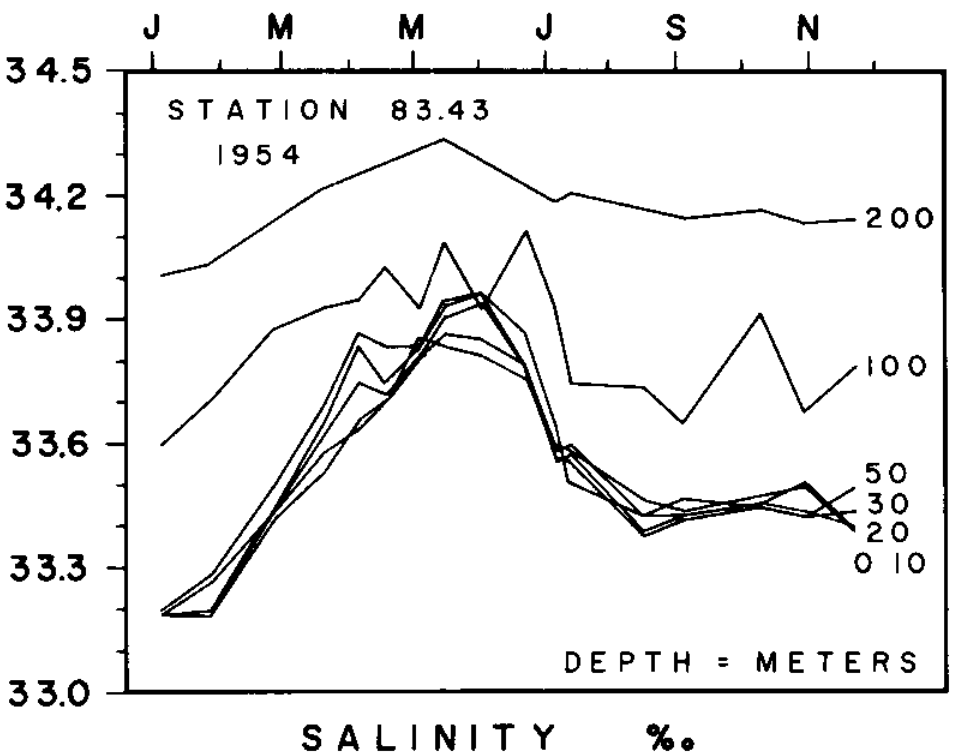
The oceanographic study of the channel area consumed more time than any other portion of the physical, chemical and geological programs. Consequently, many individuals contributed support, encouragement and criticism. In the interest of keeping this report brief and at the risk of possibly offending someone, the interested reader is referred to the acknowledgment section at the beginning of this volume.

SURFACE CURRENTS

Surface current patterns derived from drift card surveys are usually the result of a considerable amount of interpretation. It must be recognized that the method can yield general qualitative patterns only. However, the patterns that evolve are extremely useful if a sufficient

Figure 1. Temperature and salinity values from a CALCOFI station in Santa Barbara Channel. The dominant seasonal variations are clearly depicted in the surface water temperature values.





CALCOFI DATA

Figure 2. Hydrographic station grid for May, August and December, 1969. The stations between Anacapa Island and Santa Cruz Island are STD and surface water stations only.

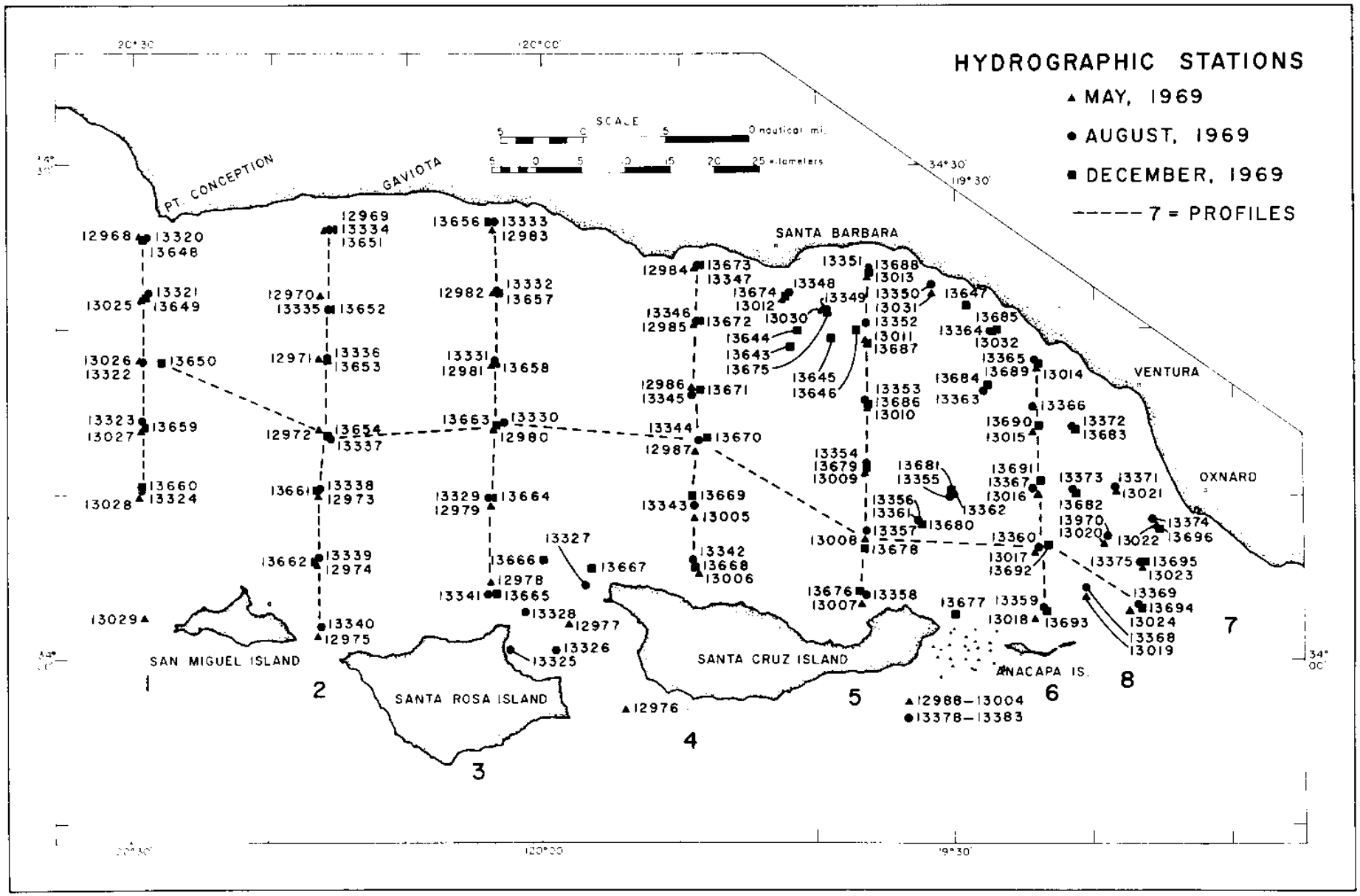
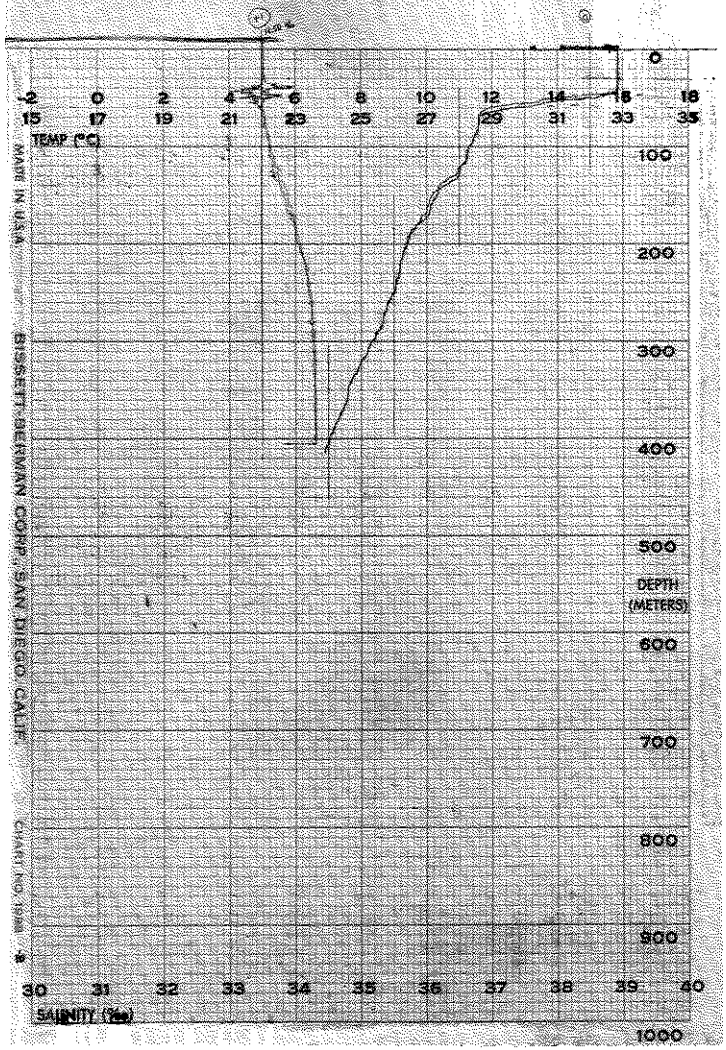
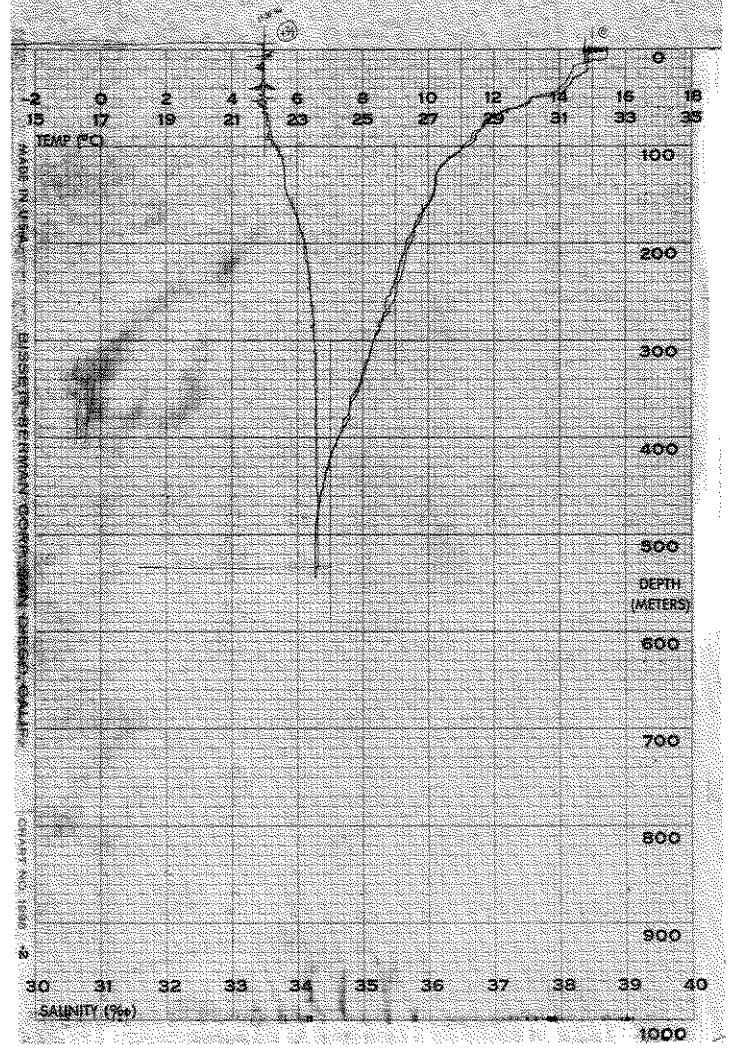

HYDROGRAPHIC STATIONS
▲ MAY, 1969
● AUGUST, 1969
■ DECEMBER, 1969
----- 7 = PROFILES
SCALE
0 nautical mi.
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
1
2
3
4
5
6
7
8
▲12988–13004
●13378–13383

Figure 3. Representative STD records for two stations occupied in December. Up and down traces were made on all stations and the values used are averages of the two traces.

RECORD NO. 13657
LOCATION
TIME 0315 Hrs.
DATE 12/11/69
REMARKS
OPERATOR
SERIAL NO.



RECORD NO.
LOCATION 13664
TIME 2000
DATE 12-11-69
REMARKS
OPERATOR
SERIAL NO.



number of cards are recovered and if supporting information obtained by other methods is used during the interpretation.

In excess of 15,000 drift cards were released during 8 cruises in the Santa Barbara Channel. Thirty weighted and 30 unweighted drift cards were usually released individually by dropping the cards, sealed in polyethylene envelopes, into the water from an elevation of 3-4 feet. Weighted cards only were released in May, 1969, but two sets of cards were released at some stations during other cruises. Some recoveries were made at sea, but the majority of returns came from beach or surf zone areas. Most of the recoveries were made along the mainland and island beaches between Pt. Conception and San Diego. The northernmost recovery came from Oregon and the southernmost recovery came from central Baja.

The surface water circulation pattern in Santa Barbara Channel is a resultant of a current entering the channel from each end. The confluence of the currents, geographic setting and wind conditions produce a complex pattern of eddies superimposed on a relatively stable counter-clockwise circulation cell in the western half of the channel and a northwesterly flowing current in the eastern part of the channel (figs. 4-18). The zone of interaction between these two currents occurs in the area between Santa Barbara and Santa Cruz Island.

Several interesting problems, especially in the eastern portion of the channel, are evident from the surface water circulation patterns and these problems will be studied in greater detail as time permits. One application of the results of this study is that we successfully predicted the trajectories of oil slicks emanating from an oil spill in the area in December, 1969.

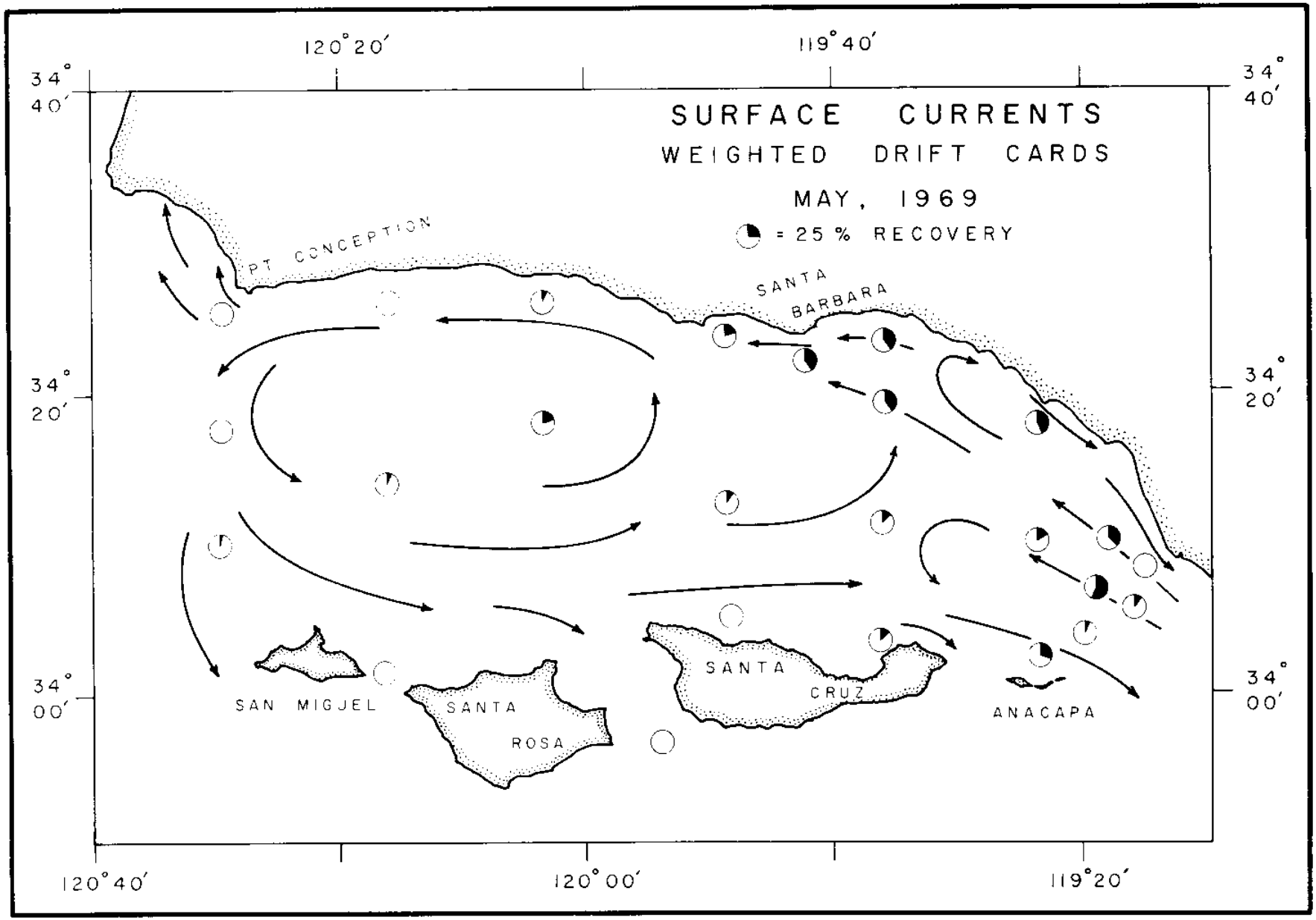
SURFACE WATER CHARACTERISTICS

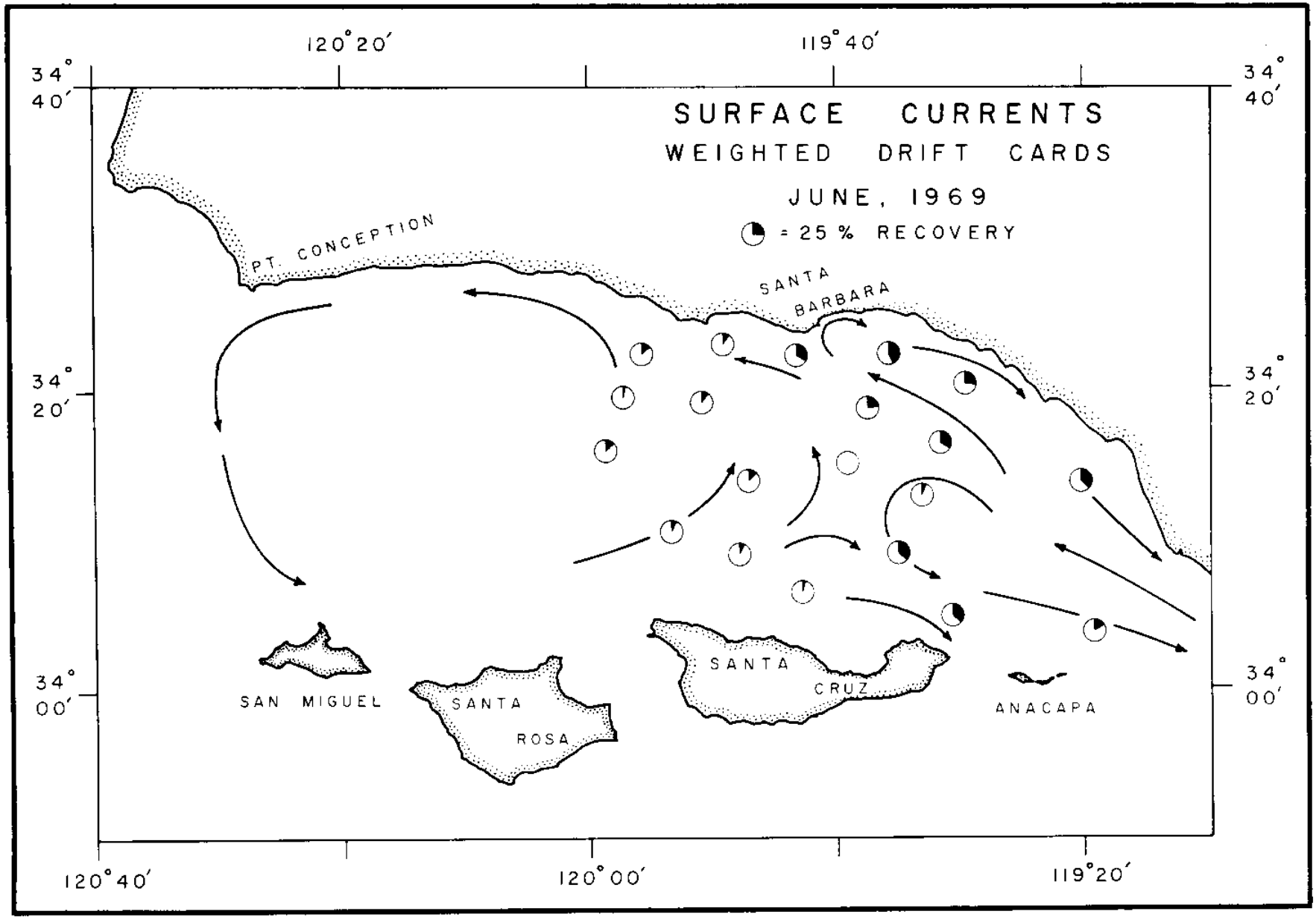
A few surface water temperature and salinity values for the period of December, 1968 through April, 1969 were provided by David Drake. This information has been contoured (figs. 19-25) even though the control is limited.

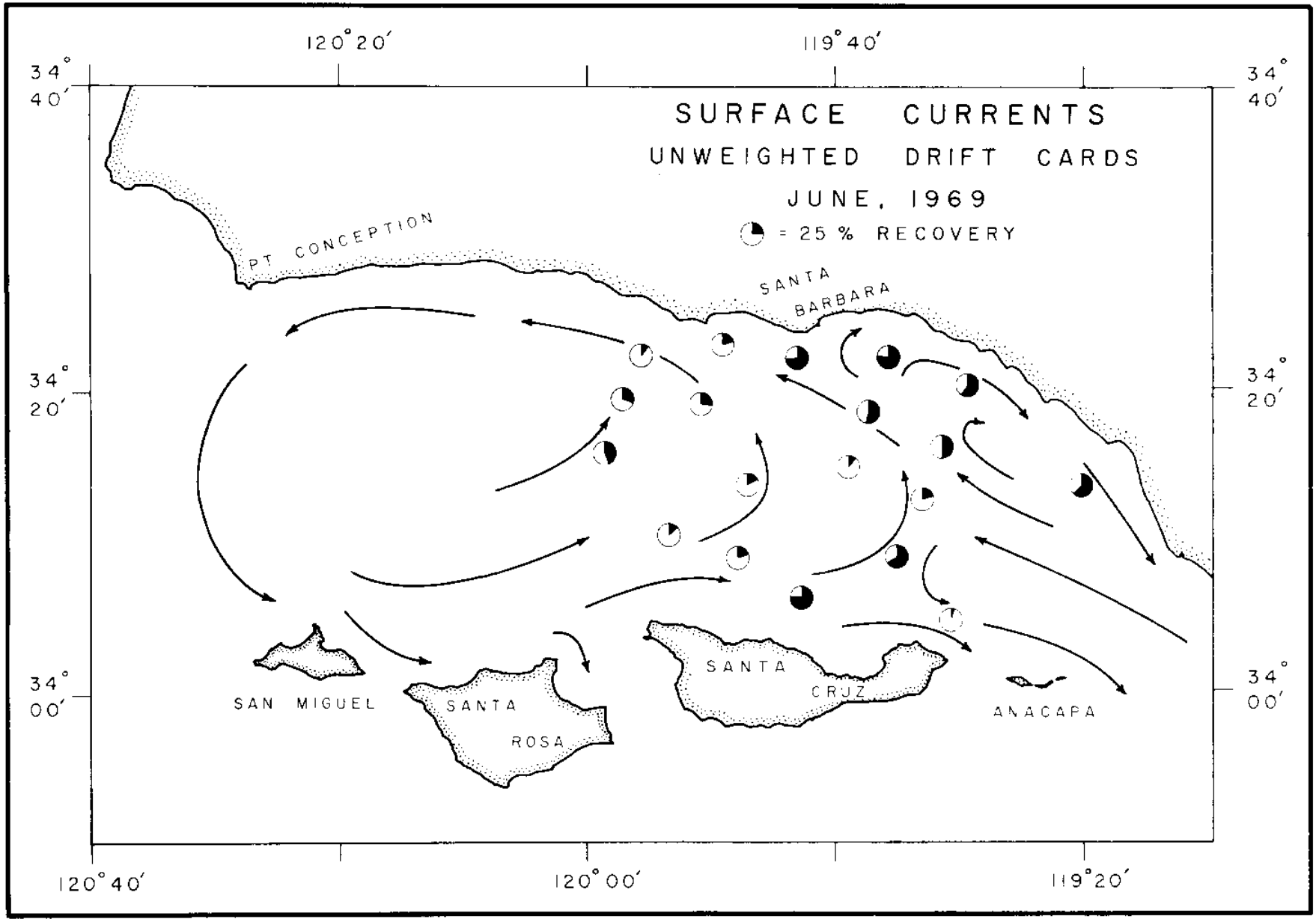
Temperature and Salinity

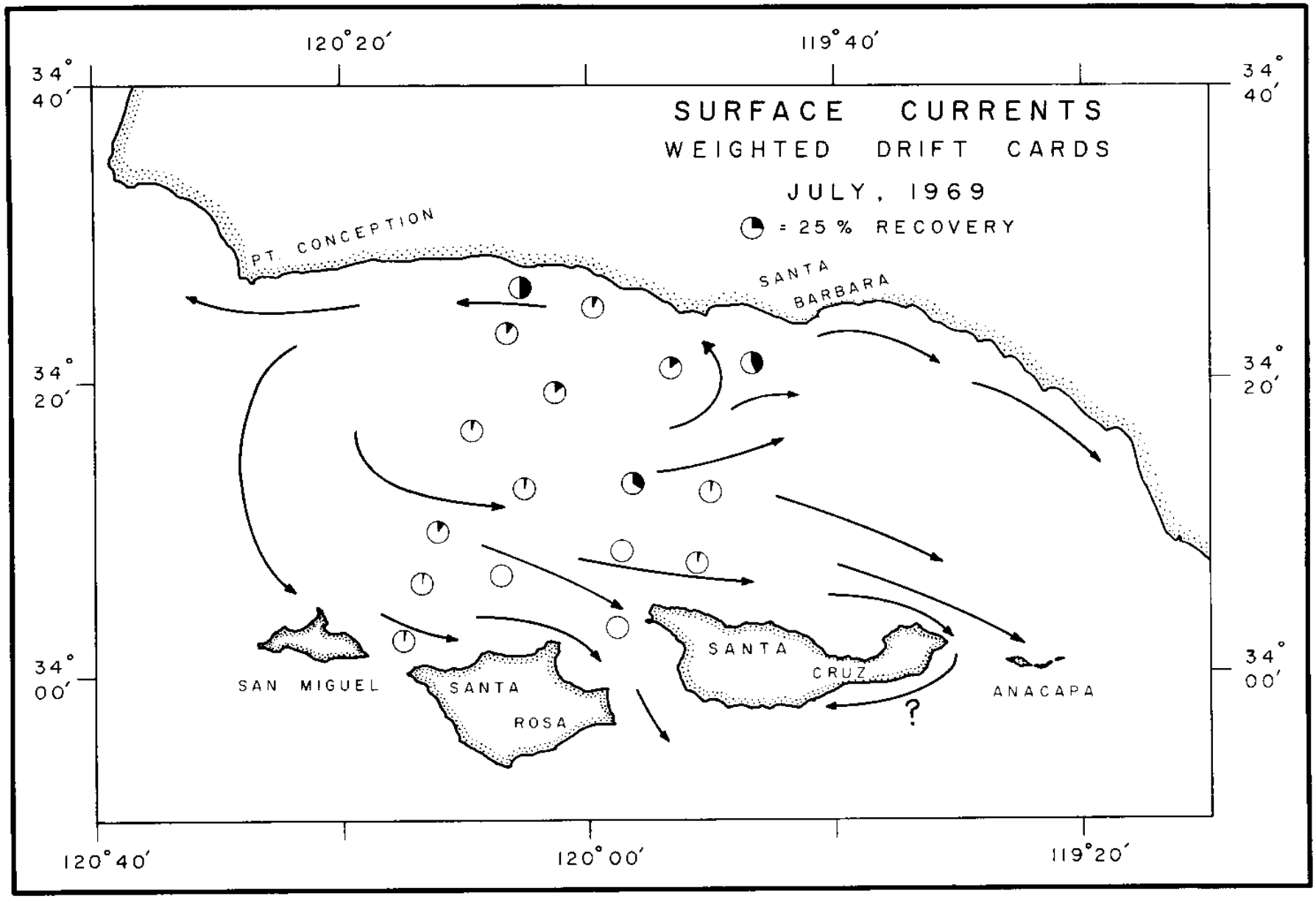
The lowest surface water temperatures, obtained during the three hydrographic cruises, occurred in May, 1969

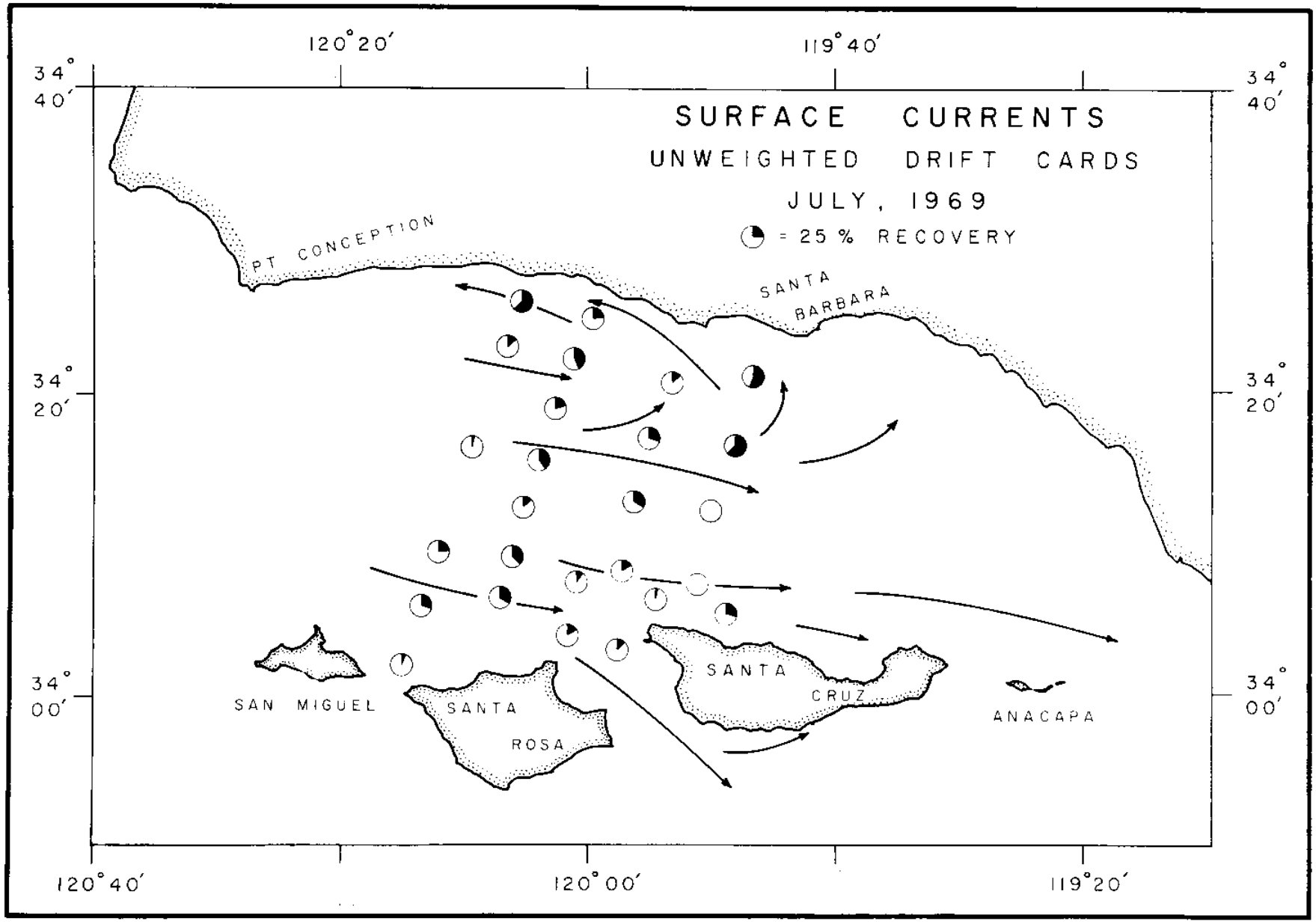
Figures 4-18. Surface water currents (arrows) derived from drift card surveys. The large circle is the position of release and the solid portion of the circle is the percent recovery for that station. Recovery information will be available from the National Oceanographic Data Center in late 1971.

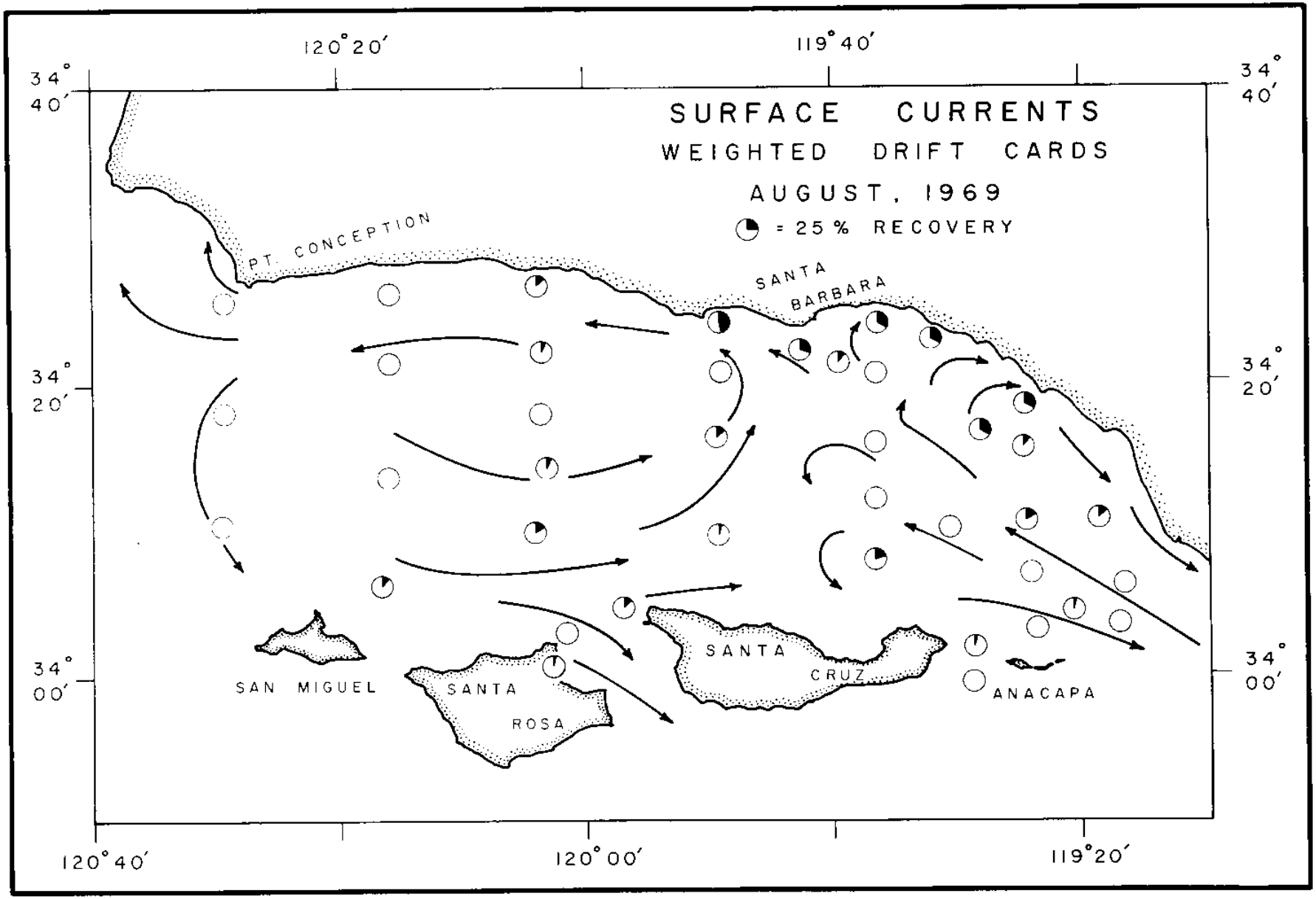

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
MAY, 1969
= 25 % RECOVERY
PT CONCEPTION
SANTA BARBARA
SAN MIGJEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

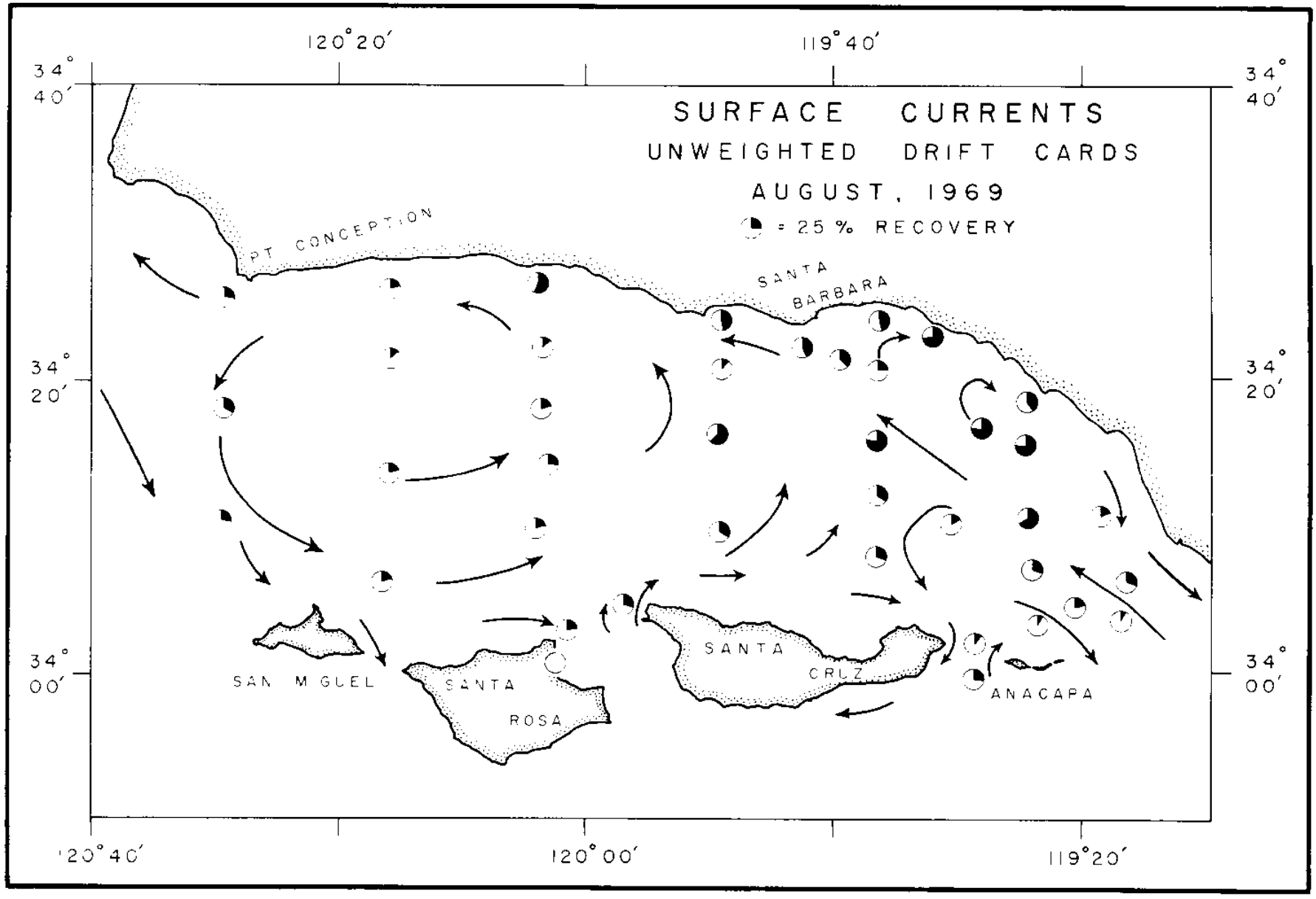

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
JUNE, 1969
= 25 % RECOVERY
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

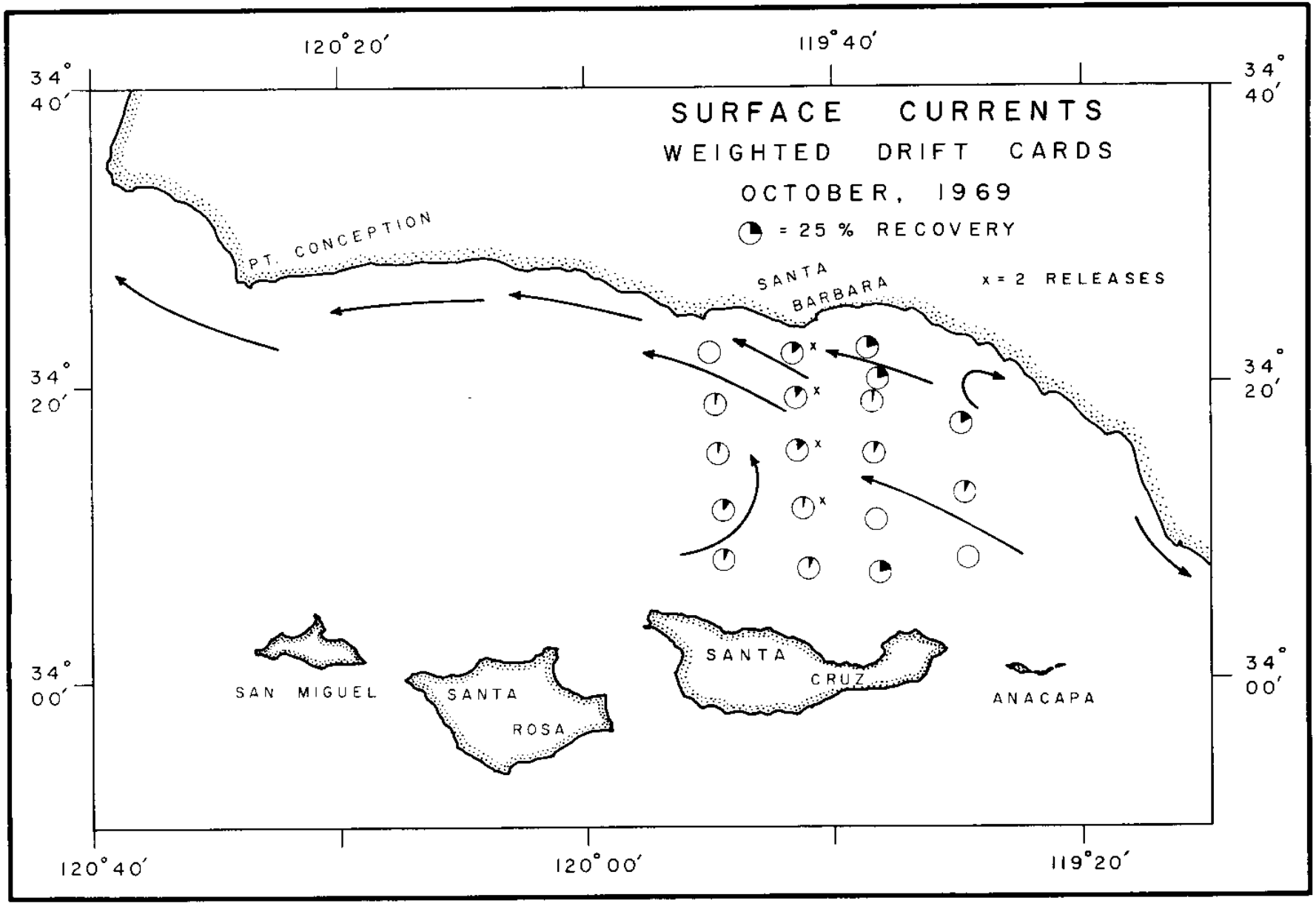

SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
JUNE, 1969
= 25 % RECOVERY
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

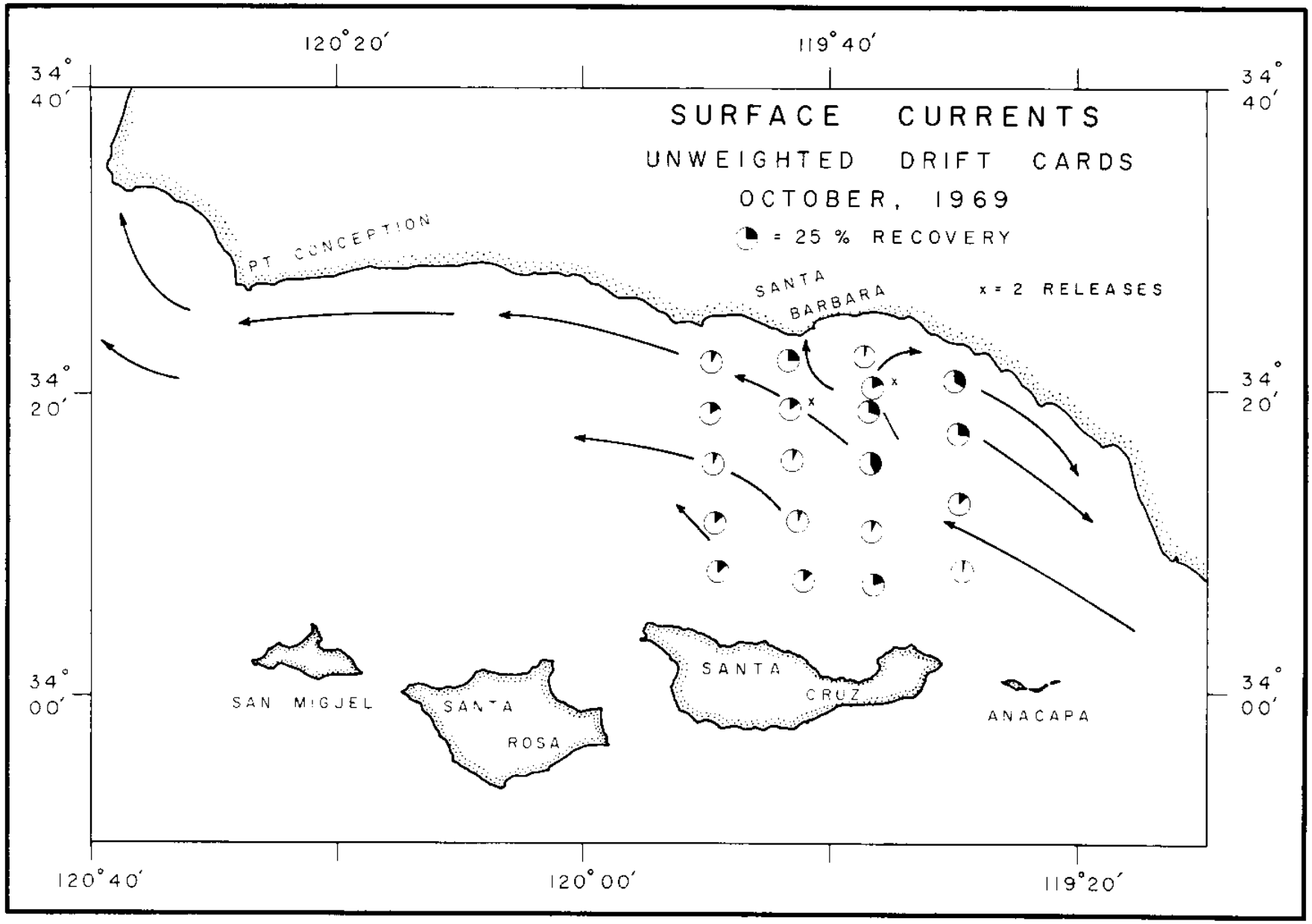

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
JULY, 1969
= 25 % RECOVERY
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
?
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

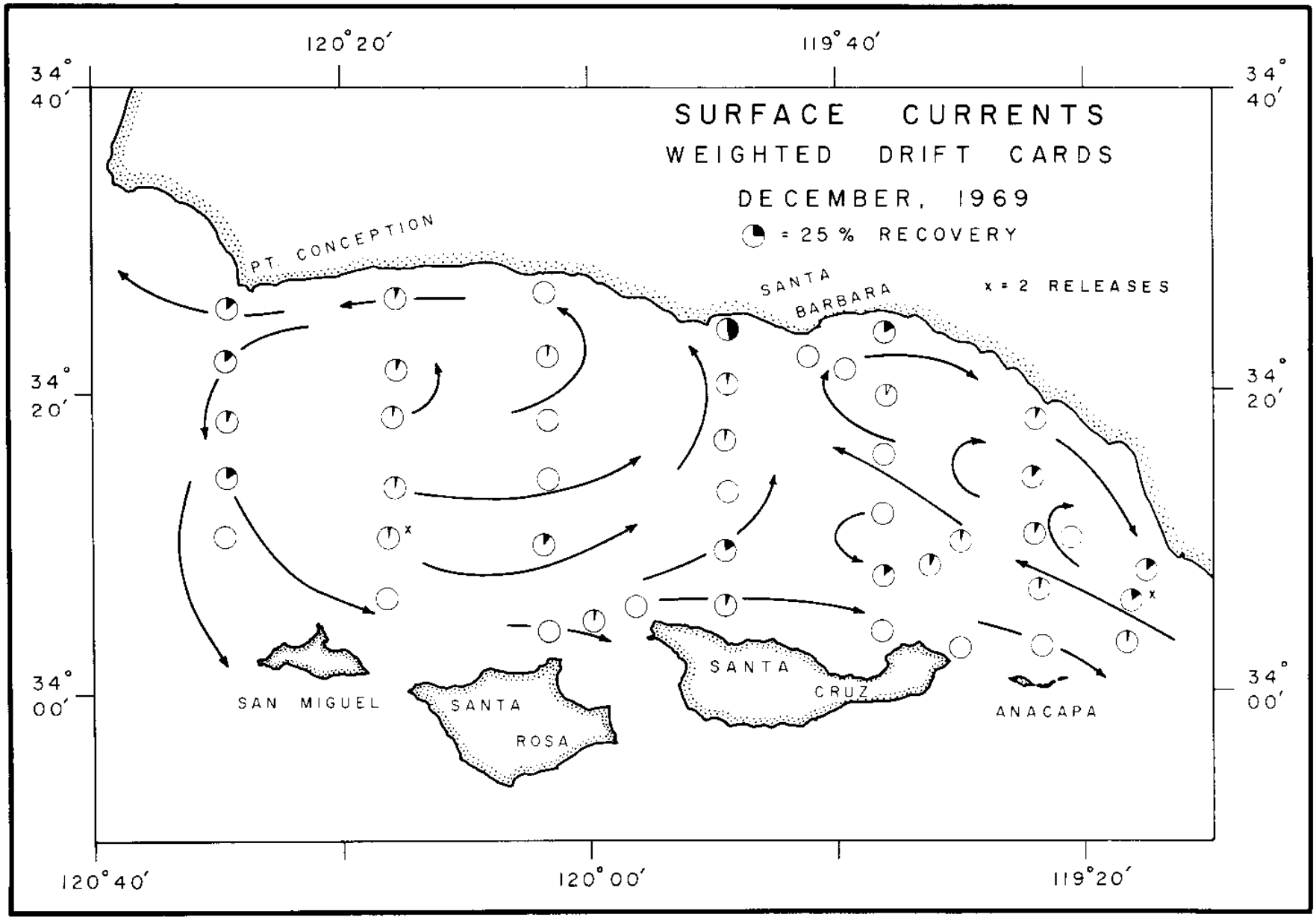

SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
JULY, 1969
= 25 % RECOVERY
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
120°40′
120°00′
119°20′
34° 40′
34° 20′
34° 00′

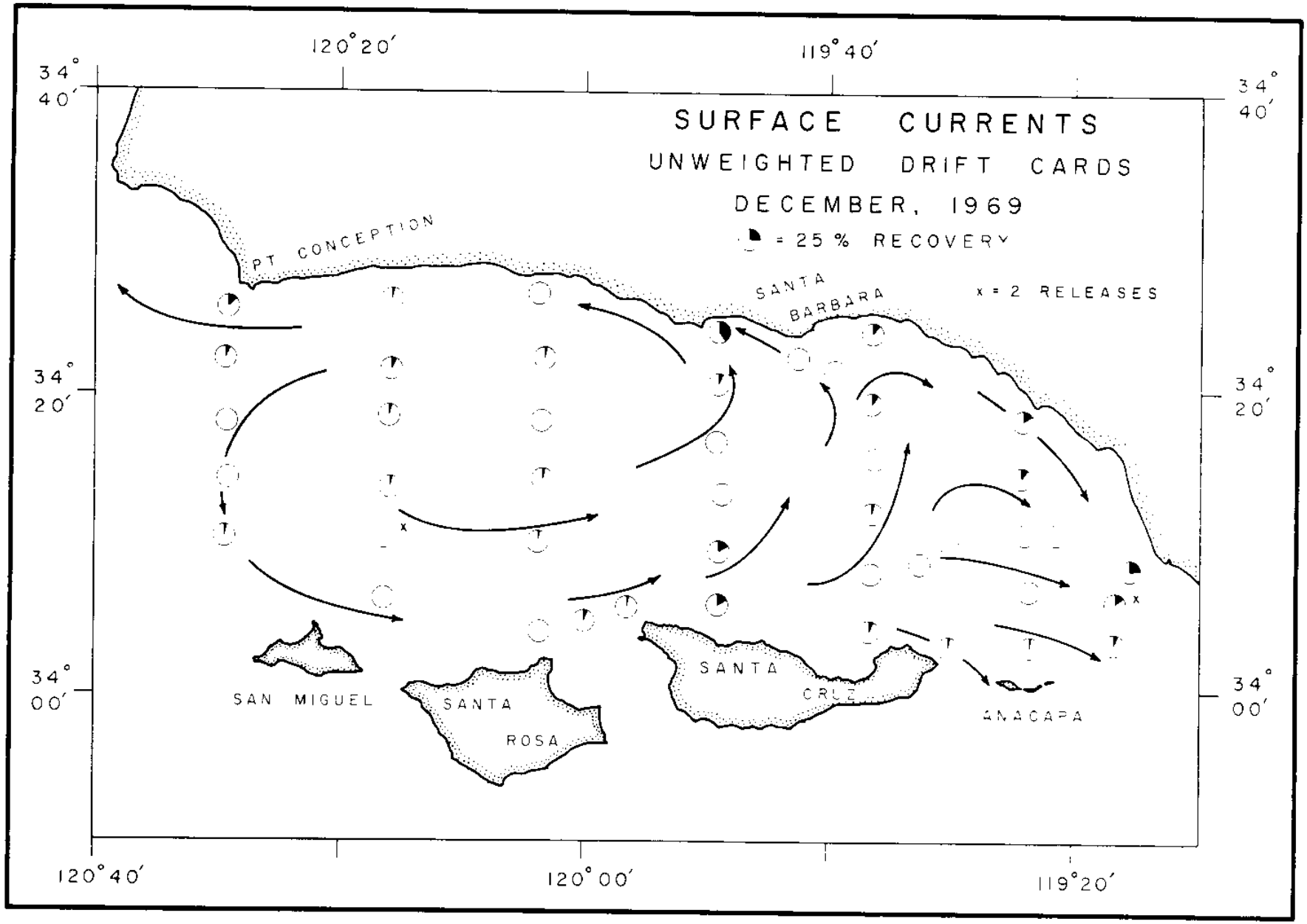

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
AUGUST, 1969
= 25 % RECOVERY
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

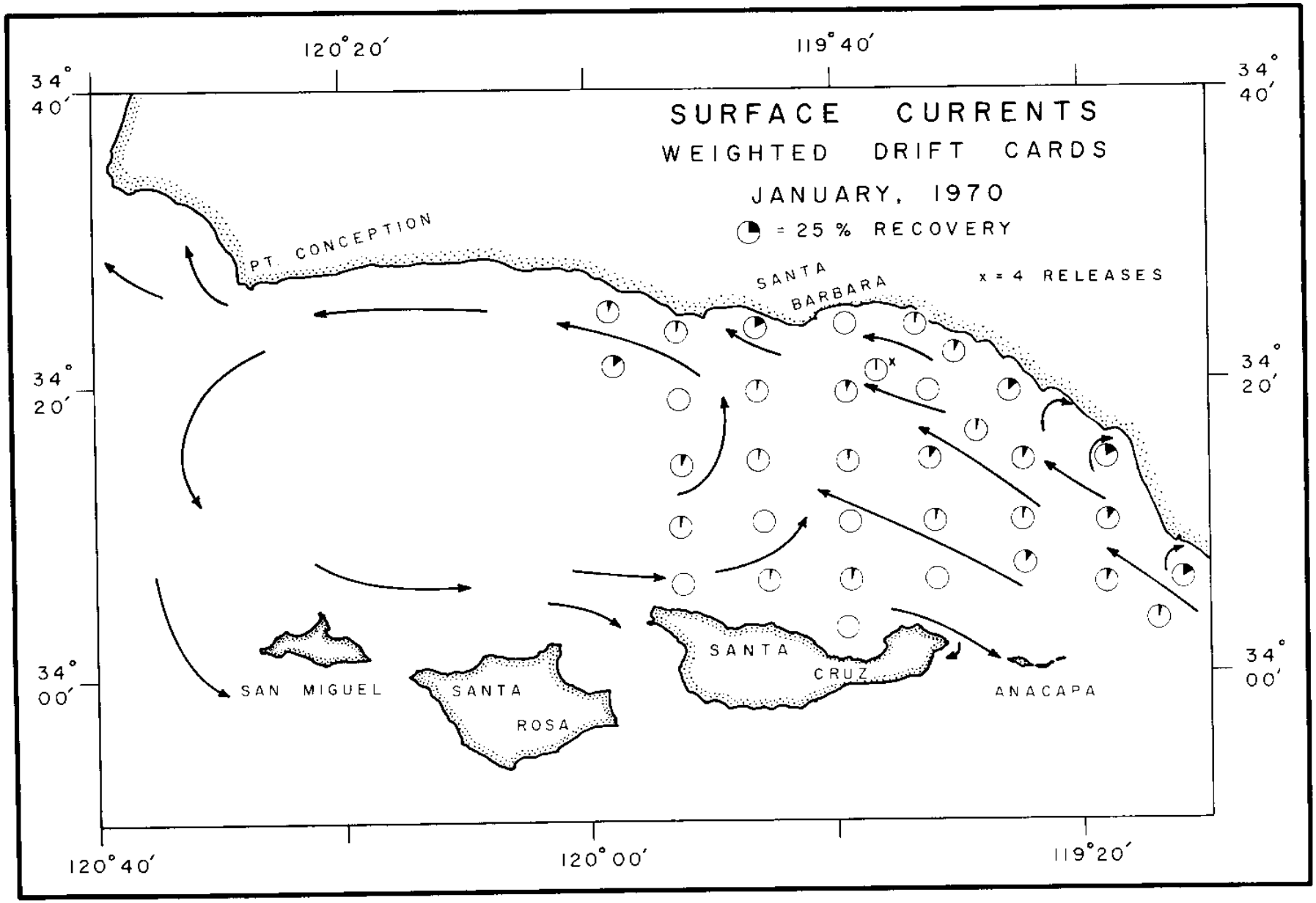

SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
AUGUST, 1969
= 25 % RECOVERY
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

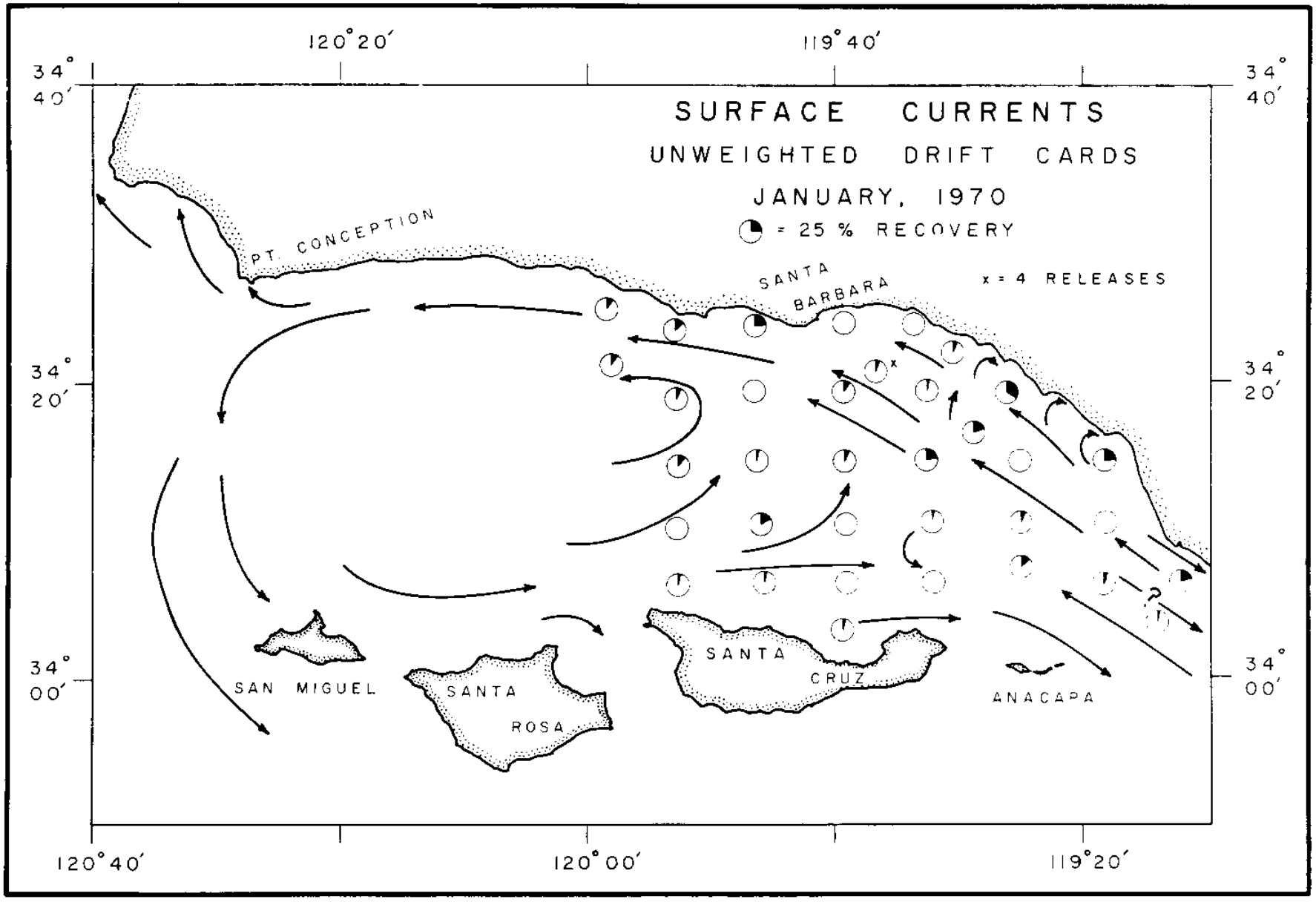

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
OCTOBER, 1969
= 25 % RECOVERY
x = 2 RELEASES
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
120°40′
120°00′
119°20′
34° 40′
34° 20′
34° 00′

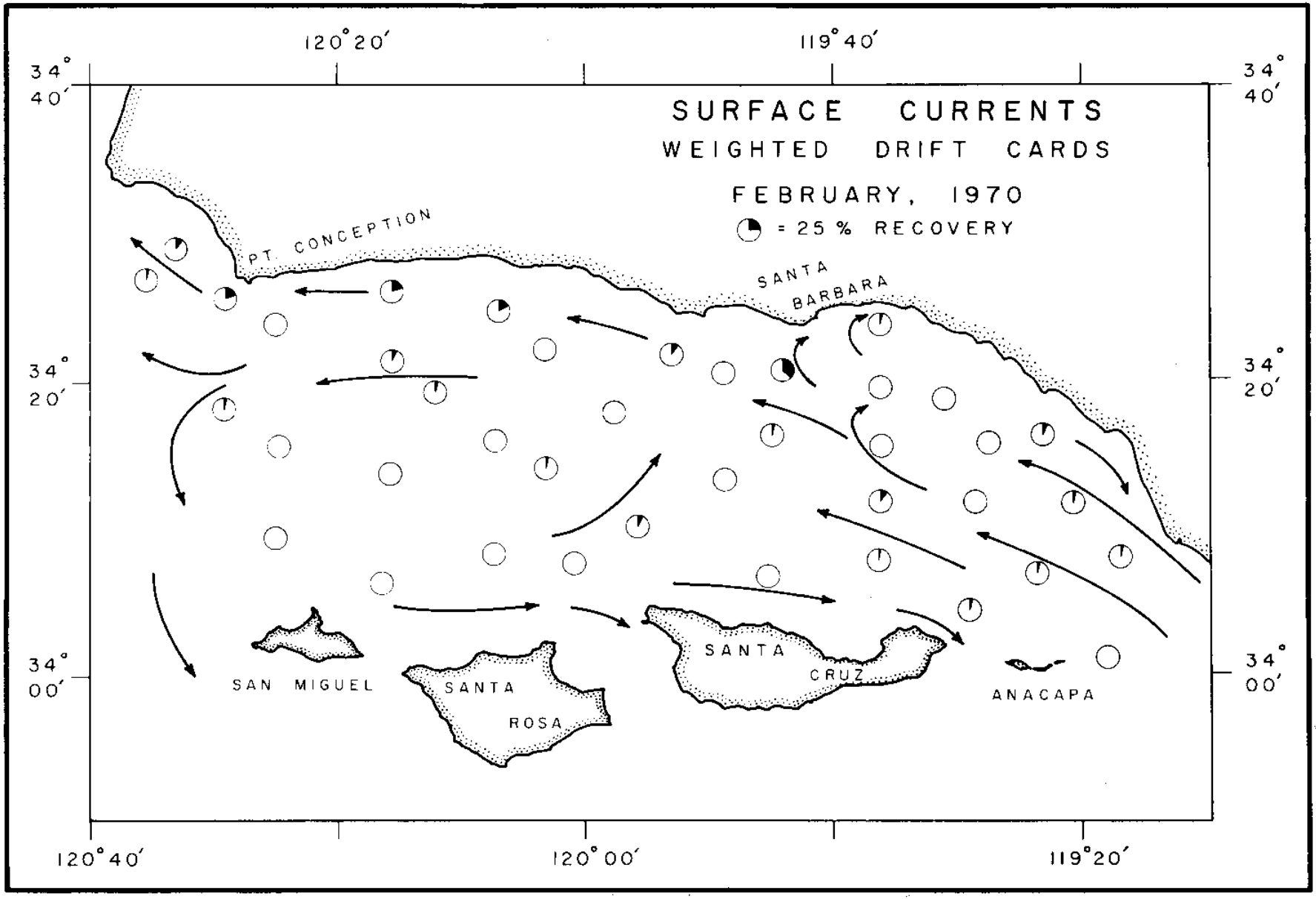

SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
OCTOBER, 1969
= 25 % RECOVERY
x = 2 RELEASES
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
120°40′
120°00′
119°20′
34° 40′
34° 20′
34° 00′

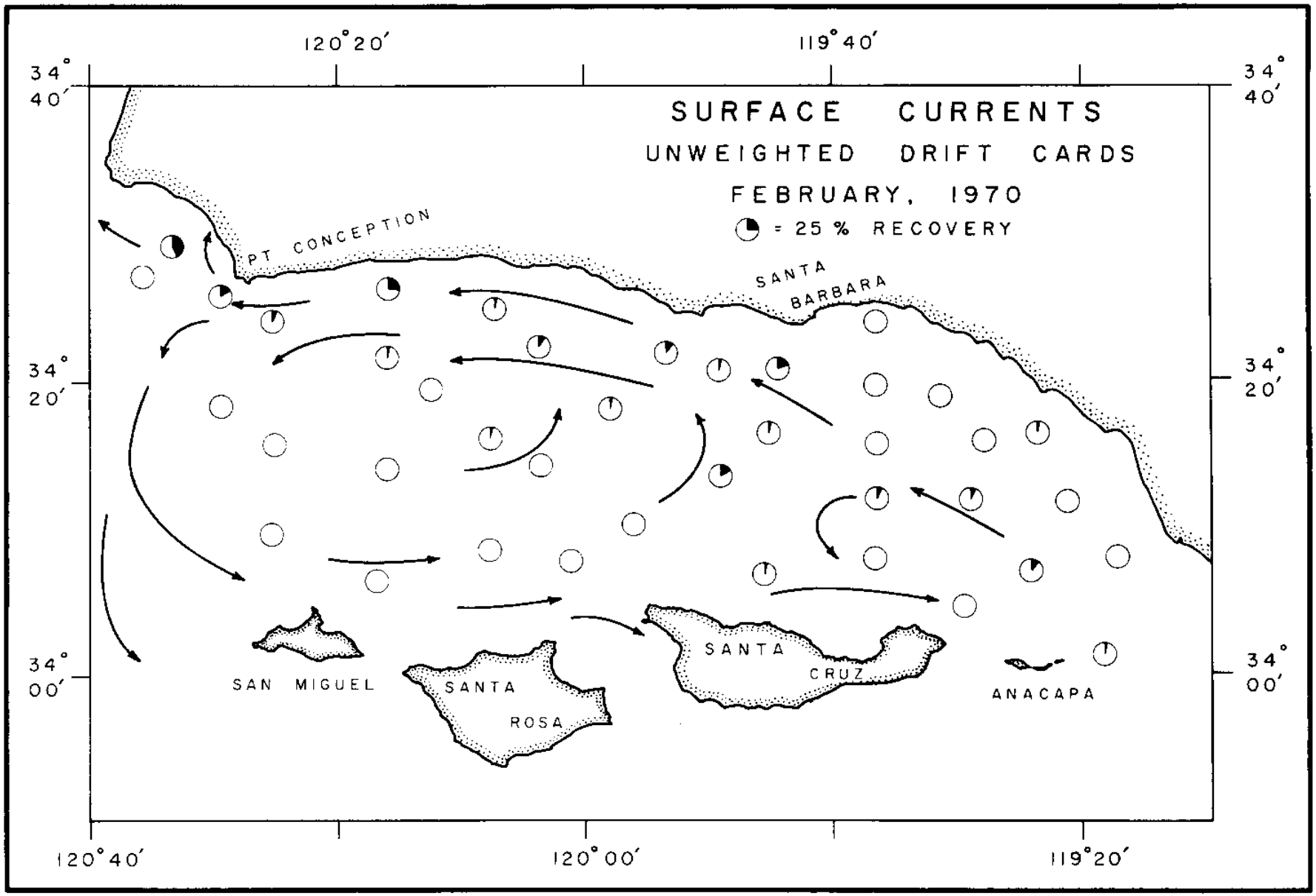

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
DECEMBER, 1969
= 25 % RECOVERY
x = 2 RELEASES
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
120°40′
120°00′
119°20′
34° 40′
34° 20′
34° 00′


SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
DECEMBER, 1969
= 25 % RECOVERY
x = 2 RELEASES
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

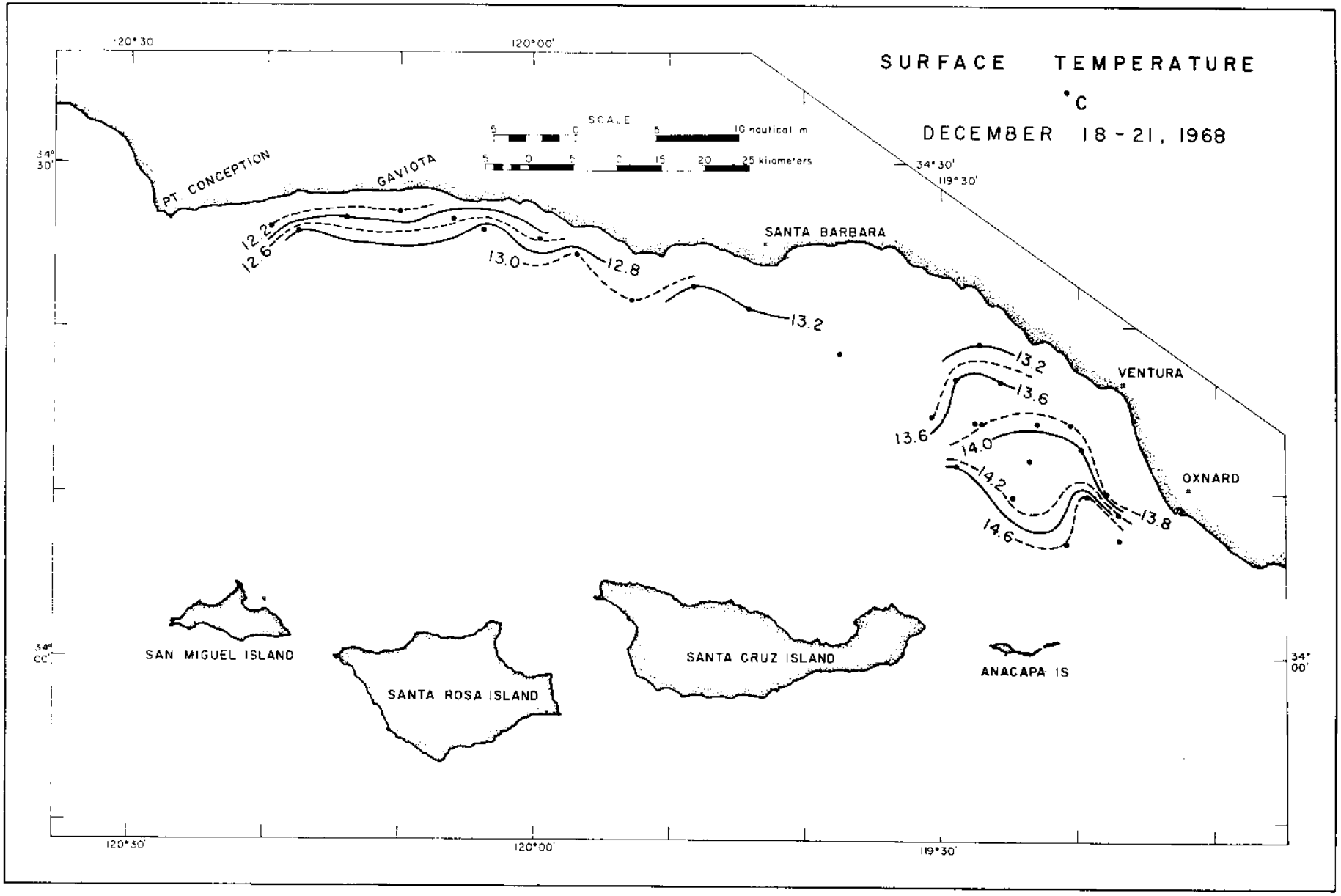

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
JANUARY, 1970
= 25 % RECOVERY
x = 4 RELEASES
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120° 20′
119° 40′
34° 40′
34° 20′
34° 00′
120° 40′
120° 00′
119° 20′

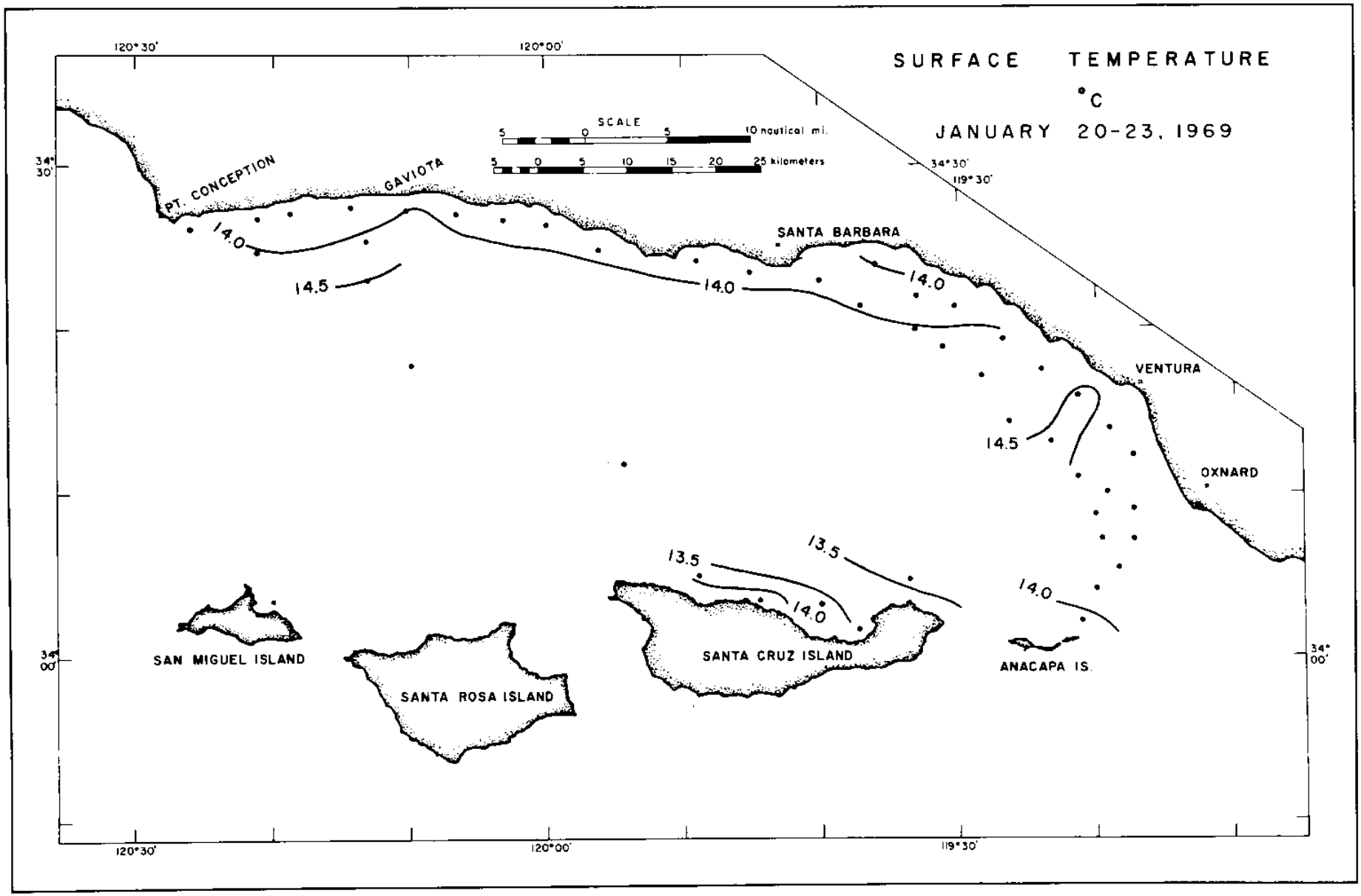

SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
JANUARY, 1970
= 25 % RECOVERY
x = 4 RELEASES
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
120°40′
120°00′
119°20′
34° 40′
34° 20′
34° 00′

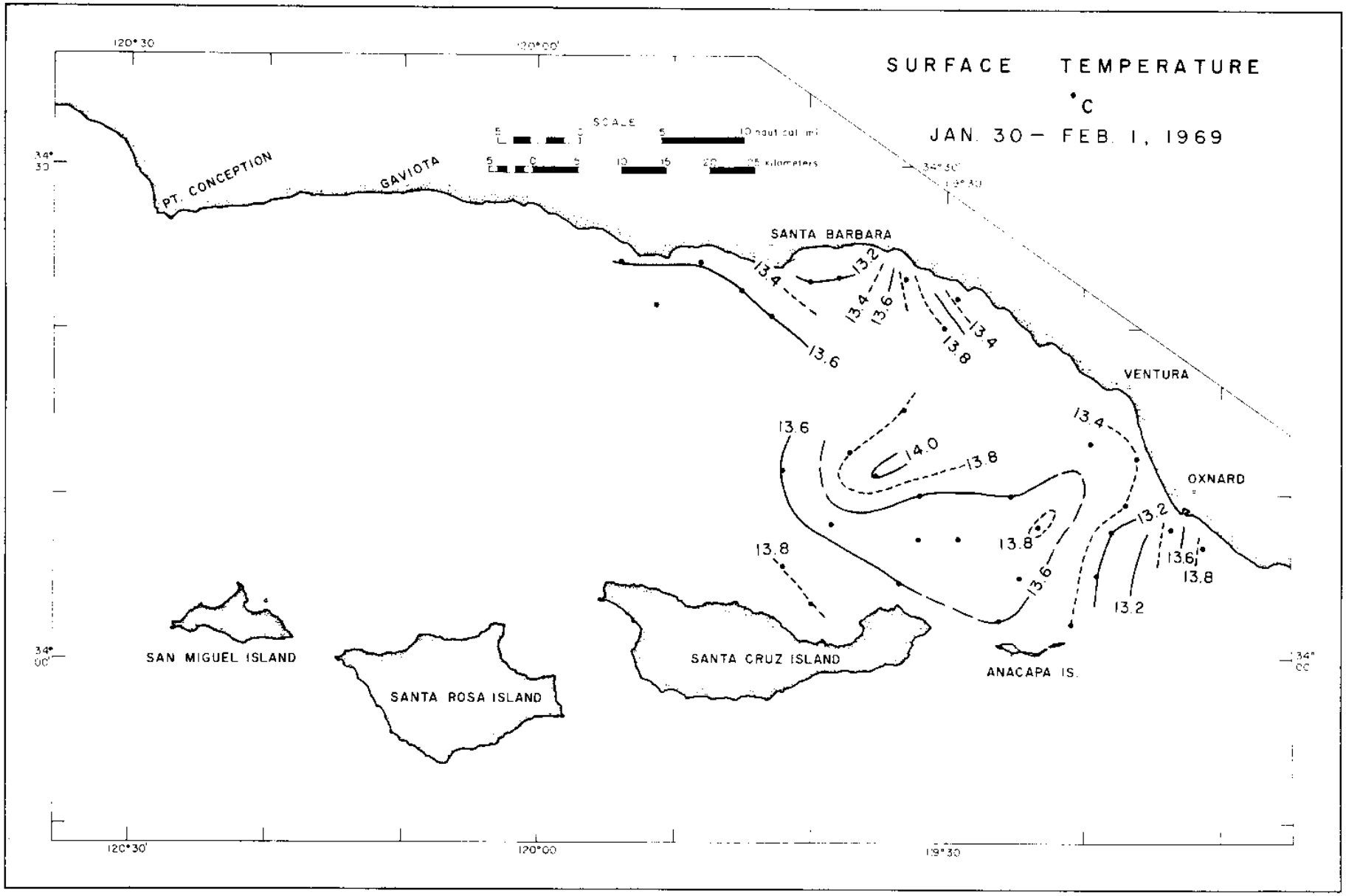

SURFACE CURRENTS
WEIGHTED DRIFT CARDS
FEBRUARY, 1970
= 25 % RECOVERY
PT. CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
120°40′
120°00′
119°20′
34° 40′
34° 20′
34° 00′

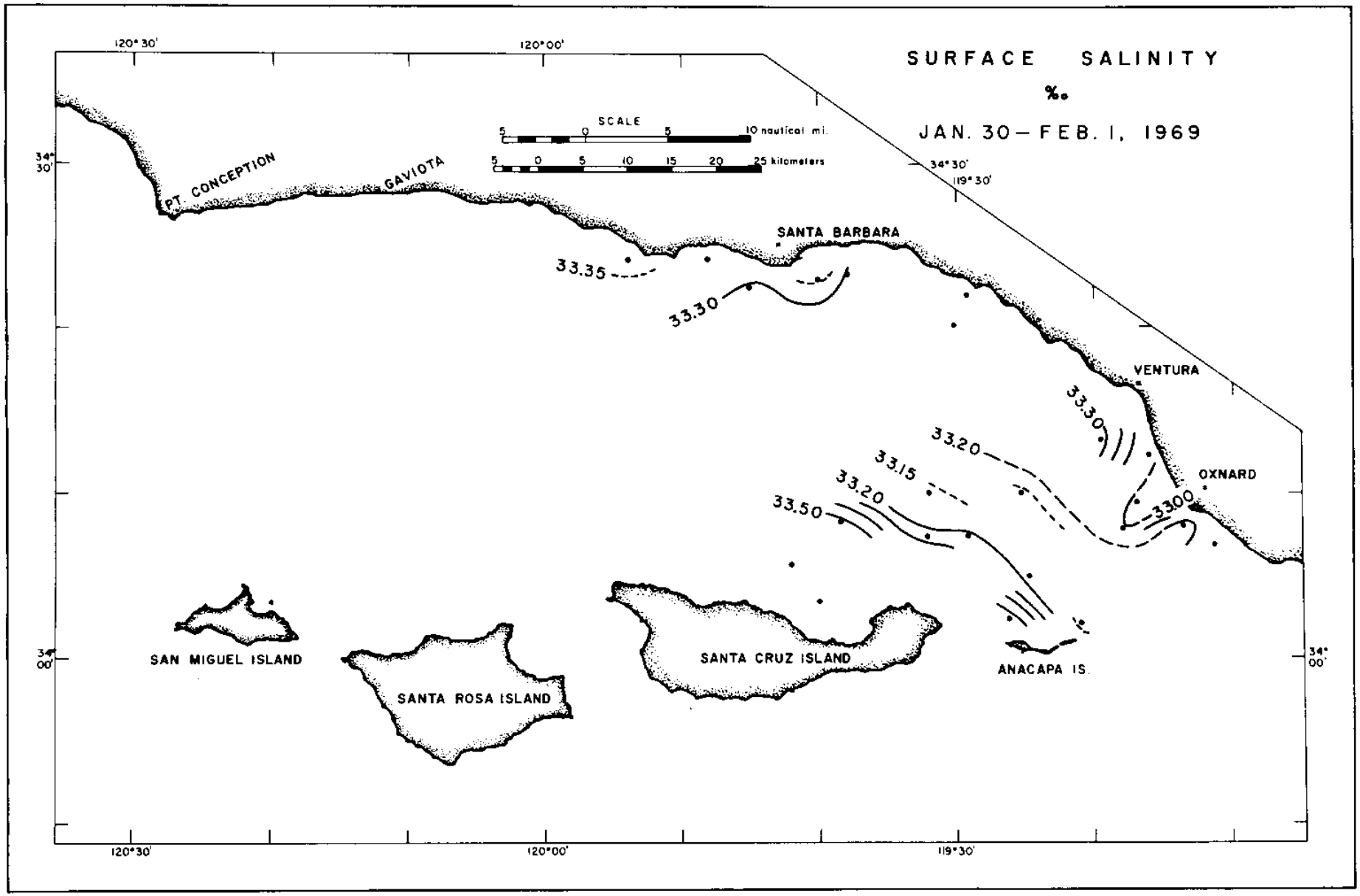

SURFACE CURRENTS
UNWEIGHTED DRIFT CARDS
FEBRUARY, 1970
= 25 % RECOVERY
PT CONCEPTION
SANTA BARBARA
SAN MIGUEL
SANTA ROSA
SANTA CRUZ
ANACAPA
120°20′
119°40′
34° 40′
34° 20′
34° 00′
120°40′
120°00′
119°20′

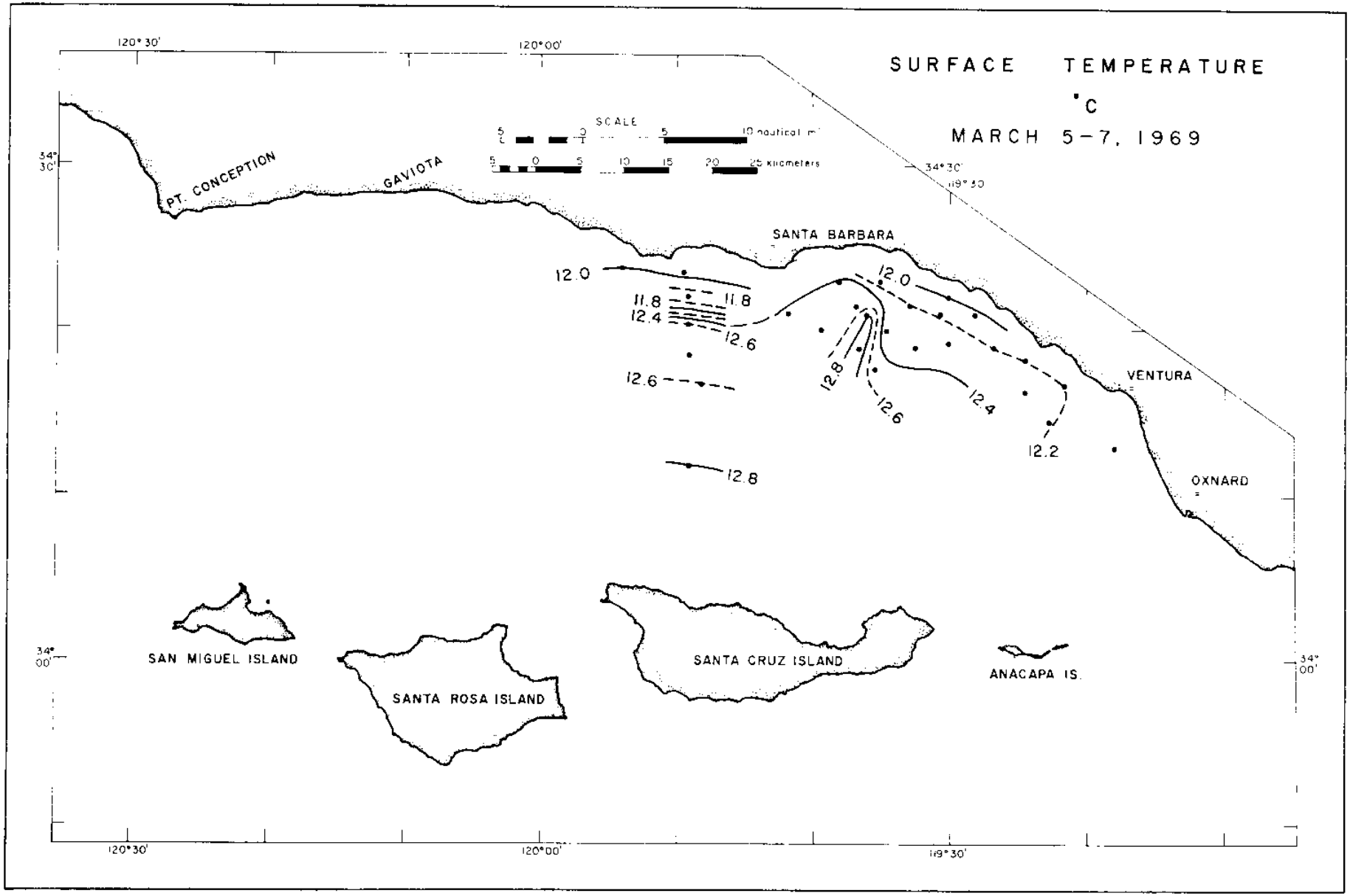
Figures 19-25. Surface water temperature and salinity values provided by David Drake for the period prior to the first hydrographic cruise in May, 1969.

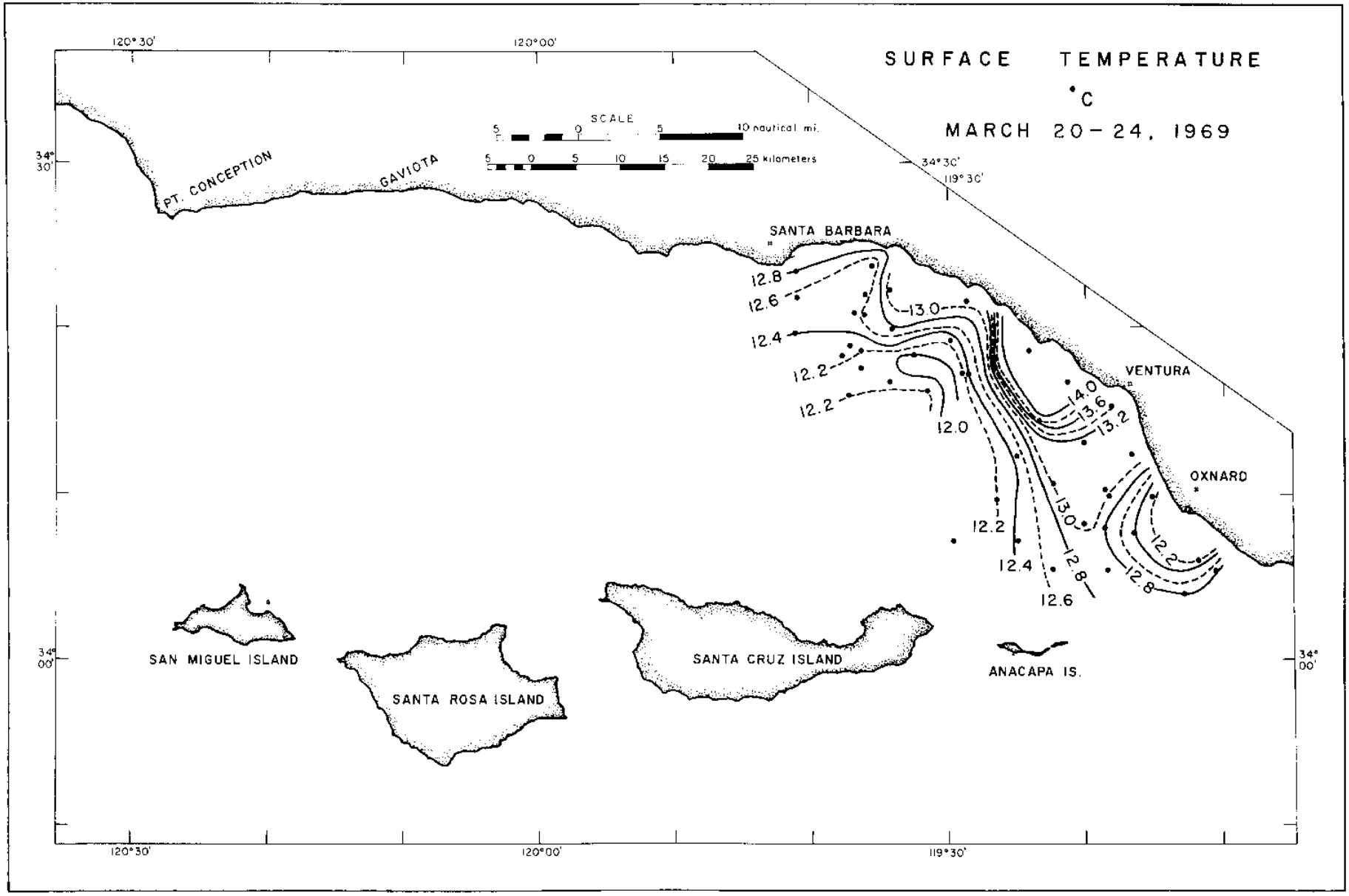

SURFACE TEMPERATURE
°C
DECEMBER 18 - 21, 1968
SCALE
10 nautical m
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS
12.2
12.6
13.0
12.8
13.2
13.2
13.6
13.6
14.0
14.2
14.6
13.8
120°30'
120°00'
119°30'
34°30'
34°00'


SURFACE TEMPERATURE
°C
JANUARY 20-23, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
14.0
14.5
13.5


SURFACE TEMPERATURE
°C
JAN. 30 – FEB. 1, 1969
SCALE
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
13.2
13.4
13.6
13.8
14.0
120°30'
120°00'
119°30'
34°30'
34°00'


SURFACE SALINITY
‰
JAN. 30 – FEB. 1, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
33.35
33.30
33.30
33.20
33.15
33.20
33.50
33.00
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.


SURFACE TEMPERATURE
°C
MARCH 5-7, 1969
SCALE
10 nautical mi
25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
12.0
11.8
12.4
12.6
12.8
12.2
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.


SURFACE TEMPERATURE
°C
MARCH 20-24, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
34°30'
119°30'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
12.8
12.6
12.4
12.2
12.2
12.0
13.0
14.0
13.6
13.2
13.0
12.8
12.6
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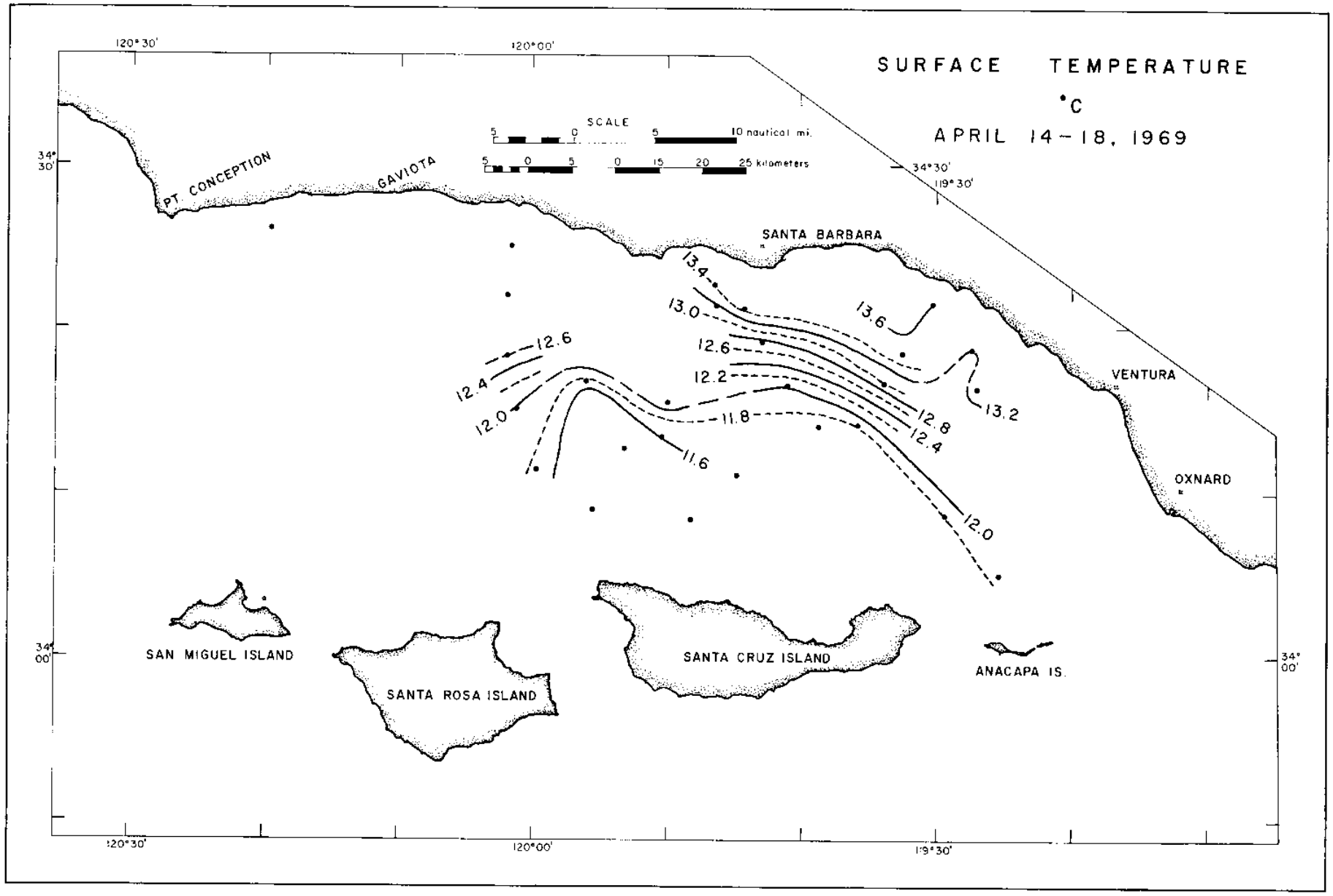
12.2
12.2
12.8


SURFACE TEMPERATURE
°C
APRIL 14-18, 1969
SCALE
10 nautical mi.
25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
13.4
13.0
12.6
12.2
11.8
11.6
12.8
12.4
12.0
13.6
13.2

and the highest temperatures were recorded in August, 1969. The distribution of the isotherms (figs. 26-28) show that cold water entered the northwestern end of the channel during May and August; was deflected northward by the three western islands, and then moved toward Santa Barbara after converging with the northwesterly flow through the Anacapa-Pt. Hueneme passage. This area is a zone of strong and complex surface currents as is evident during ship operations in the area. Temperature values indicate upwelling in the nearshore area west of Gaviota during May and August but salinity values (figs. 29-31) are not definitive. The nearshore area between Santa Barbara and Ventura is consistently an area of warmer water. The pattern in the western portion of the channel is slightly different during December, 1969 as compared to May and August. The modification appears to be a result of a southward deflection and partial entrainment of warmer water flowing toward the west along the northwestern coast of the channel.

Nutrients

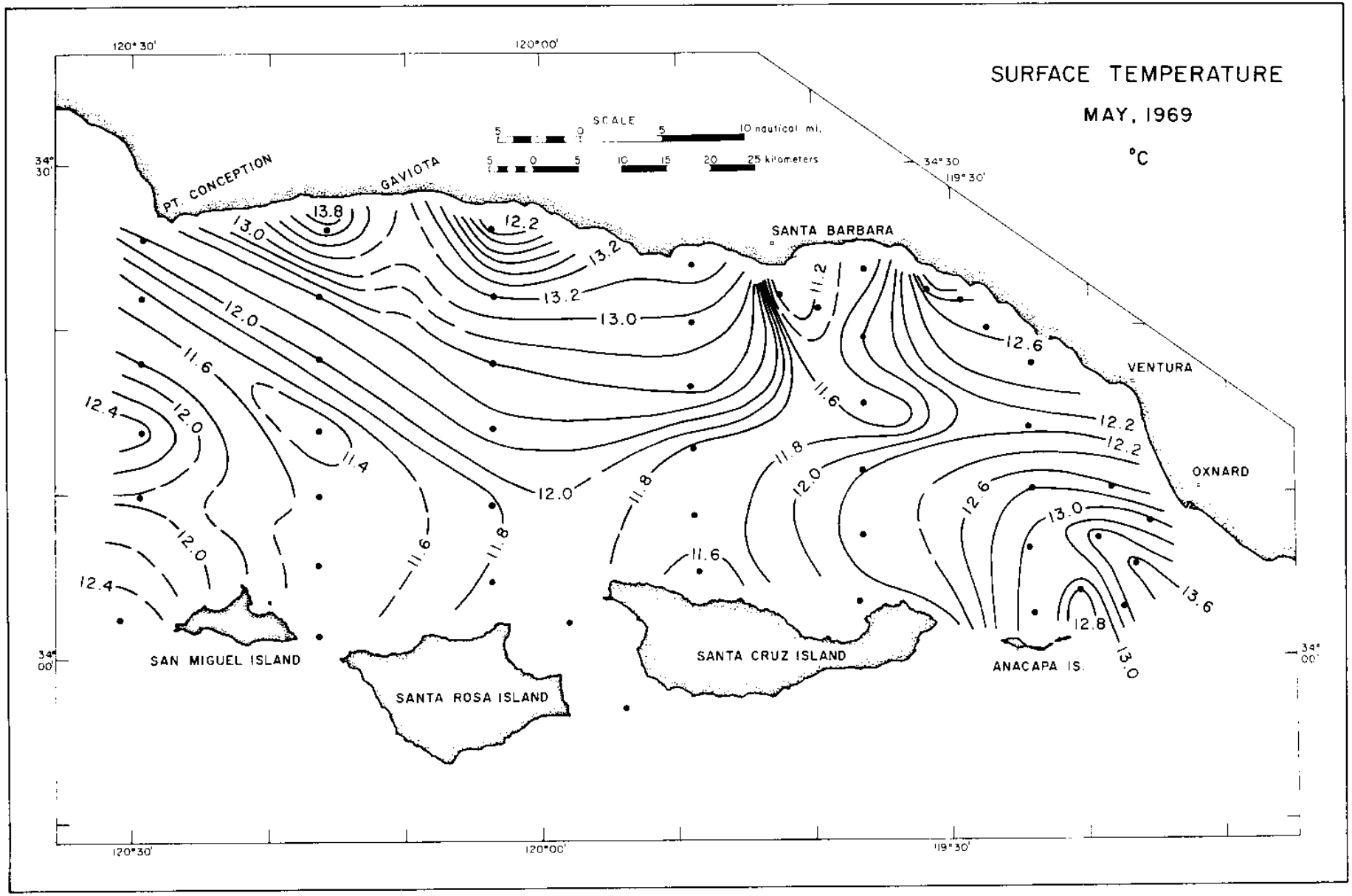
Inspection of surface water nutrient values (figs. 32-46) shows that the highest values occurred in May and the lowest in December, 1969. The distribution of silicate and phosphate is intimately related to the circulation patterns developed from temperature, salinity and drift card analyses. Nitrate and nitrite distributions are less clearly defined but nevertheless show the same trend.

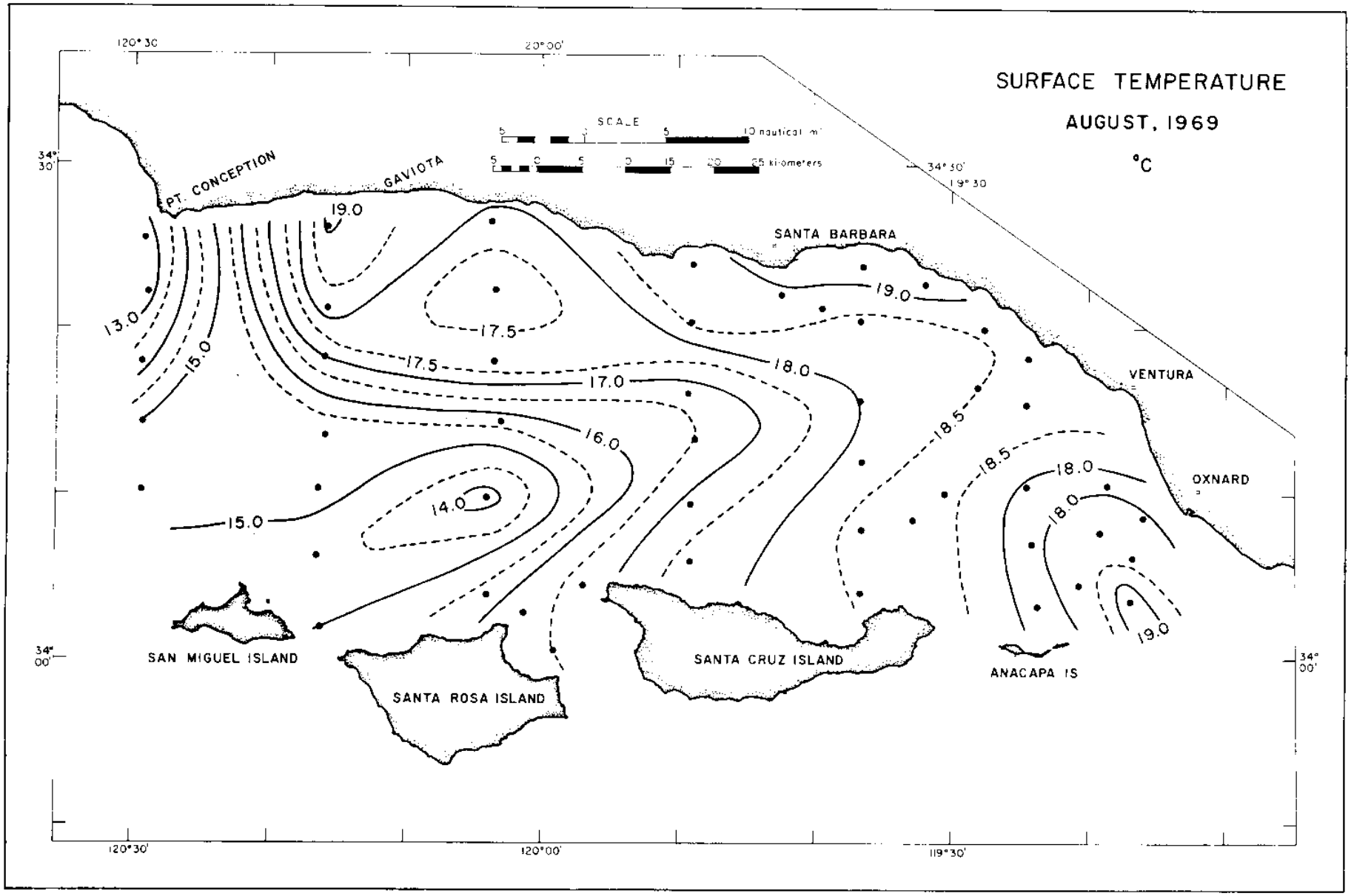
SUBSURFACE WATER CHARACTERISTICS

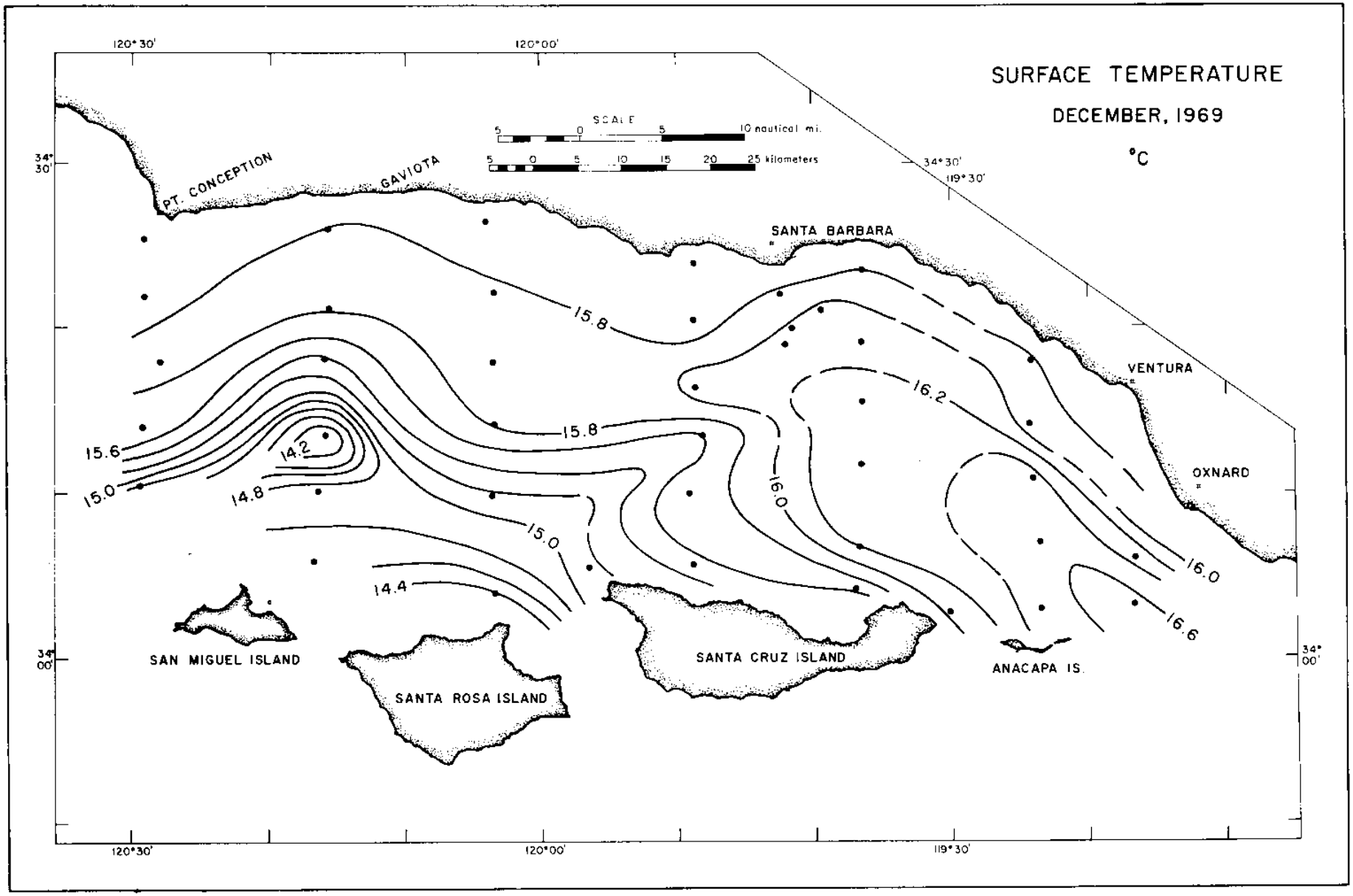
Representative cross sections of temperature, salinity, oxygen, oxygen saturation and nutrient values (figs. 47-68) depict variations within the water column and the effect of bottom topography. The relationship between bottom temperatures and salinity and bottom topography is illustrated in figures 69-71.

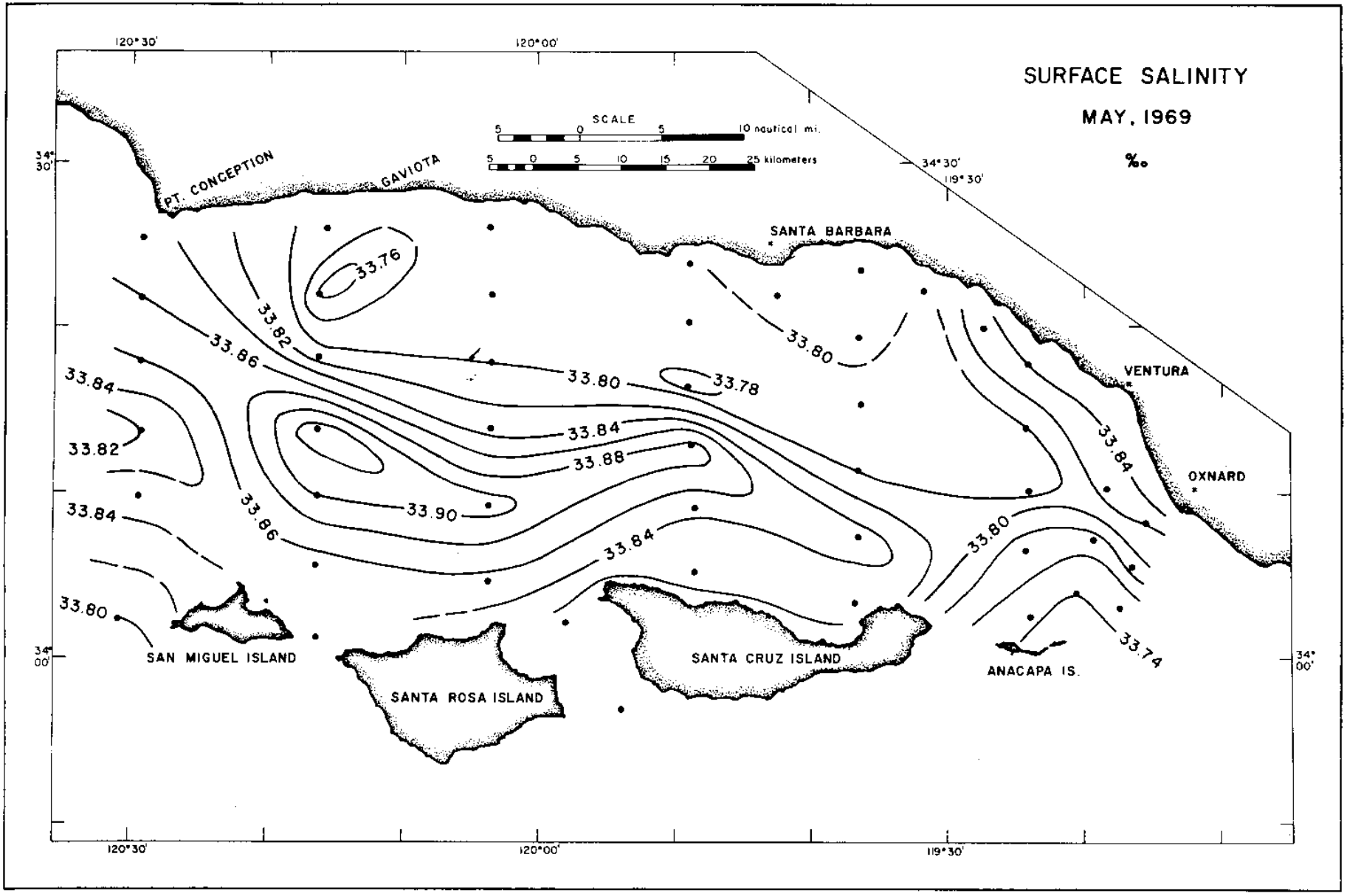
A thorough description of these parameters is beyond the limits of this report. Nevertheless, a portion of the information accumulated during the course of this study is presented graphically in order to allow the technically oriented reader to better judge some of the interpretations presented in other sections of this report. It is obvious that the largest variations occur within the

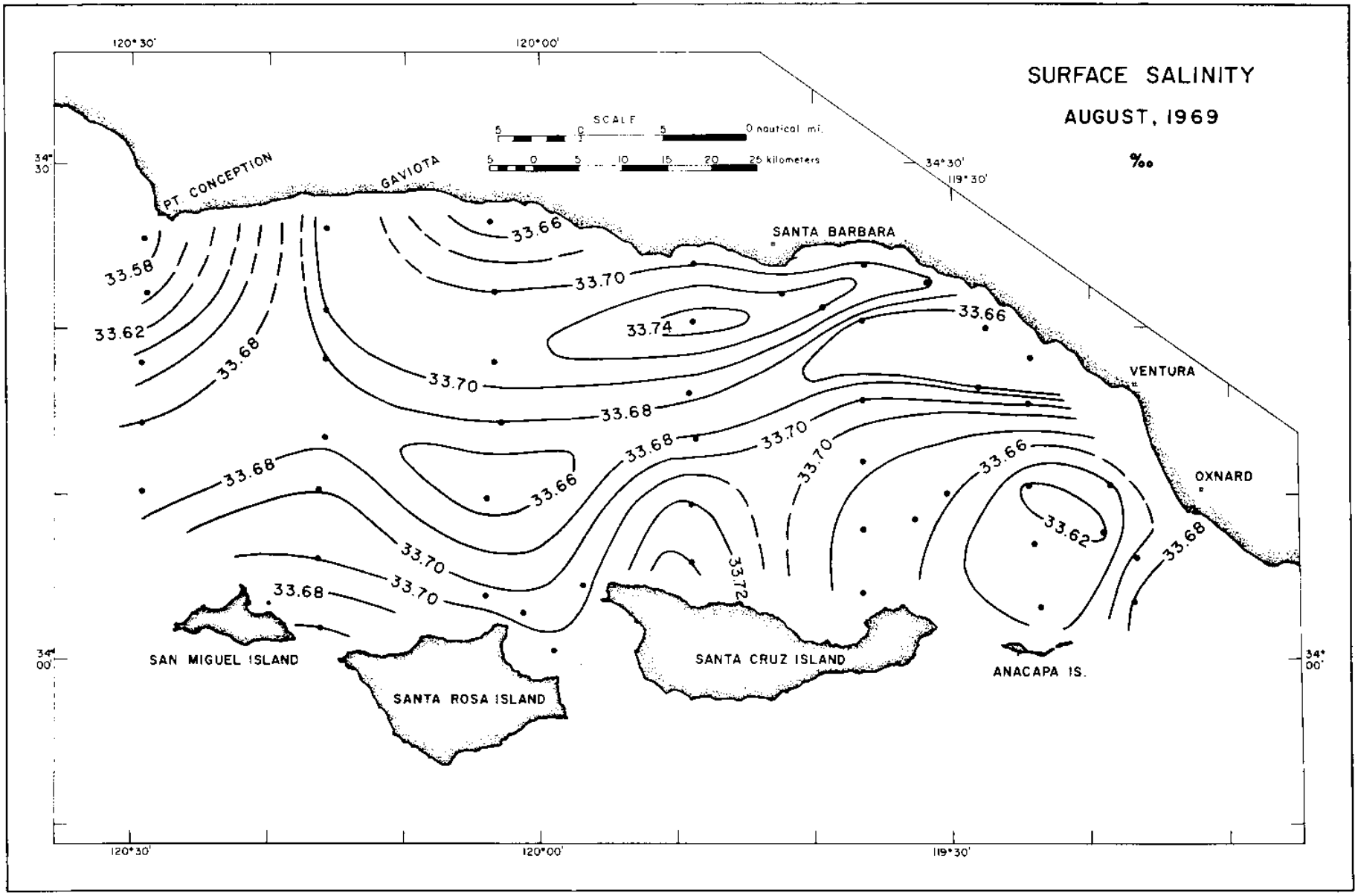
Figures 26-31. Surface water isotherms and isohalines for May, August and December, 1969.

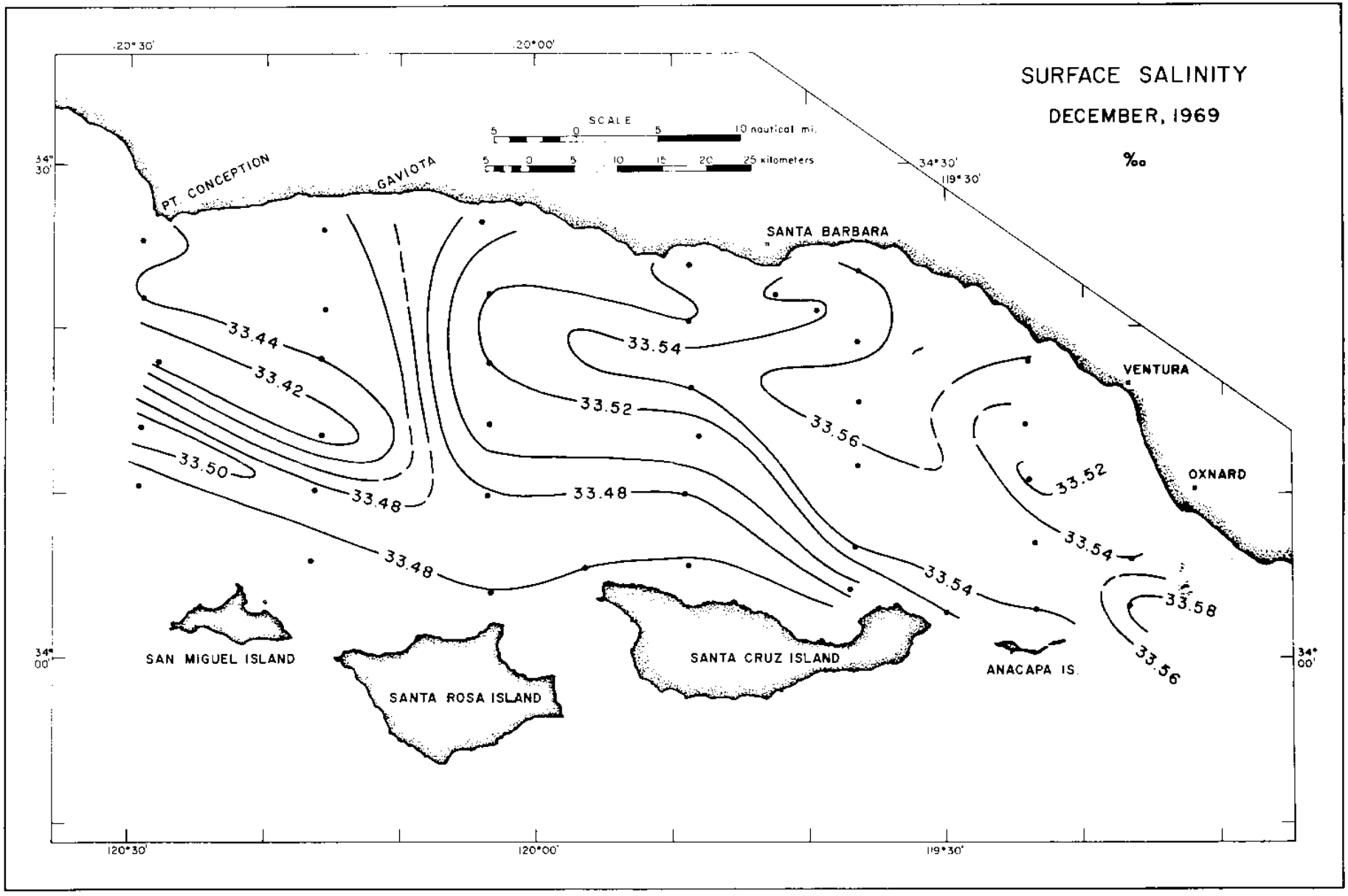

SURFACE TEMPERATURE
MAY, 1969
°C
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
13.8
13.0
12.2
13.2
13.2
13.0
11.2
12.6
12.0
11.6
12.4
12.0
11.4
12.0
11.8
11.6
12.2
12.2
11.8
12.0
12.6
13.0
12.0
11.6
11.8
12.4
11.6
13.6
12.8
13.0


SURFACE TEMPERATURE
AUGUST, 1969
°C
SCALE
10 nautical mi
kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS
120°30'
120°00'
119°30'
34° 30'
34° 00'
19.0
13.0
15.0
17.5
17.0
16.0
14.0
18.0
18.5

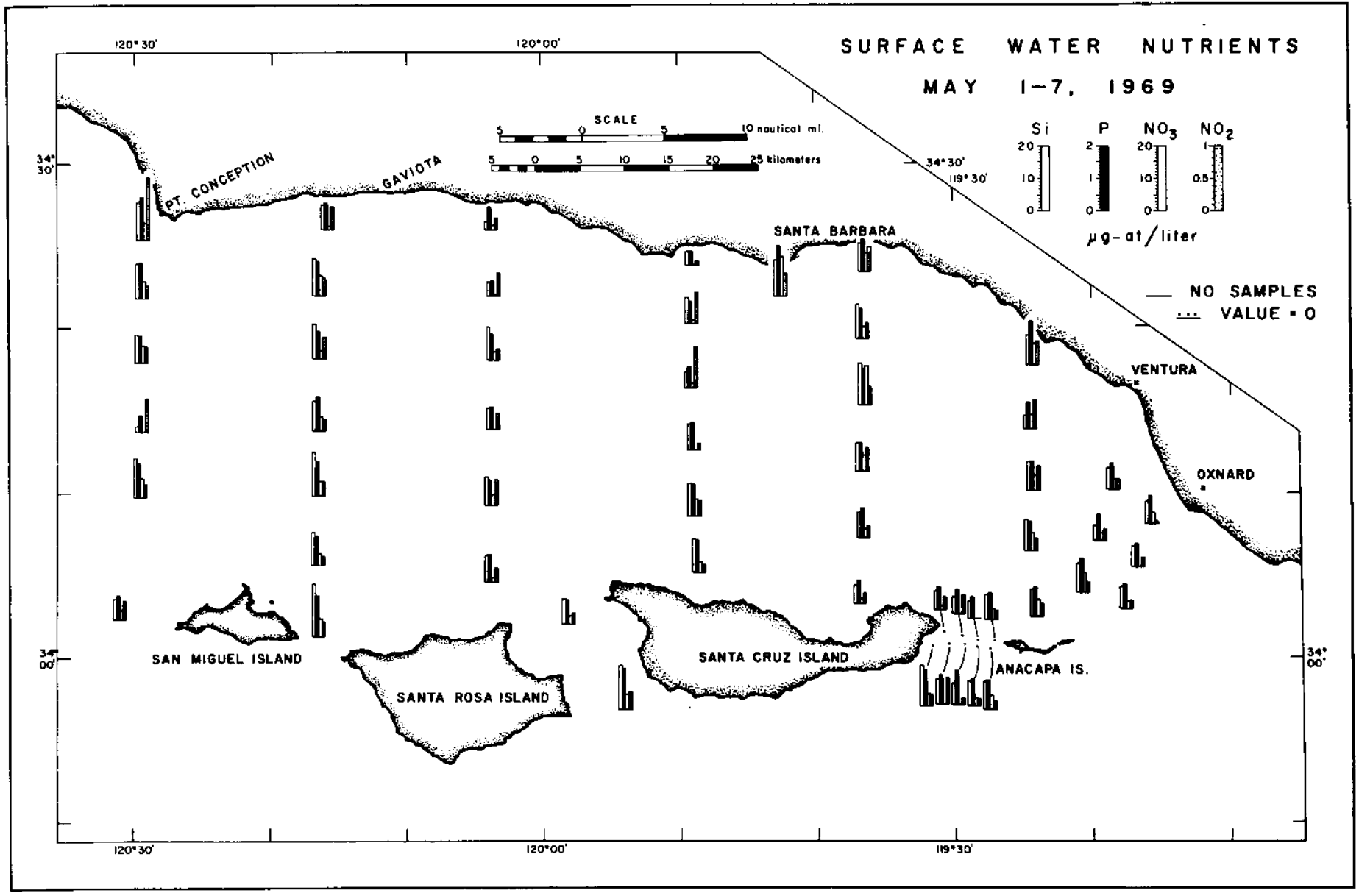

SURFACE TEMPERATURE
DECEMBER, 1969
°C
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
15.8
15.6
15.0
14.2
14.8
15.8
15.0
14.4
16.2
16.0
16.0
16.6

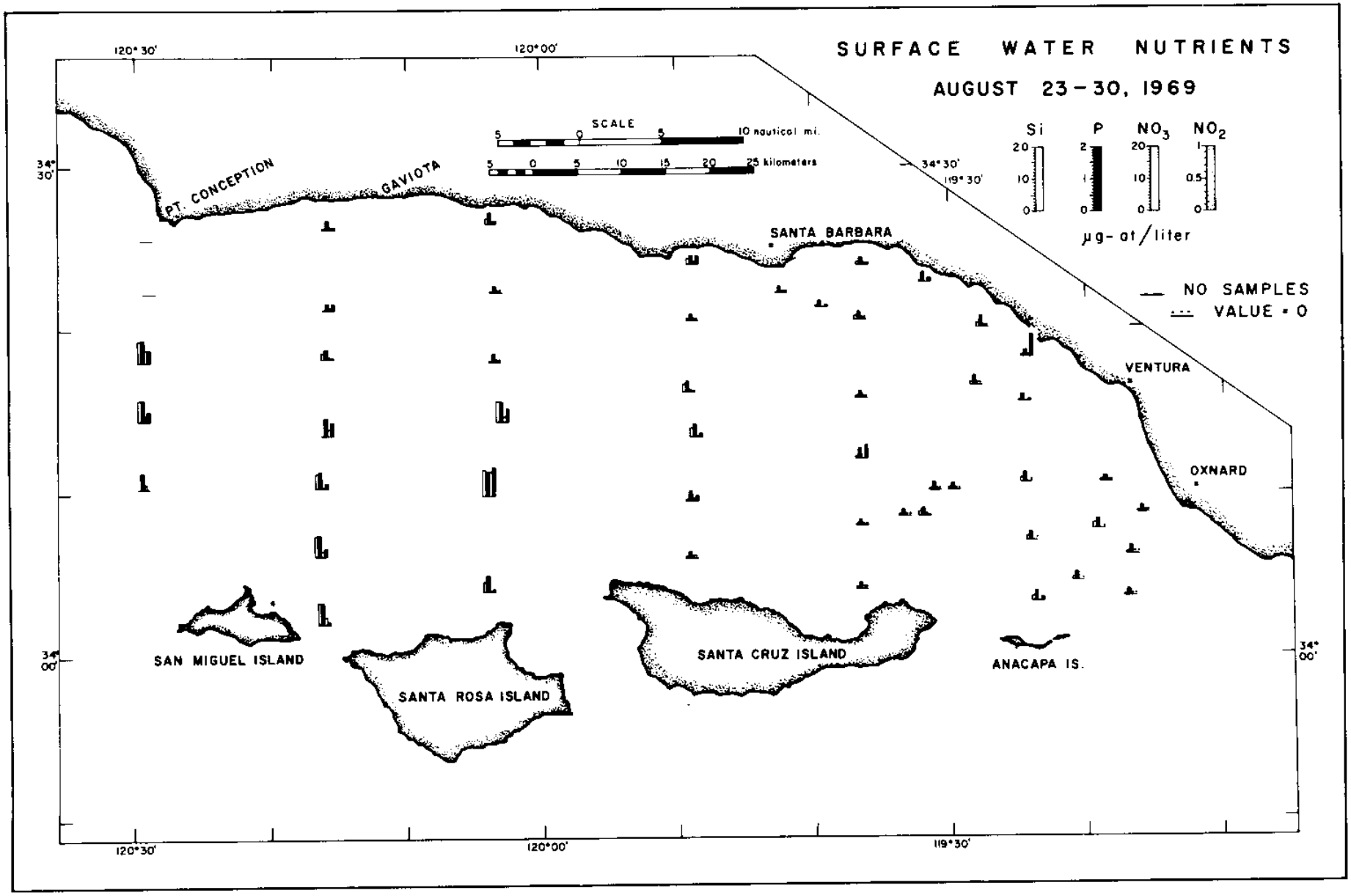

SURFACE SALINITY
MAY, 1969
‰
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
33.76
33.82
33.86
33.84
33.82
33.84
33.80
33.80
33.78
33.84
33.88
33.90
33.86
33.84
33.80
33.84
33.80
33.74

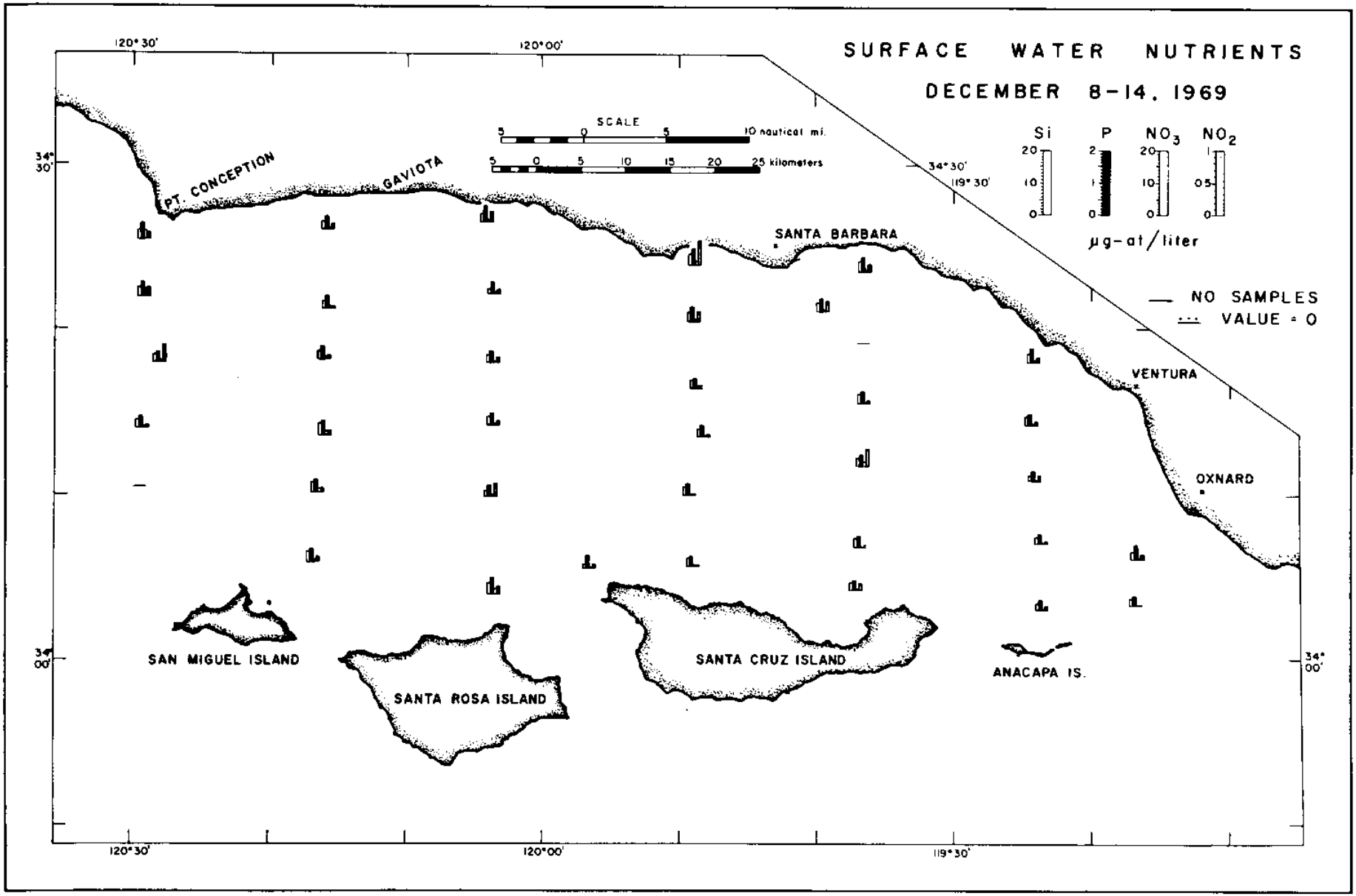

SURFACE SALINITY
AUGUST, 1969
‰
SCALE
5 0 5 0 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
33.58
33.62
33.68
33.66
33.70
33.74
33.72

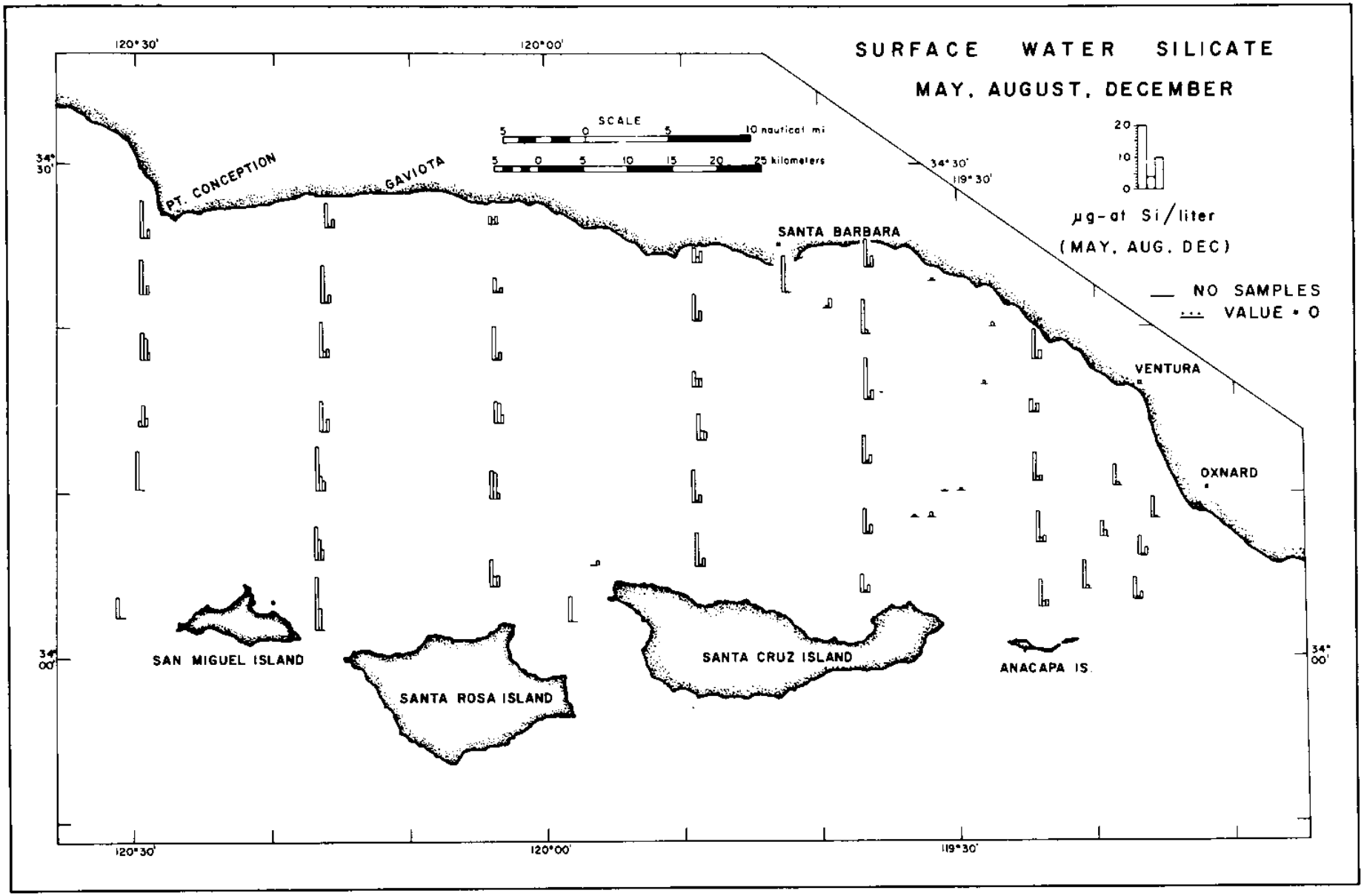

SURFACE SALINITY
DECEMBER, 1969
‰
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
33.44
33.42
33.50
33.48
33.48
33.54
33.52
33.48
33.56
33.52
33.54
33.54
33.58
33.56

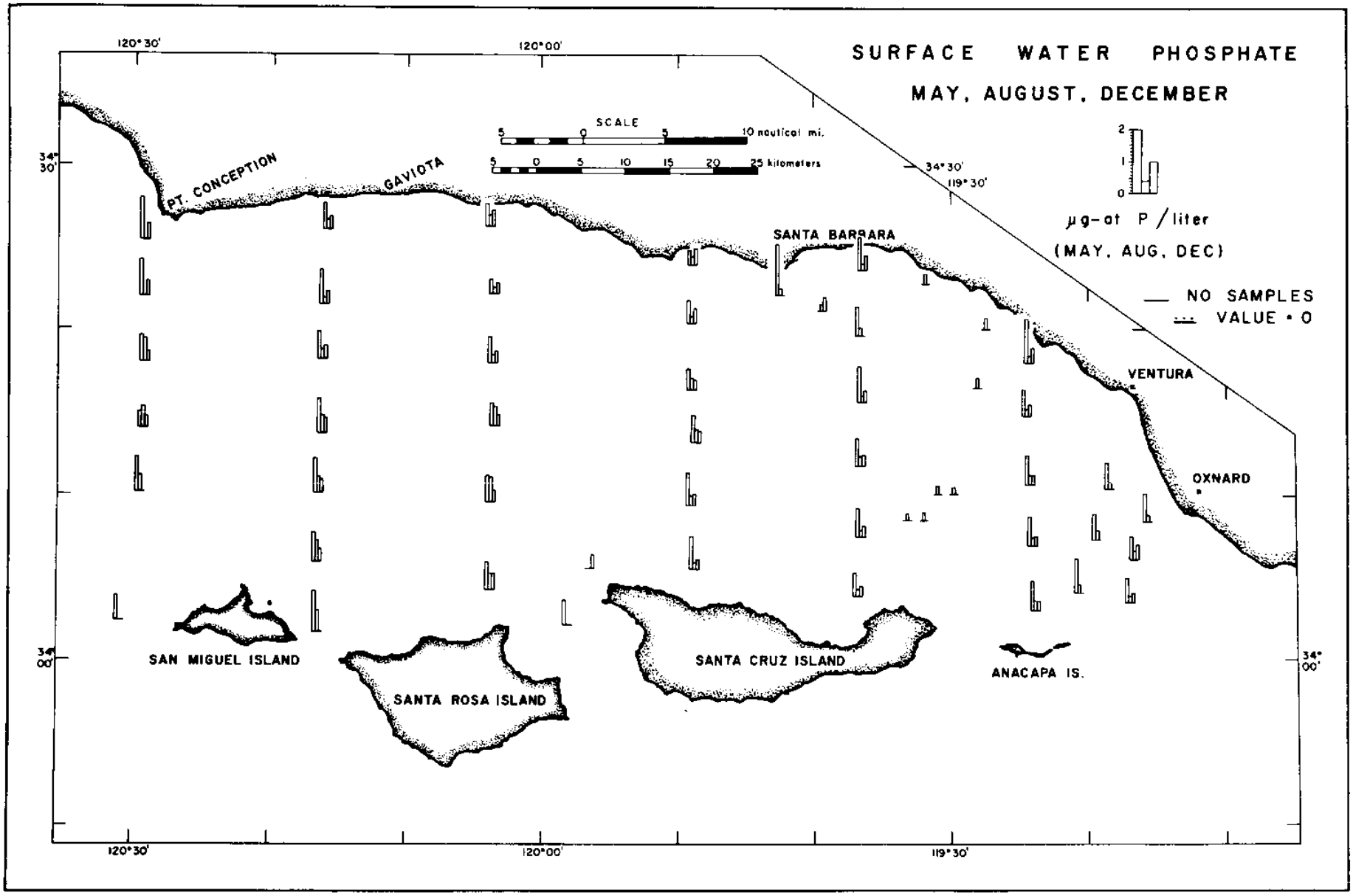
Figures 32-38. Bar graphs of surface water nutrient values. The center of the base line is the station position. A value of zero is depicted by a dot over the horizontal line. Note scale changes for nutrient values. Figures 32-34 illustrate nutrient variations for May, August and December cruises. Figures 35-38 illustrate seasonal variations for each nutrient analyzed.

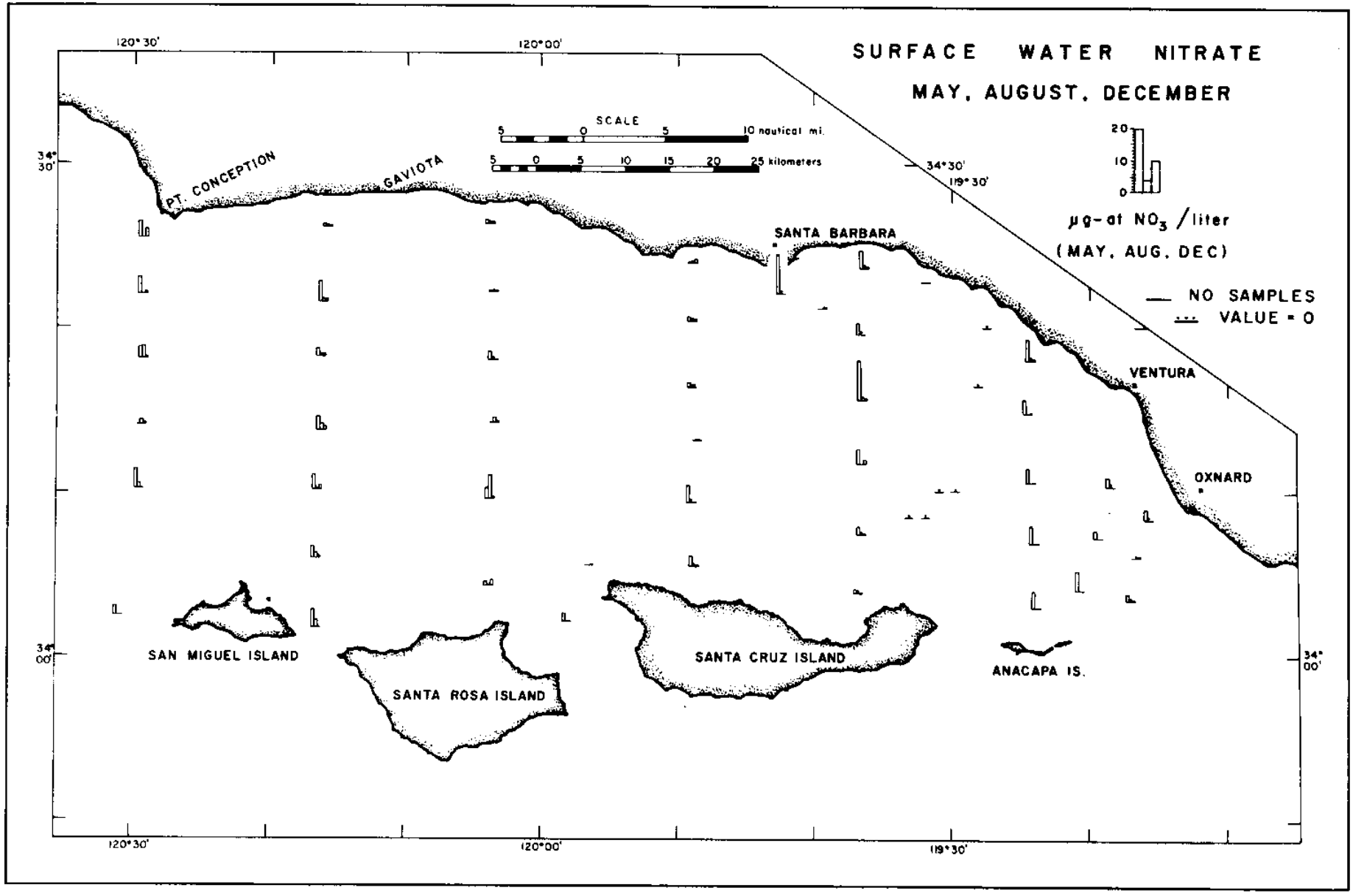

SURFACE WATER NUTRIENTS
MAY 1-7, 1969
Si
P
NO3
NO2
μg-at/liter
NO SAMPLES
VALUE = 0
SCALE
10 nautical mi.
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'

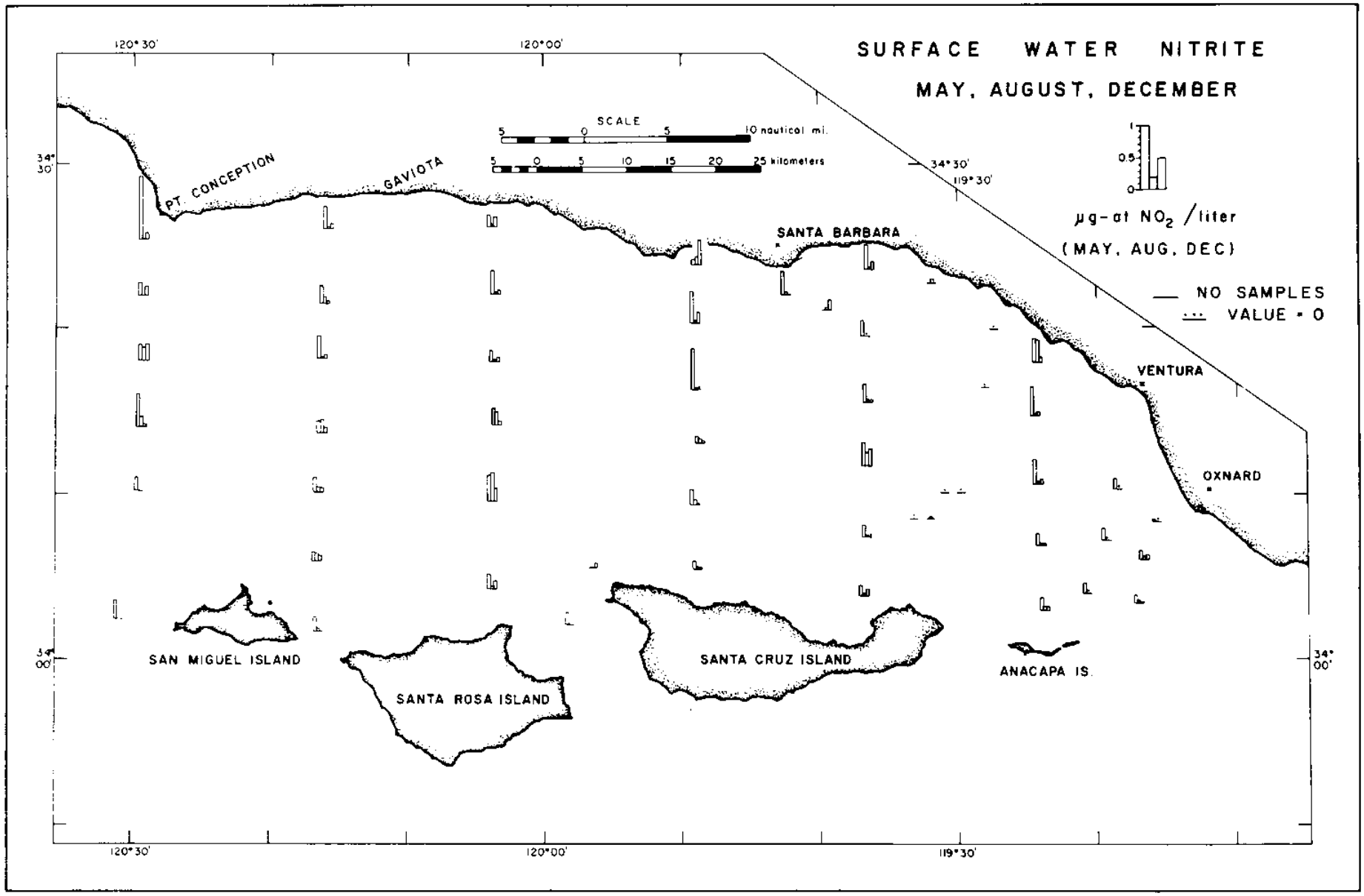

SURFACE WATER NUTRIENTS
AUGUST 23-30, 1969
Si
P
NO3
NO2
μg-at/liter
NO SAMPLES
VALUE = 0
SCALE
10 nautical mi.
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'


SURFACE WATER NUTRIENTS
DECEMBER 8-14, 1969
Si
P
NO3
NO2
µg-at/liter
NO SAMPLES
VALUE = 0
SCALE
10 nautical mi.
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
120°30'
120°00'
119°30'
34°30'
34°00'

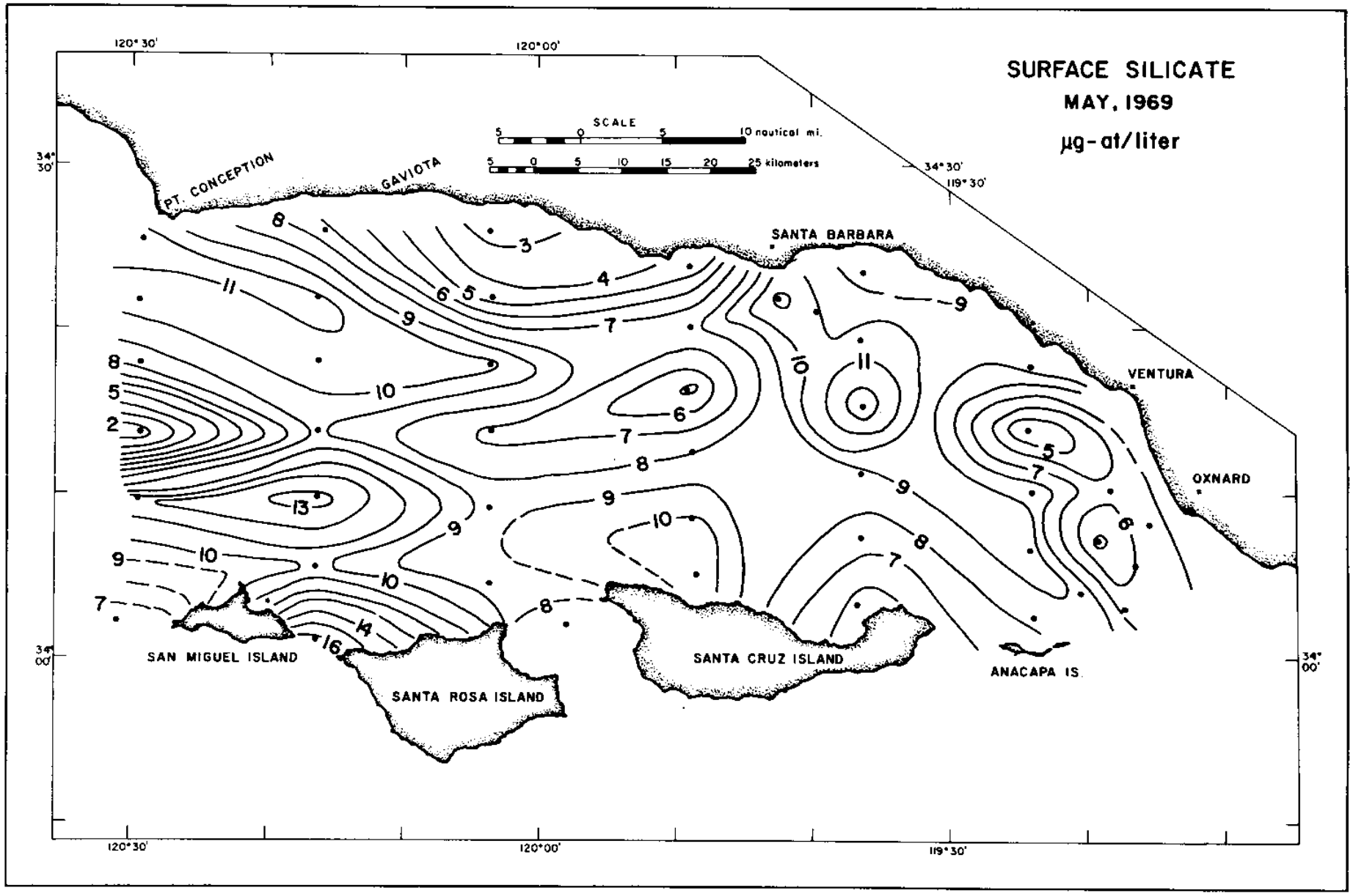

SURFACE WATER SILICATE
MAY, AUGUST, DECEMBER
SCALE
5 0 5 10 nautical mi
5 0 5 10 15 20 25 kilometers
20
10
0
µg-at Si/liter
(MAY, AUG, DEC)
NO SAMPLES
VALUE = 0
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

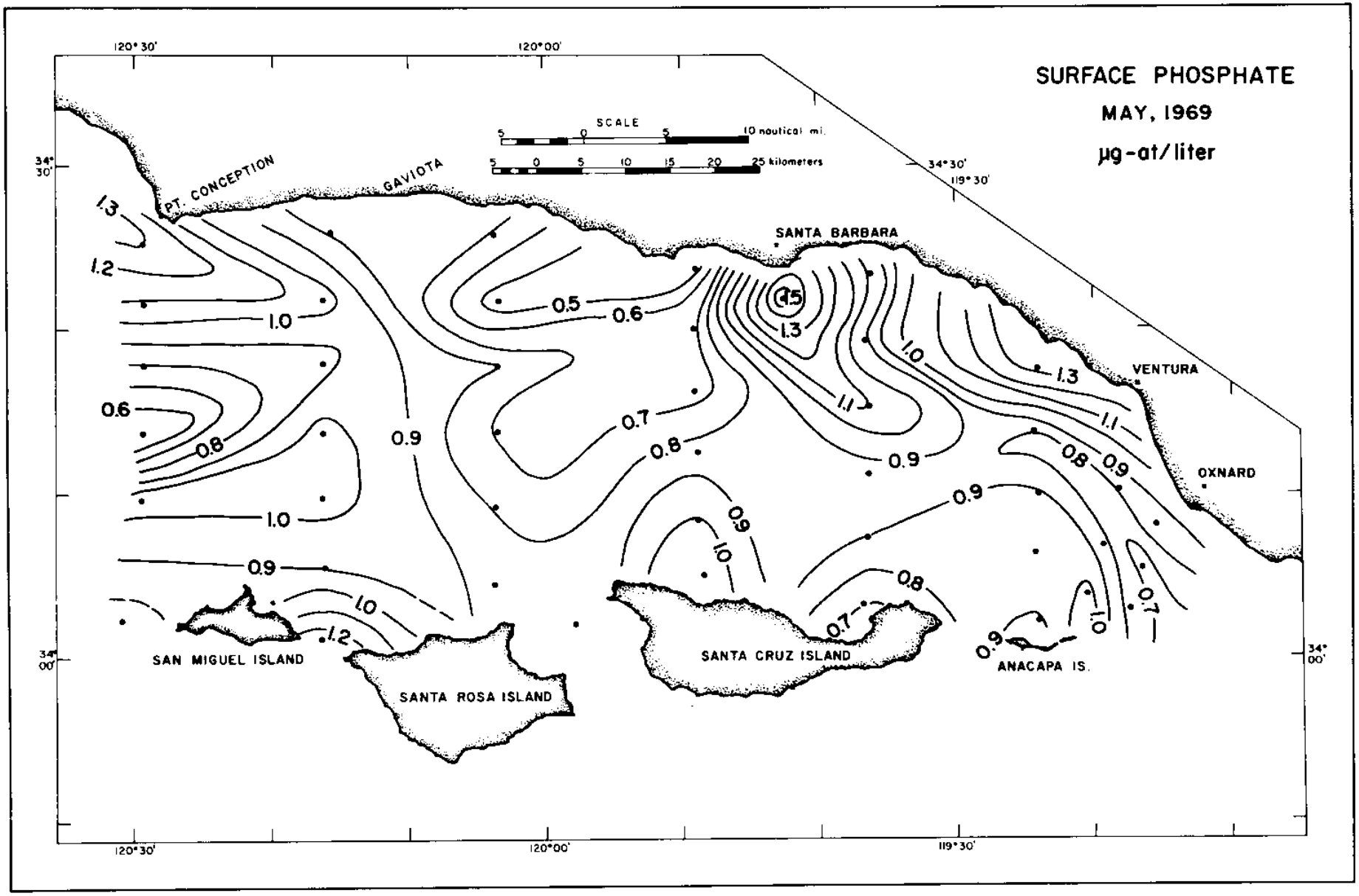

SURFACE WATER PHOSPHATE
MAY, AUGUST, DECEMBER
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
2
1
0
µg-at P / liter
(MAY, AUG, DEC)
NO SAMPLES
VALUE = 0
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

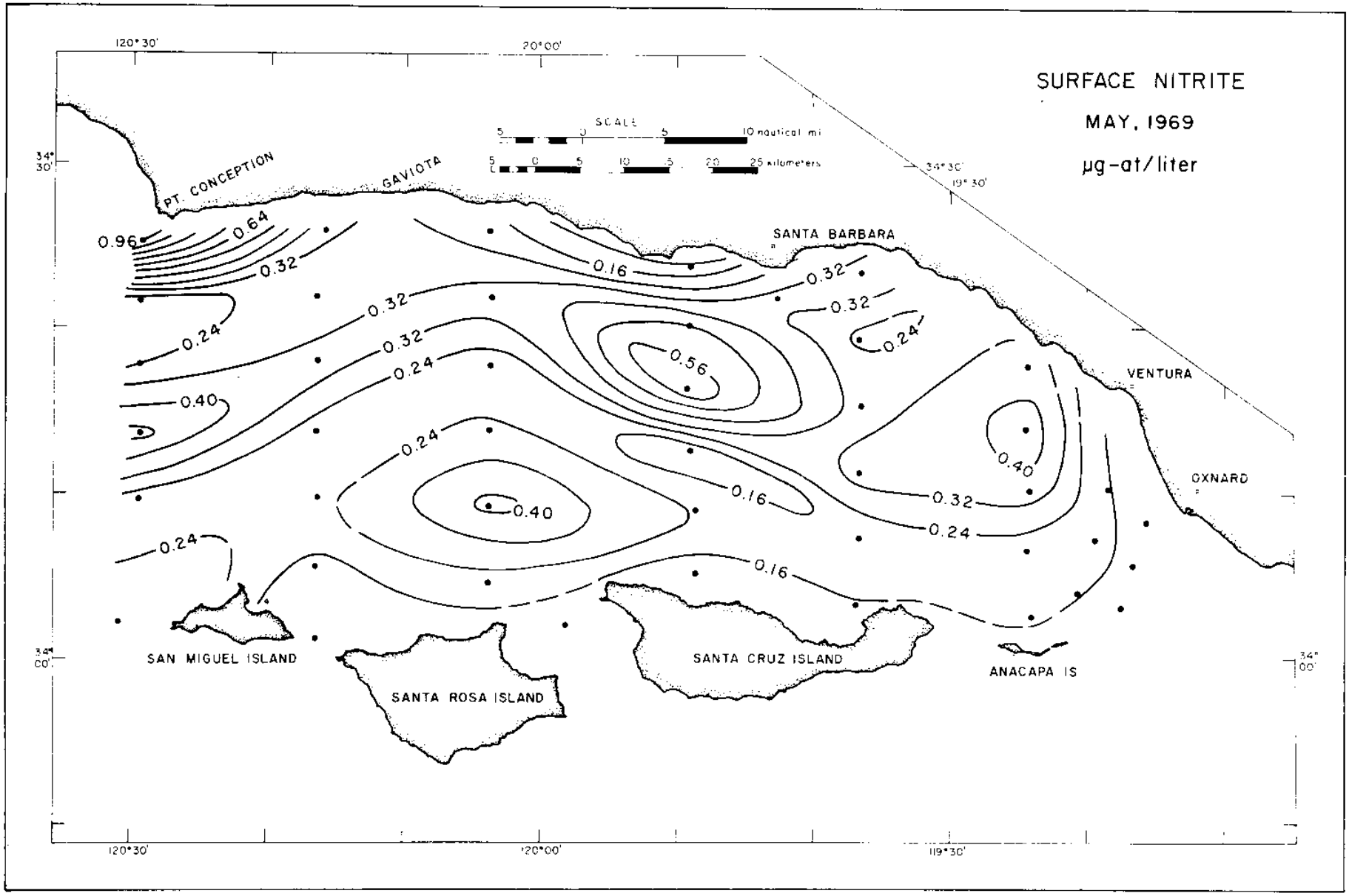

SURFACE WATER NITRATE
MAY, AUGUST, DECEMBER
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
20
10
0
µg-at NO3 /liter
(MAY, AUG, DEC)
NO SAMPLES
VALUE = 0
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

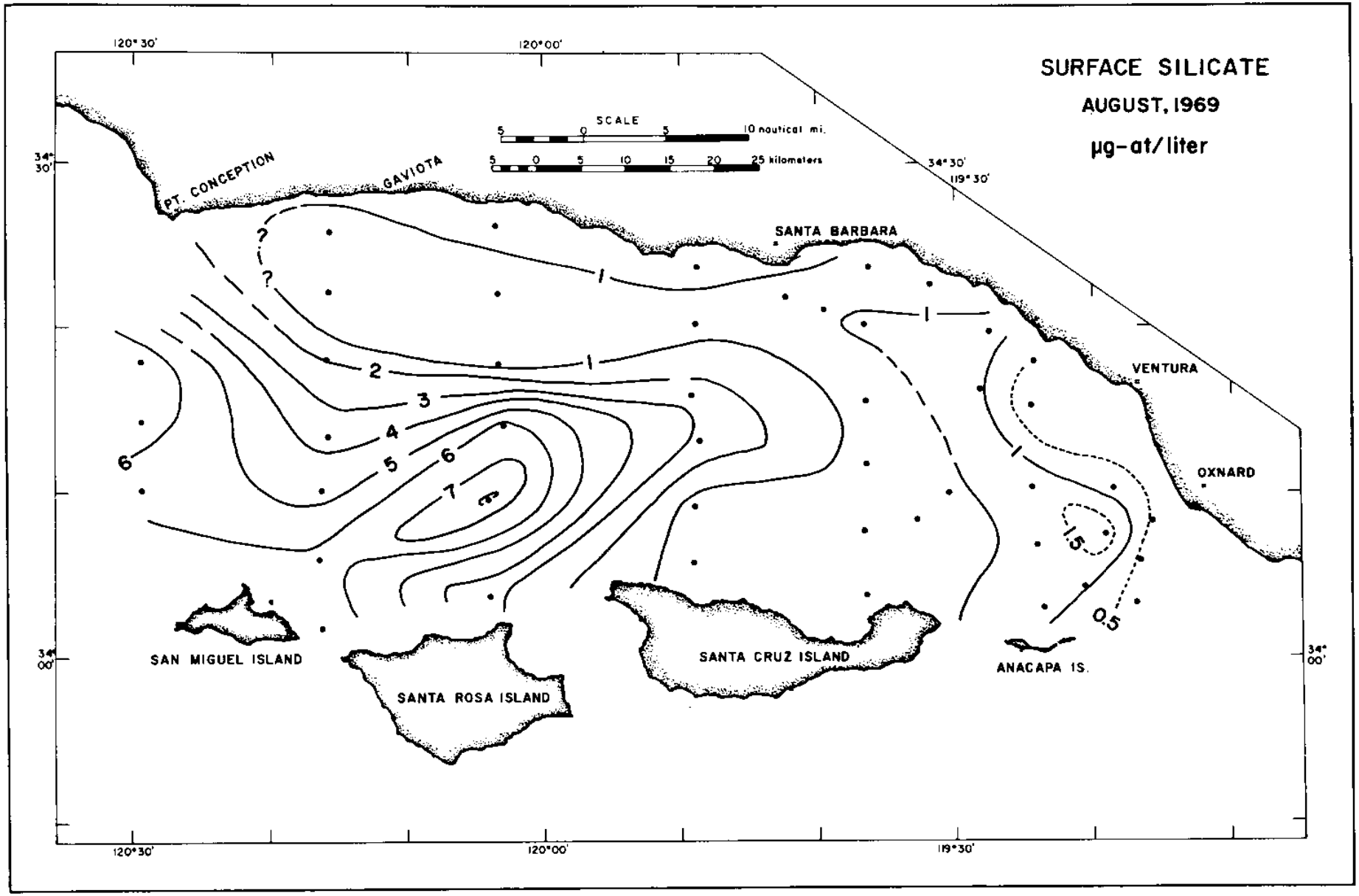

SURFACE WATER NITRITE
MAY, AUGUST, DECEMBER
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
1
0.5
0
µg-at NO_2 /liter
(MAY, AUG, DEC)
NO SAMPLES
VALUE = 0
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

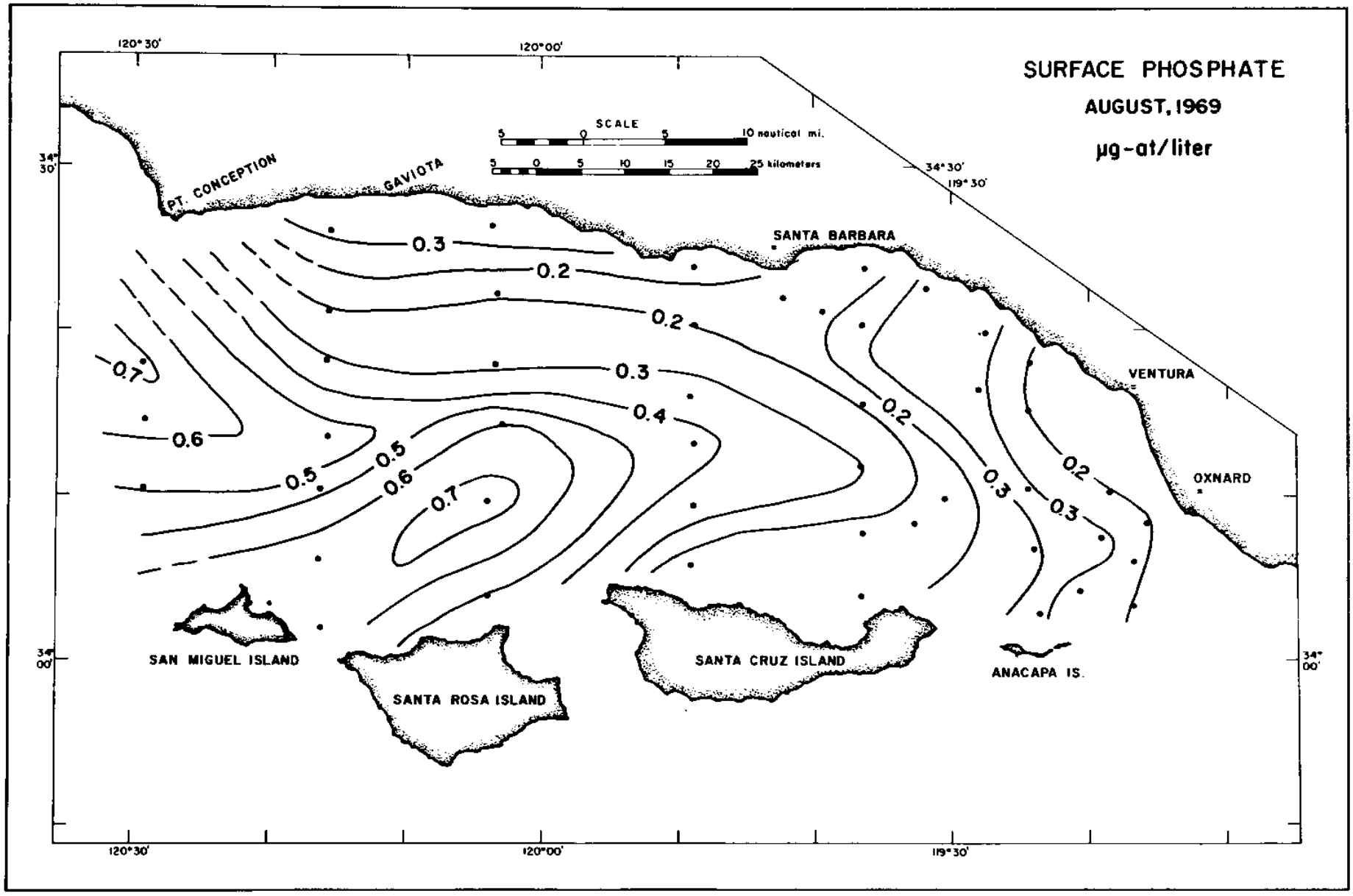
Figures 39-46. Isopleths of surface nutrient values for May, August and December, 1969.

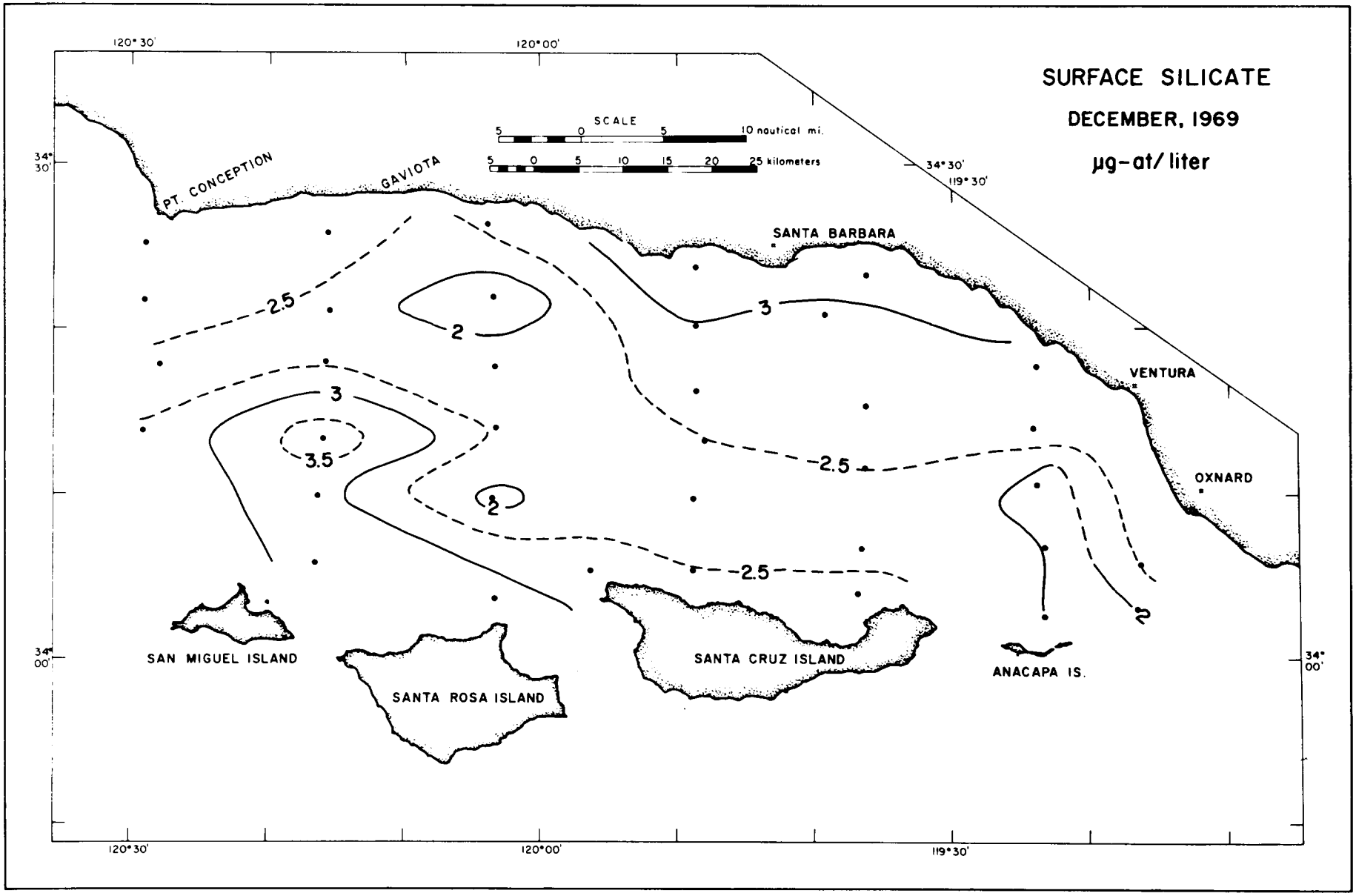

SURFACE SILICATE
MAY, 1969
µg-at/liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

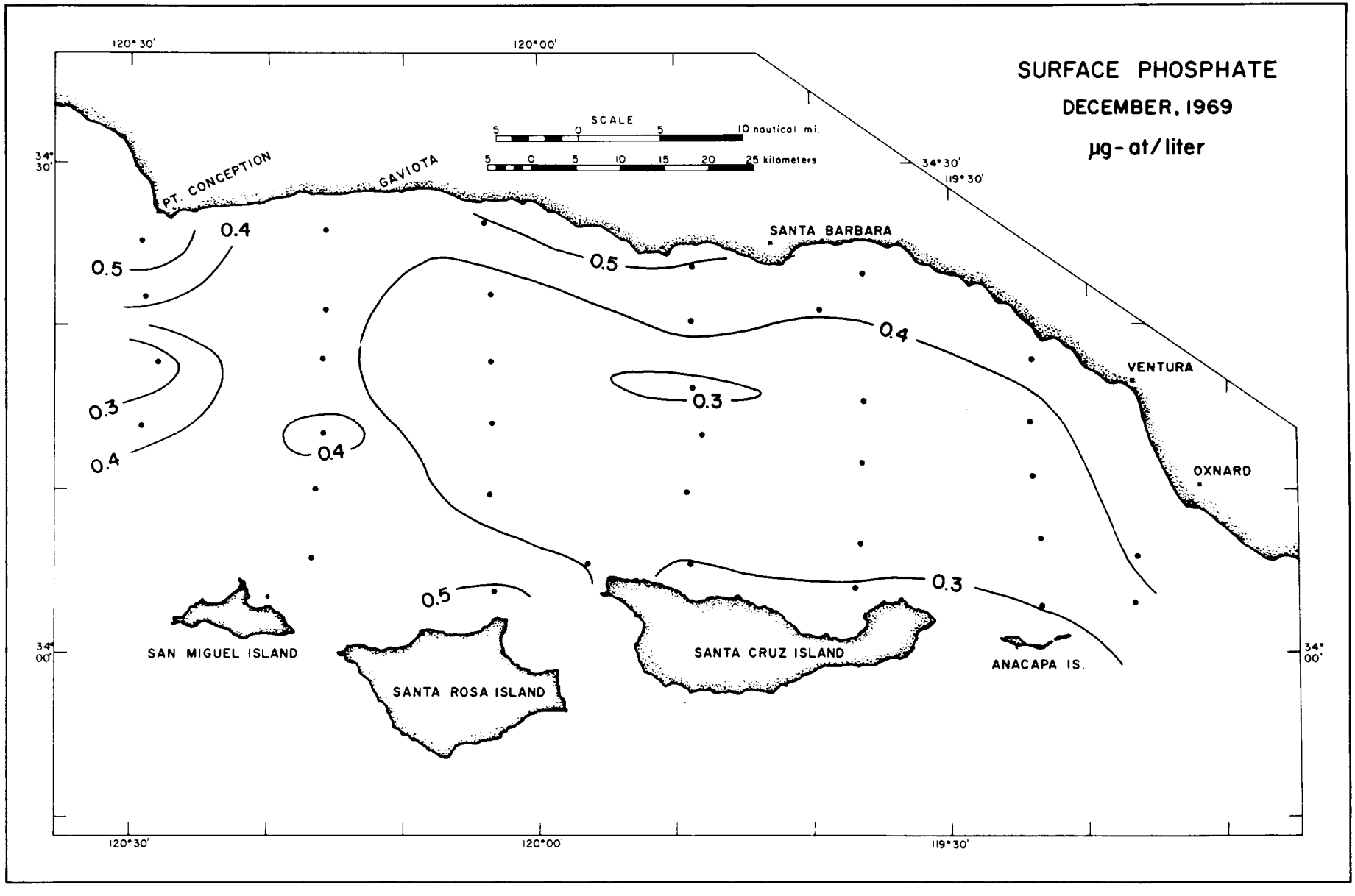

SURFACE PHOSPHATE
MAY, 1969
µg-at/liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
1.3
1.2
1.0
0.6
0.8
0.9
0.5
0.7
1.5
1.1

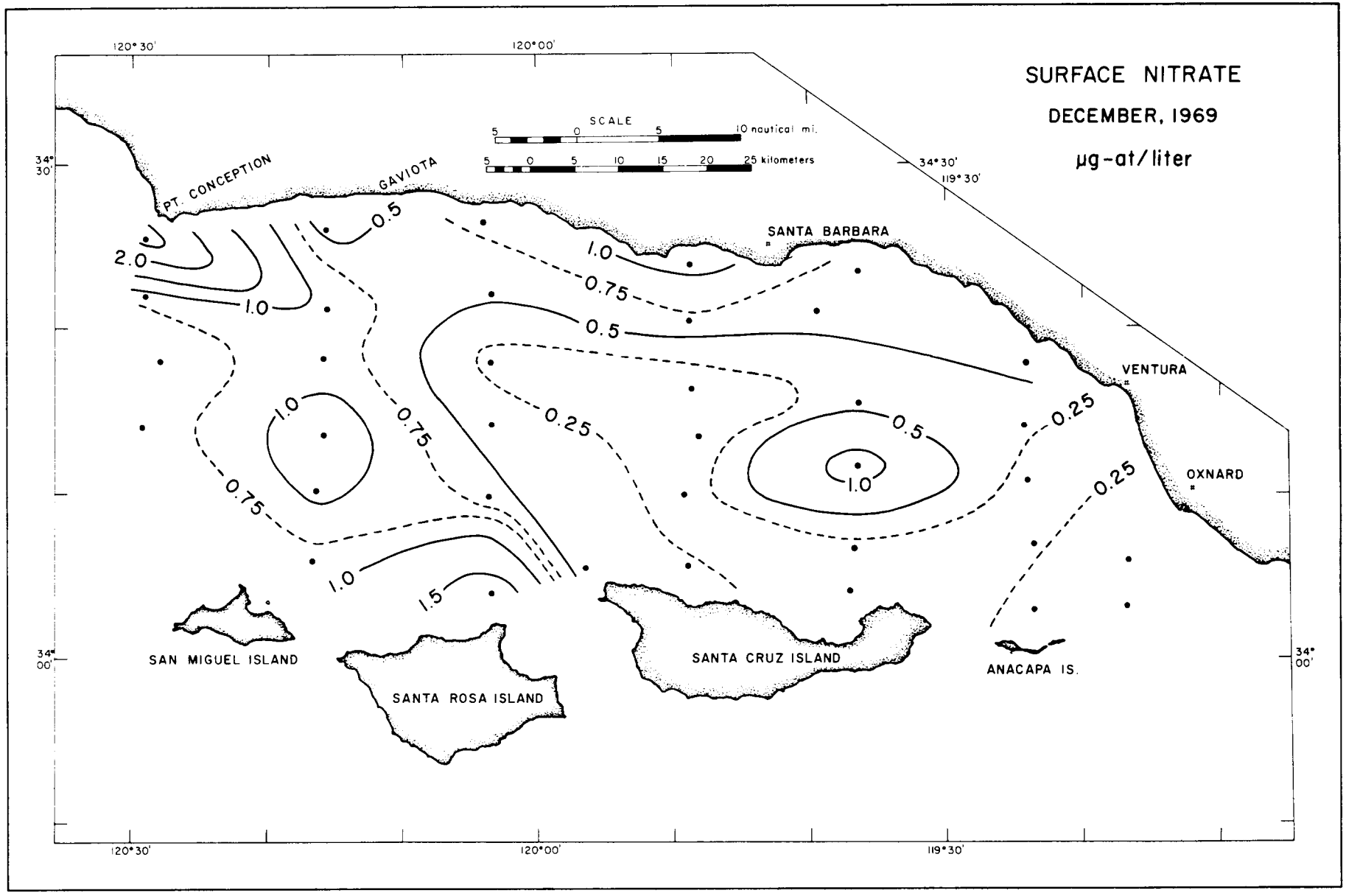

SURFACE NITRITE
MAY, 1969
µg-at/liter
SCALE
10 nautical mi
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS
0.96
0.64
0.32
0.24
0.40
0.16
0.56
120°30'
120°00'
119°30'
34°30'
34°00'


SURFACE SILICATE
AUGUST, 1969
µg-at/liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
?
1
2
3
4
5
6
7
8
1.5
0.5

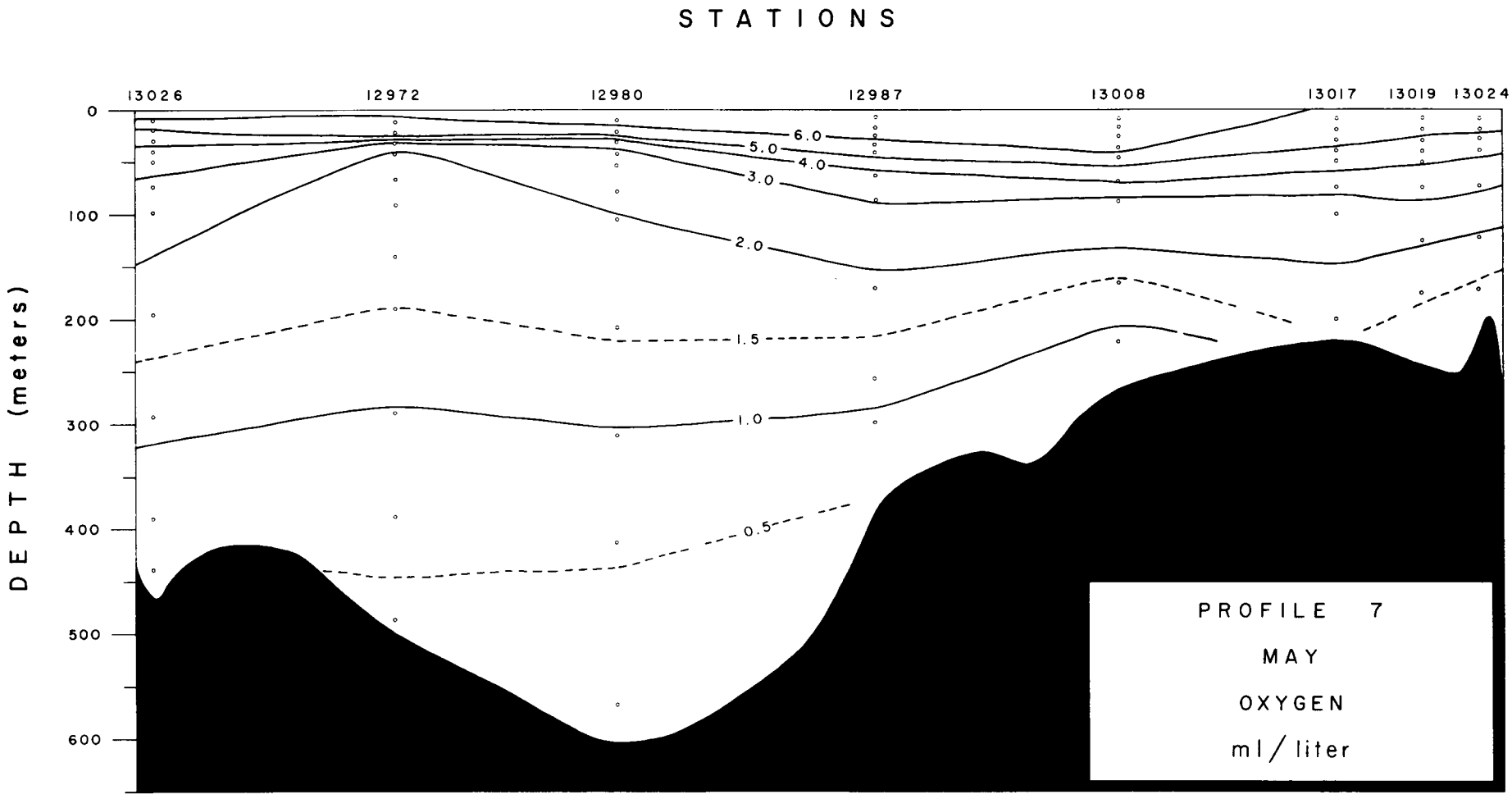

SURFACE PHOSPHATE
AUGUST, 1969
µg-at/liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
0.7
0.6
0.5
0.4
0.3
0.2

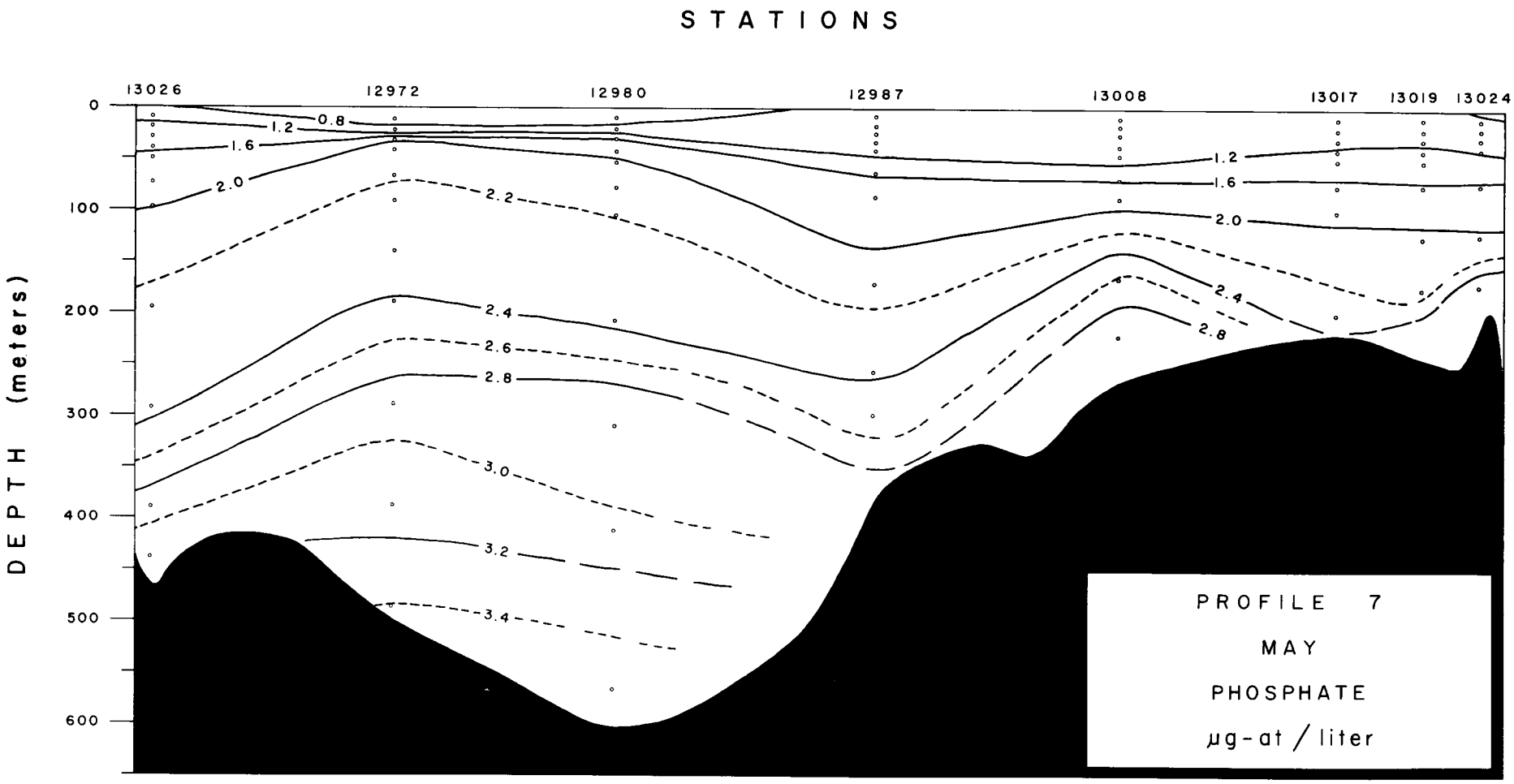

SURFACE SILICATE
DECEMBER, 1969
µg-at/ liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
2.5
2
3
3.5

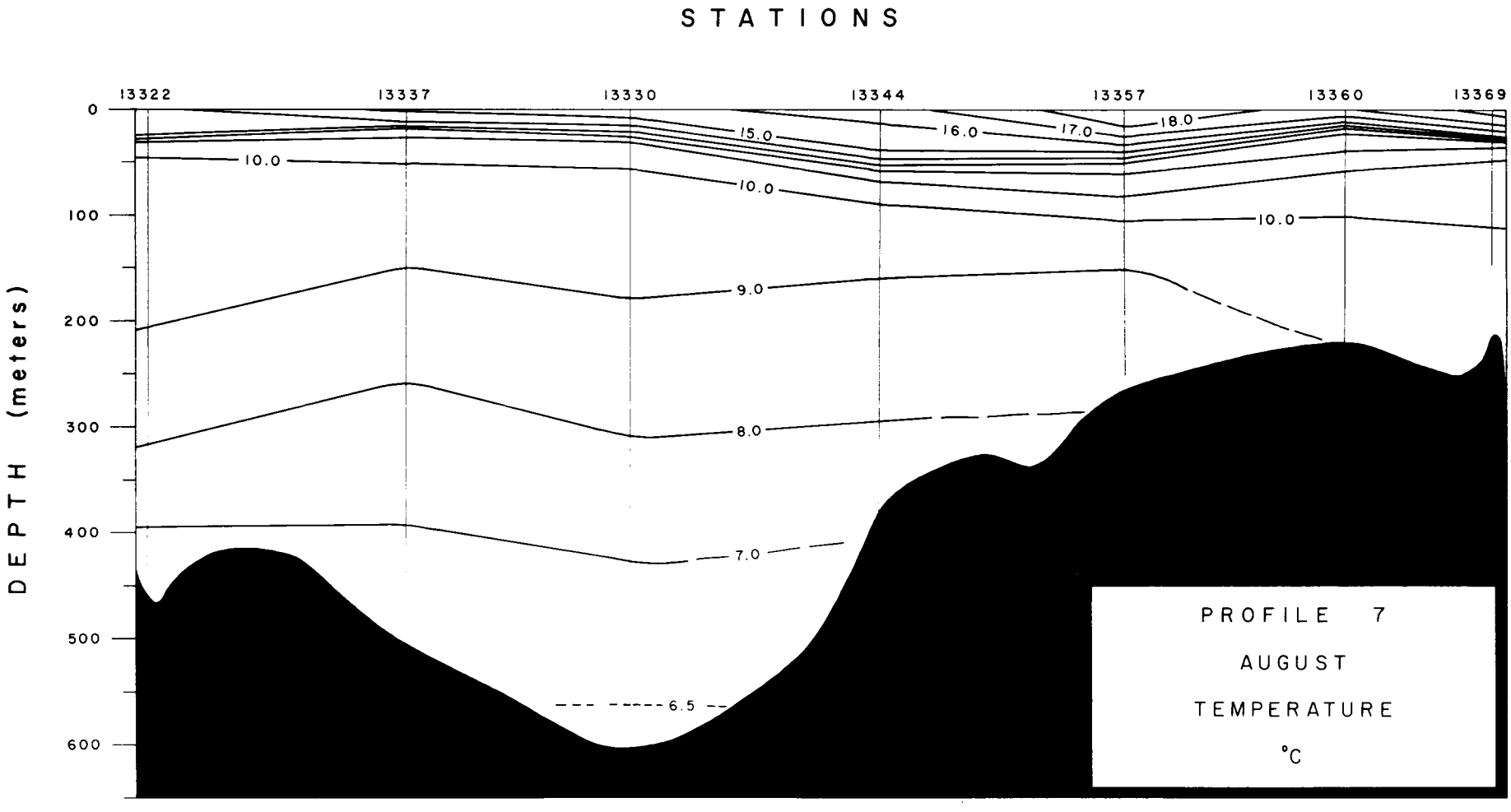

SURFACE PHOSPHATE
DECEMBER, 1969
µg-at/liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
0.5
0.4
0.3

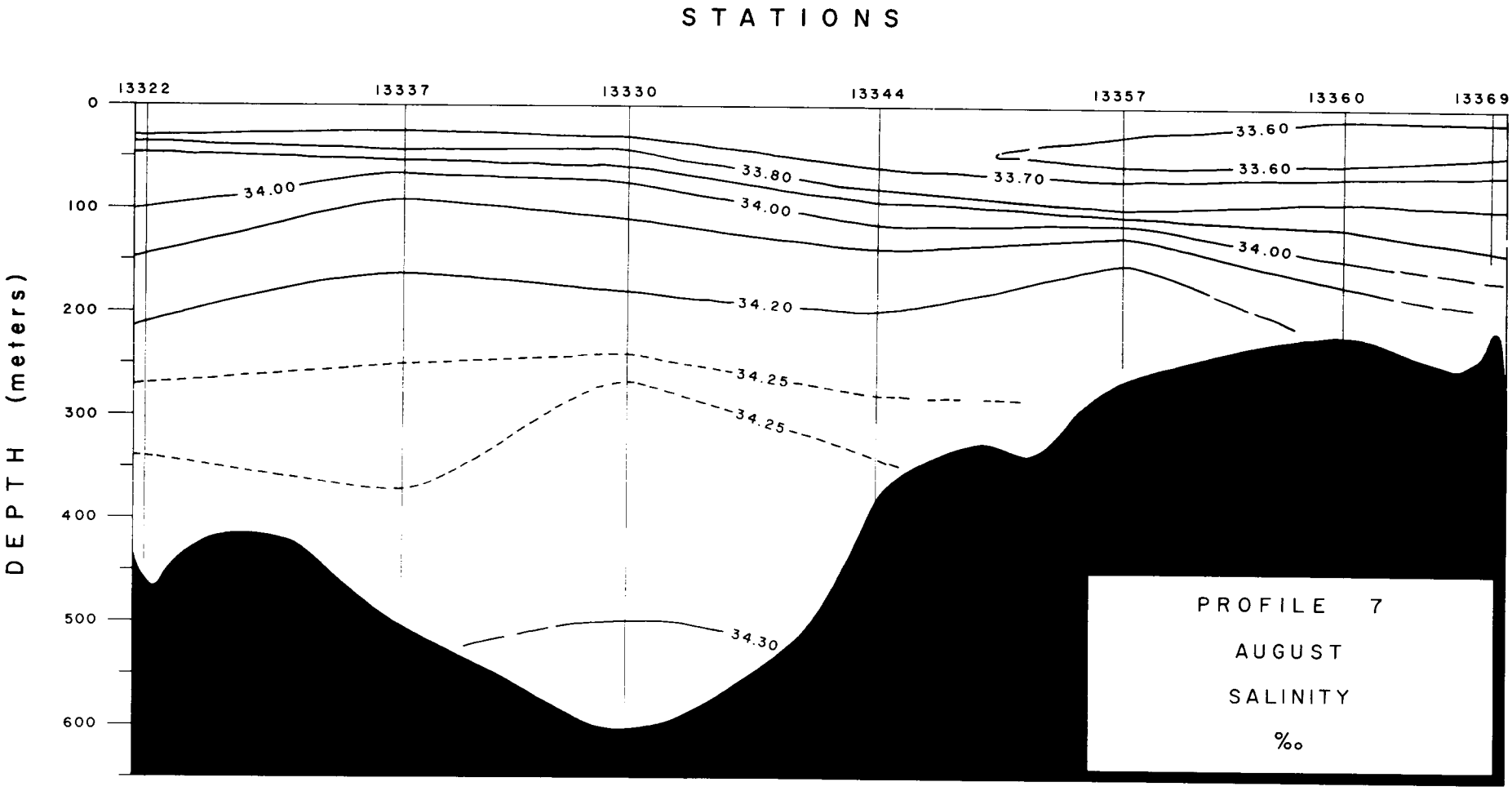

SURFACE NITRATE
DECEMBER, 1969
µg-at/liter
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
2.0
1.0
0.5
0.75
0.25
1.5

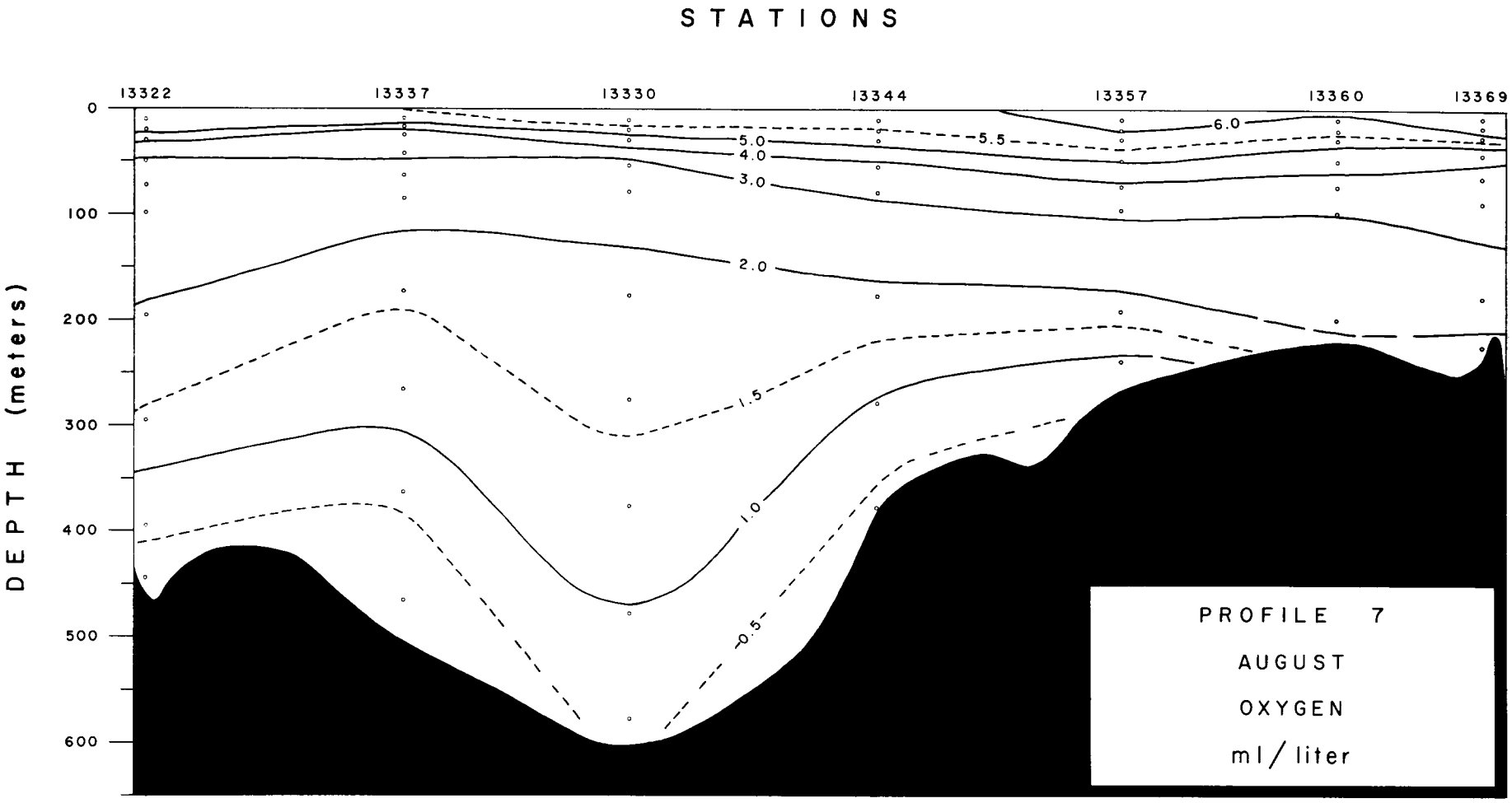
Figures 47-68. Representative cross sections of temperature, salinity, oxygen and nutrients through the Santa Barbara Channel. Refer to figure 2 for location of profile lines.

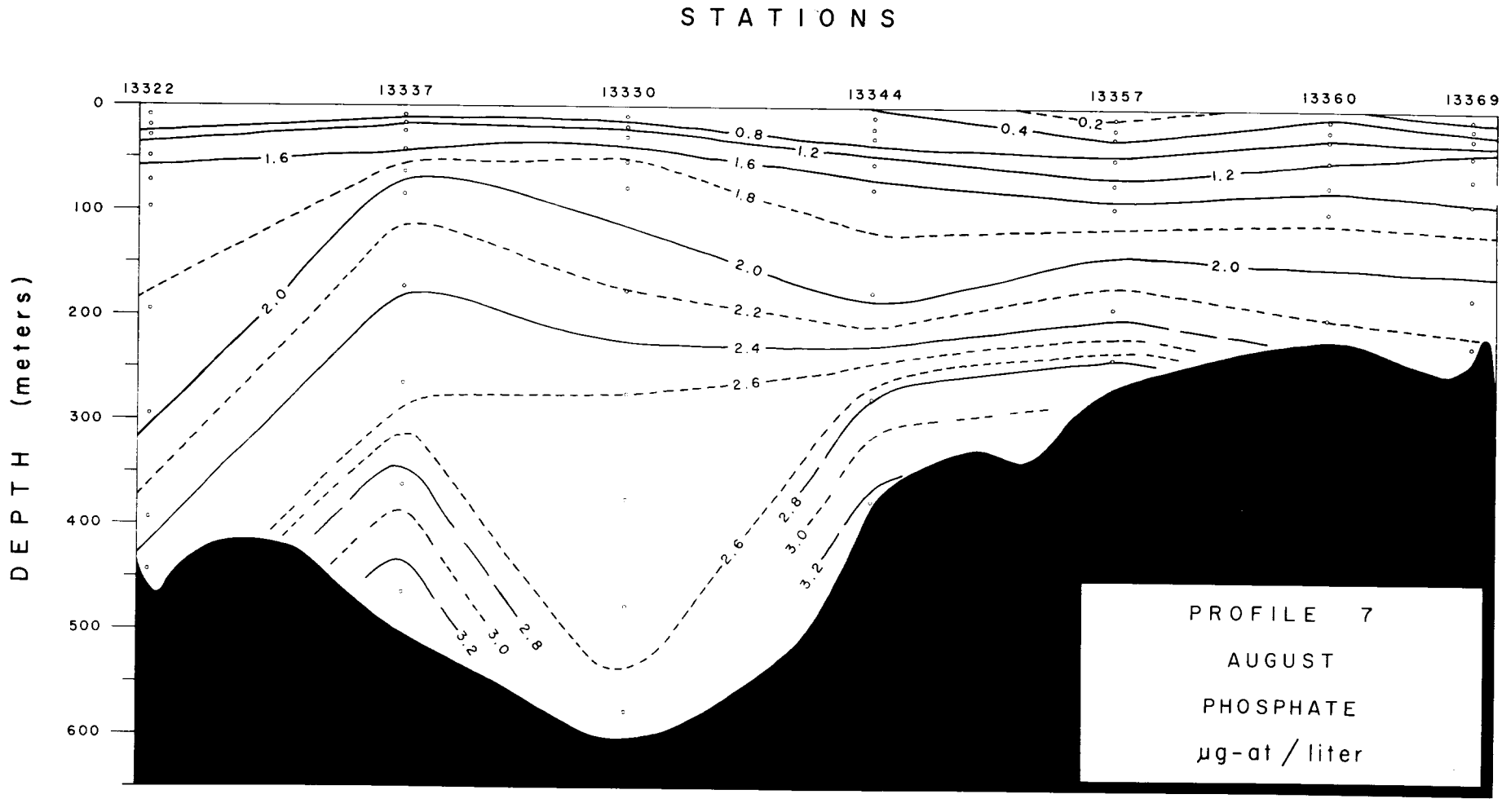

STATIONS
13026
12972
12980
12987
13008
13017
13019
13024
DEPTH (meters)
0
100
200
300
400
500
600
6.0
5.0
4.0
3.0
2.0
1.5
1.0
0.5
PROFILE 7
MAY
OXYGEN
ml / liter

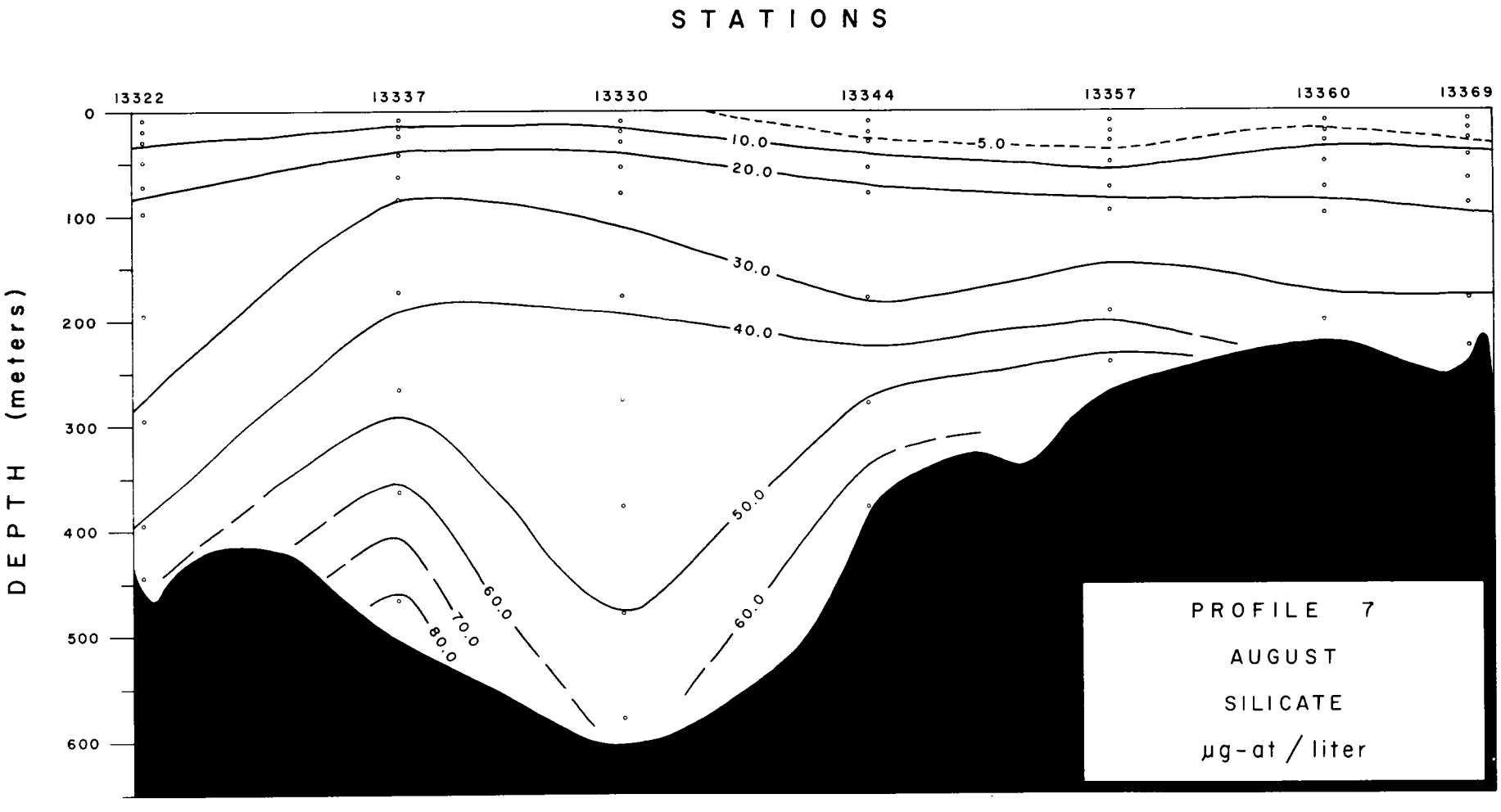

STATIONS
13026
12972
12980
12987
13008
13017
13019
13024
DEPTH (meters)
0
100
200
300
400
500
600
0.8
1.2
1.6
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
PROFILE 7
MAY
PHOSPHATE
µg-at / liter

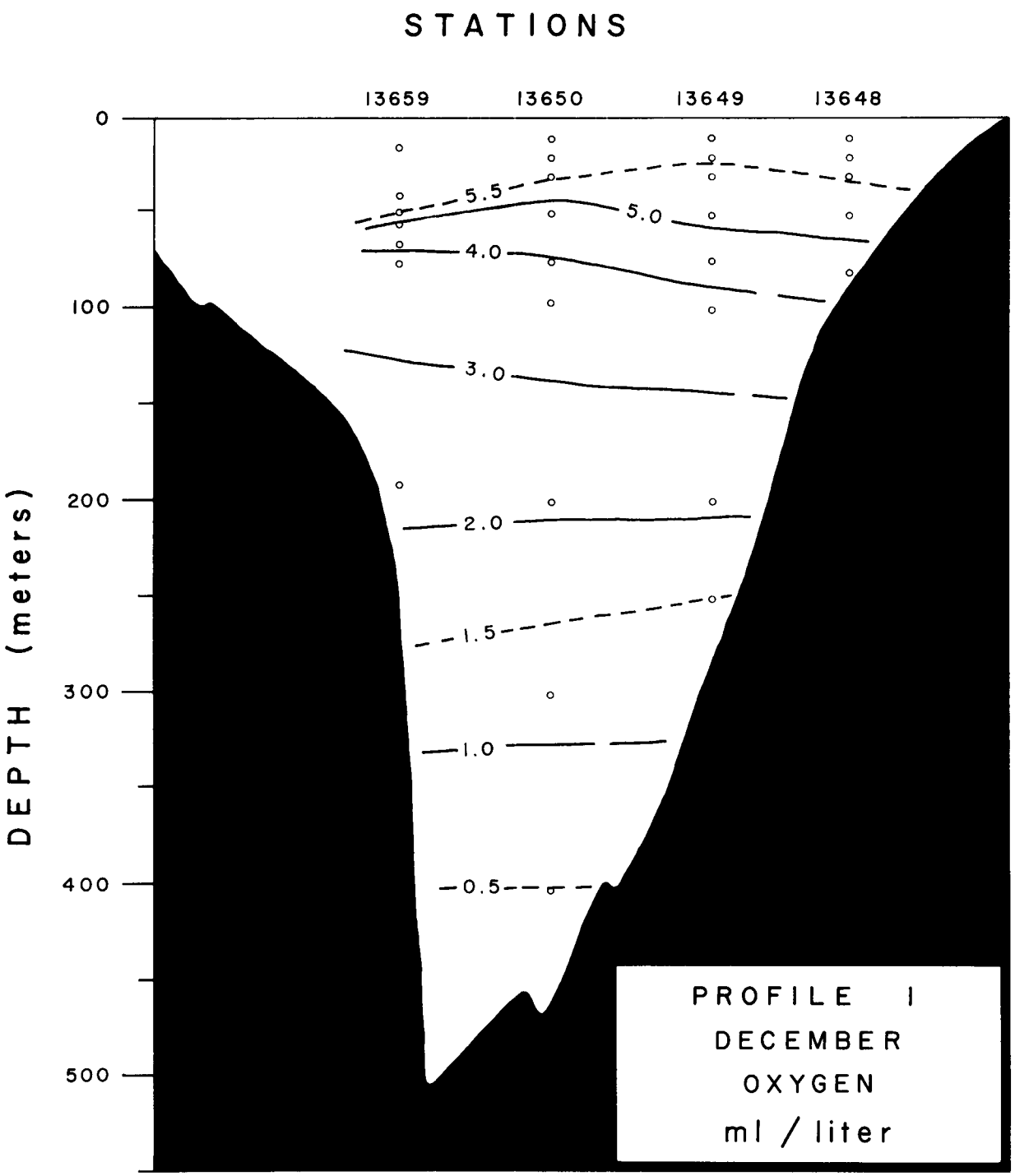

STATIONS
13322
13337
13330
13344
13357
13360
13369
DEPTH (meters)
0
100
200
300
400
500
600
15.0
16.0
17.0
18.0
10.0
10.0
10.0
9.0
8.0
7.0
6.5
PROFILE 7
AUGUST
TEMPERATURE
°C

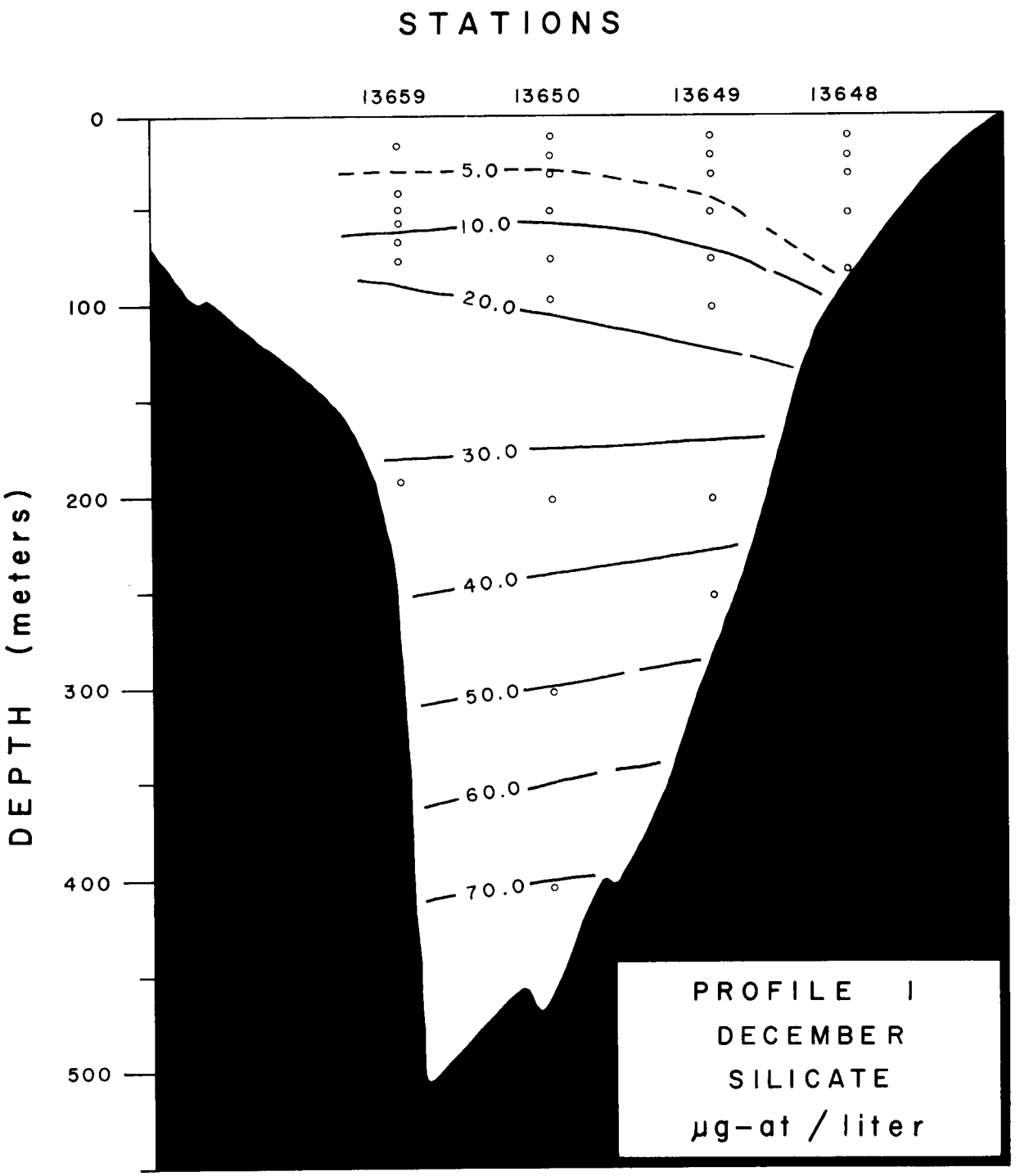

STATIONS
13322
13337
13330
13344
13357
13360
13369
DEPTH (meters)
0
100
200
300
400
500
600
33.60
33.60
33.80
33.70
34.00
34.00
34.00
34.20
34.25
34.25
34.30
PROFILE 7
AUGUST
SALINITY
‰

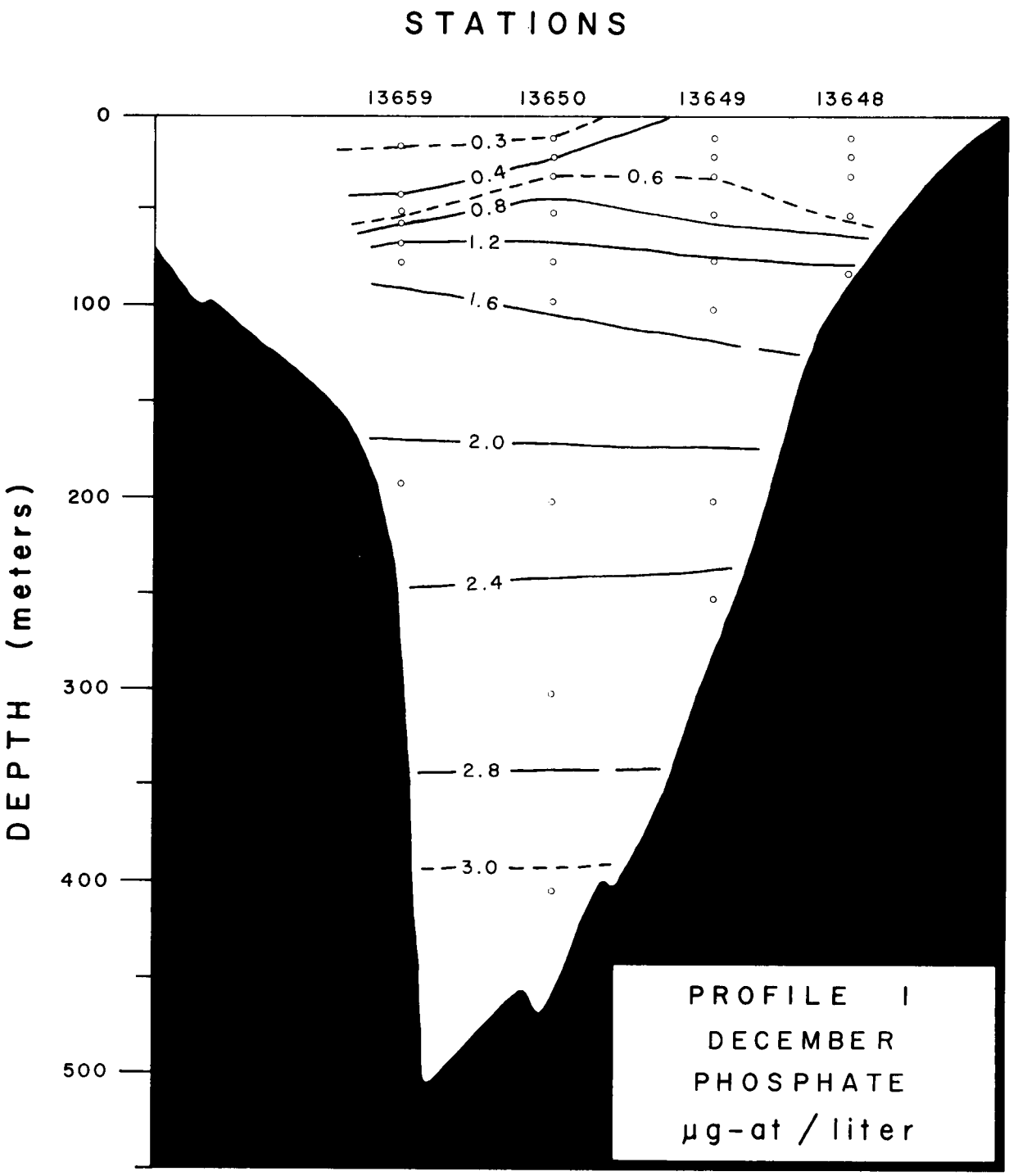

STATIONS
13322
13337
13330
13344
13357
13360
13369
DEPTH (meters)
0
100
200
300
400
500
600
6.0
5.5
5.0
4.0
3.0
2.0
1.5
1.0
0.5
PROFILE 7
AUGUST
OXYGEN
ml/liter

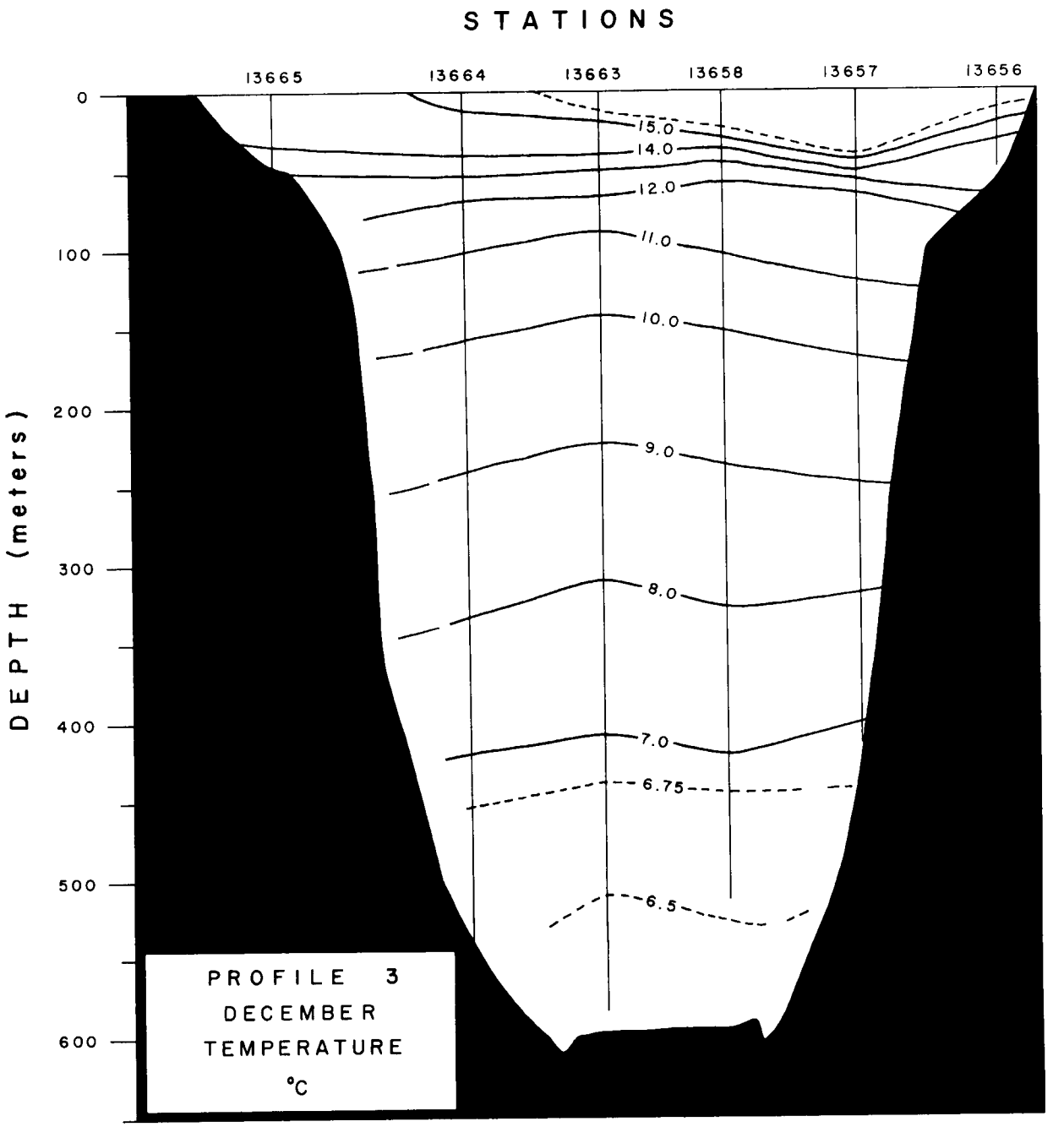

STATIONS
13322
13337
13330
13344
13357
13360
13369
DEPTH (meters)
0
100
200
300
400
500
600
0.2
0.4
0.8
1.2
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
PROFILE 7
AUGUST
PHOSPHATE
µg-at / liter

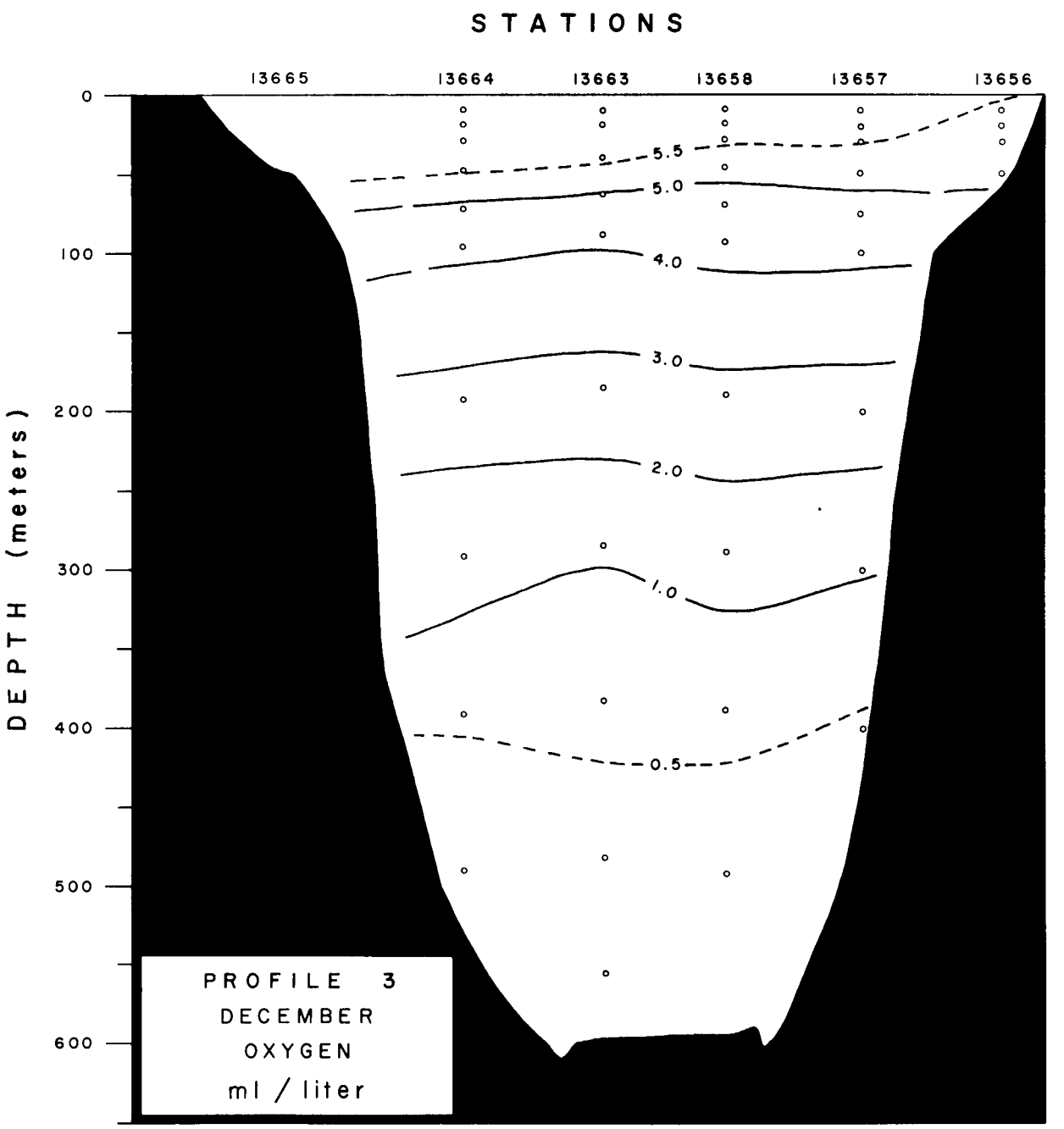

STATIONS
13322
13337
13330
13344
13357
13360
13369
DEPTH (meters)
0
100
200
300
400
500
600
10.0
5.0
20.0
30.0
40.0
50.0
60.0
60.0
70.0
80.0
PROFILE 7
AUGUST
SILICATE
µg-at / liter

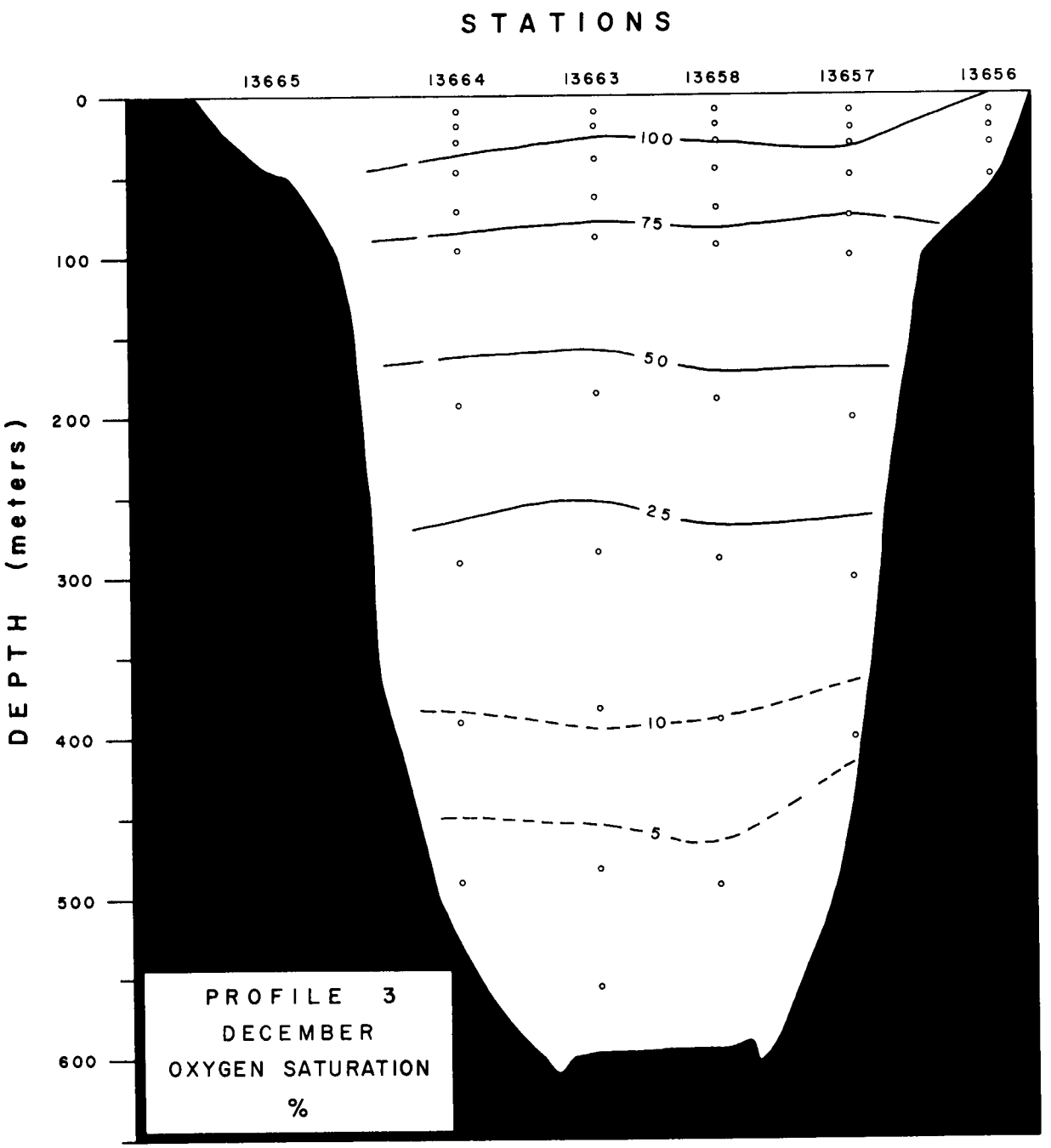

STATIONS
13659
13650
13649
13648
0
100
200
300
400
500
DEPTH (meters)
5.5
5.0
4.0
3.0
2.0
1.5
1.0
0.5
PROFILE I
DECEMBER
OXYGEN
ml / liter

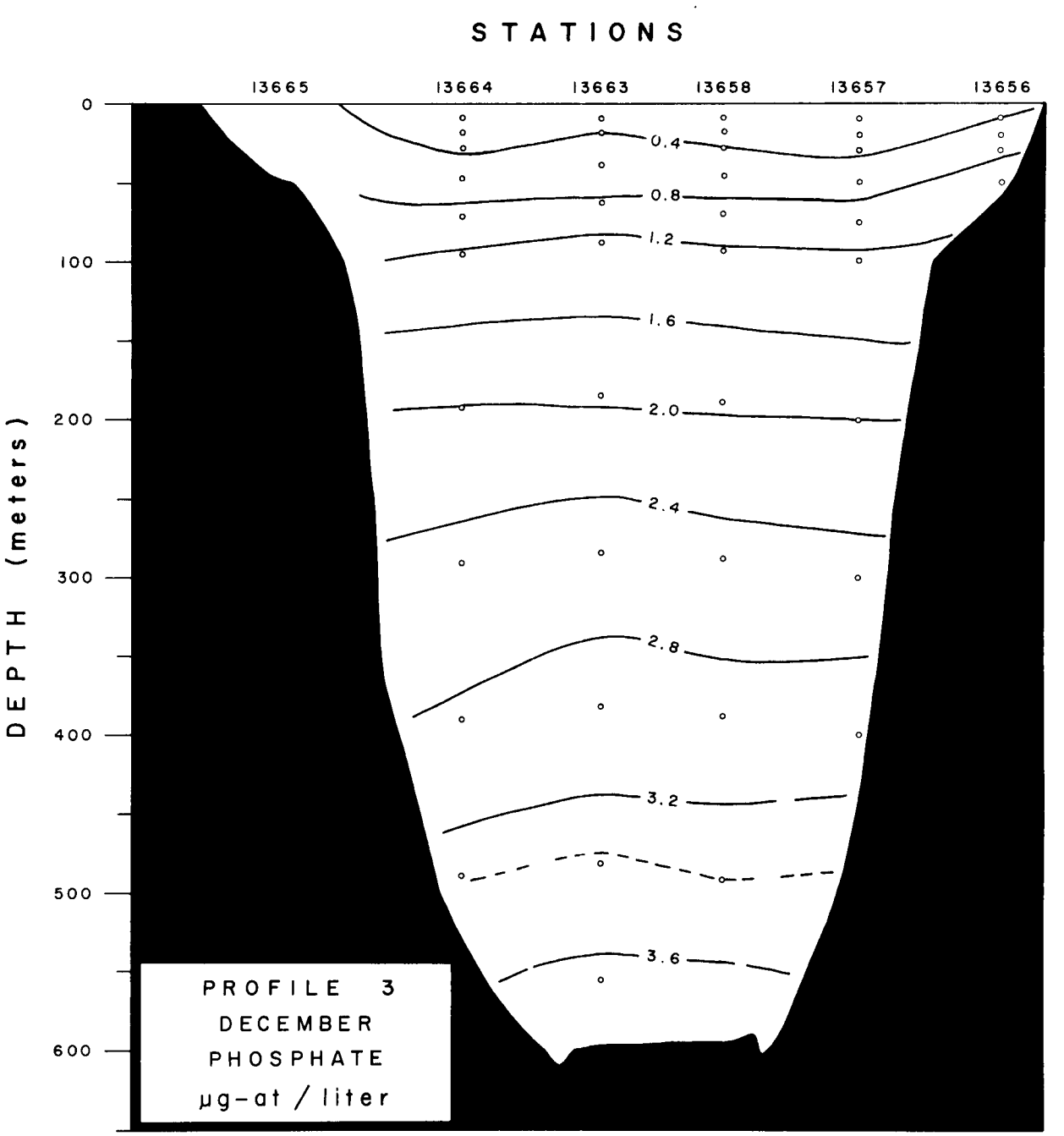

STATIONS
13659
13650
13649
13648
0
100
200
300
400
500
DEPTH (meters)
5.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
PROFILE I
DECEMBER
SILICATE
µg-at / liter

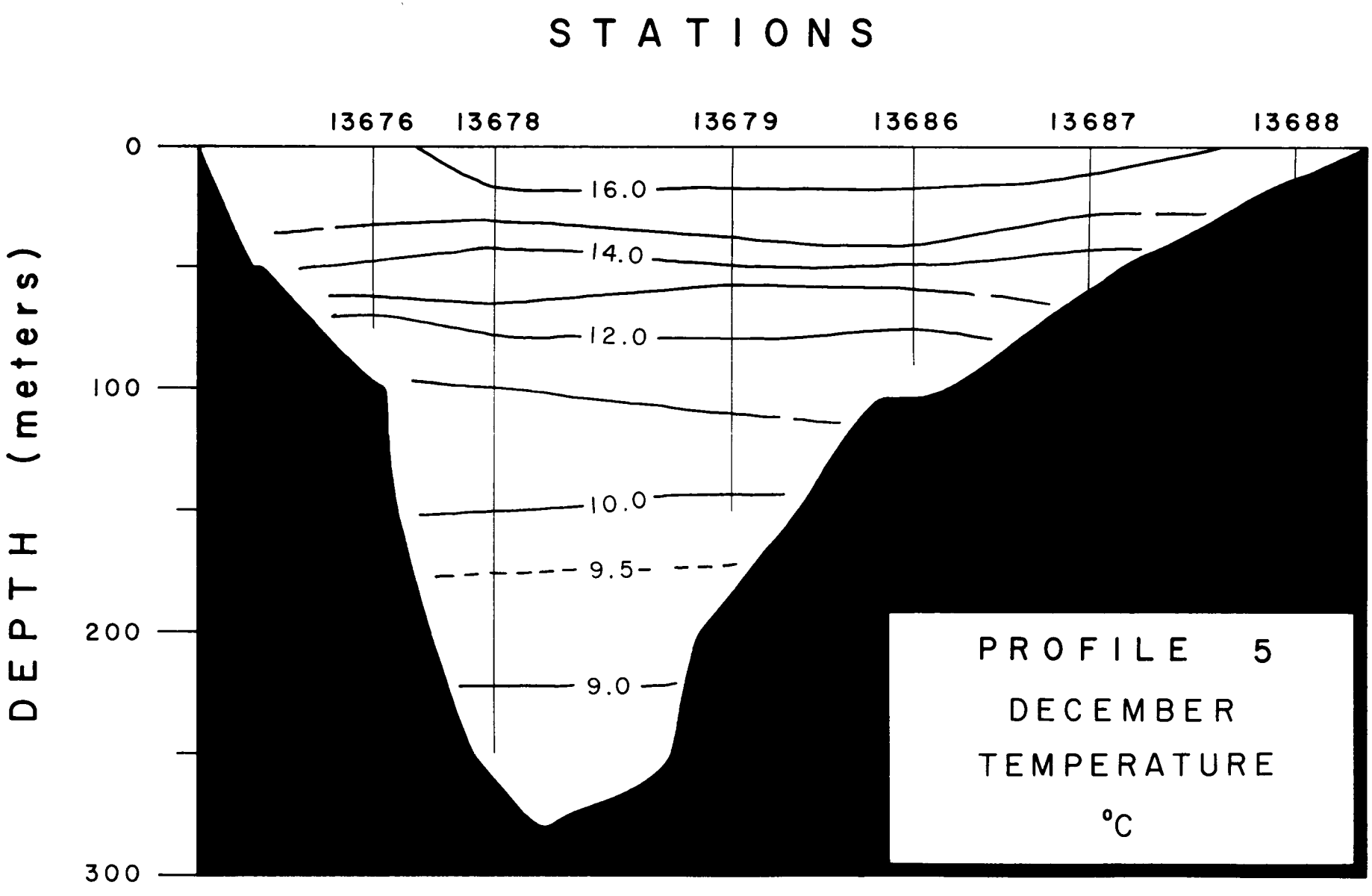

STATIONS
13659
13650
13649
13648
0
100
200
300
400
500
DEPTH (meters)
0.3
0.4
0.6
0.8
1.2
1.6
2.0
2.4
2.8
3.0
PROFILE I
DECEMBER
PHOSPHATE
µg-at / liter

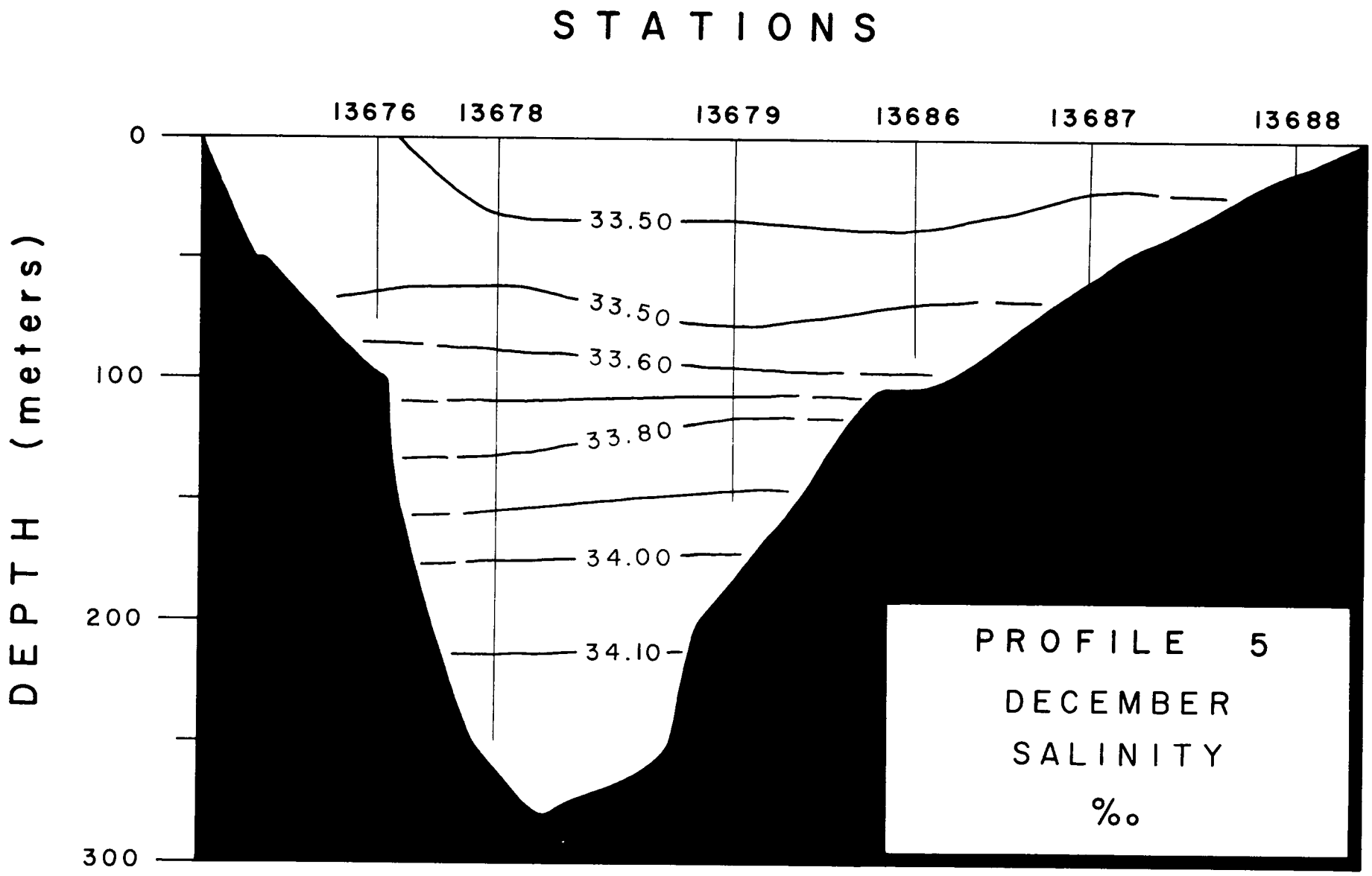

STATIONS
13665
13664
13663
13658
13657
13656
DEPTH (meters)
0
100
200
300
400
500
600
15.0
14.0
12.0
11.0
10.0
9.0
8.0
7.0
6.75
6.5
PROFILE 3
DECEMBER
TEMPERATURE
°C

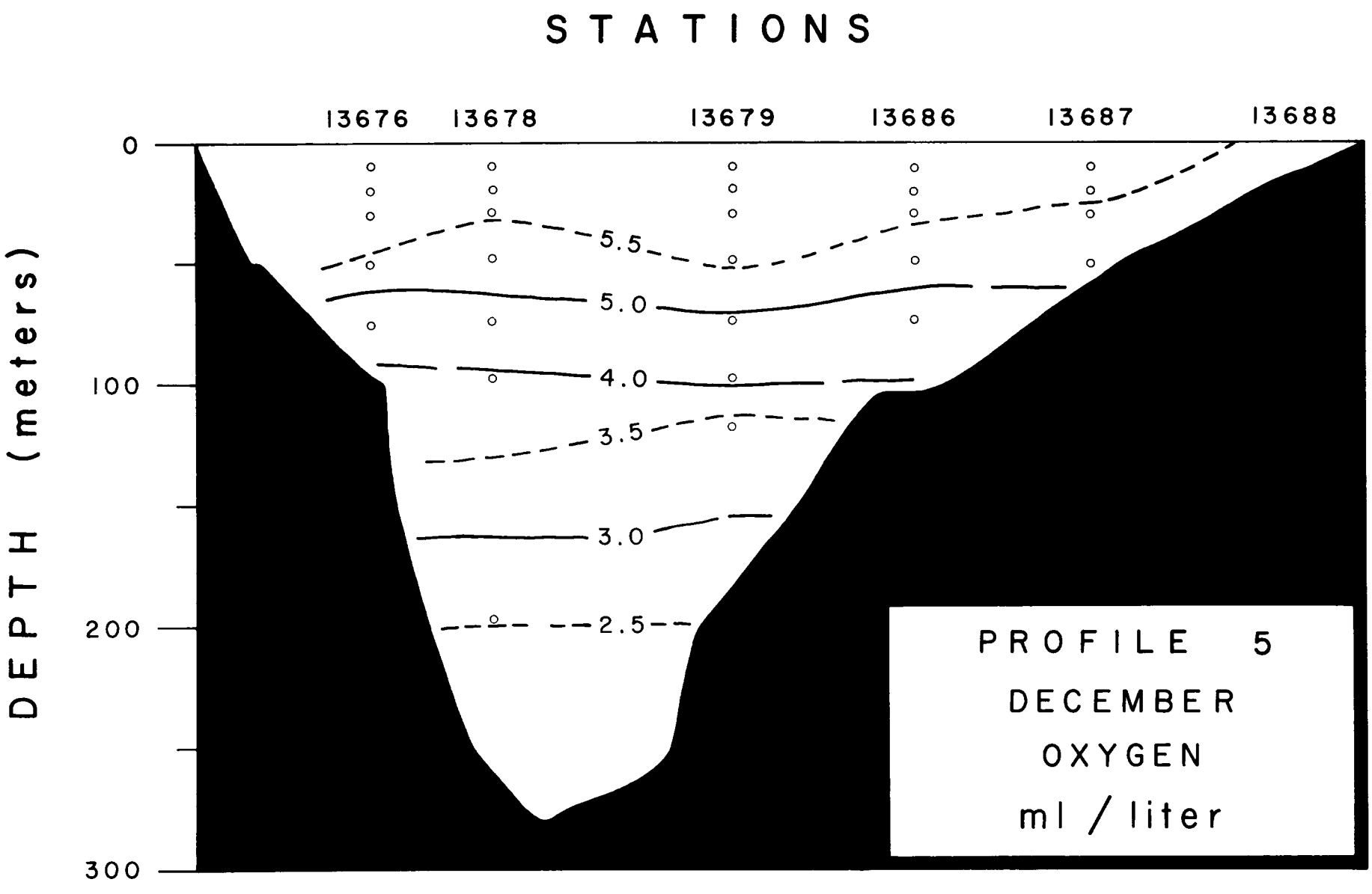

STATIONS
13665
13664
13663
13658
13657
13656
DEPTH (meters)
0
100
200
300
400
500
600
5.5
5.0
4.0
3.0
2.0
1.0
0.5
PROFILE 3
DECEMBER
OXYGEN
ml / liter

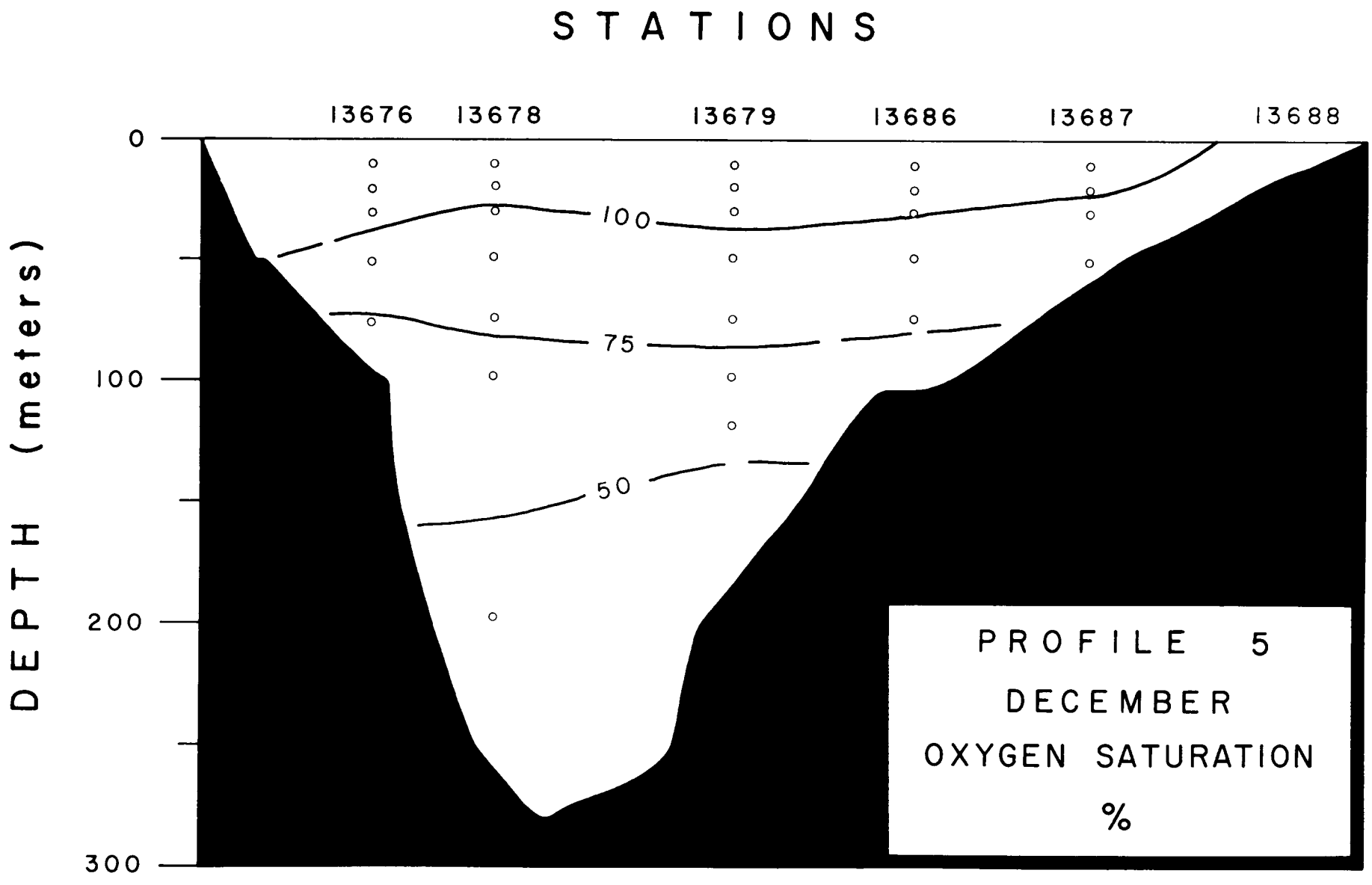

STATIONS
13665
13664
13663
13658
13657
13656
DEPTH (meters)
0
100
200
300
400
500
600
100
75
50
25
10
5
PROFILE 3
DECEMBER
OXYGEN SATURATION
%

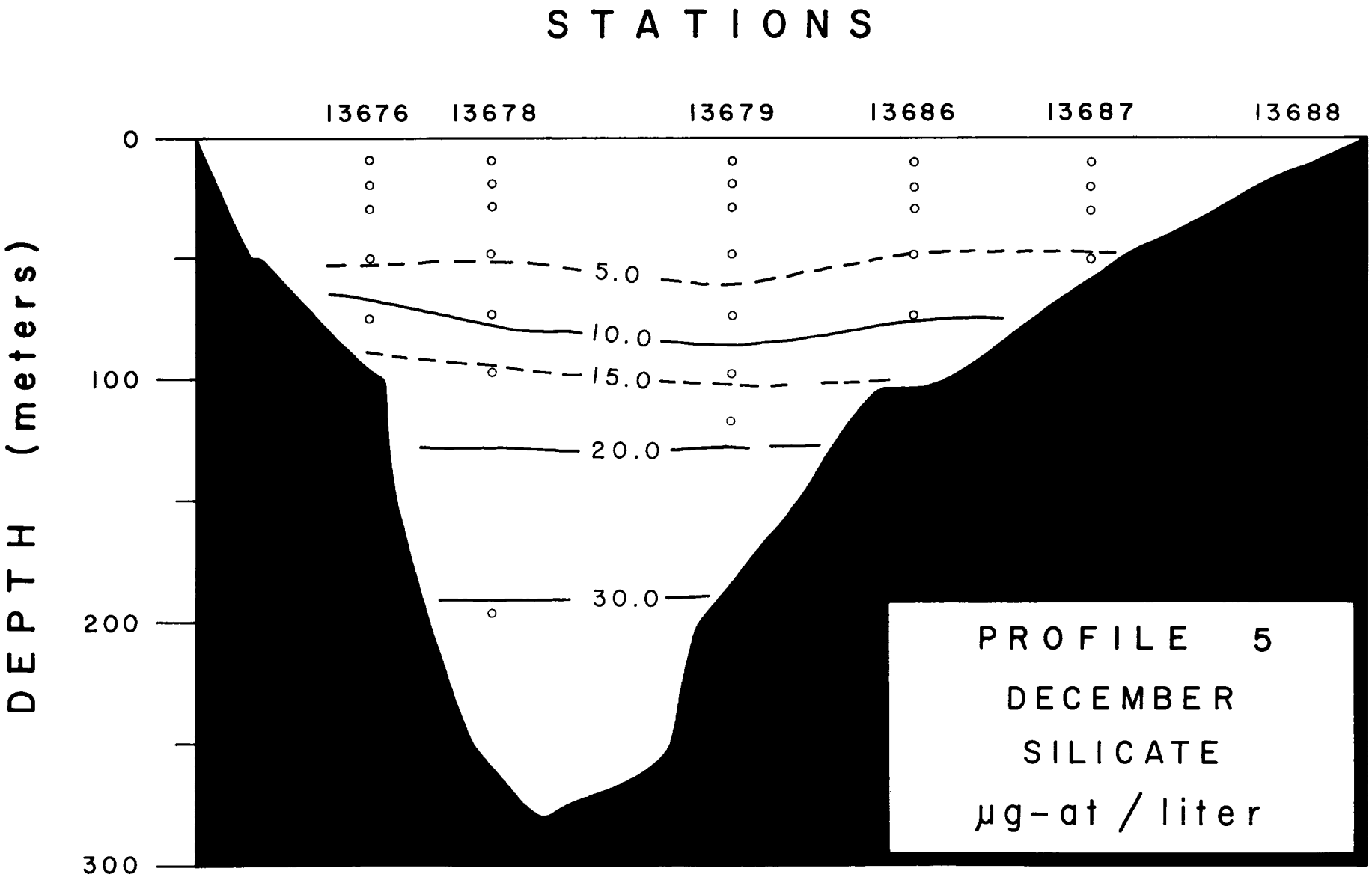

STATIONS
13665
13664
13663
13658
13657
13656
DEPTH (meters)
0
100
200
300
400
500
600
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
PROFILE 3
DECEMBER
PHOSPHATE
µg-at / liter

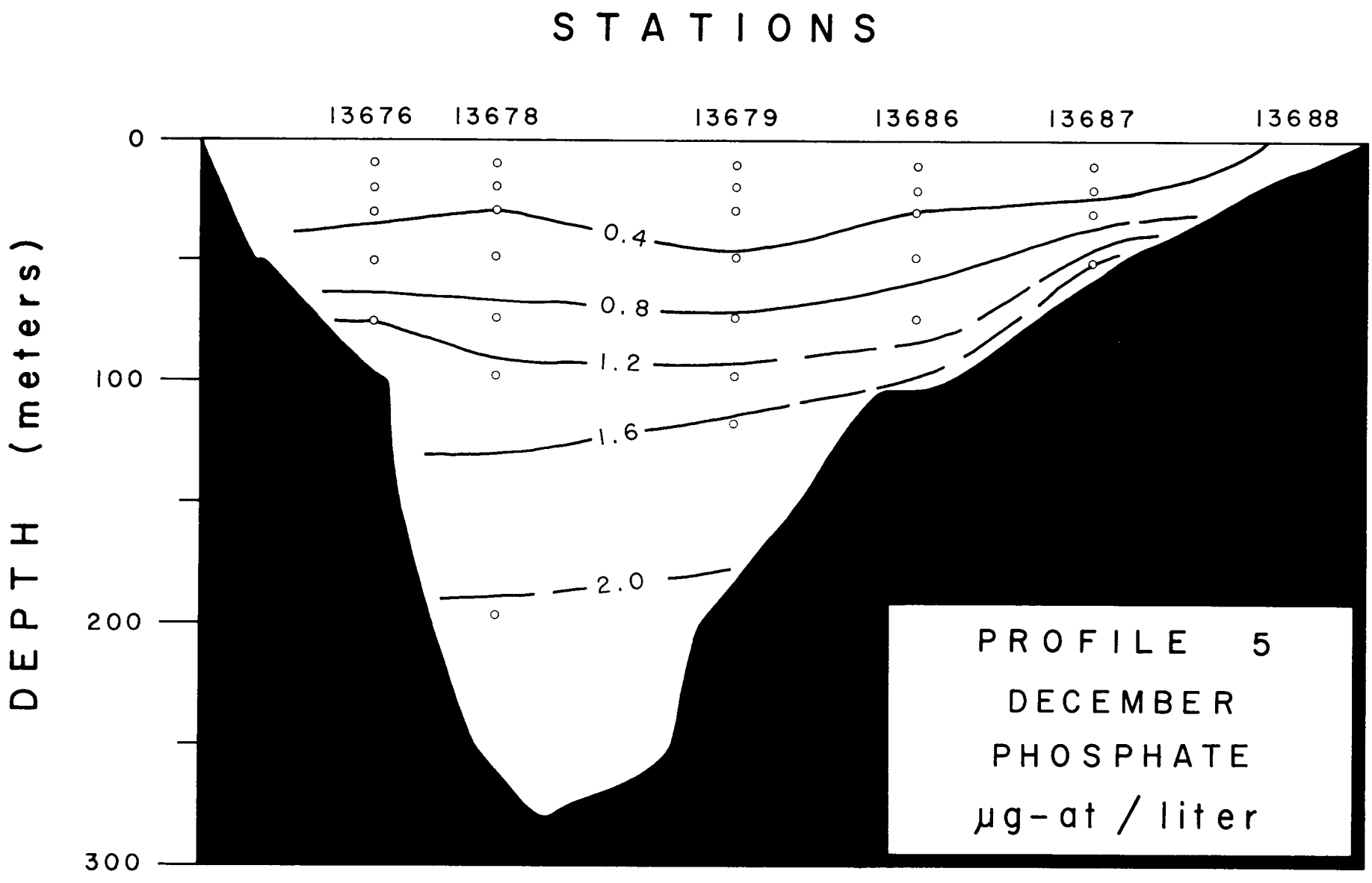

STATIONS
13676
13678
13679
13686
13687
13688
DEPTH (meters)
0
100
200
300
16.0
14.0
12.0
10.0
9.5
9.0
PROFILE 5
DECEMBER
TEMPERATURE
°C

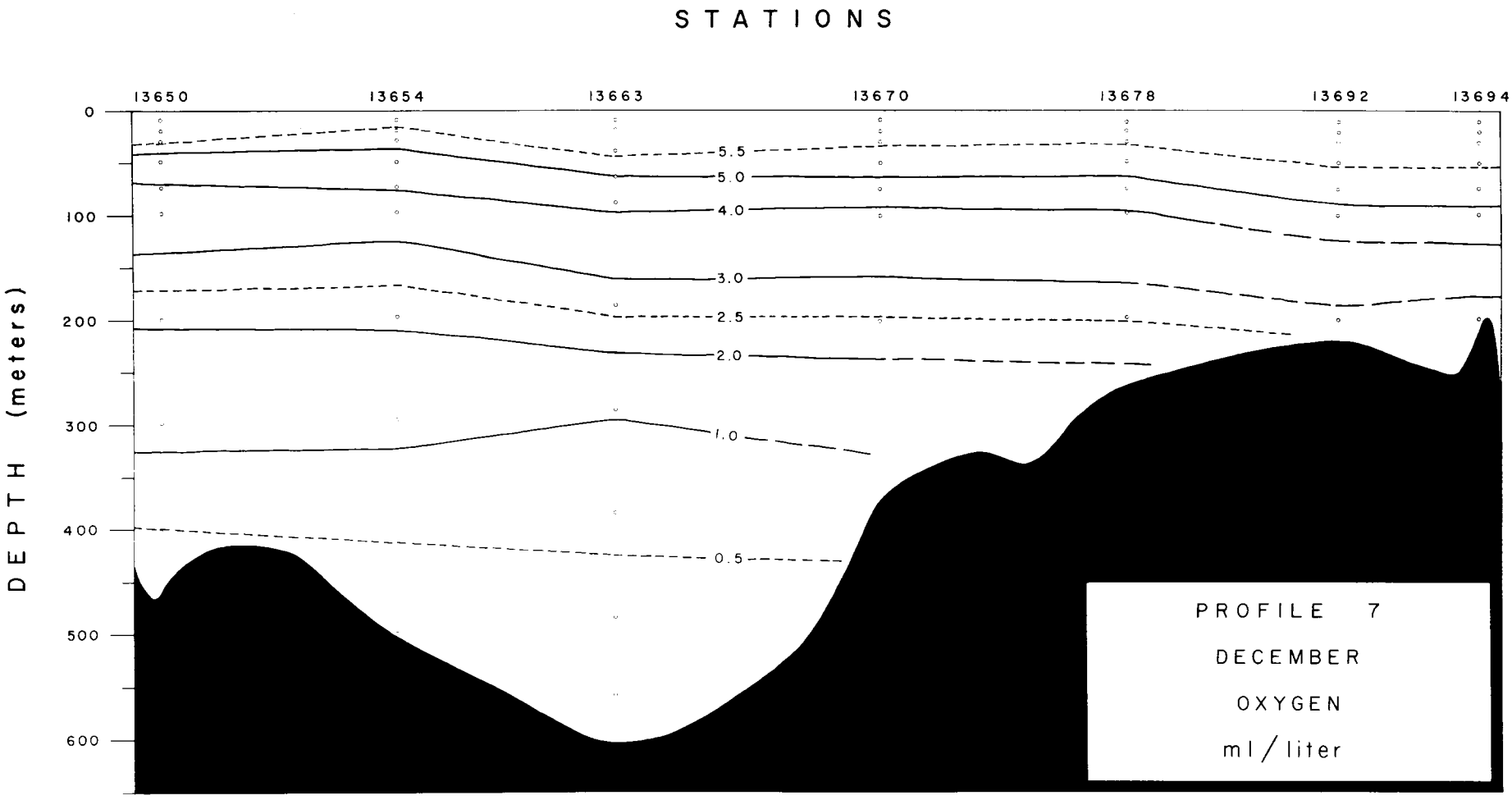

STATIONS
13676
13678
13679
13686
13687
13688
DEPTH (meters)
0
100
200
300
33.50
33.50
33.60
33.80
34.00
34.10
PROFILE 5
DECEMBER
SALINITY
‰

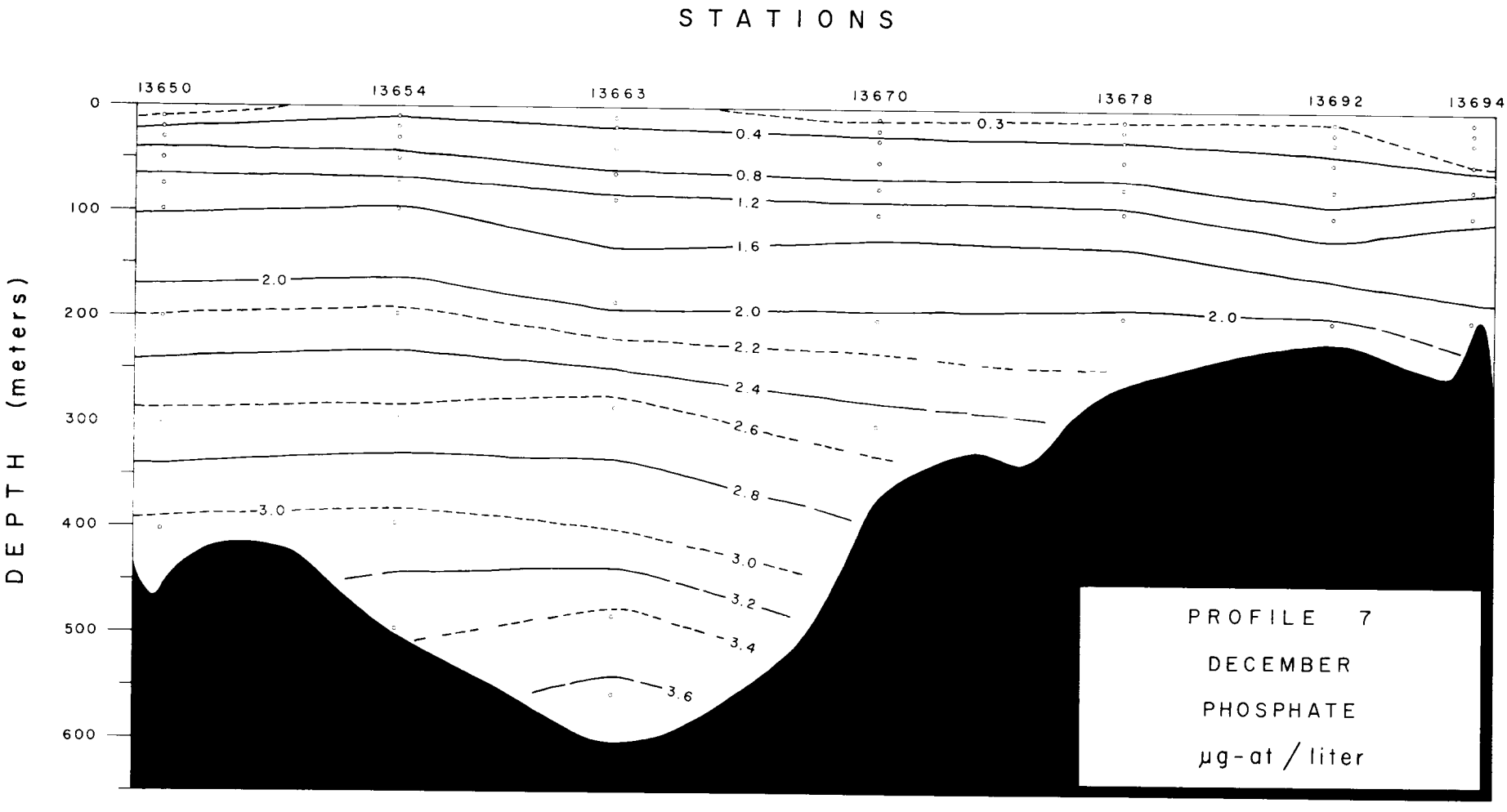

STATIONS
13676
13678
13679
13686
13687
13688
DEPTH (meters)
0
100
200
300
5.5
5.0
4.0
3.5
3.0
2.5
PROFILE 5
DECEMBER
OXYGEN
ml / liter


STATIONS
13676
13678
13679
13686
13687
13688
DEPTH (meters)
0
100
200
300
100
75
50
PROFILE 5
DECEMBER
OXYGEN SATURATION
%

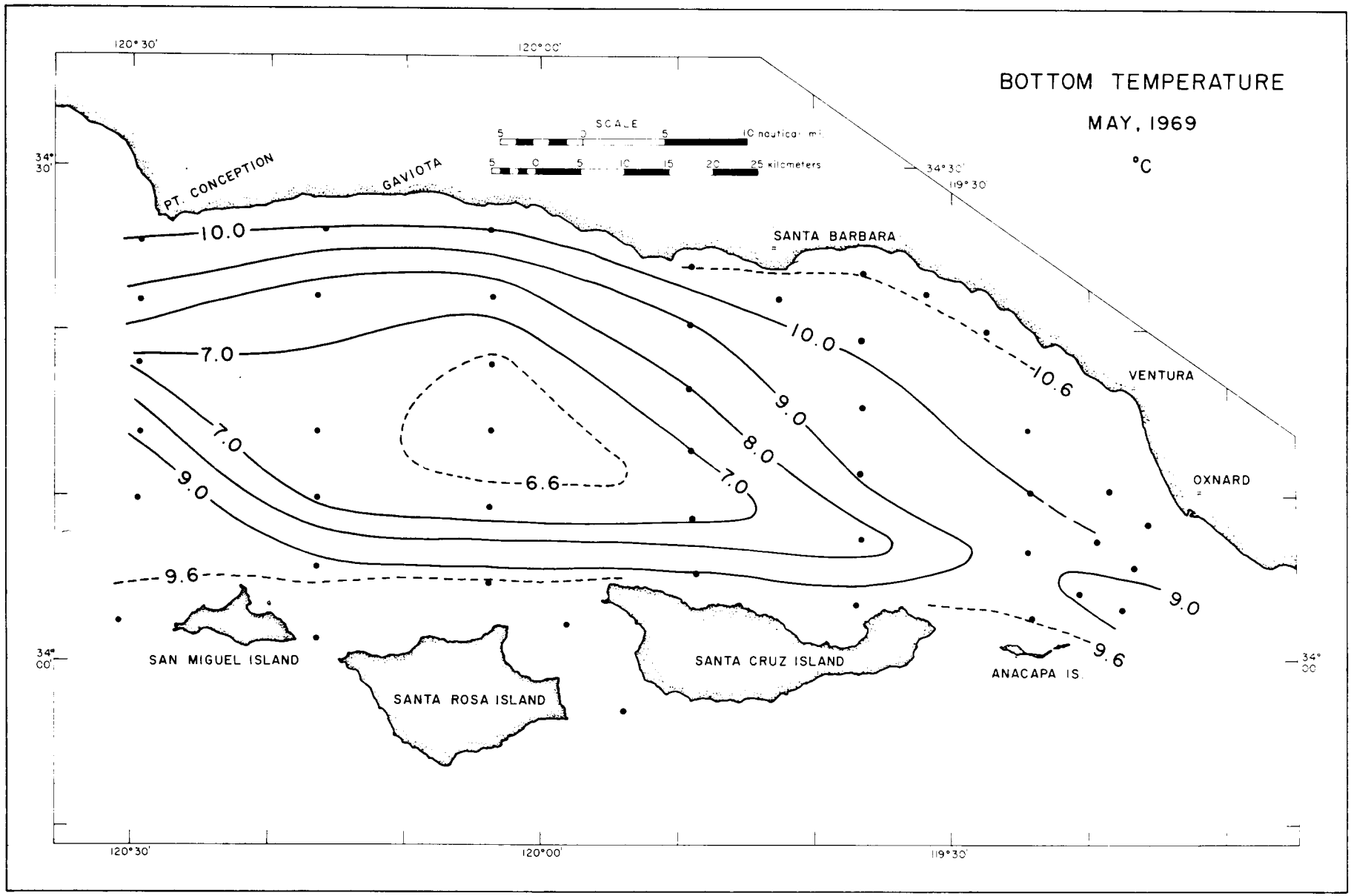

STATIONS
13676
13678
13679
13686
13687
13688
DEPTH (meters)
0
100
200
300
5.0
10.0
15.0
20.0
30.0
PROFILE 5
DECEMBER
SILICATE
µg-at / liter


STATIONS
13676
13678
13679
13686
13687
13688
DEPTH (meters)
0
100
200
300
0.4
0.8
1.2
1.6
2.0
PROFILE 5
DECEMBER
PHOSPHATE
µg-at / liter


STATIONS
13650
13654
13663
13670
13678
13692
13694
DEPTH (meters)
0
100
200
300
400
500
600
5.5
5.0
4.0
3.0
2.5
2.0
1.0
0.5
PROFILE 7
DECEMBER
OXYGEN
ml/liter


STATIONS
13650
13654
13663
13670
13678
13692
13694
DEPTH (meters)
0
100
200
300
400
500
600
0.3
0.4
0.8
1.2
1.6
2.0
2.0
2.0
2.2
2.4
2.6
2.8
3.0
3.0
3.2
3.4
3.6
PROFILE 7
DECEMBER
PHOSPHATE
µg-at / liter

Figures 69-70. Bottom isotherms and isohalines for May, 1969. Values are from STD records just above bottom contact. Bottom temperatures in the basin are lower than 6.6° C but a smaller contour interval was not used because only a few stations were occupied in the deepest part of the basin.


BOTTOM TEMPERATURE
MAY, 1969
°C
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
10.0
7.0
9.0
9.6
6.6
8.0
10.6

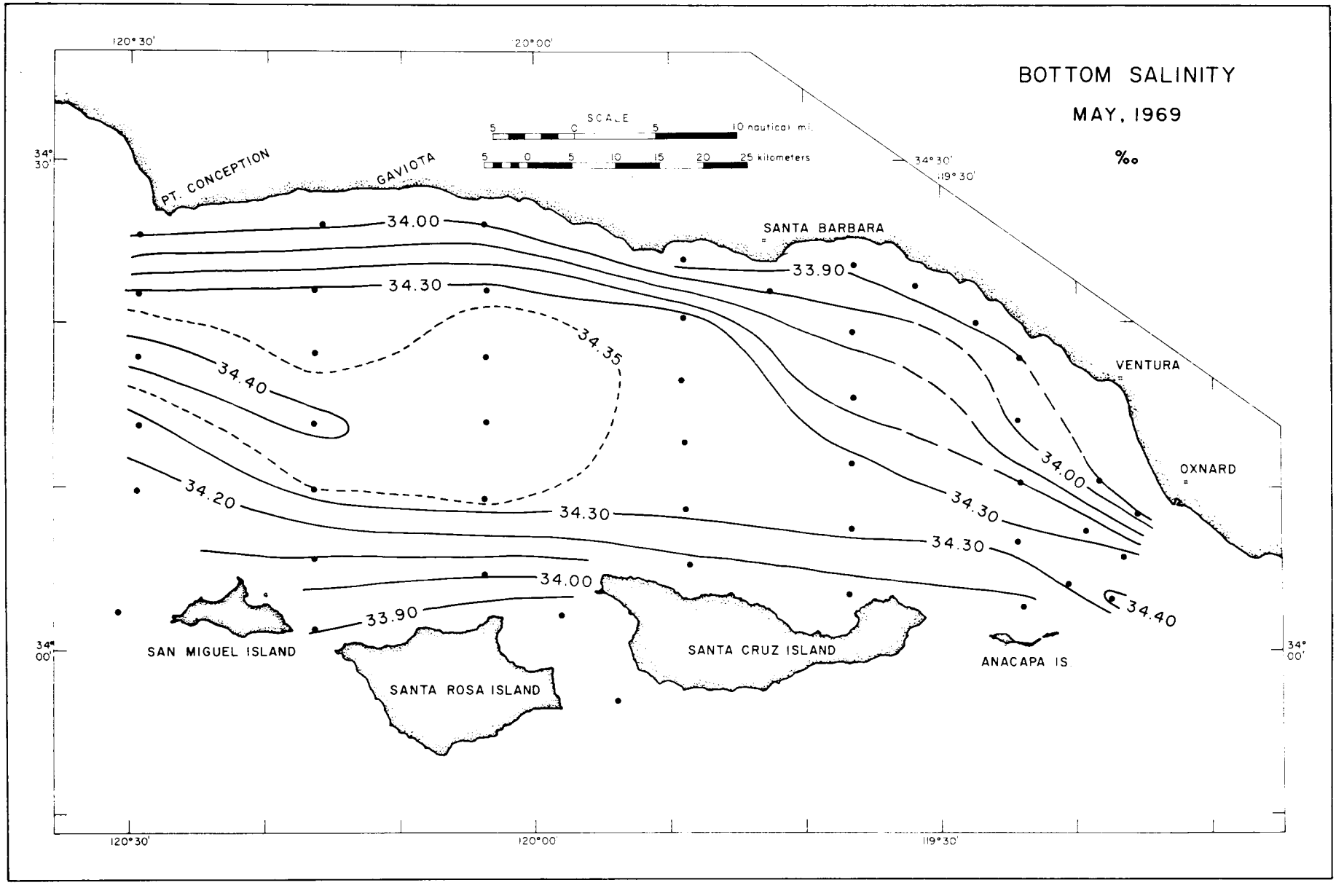
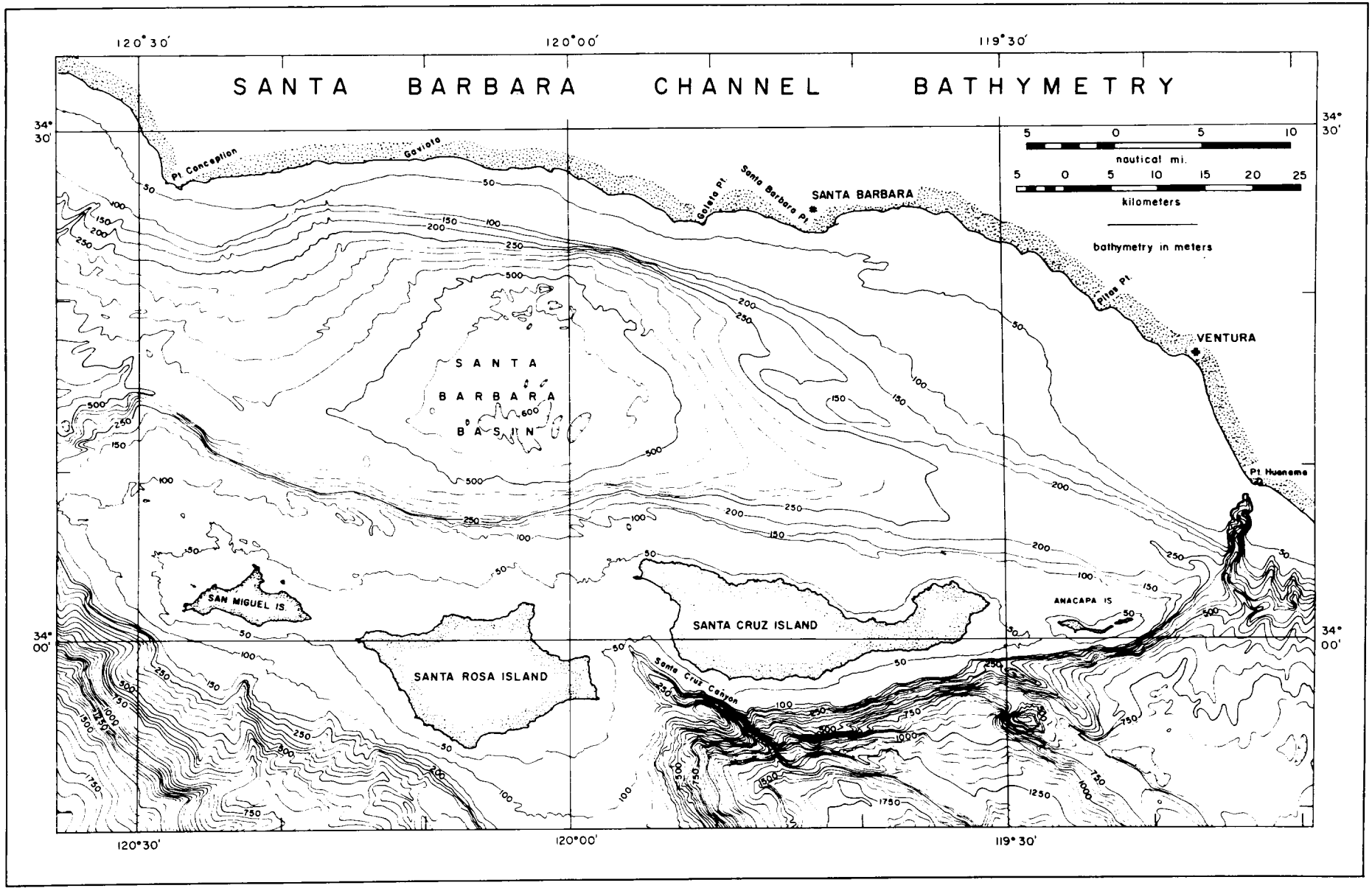

BOTTOM SALINITY
MAY, 1969
‰
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
34.00
34.30
33.90
34.35
34.40
34.20
34.30
34.00
33.90
34.00
34.30
34.30
34.40

Figure 71. Bottom topography of the Santa Barbara Channel. Contours are in meters.


SANTA BARBARA CHANNEL BATHYMETRY
120°30′
120°00′
119°30′
34° 30′
34° 00′
5 0 5 10
nautical mi.
5 0 5 10 15 20 25
kilometers
bathymetry in meters
Pt Conception
Gaviota
Goleta Pt.
Santa Barbara Pt.
SANTA BARBARA
Pitas Pt.
VENTURA
Pt Hueneme
SANTA BARBARA BASIN
SAN MIGUEL IS
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS
Santa Cruz Canyon

upper portion of the water column. However, those variations which occur below the sill depth or near the bottom pose interesting problems which influence a host of physical, chemical, geological and biological interrelationships. For example, the rate of flushing, nutrient regeneration, oxygen consumption, fate of surficial and buried oil from natural seeps and from the well blowout, deposition of fine-grained sediments and biological activity are all influenced or controlled by the physical and chemical parameters of the water masses. Although the presence of sediment "varves" in the basin are indicative of relatively static conditions in that area, it is now evident, from information presented in this report and that gathered within the past few months, that conditions within the entire channel area reflect a more dynamic environment than was previously suspected. It is also possible that our information was obtained during an atypical period and thus, is not representative of "normal" conditions. Unfortunately, information from previous studies does not allow one to define normal conditions.

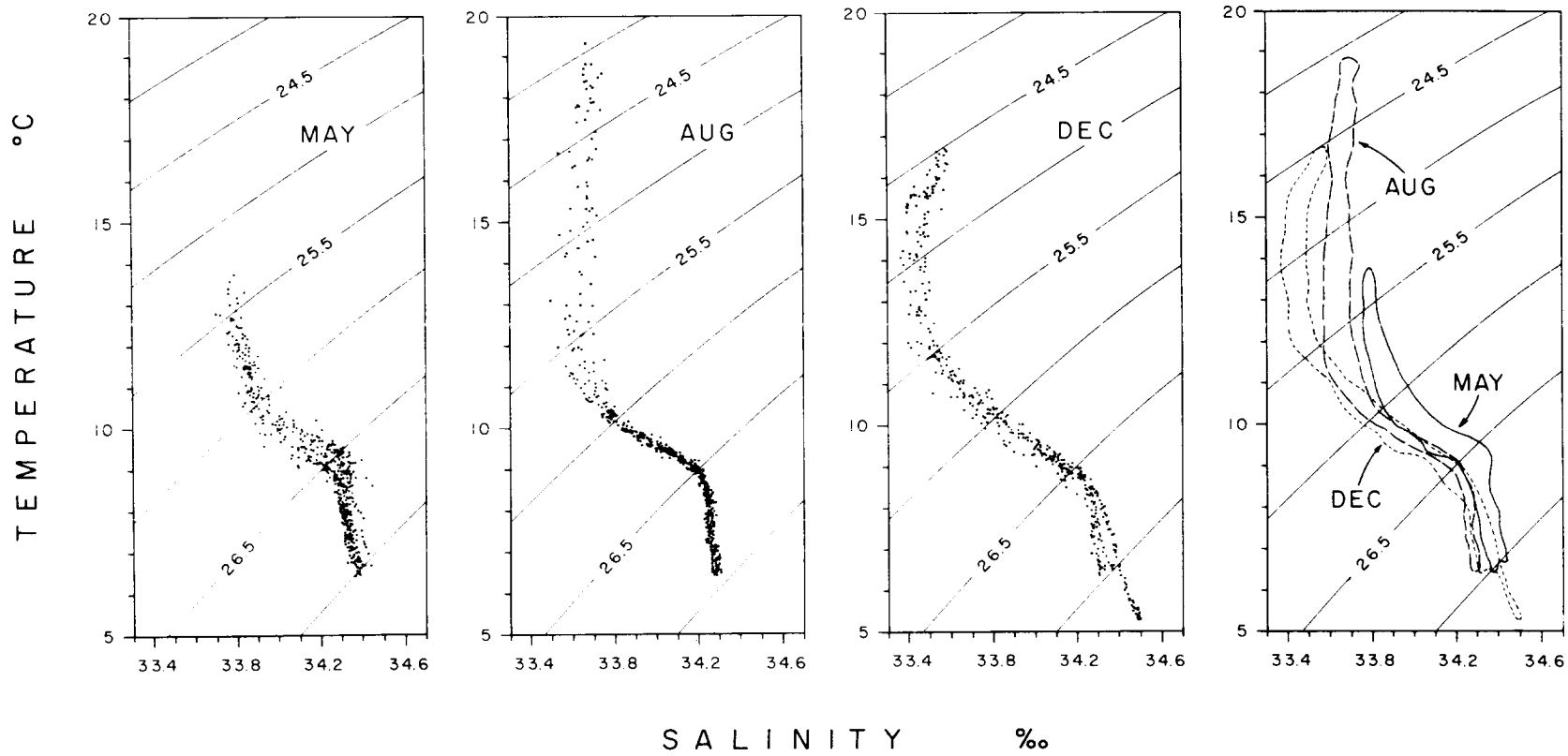
A decrease in oxygen values in the upper 30 meters of the water column beneath an oil slick was the only major observed variation in water characteristics which was directly attributable to the presence of oil on the surface of the water. Several other anomalous conditions, which appear to be related to the distribution of oil, were detected, but interpretation of that information will be presented at a later date.

SUMMARY

The surface water circulation pattern in Santa Barbara Channel consists essentially of a counter-clockwise cell in the western half of the channel and a northwesterly flowing current in the eastern part of the channel. The western cell is driven by a current entering the channel from the northwest. Convergence of these currents results in a complex pattern of eddies in the area between Santa Barbara and Santa Cruz Island. Other eddies along the eastern margin of the channel are produced by deflections resulting from current impingement near Santa Barbara and, to a lesser extent, the area between Santa Barbara and Ventura. Surface water temperature, salinity and nutrient values all reflect the same circulation pattern. Surface water nutrient values were highest in May, 1969 and lowest in December, 1969.

Subsurface water values are indicative of the interaction of two slightly different water masses (fig. 72) entering the channel from either end. Mixing and entrainment of near bottom water near the southern end of profile 5 during May, 1969 is apparent. A decrease in oxygen values in the upper 30 meters of the water column beneath an oil slick was detected but values from greater depths and from areas beyond the slick boundary were normal.

Figure 72. Composite temperature-salinity (T-S) values for May, August and December cruises. Values are from STD records read at 10 meter intervals. Sigma-t lines have been drawn on each of the T-S diagrams. Envelopes of the monthly ranges are shown at the far right.


TEMPERATURE °C
SALINITY ‰
MAY
AUG
DEC
24.5
25.5
26.5
20
15
10
5
33.4
33.8
34.2
34.6

REFERENCES

Allan Hancock Foundation Report, 1965, An Oceanographic and Biological Survey of the Southern California Mainland Shelf: California State Water Quality Control Board, Publication No. 27, 231 pp. plus Appendix, 445 pp.

California Cooperative Oceanic Fisheries Investigations, Progress Reports: Calif. Dept. Fish and Game.

Emery, K.O., 1960, The Sea Off Southern California: John Wiley and Sons, Inc., New York, New York, 366 pp.

CHAPTER 5

TRANSPORT AND DEPOSITION OF FLOOD SEDIMENT, SANTA BARBARA CHANNEL, CALIFORNIA

By

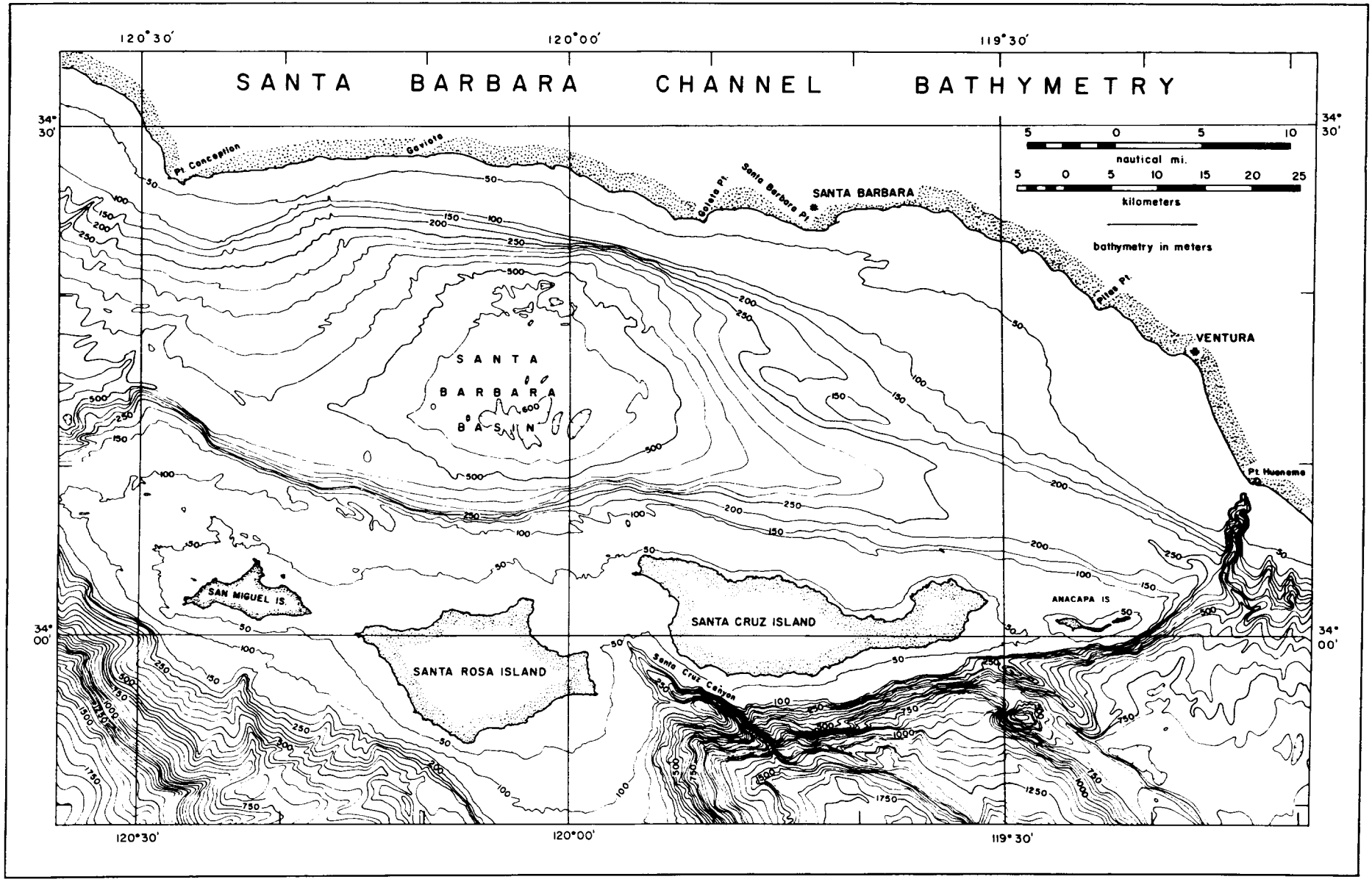
David E. Drake, Peter Fleischer and Ronald L. Kolpack
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

INTRODUCTION

Two periods of heavy rainfall and record runoff in southern California during January and February, 1969 produced a river contribution of more than 80 X 10^6 metric tons of oxidized red-brown sediment to the Santa Barbara Channel area (fig. 1). Inasmuch as the normal marine sediments in the basins of the California Continental Borderland are olive gray (Emery, 1960), the oxidized flood detritus was readily traceable. This provided an excellent opportunity to examine the transport and deposition of fine-grained particles in a small nearshore basin and relate the results to both the present environment and to piston-core stratigraphy.

A comprehensive study of suspended particulate matter in the Santa Barbara Channel had been in progress for two months (fig. 2) prior to the floods. In an effort to determine the fate of the flood sediment offshore, this research was expanded to include: aerial photography during and following the floods, an extensive bi-monthly bottom sampling program, and investigation of the hydrography of the channel.

Figure 1. Bathymetric chart of Santa Barbara Channel. Note the 70 meter high ridge tranding 290° which extends from the Ventura Shelf to a point 14 km south of Santa Barbara. For convenience, this elongated topographic feature will be referred to as Montalvo Ridge. Hueneme Submarine Canyon is located between Anacapa Island and Pt. Hueneme on the mainland.


SANTA BARBARA CHANNEL BATHYMETRY
120°30′
120°00′
119°30′
34° 30′
34° 00′
5 0 5 10
nautical mi.
5 0 5 10 15 20 25
kilometers
bathymetry in meters
Pt. Conception
Gaviota
Gaviota Pt.
Santa Barbara Pt.
SANTA BARBARA
Pitas Pt.
VENTURA
Pt. Hueneme
SANTA BARBARA BASIN
SAN MIGUEL IS.
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS
Santa Cruz Canyon

METHODS

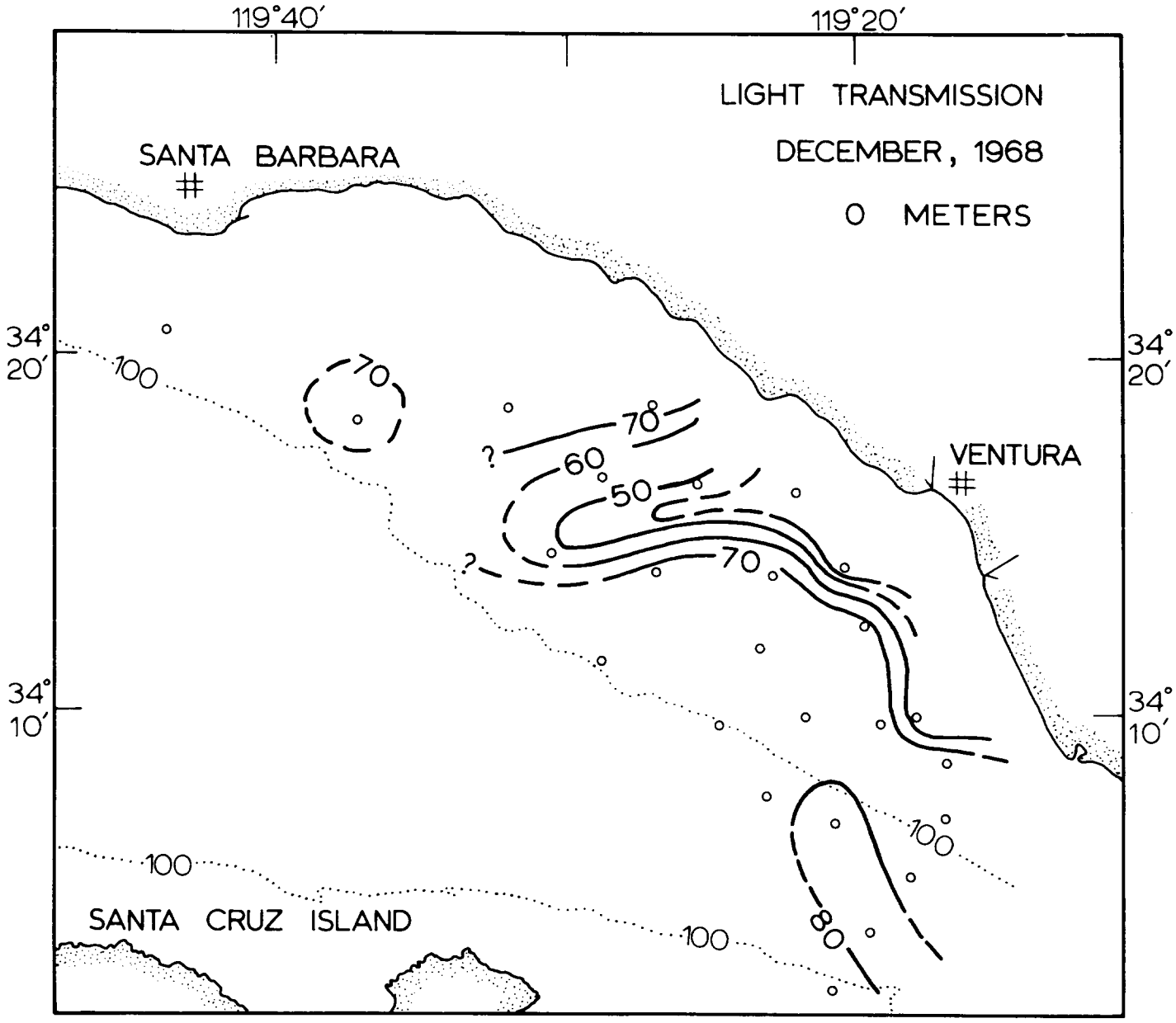
Information on the distribution of suspended particles within the water column was obtained with a continuously-recording beam transmissometer (Drake, in preparation). Light attenuation is dependent, in a complex manner, upon factors other than mere particle concentration. Consequently only approximate suspended load can be measured with the transmissometer. More accurate particulate matter concentrations were determined by vacuum filtration of water samples recovered with 7-liter Van Dorn and 30-liter Niskin bottles. Filtration of 4-liter samples was accomplished in the shore laboratory using 0.45μ pore-size Millipore membrane filters following the method of Banse, Falls and Hobson (1963). Each water sample was passed through two stacked filters to provide a weight blank correction. Filters were weighed on a Mettler Model B balance. Reproducibility of particle concentrations determined in this manner was $\pm$ 20% of the measured value.

Studies of filter efficiency by Wildharber (1966) and Drake (unpublished data) show significant fine particles passing through larger (0.8μ) pore-size filters; amounting to 10% of some samples. Whitehouse, Jeffrey and Delbrecht (1960), Wildharber (1966) and Fleischer (1970) have demonstrated that a majority of montmorillonite mineral grains are in the $< 1\mu$ size range, and probably most are finer than 0.5μ. Thus, appreciable filter loss will produce erroneous montmorillonite deficiencies.

An important portion of fine particle transport occurs within a few meters of the sea floor over the continental shelf (Rodolfo, 1964; Wildharber, 1966; Drake, in preparation). In order to document this movement, water samples one meter above bottom were obtained with Van Dorn and Niskin bottles modified to trigger when a lead weight strikes bottom. Comparisons of particle concentration results from the two samplers and the beam transmissometer show no detectable contamination owing to disturbance of the bottom.

Flood layer thicknesses offshore were obtained from Reineck box core, Phleger core and, in shallow water (< 100 meters), from Shipek grab samples. Box core and Phleger core data are considered good, whereas information from Shipek grabs is considered to have a maximum error of $\pm$ 20% of the measurement. Isopach maps were drawn using box core

Figure 2. Surface water turbidity (December, 1968) pattern from % light transmission/meter. High % transmission values represent clearer water. Station control shown by small circles.


119°40′
119°20′
LIGHT TRANSMISSION
DECEMBER, 1968
0 METERS
SANTA BARBARA
#
VENTURA
#
34° 20′
34° 10′
100
70
60
50
80
?
SANTA CRUZ ISLAND

and Phleger core data wherever possible. Deposits less than 2-4mm thick could not be confidently measured and therefore are recorded as "present" only.

All granulometric analyses were accomplished by settling methods (Krumbein and Pettijohn, 1938; Felix, 1969). Mineralogical analysis of the silt and clay fractions of flood and basin-core sediment were carried out according to the methods of Jackson (1956)

BASIN HYDROGRAPHY

Inflow and outflow of basin water occurs predominantly through the southeast Anacapa-Oxnard passage and the western opening between Pt. Conception and San Miguel Island. Subsurface circulation is restricted by sill depths of 230 meters at the southeastern margin and 475 meters at the western margin of the basin. The Channel Island ridge forms an effective barrier to all flow below about 40 meters. Emery (1960), on the basis of the physical and chemical characteristics of the basin water, demonstrated that water below the deepest sill is derived from open sea water at the level of, or somewhat deeper than, that sill. Therefore, the deep water of Santa Barbara Basin (below about 500 meters) is replenished by water from the low oxygen zone (400-600m) in the North Pacific. Emery and Rittenberg, (1952) and Rittenberg, Emery, and Orr, (1955), based on consideration of nutrient regeneration, determined that complete deep basin recharge must occur in less than 2 years. More recent information indicates that basin recharge probably occurs on a yearly basis. The North Pacific Water is further depleted in oxygen within the basin, resulting in levels (0.1 to 0.3 ml/l) which will not support large benthic organisms. In the absence of burrowing animals, an undisturbed record of sediment accumulation is preserved.

FLOOD SEDIMENT

Magnitude and Composition

The Ventura and Santa Clara Rivers terminate at the eastern end of the basin and the Santa Ynez River terminates 30km northwest of Pt. Conception. The effective (uncontrolled) drainage areas of these rivers are given

in Table I; they include more than 70% of the land which naturally drains to the channel. Contributions of sediment by the Channel Islands are minor and measurable layers of flood sediment on the insular ridge were found only in well-protected coves.

Hourly information on water discharge and suspended load of the Santa Clara River, supplied by the Water Resources Division of the U.S. Geological Survey, shows that this river transported 50 $\pm$ 3 X 10^6 metric tons of suspended sediment to the coast during the floods. Discharge peaked at 165,000 cubic feet/second (cfs) with a mean daily suspended load of 20 X 10^6metric tons. More than 70% of the total flood contribution occurred on two days, January 25th and February 25th.

The uncontrolled drainage area of Ventura River is approximately 1/8 the area of Santa Clara River. Although the USGS gauging station on this river was destroyed, discharge was estimated and suspended sediment samples were recovered on 22 days during the one-month flood period. These data indicate a suspended sediment contribution of 6.0 X 10^6 tons by the Ventura River, a figure in good agreement with calculations based solely on direct comparison to the drainage area and well-established suspended load of the Santa Clara River.

Estimates of the discharge of suspended material by Santa Ynez River must be based entirely on a drainage area comparison to the monitored streams because this river is not gauged and was not adequately sampled. Using an uncontrolled area, we calculate between 15 and 20 X 10^6 tons of suspended detritus. This river is not a direct tributary to the basin and consideration of offshore current flow suggests that the uncertainty of this figure is not critical.

Although these three rivers transported the bulk ($\sim$ 75 X 10^6 tons) of suspended sediment, it is estimated that an addition of about 8-10 X 10^6 tons was made by smaller intermittent streams along the steep northern margin of the Channel. Thus, the total contribution from all sources is estimated to have been 83 X 10^6metric tons.

The size distribution and mineralogy of the suspended flood sediments was determined by the USGS and the authors. The difficulty of obtaining representative samples of flooding rivers produces a large degree of variation in the

TABLE I: FLOOD SEDIMENT DATA

	Suspended Load	Drainage Area	Grain Size
Santa Clara River	50×10^6 tons*	1011	15-20% Clay 40-50% Silt 30-35% Sand
Ventura River	6.0×10^6 tons*	131	Same
Santa Ynez River	$15\text{-}20 \times 10^6$ tons+	400**	Same
Smaller Streams	$8\text{-}10 \times 10^6$ tons	200**	Same

** = estimated from topographic maps
* = from USGS gauging records
+ = estimated by authors (see text)

TABLE II: < 62μ TOTAL MINERAL COMPOSITION

Sample	KAOL.	CHLOR.	ILL.	MONT.	VERM.	QTZ.	PLAG.	ORTH.	AMPH.	RANK SCORE	REL. FIT
Flood Layer*	8.9	2.2	39.0	20.5	2.1	22.2	3.9	1.3	0.09		
Gray Layers+	11.2	2.3	33.5	22.6	1.9	22.0	4.5	1.5	0.0		
Green Layers**	12.9	3.5	27.5	25.6	4.2	20.9	4.3	1.4	0.08		
Santa Ynez River	16.1	3.9	34.6	15.8	8.3	14.7	4.2	1.7	0.7	13	2
Gaviota Creek	11.3	0.0	25.7	16.0	0.4	29.2	15.1	2.2	0.10	12	3
Ventura River	6.6	4.6	31.1	10.3	8.3	30.3	6.9	1.9	0.0	7	4
Santa Clara River	9.1	0.5	38.0	18.8	7.2	18.5	6.2	1.6	0.16	22	1

* = average of 4 samples
\+ = average of 11 samples
** = average of 15 samples

TABLE III: < 2μ MINERAL COMPOSITION

Sample	Kaolinite	Chlorite	Illite	Mont.	Verm.
Flood Layer*	9.4	0.8	34.7	52.7	2.4
Gray Layers+	10.2	1.6	37.6	47.5	3.1
Green Layers**	10.4	3.1	35.9	46.6	4.0
Santa Ynez River	14.2	3.1	52.1	24.1	6.5
Gaviota Creek	7.7	3.0	47.0	37.4	4.9
Ventura River	10.2	2.4	52.8	30.3	4.4
Santa Clara River	15.0	0.3	33.5	50.8	0.4

* = average of 4 samples
+ = average of 11 samples
** = average of 15 samples

size data. Loss of the coarse particles concentrated near the river bed constitutes the principal source of error. Owing to the large data variation and known sample bias, we can only estimate the average percentages of clay, silt and sand carried in suspension during peak flow. Using data from 10 samples recovered at river discharges of more than 10,000 cfs, these ratios are 15-20% clay, 40-50% silt, and 30-35% sand.

Results of X-ray diffraction analyses of the less than 62μ and less than 2μ size fractions of river material are given in Tables II and III. Ventura River is relatively enriched in chlorite and quartz, and deficient in montmorillonite in the $< 62\mu$ fraction; whereas Santa Ynez River carried a slightly greater percentage of kaolinite with respect to either Santa Clara or Ventura Rivers. More striking differences are found in the $< 2\mu$ clay size. In this size range, Santa Clara River carried significantly more montmorillonite and less chlorite than the other rivers, probably a reflection of the presence of basic and ultrabasic rocks high in its drainage basin (Bailey and Jahns, 1954).

TRANSPORT AND DEPOSITION OF FLOOD MATERIAL

An important gradient reduction and decrease in transport power near the coast led to deposition of coarse particles from suspension and bed load within a few kilometers both upstream and downstream of the river mouths. Only the sediment load of Santa Clara River was sufficient to construct a significant sand delta. Aerial photographs and bathymetric survey data, both preflood and postflood, (supplied by the U.S. Army Corps of Engineers) showed that the subaerial portion of the delta extended 0.7km offshore whereas detectable submarine shoaling occurred to about 2km from the coast. We calculate, using a density of 1.5 gm/cm^3 for the newly deposited material, that between 12 and 16×10^6 metric tons of material accumulated in the delta. The preceeding information indicates that the fate of $42 \times 10^6 \pm 5 \times 10^6$ tons of silt and clay delivered to the northeastern shelf by the Santa Clara and Ventura Rivers must be determined. Assuming no major difference in the sizes of sediment carried, an additional $15 \times 10^6 \pm 5 \times 10^6$ tons of silt and clay was available from Santa Ynez River and all other smaller streams. However, in terms of deposition on the northeastern shelf, this added supply

was more remote and not of immediate consequence. Thus, the influx of Santa Ynez River fine grained material around Pt. Conception was significant only in the deep western parts of the basin.

Initial Deposition (March-April, 1969)

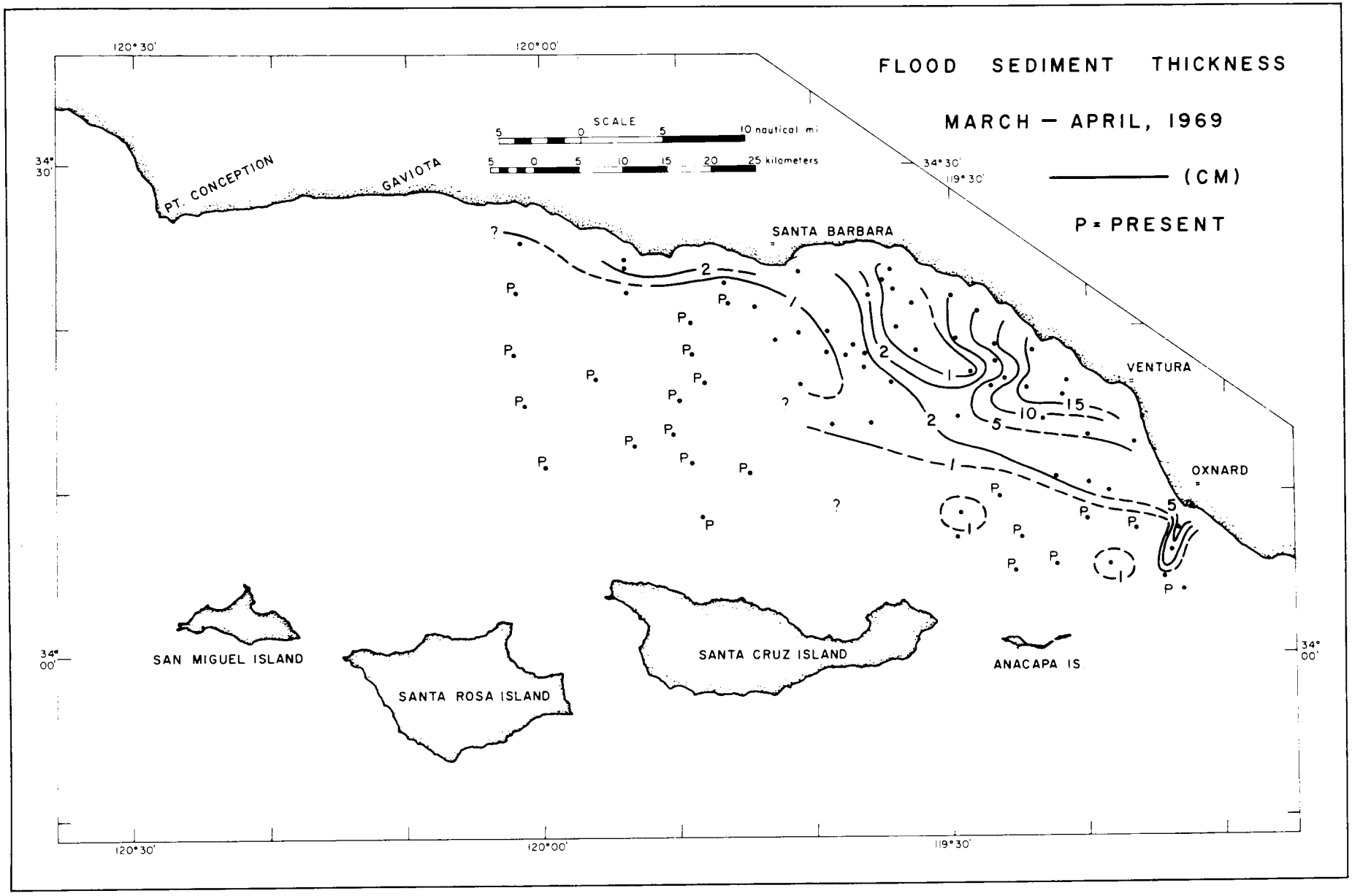
Initial deposition of flood detritus occurred on the Ventura Shelf predominantly within 20km of the Santa Clara River mouth (fig. 3). Granulometric analysis of flood material recovered from the bottom 5.0km off Pitas Point at a depth of 37m shows that 37% of the total sediment was finer than 8μ. This material settled to the sea floor in spite of long swell stirring and estimated currents of greater than 10 cm/sec. The conclusion that clay and fine silt were forming larger floccules is unavoidable.

Assuming an average bulk density of 1.4 gm/cm^3, we calculate that about 92-95% of the Ventura and Santa Clara River contribution (39-40 X 10^6 tons) was rapidly deposited in depths of less than 100m on the Ventura shelf. This estimate is based on an assumed gradual thickness increase to a maximum of 0.7m at a distance of 1.0km from the Santa Clara River. Although aerial photographs indicated appreciable quantities of suspended material were transported southward in the longshore drift zone, little of this sediment was lost from the Santa Barbara Channel. Two patterns of shallow circulation occur over the Ventura Shelf and both appear to block the downcoast loss of significant amounts of fine sediment (see chapter on surface water circulation). Sand and some finer fractions settled into the Hueneme submarine canyon. However, the northwestward flowing current between Anacapa Island and the mainland appears to be an effective barrier to southward suspended sediment movement.(figs. 4,5,and6)

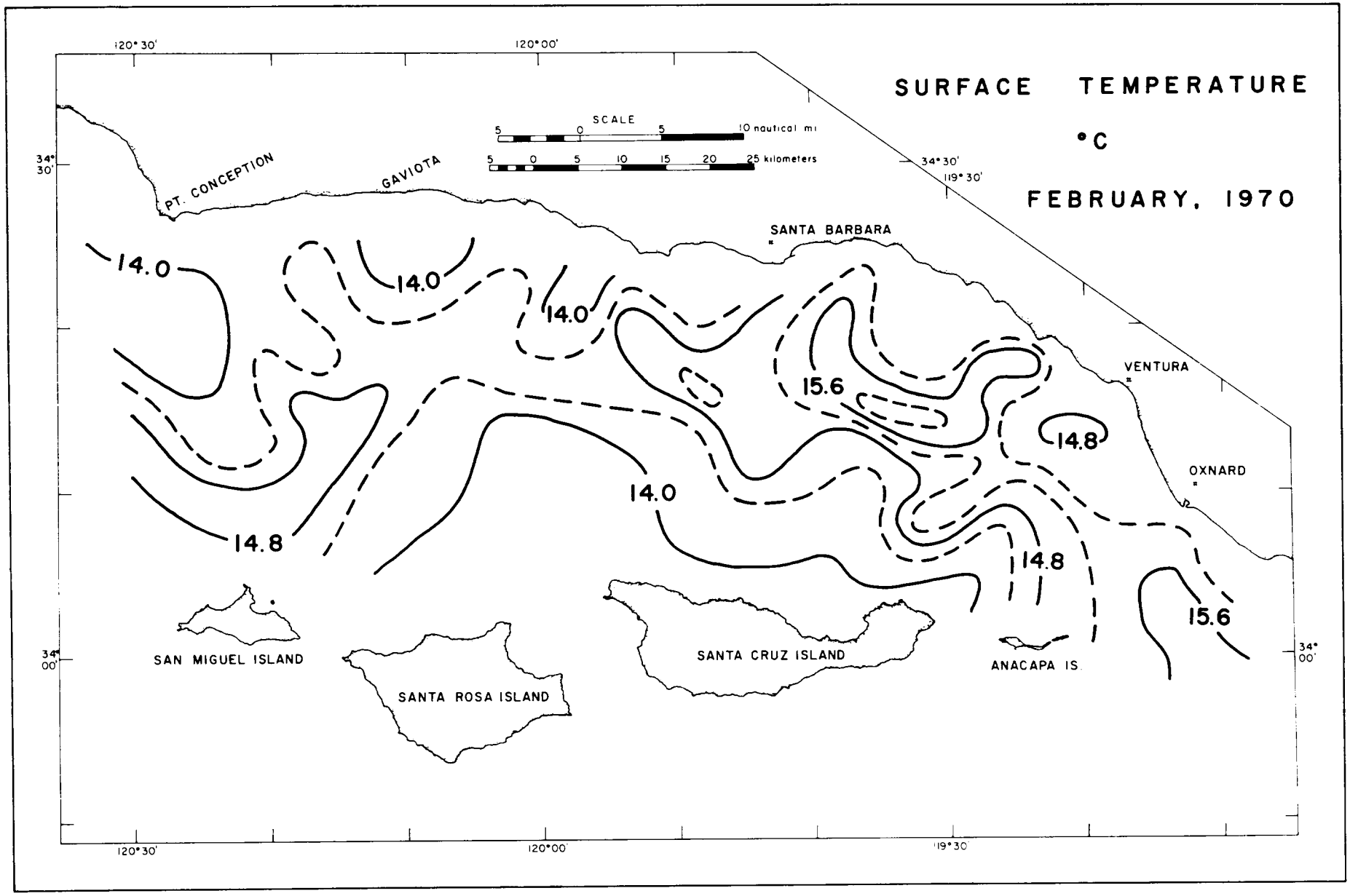
Traces of fine silt and clay were first recorded at depths greater than 500m in late March and April, 1969, implying a particle settling rate of from 7 to 10m/day (about 10 times the Stokes Law settling rate of the average particle in bottom sediments at these depths).

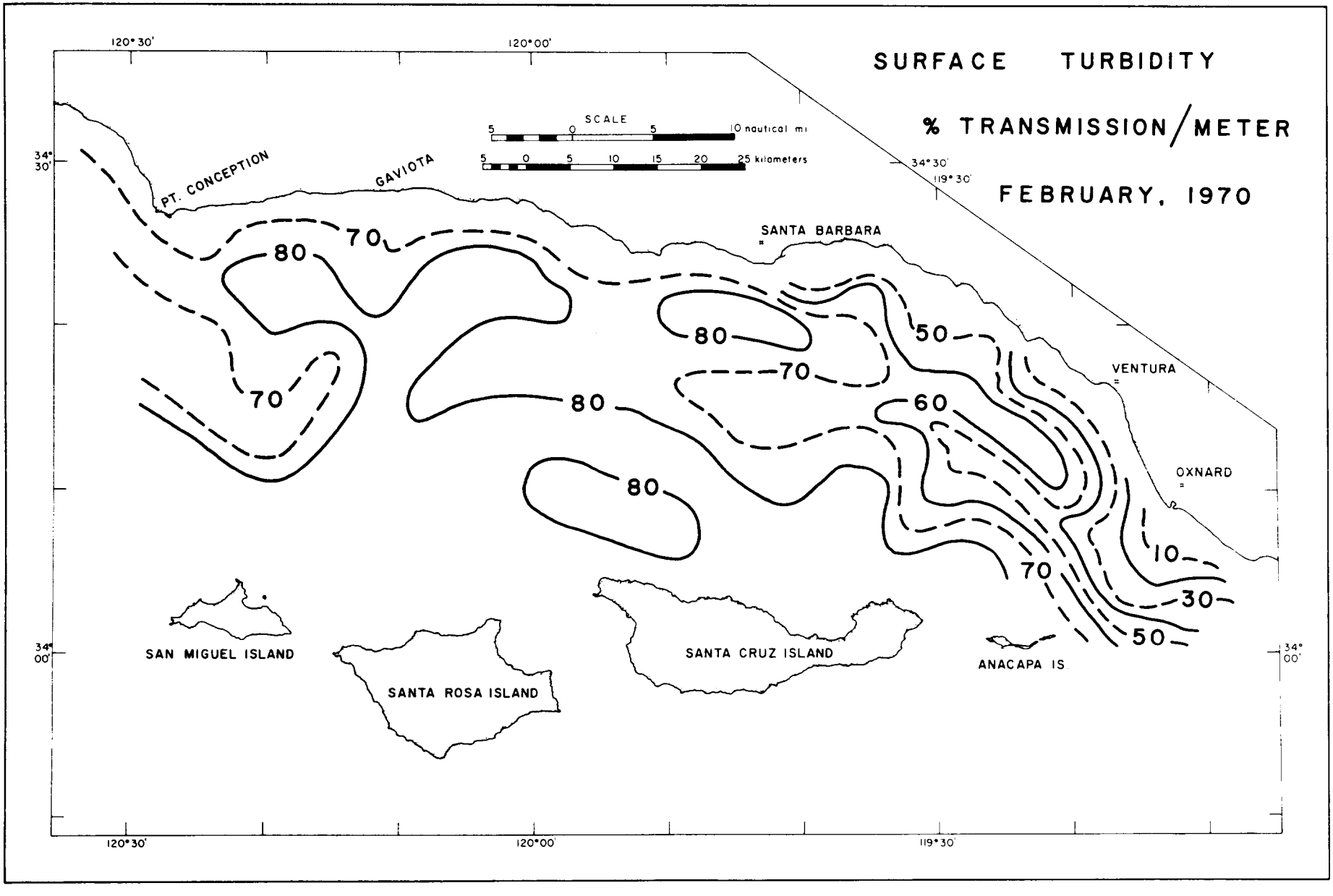
The quantity of material in suspension over the Ventura Shelf can be estimated with some confidence by using beam transmissometer, verticle profile and filter concentration information. Two layers of turbid water were found over the shelf during and a few weeks after the floods:

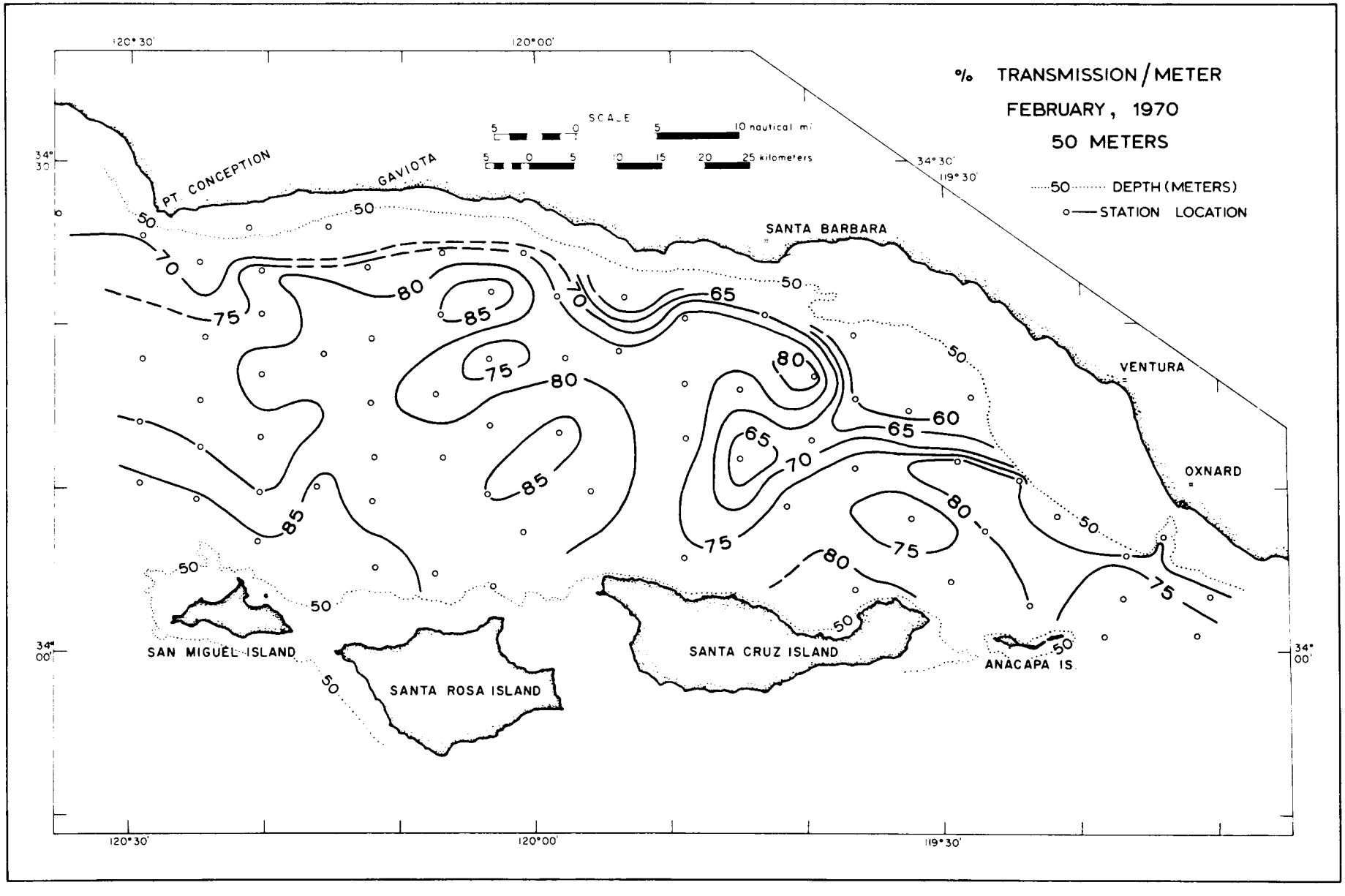
Figure 3. Flood sediment thickness in March-April, 1969. Station control shown by small dots.


FLOOD SEDIMENT THICKNESS
MARCH – APRIL, 1969
(CM)
P = PRESENT
SCALE
5 0 5 10 nautical mi
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

Figures 4,5, and 6. The surface termperature for February, 1970 is a reflection of the general surface water circulation for that period. The same pattern is shown by the surface turbidity. Note that the relatively turbid surface layer southwest of Oxnard is not present at a depth of 50 meters. Deflection of subsurface currents by Montalvo Ridge is indicated by the mid-channel tongue of turbid water south of Santa Barbara.


SURFACE TEMPERATURE
°C
FEBRUARY, 1970
SCALE
5 0 5 10 nautical mi
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
14.0
14.8
15.6


SURFACE TURBIDITY
% TRANSMISSION/METER
FEBRUARY, 1970
SCALE
5 0 5 10 nautical mi
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS
80
70
50
60
10
30


% TRANSMISSION / METER
FEBRUARY, 1970
50 METERS
50 DEPTH (METERS)
STATION LOCATION
SCALE
10 nautical mi
25 kilometers
PT CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'

a surface plume of lower salinity water with an average particle concentration of 2-3mg/l and a near bottom layer averaging 10m in thickness and carrying ~ 10mg/l of suspended matter. Thus, during the early flood stages, an average of about 0.80×10^5 tons of detritus was in suspension at any given instant. Comparison of this value to the total river contribution shows that deposition was rapid and particle resuspension and reestablishment of preflood conditions on the shelf was slow. In fact, material was still being resuspended and transferred to deeper water 1½ years after the floods.

Transport of Resuspended Particles

Particulate matter concentrations one meter above the basin floor in August, 1969, (fig. 7) were obtained by 0.45μ pore-size Millipore membrane filtration of water samples recovered with a bottom-actuated 30-liter Niskin bottle. The pattern of near bottom turbidity is strongly related to sediment sources, currents, and basin topography. Two areas of high particle concentrations, the shelf off Ventura and the basin slope south of Pt. Conception, result from resuspension of flood sediment by wave surge and current agitation in the former area, and transport of material around Pt. Conception from the north coast in the latter area.

Light attenuation and temperature profiles indicate that resuspended particles are concentrated over the Ventura Shelf predominantly within 10 meters of the sea floor. Vertical eddy diffusion, in the absence of sharp density gradients, would probably produce a more even transfer of suspensate toward the surface; however, thermal stratification over the shelf limits mixing and consequently restricts the distribution of resuspended particles to a sharply defined, near bottom zone. Furthermore, influence of temperature on water density and, in turn, upon particle settling rates, produces a close association of turbid layers and thermal density gradients elsewhere in the water column. Transmissometer records near the shelf edge south of Santa Barbara (fig. 8) reveal that the near bottom layer is transported westward becoming detached from the sea floor at the shelf-slope juncture and continuing at about the same depth into the deep basin water column. The distribution of particles one meter above bottom in August, 1969, is compatible with this conclusion and there is no indication of a continuous layer moving down the slope from shelf to basin floor.

Figure 7. Total particulate matter concentrations one meter above bottom for August, 1969.

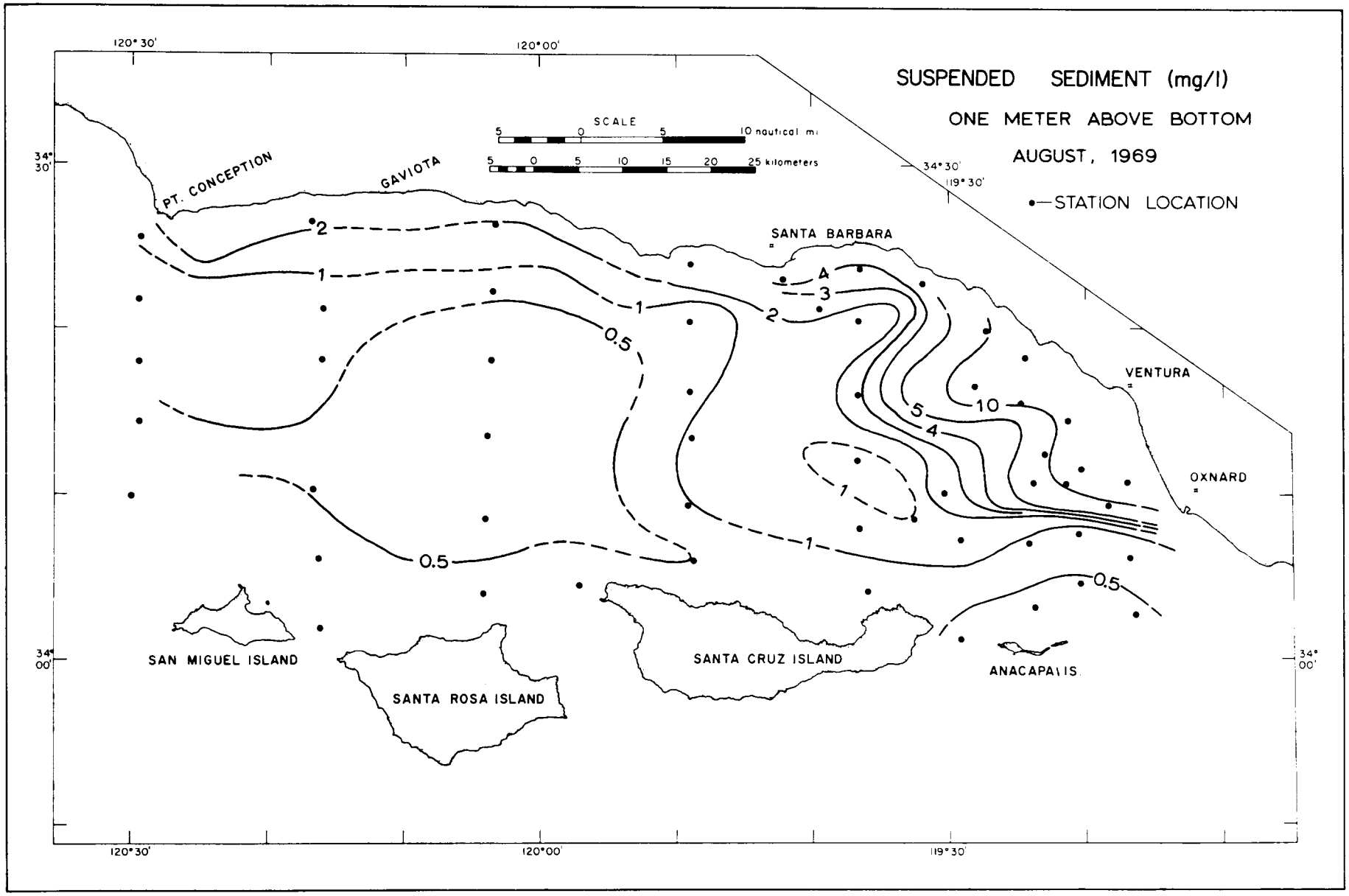
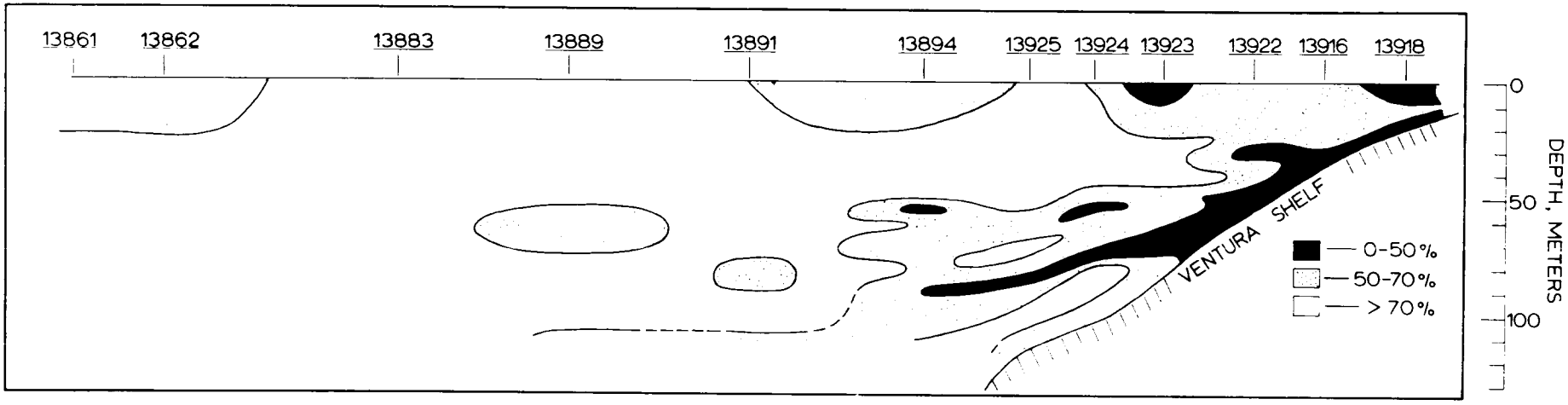

SUSPENDED SEDIMENT (mg/l)
ONE METER ABOVE BOTTOM
AUGUST, 1969
•—STATION LOCATION
SCALE
10 nautical mi
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'

Figure 8. Northeast--southwest cross section of turbidity distribution (from continuous transmissometer profiles) across the Ventura Shelf during February, 1970. Values are in % light transmission/meter.


13861
13862
13883
13889
13891
13894
13925
13924
13923
13922
13916
13918
VENTURA SHELF
0-50%
50-70%
> 70%
0
50
100
DEPTH, METERS

Longitudinal division of westward water flow by Montalvo Ridge induces a channeling of resuspended shelf sediment into the depressions to the north and south. Increased depths may result in a sufficient current decrease to allow particles to settle and concentrate in these troughs.

Patches of high particle concentrations one meter above the bottom were observed south of Pt. Conception on two of four surveys. "Sporadic" accumulation of suspended matter in this area results from transport of detritus around Pt. Conception (fig. 9) with possible additional contributions from material carried westward by the current entering the Channel through the Anacapa-mainland passage. The convergence of currents in the lee of the promontory produces local eddies, reduced net transport and a channeling of nearshore suspension offshore.

Flood Layer Distribution (May-August, 1969)

Following rapid initial deposition on the Ventura Shelf, resuspension and transfer westward occurred according to the previously described pattern. Five months after the floods, the thick layer off the river mouths had been thinned and spread to cover a larger portion of the shelf (fig. 10). Appreciable, but not quantitatively measurable, amounts of oxidized detritus were found in the trough north and south of Montalvo Ridge and in the deepest parts of the basin; 35 X 10^6 tons or 83% of the Ventura and Santa Clara River contribution could be accounted for in May, 1969 on the Ventura Shelf. In 4½ months, about 7 X 10^6 tons had been transferred from the shelf and/or mixed down into underlying sediment by benthic organisms.

Flood Layer Distribution (February-June, 1970)

One and one-half years after the floods, 38% of the oxidized silt and clay had been transferred from the shelf (fig. 11). The bulk of the material, forming a measurable surface layer, was transported to the troughs north and south of Montalvo Ridge and into the deep basin. The north trough aligned beneath the predominant axial trend of the westward-flowing current, had received and acted as the conduit for the major portion of the flood detritus. This pattern is entirely compatible with the distribution of near bottom turbidity and the topographically influenced current regime.

Figure 9. Surface water turbidity for November, 1969. The high particle concentrations in samples one meter above bottom from the area south of Pt. Conception are several km south of the surface water expression of high turbidity.

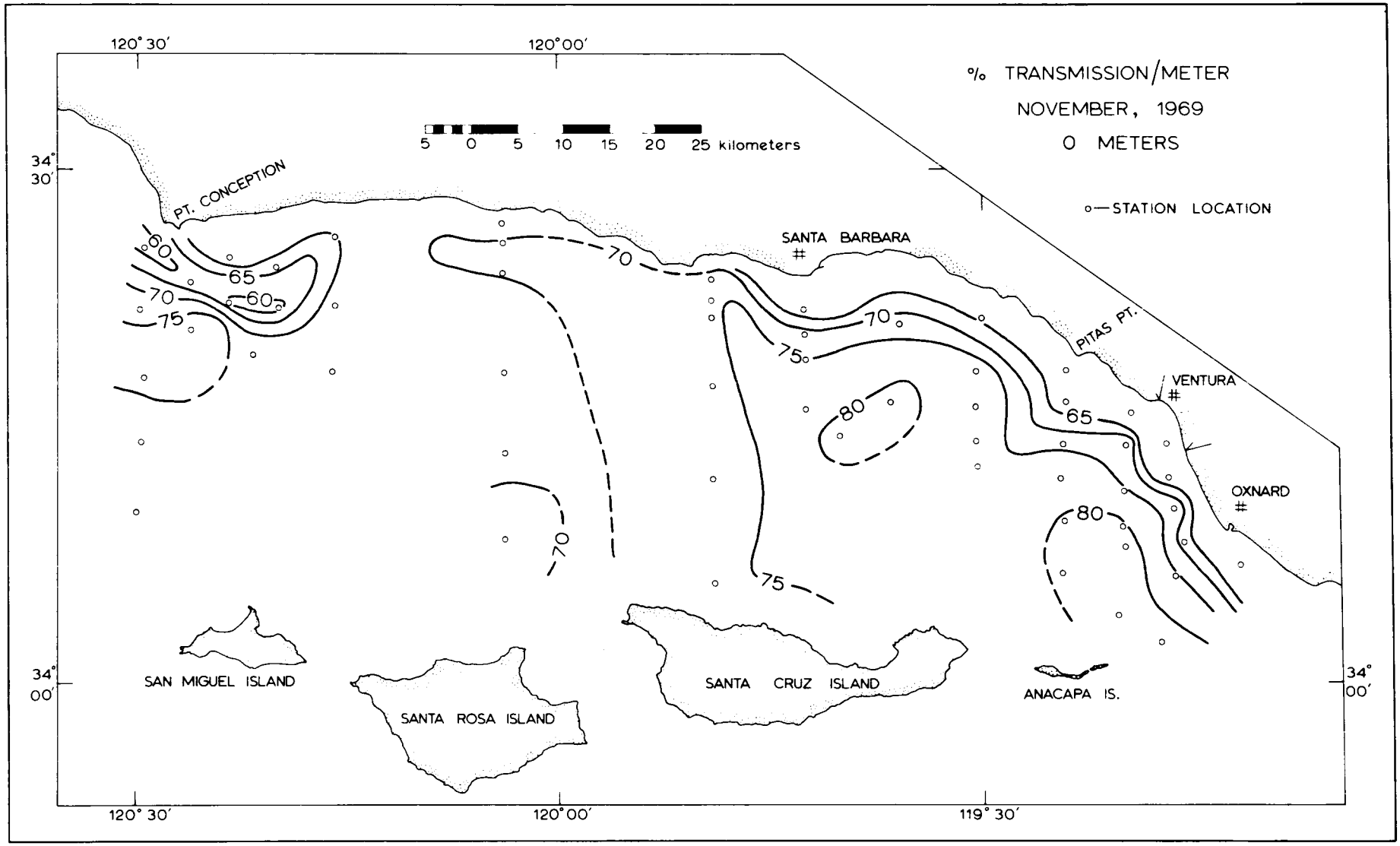

% TRANSMISSION/METER
NOVEMBER, 1969
0 METERS
o—STATION LOCATION
5 0 5 10 15 20 25 kilometers
120° 30′
120° 00′
119° 30′
34° 30′
34° 00′
PT. CONCEPTION
SANTA BARBARA
PITAS PT.
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
60
65
70
75
80

Figure 10. Flood sediment thickness for the period May-August, 1969. The control for this period is primarily that of the hydrographic station grid. Thus, each control point usually represents more than one sample.

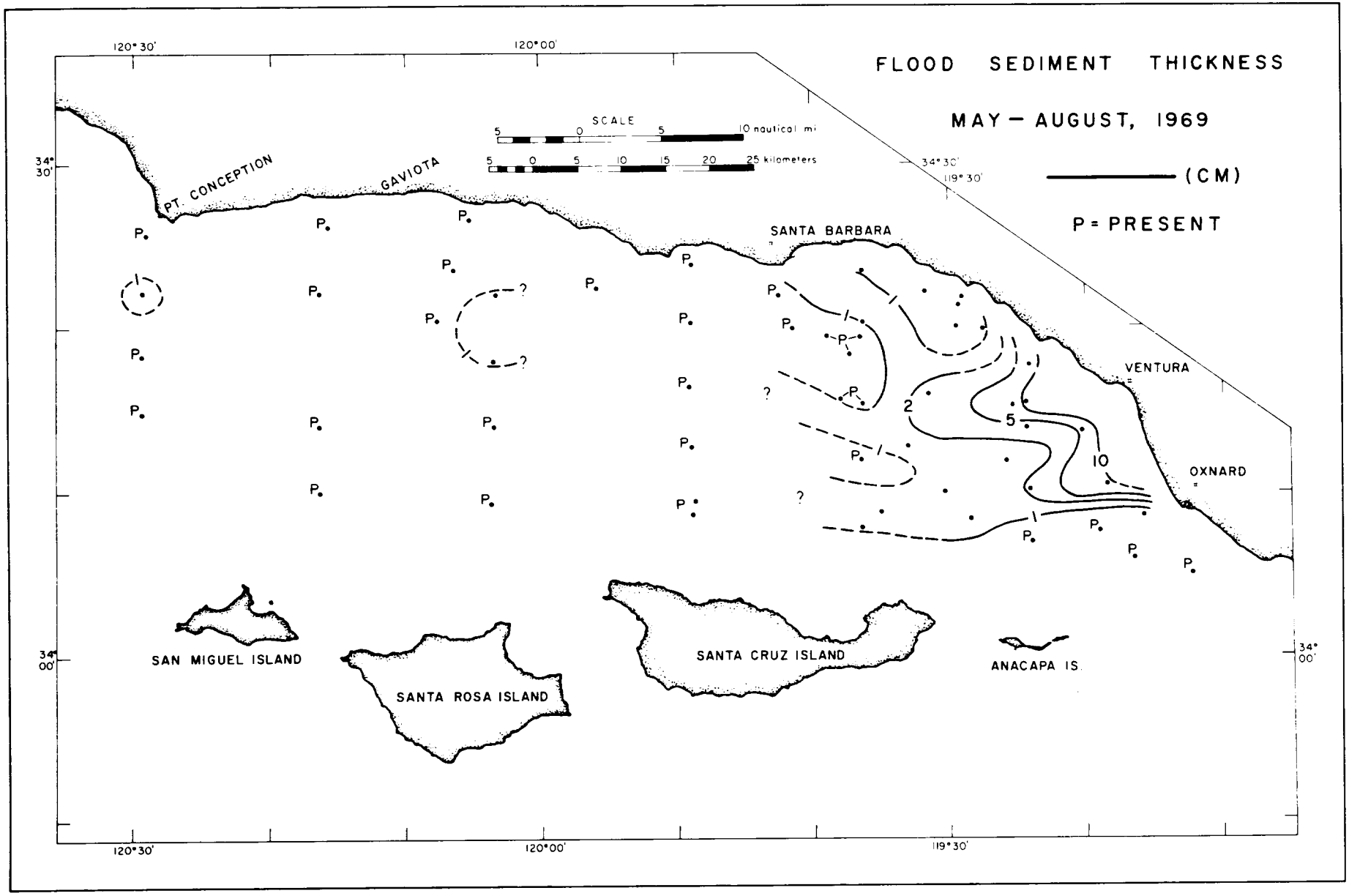
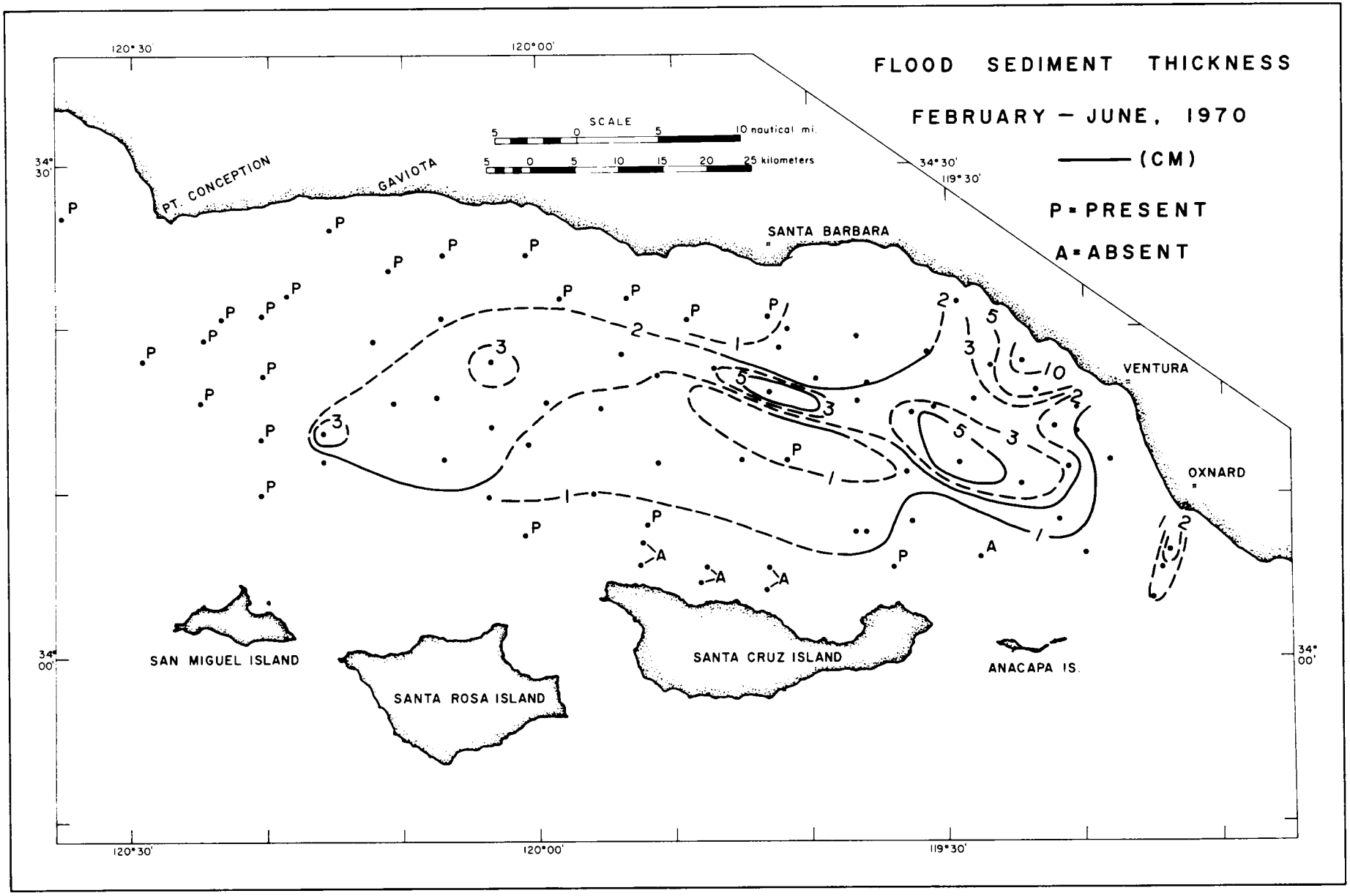

FLOOD SEDIMENT THICKNESS
MAY – AUGUST, 1969
(CM)
P = PRESENT
SCALE
5 0 5 10 nautical mi
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
2
5
10

Figure 11. Flood Sediment thickness measurements derived from samples taken in February and June, 1970. The nearshore area northwest of Ventura (Pitas Point) appears to be an area of net accumulation on the shelf. The absence of flood sediments in the channel north of Anacapa Island is a result of winnowing by strong bottom currents.


FLOOD SEDIMENT THICKNESS
FEBRUARY – JUNE, 1970
(CM)
P = PRESENT
A = ABSENT
SCALE
10 nautical mi.
25 kilometers
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'

Between 40 and 45 X 10^6 tons of flood material remained within the basin 1½ years after the floods. At that time, a 2-3cm layer of clay and silt covered that portion of the basin below 500 meters. Best described as a "sponge-like" surface mat, the initially red-brown particles had now changed to yellow and gray in the near-anaerobic bottom water. The sponge-like consistency of the surface mat was well preserved during box coring.

Most of the shelf layer had been transferred to the shelf break and beyond, becoming aligned beneath the northwestward and westward moving current. However, a small triangular wedge of flood sediment remained off of Pitas Point 1½ years after the floods. In fact, the thickness of this lens appears to have increased somewhat with time. This accumulation suggests a current convergence and decrease in transport power off Pitas Point; a pattern compatible with the circulation system outlined in the chapter on surface currents. The clockwise eddy between Santa Barbara and Pitas Point was found on the majority of surveys and therefore appears to be a relatively stable feature. However, the current moving northwestward between Anacapa Island and the mainland is more variable in position.

The total flood sediment tonnage remaining within the basin 1½ years later does not include any correction for material mixed into older sediments by benthic burrowers. Although the sediment present at this time was conservatively estimated and is based principally on reliable box cores, it is at least equivalent to the initial contribution of the Santa Clara and Ventura Rivers. Either the Santa Barbara Channel is a nearly perfect sediment trap or additional supplies of sediment were made from outside the area.

Subsurface Basin Sediments

During the course of this investigation, a study of the mineralogy of silt and clay in the basins of the Continental Borderland was being completed (Fleischer, 1970). A 7m long piston core from 620m in Santa Barbara Basin contained 34 distinct layers of gray silt and clay intercalated with green "homogeneous" mud and laminated green sediment. Emery and Hülsemann (1962) determined that the laminated sediment represents seasonal deposition of biogenic-rich (diatoms) and biogenic-poor sediment layers. They considered the homogeneous green mud to be disturbed laminated material

produced by periodic invasions of burrowing organisms from the basin slopes.

The gray layers in the core described previously ranged from 0.5 to 12cm thick and were low in organic matter and carbonate relative to the interbedded green muds. Similar layers in cores described by Hülsemann and Emery (1961) were thought to be coarser-grained than the green sediments. In addition, they cited graded bedding and a numerical increase in gray layers toward the northern basin margin as evidence of a turbidite origin.

Of the 34 gray layers in the 7m core, 25 are less than 2cm thick, 5 are from 2 to 10cm thick and 4 are between 10 and 12cm thick. Only the thickest layers show slight indications of normal grading, and analyses of 11 gray layers and 15 green sediment (both laminated and homogeneous) samples reveal that the gray layers are actually finer-grained, better-sorted, and contain only 25% as much carbonate (2.5% by wt). The smaller mean grain size and better sorting are attributable to a deficiency of particles larger than 20μ in the gray layers. The low carbonate value is similar to that of the shelf sediment (Hülsemann and Emery, 1961) and suggests that the deficiency of larger particles is the result of a deficiency in biogenic debris.

A proposed provenance and depositional history for the gray layers must explain their better sorting, low carbonate and organic content, numerical increase toward the mainland coast, color, and the near absence of coarse silt and complete absence of sand.

Mineralogy of the Flood Deposits and Subsurface Sediments

Comparison of flood, gray and green sediment mineralogies (tables II and III) indicates that both size fractions for the three deposits are similar. The values for the gray layers are intermediate between the flood layer and the green layers for most minerals in both fractions. This suggests the influence of a dilutant or mixing process wherein a predominant assemblage is being diluted by subordinate assemblages. In addition, examination of individual analyses of green and gray sediment reveals a small but significant shift of composition with time.

The proportions of chlorite, illite and montmorillonite in the < 2μ fraction (table III) are of particular significance because Santa Barbara Basin has the lowest chlorite values in the northern part of the California Continental Borderland, and the highest values here are in the green layers. The only major source of low-chlorite sediment on the southern California coast appears to be the Santa Clara River. If one calculates the combined percentage of chlorite in the flood detritus contributed by the Ventura and Santa Clara Rivers, one obtains a value of 2.5%; essentially identical to the chlorite content of the flood layer and the subsurface gray layers. Furthermore, the Santa Clara River is the only source on the basin perimeter that has the proportions of illite and montmorillonite found in all three of the basin deposits.

In addition, examination of the < 62μ total mineral composition suggests that the Santa Clara River assemblage is in best agreement with the basin deposits. To make this pattern more visible, the nine-mineral species in each type of basin sediment were compared to the assemblages of the four rivers, the differences for each mineral ranked by absolute value, and the rankings summed for each river (table II). The ranking score then represents the relative degree of agreement. For all three basin sediment types the Santa Clara River shows the highest score and thus is the assemblage in greatest agreement with the basin sediment. It is noteworthy that of the three sediments, the flood layers has the greatest, the gray layers an intermediate, and the green layers the least degree of agreement.

SUMMARY

The largest recorded flood in southern California occurred in winter, 1969. Santa Clara and Ventura Rivers contributed more than 50 X 10^6 tons of suspended sediment to the eastern end of Santa Barbara Channel. The oxidized, red color of this sediment facilitated offshore tracing. Initial deposition of about 40 X 10^6 tons of flood sediment occurred on the shelf within 20km of the river mouths. Layer thickness increased in the deep parts of the basin with time; 1½ years after the floods more than 15 X 10^6 tons had accumulated at depths of between 500 and 600m in the central portion of the basin. Postulated low-density downslope turbid layer flow was not observed. Particle

concentrations one meter above bottom and light transmission profiles show that movement of resuspended material westward into the deep basin was controlled by subsurface currents, water stratification, and topography. Subsurface basin sediments contain numerous gray silt layers previously thought to be turbidites. Comparison of the $< 62\mu$ size fraction mineralogy of these layers, the flood layer, and river suspended material demonstrates that the gray layers are flood-year deposits supplied predominantly by the Santa Clara River.

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CHAPTER 6

FORAMINIFERAL POPULATIONS IN THE SANTA BARBARA CHANNEL: OFFSHORE SPECIES

by

Ronald W. Morin
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

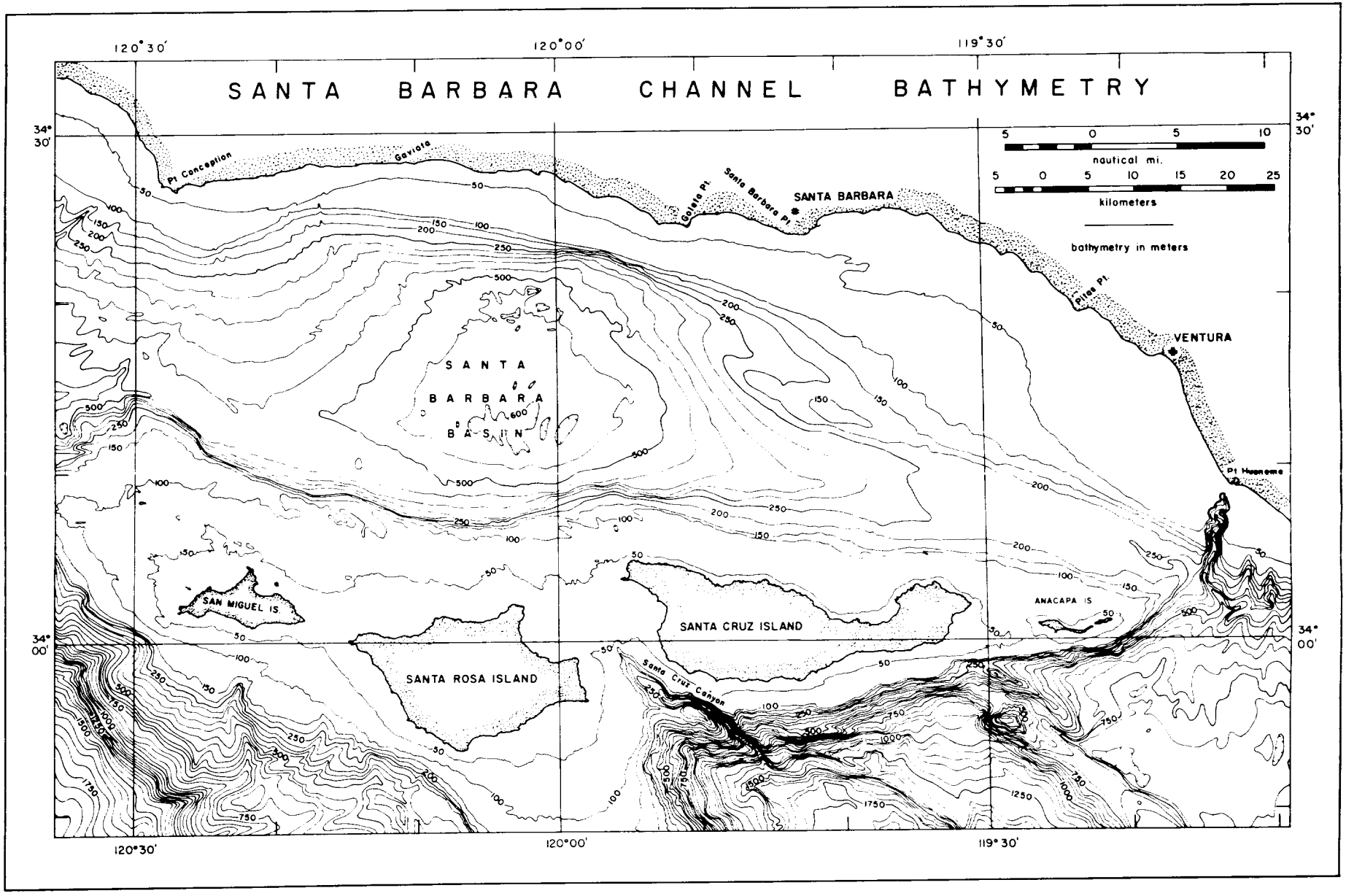
INTRODUCTION

Introduction of organic waste from sewer outfalls on the southern California mainland shelf has been shown to influence the distribution of a group of marine protozoans, the Foraminiferida (Zalesney, 1959; Resig, 1960; Watkins, 1961; Bandy, Ingle, and Resig, 1964a, b, 1965a, b). Another source of pollution, seepage of oil from the sea floor, was introduced into the marine environment offshore of Santa Barbara, California. This pollution resulted from a series of natural seeps and from the rupture of well 21 on Union Oil Company's platform A on January 28, 1969. Shortly after this incident, a study of foraminiferal species from the beach, nearshore, and offshore environments was begun. The purpose of this report is to present the results of a study of the offshore foraminiferal populations in the Santa Barbara Channel region from March 5 to December 12, 1969.

LOCATION

The 141 samples used for this portion of the investigation were collected within the geographic limits of the Santa Barbara Channel region (fig. 1) as defined by Vedder, Wagner, and Schoellhamer (1969). Pt. Conception and

Figure 1. Santa Barbara Channel Bathymetry.


SANTA BARBARA CHANNEL BATHYMETRY
120°30′
120°00′
119°30′
34° 30′
34° 00′
Pt Conception
Gaviota
Goleta Pt.
Santa Barbara Pt.
SANTA BARBARA
Pitas Pt.
VENTURA
Pt Hueneme
5 0 5 10
nautical mi.
5 0 5 10 15 20 25
kilometers
bathymetry in meters
SANTA BARBARA BASIN
SAN MIGUEL IS.
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
Santa Cruz Canyon
ANACAPA IS

San Miguel Island delimit the western boundary while the eastern boundary is approximated by the channel between Anacapa Island and Pt. Hueneme. The northern and southern limits consist of the Santa Ynez Mountains and the Channel Islands, respectively. These boundaries form a region about 129 km long, 40 km wide, and 4650 km^2 in area.

METHODS

Samples used in this investigation were collected by the Department of Geological Sciences personnel aboard the marine research vessels Velero IV and Golden West. Only the upper 2-3 cm of sediment was collected for microfaunal analysis. All other analytical techniques were similar to those described in the chapter on beach foraminifera.

Relative abundance of foraminiferal species was determined from an average of about 340 tests per sample. The initially large size of the populations required the use of a modified Otto microsplitter to obtain the desired number of specimens.

ACKNOWLEDGMENTS

The author wishes to express appreciation to Dr. O.L. Bandy for many helpful suggestions during this study, for verifying foraminiferal identifications, and for reading the manuscript. Dr. R.L. Kolpack also gave constructive criticism of the manuscript as well as supervised the sample collecting and provided both sedimentological and oceanographic data. Thanks are due many members of the Department of Geological Sciences for assistance during this study.

FAUNAL TRENDS

General

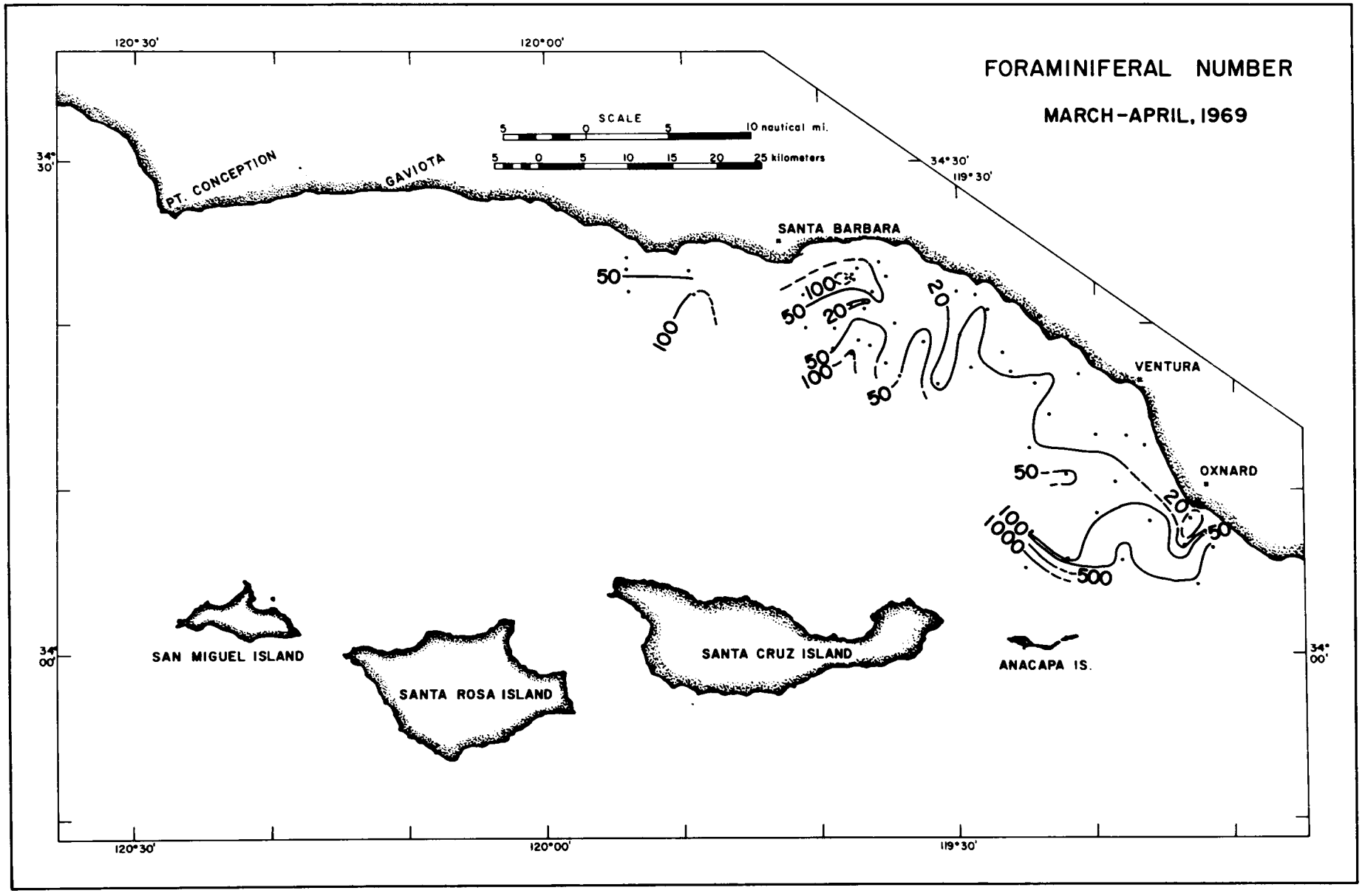
The size of foraminiferal populations in bottom sediments may be expressed in terms of the number of specimens/gram of dry sediment, the foraminiferal number. The foraminiferal number generally increases from the littoral to the upper bathyal zone in modern oceans (Bandy and Arnal, 1960), and this trend held up in the Santa Barbara Channel region (figs. 2-4). Foraminiferal numbers generally increased

Figures 2-4. Foraminiferal number.

2. March-April, 1969

3. June-August, 1969

4. December, 1969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SCALE
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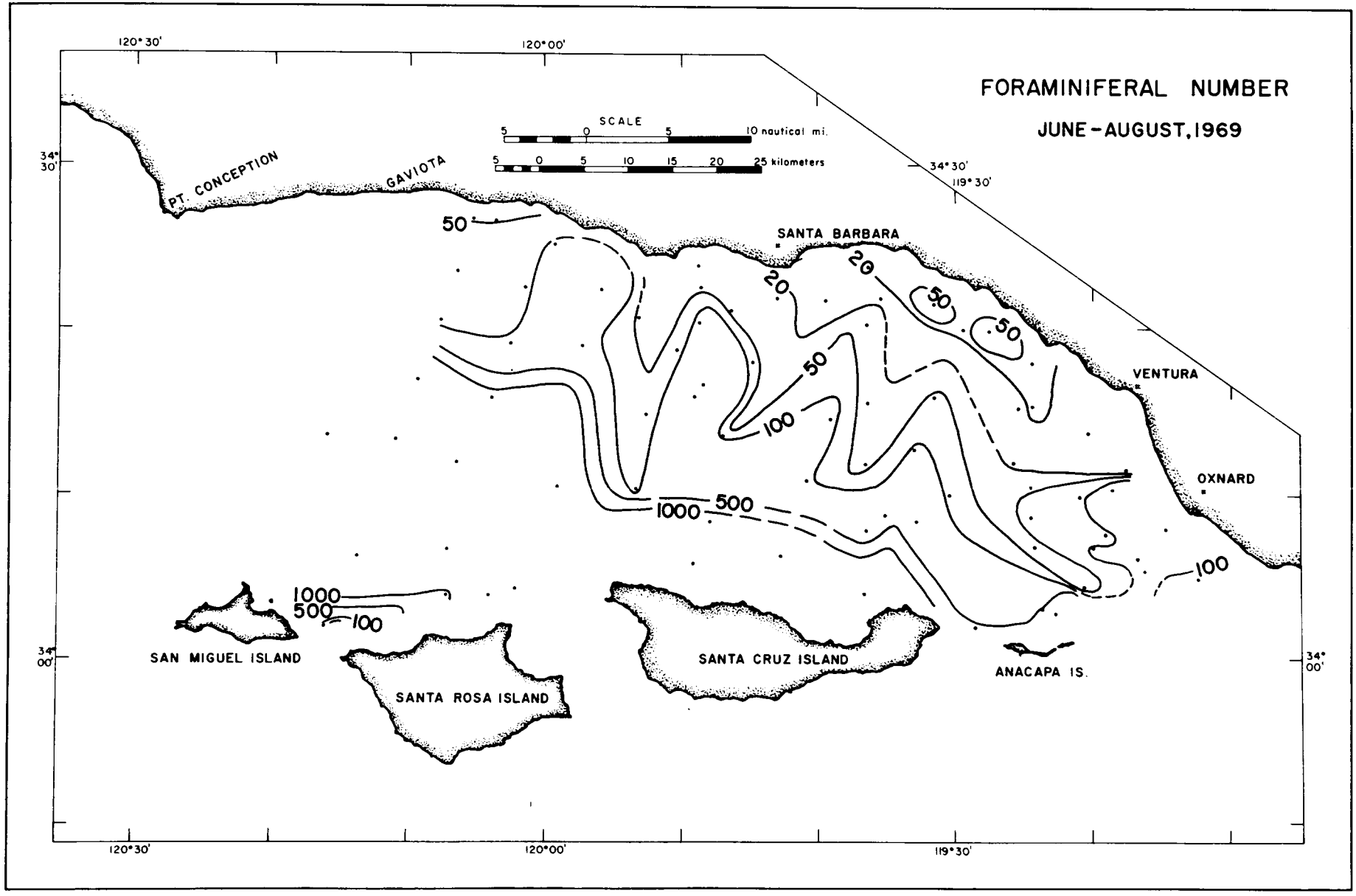
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
50
100
20
1000
500


FORAMINIFERAL NUMBER
JUNE-AUGUST, 1969
SCALE
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5 0 5 10 15 20 25 kilometers
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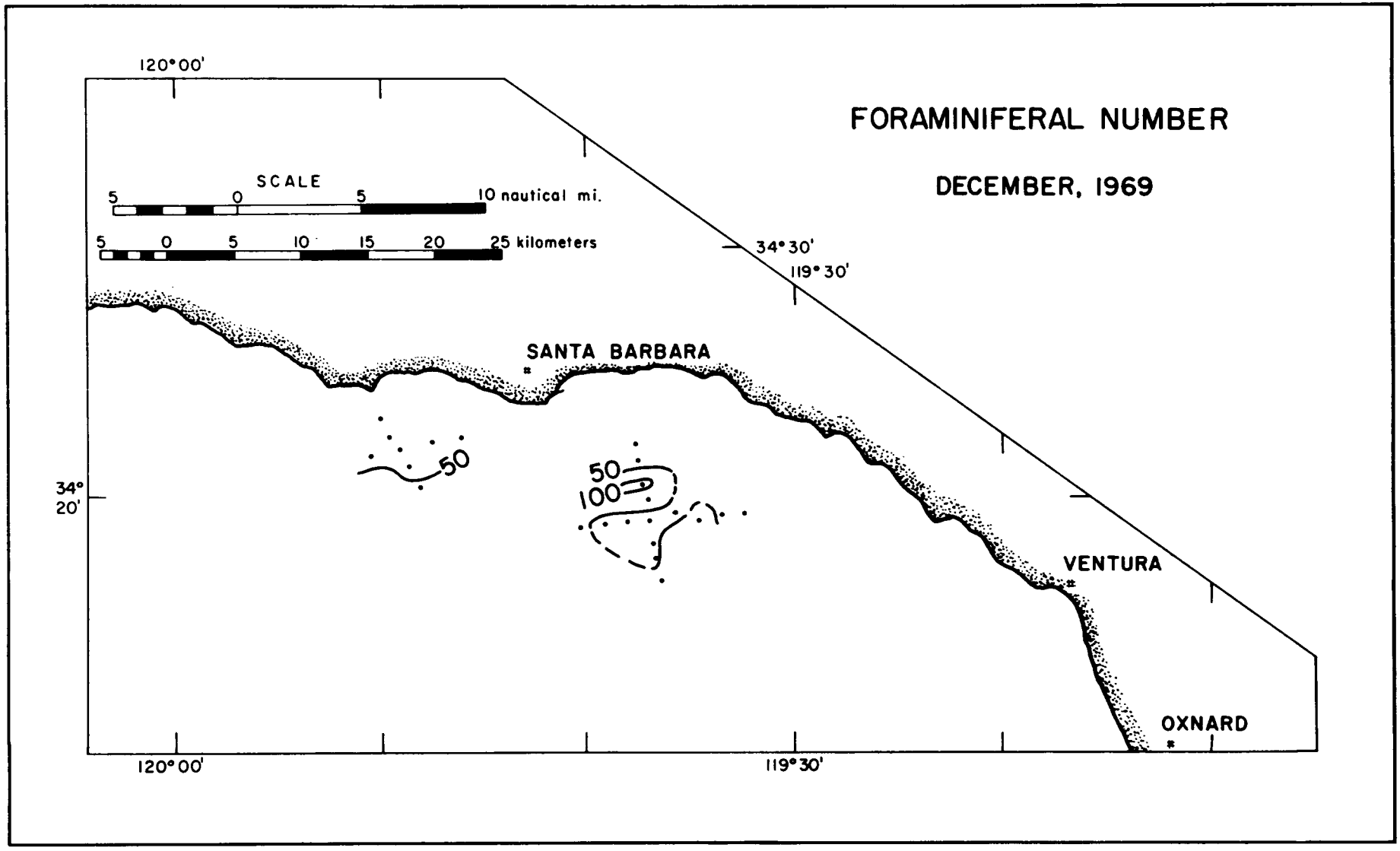
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
50
20
20
50
50
50
100
1000
500
100
1000
500
100


FORAMINIFERAL NUMBER
DECEMBER, 1969
SCALE
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5 0 5 10 15 20 25 kilometers
120° 00'
34° 30'
119° 30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
50
50
100
120° 00'
119° 30'

from about 20 near the middle of the shelf to about 100 at the mainland shelf's edge from March to December, 1969. Relatively large populations did occur in the nearshore area between Carpinteria and Ventura and did extend up small gullies onto several areas near the shelf edge. The ruptured oil well was near one of the latter highs during March and April but typical shelf values were found in the vicinity of platform A during this study. Trends of the foraminiferal number were further complicated by the displacement of shelf-type foraminiferal numbers down into Santa Barbara Basin. Populations of more than 100 specimens/gram were found in most parts of both the basin and the insular shelves in contrast to 100 or fewer specimens on the mainland shelf. Such divergent foraminiferal numbers are the result of different degrees of dilution by terrigenous sedimentation; slower addition of detritus to the basin and the insular shelves allowing more generations of foraminiferans to contribute to the population in a gram of sediment. Foraminiferal numbers similar in magnitude to those of the insular shelves in the channel region were found around Santa Catalina Island by McGlasson (1959).

The foraminiferal population of the mainland shelf in the channel region is comprised principally of benthonic species as seen in a comparison of benthonic and planktonic foraminiferal numbers (figs. 5-7 and 8-10). This relationship is consistent with previous studies of the southern California shelf as is the size of the benthonic and planktonic populations. Neither parameter showed significant changes in the vicinity of platform A during this investigation. In the Santa Barbara Basin and on the insular shelves, planktonic and benthonic species made approximately equal contributions to the total population. Several different mechanisms have been suggested by Harman (1964) and Berger and Soutar (1970) as explanations for low planktonic foraminiferal numbers on the mainland shelf and much higher numbers in Santa Barbara Basin. The relatively high numbers on the insular shelves support the importance of lower sedimentation rates as the main influence on planktonic foraminiferal population size as Harman (1964) suggested.

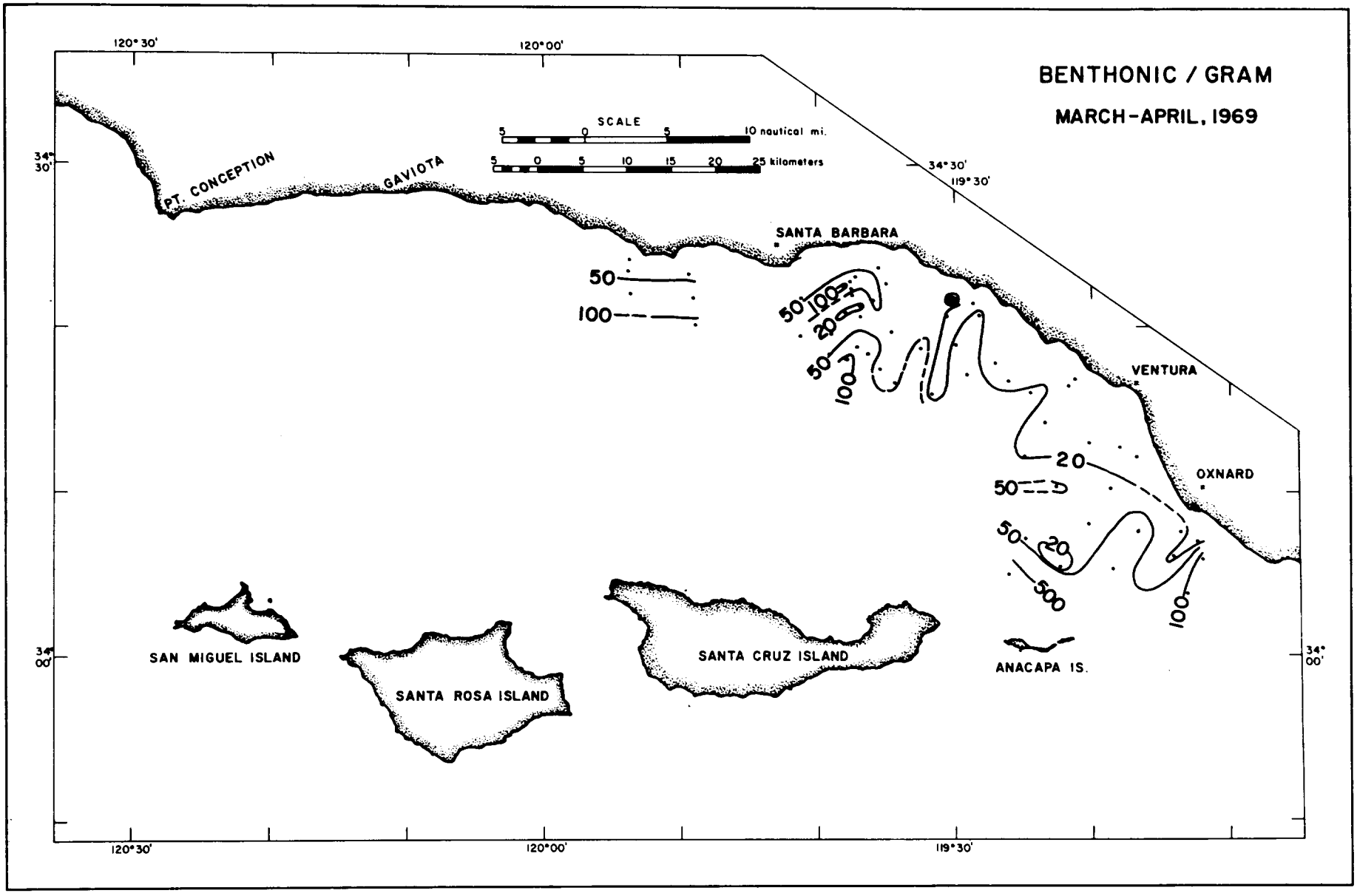
The relationship between planktonic and benthonic foraminiferal species may be expressed, without involving the problem of different sedimentation rates, by the ratio between the two types (figs. 11-13). Planktonic/benthonic foraminiferal ratios of less than 0.5 characterized the Santa Barbara mainland shelf which is typical of portions of the southern California mainland shelf unaffected by

Figures 5-7. Benthonic foraminifera/gram of dry sediment.

5. March-April, 1969

6. June-August, 1969

7. December, 1969


BENTHONIC / GRAM
MARCH-APRIL, 1969
SCALE
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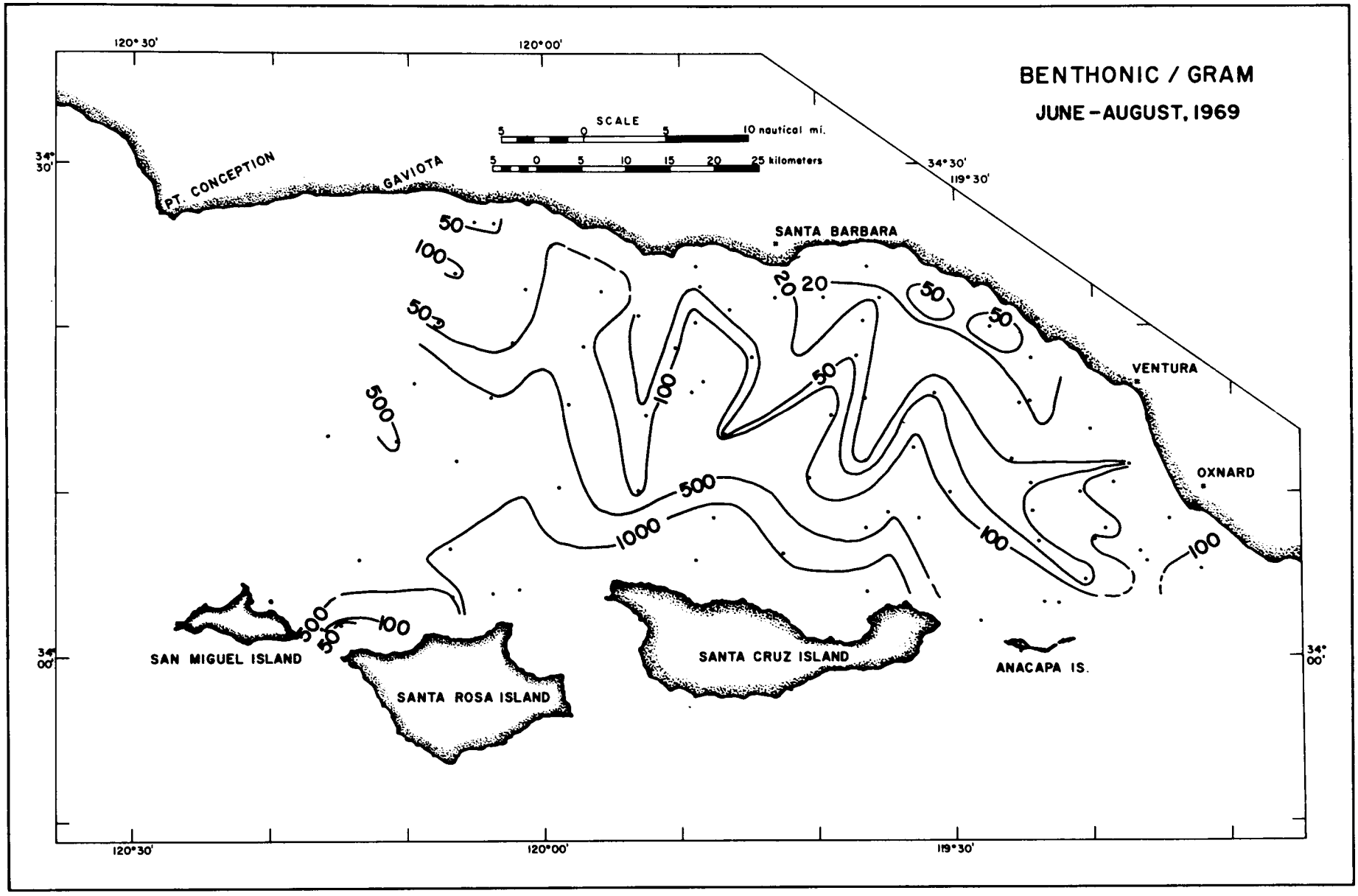
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
50
100
20
500


BENTHONIC / GRAM
JUNE - AUGUST, 1969
SCALE
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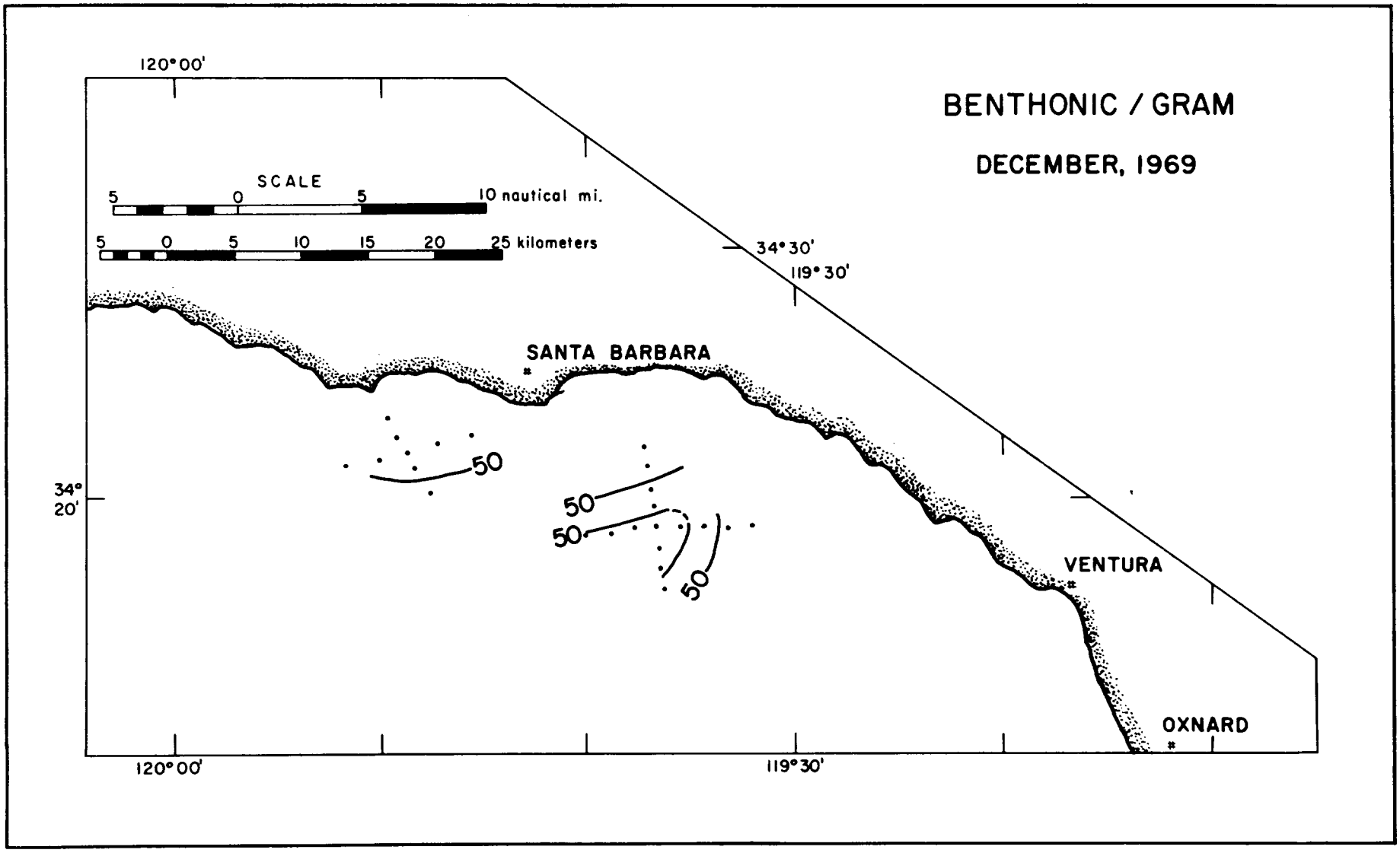
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
50
100
500
1000
20


BENTHONIC / GRAM
DECEMBER, 1969
SCALE
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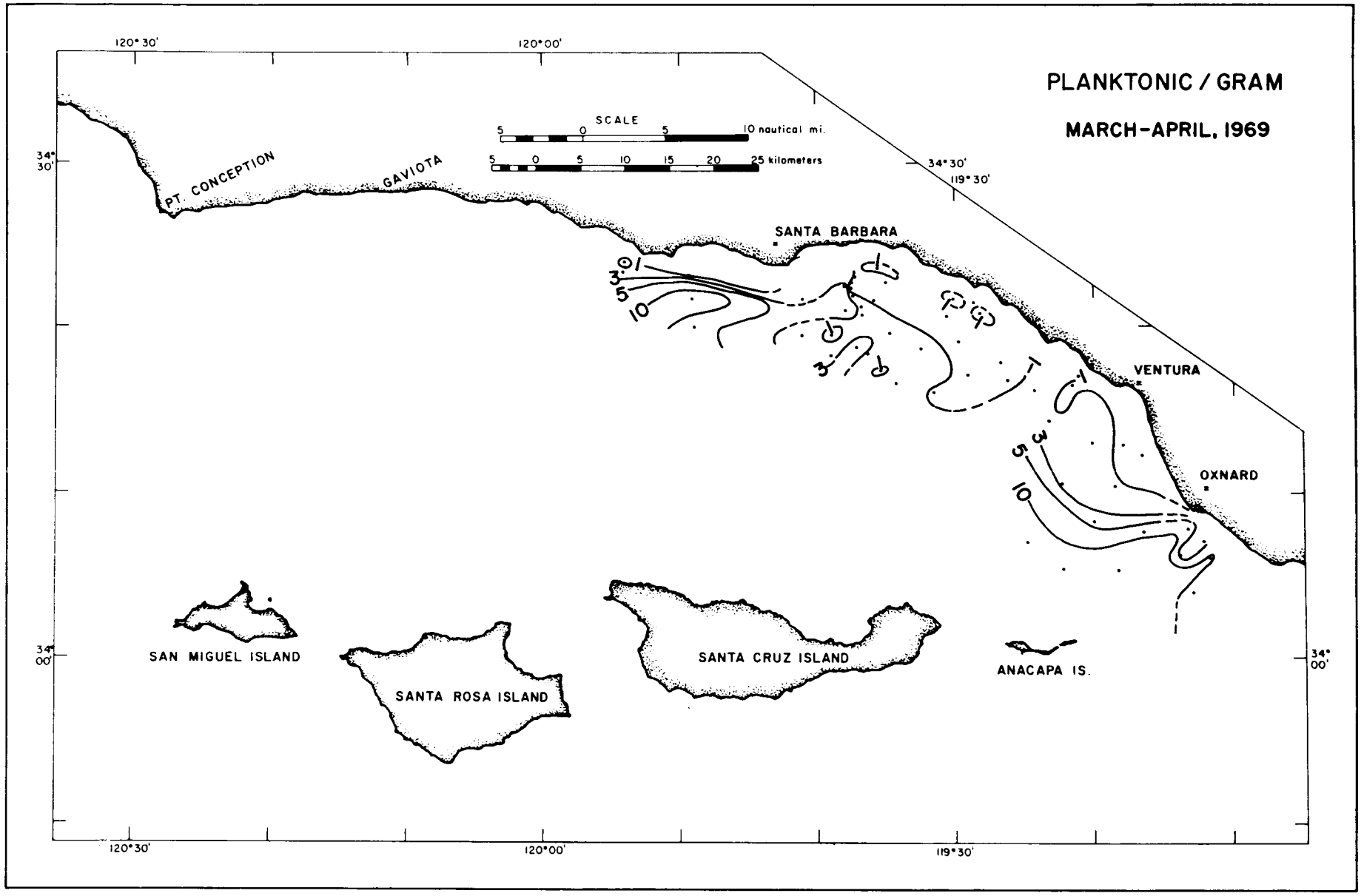
5 0 5 10 15 20 25 kilometers
120°00'
34°30'
119°30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
50
50
50
50
120°00'
119°30'

Figures 8-10. Planktonic foraminifera/gram of dry sediment.

8. March-April, 1969

9. June-August, 1969

10. December, 1969


PLANKTONIC / GRAM
MARCH-APRIL, 1969
SCALE
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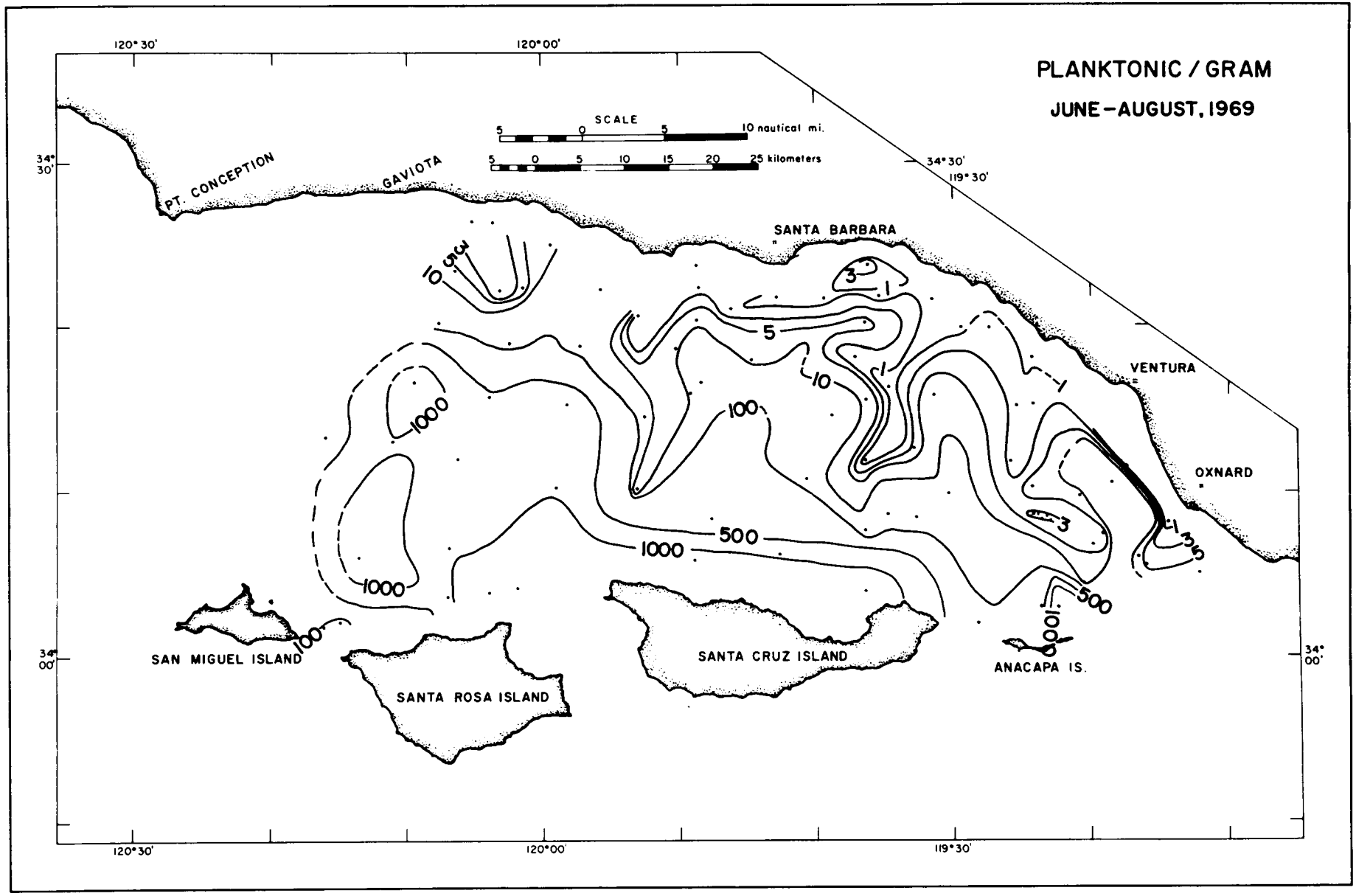
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
1
3
5
10


PLANKTONIC / GRAM
JUNE–AUGUST, 1969
SCALE
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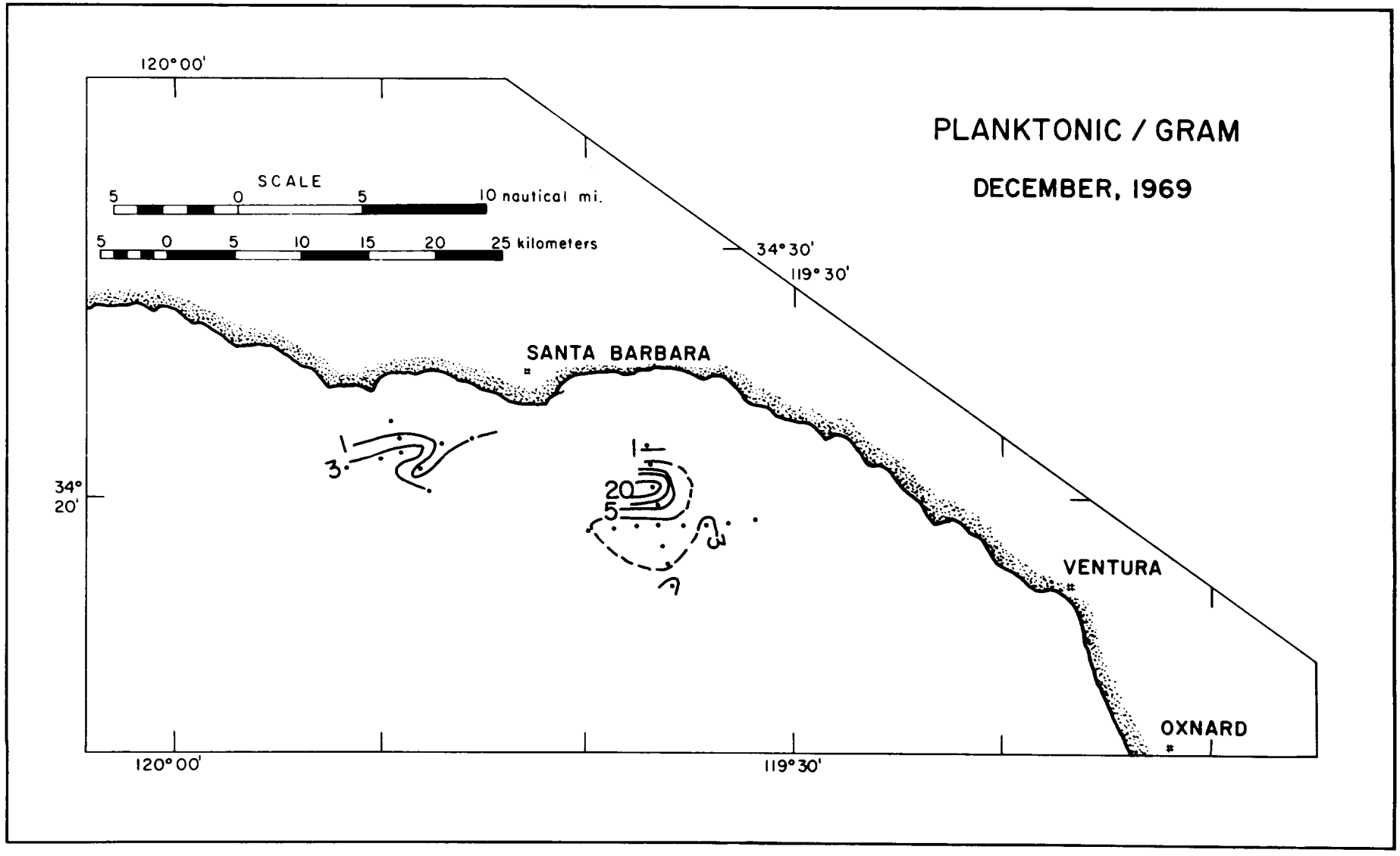
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
10 gm
3
1
5
10
1
1
100
1000
1000
1000
500
1
3
1 gm
500
100
100


PLANKTONIC / GRAM
DECEMBER, 1969
SCALE
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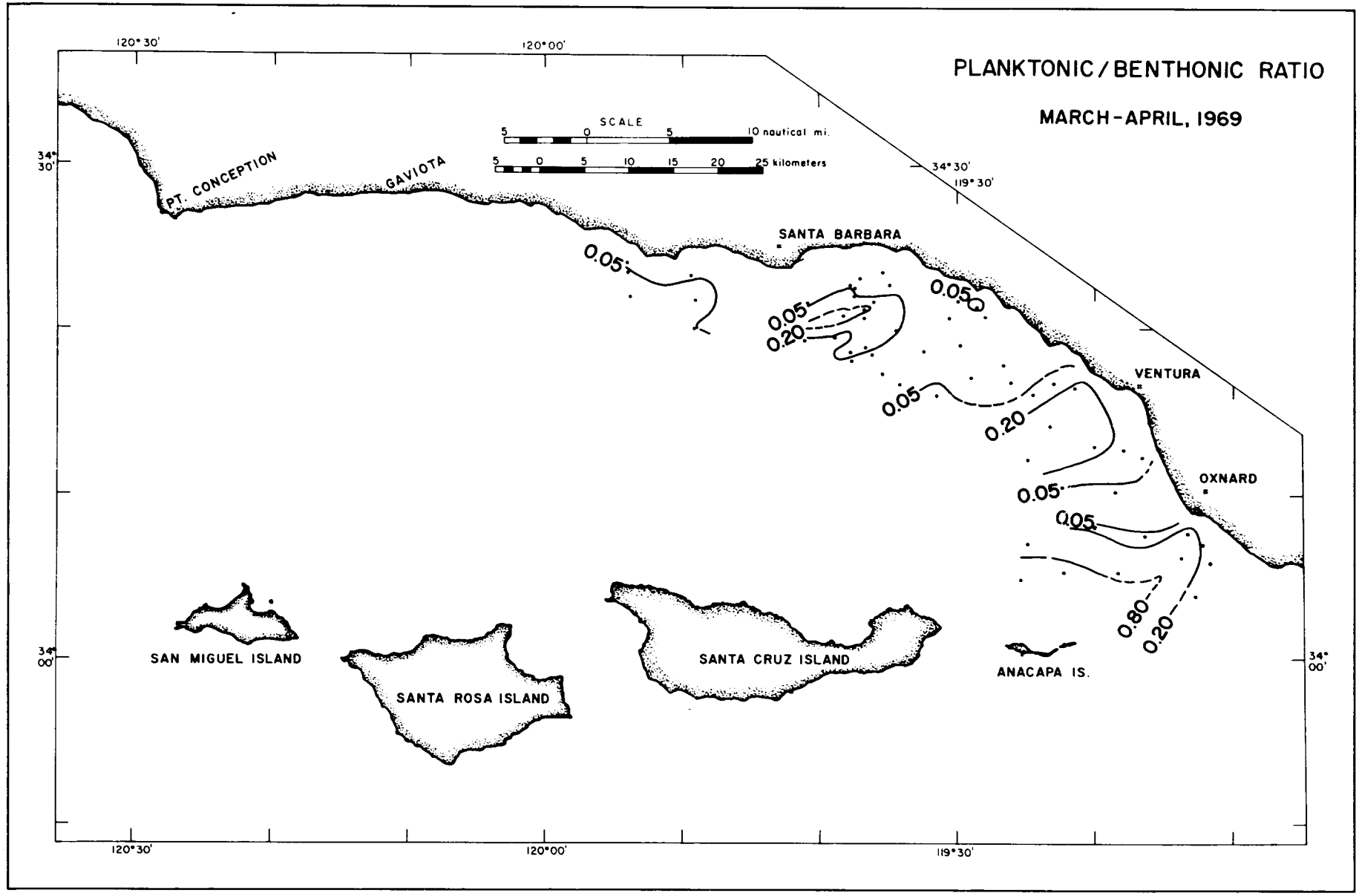
5 0 5 10 15 20 25 kilometers
120° 00'
34° 30'
119° 30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
1
3
20
5

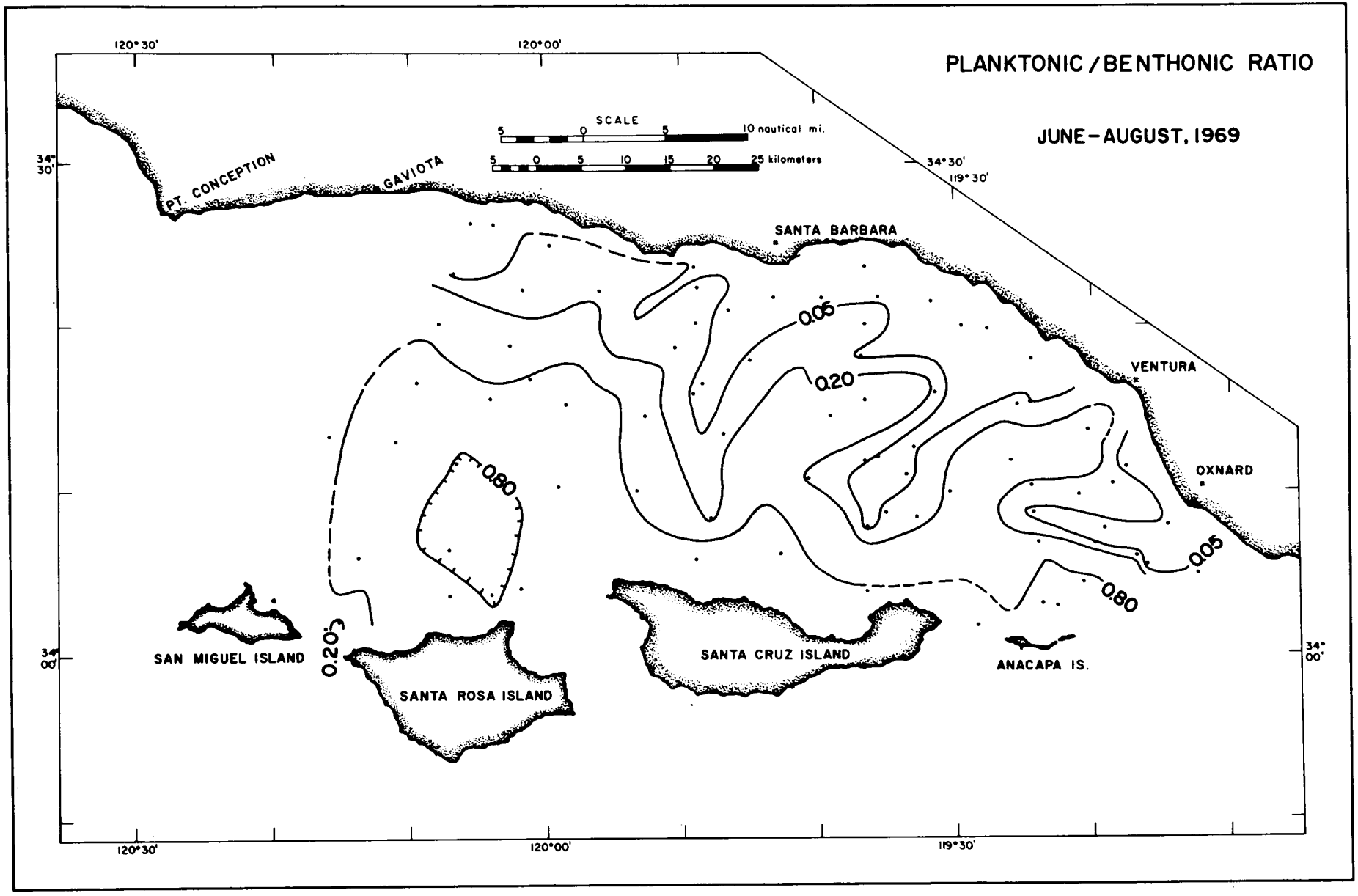
Figures 11-13. Planktonic/benthonic foraminiferal ratio.

11. March-April, 1969

12. June-August, 1969

13. December, 1969


PLANKTONIC / BENTHONIC RATIO
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
0.05
0.20
0.80


PLANKTONIC / BENTHONIC RATIO
JUNE-AUGUST, 1969
SCALE
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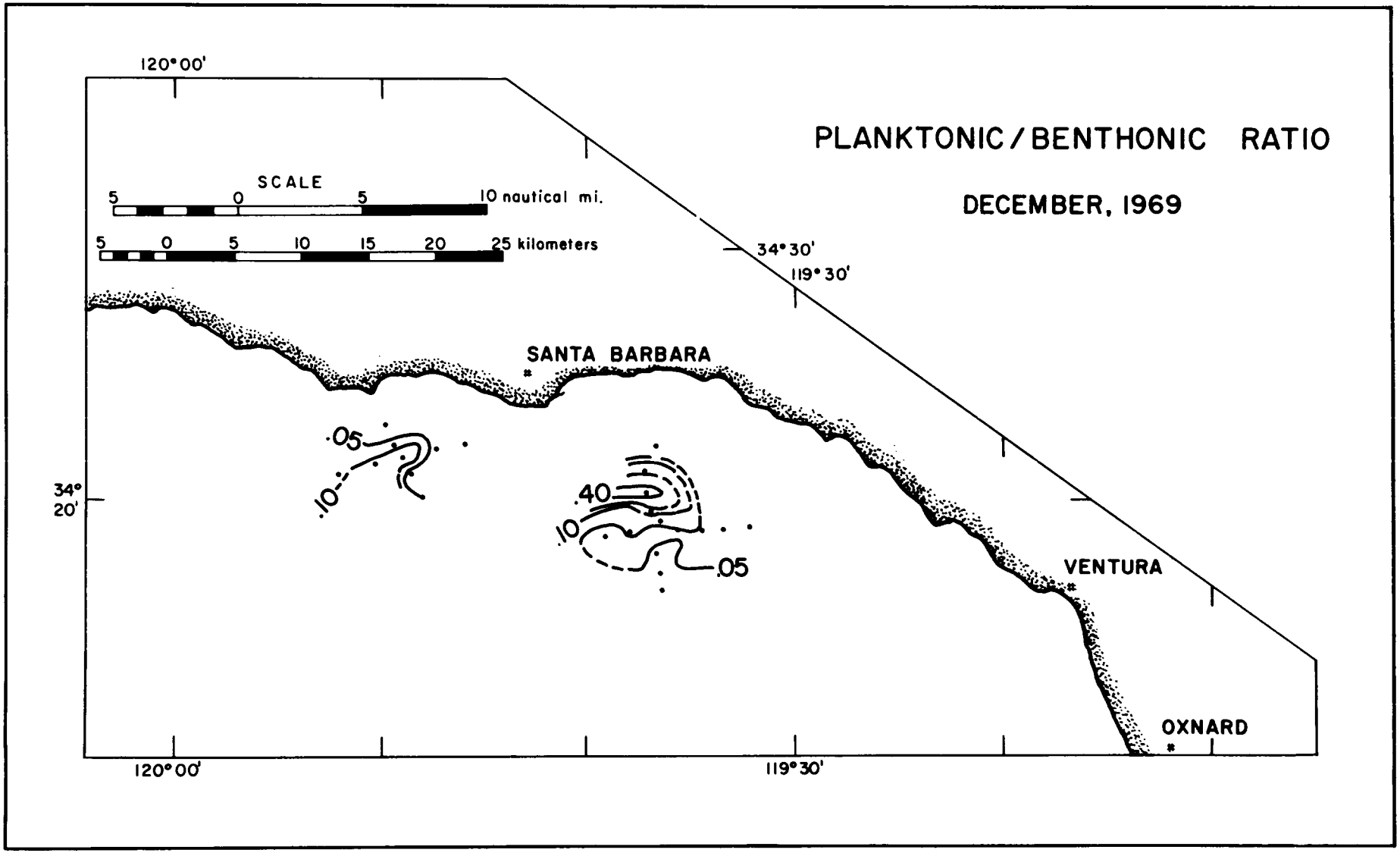
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
0.05
0.20
0.80
0.05
0.80
0.20


PLANKTONIC / BENTHONIC RATIO
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°00'
34°30'
119°30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
.05
.10
.40
.10
.05
120°00'
119°30'

outfall pollution (Bandy, Ingle, and Resig, 1964a, b, c, 1965a, b). Relatively high ratios extend across some portions of the shelf. These highs may be the result of upwelling in the vicinity of small sea gullies and Hueneme Canyon or some other cause since a relationship between relatively high planktonic/benthonic ratios and the presence of submarine canyons has been reported previously in the southern California offshore area (Bandy, Ingle, and Resig, 1964c, 1965a). In the vicinity of platform A, the planktonic/benthonic ratio remained about the same throughout this study.

All of the criteria discussed thus far show that foraminiferal population size and the relationship between its constitutents are similar to other areas of the southern California mainland shelf. However, the living population has not been considered. The ratio of live to dead benthonic foraminiferans (figs. 14-16) gives some insight into the size of the living population. Between Santa Barbara and Carpinteria, the average live/dead ratio was higher during March and April, 1969, than that reported by Resig (1960) although the maximum values are about the same, 0.57 and 0.49, respectively. The high values observed during March and April, 1969, reflect the relatively rapid burial of empty foraminiferal tests by abnormally large amounts of detritus resulting from the winter floods of 1969. The coincidence of high ratios with relatively high sedimentation rates is in accordance with the work of Walton (1955), Phleger (1960), and others, and this relationship appears to have existed in the channel region during the length of this study. The highest ratios, with three exceptions, were found near the Ventura and Santa Clara Rivers which are the major source of detritus. The lowest ratios occurred on the Santa Barbara Basin Plain where sedimentation rates were lower during this particular time. The live/dead ratio decreased around platform A and on most of the mainland shelf as a result of negligible sedimentation rates after April, 1969 (see chapter on flood sediment). Erosion and redeposition of detritus on the mainland shelf between Ventura and Pt. Hueneme, that is, near the mouths of the Ventura and Santa Clara Rivers, may explain the relatively high ratios in this area from June through August, 1969.

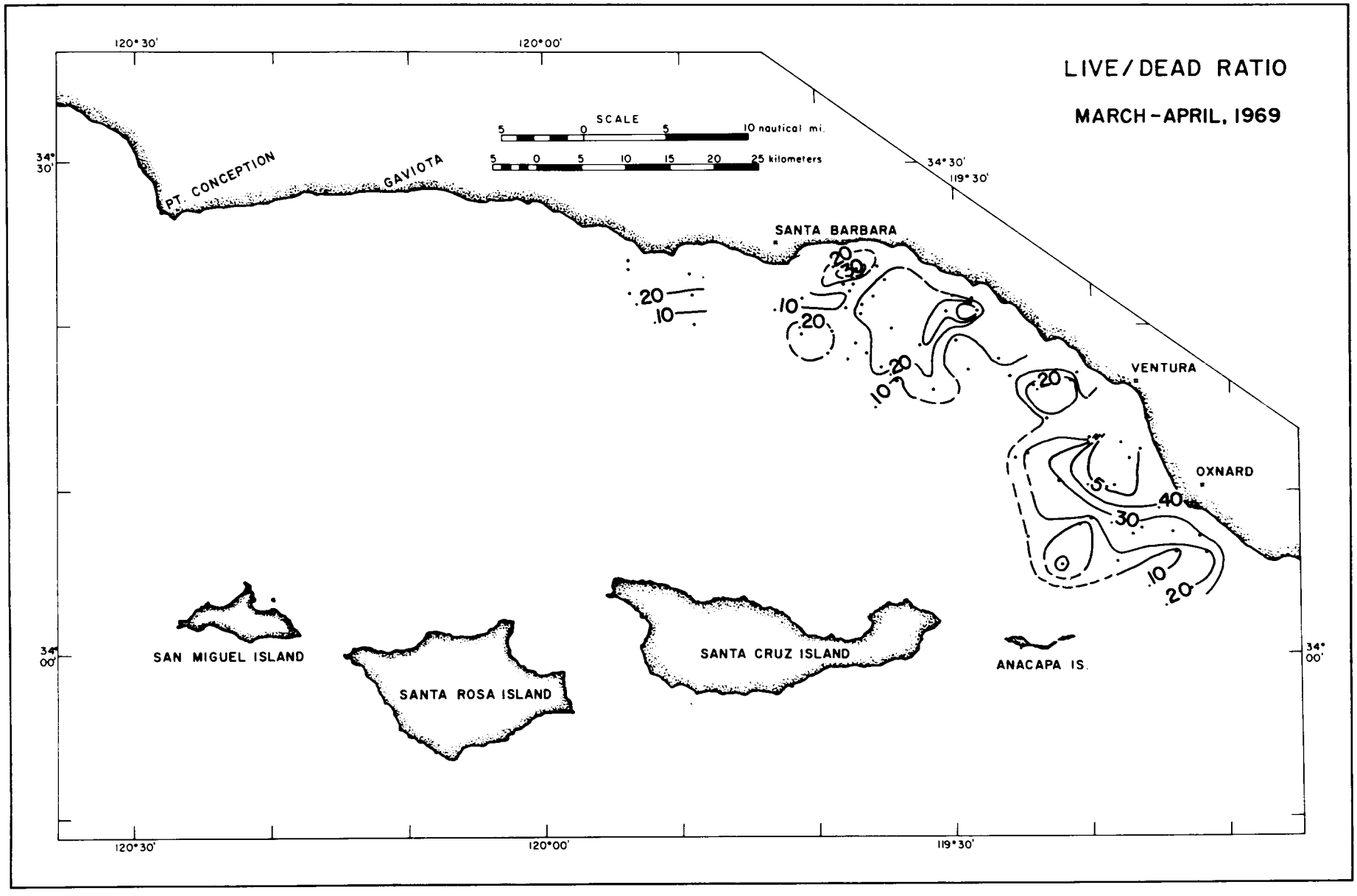
The number of living benthonic foraminiferans/gram was found by Bandy, Ingle, and Resig (1964a, b, 1965a, b) to be more effective in illustrating the extent of pollution by the effluent from sewer outfalls than the live/dead ratio. In addition, the live/dead ratio did not always appear to be influenced by sedimentation rates in Santa Monica Bay

Figures 14-16. Live/dead ratio of benthonic foraminifera.

14. March-April, 1969

15. June-August, 1969

16. December, 1969


LIVE/DEAD RATIO
MARCH-APRIL, 1969
SCALE
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5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
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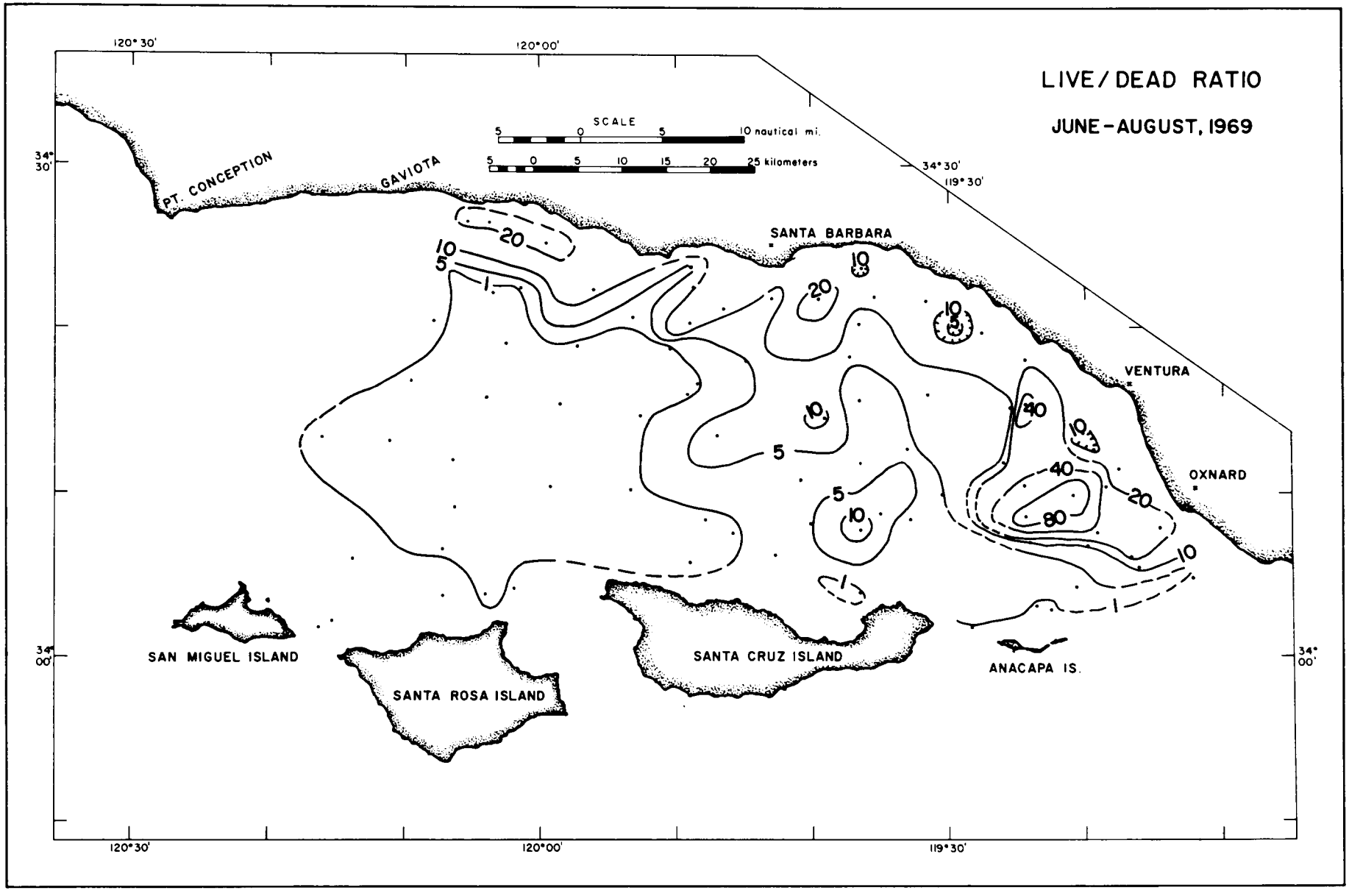
.5
.40
.30
.10
.20


LIVE/DEAD RATIO
JUNE-AUGUST, 1969
SCALE
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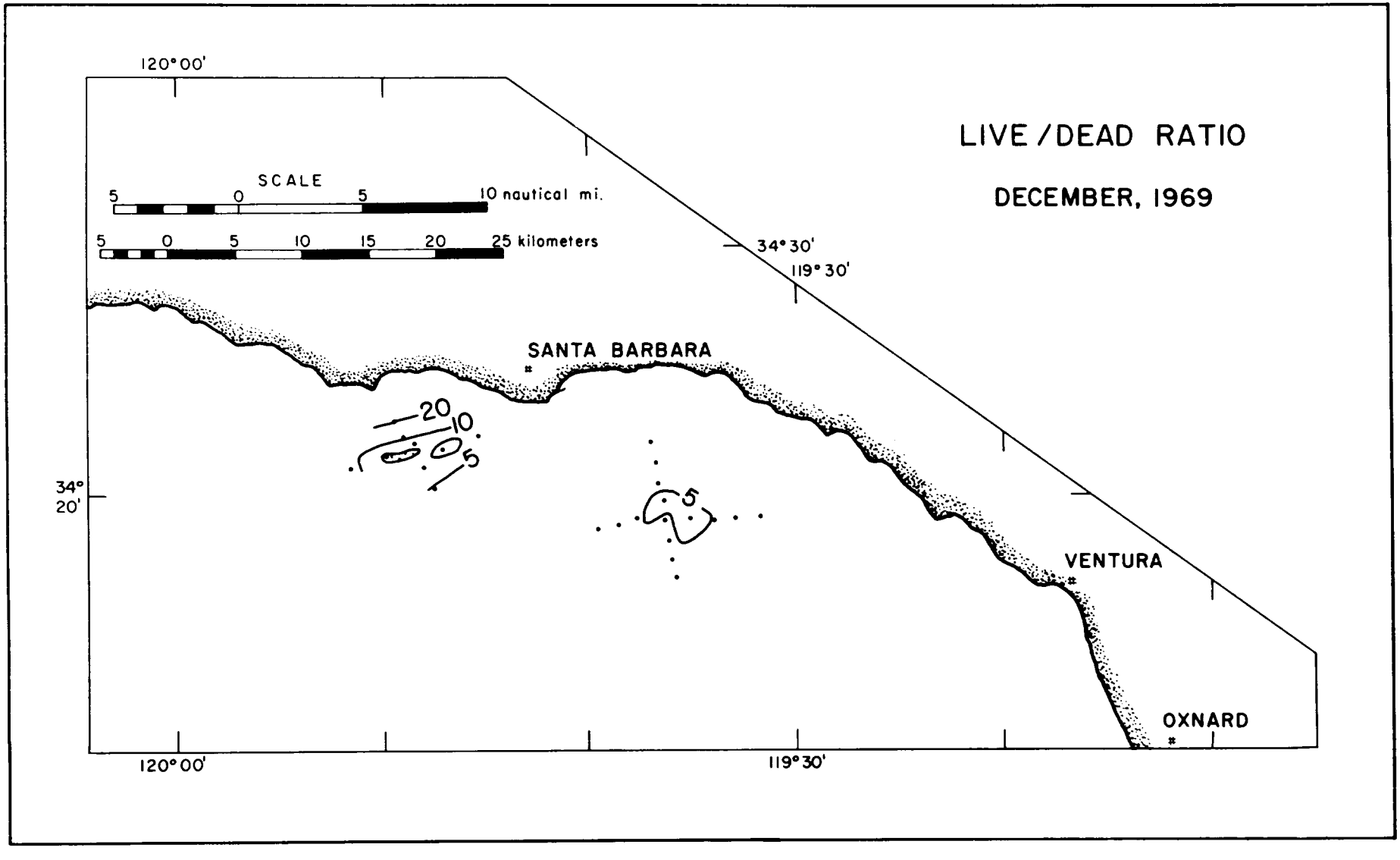
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
20
10
5
1
40
80


LIVE / DEAD RATIO
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 00'
34° 30'
119° 30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
20
10
5
5
120° 00'
119° 30'

(Bandy, Ingle and Resig, 1965a). For these reasons, the number of living benthonic foraminiferans/gram of dry sediment was determined (figs. 17-19) in addition to the live dead ratio. Less than 10 living specimens/gram were generally found on the channel's mainland shelf which is characteristic of "normal" portions of the southern California mainland shelf whereas portions polluted by sewer outfalls often had 20 or more specimens/gram (Bandy, Ingle, and Resig, 1964a, b, c, 1965a, b). Populations of 20 or more specimens/gram occurred near the Ventura and Santa Clara Rivers in addition to several isolated stations. Large living populations near the rivers could be the result of greater productivity, not just high sedimentation rates as the live/dead ratio suggests.

Specific Trends

One of the most important mainland shelf species in the channel region is *Buliminella elegantissima* d'Orbigny. Resig (1960) showed that this species was a major constituent of the inner shelf faunas prior to the oil well blowout. Subsequently, the distribution pattern of *B. elegantissima* in both the total and the living (figs. 20-22 and 23-25) benthonic foraminiferal populations was typical of "normal" portions of the southern California mainland shelf (Bandy, Ingle, and Resig, 1964c, 1965a, b) with several major exceptions. Values characteristic of the inner shelf extend out to the shelf edge between Ventura and Pt. Hueneme throughout this investigation and around platform A during March and April, 1969. Displacement of this species in both living and total populations has been previously reported only in association with effluent from sewer outfalls (Bandy, Ingle, and Resig, 1965b).

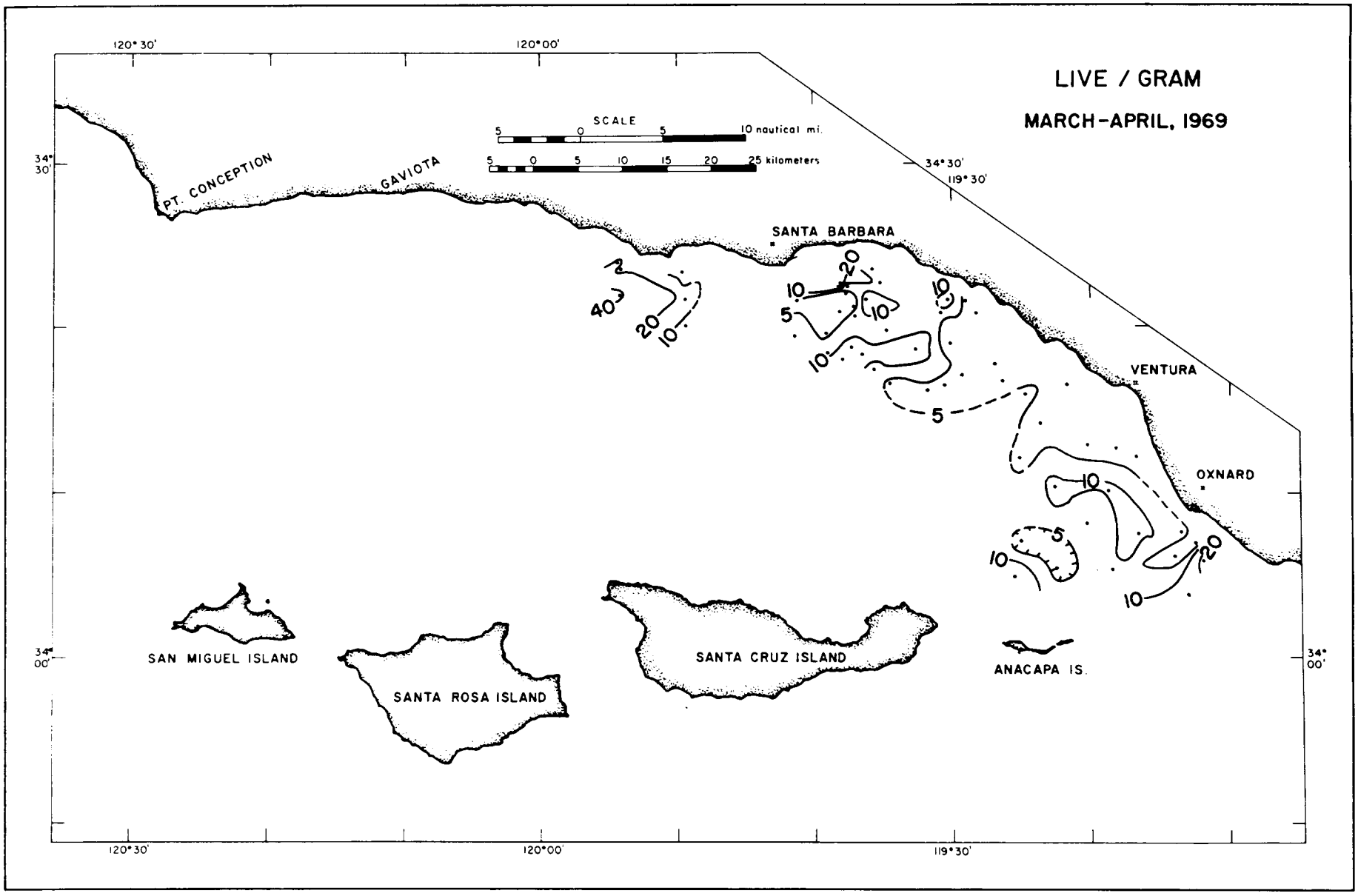
Unlike *Buliminella elegantissima*, *Florilus scaphus basispinatus* (Cushman and Moyer) and *Nonionella miocenica stella* Cushman and Moyer are cited by Bandy, Ingle, and Resig (1964a, b, 1965a, b) to be relatively intolerant of oceanic pollution by sewer outfalls. The abundance of these two species has been combined in this report with the less common members of the Nonionidae, *Florilus grateloupi* (d'Orbiny) and *Nonionella astricta* McCulloch. In both the total and living benthonic foraminiferal populations (figs. 26-28 and 29-31), the Nonionidae were generally found to increase in abundance offshore, to dominate the middle shelf fauna, and to become less important near the shelf edge over most of the channel's mainland shelf.

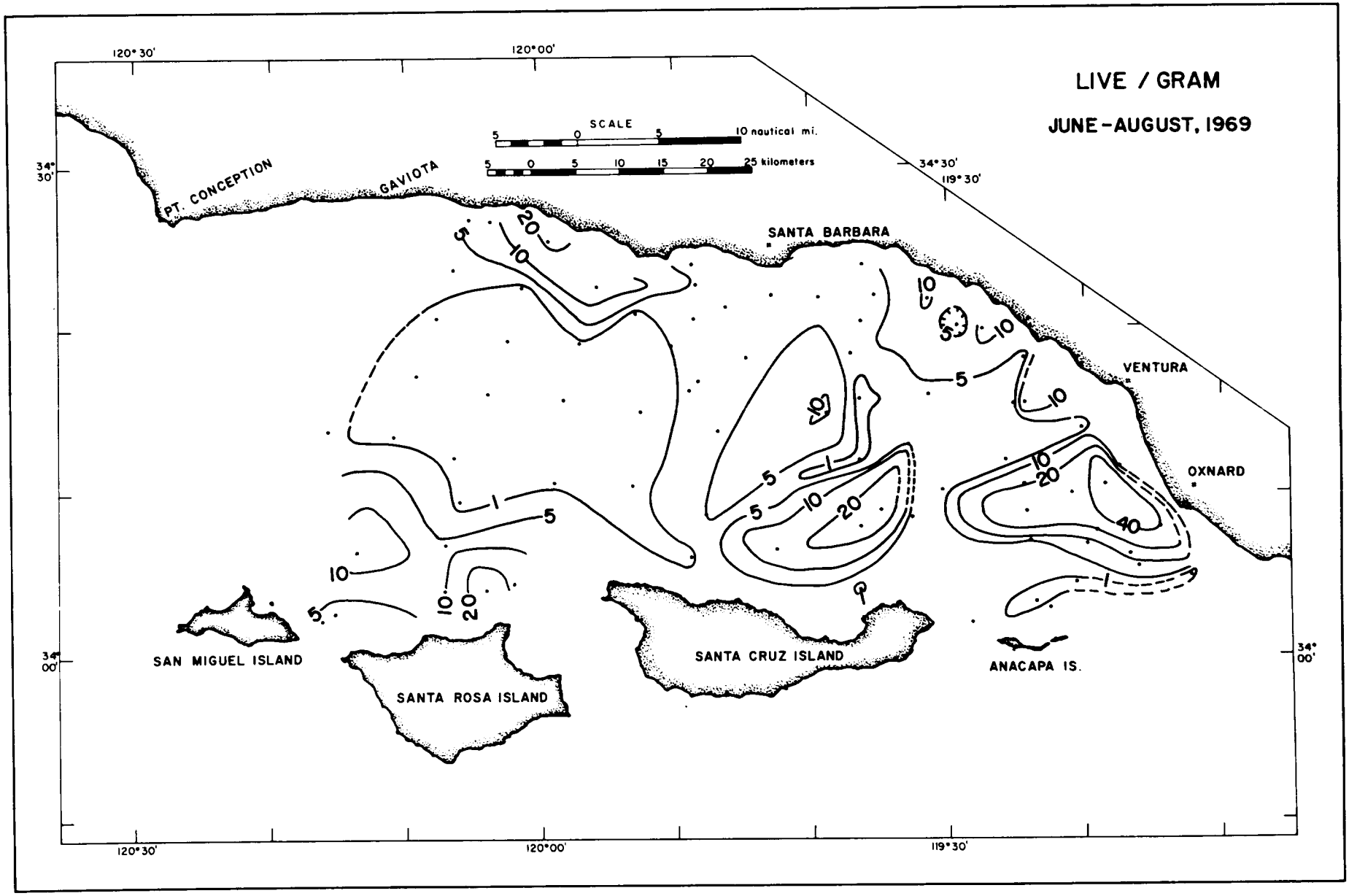
Figures 17-19. Number of living benthonic foraminiferans/gram of dry sediment.

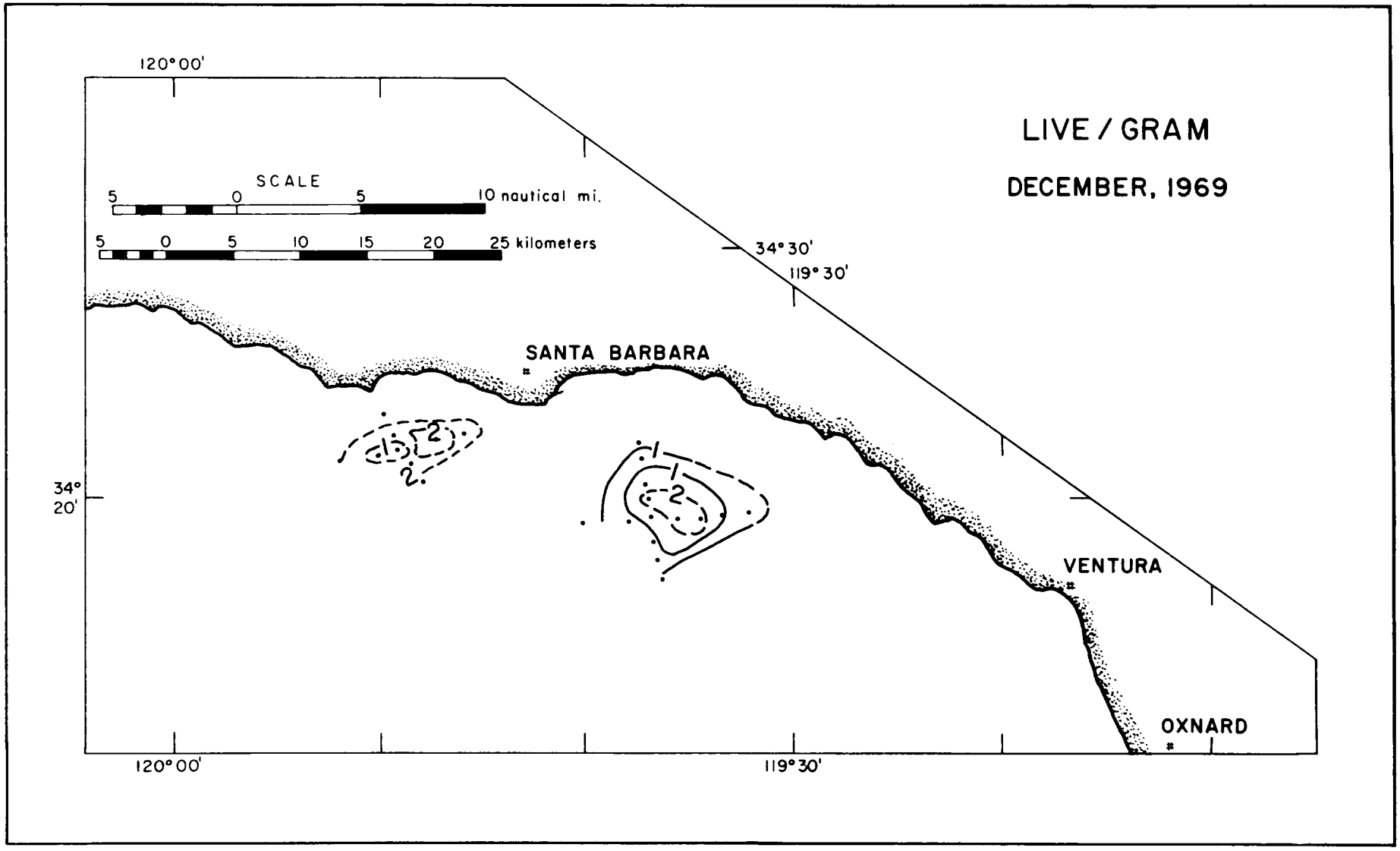
17. March-April, 1969

18. June-August, 1969

19. December, 1969


LIVE / GRAM
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
40
20
10
5


LIVE / GRAM
JUNE-AUGUST, 1969
SCALE
10 nautical mi.
25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

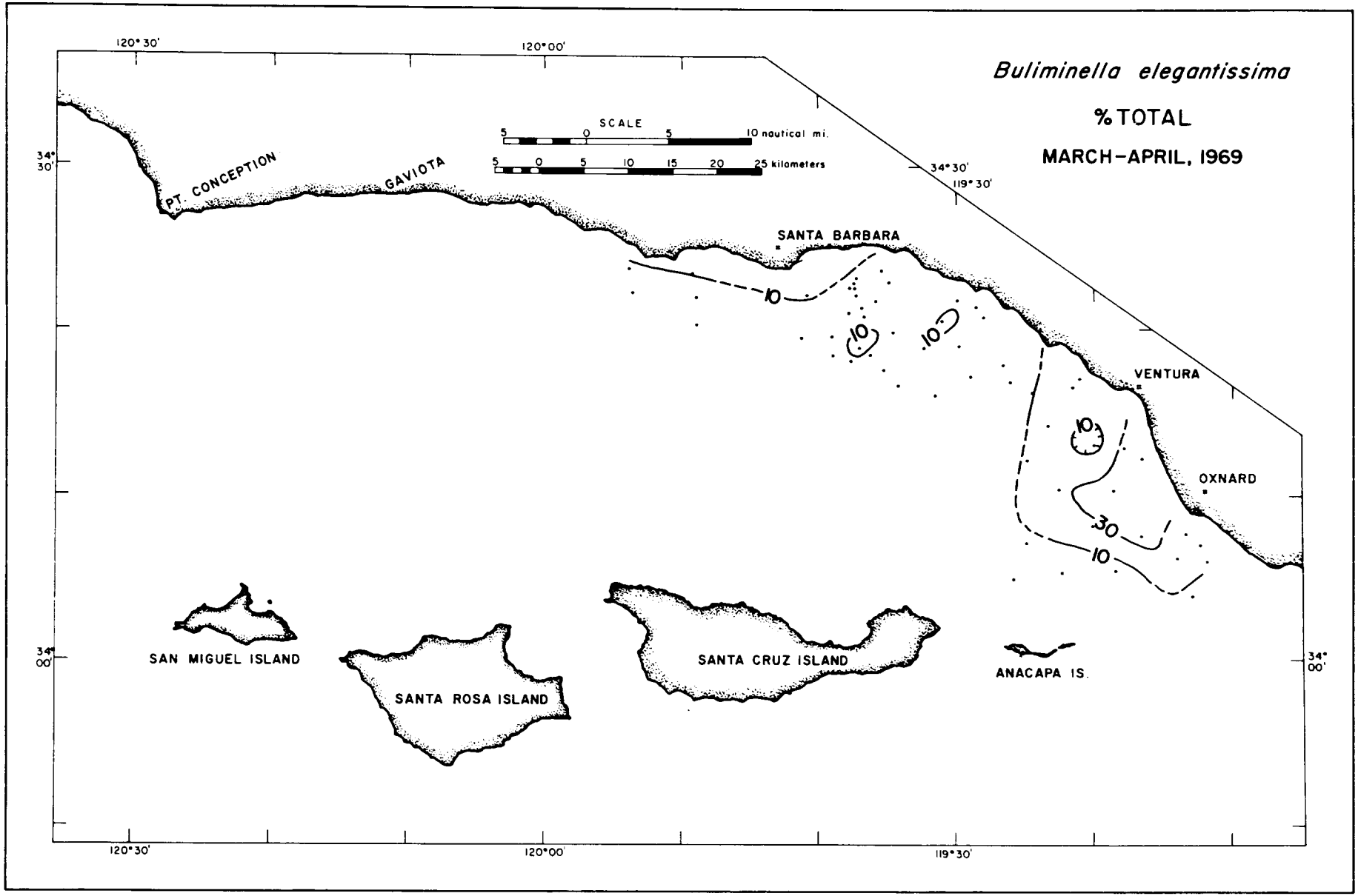

LIVE / GRAM
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 00'
34° 30'
119° 30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
120° 00'
119° 30'

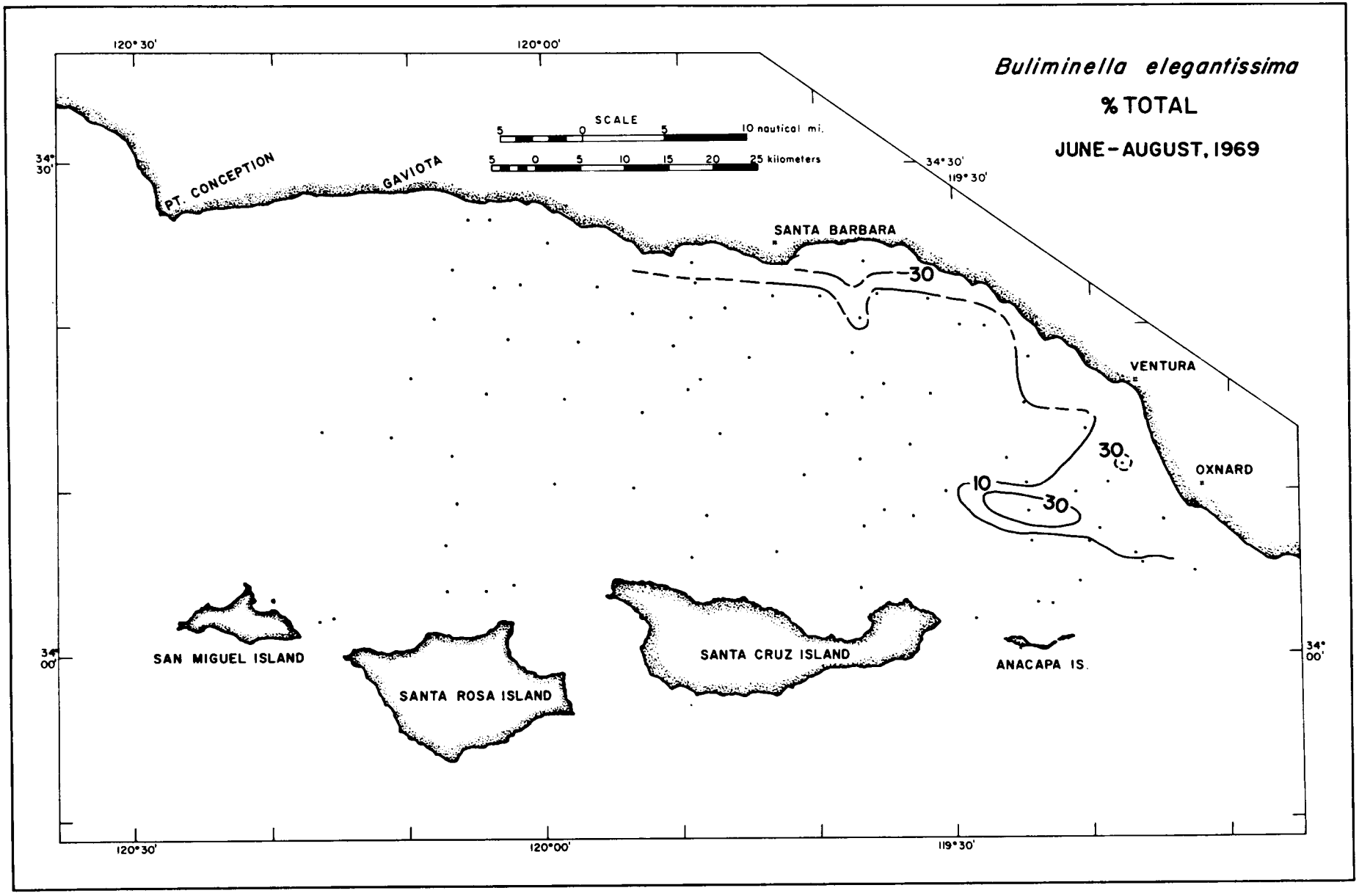
Figures 20-22. Percentage of *Buliminella elegantissima* d'Orbigny in the total benthonic foraminiferal population.

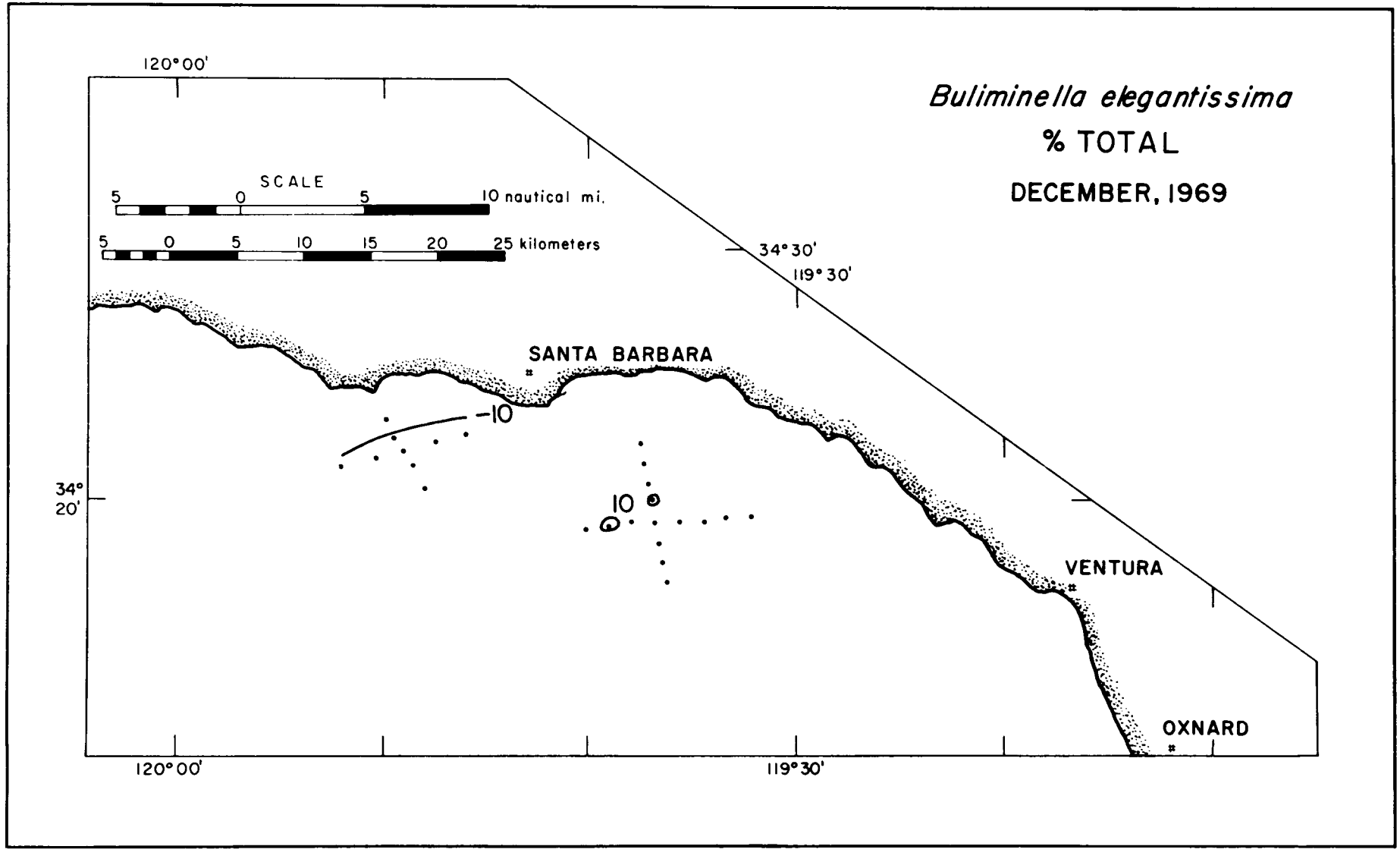
20. March-April, 1969

21. June-August, 1969

22. December, 1969


Buliminella elegantissima
% TOTAL
MARCH–APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
10
30
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.


Buliminella elegantissima
% TOTAL
JUNE-AUGUST, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
30
30
10
30
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

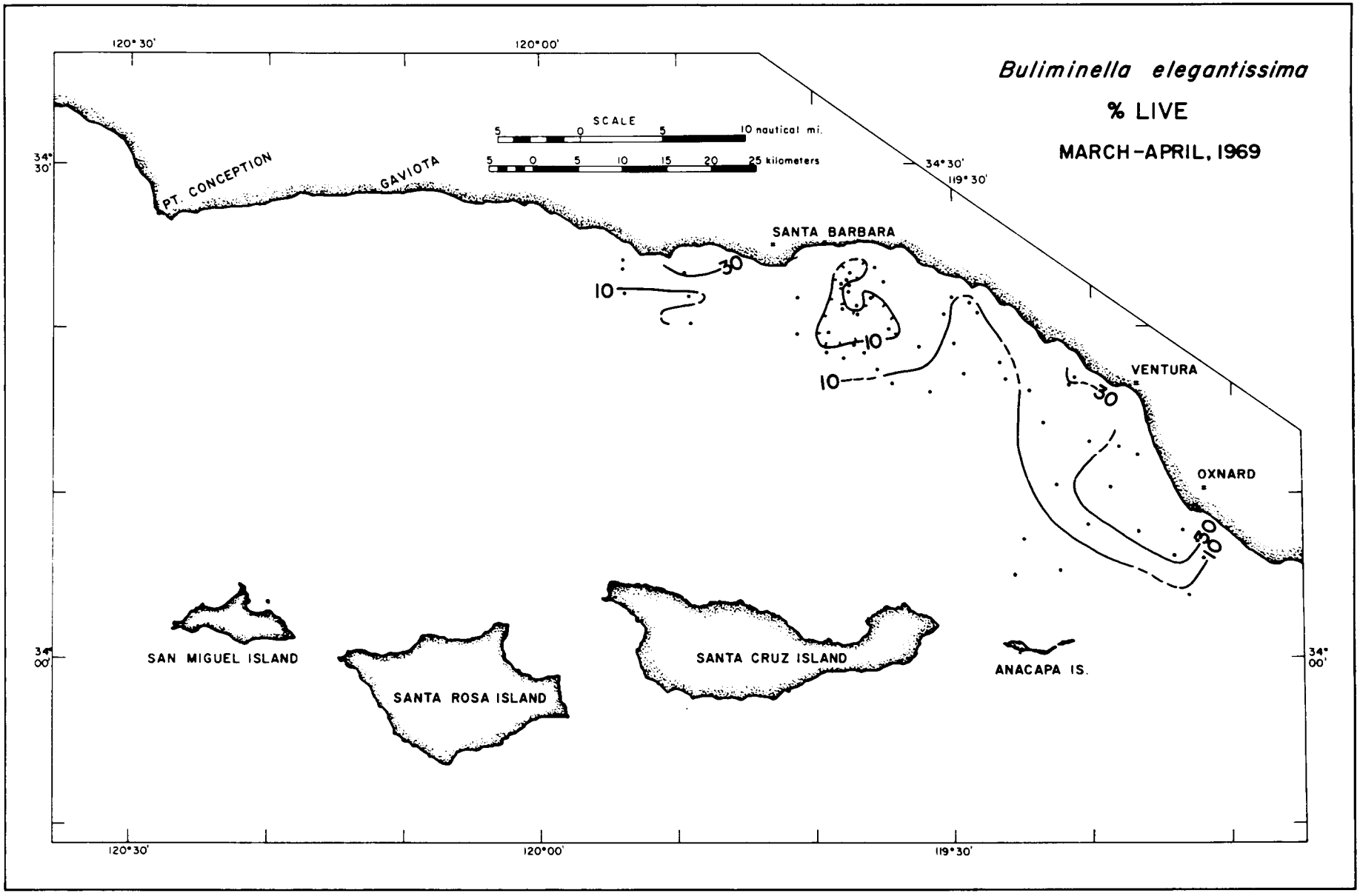

Buliminella elegantissima
% TOTAL
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 00'
34° 30'
119° 30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
-10
10
120° 00'
119° 30'

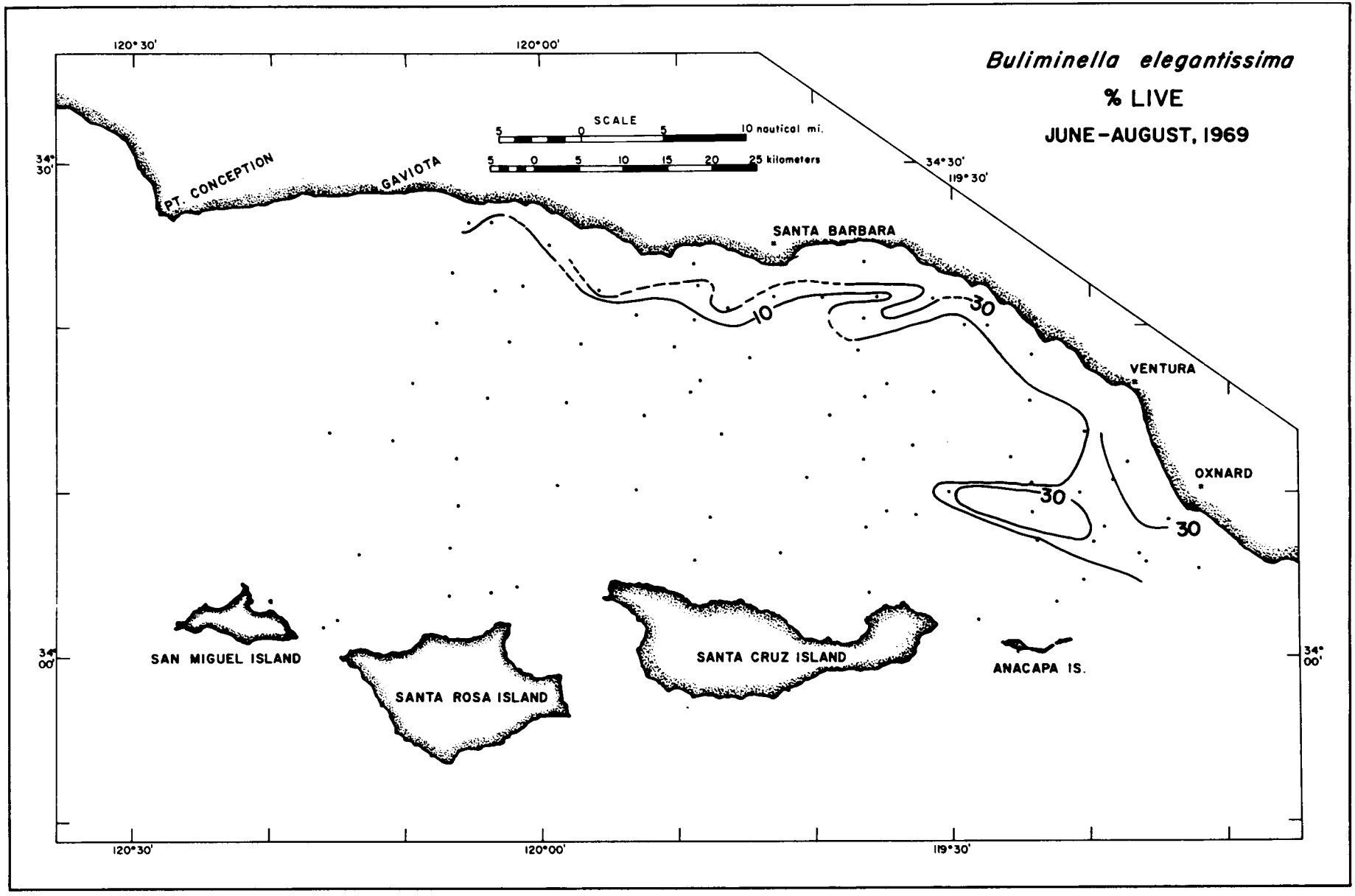
Figures 23-25. Percentage of *Buliminella elegantissima* d'Orbigny in the living foraminiferal population.

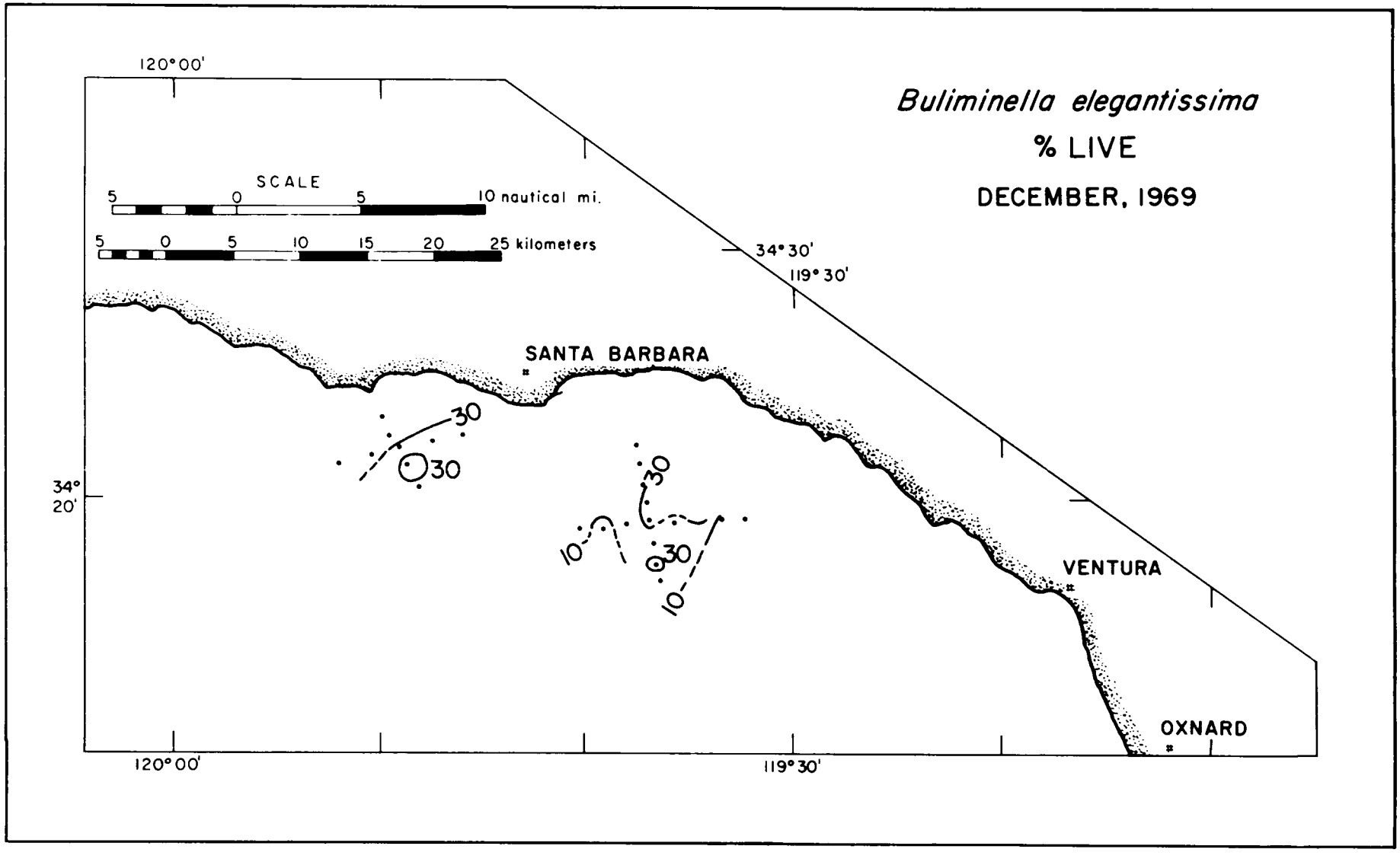
23. March-April, 1969

24. June-August, 1969

25. December, 1969


Buliminella elegantissima
% LIVE
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
10
30


Buliminella elegantissima
% LIVE
JUNE-AUGUST, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
10
30
30
30
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

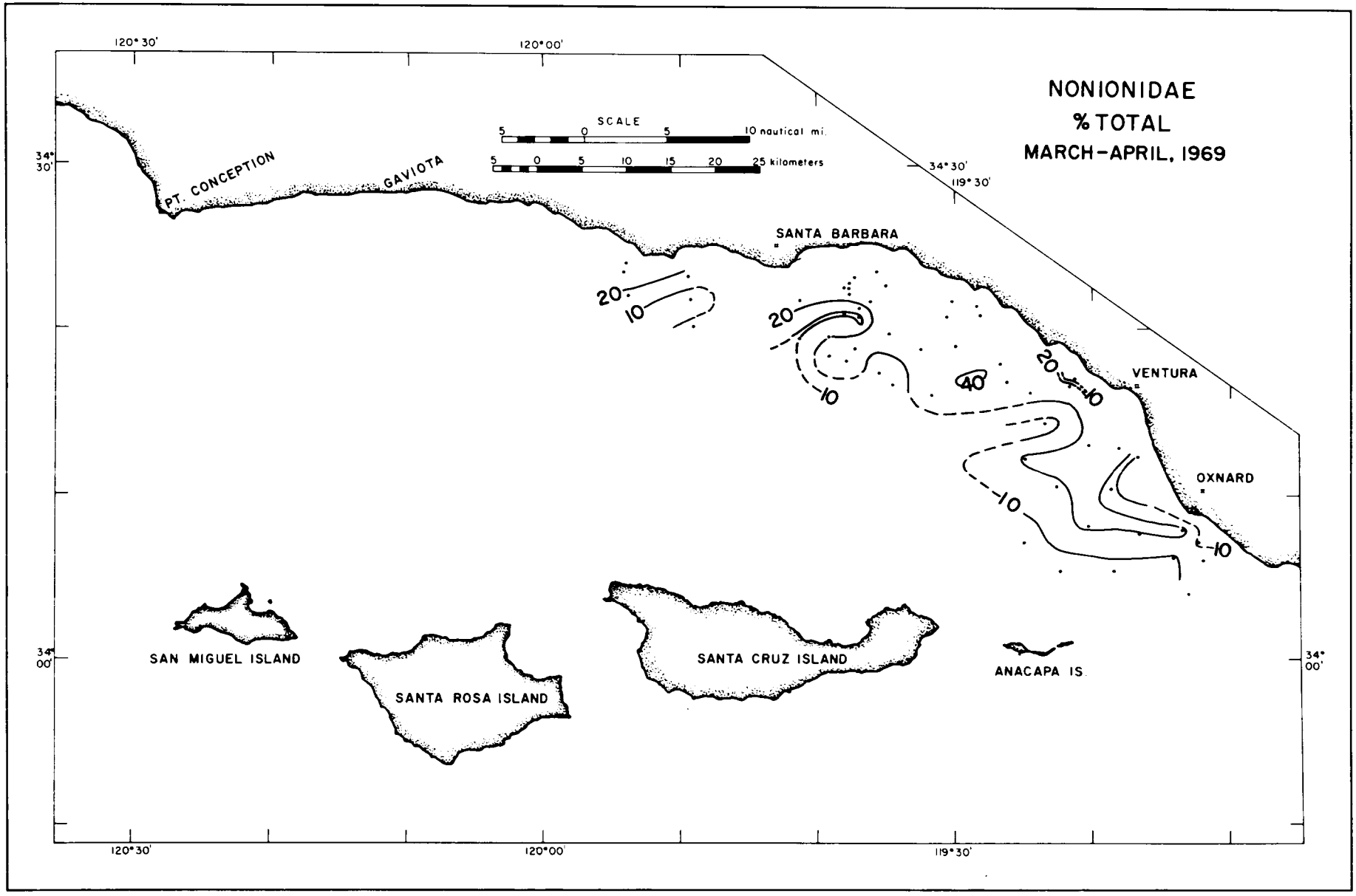

Buliminella elegantissima
% LIVE
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°00'
34°30'
119°30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
30
30
30
30
10
10
120°00'
119°30'

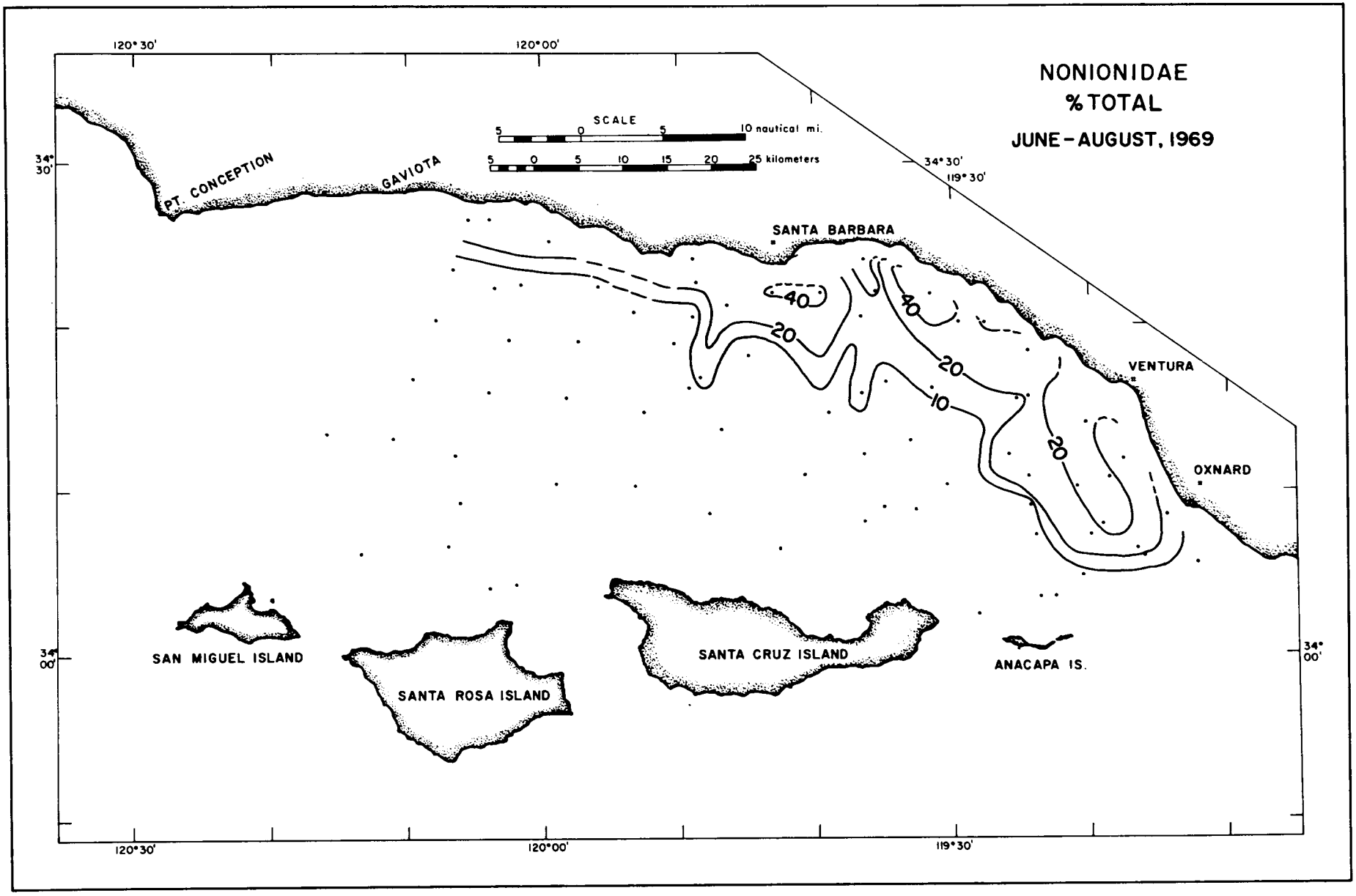
Figures 26-28. Percentage of Nonionidae in the total benthonic foraminiferal population.

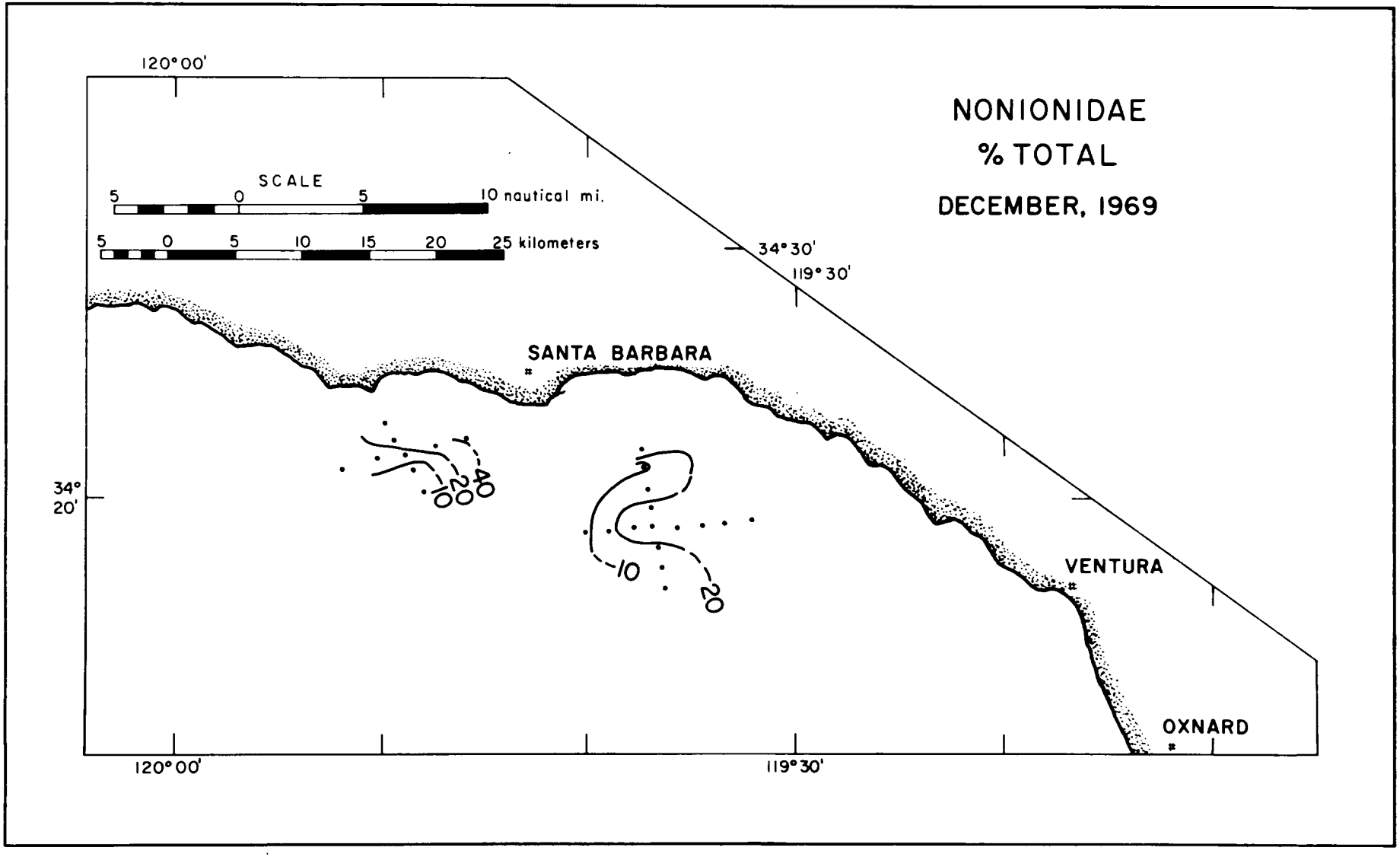
26. March-April, 1969

27. June-August, 1969

28. December, 1969


NONIONIDAE
% TOTAL
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
20
10
40
-10


NONIONIDAE
% TOTAL
JUNE - AUGUST, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
40
20
10
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

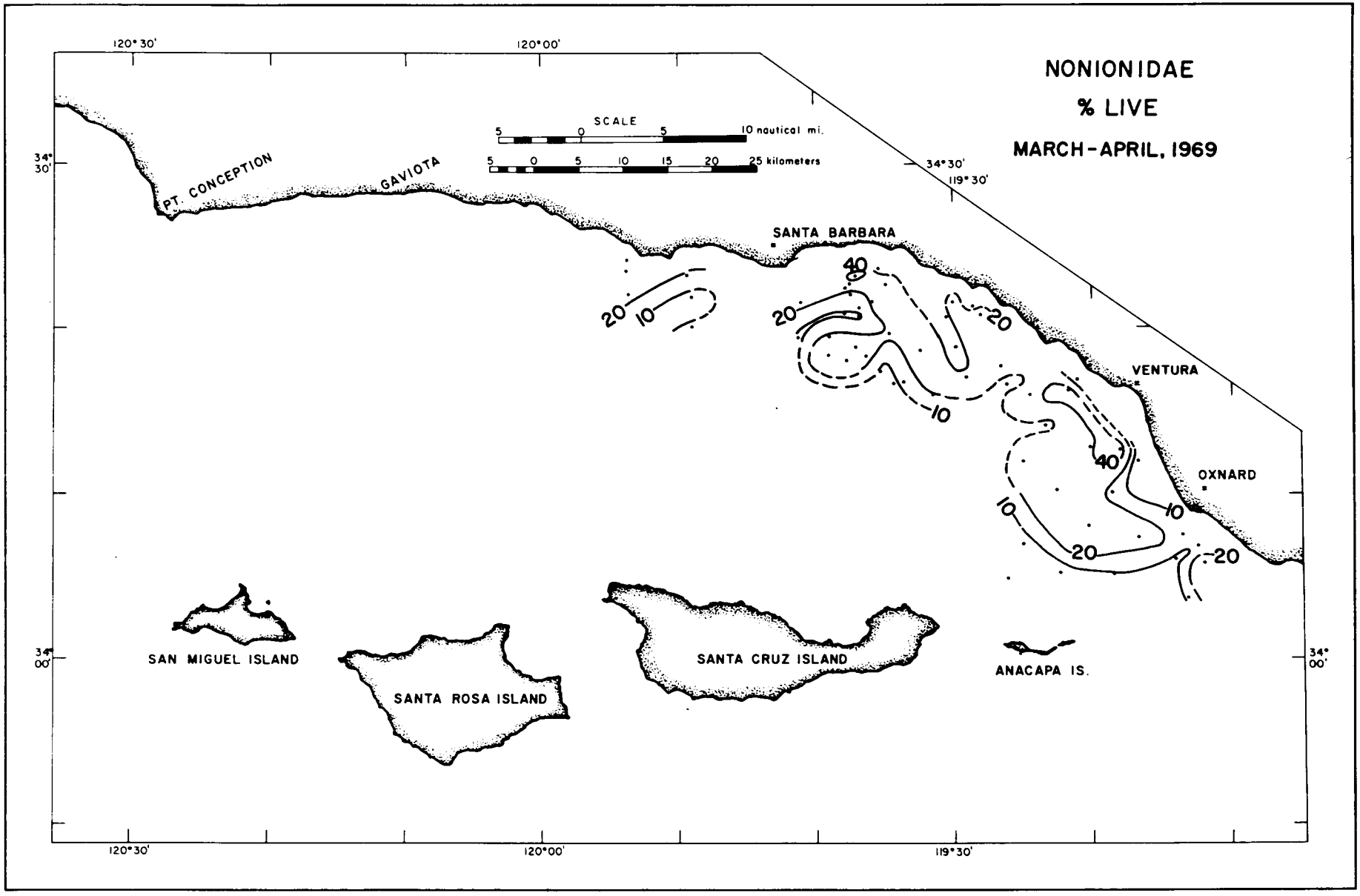

NONIONIDAE
% TOTAL
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 00'
34° 30'
119° 30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
40
20
10
10
20
120° 00'
119° 30'

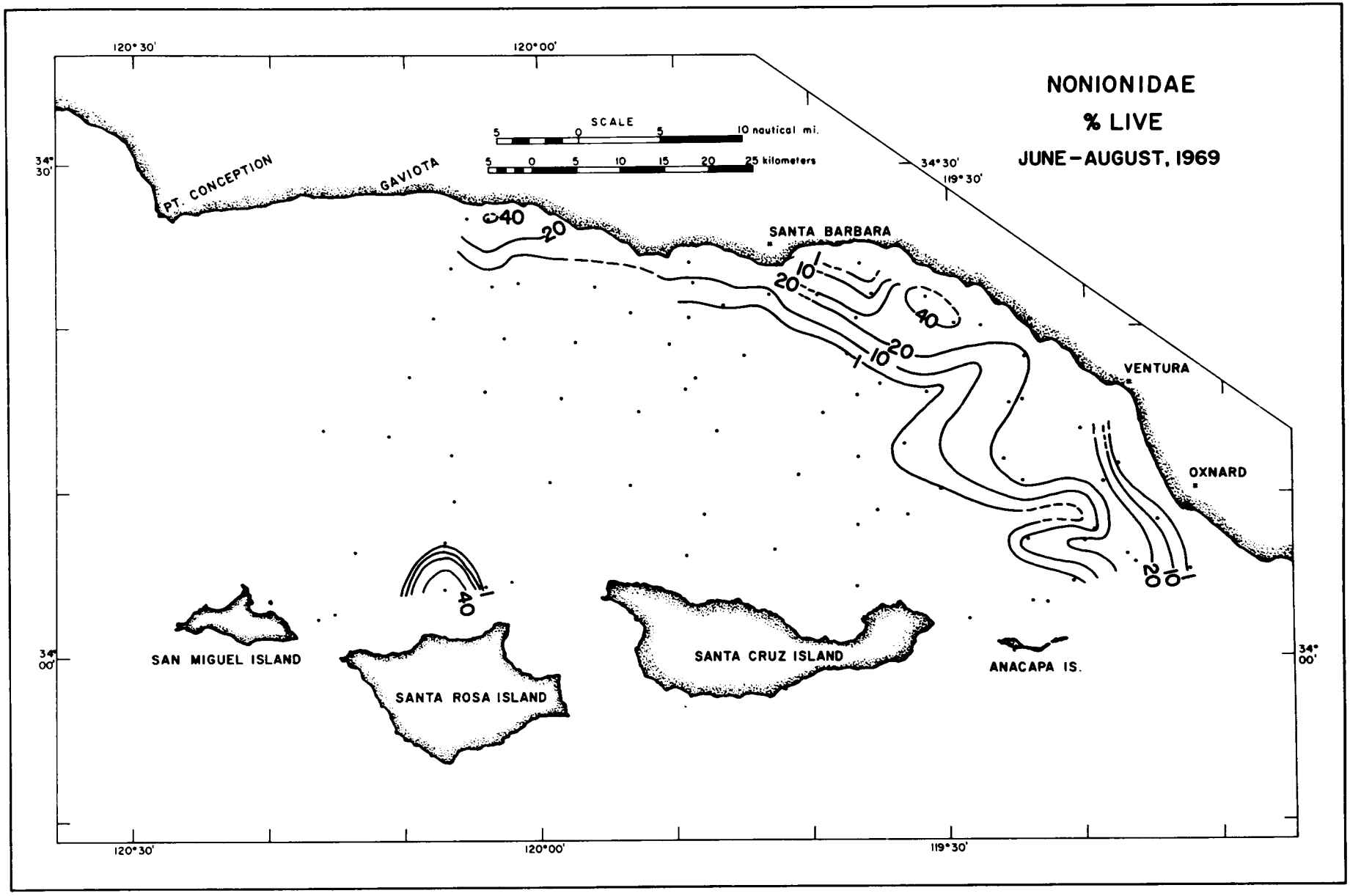
Figures 29-31. Percentage of Nonionidae in the living benthonic foraminiferal population.

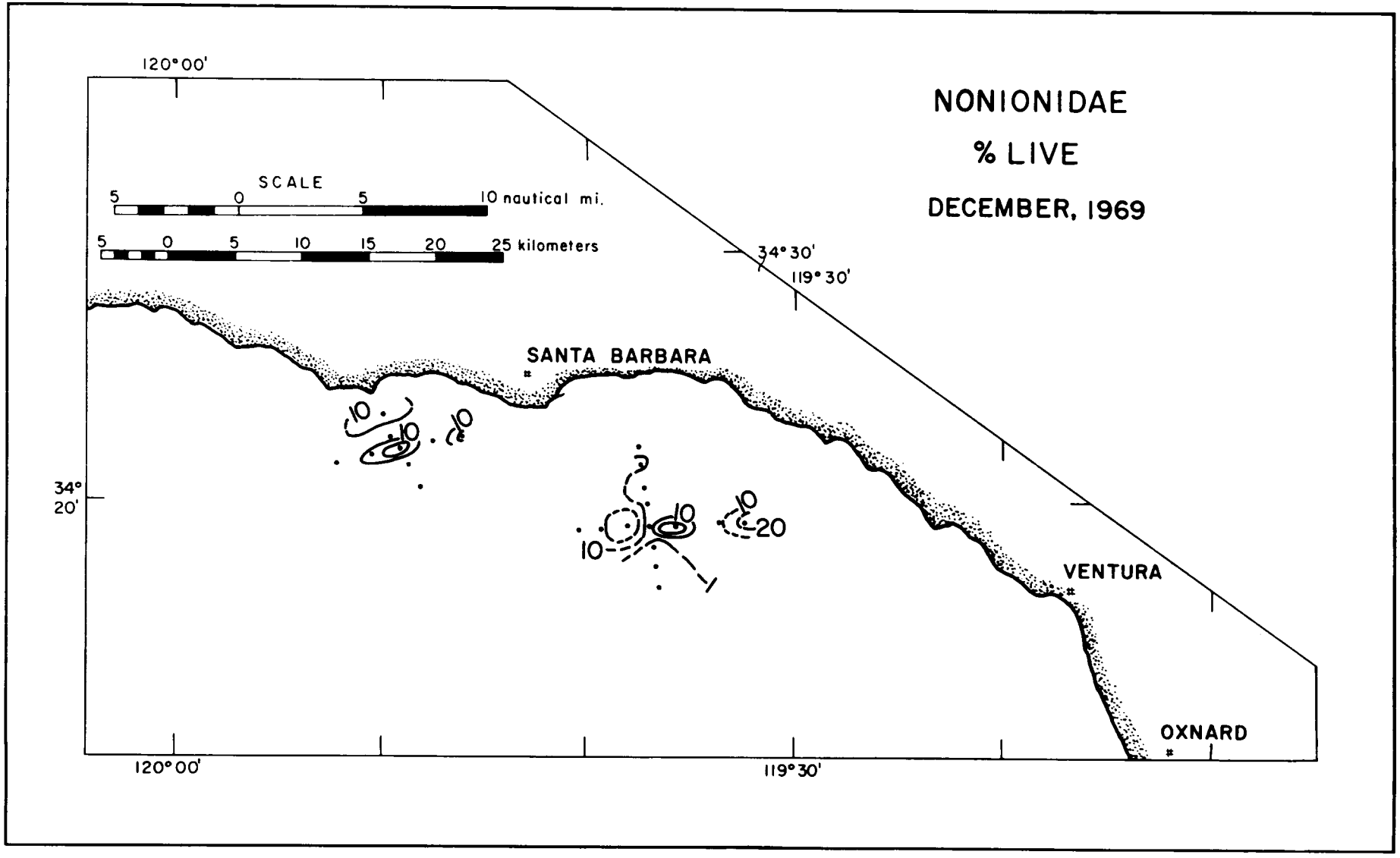
29. March-April, 1969

30. June-August, 1969

31. December, 1969


NONIONIDAE
% LIVE
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
40
20
10
-20
-10


NONIONIDAE
% LIVE
JUNE–AUGUST, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
40
20
10
1


NONIONIDAE
% LIVE
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°00'
34°30'
119°30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
10
10
10
10
10
10
20
120°00'
119°30'

This relationship has been noted on those portions of the southern California mainland shelf unaffected by effluent from sewer outfalls (Zalesney, 1959; Resig, 1960; Bandy, Ingle, and Resig, 1964a, b, c, 1965a, b). In the vicinity of platform A and between Ventura and Pt. Hueneme, the Nonionidae consistently made up abnormally large percentages of the total benthonic population near the shelf edge. The percentage of this group of species in the living population was similarly high in these areas during March and April, 1969, but these highs became less continuous with time.

Whereas the species examined to this point are major constituents of inner and middle shelf faunas, Bulimina marginata denudata Cushman and Parker was found by Bandy, Ingle, and Resig (1964b, c, 1965a, b) to be generally rare on the middle shelf and to increase to more than 20% of the fauna at the shelf edge. The primary exception to this trend was around sewer outfalls where relatively large populations existed even on the central shelf. In the channel region, Bulimina marginata denudata shows normal offshore increases in both total and living benthonic foraminiferal populations (figs. 32-34 and 35-37). Relatively large populations of this species extend up onto the mainland shelf to the southeast and northwest of platform A, but normal abundances were found between Ventura and Pt. Hueneme.

SUMMARY

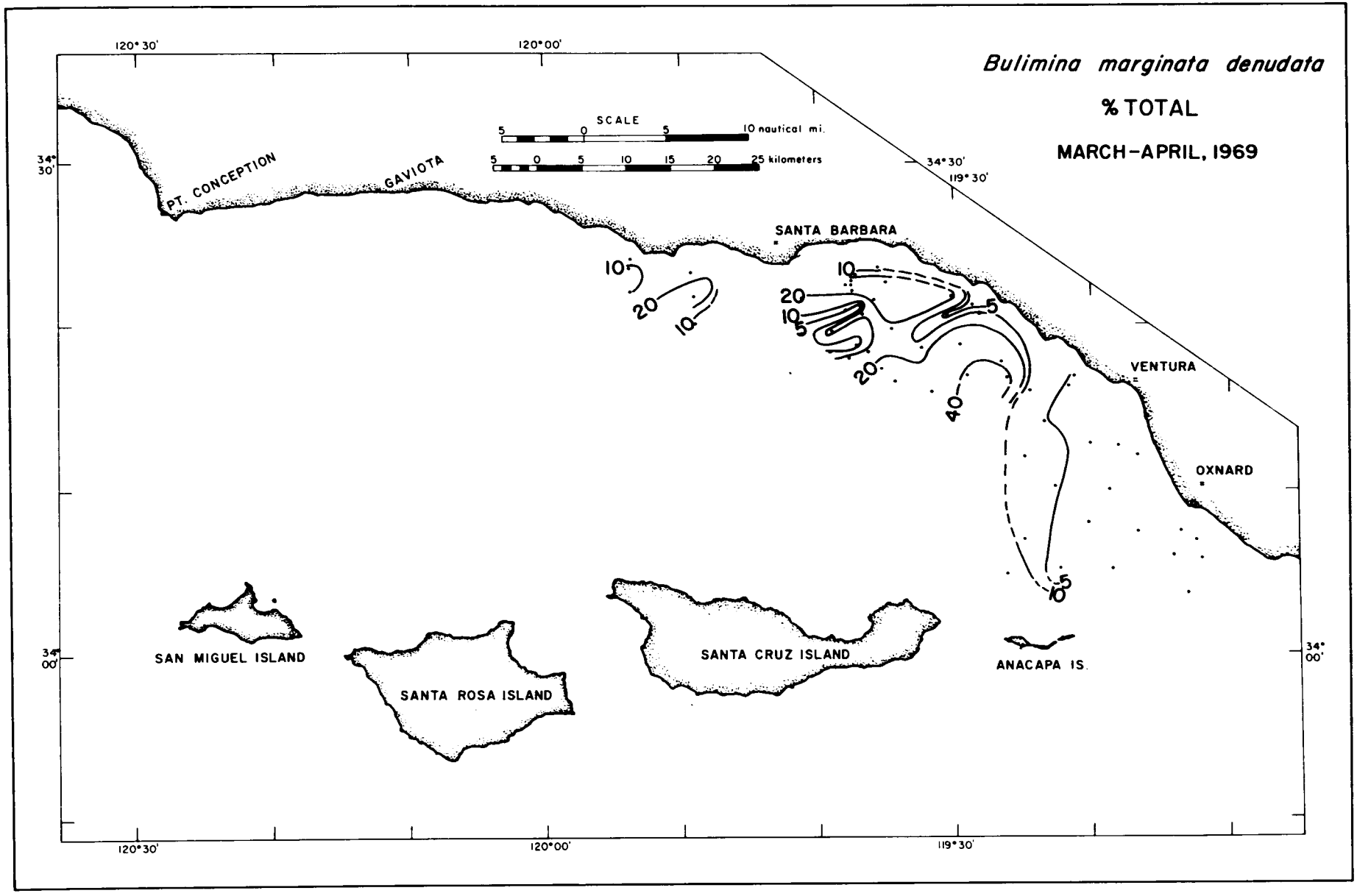
Foraminiferal populations from bottom sediments on the channel's mainland shelf show only a local divergence from normal trends during March to December, 1969. The size of and relationship between planktonic and benthonic foraminiferal populations are typical of "normal" portions of the southern California mainland shelf. The size of the living benthonic population was similar, with one possible exception. Both the live/dead ratio and the number of living benthonic species/gram of dry sediment were relatively large on the mainland shelf between Ventura and Pt. Hueneme. In this area, Buliminella elegantissima d'Orbigny, which flourishes in the effluent track of sewer outfalls, extended out from its normal inner shelf habitat to the shelf edge. Members of the Nonionidae maintained their normal central shelf distribution although they are relatively intolerant of pollution by sewer outfalls. Bulimina marginata denudata is an outer shelf species which does increase in abundance around sewer outfalls on the central shelf but it had normal distributional patterns between Ventura and Pt. Hueneme.

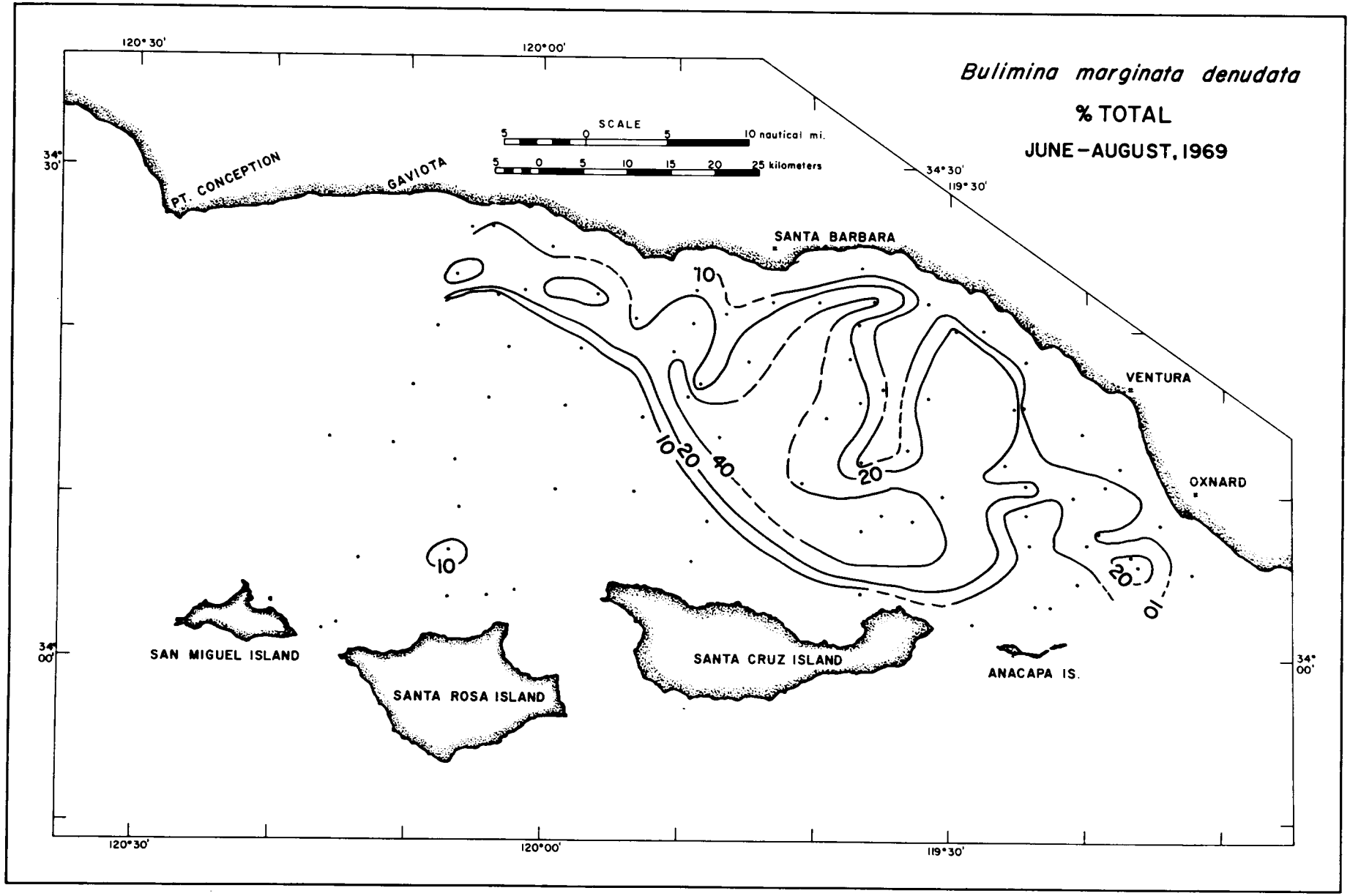
Figures 32-34. Percentage of *Bulimina marginata denudata* Cushman and Parker in the total benthonic foraminiferal population.

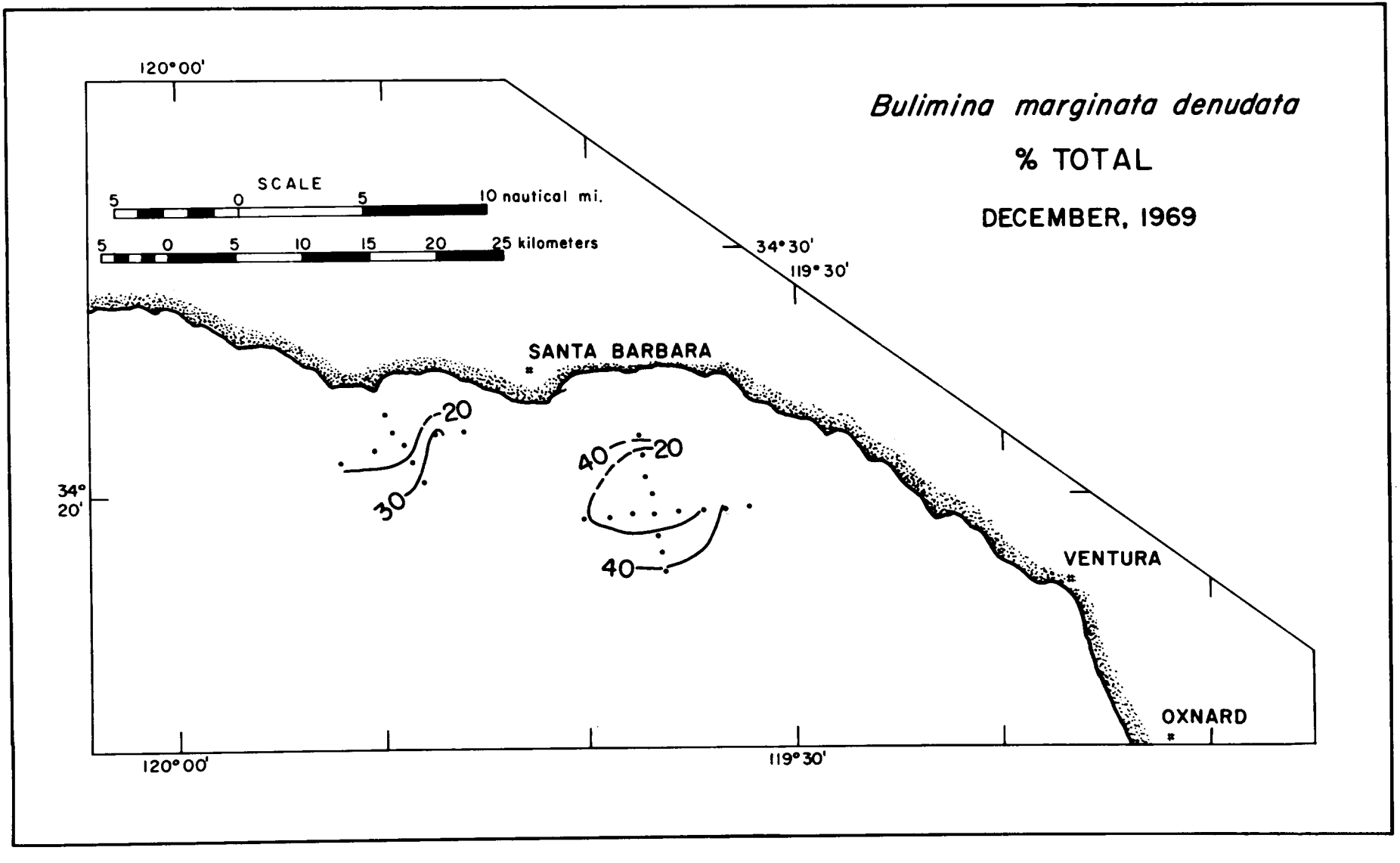
32. March-April, 1969

33. June-August, 1969

34. December, 1969


Bulimina marginata denudata
% TOTAL
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
10
20
10
5
10
20
10
5
20
40
5
10


Bulimina marginata denudata
% TOTAL
JUNE–AUGUST, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
10
20
40

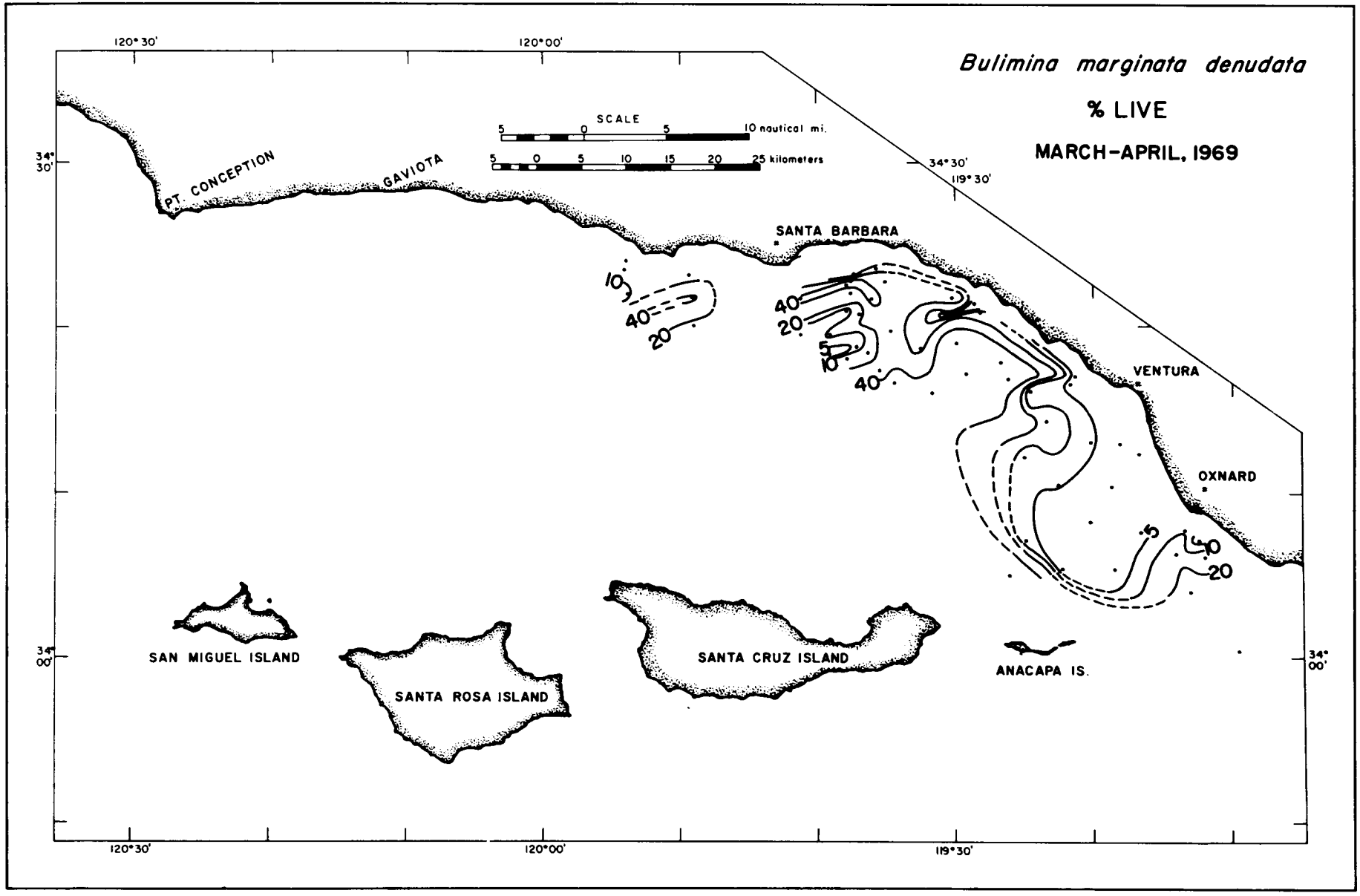

Bulimina marginata denudata
% TOTAL
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°00'
34°30'
119°30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
20
30
40
20
40
120°00'
119°30'

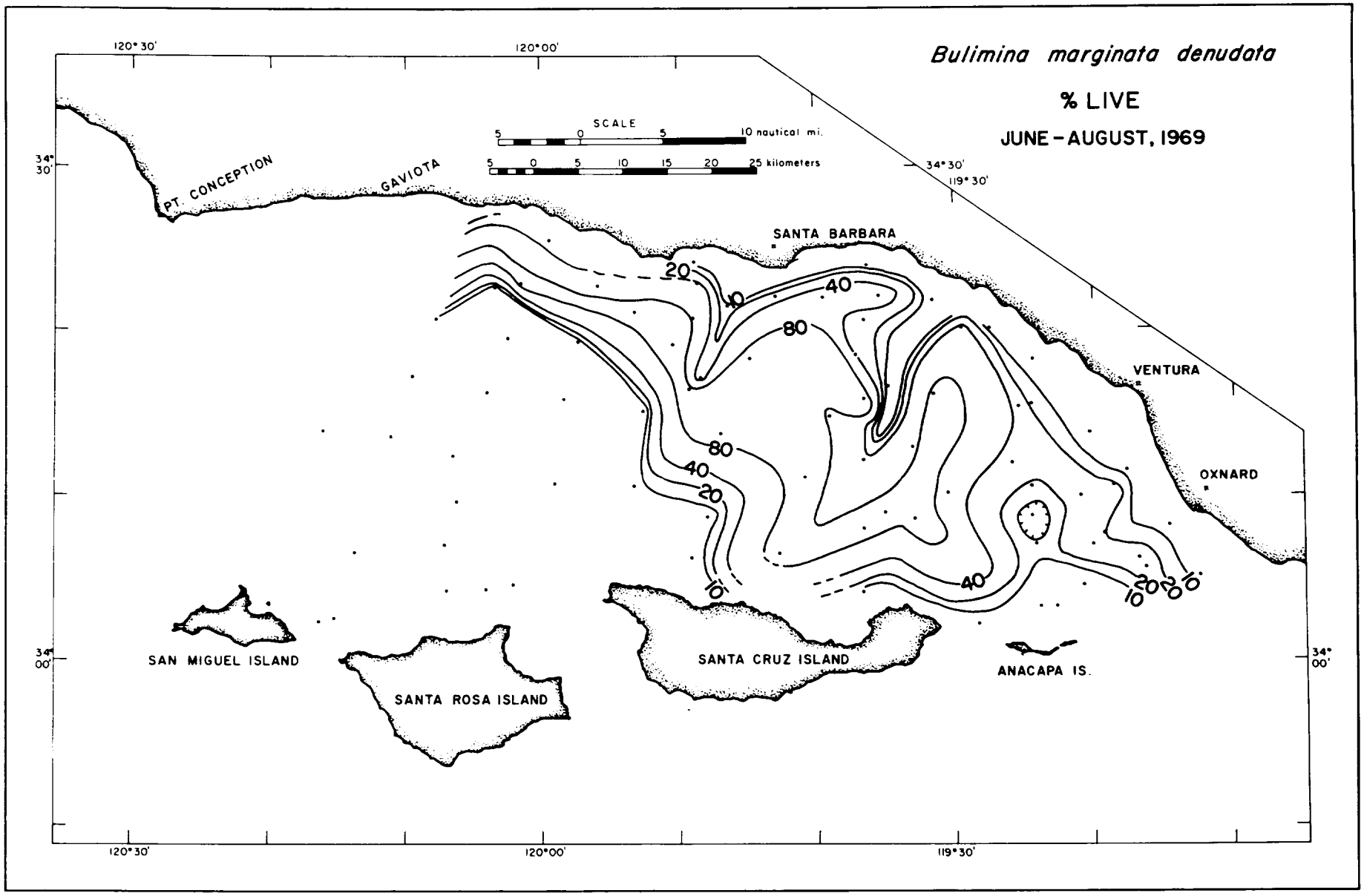
Figures 35-37. Percentage of *Bulimina marginata denudata* Cushman and Parker in the living benthonic foraminiferal population.

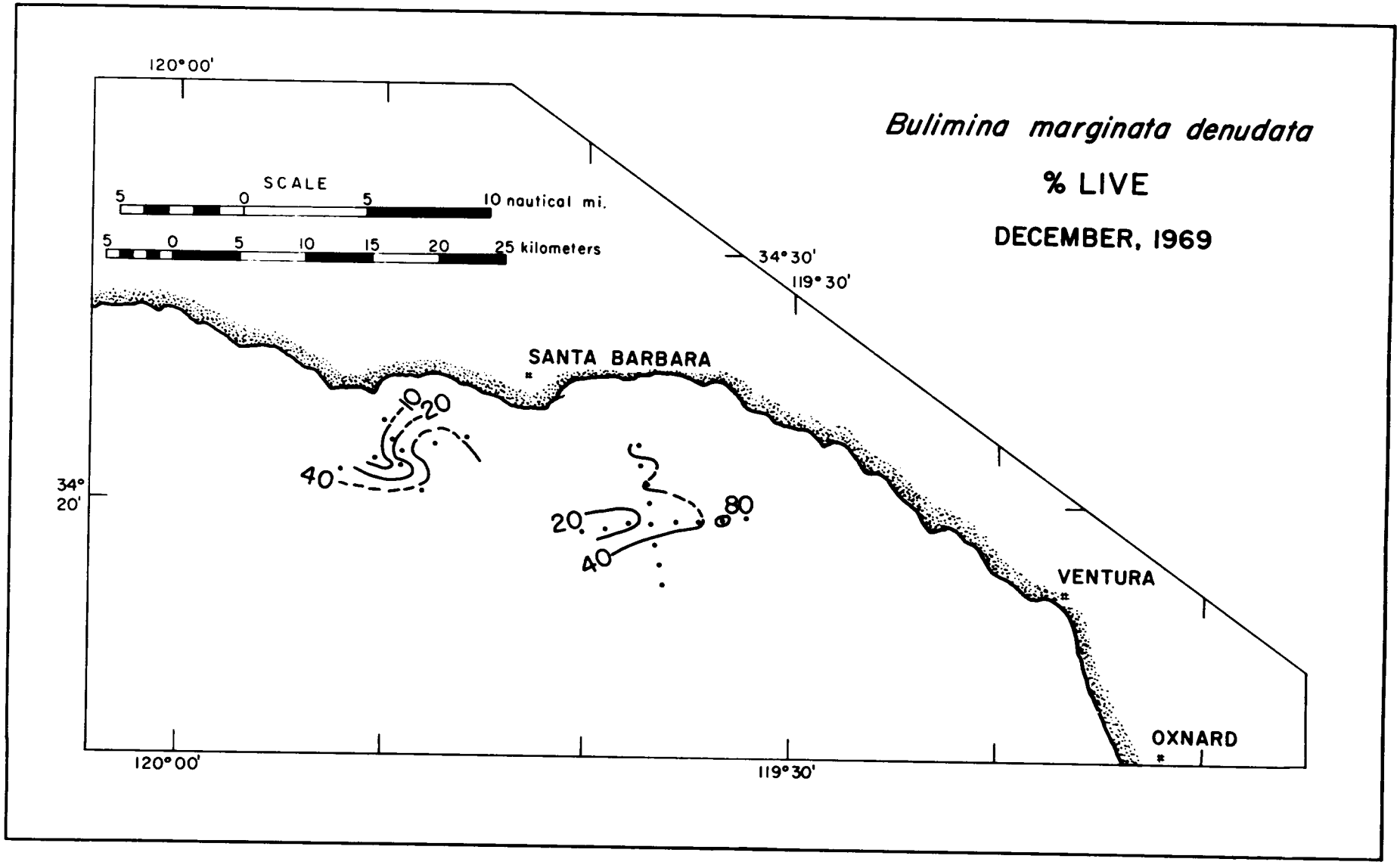
35. March-April, 1969

36. June-August, 1969

37. December, 1969


Bulimina marginata denudata
% LIVE
MARCH-APRIL, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
10
40
20
5
10
40
5
40
20


Bulimina marginata denudata
% LIVE
JUNE - AUGUST, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
20
40
80
10


Bulimina marginata denudata
% LIVE
DECEMBER, 1969
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°00'
34°30'
119°30'
34° 20'
SANTA BARBARA
VENTURA
OXNARD
10
20
40
20
40
80

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CHAPTER 7

HYDROCARBON CONTENT OF SANTA BARBARA CHANNEL SEDIMENTS

by

Ronald L. Kolpack
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

James S. Mattson
Gulf General Atomic Company
P.O. Box 608
San Diego, California 92112

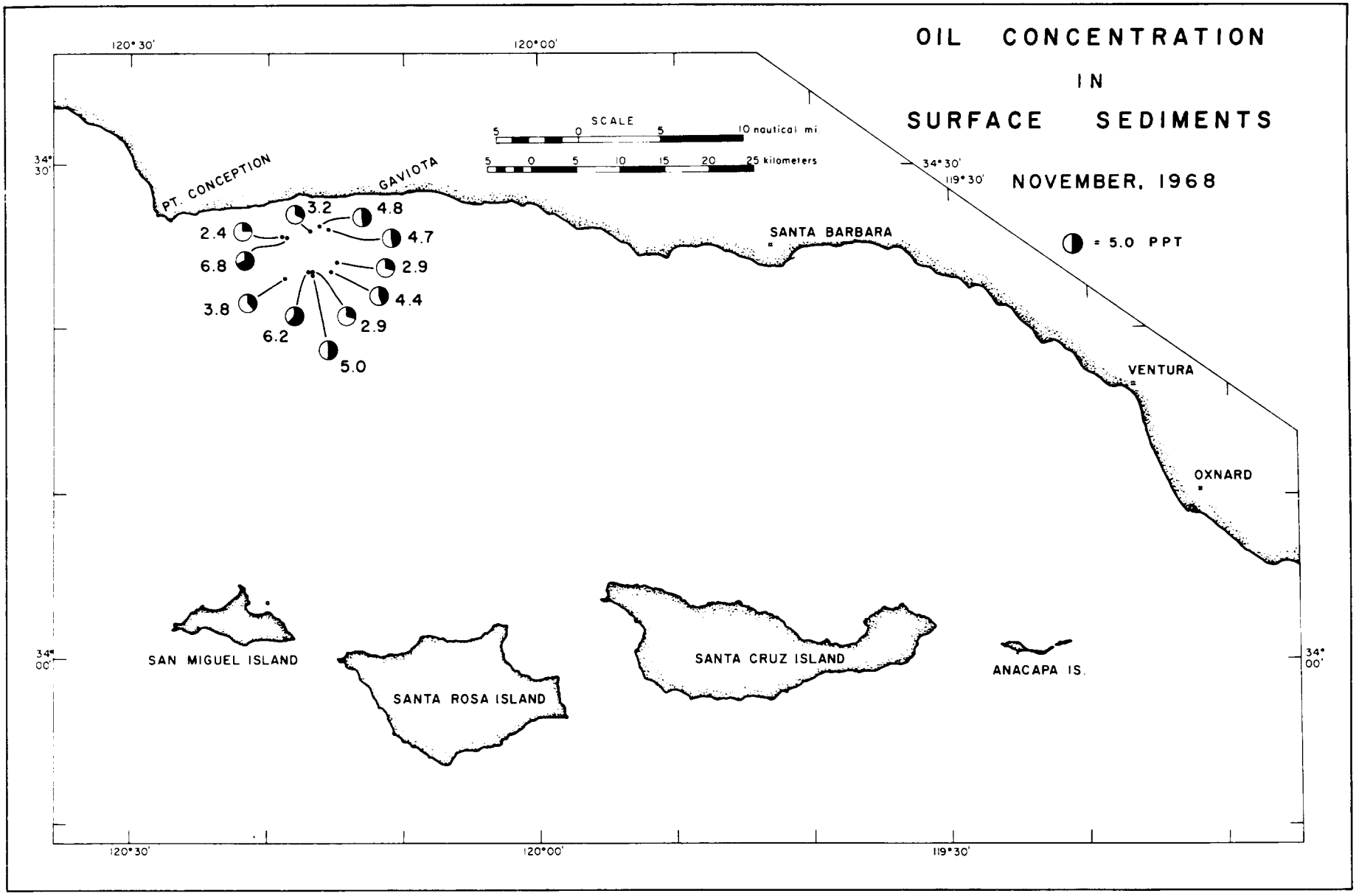
Harry B. Mark, Jr. and Ta-Ching Yu
Department of Chemistry
University of Cincinnati
Cincinnati, Ohio 45221

INTRODUCTION

A cooperative study by the Department of Geological Sciences at the University of Southern California and the Department of Chemistry at the University of Michigan aimed at studying the hydrocarbon content of marine sediments in the California Continental Borderland commenced in late 1968. The purpose of the study was to evaluate infrared analytical techniques and to establish background levels of the hydrocarbon content of surficial marine sediments.

Santa Barbara Channel was selected for primary evaluation because tar and oil had been observed in shelf and basin sediments collected from the area (Emery, 1960; Gatto, 1970). The first samples collected for this study were obtained on November 8, 1968 (fig. 1) from box cores, taken south of Pt. Conception and Gaviota. The objectives of that study were significant but unfortunately a shortage of

Figure 1. Total hydrocarbon concentration in surficial sediments from southeast of Pt. Conception prior to the well blowout. There are several natural seeps in this area and transportation of shallow water sediments to deeper water occurs via several small "canyons" (Gatto, 1970).


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
NOVEMBER, 1968
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
3.2
4.8
2.4
4.7
6.8
2.9
3.8
4.4
6.2
2.9
5.0
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.

research funds as well as our incomplete perception of urgency prevented a complete study of the area prior to the well blowout on January 28, 1969.

PREPARATION OF SEDIMENT SAMPLES

The samples collected for this study were obtained from either a Reineck box corer or a Shipek grab sampler operated from the R/V Velero IV or the R/V Golden West. A sample was obtained from the top cm of sediment and, in some instances, additional samples were obtained from representative depths below the surface. These samples were placed in plastic vials, frozen aboard ship, and kept frozen until prepared for analysis.

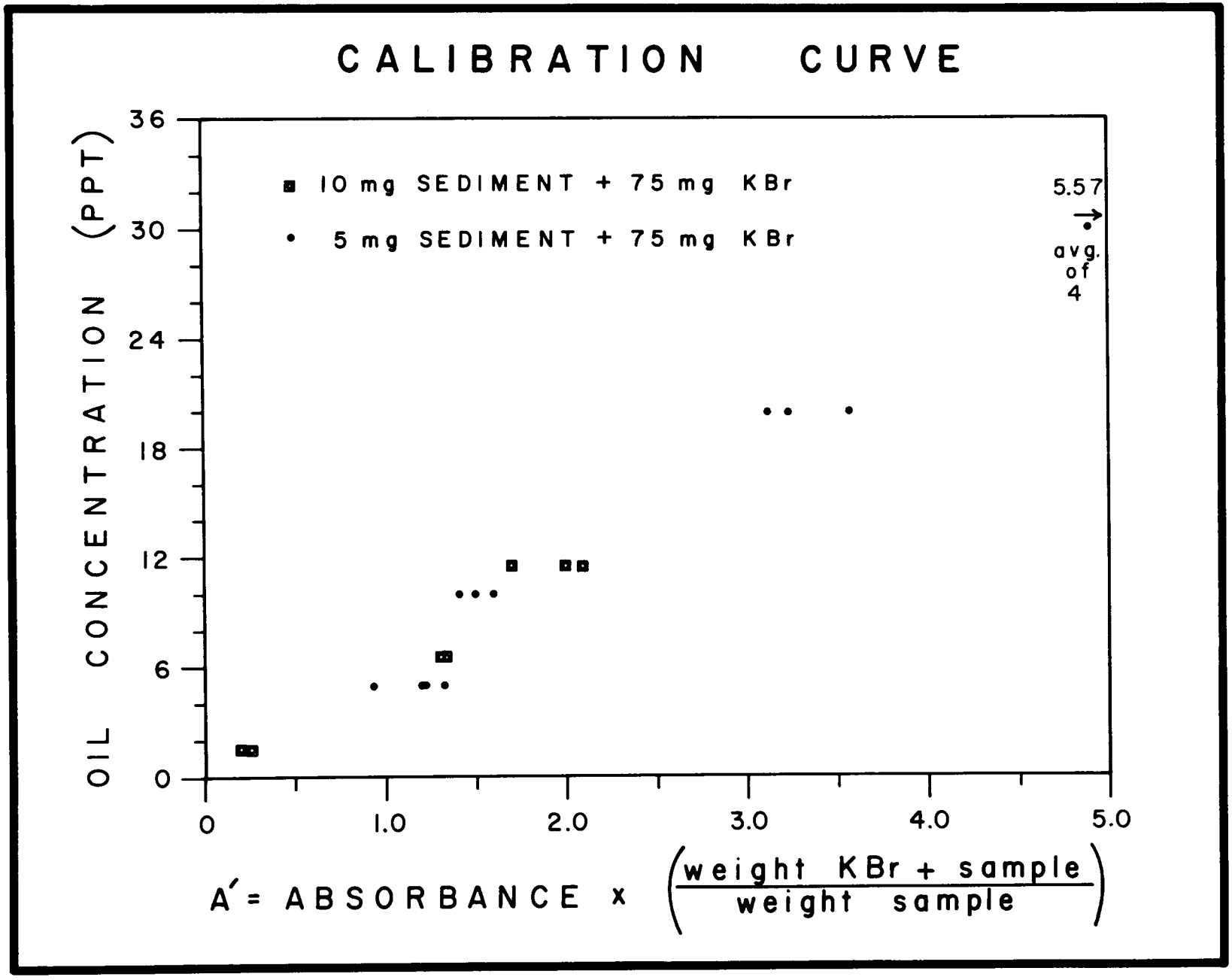
To obtain a finely pulverized sample for infrared analysis, the frozen material was first transferred to 25ml beakers and pumped dry with a vacuum pump. Large pebbles, twigs and shell fragments were removed and the samples were then ground to a coarse powder. A portion of the coarse powder (ca. 50mg) was subjected to additional grinding with an agate mortar and pestle until a fine powder was obtained. This fine powder was again dried under vacuum (ca. 1 to 50mm Hg) overnight.

INFRARED SPECTROSCOPIC ANALYSIS--KBr TECHNIQUE

Ten mg of the ground sediment sample and 75mg of dry KBr, infrared grade, were ground together using an agate mortar and pestle. The mixture was pressed into an 8mm diameter pellet using a Wilks Minipress™ pellet press. The spectrum of the pellet was then obtained with a Hilger-Watts H-1200 grating infrared spectrometer. The absorbance at 2925^{-1}cm, the CH_2 stretching band, was measured. The extinction coefficient of this peak varies over a factor of 2 from very light crude oils to heavy tars, but that is one factor that cannot be accounted for analytically. This procedure measures only the total hydrocarbon content of the sediment, of course, and the implications of this must be taken into account when interpreting the data.

A calibration curve (fig. 2) was obtained by adding a 600°F residual "Bunker C" oil to a sample of sediment with a low hydrocarbon content. This oil has an extinction coefficient at 2925^{-1}cm which closely approximates that of the

Figure 2. Calibration curve for the infrared analyses of total hydrocarbon concentrations in Santa Barbara Channel sediments.


CALIBRATION CURVE
OIL CONCENTRATION (PPT)
36
30
24
18
12
6
0
10 mg SEDIMENT + 75 mg KBr
5 mg SEDIMENT + 75 mg KBr
5.57
avg. of 4
0
1.0
2.0
3.0
4.0
5.0
A′ = ABSORBANCE x (weight KBr + sample / weight sample)

blowout oil from Well A-21 which was collected at sea and refrigerated until prepared for analysis. The minimum detectable level of hydrocarbon was about 0.2 parts per thousand (ppt). The calibration curve was linear (standard deviation 0.2 ppt) up to a hydrocarbon concentration of 20 ppt. A second calibration was obtained, using only 5 mg of sample in 75 mg KBr, which gave the same accuracy, but was linear to over 30 ppt. Twenty three samples were used in the calibration procedure. A sampling of 95 analyses carried out in duplicate or triplicate yielded a relative precision of ±10% for the analytical procedure. Thus, the reported values are accurate to ±0.2 ppt or ±10%, whichever is greater. Additional details are available in Harrick (1967) and Mattson, Mark and Weber (1970).

OIL CONCENTRATIONS

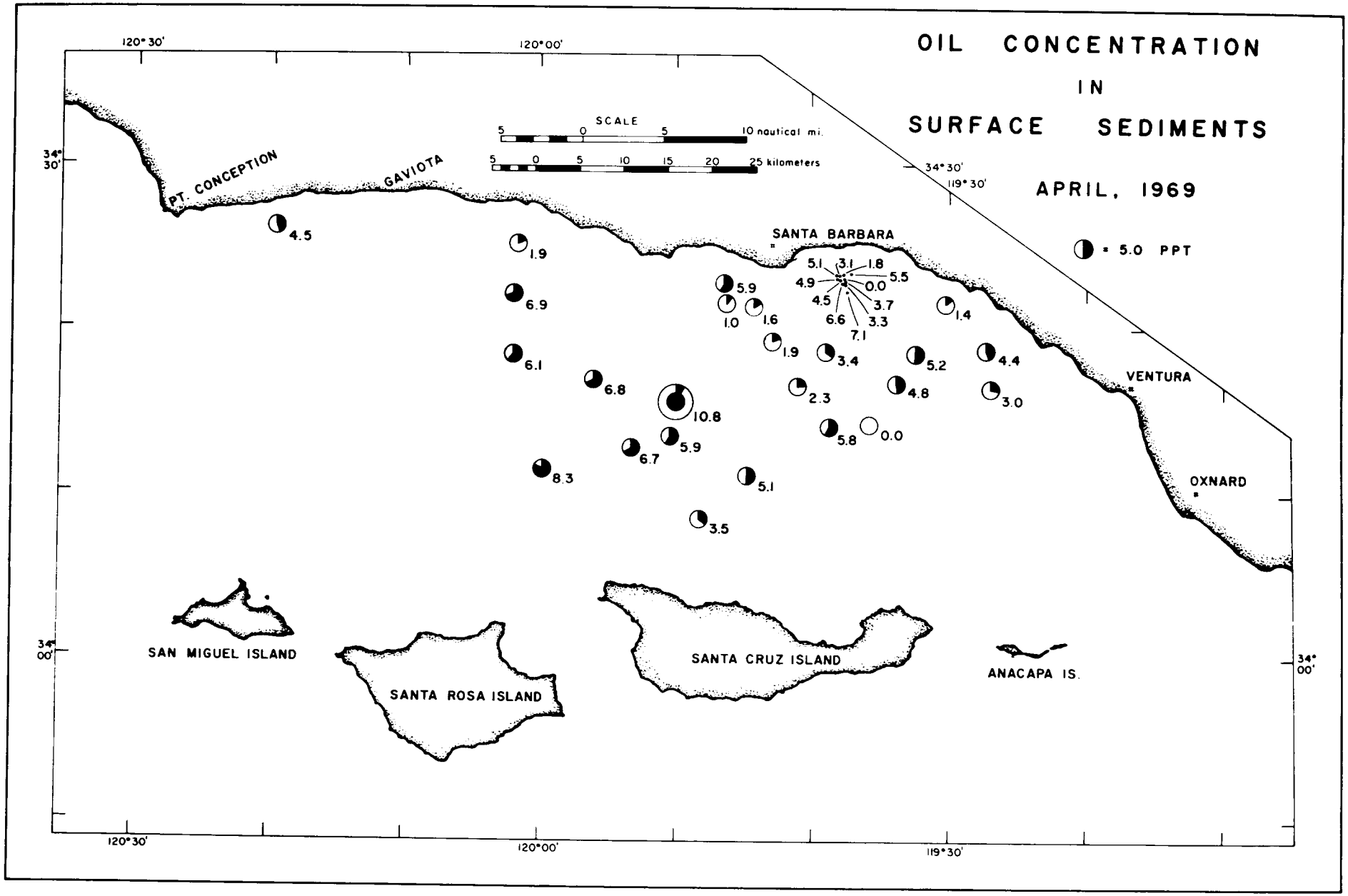
The initial pattern that emerged from the results of the infrared analyses showed higher total hydrocarbon concentrations in the areas southeast of Well A-21, west of Montalvo Ridge and in the western portion of the basin (figs. 3-4). The area southeast of Well A-21 is closely related to maximum oil slick coverage of the water surface and is interpreted as the area of maximum deposition of oil at the sediment-water interface. The high values in the western portion of the basin occurred in areas of low rates of sediment deposition and probably represent relative non-dilution by detrital components.

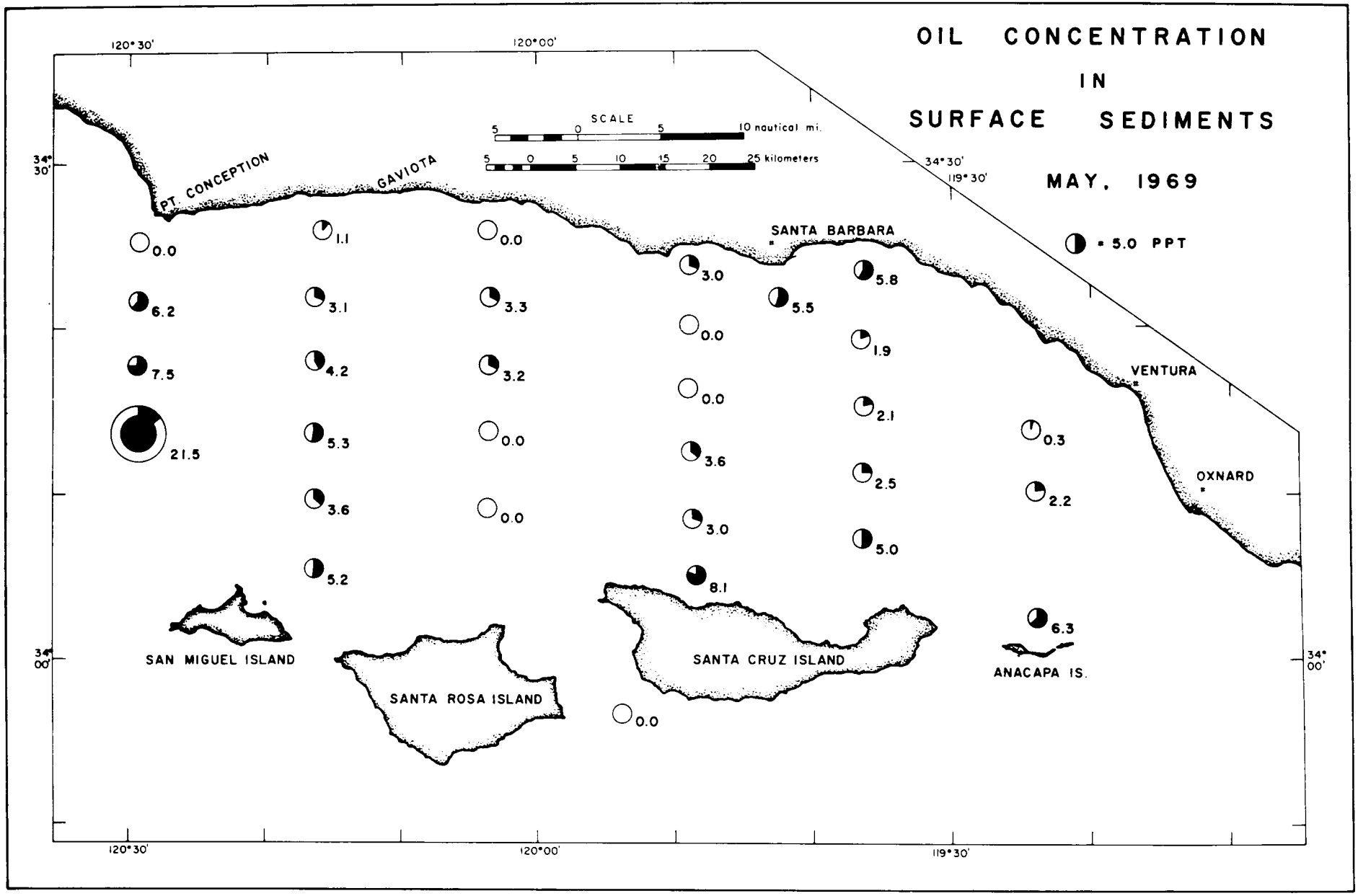
An indication of local variability resulting from fluctuations in flood sediment accumulation and non-uniform deposition of oil from the well blowout is shown by the range of values from closely spaced stations in the area approximately 7 km southeast of Santa Barbara (fig. 3).

The first alignment of higher oil concentrations within the main avenues of sediment transport toward the central basin was observed during June-August, 1969 (figs. 5-7). The associated decreasing values in shallow water areas was a reflection of the removal by retransportation of oil initially deposited in those areas. This pattern continued to evolve and it was reasonably well developed by the end of August, 1969.

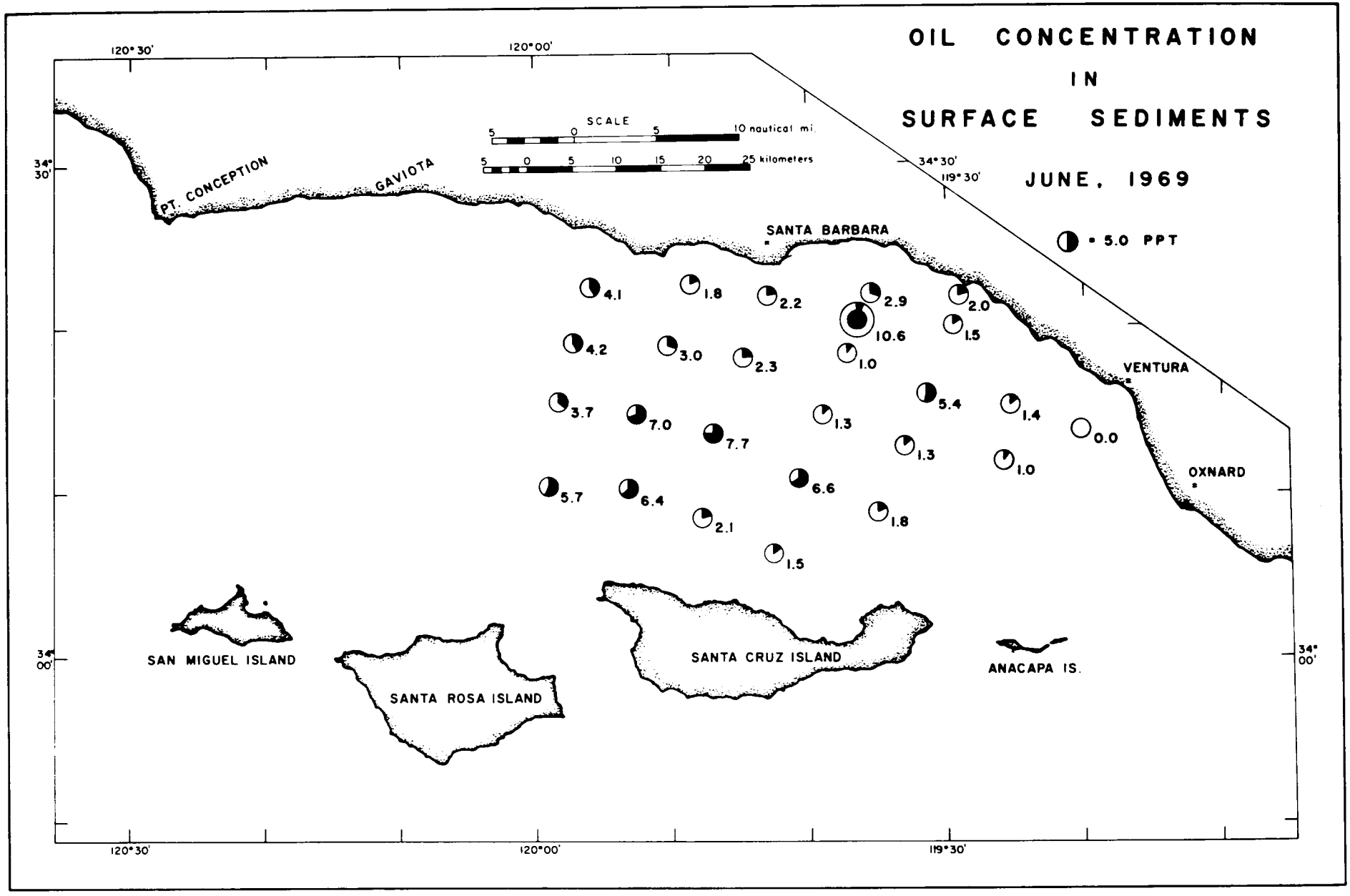
Inspection of the results from the February cruise (fig. 8) revealed that the "anomalously" low values in the

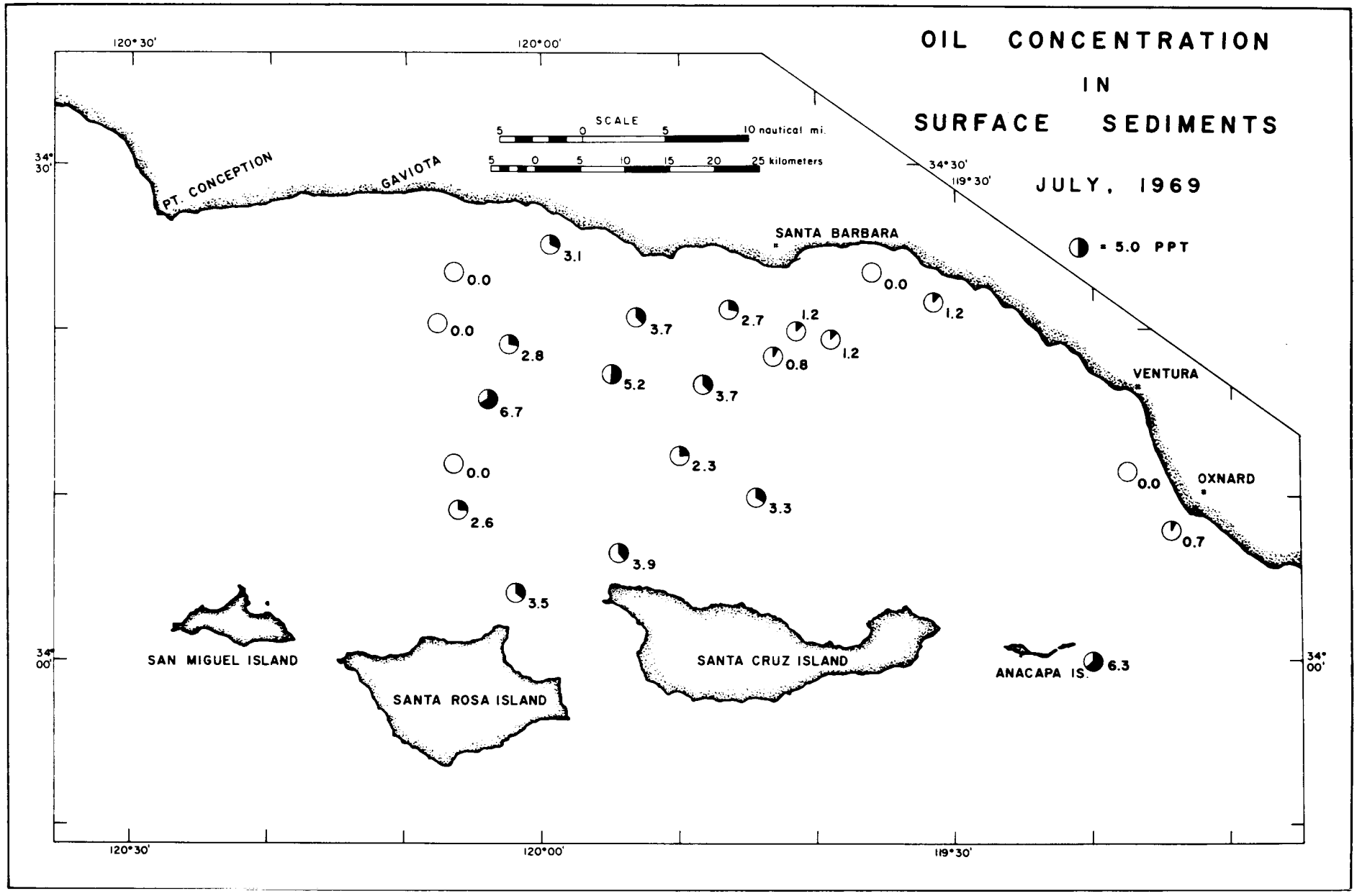
Figures 3-4. Hydrocarbon concentrations in sediments collected in April and May, 1969. A full circle portrays a value of 10 parts per thousand (ppt). If a value is greater than 10 ppt then each successively larger circle portrays an additional 10 ppt.

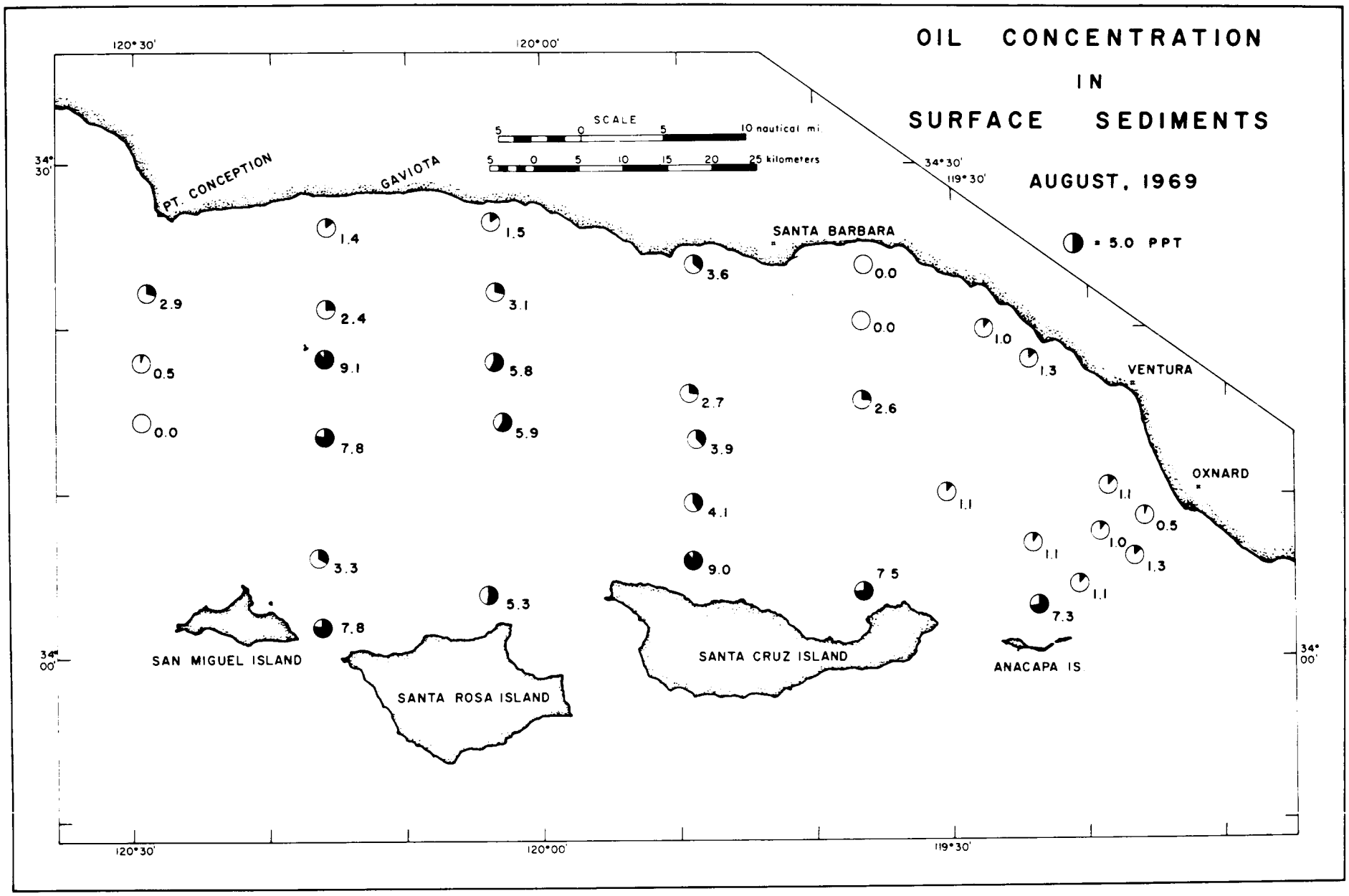

OIL CONCENTRATION
IN
SURFACE SEDIMENTS
APRIL, 1969
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
4.5
1.9
6.9
6.1
6.8
10.8
5.9
6.7
8.3
5.1
3.5
5.9
1.0
1.6
1.9
2.3
5.8
0.0
3.4
4.8
5.2
4.4
3.0
1.4
5.1
3.1
1.8
4.9
5.5
0.0
4.5
3.7
6.6
3.3
7.1


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
MAY, 1969
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
0.0
1.1
0.0
6.2
3.1
3.3
7.5
4.2
3.2
21.5
5.3
0.0
3.6
0.0
5.2
3.0
5.8
5.5
0.0
1.9
0.0
2.1
3.6
2.5
3.0
5.0
8.1
0.0
0.3
2.2
6.3

Figures 5-7. Hydrocarbon concentrations for June, July and August, 1969. The sample grid for August is the same as for May; however, some stations are missing from the August grid because of difficulties encountered during field work.


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
JUNE, 1969
• 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
4.1
1.8
2.2
2.9
2.0
10.6
1.5
4.2
3.0
2.3
1.0
3.7
7.0
7.7
1.3
5.4
1.4
0.0
1.3
1.0
5.7
6.4
6.6
2.1
1.8
1.5


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
JULY, 1969
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
0.0
3.1
0.0
2.8
3.7
2.7
1.2
1.2
1.2
0.8
5.2
3.7
6.7
0.0
2.3
2.6
3.3
3.9
3.5
0.0
0.7
6.3


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
AUGUST, 1969
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120°30'
120°00'
119°30'
34°30'
34°00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
2.9
0.5
0.0
1.4
2.4
9.1
7.8
3.3
7.8
1.5
3.1
5.8
5.9
5.3
3.6
2.7
3.9
4.1
9.0
0.0
0.0
2.6
7.5
1.0
1.3
1.1
1.1
1.1
7.3
1.1
1.0
0.5
1.3

central basin did not conform to the general pattern observed previously. The initial interpretation of February, 1970 infrared values indicated that there may have been a loss of total hydrocarbons in the sediments and this possibility appeared to be real until an evaluation of other parameters was completed. The question of considerable concern was the sample recovery from Shipek grabs taken in deep water because the probability of sample "washing" was evident during shipboard work. Other sediment, chemical and microfaunal values from the samples in question yielded values which can only be interpreted as evidence for "washing" during recovery through the water column. Thus, the results from the February, 1970 cruise presented a perplexing problem which required additional evidence before the fate of the deposited oil could be defined.

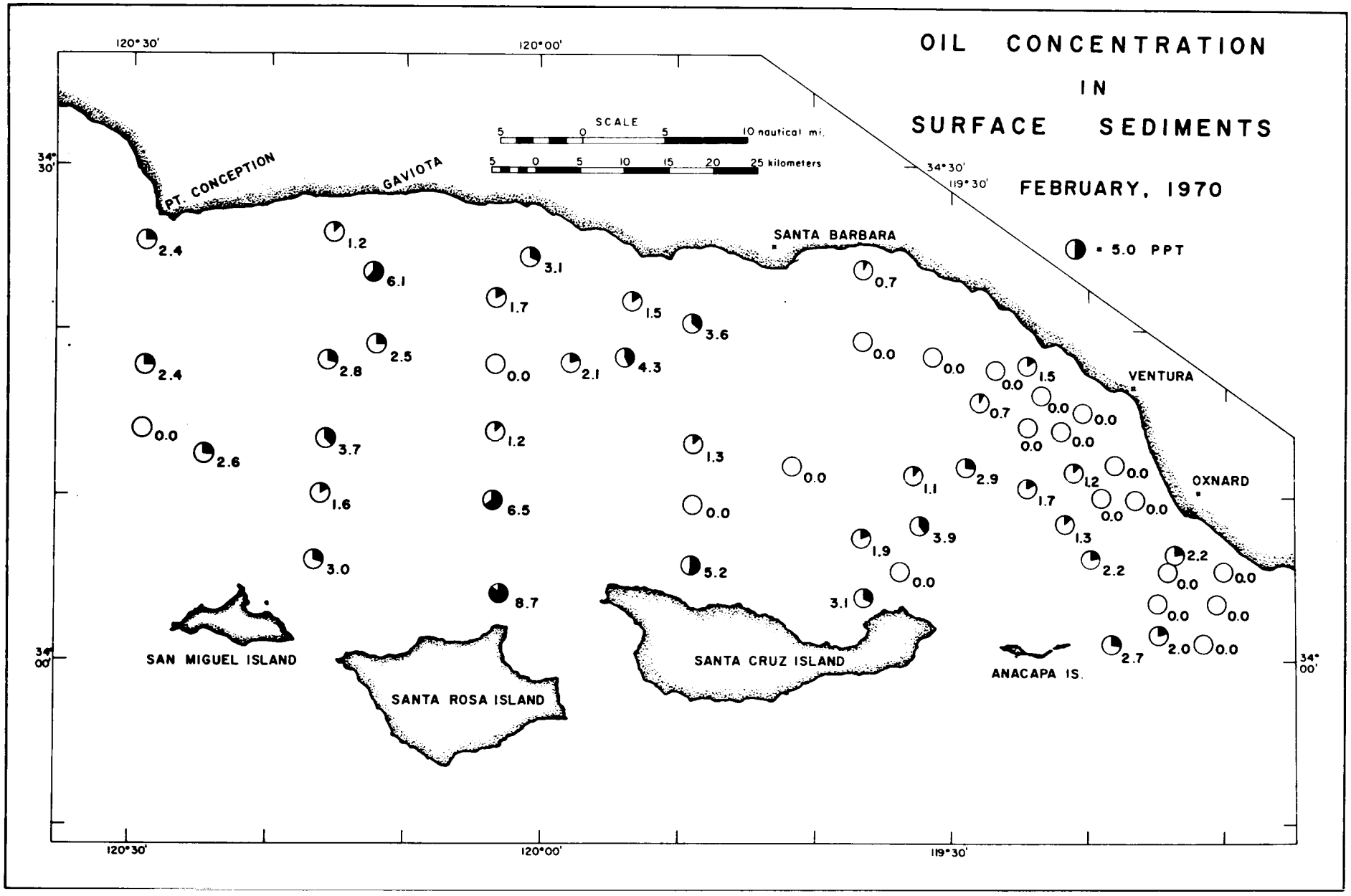
The answer to this problem was crucial because the results could be indicative of a loss of total hydrocarbons and therefore evidence of degradation. For this reason, a number of carefully selected stations were occupied in June, 1970 (fig. 9) and all surficial material from deep water was obtained by a box corer. The infrared results subsequently confirmed the pattern observed prior to February, 1970.

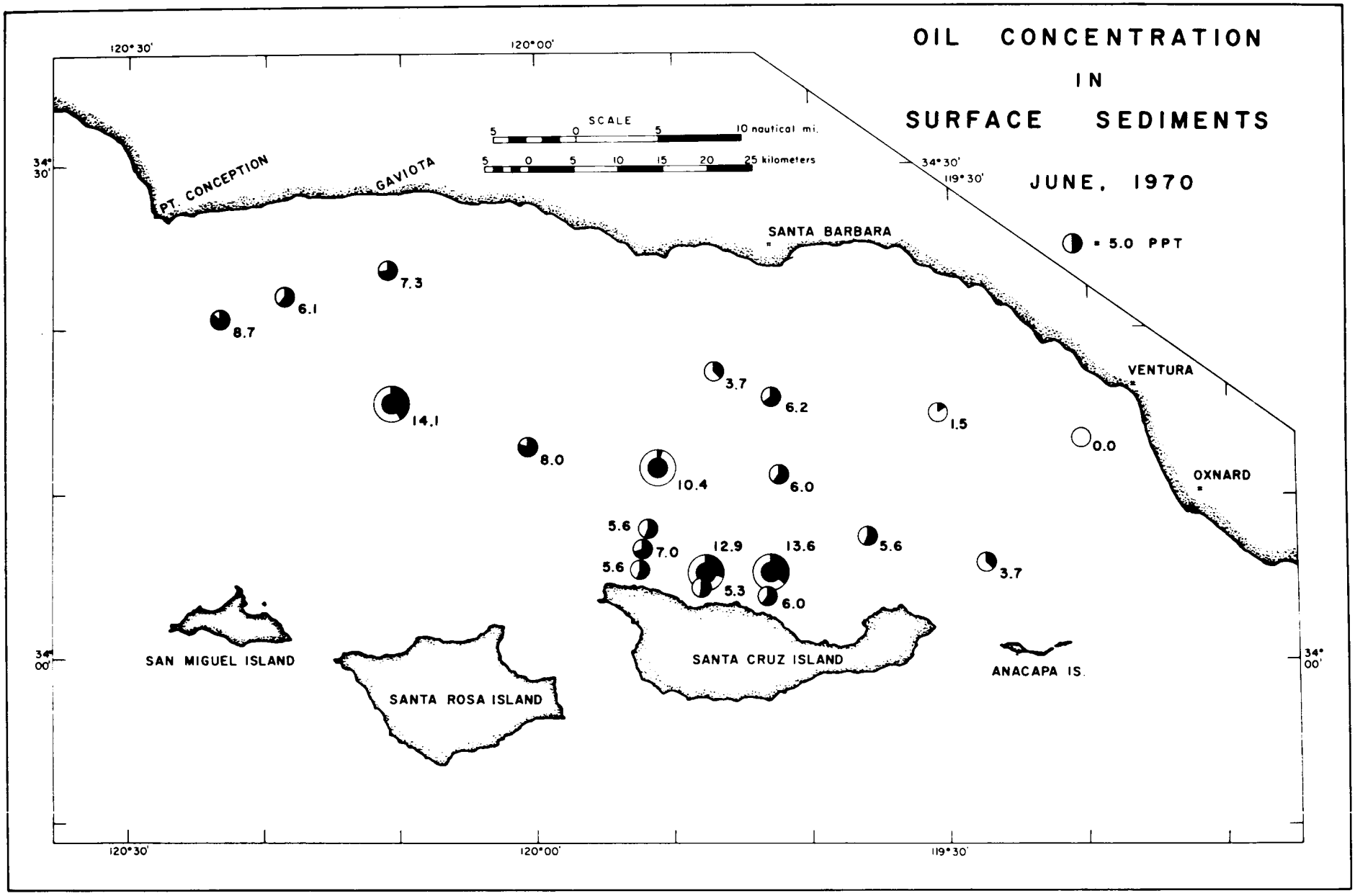
An interesting pattern was observed in the results from the area of the shelf-slope break north of Santa Cruz Island. We believe that the hydrocarbons were derived from oil slicks deposited in shallow water along the north side of the island because samples of globular tar were recovered by SCUBA dives from depths of 5-10 meters during March, 1969. Much of the tar contained straw, feathers and storm debris which was associated with the surface oil slicks. Agitation of the material at the sediment-water interface by bottom currents resulted in transportation of the negatively buoyant tar globules and the higher values are indicative of movement of hydrocarbons off the shelf and toward deeper water.

SUMMARY

Deposition of large quantities of oxidized flood runoff detritus at approximately the same time as the well blowout facilitated tracing the events related to the objective of evaluating the physical and chemical effects of the well blowout. Inasmuch as we have been able to positively identify detrital material deposited after the floods occurred, we

Figures 8-9. Hydrocarbon concentrations for February and June, 1970. All values for the February cruise have been plotted although several values from deeper water samples are erroneously low because of sample washing.


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
FEBRUARY, 1970
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
2.4
1.2
6.1
3.1
1.7
1.5
3.6
0.7
2.4
2.8
2.5
0.0
2.1
4.3
0.0
0.0
0.0
1.5
0.0
0.7
0.0
0.0
0.0
0.0
2.6
3.7
1.2
1.3
0.0
1.1
2.9
1.2
0.0
1.7
0.0
0.0
1.6
6.5
0.0
3.9
1.3
1.9
0.0
2.2
2.2
0.0
0.0
3.0
5.2
3.1
8.7
0.0
0.0
2.7
2.0
0.0


OIL CONCENTRATION
IN
SURFACE SEDIMENTS
JUNE, 1970
= 5.0 PPT
SCALE
5 0 5 10 nautical mi.
5 0 5 10 15 20 25 kilometers
120° 30'
120° 00'
119° 30'
34° 30'
34° 00'
PT. CONCEPTION
GAVIOTA
SANTA BARBARA
VENTURA
OXNARD
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
ANACAPA IS.
8.7
6.1
7.3
14.1
8.0
3.7
6.2
10.4
6.0
1.5
0.0
5.6
7.0
5.6
12.9
5.3
13.6
6.0
5.6
3.7

are also certain that the hydrocarbon concentrations of these surficial sediments were also deposited after the floods occurred. The information presently available does not allow us to positively determine what proportions of the hydrocarbon concentrations in the surficial sediments were derived from Well A-21, and from natural seeps in the area. However, additional infrared analyses of core samples from depths below the sediment-water interface, supplementary analyses of hydrocarbon concentrations by gas chromatography and the flood sediment data enable us to conclude that most of the hydrocarbons detected in the surficial sediments were derived from Well A-21.

The pattern of hydrocarbon deposition with time showed that initial deposition occurred southeast of Well A-21. Subsequently, hydrocarbons were deposited or redeposited at the sediment-water interface in the western portions of the channel.

The higher hydrocarbon concentrations eventually became aligned with the main avenues of sediment transport toward the central basin. This pattern continued through June, 1970. Thus, the basin is the final deposition site.

A calculation of the total amount of hydrocarbons contained in the surficial sediments deposited after the floods is possible with the information presently available, but this calculation would not account for losses of the more volatile components nor would it differentiate natural seep material from Well A-21 material. Additional information will allow for a more definitive assignment of the amount of oil which was released into the marine environment from Well A-21, but it will increase the total hydrocarbon volume calculations. At this time, we believe that the results from the infrared study and supplementary information not presented in this report indicate that the estimates of the amount of oil released as a result of the well blowout (U.S. Geological Survey Prof. Paper 679, 1969) are too low.

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U.S. Geol. Survey Prof. Paper 679, 1969, Geology, Petroleum Developments and Seismicity of the Santa Barbara Channel Region, California, 77 pp.

CHAPTER 8

GENERAL CHARACTERISTICS OF NEARSHORE SEDIMENTS FROM EL CAPITAN TO VENTURA, CALIFORNIA, 1969-70

by

D. S. Gorsline, B. M. Brenninkmeyer, W. C. Meyer,
M. R. Ploessel, G. I. Shiller and S. P. Vonder Haar
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

INTRODUCTION

Bottom sediments were sampled in the nearshore zone along the mainland coast as part of the investigation of the Santa Barbara Channel area following the oil spill of February, 1969. Surface sediment was collected in August, 1969 with a Shipek Grab Sampler from aboard the R. V. Golden West. The basic pattern was a series of traverses arranged normal to shore at equal intervals of about one nautical mile. Stations were occupied along each traverse line at depths of from 3 to 30 fathoms at roughly equal spacing seaward and an average of four stations per line. After recovery, representative splits of the upper 2-3 cm of each sample were stained for live microfaunal determinations, another for chemical analysis, one for future organic analysis (this split was frozen) and the bulk of the sample for textural and mineralogical analysis. A field description was recorded for each sample at the time of collection.

This report will briefly review the texture, coarse fraction components, carbonate content and organic carbon content. These data were obtained by conventional analytical procedures as described by Moore and Gorsline (1960), Kolpack and Bell (1968) and Krumbein and Pettijohn (1938).

ACKNOWLEDGEMENTS

The writers acknowledge the assistance of the geological project staff at the University of Southern California under the direction of Dr. R. L. Kolpack for preparation of samples, drafting and field assistance. Mr. Richard Bergeron, captain of the Golden West, was responsible for all navigation and freely contributed his expertise to the problems of field collection. Funding was under a grant from the Western Oil and Gas Association to the University of Southern California.

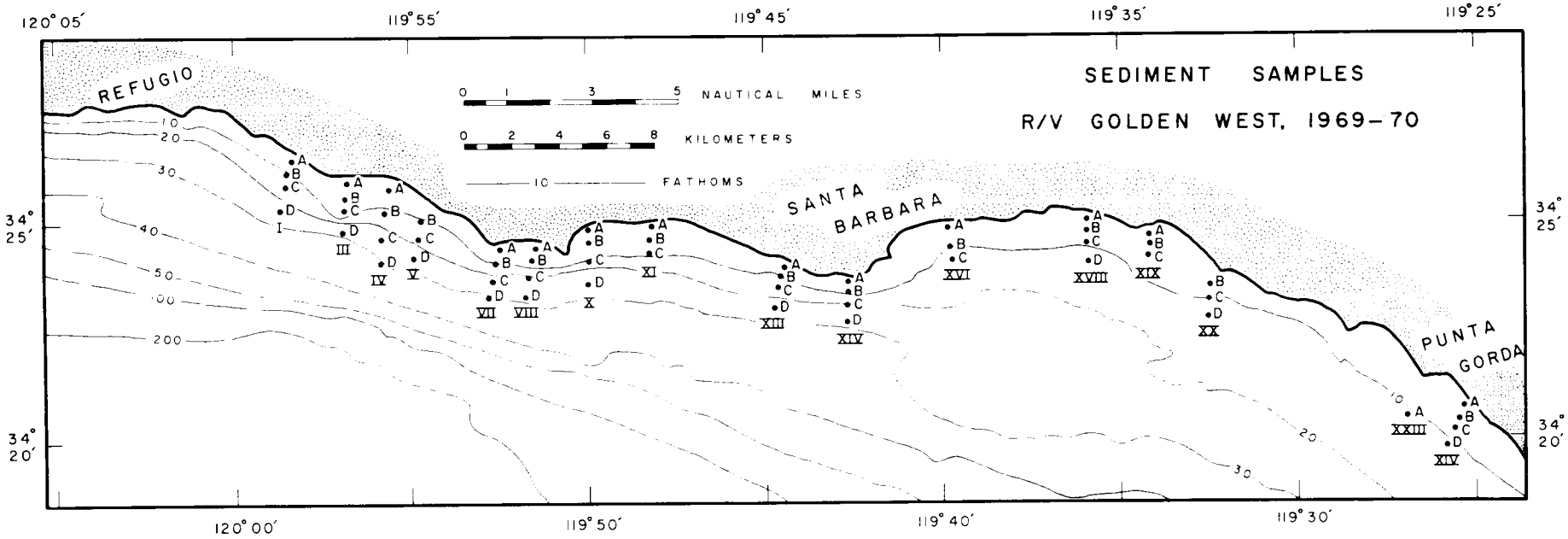
BACKGROUND INFORMATION

Emery (1960) has summarized and reduced the data available prior to 1960 for all of the southern California nearshore. He notes data from a maximum of 50 bottom samples between longitude 119° 30' West and 119° 55' West, which, in the area described in this report, is between traverse lines V and XX of figure 1. Gross sediment texture, carbonate content, color, organic content and dominant sand fraction components are reported by Emery in several small charts.

The Allan Hancock Foundation Staff reviewed and tabulated sediment data for the entire southern California Continental Shelf using analyses of samples collected over a five-year period from 1957-1962. Parts of these data were also used by Wimberley (1963) in his study of the distribution of sediments from the main coastal river sources along the Santa Barbara coast. Gatto (1970) collected grab and box core samples from the shelf off Gaviota as part of an investigation of two small submarine canyons. Numerous samples have been collected by various petroleum companies in the course of field work for well location, lease development and selection. Unfortunately, most of this information was not available during the period of this study, although much has been released in recent weeks as a result of reevaluation of offshore opportunities and shifting of regional offices.

Since shelf sediments are, by nature, complex because the zone is one of reworking, transportation and high turbulence, it is often difficult to separate this natural "noise" from short term temporal changes. Artifacts of sampling method are also present and may be larger than the changes that occur. This is certainly true for

Figure 1. Location map showing distribution of samples analyzed for this paper. Contours are in fathoms.


SEDIMENT SAMPLES
R/V GOLDEN WEST, 1969-70
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
10
20
30
40
50
100
200
I
III
IV
V
VII
VIII
X
XI
XIII
XIV
XVI
XVIII
XIX
XX
XXIII
XIV

the southern California shelf areas as has been demonstrated in several investigations (e.g., Terry, Keesling and Uchupi, 1956). As a result, the writers can only select those anomalies that are very large for discussion and identification, recognizing that other subtle changes may well take place in shelf sediments. That they do indeed occur is evidenced by the fact that most shelves are still out of sedimentary equilibrium since the last sealevel change that commenced about 18,000 years Before Present and reached its probable maximum only about three thousand years ago. It is theorized that the equilibrium shelf deposit would exhibit a regular progradation of grain size from coarse to fine offshore and with concommittant increases in carbonate and carbon content reflecting the finer size and slower accumulation rates away from the active transport of the surf zone. That this has not occurred is shown by the complexity of the actual shelf surface. Patches of older cycle sediment still remain and winnowing is producing residual deposits in other locations. Only very near shore and in water depths of less than 10 to 15 fathoms is the contemporary sediment belt well established. This marks the probable usual depth of wave transport and reworking (Vernon, 1966). Fine sediment is carried seaward in suspension, but has not yet accumulated to the point where the older sedimentary surface is covered, although fine sediments do fill much of the void spaces in the older coarse deposits offshore. These deposits are most probably old beach and nearshore belts of sands located along shorelines of lower sea stands occupied during the past few thousands of years and probably none older than about 7,000 to 9,000 years Before Present.

These present coarse bands also follow the pattern of submerged terrace surfaces (see Emery, 1958) that are typically found in the central shelf areas. Field sampling for this investigation was designed to avoid these deeper older surfaces and most of the samples are probably within the zone of contemporary sediment transport and deposition by present coastal processes.

Variation in the textures of these nearshore sediments is a function of the interaction of transporting agents and sediment supply. Dominant agent of transport is probably wave action, at least to depths of 15 fathoms. Coastal currents are probably increasingly important from 15 to 30 fathoms and must begin to influence the suspension transport from just seaward of the surf zone, although wave motion is still important there. Internal waves

likely affect some movement of fine sediment over the inner shelf. Tidal currents, and the slow eddy flow of these resulting from interaction of the tide wave and the irregular shelf outline (Stevenson, Tibby and Gorsline, 1956) must also influence the ultimate path of suspended sediments.

Comparison of the previous studies with the present work is made difficult by the fact that only a few samples of the older cruises were collected in water shallower than 30 fathoms. As has been briefly noted above, the contemporary sedimentation path is probably mainly within that contour. Thus, most of the literature available is only indicative of gross regional trends and probably is much more strongly influenced by relict sediments than the present investigation.

Another factor is the time problem of analysis of large numbers of sediment samples. A compromise has been made between complete sample analysis and available time and so only 16 of a total of 25 traverses are discussed in this report (fig. 1) although all samples have been prepared and curated and are available for future analysis. The selection of samples was designed to provide maximum areal coverage and to examine areas of obvious interest or anomalous field description. In all, a total of 56 samples were studied.

An important factor that must also be considered is that a major flood, with high runoff and sediment contribution, struck the California coastal areas in early 1969. The vast quantities of fine silt and clay were greater than the transport capacity of the nearshore transport agents and consequently much fine material temporarily accumulated on the shelf surface, particularly in the vicinity of the Ventura and Santa Clara Rivers. The effects of this "Flood of the Century" may well have strongly affected the textures of the "normal" shelf sediments.

PHYSIOGRAPHY OF THE INNER SHELF

The inner shelf from Gaviota to Santa Barbara, as defined by the 30 fathom contour line, is 1½ to 2 nautical miles in width and has a relatively smooth surface. From Santa Barbara to Ventura, the width of this strip increases to 5 nautical miles and two relief features indent the shelf. The first of these is a shallow trough running

parallel to the coast from the Punta Las Pitas area west alongshore to Santa Barbara after which it curves down into the Santa Barbara Basin. This trough is formed by an anticlinal structural trend that passes out of the Ventura Basin and into the Santa Barbara Basin. Wimberley has called this rise the Carpinteria Shelf Rise and the name Montalvo Ridge has been used in several papers in this report. It is apparently an actively forming structure that is related to the general east-west trend of the major features of the Santa Barbara Channel and the Northern Channel Islands. The trough shoreward of this rise channels fine sediment to the Basin floor (see paper by Drake and others). The rise causes the relatively abrupt widening of the inner shelf. The second major relief feature is a broad swale in the shelf between Carpinteria and Punta Las Pitas. This feature is bounded by the Carpinteria Rise on its western side and by a north-south slope on its eastern side. East of this gentle sloping surface the 30 fathom contour moves seaward to a position almost 10 nautical miles offshore. The seaward edge of this wide surface terminates at a steep northwest-southeast slope that is probably fault controlled. Much of the fine Ventura and Santa Clara River sediment is channeled into the broad swale (Wimberley, 1963).

The shelf is then abruptly truncated off Hueneme by the Hueneme Submarine Canyon. The only other submarine canyons are located off Gaviota but do not extend into the 30 fathom belt.

WAVE AND CURRENT PATTERNS

The prevailing waves move into the channel from the west and sweep along the shore driving the longshore surf-generated currents predominantly to the east. Southerly swell is usually limited in development by the Northern Channel Islands which screen off the Santa Barbara shore from open sea to the south. Southerly open ocean swell does reach the coast at the eastern end of the channel (see paper on beach characteristics in this volume). Wave refraction around the various points diminishes the wave energy east of each point.

Currents outside the surf zone are large eddies that are generally to the east from Summerland to Ventura and to the west from Goleta to Gaviota (see the discussions of the oceanography of the Channel in other papers in this volume).

DISCUSSION OF NEARSHORE SEDIMENT CHARACTERISTICS

Gross Texture

Texture has been shown in figures 2-4 in terms of percent clay, silt and sand. This is less precise than the use of the moment measures of the individual size distributions (i.e., mean diameter, standard deviation, skewness, kurtosis), but has the advantage of simplifying the complex shelf pattern so that the major anomalies or trends can be seen (as discussed earlier).

Clay Distribution

Within the 10 fathom contour, clay content is generally less than 5% all along the coast west of Santa Barbara. From that point east, the clay content in this same depth zone increases to a maximum of over 20% off Summerland and then decreases to a high of slightly more than 10% near the Ventura area. Stated in other terms, the 5% clay contour moves inshore almost to the surf line in the eastern sector. This probably is in part the result of the major floods of early 1969. The collection of fine sediments in this region is apparently a normal feature since the paper by Wimberley (1963) and the Hancock staff report (1965) both show that clay content is high in the inner shelf in this same area. Currents also match this concentration since a large eddy is centered just south of the eastern coastal segment and this might well tend to hold turbid water in the area. Another eddy to the west may provide the explanation for the second less pronounced clay maximum located in somewhat deeper water (30 fathoms) off the Goleta coast. Again, turbidity passed along shore in this current system meets a convergence in that general area and might then be deposited.

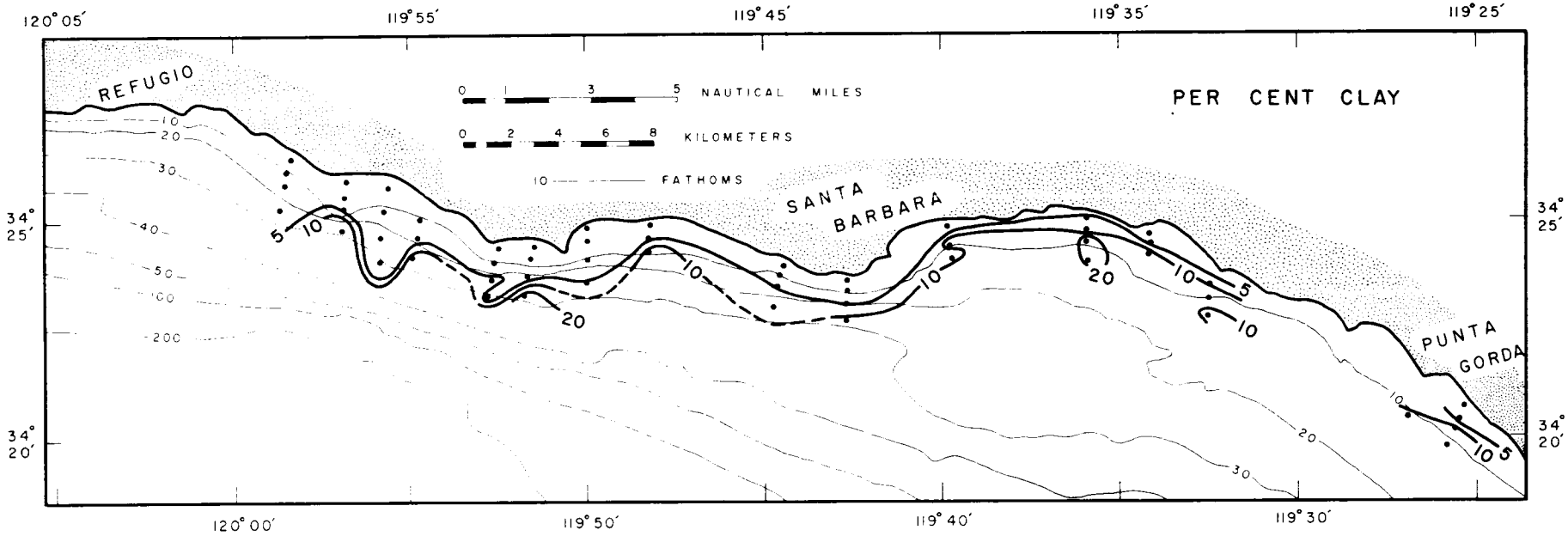
The amount of clay at water depths of more than 20 fathoms in the western sector appears to be increasing rapidly to as much as 20% in the area south of Goleta (see above) although the wave and current action apparently keep it swept out of the shallower, less than 10 fathom depth zone. For this eastern sector, clay content is over 20% in the trough and broad swale of this shelf as indicated by Velero IV samples in deeper water of the outer shelf and is probably deposited there after introduction from the Ventura and Santa Clara Rivers. This is an apparently permanent feature of this shelf as shown by Emery (1960) and Wimberley (1963). Wimberley has called the deposit the

Figures 2-4. Sediment texture in terms of percent clay, silt and sand.

2. percent clay

3. percent silt

4. percent sand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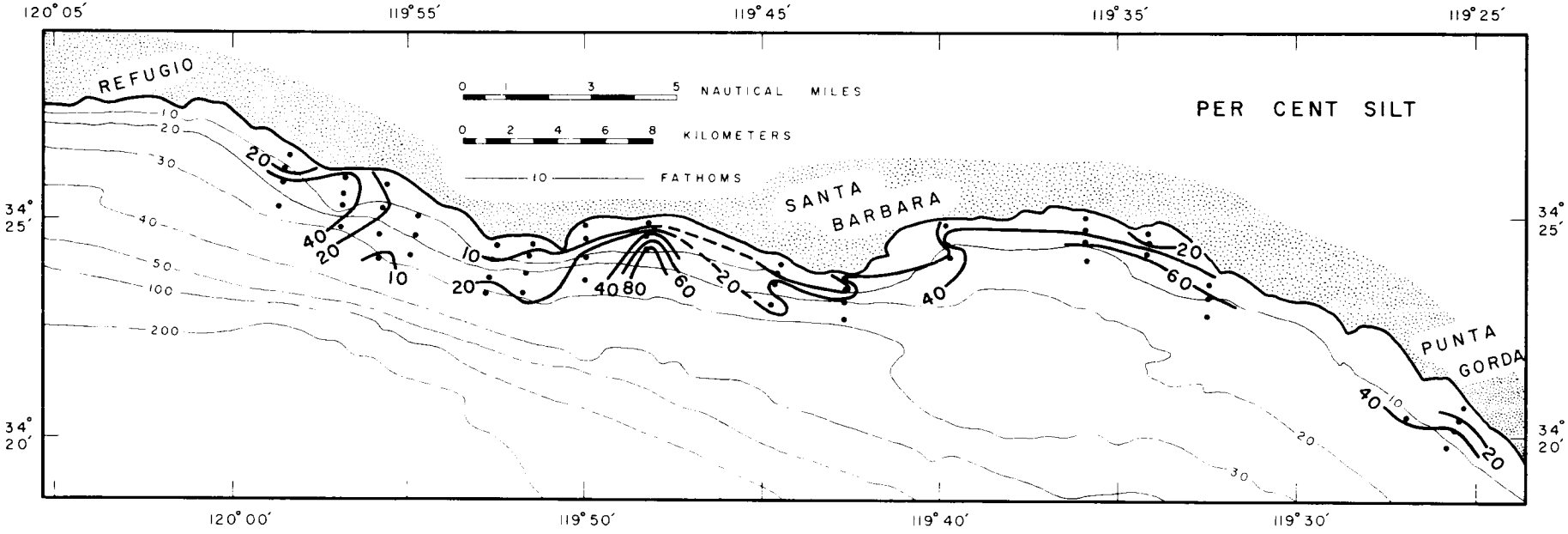
119° 40′
119° 30′
34° 25′
34° 20′
REFUGIO
SANTA BARBARA
PUNTA GORDA
PER CENT CLAY
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
10
20
30
40
50
100
200
5
10
20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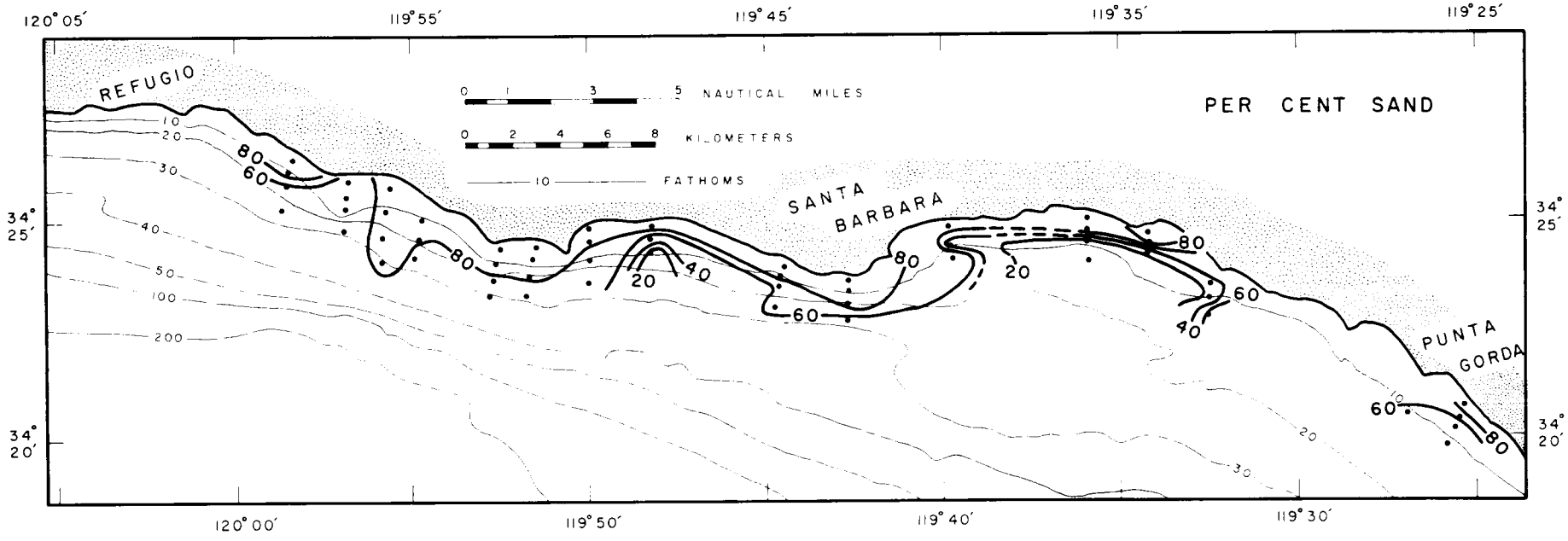
34° 25′
34° 20′
REFUGIO
SANTA BARBARA
PUNTA GORDA
PER CENT SILT
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
10
20
30
40
50
100
200
20
40
20
10
10
20
40
80
60
20
40
20
60
40
10
20
20
30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REFUGIO
SANTA BARBARA
PUNTA GORDA
PER CENT SAND
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
10
20
30
40
50
100
200
80
60
40
20

Las Pitas Mud and regards it as the bottomset deposits of the Santa Clara and Ventura prodeltaic facies. Coarse sediments are typical on the crest of the Carpinteria Rise and is also seen in the Velero IV samples of this investigation. Current and wave winnowing must occur on the higher rise.

Silt Distribution

Figure 3 illustrates the distribution of silt. The general pattern is essentially as shown by clay content. It is evident that silt is a major component of the shelf sediments outside the range of normal wave surge (10 to 15 fathoms). One interesting feature of the silt content of the western sector is that the highest silt content is somewhat east of the high clay content in the outer section of the 30 fathom depth zone near Goleta. If the current cell is weakening as it approaches a convergence at the western end of the shelf, one would expect the silt to deposit first.

In the eastern sector, the silt is high in the inner edge of the trough off Carpinteria matching the clay pattern and also generally following the patterns described by Wimberley.

Sand Distribution

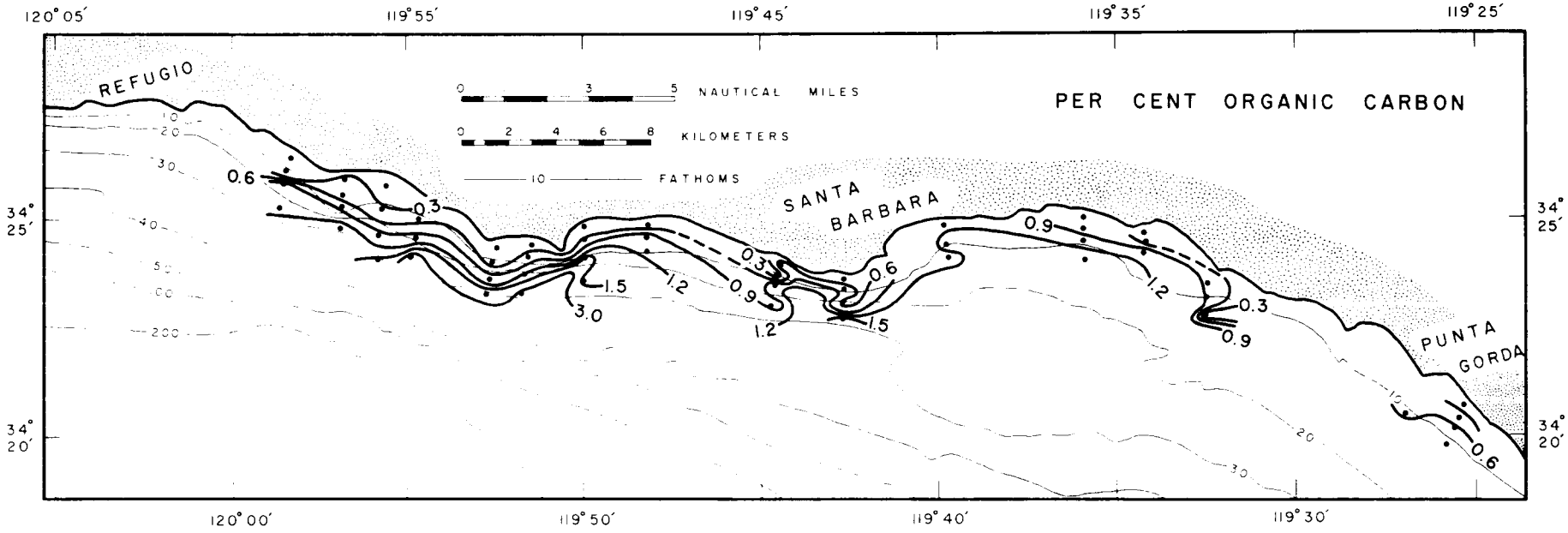
Sand is the inverse of the clay and silt but the main trend is indicative of the same pattern of energy application. Sands are relatively clean in the western sector and then become a much thinner and restricted band in the eastern sector.

Organic Content

As a rule, organic content correlates positively with clay content in sediments. This reflects the similar transport characteristics and also is influenced by the adsorption of organics on clays. Figure 5 shows the organic carbon content of the sediments in the 30 fathom belt. Note that a typical increase offshore is present and reflects the finer sediment trend and also is probably in part a function of decreased rates of sedimentation.

The anomalous condition is that the highest organic content is in areas that are not necessarily the finest sediment. Note that the 3% contour off the Goleta area

Figure 5. Organic carbon content of nearshore sediments (dry weight basis). Organic carbon values are derived from the total carbon content minus the carbonate carbon content.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119° 40′
119° 30′
34° 25′
34° 20′
PER CENT ORGANIC CARBON
0 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
0.6
0.3
1.5
3.0
1.2
0.9
0.3
0.6
1.5
1.2
0.9
1.2
0.3
0.9
0.6
10
20
30
40
50
100
200

spans both the highest clay sample and a relatively clean silty sand (see figs. 2 and 3). Similarly, a higher content off Santa Barbara is located in a silty sample in which clay is not markedly high. In the area of finest sediment off Carpinteria, the organic content is relatively high inshore (0.9% versus 0.3% off Goleta at the same position) but that the offshore content is about the same as that in the silty sands along the 10-20 fathom belt in the western sector.

Two factors are important here. One is that the central fine lobe off Carpinteria is an area of relatively rapid sedimentation as well as of fine sediment and hence the organics are probably somewhat diluted as compared to the areas of slower sedimentation to the west which are more distant from the major river sources. In addition, coarse fraction analysis (sand fraction) shows the presence of tar bits in the sediments off Coal Oil Point and along the Santa Barbara Point shore. These are less common in the high sedimentation rate zones of the Las Pitas Mud. The interesting fact that most coarse fractions contained tar bits would suggest that this is the major source of the organic carbon content in these inner shelf sediments. It is also possible that the fine suspended fraction adsorbs hydrocarbons and carries them into the deposition sites. The question of source is difficult to define except to note that the highest content is in and adjacent to the oil seep areas of the Goleta coast.

Organic contents noted in Emery's (1960) review of the Santa Barbara shelf sediments show a grossly similar trend although the values and pattern are different in detail. This is probably in part a function of method and sample density. Content is appreciably higher if averages for the shelf are compared. The average of Emery's samples is roughly similar in the less than 10 fathom depth zone, but is about half the content shown by this study for the 20-30 fathom depth zone. This may be a reflection of the flood effect on the present sample set plus some addition of hydrocarbon from adsorption on clays of the suspensate.

Hancock Foundation staff (1965) and Wimberley (1963) show organic content in terms of nitrogen which would not reflect the hydrocarbon content and is probably more definitive of the planktonic contribution. In that regard, it is interesting that their nitrogen based values are generally less than half of the content indicated for the

30 fathom belt in this study. Unfortunately, carbon values are not reported to make possible a more exhaustive interpretation.

Carbonate Content

Wimberley's study and the Hancock Foundation data for the entire shelf out to the 100 fathom contour include approximately 200 samples in the region from Pt. Conception to Ventura. The average carbonate content in this zone is 2.7%. That percentage is actually for the sediments beyond much of the area reviewed in this report and is therefore difficult to compare. The much lower percentages in this report (fig. 6) may also be a product of dilution by flood sediment. A method artifact is also possibly present since the older data used a less precise procedure and may simply be indicating that contents are low.

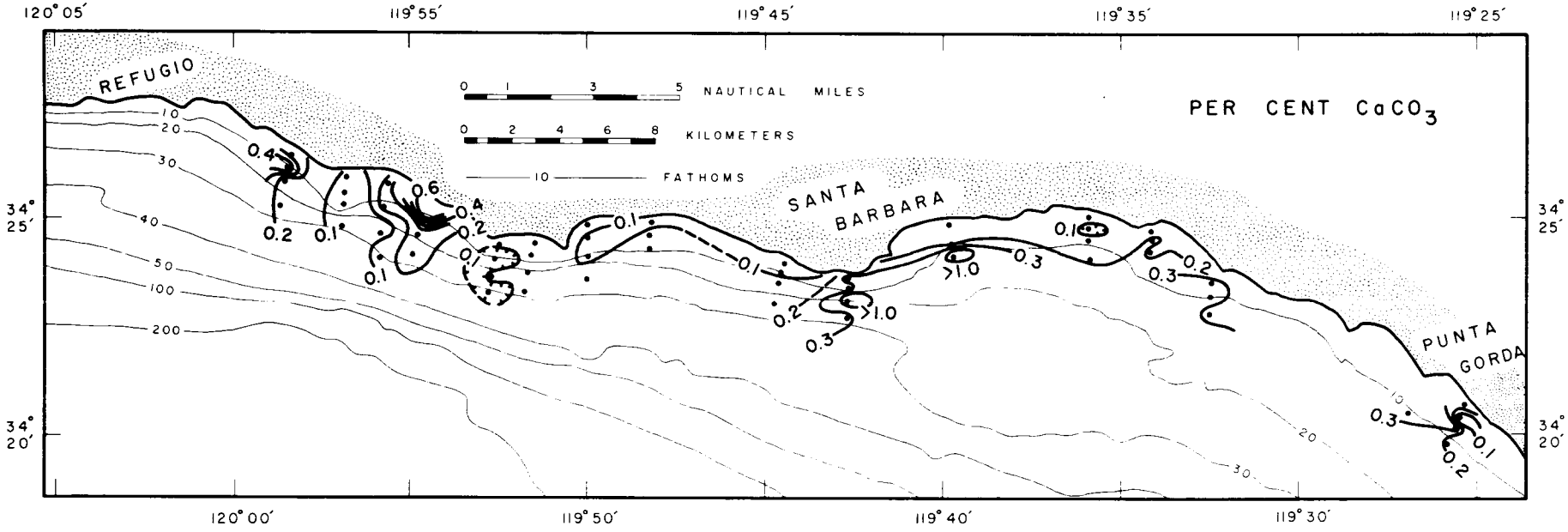
Carbonate in the shelf sediments occurs as shell fragments and as foraminiferal tests. The finer sediments generally contain the foraminiferal tests while the coarser sediments contain larger shell fragments. This is a product of the settling characteristics of the two components. Tests probably are hydrodynamically equivalent to silts.

High carbonate is also sometimes indicative of low sedimentation rates. This may well explain the high values west of Goleta in figure 6 (0.6%). High values off Santa Barbara Point probably indicate a site of active wave winnowing and low accumulation. The values greater than 0.3% in the Carpinteria area are probably foraminiferal tests in the silts and muds of the fine grained sediment lobes. Currents in the region would tend to move planktonic tests into the Santa Barbara Point zone and then to the east where deposition progressively occurs adding fine carbonate to the silts.

SUMMARY

The principal question is: what differences exist between the samples collected in this study and those of earlier investigation. As has been noted, this is not easy to answer because much of the variability is a function of sampling density, analytical methods and component measured. For example, a close look at the sample locations described by Emery (1960), Wimberley (1963) and in the Hancock Foundation reports (1965) shows that the patchy

Figure 6. Carbonate content of nearshore samples (calculated as percent $CaCO_3$ on dry weight basis).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119° 25′
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34° 20′
120° 00′
119° 50′
119° 40′
119° 30′
REFUGIO
SANTA BARBARA
PUNTA GORDA
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
PER CENT CaCO3
10
20
30
40
50
100
200
0.4
0.2
0.1
0.6
0.4
0.2
0.1
0.1
0.1
0.2
0.3
>1.0
>1.0
0.3
0.1
0.3
0.2
0.3
0.1
0.2

distribution influences the detail shown in the contours of data. Thus, one must attempt to seek broad regional patterns. If this is done, then the various studies all show essentially similar trends. All show more sand in the western sector and more silt in the eastern sector. All show low carbonate contents. High values (greater than 5%) occur on topographic highs and in areas where detrital sedimentation is low or bypassed. Organic contents definitely show the influence of the seeps in the Coal Oil Point area and the sand fraction in all samples contains tar bits and plant debris.

General sediment trends also support the tentative conclusion that the fine load is from the Ventura and Santa Clara Rivers and that the sand fraction is probably locally derived and is moved primarily by an eastward moving longshore drift. Silts and clays are moved primarily by the shelf current systems and this in places opposes the pattern of the sand drift. The influence of the two current eddies offshore appears to explain the distribution of fine sediment. Topography plays a part in that the two relief features of the eastern shelf, the Carpinteria Trough and the broad swale off Las Pitas, obviously act as channels and depositional sites for the suspended silts from the main rivers.

Sedimentation rates probably are high in the eastern sector and low in the western sector.

Carbonate is probably influenced mainly by the currents since the major portion of this content is in the fine grain sizes and is in the form of foraminiferal tests. Thus, somewhat higher concentrations occur in the eastern area.

An important factor in the patterns of fine sediment, organic content and apparent sedimentation rates is the major flood of early 1969. It is already evident that fines are being reworked from the shelf as described by Drake, Fleischer and Kolpack in this volume. It may be that a resampling of these shelf stations in 1971 would show an even closer correlation with the older sedimentological patterns.

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CHAPTER 9

FORAMINIFERAL POPULATIONS IN THE SANTA BARBARA REGION: NEARSHORE SPECIES

by

Ronald W. Morin
Department of Geological Sciences
University of Southern California
Los Angeles, California 90007

INTRODUCTION

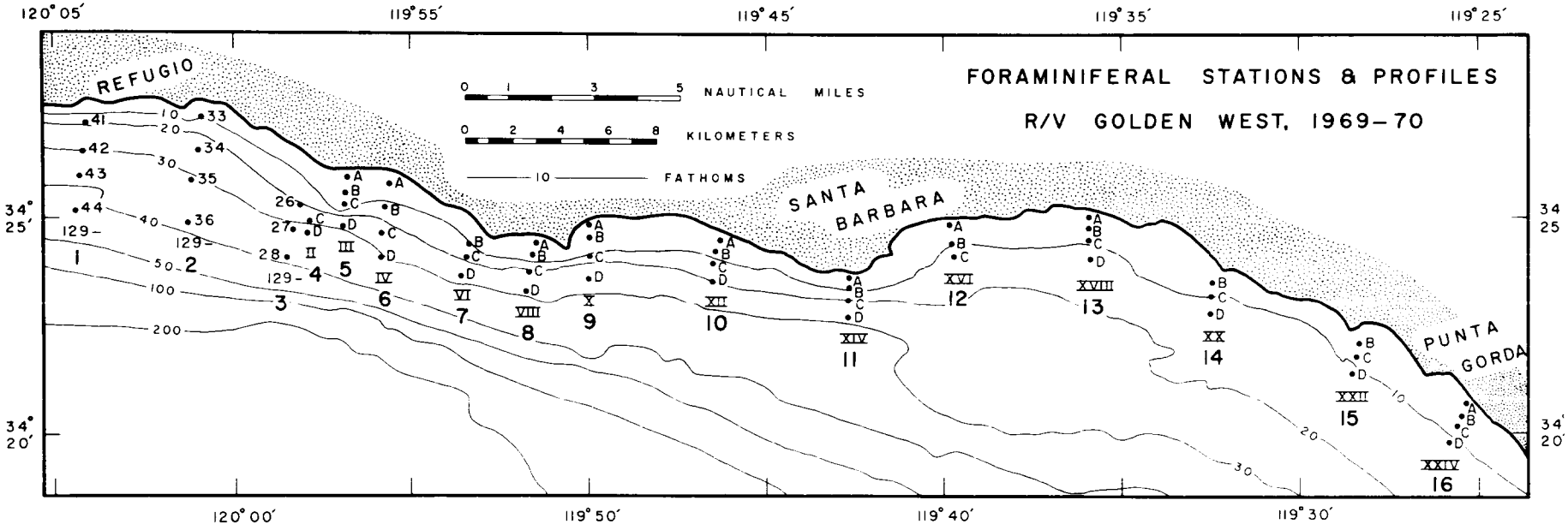
The mainland shelf of the Santa Barbara Channel region was sampled between Refugio State Beach and Punta Gorda (fig. 1), a linear distance of 54 km. Using the 100 m depth contour to approximate the shelf's edge, the mainland shelf is shown to be relatively wide and to have a low gradient southeast of Santa Barbara whereas it is narrower and steeper to the northwest. Traverse numbers 4 to 16 were made on the inner shelf from 6 to 37 m, during August, 1969. Samples collected in December, 1969, were obtained from traverse numbers 1 to 3 which covered both the inner and outer shelf from 18 to 82 m.

METHODS

The 81 samples used in this study were taken by the Department of Geological Sciences personnel aboard the marine research vessel Golden West. The upper 2.5 cm of sediment from an orange-peel grab was collected for microfaunal analysis. Rose Bengal, dissolved in fresh water, was added to identify the presence of protoplasm in the living foraminiferal species (Walton, 1952).

Samples were immediately dried and weighed after being brought to the laboratory. Subsequently, the samples

Figure 1. Nearshore samples analyzed for foraminiferal populations. Solid circles represent sample locations. Sample numbers are shown next to each solid circle with sample number prefix listed at the outer end of each profile. The supplementary profile index (1-16) is used in the text as a convenience to the reader. Platform A is located southeast of Santa Barbara near the bottom border of the chart.


FORAMINIFERAL STATIONS & PROFILES
R/V GOLDEN WEST, 1969-70
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
10
20
30
40
50
100
200
129-
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
II
III
IV
VI
VIII
X
XII
XIV
XVI
XVIII
XX
XXII
XXIV

were washed on a 250 mesh Tyler screen (62 micron openings)[321] to remove excess Rose Bengal and fine sediment. Foraminiferal tests were concentrated by flotation in carbon tetrachloride. Counts of an average of about 300 tests per sample were made to determine the relative abundance of foraminiferal species. Abundant specimens in most of the samples analyzed necessitated the use of a modified Otto microsplitter to obtain the desired number of individuals.

ACKNOWLEDGMENTS

The author is indebted to Drs. O.L. Bandy and R.L. Kolpack for critical reading of the manuscript. Dr. Kolpack also supervised the collection of samples and provided sedimentological and oceanographic data. Many helpful suggestions were offered during the course of this study by Dr. Bandy who also verified the identification of the foraminiferal species. Many thanks are due members of the Department of Geological Sciences who offered assistance during this study.

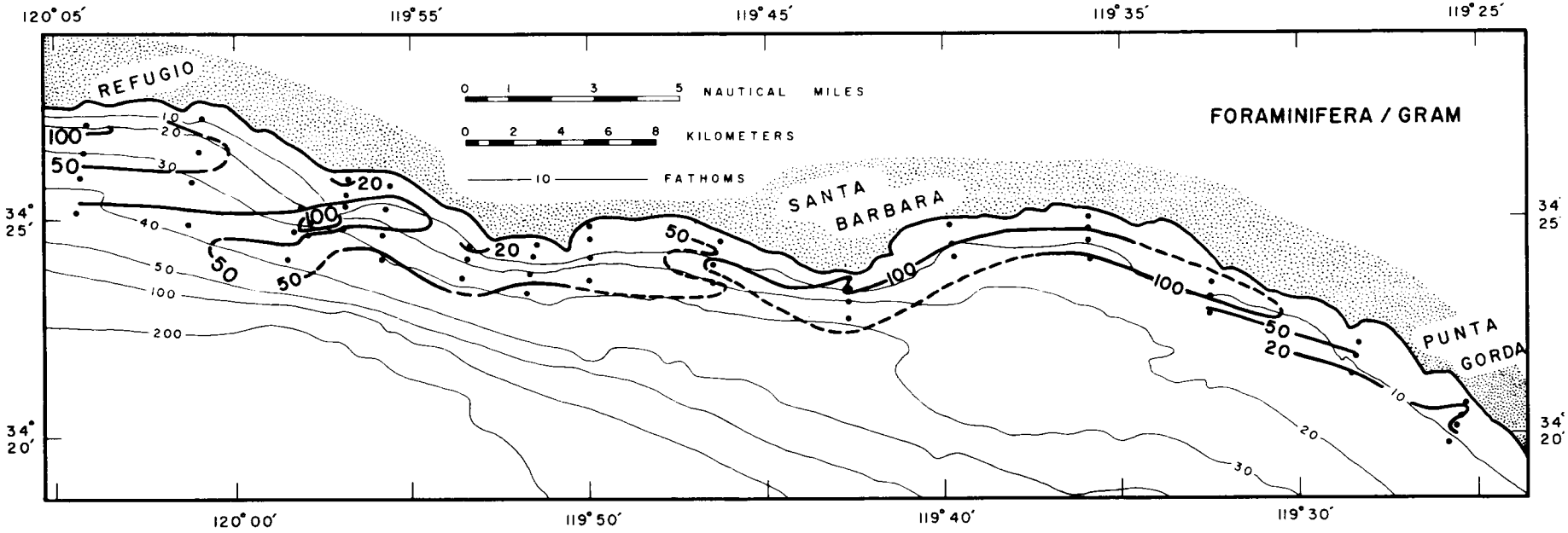
FAUNAL TRENDS

General

Foraminiferal abundance in marine sediments generally increases offshore (Bandy and Arnal, 1960). The abundance of foraminiferans may be expressed as the number of specimens/gram of dry sediment, the foraminiferal number. In southern California waters, foraminiferal numbers of less than 100 were found by Bandy, Ingle, and Resig (1964a, b, c, 1965a, b) to characterize the mainland shelf except for aureoles of relatively high values around sewer outfalls. The nearshore environment between Refugio State Beach and Punta Gorda, similarly, has foraminiferal numbers below 100 with 3 exceptions (fig. 2). Two isolated highs occur in the northwestern portion of the area studied. Numerous highs form a belt extending from traverse 10 to 14. This area of foraminiferal numbers greater than 100 may have been caused by the presence of oil from the blowout, by effluent from the sewer outfall just east of the entrance to Santa Barbara harbor, or by some other environmental factor.

Benthonic species are the dominant constituents of the foraminiferal population as is shown by parallel trends

Figure 2. Foraminifera/gram (foraminiferal number).


FORAMINIFERA / GRAM
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
100
50
20
10
30
40
200

between the number of benthonic specimens/gram (fig. 3) and the foraminiferal number. Divergences from this parallelism are the result of relatively high numbers of planktonic foraminiferal species/gram of sediment, the planktonic number (fig. 4). The planktonic number generally is less than 10 on the mainland shelf and ranges from 40 to 100 immediately beyond the shelf edge in southern California (Bandy, Ingle, and Resig, 1964a, b, c, 1965a, b). In the Santa Barbara Channel area, values greater than 10 were observed in traverses 3, 4, 11, 12, 14, and 15. These highs are caused principally by admixtures of fossil planktonic specimens.

The large benthonic foraminiferal populations between traverses 10 and 14 may have resulted from either relatively high productivity rates or relatively low sedimentation rates. Walton (1955), Phleger (1960), and others noted that lower depositional rates generally coincide with lower ratios of living to dead benthonic foraminiferans although Bandy, Ingle, and Resig (1965) found the reverse in a few areas. Where the benthonic populations are the largest in the area of this study, relatively high live/dead ratios are common (fig. 5). This relationship suggests relatively high rates of sedimentation, or sediment transport, which would reduce the size of the total population. Consequently, a higher rate of productivity is the most probable reason for the large benthonic populations.

The importance of productivity is further illustrated by the striking similarity between the abundance of benthonic foraminiferans and the number of living benthonic specimens/gram of dry sediment (fig. 6). The only exception, as was the case for the live/dead ratios, was found in 3 samples of traverse number 11 which have typical shelf values of less than 10 tests per gram. Low sedimentation rates, indicated by the live/dead ratio, and admixtures of fossil assemblages explain the relatively low number of living specimens in this area characterized by high foraminiferal numbers. The occurrence of a large number of living specimens, excluding traverse number 11, coinciding with a large benthonic population is analagous to previously reported values from the nearshore sewer outfall environment (Bandy, Ingle, and Resig, 1964a, 1965b). It appears then, that the presence of either oil from the ruptured well or effluent from the sewer outfall may explain high rates of productivity indicated by samples from the nearshore environment during August and December, 1969.

Figures 3-6.

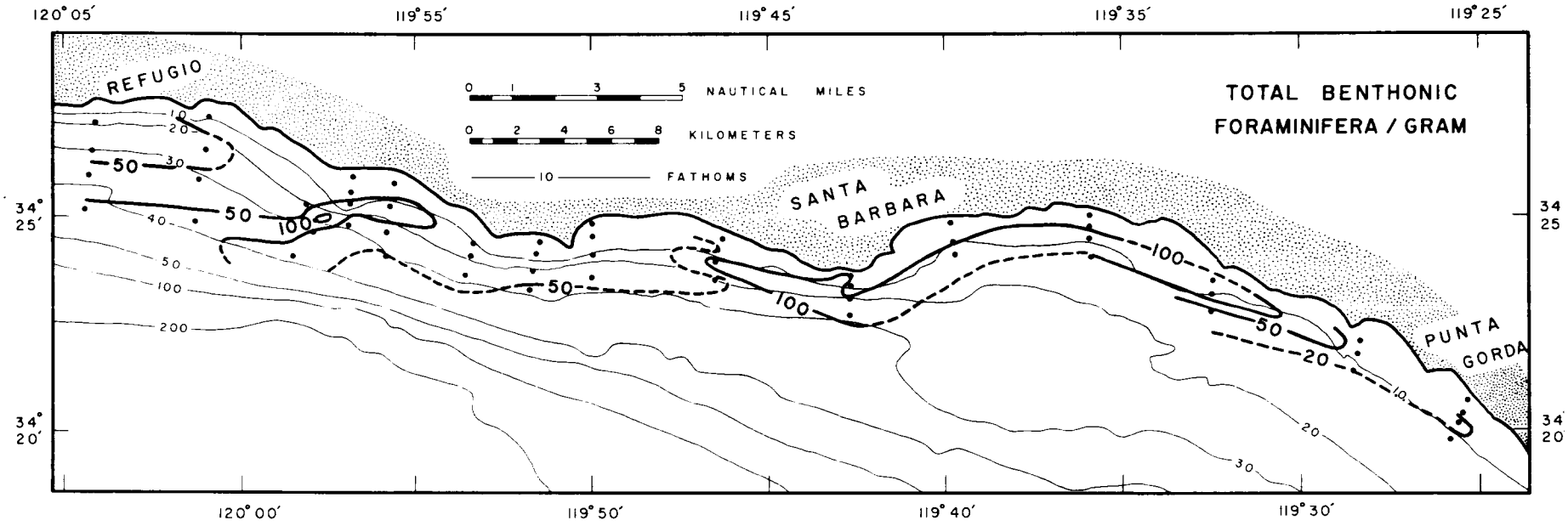
3. Total benthonic foraminifera/gram

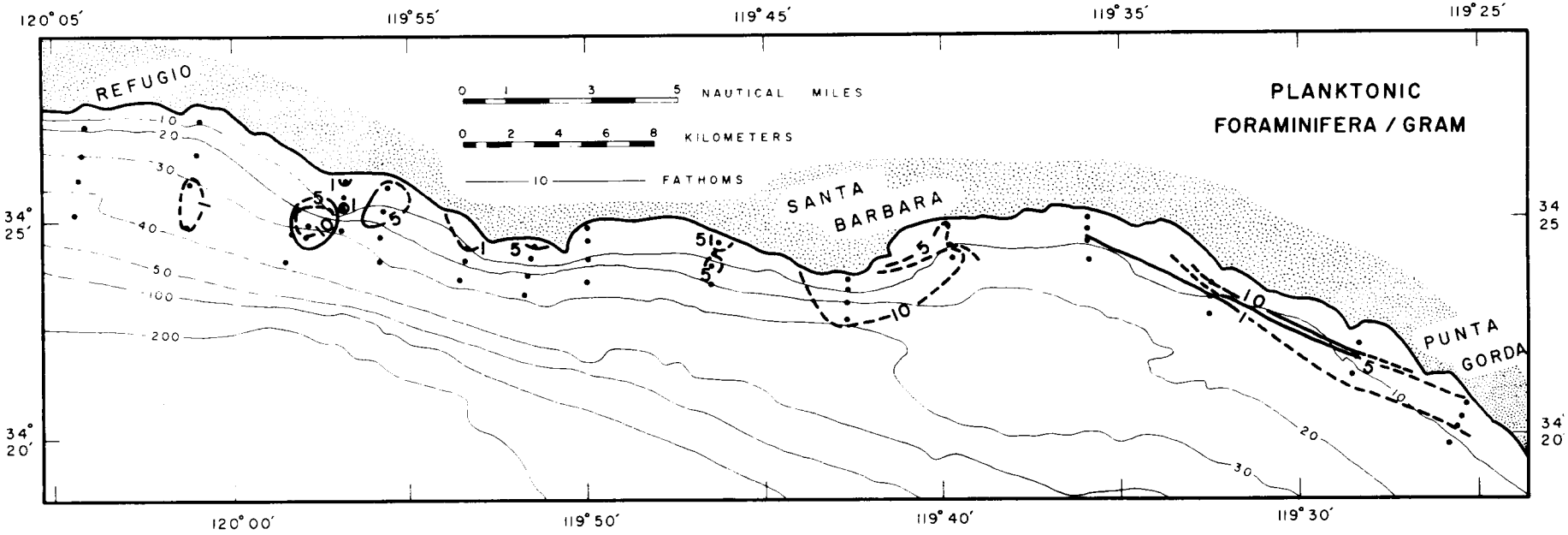
4. Planktonic foraminifera/gram

5. Live-dead ratio

6. Live benthonic foraminifera/gram

Dashed contours were used as an interpretative aid whenever the sample control did not adequately allow for elimination of an alternate interpretation.


TOTAL BENTHONIC
FORAMINIFERA / GRAM
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
10
20
30
40
50
100
200


PLANKTONIC
FORAMINIFERA / GRAM
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
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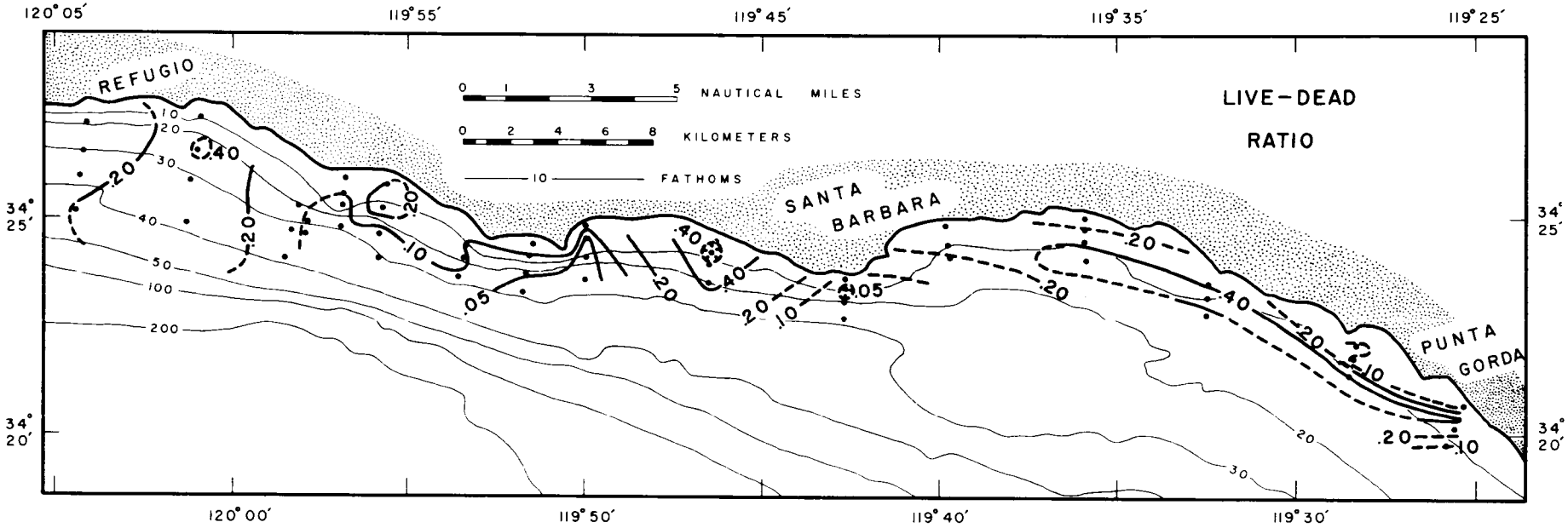
30
40
50
100
200


LIVE-DEAD
RATIO
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA
BARBARA
PUNTA
GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
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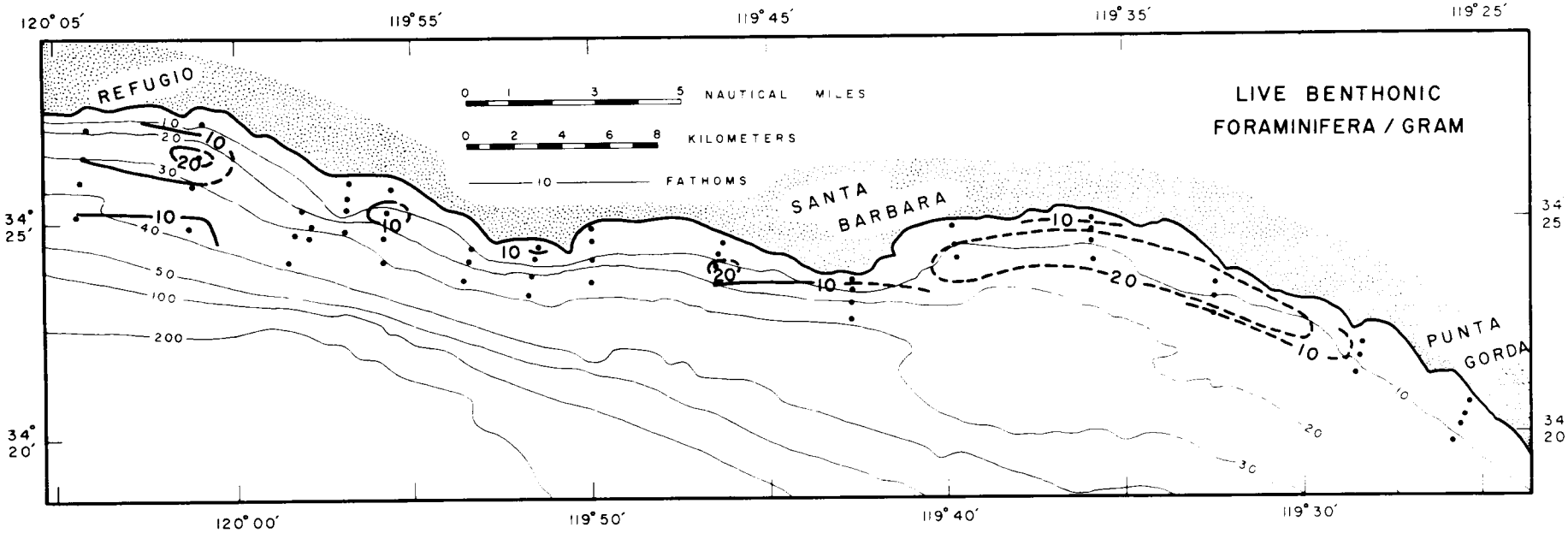
.10
.20
.40


LIVE BENTHONIC
FORAMINIFERA / GRAM
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
34 25
34 20
10
20
30
40
50
100
200

Specific Trends

Examination of selected benthonic foraminiferal species known to be affected by effluent from sewer outfalls may indicate what caused the increased productivity.

On the Santa Barbara Channel mainland shelf, Buliminella elegantissima d'Orbigny has a distributional pattern (fig. 7) characteristic of "normal" portions of the southern California Shelf (Bandy, Ingle, Resig, 1964c, 1965 a, b). Buliminella elegantissima dominates the inner shelf fauna and becomes less important on the middle shelf. Areas of relatively large numbers of this species extend out onto the shelf in traverse number 1 and between traverse numbers 7 and 8. The large number of specimens in traverse number 10 coincides with the largest number of Buliminella elegantissima within the area of relatively large benthonic populations. Even this maximum number is not similar in magnitude to values reported from the vicinity of sewer outfalls (Bandy, Ingle, and Resig, 1965a, b). The percentage of Buliminella elegantissima in the living population (figs.7-8) parallels the trend in the total population except for traverse 1 where relatively low values occur.

The combined percentages of Eggerella advena (Cushman) and Trochammina pacifica Cushman in the total benthonic population (figs. 9-10) are also similar, with several exceptions, to that of areas unaffected by sewer outfalls (Bandy, Ingle, and Resig, 1965a, b). Two samples from the belt of large benthonic populations have more than 20% of these two species as do single samples in traverse numbers 2 and 16. A belt of high values for these two species extends from traverse 3 to 9. In living populations, relatively high percentages of Eggerella advena and Trochammina pacifica also occur within this strip (figs. 9-10) where Yerkes, Wagner, and Yenne (1969) have reported the presence of oil seeps. If the oil seeps were responsible for the relatively high percentage of these two species, it would seem that the remainder of the nearshore area was little affected by pollution from oil or from sewer outfall effluent.

In contrast to Buliminella elegantissima, Eggerella advena, and Trochammina pacifica which show a much increased abundance in the vicinity of sewer outfalls, Florilus scaphus basispinatus (Cushman and Moyer) and Nonionella miocenica stella Cushman and Moyer appear to be relatively intolerant of oceanic pollution by sewer outfalls (Bandy, Ingle, and

Figures 7-10.

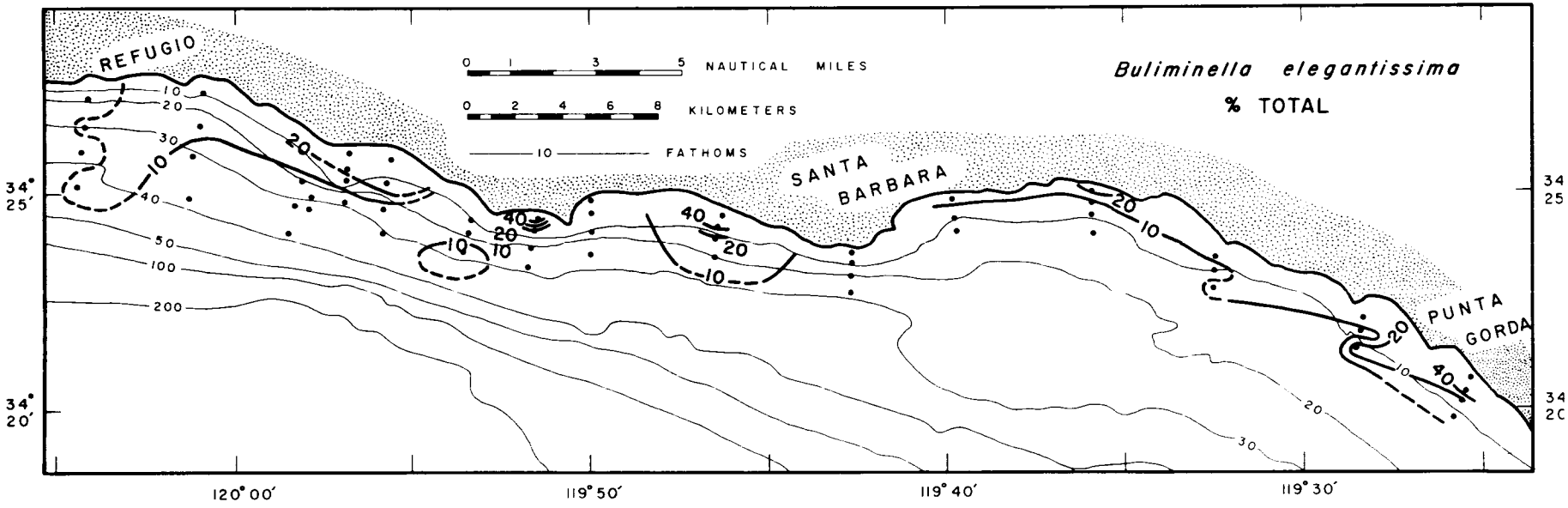
7. *Buliminella elegantissima* % of total population.

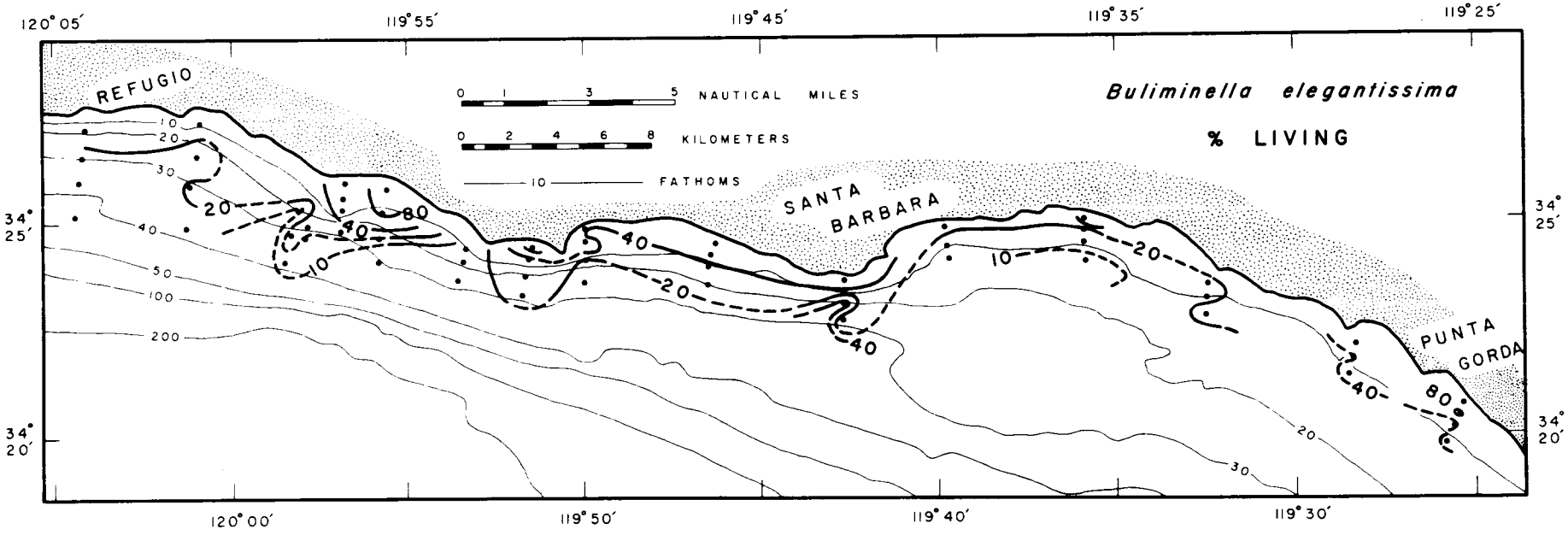
8. *Buliminella elegantissima* % of living population.

9. *Eggerella advena* and *Trochammina pacifica* (combined) % of total population.

10. *Eggerella advena* and *Trochammina pacifica* (combined) % of living population.

Sample control is shown by solid circles.


Buliminella elegantissima
% TOTAL
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
34° 25′
34° 20′
120° 00′
119° 50′
119° 40′
119° 30′


Buliminella elegantissima
% LIVING
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
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34° 20′
10
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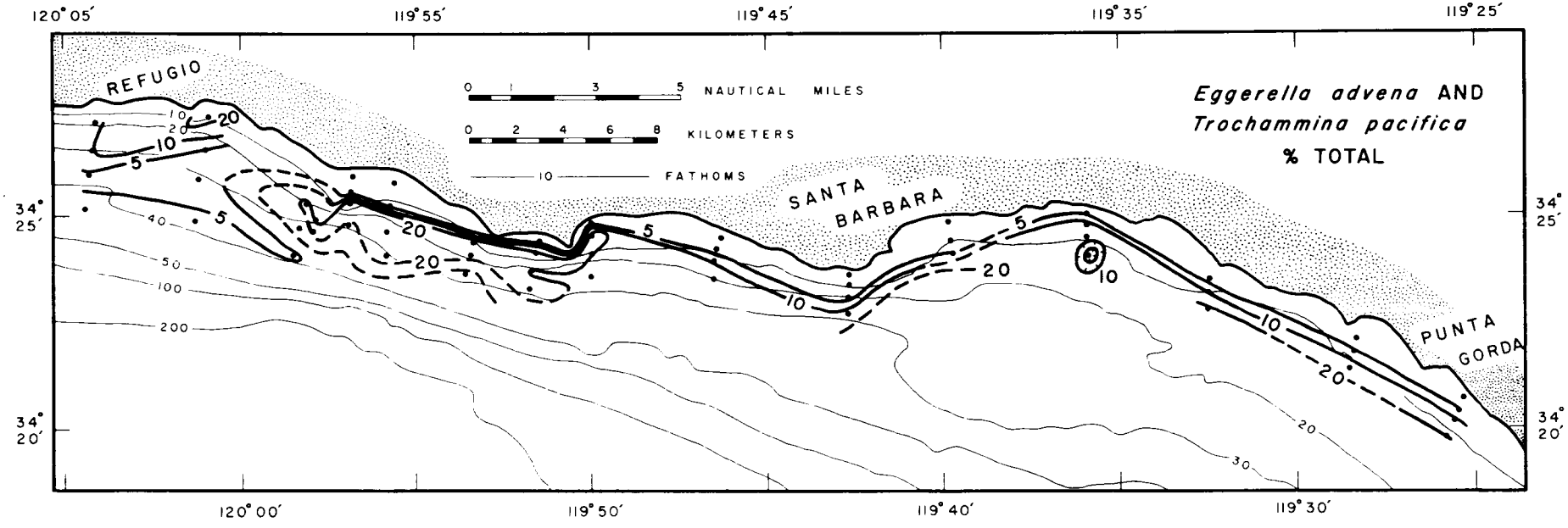
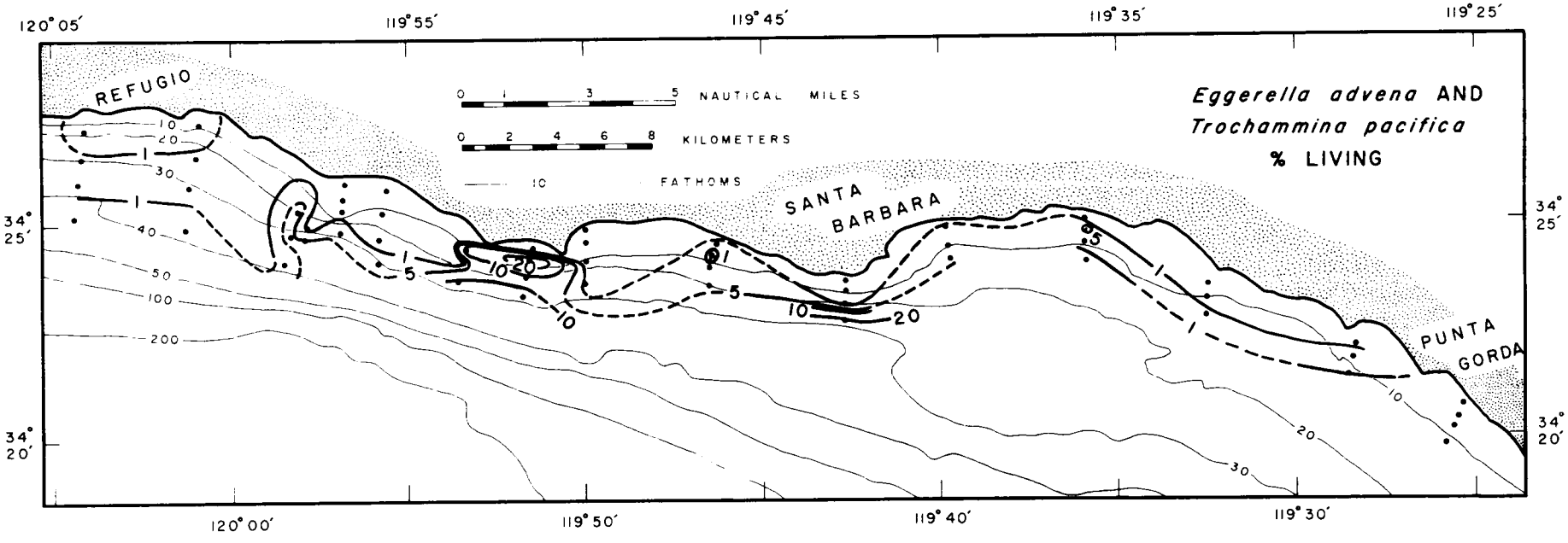
50
100
200
80


Eggerella advena AND
Trochammina pacifica
% TOTAL
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
10
20
5
40
50
100
200
30


Eggerella advena AND
Trochammina pacifica
% LIVING
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
10
20
30
40
50
100
200
1
5
10
20

Resig, 1964a, b, 1965a, b). The abundance of these members of the Nonionidae and the less common Florilus grateloupi (d'Orbigny) and Nonionella japonica mexicana Cushman and McCulloch were combined for this study (figs 11-12). Both the percentage of Nonionidae in the living and the total benthonic foraminiferal population show typical offshore increases over the entire area studied, a dominance of the middle shelf fauna, and the normal decrease near the outer shelf. The dominance of this family within the belt of relatively large benthonic foraminiferal populations indicates that the Santa Barbara sewer outfall has not caused increased productivity in this area.

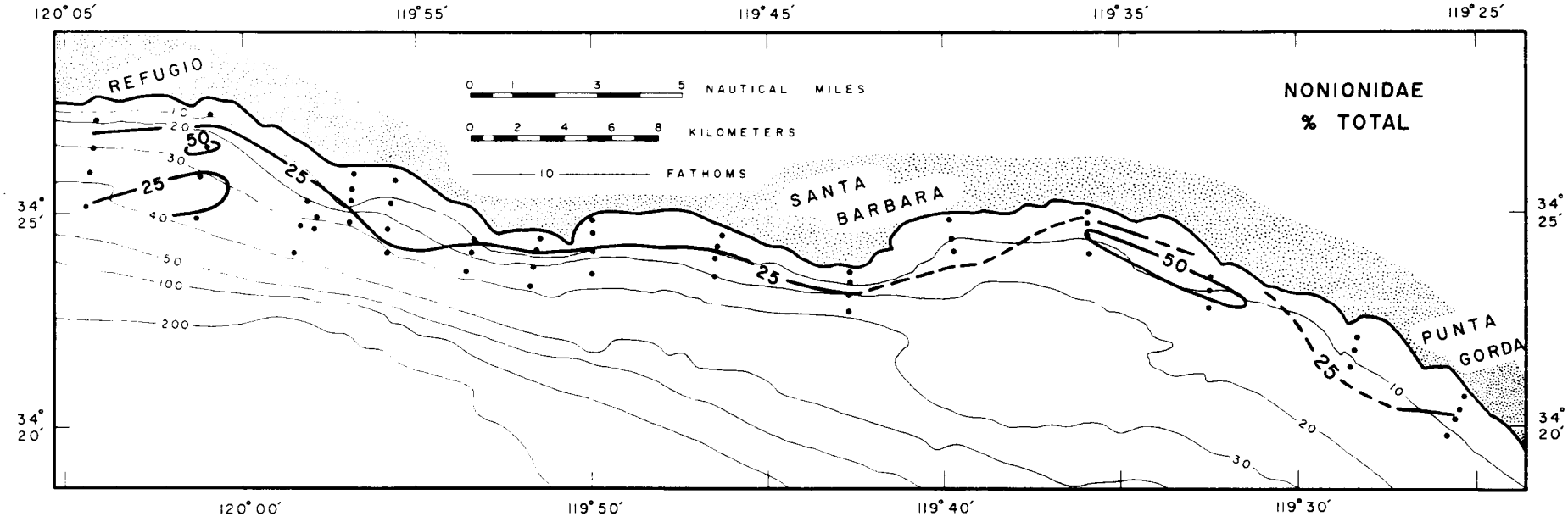
SUMMARY

The size of benthonic foraminiferal populations was either "normal" or relatively large, as compared to other southern California areas, after oil from an offshore oil well entered the nearshore marine environment in the vicinity of Santa Barbara, California. High live/dead benthonic foraminiferal ratios, within the area of relatively large populations, suggest that higher rates of productivity caused the large populations. This conclusion is supported by the parallel between high numbers of benthonic foraminiferans and high numbers of living specimens per gram of dry sediment. Planktonic foraminiferal populations in bottom samples were characteristic of "normal" portions of the southern California mainland shelf.

Distributional patterns of Buliminella elegantissima d'Orbigny, Eggerella advena (Cushman), four members of the Nonionidae, and Trochammina pacifica Cushman were generally typical of "normal" portions of the southern California mainland shelf. Thus, effluent from the Santa Barbara sewer outfall probably was not responsible for increased productivity in the Santa Barbara area.

It appears, then, that the presence of oil or some other environmental factor may have caused the high rates of productivity in this nearshore marine environment.

Figures 11-12. Nonionidae % of total population and % of living population.


NONIONIDAE
% TOTAL
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
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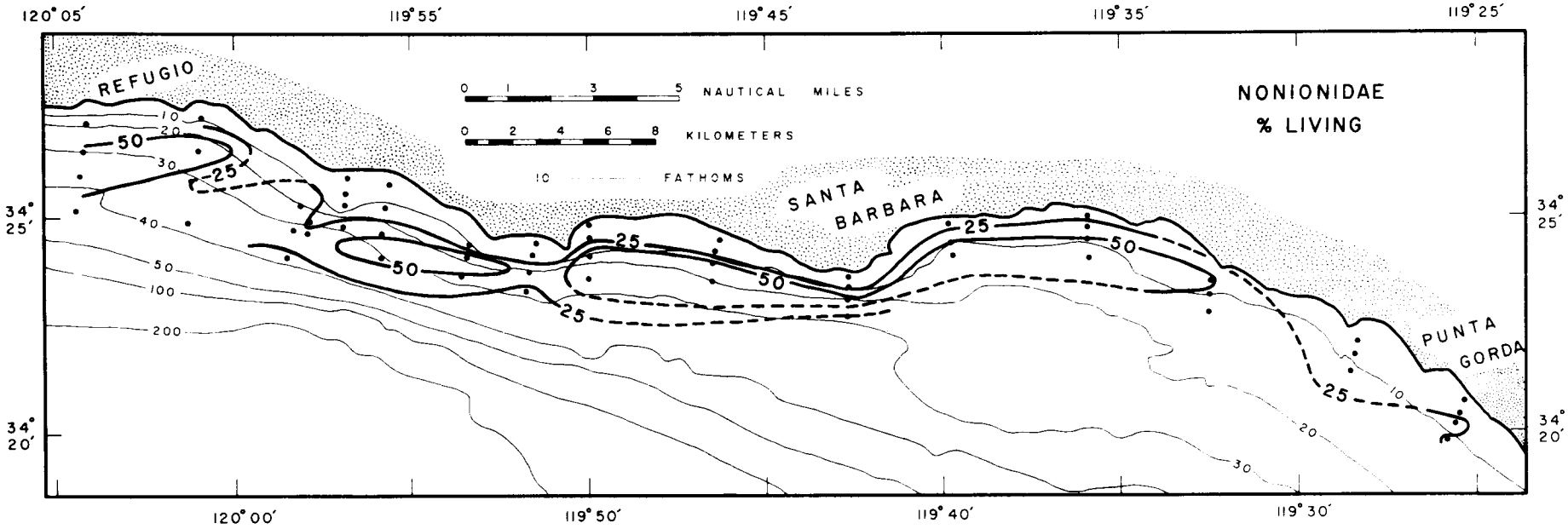
50
100
200
25
50


NONIONIDAE
% LIVING
0 1 3 5 NAUTICAL MILES
0 2 4 6 8 KILOMETERS
10 FATHOMS
REFUGIO
SANTA BARBARA
PUNTA GORDA
120° 05′
119° 55′
119° 45′
119° 35′
119° 25′
120° 00′
119° 50′
119° 40′
119° 30′
34° 25′
34° 20′
10
20
30
40
50
100
200
25
50

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_____, 1964c, Facies trends, San Pedro Bay, California: Geol. Soc. Am. Bull., V. 75, pp. 403-424.

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Yerkes, R.F., Wagner, H.C., and Yenne, K.A., 1969, Petroleum development in the region of the Santa Barbara Channel: U.S. Geol. Surv., Prof. Paper 679-B, pp. 13-27.

CHAPTER 10

SUMMARY

The largest recorded flood in southern California occurred during January and February, 1969 and the abnormally large quantities of detrital material contributed to the beach and channel areas facilitated tracing the depositional history of sediments in this area.

The primary source areas for the flood material were the Santa Ynez, Ventura and Santa Clara Rivers. Initial deposition of much of the coarse-grained sediments occurred near the river mouths but the sediments were subsequently redistributed during the following year. Oil from the well blowout was deposited on some beaches during the period when foreshore areas were cut back as a result of the normal seasonal transgressive-regressive cycle of beach sand movement. However, most of the oil deposited on beaches south of the Ventura River was removed within a period of months because sand was being transported away from the areas of initial deposition. A portion of the oil deposited on beaches north of the Ventura River was buried and remained buried until approximately November, 1969. Only isolated remnants of the buried oil remained at the end of February, 1970. It is apparent that oil deposited on the beaches did not significantly alter the normal movement of beach sand.

Tar which was removed from the foreshore area of some beaches, as a result of seasonal cutting, accumulated in troughs inshore of the breaker line. The tar globules were physically broken down to small fragments within a period of, at most, several weeks as a result of intense abrasion from the breaking waves. This material was probably then transported offshore.

The ten sandy beaches studied can be classified in order of average energy conditions. The order, from high to low energy is: Jalama, Hollywood, Emma Wood, El Capitan, Arroyo Burro, Zuma, Carpinteria, Gaviota, Summerland and Goleta.

The foraminiferal changes observed in the beach environment from April, 1969 to February, 1970 appear to result primarily from seasonal variations in both productivity and the intensity of beach processes. The presence of oil did not produce high foraminiferal mortality in any of the environments studied.

The surface water circulation pattern in the channel consists essentially of a counter-clockwise cell in the western half of the channel and a northwesterly flowing current in the eastern part of the channel. A complex pattern of eddies is produced as a result of convergence of these currents and current impingement along the coast.

Surface water nutrient values were highest in May, 1969 and lowest in December, 1969. A decrease in dissolved oxygen values in the upper 30 meters of the water column beneath an oil slick was detected, but values from greater depths and from areas beyond the slick boundary were normal.

Topography and sill depths of 230 meters and 475 meters at the eastern and western margins, respectively, of the basin influenced the water characteristics and subsurface circulation. A northwesterly flowing subsurface current in the eastern portion of the channel is deflected into a westerly flow by a ridge south of Santa Barbara. The main avenues of sediment transport into the basin occur on either side of the ridge.

Nearly all of the flood sediments initially introduced into the channel can be accounted for 1½ years later. Apparently, the Santa Barbara Channel is an efficient sediment trap.

A large portion of the oil slicks emanating from the well blowout were transported into areas of high suspended sediment concentrations in the surface water. However, oil slicks usually penetrated only a short distance into these suspended sediment plumes (fig. 1). In addition, the total hydrocarbon concentrations in surficial sediments, from infrared analyses, reveal that initial deposition of large quantities of oil occurred in areas of high flood sediment deposition.

The mechanism responsible for this relationship appears to be adsorption (or sorption) of oil on the

suspended detrital particles introduced into the area as a result of flood runoff. A diagramatic representation of the proposed mechanism which resulted in sinking large quantities of oil from the water surface in Santa Barbara Channel is shown in figure 2.

Subsequently, much of the oil deposited at the sediment-water interface was removed from the area of initial deposition and was retransported into deeper water. The pattern that evolved showed alignment of higher oil concentrations within the main avenues of sediment transport toward the central basin. Oil deposited in areas of net sediment accumulation, however, remained buried at the end of June, 1970.

Interpretation of the surface current patterns, subsurface water circulation, flood sediment distribution and the distribution of oil slicks emanating from the A-21 well blowout reveals that the position of the well was crucial because oil released from that position could have been transported to all portions of the channel. The dynamics of the system are so complex and so variable that we can not provide irrefutable proof of the fate of a particular fragment of oil released at a given instant in time. However, the accumulated evidence from the physical and chemical program has provided a consistent pattern for the events covered by the period of study. Several conclusions can be drawn from this evidence. Oil from well A-21 could have been transported to any or all shallow water areas within the channel within a period of no more than four months. The shortest time required would depend on water depth and distance from the source. Resuspension and transportation of oil initially deposited in shallow water occurred and much of this material was subsequently deposited in deeper water. This process was active through June, 1970 with the net result being that the basin will be the final depositional site for most of this material.

Figure 1. An example of the relationship between oil slicks and suspended sediment plumes. Note that the oil slick only penetrates a short distance into this plume south of the Ventura River.

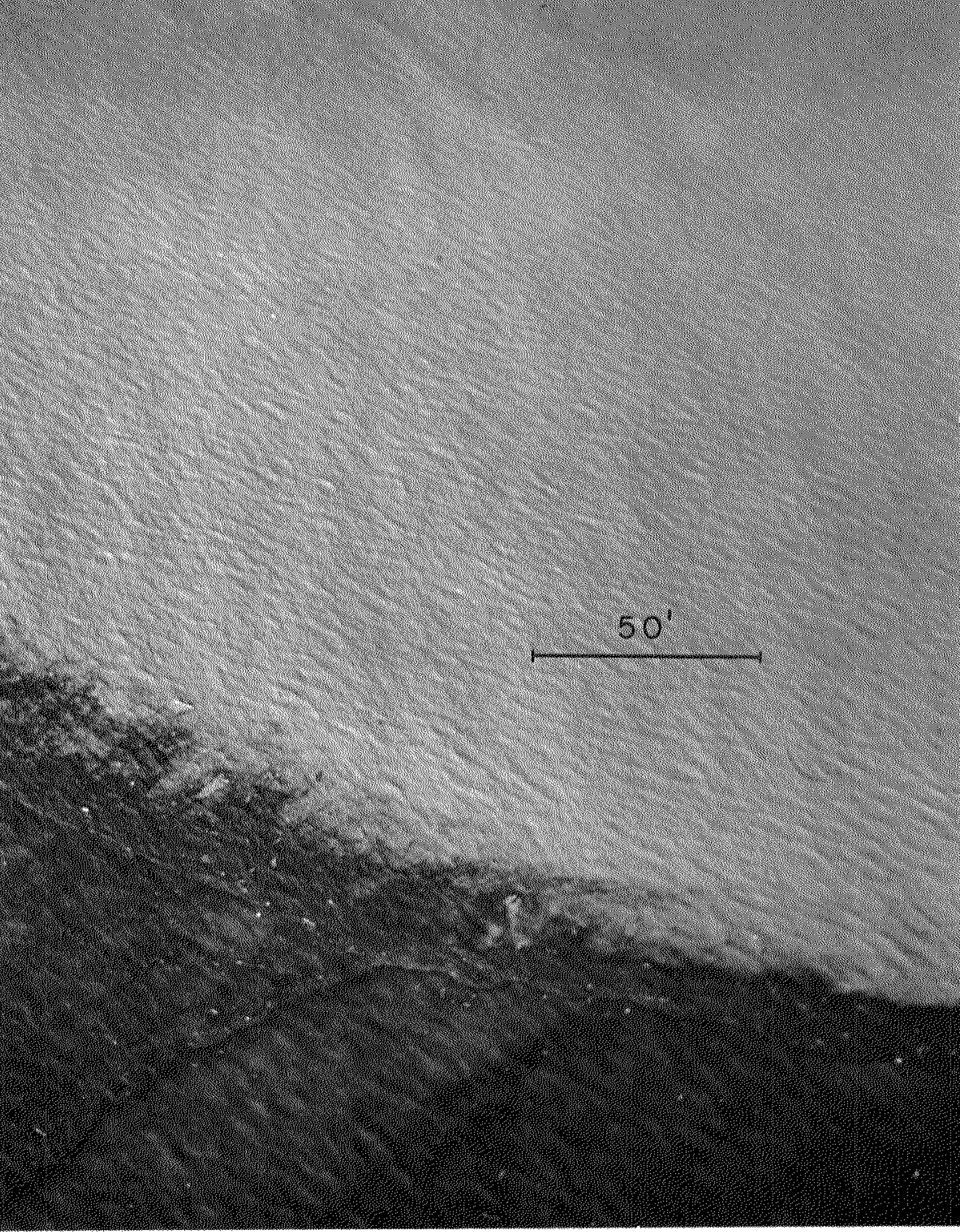
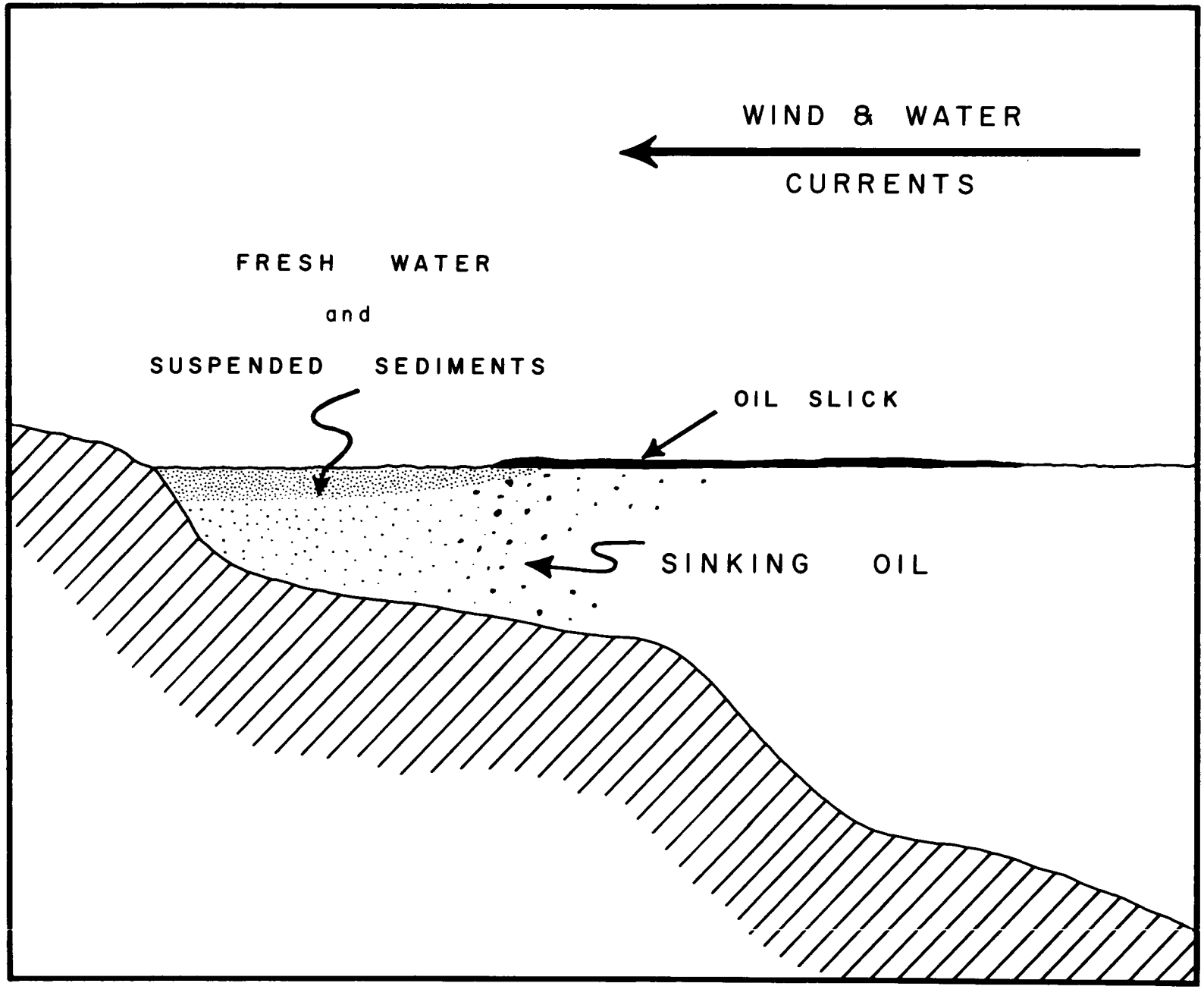
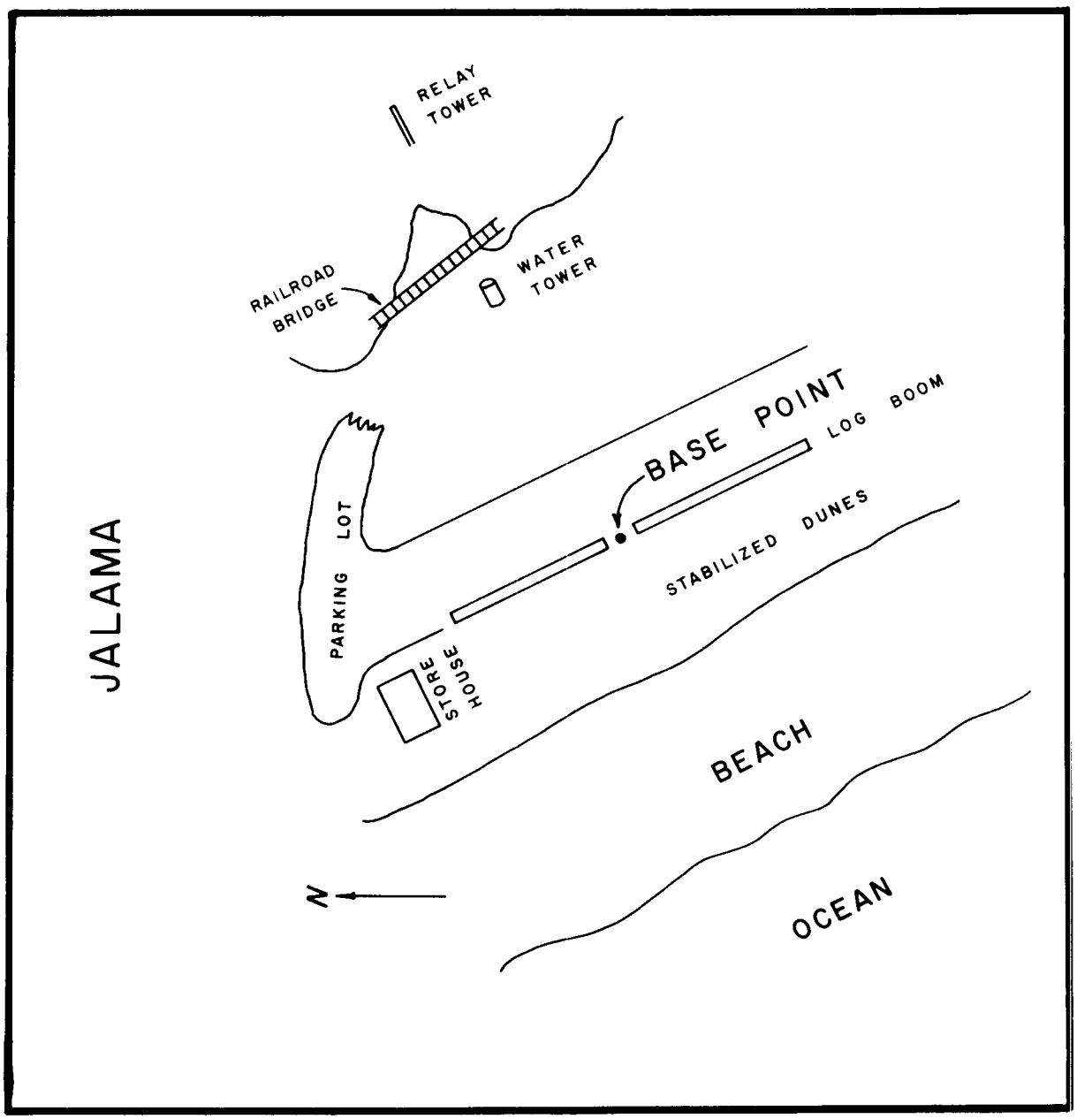

50'

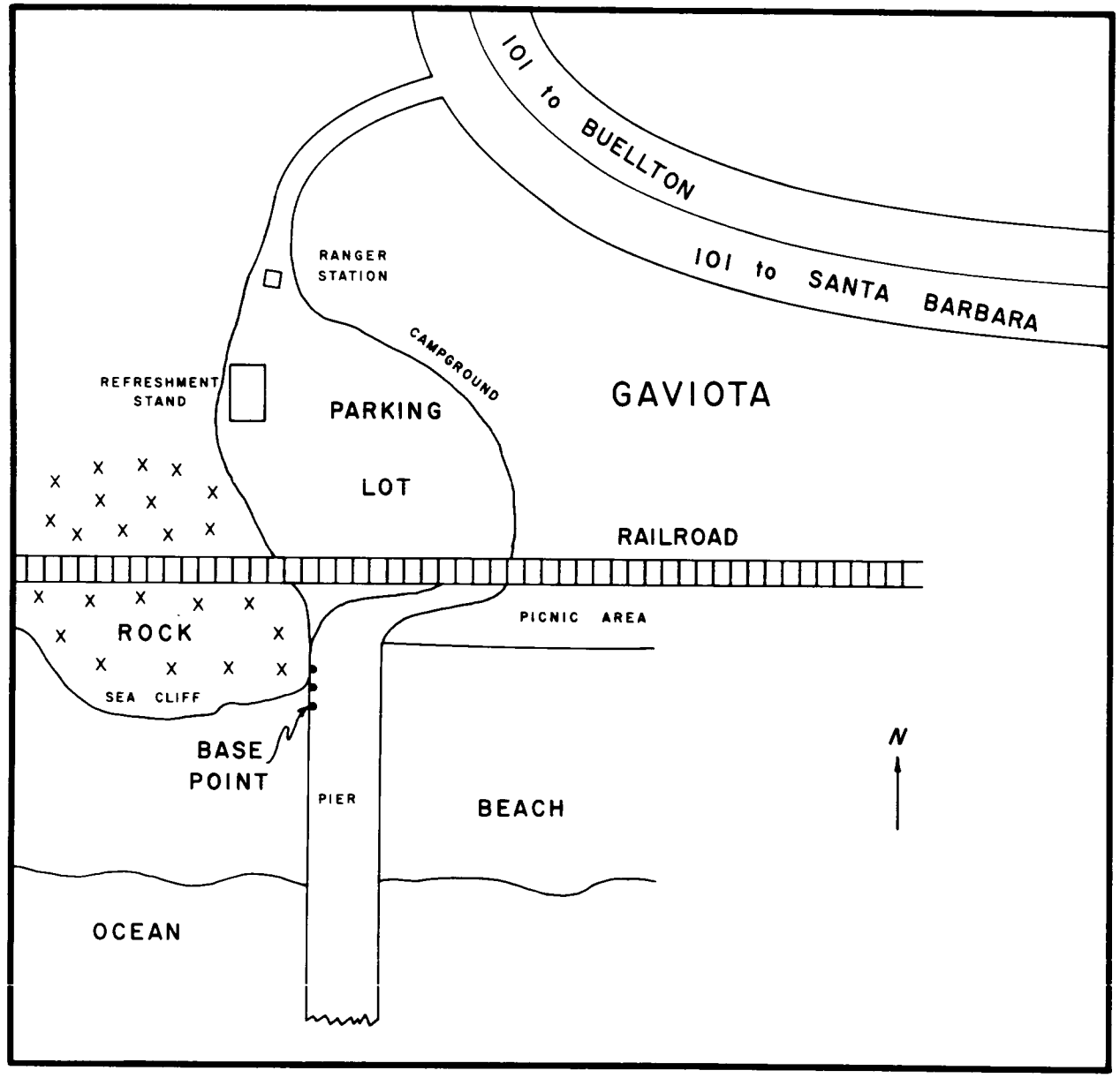
Figure 2. Proposed mechanism responsible for sinking oil in Santa Barbara Channel.

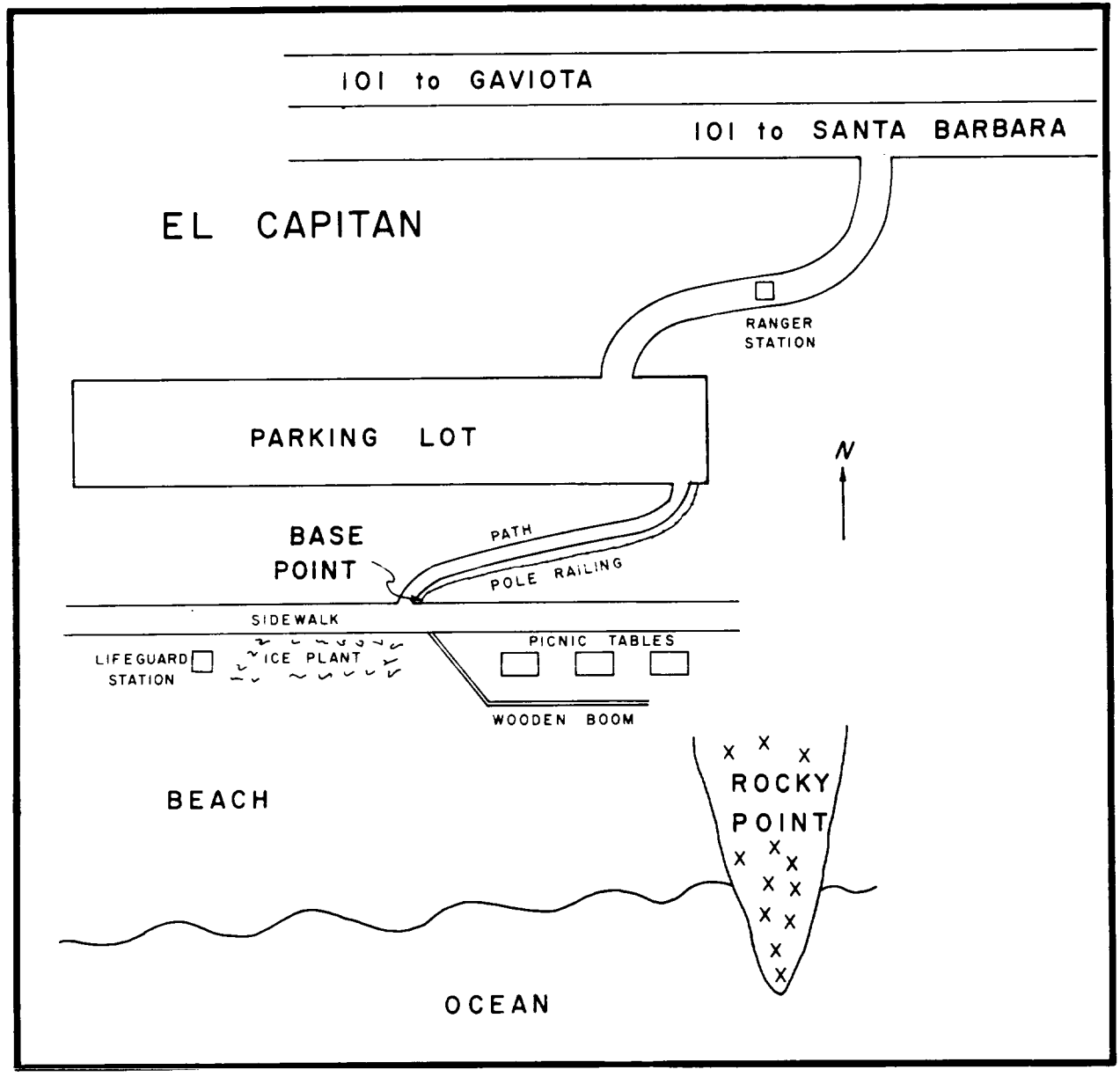

WIND & WATER
CURRENTS
FRESH WATER
and
SUSPENDED SEDIMENTS
OIL SLICK
SINKING OIL

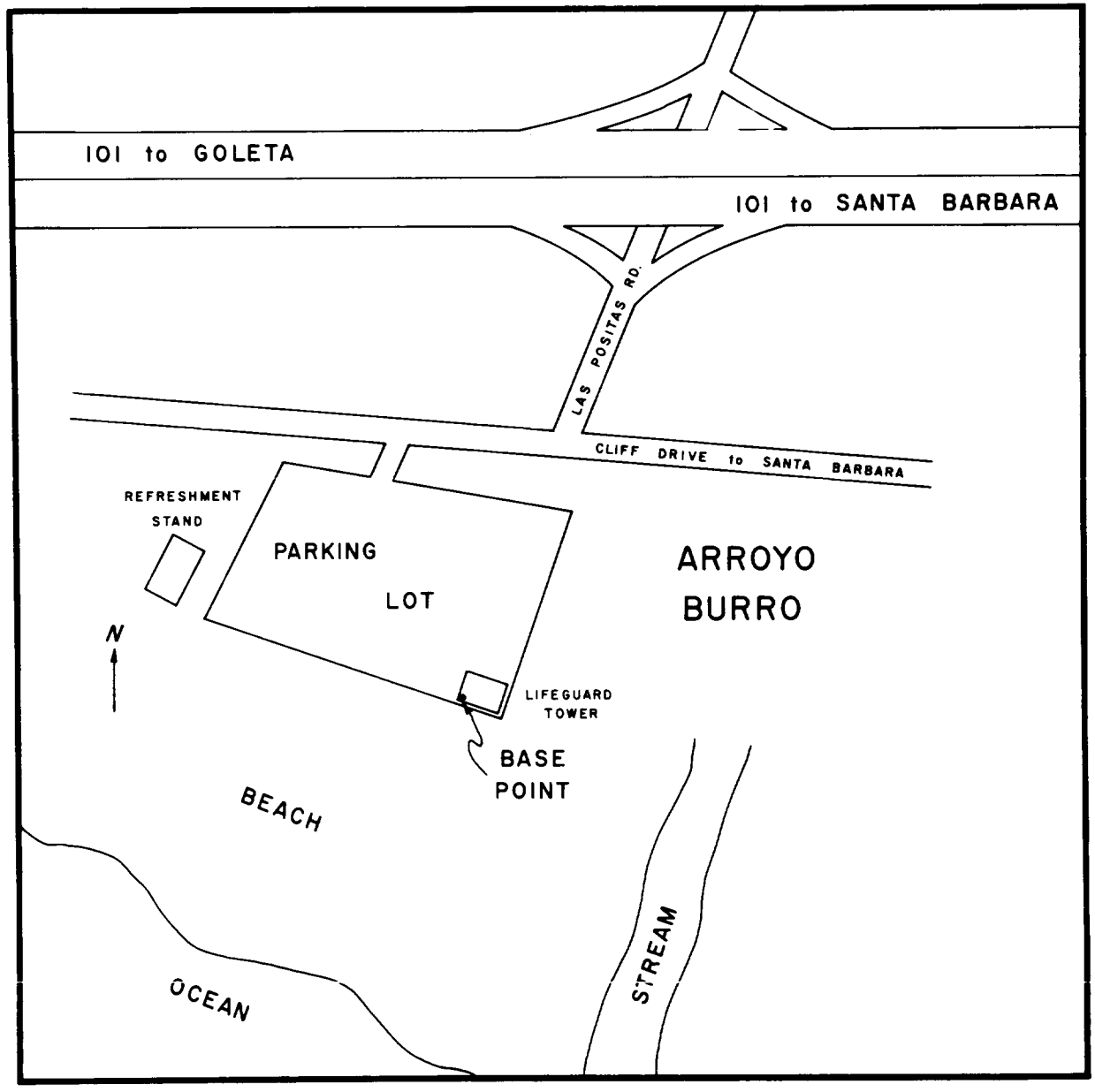
APPENDIX I

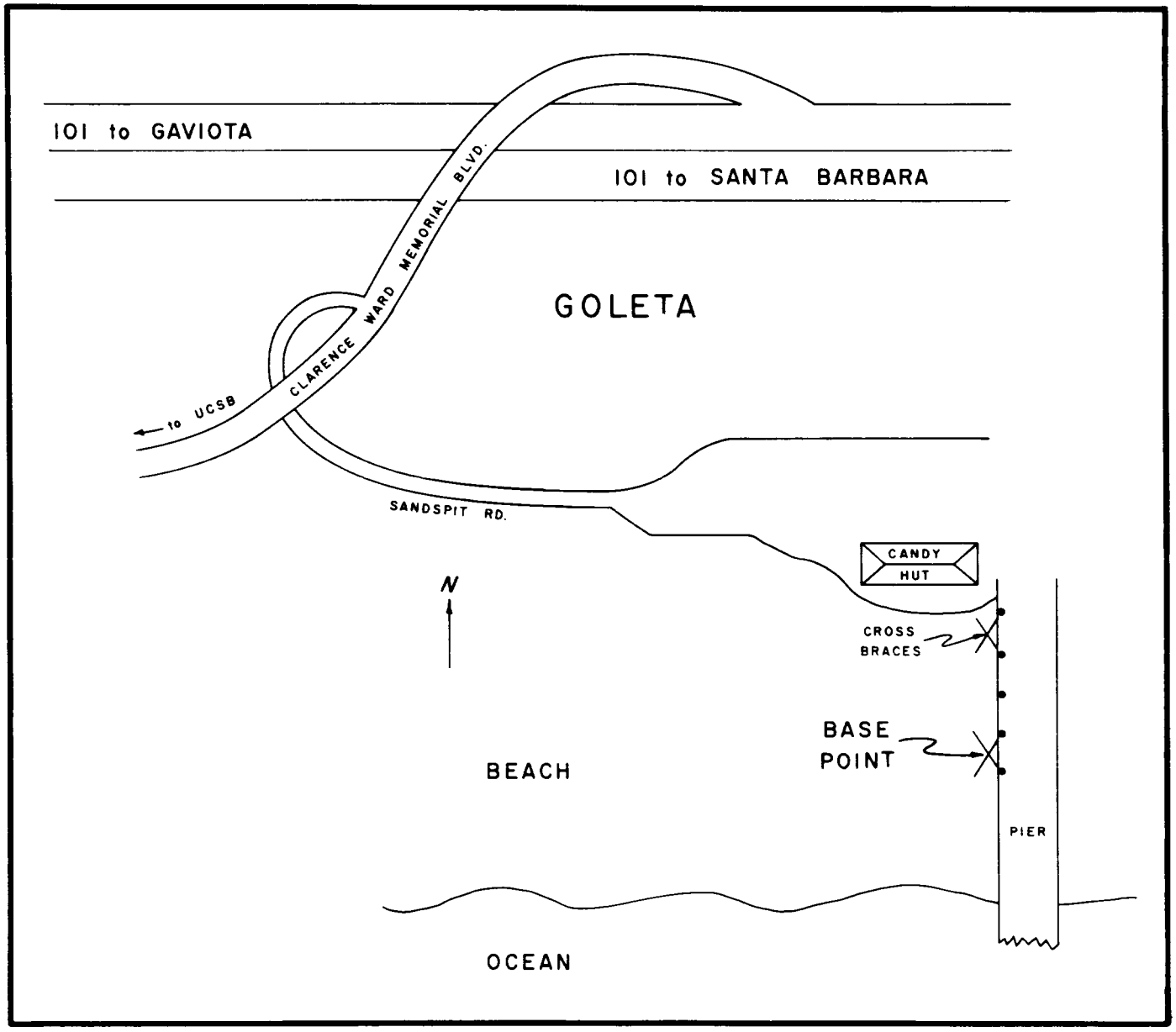
Location maps for beach surveys. Profile lines are normal to the base points for all beaches except Gaviota, Goleta and Summerland. The starting point for profiles at these three beaches was 150 feet west of the base point.

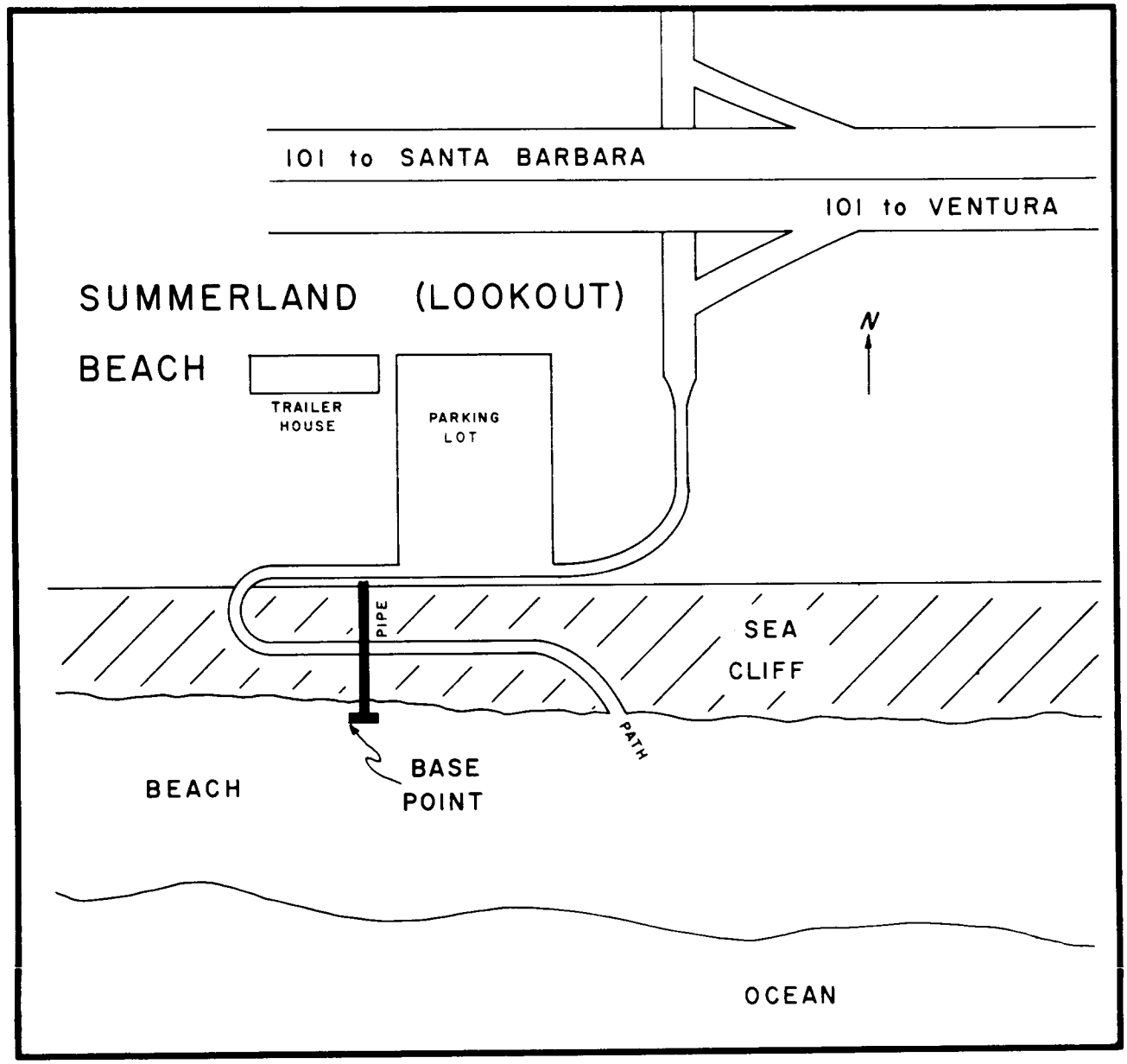

JALAMA
RELAY TOWER
RAILROAD BRIDGE
WATER TOWER
BASE POINT
LOG BOOM
PARKING LOT
STABILIZED DUNES
STORE HOUSE
BEACH
OCEAN
N

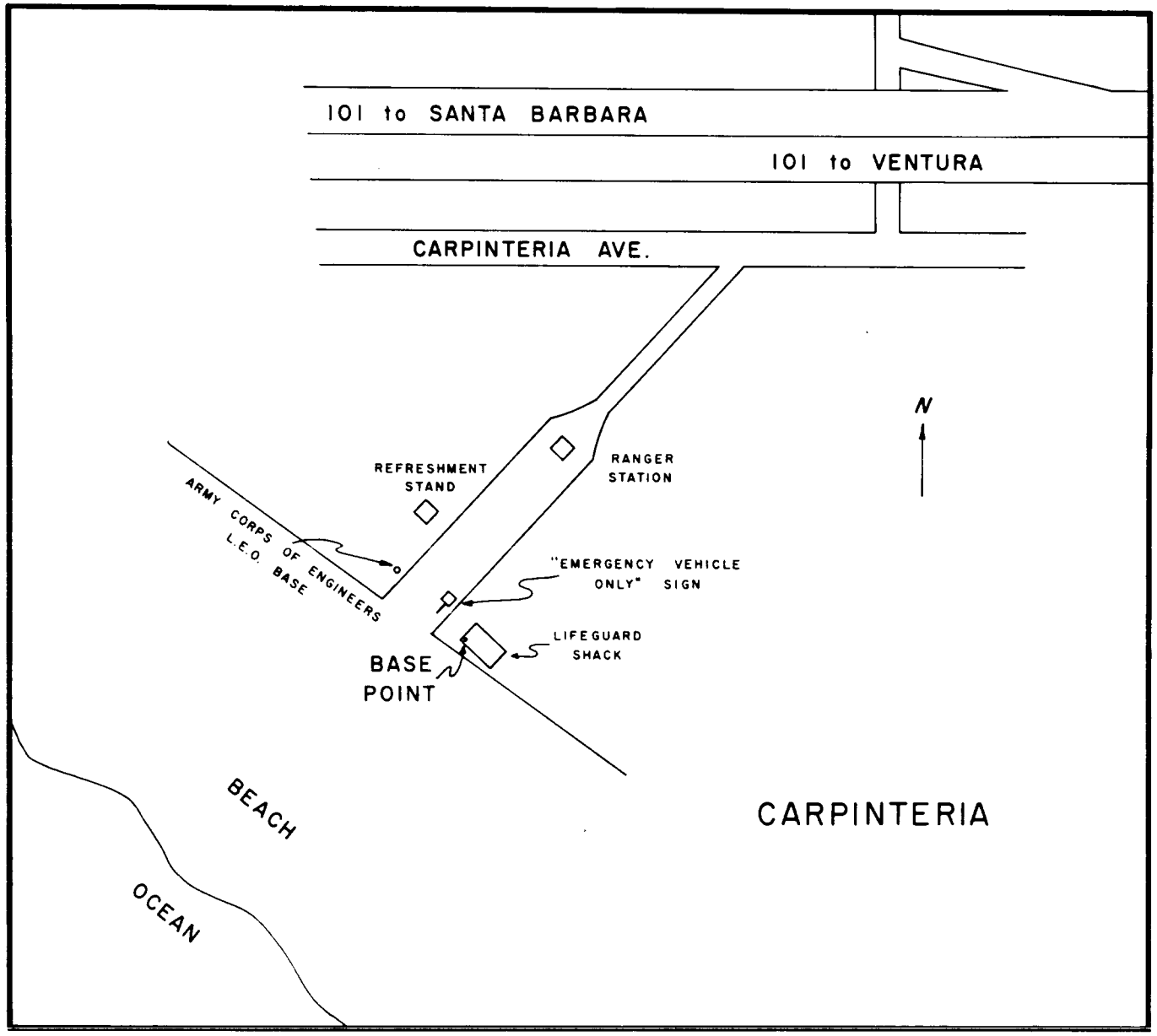

101 to BUELLTON
101 to SANTA BARBARA
RANGER STATION
CAMPGROUND
REFRESHMENT STAND
PARKING LOT
GAVIOTA
RAILROAD
ROCK
SEA CLIFF
PICNIC AREA
BASE POINT
PIER
BEACH
OCEAN
N

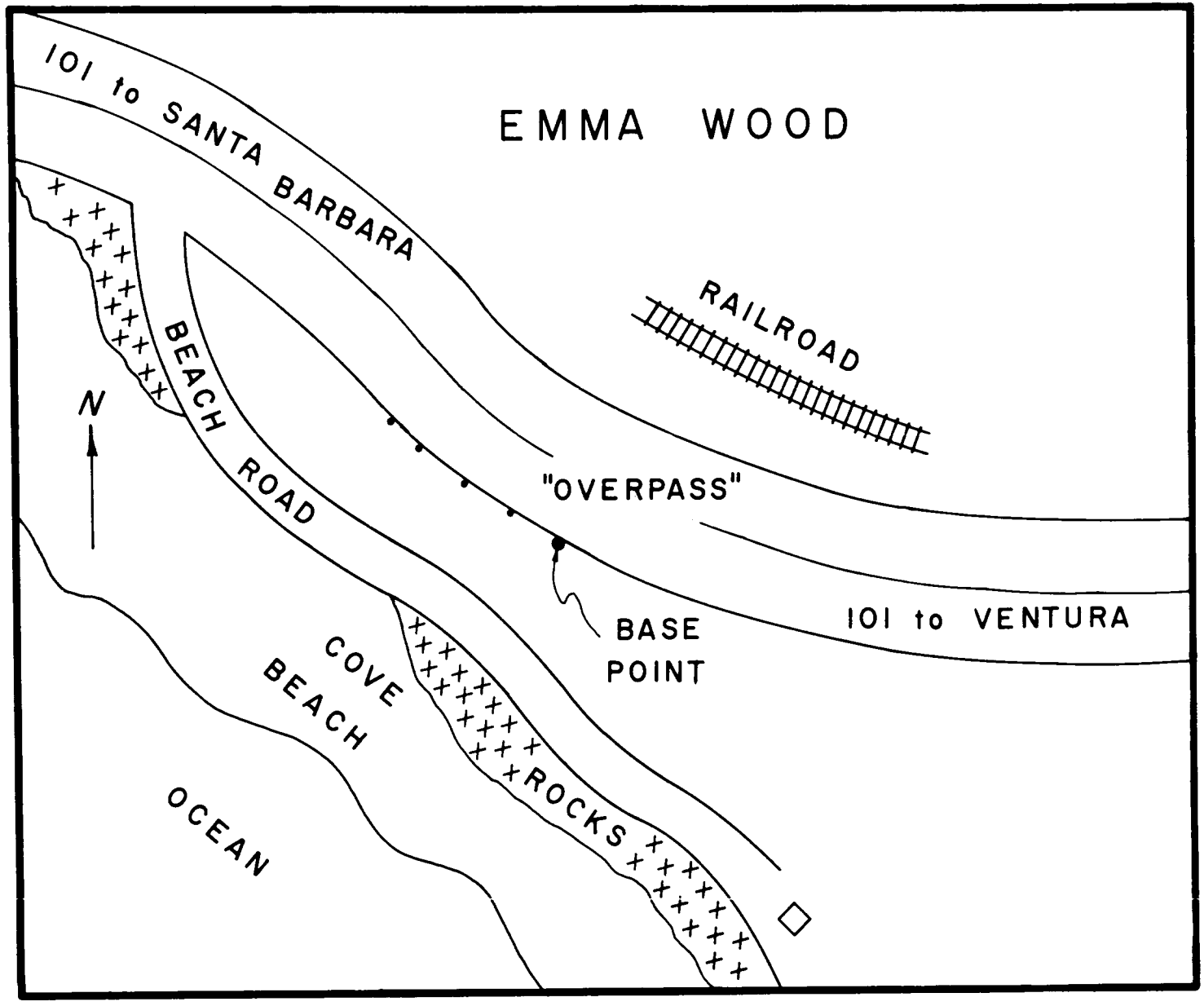

101 to GAVIOTA
101 to SANTA BARBARA
EL CAPITAN
RANGER STATION
PARKING LOT
N
BASE POINT
PATH
POLE RAILING
SIDEWALK
LIFEGUARD STATION
ICE PLANT
PICNIC TABLES
WOODEN BOOM
BEACH
ROCKY POINT
OCEAN

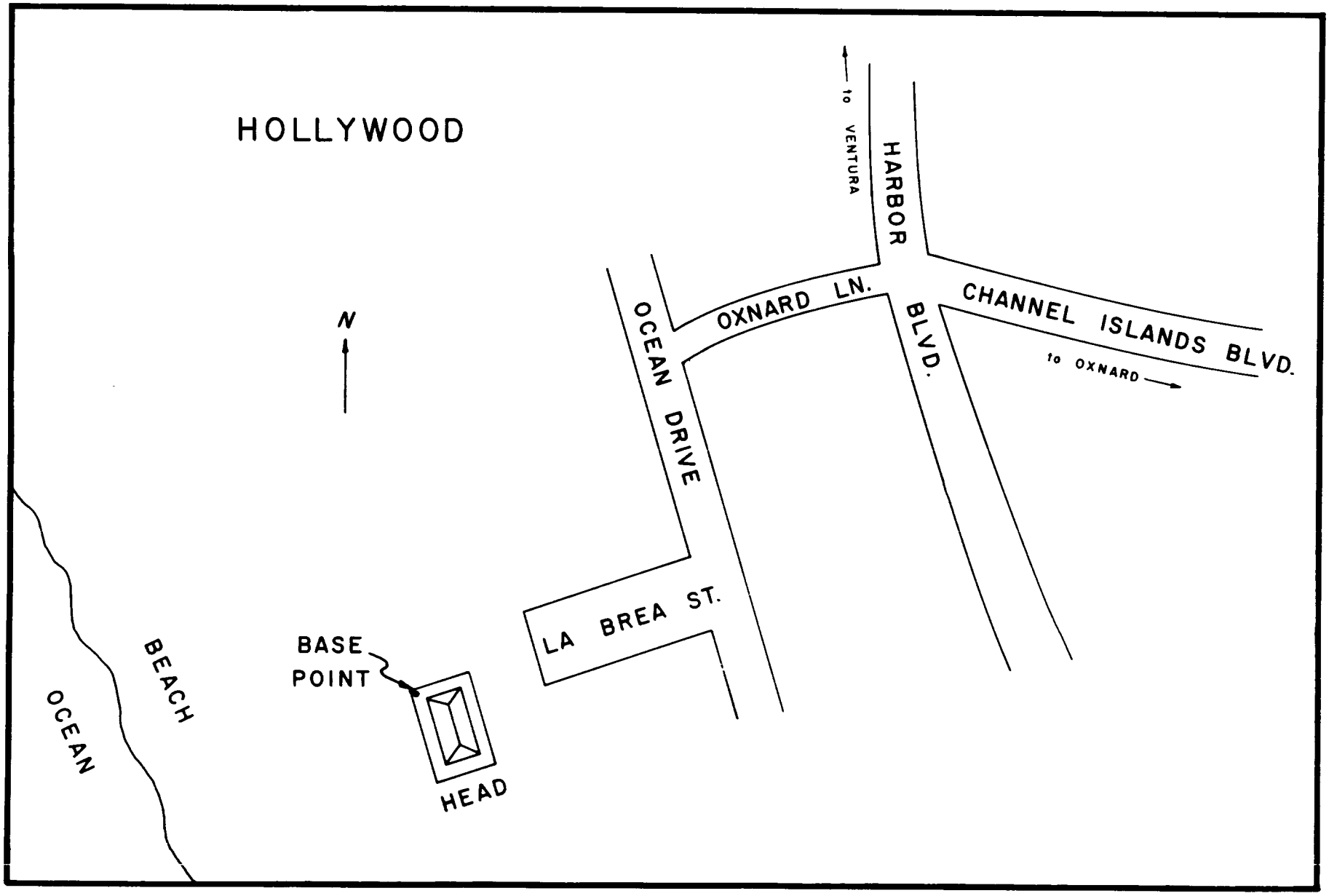

101 to GOLETA
101 to SANTA BARBARA
LAS POSITAS RD.
CLIFF DRIVE to SANTA BARBARA
REFRESHMENT STAND
PARKING LOT
ARROYO BURRO
N
LIFEGUARD TOWER
BASE POINT
BEACH
OCEAN
STREAM

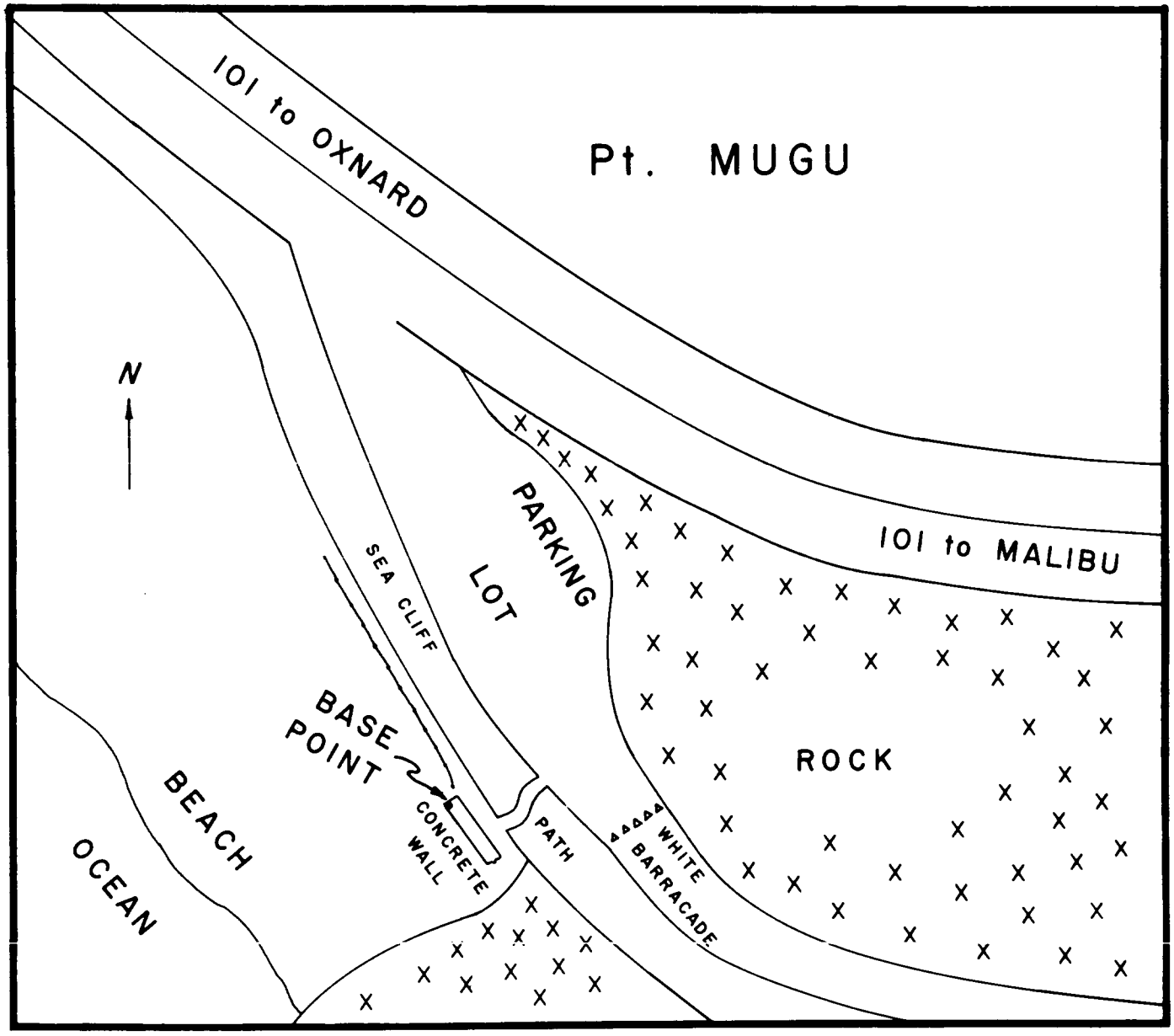

101 to GAVIOTA
101 to SANTA BARBARA
CLARENCE WARD MEMORIAL BLVD.
GOLETA
to UCSB
SANDSPIT RD.
CANDY HUT
N
CROSS BRACES
BASE POINT
BEACH
PIER
OCEAN

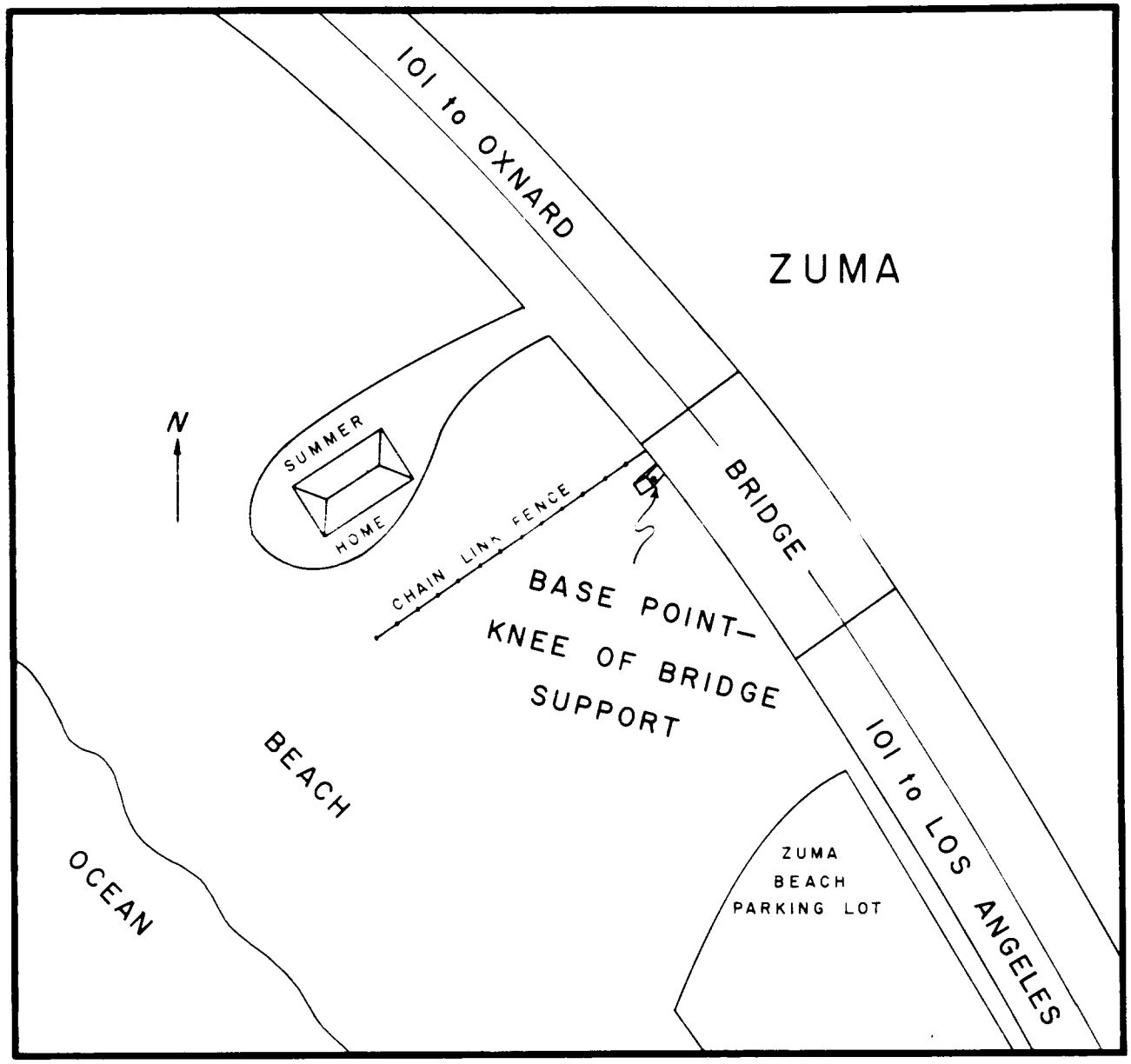

101 to SANTA BARBARA
101 to VENTURA
SUMMERLAND (LOOKOUT)
BEACH
TRAILER HOUSE
PARKING LOT
N
PIPE
SEA CLIFF
PATH
BASE POINT
BEACH
OCEAN


101 to SANTA BARBARA
101 to VENTURA
CARPINTERIA AVE.
N
REFRESHMENT STAND
RANGER STATION
ARMY CORPS OF ENGINEERS L.E.O. BASE
"EMERGENCY VEHICLE ONLY" SIGN
LIFEGUARD SHACK
BASE POINT
BEACH
OCEAN
CARPINTERIA


EMMA WOOD
101 to SANTA BARBARA
RAILROAD
BEACH ROAD
N
"OVERPASS"
BASE POINT
101 to VENTURA
COVE BEACH
ROCKS
OCEAN


HOLLYWOOD
N
to VENTURA
HARBOR
BLVD.
OXNARD LN.
OCEAN DRIVE
CHANNEL ISLANDS BLVD.
to OXNARD
LA BREA ST.
BASE POINT
HEAD
BEACH
OCEAN


101 to OXNARD
Pt. MUGU
N
PARKING
LOT
101 to MALIBU
SEA CLIFF
BASE
POINT
ROCK
BEACH
OCEAN
CONCRETE
WALL
PATH
WHITE
BARRACADE


101 to OXNARD
ZUMA
N
SUMMER
HOME
CHAIN LINK FENCE
BRIDGE
BASE POINT-
KNEE OF BRIDGE
SUPPORT
BEACH
OCEAN
ZUMA
BEACH
PARKING LOT
101 to LOS ANGELES

APPENDIX 2

Summary of beach measurements exclusive of profile and longshore drift values.

Beach: Jalama

Date:	4-3-1969	5-12-1969	6-18-1969	7-16-1969	8-13-1969	9-18-1969	10-10-1969	11-25-1969	12-30 1969	1-27-1970	2-26-1970
Time	0900	1630	1020	1130	0910	0925	0920	0915	0825	0815	0810
Wave Per. (Ave:Secs)	16.9	13.0	13.5	10.3	12.5	12.5	16.0	12.5	12.0	11.5	12.4
Wave Height (Ave:Feet)	3	3.5	3.5	3	2.8	3	5	3	3.5	3.5	4
Shoreline Trend		N20W	N25W	N20W	N22W	N25W	N24W	N14W	N22W	N20W	N13W
Wave Trend		N25W	N25W	N20W	N25W	N25W	N12W	N26W	N12W	N15W	N15W
Water Temp. (°C)		14.0	15.5	14.1	16.1	15.0	14.0	15.3	12.0	12.2	12.8
Air Temp. (°C)		18.2	19.4	18.2	18.7	18.0	19.8	16.8	6.2	13.0	14.4
Cloud Cover (Tenths)	0	3	10	0	3	5	0	1	0	10	1
Wind Vel. (mph)	14	18	0	9	7	0	18	5	9	5	4
Wind Dir.	N10W	N45W		N75E	N55E		N39W	S65W	S85E	N63W	N75W
Salinity (o/oo)			33.539	33.670	33.599			33.416	33.510	33.346	33.390

Beach: Gaviota

Date:	4-3-1969	5-12-1969	6-18-1969	7-16-1969	8-13-1969	9-18-1969	10-10-1969	11-25-1969	12-30-1969	1-27-1970	2-26-1970
Time	1250	1425	1320	1525	1200	1210	1215	1200	1100	1040	1130
Wave Per. (Ave:Secs)	16.9	12.8	13.8	8.3	8.4	12.0	8.9	13.8	8.8	12.3	10.2
Wave Height (Ave:Feet)	2	2	2	1.5	1	1	2.5	1.5	1	1.3	4
Shoreline Trend		N85W	N90W	N90W	N90W	N90W	N82W	N90W	N80W	N80W	N90W
Wave Trend		N80W	N80W	N75W	N85W	N85W	N73W	N80W	N85W	N75W	N80W
Water Temp. (°C)		14.6	18.2	20.1	20.8	16.8	17.0	16.2	12.2	13.2	13.9
Air Temp. (°C)		18.3	18.9	20.3	18.6	17.0	26.2	22.1	18.0	18.6	17.8
Cloud Cover (Tenths)		0	2	0	8	10	0	1	0	8	10
Wind Vel. (mph)	20	10	12	4	9	0	8	3	0	8	15
Wind Dir.	N20W	S45W	N70W	N30W	S60W		S54W	S33W		S70W	S40W
Salinity (o/oo)			33.548	33.654	33.451	33.622	33.553	33.409	33.478	33.420	33.434

Beach: El Capitan

Date:	4-3-1969	5-12-1969	6-18-1969	7-16-1969	8-13-1969	9-18-1969	10-10-1969	11-25-1969	12-30-1969	1-27-1970	2-26-1970
Time	1600	1250	1545	1715	1500	1500	1445	1430	1230	1200	1345
Wave Per. (Ave:Secs)	16.0	11.9	8.5	10.3	10.0	13.9	7.4	14.2	7.4	10.8	10.6
Wave Height (Ave:Feet)	2	3	2	2	1.3	1	3.5	1.5	2	2.5	2.8
Shoreline Trend		N60W	N55W	N63W	N62W	N57W	N53W	N56W	N59W	N60W	N58W
Wave Trend		N30W	N55W	N55W	N55W	N57W	N48W	N70W	N50W	N60W	N47W
Water Temp. (°C)		15.6	18.9	20.0	22.6	18.0	17.0	17.1	13.3	14.2	14.6
Air Temp. (°C)		17.2	20.0	21.8	21.7	20.0	27.0	20.0	19.4	16.8	16.2
Cloud Cover (Tenths)	0	1	0	0	1	10	0	1	0	7	1
Wind Vel. (mph)	10	9	10	6	10	6	17	9	0	16	12
Wind Dir.	N90W	S70W	N90W	N84E	N90W	N90W	N74W	S68W		N90W	S77W
Salinity (‰)			33.428	33.554	33.530	33.548	33.464	33.404	33.454	33.410	33.411

Beach: Arroyo Burro

Date:	4-4-1969	5-10-1969	6-17-1969	7-15-1969	8-13-1969	9-17-1969	10-9-1969	11-24-1969	12-29-1969	1-27-1970	2-25-1970
Time	0800	1435	1615	1630	1800	1740	1840	1645	1550	1600	1530
Wave Per. (Ave:Secs)	13.1	7.2	13.1	11.5	8.6	12.5	10.7	13.5	10.8	12.5	11.2
Wave Height (Ave:Feet)	2	2	1.5	1.5	1.5	1	3.5	1.5	1	1.5	2.5
Shoreline Trend		N90W	N70W	N70W	N73W	N73W	N57W	N70W	N75W	N75W	N70W
Wave Trend		N80W	N70W	N70W	N73W	N68W	N40W	N58W	N75W	N60W	N49W
Water Temp. (°C)		18.3	15.5	19.3	22.2	18.0	18.9	16.8	13.9	14.4	14.7
Air Temp. (°C)		17.4	18.9	21.0	22.0	19.0	19.5	13.3	13.8	14.5	21.2
Cloud Cover (Tenths)	0	0	8	0	8	1	2	4	0	2	2
Wind Vel. (mph)	3	6	4	4	11	11	2	0	8	0	6
Wind Dir.	S45E	S90W	N70W	N80E	S75W	S75W	N20E		S65W		S55W
Salinity (o/oo)			33.638	33.515	33.619	33.528	33.628	33.421	33.433	33.326	33.455

Beach: Goleta

Date:	4-3-1969	5-10-1969	6-17-1969	7-15-1969	8-13-1969	9-18-1969	10-10-1969	11-25-1969	12-30-1969	1-27-1970	2-26-1970
Time	1730	1605	1830	1830	1630	1700	1630	1615	1415	1405	1550
Wave Per. (Ave:Secs)	14.7	9.4	11.1	10.9	7.9	12.2	9.8	12.8	12.2	10.5	12.3
Wave Height (Ave:Feet)	1	0.5	1	1.5	0.5	0.5	2	1	1	0.8	1
Shoreline Trend		N70E	N90E	N85E	N90E	N85E	N84E	N86E	N75E	N80E	N84E
Wave Trend		N90E	N80W	N85E	N90E	N85E	N84W	N78E	N69E	N85W	N80W
Water Temp. (°C)		18.4		21.3	20.5	18.7	19.6	16.8	14.5	15.2	14.4
Air Temp. (°C)		17.8		19.8	21.5	18.2	23.2	16.2	14.2	18.4	19.0
Cloud Cover (Tenths)	0	2	10	0	2	10	0	0	0	5	2
Wind Vel. (mph)	0	7	7	5	8	4	20	6	5	9	6
Wind Dir.		S30W	N90W	S15W	S60W	S66W	N90W	N76W	S30W	N90W	S88W
Salinity (o/oo)			33.699	33.636	33.630	33.566	33.594	33.444	33.478	33.338	33.449

Beach: Summerland

Date:	4-4-1969	5-10-1969	6-17-1969	7-15-1969	8-12-1969	9-17-1969	10-9-1969	11-24-1969	12-29-1969	1-26-1970	2-26-1970
Time	1030	1215	1400	1445	1730	1600	1635	1505	1420	1530	1730
Wave Per. (Ave:Secs)		7.7	7.5	10.3	10.7	10.5	8.0	14.4	7.8	10.9	11.2
Wave Height (Ave:Feet)		1.5	1	1.5	1.5	1	2.5	1.5	1	1	1.5
Shoreline Trend		N90W	N75W	N80W	N70W	N85W	N73W	N77W	N70W	N90W	N80W
Wave Trend		N70W	N75W	N88W	N53W	N70W	N55W	N70W	N75W	N90W	N74W
Water Temp. (°C)		17.4	17.4	20.8	23.5	18.7	20.5	17.1	14.3	14.9	14.5
Air Temp. (°C)		21.8	19.4	22.1	23.0	20.0	20.8	20.4	16.2	14.5	13.6
Cloud Cover (Tenths)	0	0	10	0	0	1	0	1	0	0	2
Wind Vel. (mph)	8	4	0	7	9	11	3	0	6	0	3
Wind Dir.	N90W	S45E		N75W	N90W	S45W	S38E		S75W		S80W
Salinity (o/oo)			33.479	33.376	33.506	33.520		33.370	33.455		33.314

Beach: Carpinteria

Date:	5-16-1969	6-18-1969	7-15-1969	8-12-1969	9-17-1969	10-9-1969	11-24-1969	12-29-1969	1-26-1970	2-25-1970
Time	1450	1745	1215	1430	1345	1420	1300	1210	1300	1340
Wave Per. (Ave:Secs)	8.5	13.0	11.8	10.8	15.4	14.0	14.3	12.0	11.6	14.0
Wave Height (Ave:Feet)	1.5	2	1	0.8	1	3.5	1	1	2	2
Shoreline Trend	N55W	N55W	N53W	N53W	N57W	N45W	N50W	N55W	N59W	N53W
Wave Trend	N45W	N40W	N53W	N47W	N40W	N38W	N50W	N47W	N59W	N48W
Water Temp. (°C)	17.5	18.3	18.8	23.5	17.4	19.9	17.0	13.4	14.6	14.8
Air Temp. (°C)	16.8	21.1	21.5	24.7	22.0	22.0	20.1	15.8	17.4	22.8
Cloud Cover (Tenths)	9	0	0	0	3	1	1	1	0	1
Wind Vel. (mph)	8	10	6	10	7	6	4	7	0	2
Wind Dir.	S80W	N35W	N80E	N90W	S45W	N89E	S76W	S80W		S12W
Salinity (o/oo)		33.553	33.408	33.567	33.441	33.536	33.352	33.438	33.329	33.441

Beach: Emma Wood

Date:	5-16-1969	6-11-1969	7-17-1969	8-12-1969	9-19-1969	10-13-1969	11-4-1969	12-30-1969	1-28-1970
Time	1315	1230	1110	1100	1215	1300	1335	1330	1400
Wave Per. (Ave:Secs)	13.9	8.8	9.6	10.0	12.0	14.0	11.0	9.3	8.7
Wave Height (Ave:Feet)	2	1	2.5	2	3	2.5	1.5	2.5	1.5
Shoreline Trend	N30W	N30W	N35W	N34W	N34W	N35W	N36W	N30W	
Wave Trend	N38W	N30W	N40W	N28W	N34W	N21W	N25W	N05W	
Water Temp. (°C)	15.7	16.7	17.9	19.2	17.0	18.6	17.0		
Air Temp. (°C)	16.0	18.2	22.5	20.5	19.5	25.8	20.4	18.3	
Cloud Cover (Tenths)	10	10	9	0	10	2	0	2	0
Wind Vel. (mph)	10	6	0	9	4	6	8	6	0
Wind Dir.	N70W	N00E		N60W	N67W	S51W	N74W	N18E	
Salinity (o/oo)		33.584	33.548		33.367	33.544	33.450	33.458	

Beach: Hollywood

Date:	4-11-1969	5-9-1969	6-11-1969	7-17-1969	8-14-1969	9-19-1969	10-13-1969	11-4-1969	12-23-1969	1-28-1970	2-24-1970
Time	1000	1140	1505	1520	1425	1525	1500	1515	1145	1220	1545
Wave Per. (Ave:Secs)	10.1	10.3	9.5	8.9	9.4	9.5	13.8	9.1	13.2	9.9	14.7
Wave Height (Ave:Feet)	3	2	1	4	2	3.5	2.5	3	4	4	1.8
Shoreline Trend	N20W	N25W	N25W	N24W	N25W	N20W	N20W	N20W	N24W	N25W	N27W
Wave Trend	N20W	N25W	N25W	N20W	N15W	N20W	N39W	N18W	N02W	N19W	N62W
Water Temp. (°C)	13.1	14.0	18.1	18.5	19.2	16.9	18.8	17.0	15.6		14.0
Air Temp. (°C)	15.8	15.1	19.8	23.2	19.4	19.2	19.8	17.0	16.9		19.2
Cloud Cover (Tenths)	1	0	4	2	10	10	3	4	2	0	0
Wind Vel. (mph)	2	12	12	7	13	10	9	15	9	25	5
Wind Dir.	N70W	N80W	N30E	S20W	N50W	N78W	S37W	S80W	N72W	N58E	S28W
Salinity (o/oo)			33.439	33.509	33.526	33.497	33.529	33.389	33.419	33.649	33.431

Beach: Pt. Mugu

Date:	4-11-1969	5-9-1969	6-11-1969	7-17-1969	8-14-1969
Time	1230	1340	1700	1730	1540
Wave Per. (Ave:Secs)	15.7	12.1	17.2	13.8	14.5
Wave Height (Ave:Feet)	3	2.5	1	4.5	3.5
Shoreline Trend	N50W	N50W	N55W	N56W	N55W
Wave Trend	N30W	N50W	N30W	N56W	N60W
Water Temp. (°C)	15.1	14.4	13.9	19.4	19.6
Air Temp. (°C)	19.1	16.4	20.0	21.0	21.6
Cloud Cover (Tenths)	1	0	1	9	3
Wind Vel. (mph)	2	10	7	5	15
Wind Dir.	S40W	N80W	N85W	S35W	N60W
Salinity (o/oo)			33.548	33.543	33.538

Beach: Zuma

Date:	4-11-1969	5-9-1969	6-20-1969	7-18-1969	8-14-1969	9-23-1969	10-13-1969	11-26-1969	12-23-1969	1-28-1970	2-24-1970
Time	1530	1450	1510	1500	1720	1530	1730	1230	0935	0900	1255
Wave Per. (Ave:Secs)	9.3	11.7	13.8	16.5	12.0	14.8	15.8	13.6	12.6	12.6	17.2
Wave Height (Ave:Feet)	2.5	2	2	3	1	2	1.5	2	3	2.5	2
Shoreline Trend	N55W	N55W	N53W	N55W	N55W	N55W	N56W	N49W	N60W	N62W	N54W
Wave Trend	N50W	N55W	N60W	N55W	N45W	N55W	N54W	N68W	N40W	N57W	N65W
Water Temp. (^{o}C)	14.8	15.6	16.6	20.0	20.6	17.6	19.2	17.0	15.6	13.3	13.7
Air Temp. (^{o}C)	15.8	16.2	23.3	23.0	18.7	19.0	18.4	19.7	16.2	15.9	21.1
Cloud Cover (Tenths)	1	0	10	0	0	0	1	9	4	0	0
Wind Vel. (mph)	9	10	9	10	22	14	6	4	6	22	5
Wind Dir.	S70W	N85W	N75W	N87W	N90W	N81W	S74W	N80W	S75W	N40E	S05W
Salinity (o/oo)			33.558	33.537	33.524	33.472	33.653	33.415	33.477	33.400	33.432

APPENDIX 3

Summary of longshore drift measurements made during beach surveys

Beach: Jalama

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/16/69	100	0.85	SE
	150	0.93	SE
8/13/69	100	1.72	NW
	200	1.45	NW
9/18/69	75	0.93	NW
	150	0.62	NW
10/10/69	125	2.83	SE
11/25/69	75	0.67	NW
	100	1.58	SE
	125	0.58	NW
12/30/69	50	1.25	SE
	150	1.38	SE
1/27/70	50	0.67	SE
	100	2.08	SE
2/26/70	75	1.72	SE
	150	0.25	SE

Beach: Gaviota

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/16/69	100	0.92	E
	200	0.38	E
8/13/69	75	0.83	E
	150	0.35	E
9/18/69	50	0.27	E
	125	0.17	E
10/10/69	125	0.20	E
11/25/69	50	0.55	E
	125	0.28	E
12/30/69	50	0.75	W
	100	0.00	-
1/27/70	50	1.00	E
	150	0.55	E
2/26/70	50	2.12	E
	150	0.97	E

Beach: El Capitan

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/16/69	100	1.08	E
	150	1.53	E
8/13/69	100	0.83	E
	200	1.13	E
9/18/69	25	0.03	W
	75	0.18	W
10/10/69	175	2.92	E
11/25/69	75	0.22	E
	125	0.17	E
12/30/69	50	0.57	W
	200	0.07	E
1/27/70	50	1.58	E
	120	1.83	E
2/26/70	75	0.97	E
	150	2.30	E

Beach: Goleta

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/15/69	10	0.62	E
	75	0.32	E
	150	0.08	E
8/13/69	75	0.15	E
9/18/69	25	0.05	E
10/10/69	50	0.70	E
11/25/69	50	0.25	E
	100	0.02	E
12/30/69	50	0.37	E
	125	0.15	E
1/27/70	50	1.00	E
	150	0.42	E
2/26/70	75	1.17	E
	150	0.47	E

Beach: Arroyo Burro

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/15/69	100	0.25	E
	200	0.35	E
8/13/69	75	1.92	E
	150	0.42	E
9/17/69	50	0.75	E
	100	0.08	E
10/9/69	50	1.33	E
	100	1.58	E
11/24/69	75	0.25	E
12/29/69	100	0.20	W
	200	0.00	-
1/27/70	75	0.62	W
	100	0.83	E
2/25/70	75	0.95	E
	150	0.93	E

Beach: Summerland

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/15/69	100	0.20	E
	200	0.57	E
8/12/69	75	0.88	E
	150	0.33	E
9/17/69	25	0.22	E
	50	0.43	E
10/9/69	50	2.08	E
	125	0.42	E
11/24/69	50	0.17	E
	125	0.12	E
12/29/69	50	0.08	E
	100	0.27	E
1/26/70	50	0.50	E
	100	1.03	E
2/26/70	75	0.67	E
	125	0.72	E

Beach: Carpinteria

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/15/69	100	0.83	E
	300	0.33	E
8/12/69	100	0.50	E
	200	0.00	-
9/17/69	30	0.13	E
	75	0.53	W
	150	0.05	E
10/9/69	50	1.33	E
	150	1.75	E
11/24/69	75	0.22	E
	150	0.22	E
12/29/69	50	0.77	W
	150	0.04	W
1/26/70	75	0.80	W
	150	0.38	E
2/25/70	50	0.82	W
	125	0.83	E

Beach: Emma Wood

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/17/69	100	0.19	SE
	200	0.87	NW
8/12/69	100	0.33	NW
	200	0.37	SE
9/19/69	100	0.00	-
	150	0.83	SE
10/13/69	50	0.55	SE
11/4/69	75	0.75	SE
	150	0.23	NW
12/30/69	50	0.50	SE
1/28/70	50	1.00	SE

Beach: Hollywood

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/17/69	25	1.33	SE
	90	0.50	SE
	100	0.47	SE
8/14/69	50	1.25	SE
9/19/69	75	1.00	SE
10/13/69	100	1.53	NW
11/4/69	50	1.83	SE
	150	1.30	SE
12/23/69	50	0.67	SE
	125	1.00	SE
1/28/70	50	1.25	SE
2/24/70	75	1.03	NW
	150	0.92	NW

Beach: Zuma

Longshore Drift

Date	Dist. from Swash (ft.)	Velocity (ft./sec.)	Direction
7/18/69	100	1.52	NW
	200	1.07	NW
9/23/69	100	0.58	NW
	175	0.25	SE
10/13/69	125	0.45	NW
11/26/69	50	0.95	SE
	125	0.50	SE
12/23/69	50	0.62	SE
	150	1.37	SE
1/28/70	50	1.20	SE
	150	1.20	SE
2/24/70	25	0.68	NW
	75	0.70	NW
	150	0.75	NW

APPENDIX 4

Hydrocarbon concentrations (by infrared) of Santa Barbara Channel sediments.

RESULTS OF INFRARED ANALYSES OF SANTA BARBARA CHANNEL SEDIMENTS

Oil concentrations in parts per thousand (PPT)

Error = ± 10% or 0.2 PPT, whichever is larger.
0 indicates less than 0.2 PPT

Sample	PPT Oil	Sample	PPT Oil	Sample	PPT Oil
XI-A	1.0	XIX-B	1.3	2-0-38	1.7
XI-B	2.1	XIX-C	2.0	2-0-39	2.0
XI-C	4.8	XX-B	2.5	2-0-44	1.1
XII-A	0.6	XX-D	1.7	2-0-45	2.1
XII-B	0.9			2-0-46	1.9
XII-C	1.7	2-0-1	0.8	2-0-47	0.8
XII-D	2.4	2-0-2	0.8	2-0-49	1.1
XIII-A	0.5	2-0-3	0	2-0-51	0.3
XIII-B	0.5	2-0-4	1.4	2-0-52	0.3
XIII-C	4.1	2-0-13	1.5	2-0-58	0.4
XIII-D	1.8	2-0-14	1.1	2-0-59	0.9
XVII-A	2.0	2-0-15	1.4	2-0-60	0.7
XVII-B	2.9	2-0-16	0.3	2-0-67	0.4
XVIII-B	1.2	2-0-26	0	2-0-68	0
XVIII-C	3.0	2-0-27	0.7		
XVIII-D	3.1	2-0-28	0.7	129-1	4.3
XIX-A	3.0	2-0-37	2.5	129-2	2.4

Sample	PPT Oil	Sample	PPT Oil	Sample	PPT Oil
129-3	8.7	12449	3.2	12888	5.9
129-4	0	12450	4.7	12889	6.8
129-5	0	12451	3.8	12890	4.5
129-6	0	12452	2.9	12928	1.9
129-10	0.9	12453	4.4	12929	6.9
129-11	0	12454	2.9	12930	6.1
129-13	0.7	12455	6.2	12932	8.3
129-15	0	12457	5.0	12934	6.7
129-16	0			12935	10.8
129-18	0	12853	5.1	12936	3.5
129-20	0	12854	3.1	12937	1.0
129-21	2.6	12855	1.8	12938	5.9
129-26	1.9	12856	4.9	12939	1.6
129-27	1.4	12857	4.5	12940	1.9
129-28	0.8	12858	0	12941	2.3
129-33	0	12859	3.7	12942	5.8
129-34	2.2	12860	6.6	12943	0
129-35	6.4	12861	3.3	12944	4.8
		12862	5.5	12945	5.2
12446	4.8	12863	7.1	12946	1.4
12447	2.4	12866	3.4	12947	4.4
12448	6.8	12887	5.1	12948	3.0

Sample	PPT Oil	Sample	PPT Oil	Sample	PPT Oil
12968	0	13011	1.9	13121	5.7
12969	1.1	13012	5.5	13122	6.4
12970	3.1	13013	5.8	13123	7.0
12971	4.2	13015	0.3	13124	3.0
12972	5.3	13016	2.2	13125	1.8
12973	3.6	13018	6.3	13126	2.2
12974	5.2	13025	6.2	13127	2.3
12976	0	13026	7.5	13128	7.7
12979	0	13027	21.5	13129	2.1
12980	0	13114 (0-1 cm)	10.6	13130	1.5
12981	3.2	13114 (1-2 cm)	15.8	13131	6.6
12982	3.3	13114 (4-6 cm)	1.0	13132	1.3
12983	0	13114 (9-11 cm)	0.9	13133	1.0
12984	3.0	13114 (12-13 cm)	1.6	13134	2.9
12985	0	13114 (20 cm)	0.5	13135	1.5
12986	0	13115 (0 cm)	2.0	13136	5.4
12987	3.6	13115 (9-11 cm)	2.5	13137	1.3
13005	3.0	13115 (14-15 cm)	1.7	13138	1.8
13006	8.1	13115 (20 cm)	2.7	13142	1.0
13008	5.0	13118	4.1	13143	1.4
13009	2.5	13119	4.2	13144	0
13010	2.1	13120	3.7	13220	0

Sample	PPT Oil	Sample	PPT Oil	Sample	PPT Oil
13222	0	13272	0.7	13353	2.6
13223	0	13321	2.9	13355	1.1
13231	2.6	13322	0.5	13358	7.5
13232	0	13323	0	13359	7.3
13233	6.7	13330	5.9	13360	1.1
13234	2.8	13331	5.8	13364	1.0
13236	3.1	13332	3.1	13365	1.3
13237	3.7	13333	1.5	13368	1.1
13238	5.2	13334	1.4	13370	1.0
13242	3.5	13335	2.4	13371	1.1
13244	3.9	13336	9.1	13374	0.5
13247	2.3	13337	7.8	13775	1.3
13248	3.3	13339	3.3	13818	3.6
13250	3.7	13340	7.8	13819	1.5
13251	2.7	13341	5.3	13821	3.1
13255	1.2	13342	9.0	13823	6.1
13256	0.8	13343	4.1	13824	1.2
13257 (15 cm)	1.1	13344	3.9	13832	2.4
13257 (0 cm)	1.2	13345	2.7	13837	8.7
13259	1.2	13347	3.6	13841	0
13268	6.3	13351	0	13842	5.2
13271	0	13352	0	13845	1.9

Sample	PPT Oil	Sample	PPT Oil	Sample	PPT Oil
13846	3.1	13889 (0 cm)	0	13916	0
13851	1.1	13889 (5 cm)	1.7	13917	0
13853	0	13889 (10 cm)	0	13918	0
13854	1.3	13889 (15 cm)	7.4	13919	0
13858	1.2	13890	2.1	13920	1.5
13860	0	13891 (0 cm)	4.3	13921	0
13861	2.4	13891 (5 cm)	3.4	13922	0.7
13864	2.6	13891 (10 cm)	2.6	13923 (5 cm)	1.7
13873	2.8	13891 (15 cm)	2.3	13923 (10 cm)	0.7
13874 (0 cm)	3.7	13902 (0 cm)	3.9	13926	0
13874 (2 cm)	2.5	13902 (5 cm)	2.7	13928	0.7
13874 (5 cm)	2.4	13902 (10 cm)	1.4	13929 (0 cm)	0
13874 (10 cm)	0	13902 (15 cm)	2.5	13929 (2-4 cm)	2.0
13874 (15 cm)	0	13903	2.7	13930	0
13875	1.6	13905	0	13931	0
13876	3.0	13906	0	13932 (0 cm)	0
13880 (0 cm)	6.5	13907	0	13932 (5 cm)	0
13880 (5 cm)	3.2	13911	0	13932 (10 cm)	0
13880 (10 cm)	4.5	13912	1.3	13932 (15 cm)	0
13880 (15 cm)	2.5	13913	1.2	13933 (0 cm)	2.2
13881	1.7	13914	1.7	13933 (5 cm)	1.8
13883	2.5	13915	2.9	13933 (10 cm)	0

Sample	PPT Oil	Sample	PPT Oil
13933 (15 cm)	0	14243 (5 cm)	10.5
13936	2.0	14246	2.3
13938	2.2	14250	1.7
13939	0	14252	0
13940	0	14253	1.9
14198 (0-5 cm)	3.7	14255	2.9
14205	5.6	14256	4.8
14219 (0-5 cm)	3.7	14257	1.1
14219 (5 cm)	10.1	14258	0
14231 (5 cm)	0	14259	3.6
14232	1.5	14260	0.5
14234	6.0	14261	3.9
14235	13.6	14262	4.3
14236	12.9	14270	6.0
14237	5.3	14271	6.2
14238	5.6	14276	6.1
14239	7.0	14279	7.3
14240	5.6	14293	8.7
14241 (0-5 cm)	10.4		
14242-A (0 cm)	8.0		
14242-B (5 cm)	8.5		
14243 (0 cm)	14.1		

APPENDIX 5

Beach foraminiferal values.

Beach: Jalama		Fauna													
DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4-3-69	0	0	0	6	0	6	0	1	0	1	1	0	15	1.3	14
5-12-69	0	2	0	42	0	28	0	16	0	1	0	1	90	33.2	37
5-12-69	1.5	35	0	63	0	186	0	62	4	15	0	10	375	253.0	58
6-18-69	0	31	0	39	1	47	7	56	13	4	0	5	203	192.7	40
6-18-69	1.5	4	0	37	0	17	1	41	3	0	0	0	103	21.6	44
7-16-69	0	30	0	111	0	105	5	145	11	8	0	4	419	221.1	67
7-16-69	1.5	32	0	63	1	102	1	78	9	12	0	4	302	100.5	59
8-13-69	0	33	0	50	1	124	7	73	68	5	0	3	364	33.6	70
8-13-69	1.5	17	0	31	0	115	2	24	8	5	1	4	207	87.7	23
9-18-69	1.5	20	0	31	0	169	4	22	11	5	5	10	277	23.9	29
10-10-69	1.5	1	0	1	0	4	3	2	11	0	0	0	22	1.9	2
11-25-69	1.5	1	0	0	0	1	0	1	31	0	0	0	34	3.3	0
11-30-69	1.5	2	0	6	1	27	1	2	0	1	0	1	41	3.6	2
2-26-70	1.5	8	0	10	1	52	0	8	2	7	1	2	91	22.1	7

Beach: Gaviota DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4- 3 -69	0	4	0	19	0	10	2	14	1	2	0	0	52	3.9	18
4- 3 -69	1.5	52	0	112	3	119	33	75	13	21	0	29	476	59.9	89
5-12-69	0	5	0	59	1	30	0	36	1	1	0	0	133	26.3	47
5-12-69	1.5	57	0	111	2	152	18	151	9	3	2	20	525	93.3	99
6-18-69	0	3	0	41	4	51	4	27	5	3	0	3	141	13.5	30
6-18-69	1.5	18	0	39	2	53	3	25	1	4	0	4	149	62.8	54
7-16-69	0	1	0	13	0	11	15	12	5	0	2	4	63	8.5	23
7-16-69	1.5	18	0	76	7	66	21	48	10	4	1	3	264	60.0	54
8-13-69	0	2	0	12	0	14	1	5	0	0	0	0	34	5.4	20
8-13-69	1.5	19	0	60	1	48	11	71	8	6	0	12	236	130.0	58
9-18-69	1.5	2	0	6	0	5	39	7	75	3	1	19	151	124.4	31
10-10-69	1.5	11	6	17	0	14	95	21	82	5	3	23	277	107.0	13
11-25-69	1.5	15	1	30	0	34	100	30	37	13	3	26	289	44.6	88
12-30-69	1.5	33	1	44	1	44	70	57	40	7	5	67	383	182.1	103

Beach: El Capitan		Fauna													
DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4- 3 -69	0	2	0	20	0	19	7	33	2	5	0	0	88	7.8	68
4- 3 -69	1.5	18	0	31	0	30	22	25	2	14	1	8	152	19.3	328
5-12-69	0	0	0	7	0	5	0	4	0	0	0	0	16	2.3	13
5-12-69	1.5	14	0	30	3	48	3	27	0	1	2	3	131	14.4	94
6-18-69	0	1	0	6	0	4	0	3	1	1	0	0	16	1.7	33
6-18-69	1.5	17	0	54	4	64	5	47	1	4	2	11	208	40.7	181
7-16-69	0	0	0	10	0	1	0	3	0	0	0	0	14	2.4	13
7-16-69	1.5	28	0	71	3	59	13	53	2	11	0	6	246	20.7	198
8-13-69	0	0	0	0	0	1	6	1	1	0	0	0	9	1.1	0
8-13-69	1.5	33	0	46	2	72	59	61	19	14	3	25	334	68.9	227
9-18-69	1.5	25	0	27	0	55	72	48	21	8	1	22	279	63.1	232
10-10-69	1.5	2	0	2	0	14	4	1	3	1	0	2	29	3.3	15
11-25-69	1.5	16	0	20	3	37	14	28	12	10	0	5	145	18.5	119
12-30-69	1.5	13	0	11	0	12	14	39	12	1	1	9	112	11.3	80
2-26-70	1.5	6	0	28	1	23	1	9	1	2	0	5	74	8.5	80

Beach: Goleta DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4- 3 -69	0	1	0	16	0	0	1	3	0	3	0	2	26	4.3	150
4- 3 -69	1.5	8	1	35	0	14	39	38	3	15	0	10	173	99.5	371
5-10-69	0	3	0	51	0	12	1	35	0	0	0	1	103	40.1	110
5-10-69	1.5	33	2	61	1	61	43	83	1	4	0	31	320	153.2	0
6-17-69	0	8	0	54	0	13	9	31	5	3	0	0	123	13.9	0
6-17-69	1.5	5	1	13	1	9	64	20	20	2	5	17	157	261.0	290
7-15-69	0	2	0	14	0	4	3	9	13	0	0	2	47	6.2	13
7-15-69	1.5	12	1	36	1	18	20	32	6	1	0	6	133	93.9	125
8-13-69	0	5	1	31	0	11	19	23	3	4	0	8	105	15.1	51
8-13-69	1.5	17	1	34	0	26	120	69	17	8	4	46	342	258.4	305
9-18-70	1.5	4	0	3	0	2	256	9	32	4	26	51	387	984.7	292
10-10-69	1.5	7	2	9	0	0	193	19	24	5	12	48	319	287.5	243
11-25-69	1.5	2	4	4	0	6	44	7	11	1	4	22	105	16.0	157
12-30-69	1.5	3	3	9	0	4	57	20	12	5	4	19	136	17.6	141
1-27-70	1.5	5	0	11	0	12	38	44	11	6	2	40	169	29.3	61
2-26-70	1.5	15	0	56	7	72	8	25	5	3	0	24	215	22.5	105

Beach: Arroyo Burro DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
		Fauna													
4- 4 -69	0	0	0	4	0	0	0	3	0	0	0	1	8	1.0	92
4- 4 -69	1.5	6	0	39	0	25	6	23	1	1	0	6	107	10.5	117
5-10-69	0	8	0	161	3	43	1	38	1	2	0	0	257	52.3	245
5-10-69	1.5	12	0	98	1	56	2	22	0	3	0	10	204	37.1	138
6-17-69	0	8	0	30	2	46	22	38	2	5	2	24	179	44.8	123
6-17-69	1.5	11	0	31	1	43	36	44	7	2	0	27	202	54.9	249
7-15-69	0	44	0	127	1	113	39	182	15	12	0	23	556	130.2	357
7-15-69	1.5	16	0	34	0	39	43	60	5	10	1	16	224	116.6	248
8-13-69	0	9	0	26	0	11	10	36	3	0	0	9	104	33.1	44
8-13-69	1.5	17	1	23	0	36	67	54	31	10	3	24	266	27.1	348
9-17-69	1.5	10	0	11	0	14	37	50	33	5	3	21	184	159.7	186
10-9-69	1.5	4	1	2	0	3	13	6	8	1	1	5	44	3.7	36
11-24-69	1.5	12	0	18	0	26	20	50	22	6	0	22	176	20.8	129
12-29-69	1.5	6	0	11	0	11	37	30	12	7	2	18	134	17.1	86
12-29-69	1.5	12	2	23	0	19	56	45	16	1	8	23	205	24.5	227
1-27-69	1.5	0	0	1	0	3	4	3	5	0	1	1	18	1.4	15
2-25-70	1.5	12	0	11	0	22	14	41	8	8	2	24	143	14.2	135

Beach: Summerland DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna: Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4- 4 -69	0	0	0	4	0	4	5	0	0	1	2	3	19	1.8	24
4- 4 -69	1.5	10	4	36	0	8	42	29	3	0	5	19	160	38.2	446
5-10-69	0	8	0	97	1	38	1	52	4	0	0	1	202	172.5	121
5-10-69	1.5	14	0	64	5	62	6	46	0	1	0	7	205	87.5	184
6-17-69	0	2	0	48	0	27	10	30	1	3	2	3	126	31.8	120
6-17-69	1.5	11	0	37	0	10	78	42	9	1	8	28	224	137.5	325
7-15-69	0	17	0	66	0	37	5	60	2	4	0	10	201	25.7	98
7-15-69	1.5	10	0	39	0	19	56	56	7	2	1	32	222	181.5	250
8-12-69	0	2	0	26	0	5	2	11	0	1	0	0	47	5.3	40
8-12-69	1.5	11	0	53	1	27	14	46	7	2	0	14	175	86.7	149
9-17-69	1.5	1	5	14	0	0	146	14	46	5	16	13	260	426.2	296
10-9 - 69	1.5	0	1	3	1	6	14	5	2	4	1	3	40	4.9	40
11-24-69	1.5	2	0	7	2	8	50	9	8	1	2	11	100	12.7	143
12-29-69	1.5	13	3	16	0	15	169	53	33	12	13	84	411	47.1	359
1-26-69	1.5	5	2	18	0	10	50	20	12	3	1	52	173	88.4	214
2-26-69	1.5	28	2	86	3	51	30	80	6	9	0	45	340	34.0	426

Beach: Carpinteria DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna: Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
5-16-69	0	2	0	27	1	11	1	19	1	2	0	1	65	14.9	66
5-16-69	1.5	15	1	89	1	31	11	82	12	0	0	8	252	47.0	266
6-18-69	0	6	0	71	1	22	7	75	5	2	0	1	190	43.4	101
6-18-69	1.5	3	0	50	0	22	0	33	1	0	0	3	112	26.8	134
7-15-69	0	13	0	111	0	33	15	67	2	7	0	3	251	29.1	127
7-15-69	1.5	11	0	68	0	14	88	68	13	8	5	35	310	42.3	298
8-12-69	0	2	0	6	0	3	24	8	2	0	0	0	45	5.5	25
8-12-69	1.5	12	1	73	1	45	13	70	9	12	2	15	253	75.1	253
9-17-69	1.5	7	2	11	0	6	49	32	12	5	0	22	146	26.5	93
10-9-69	1.5	0	0	1	0	0	1	0	0	0	0	4	6	0.5	7
11-24-69	1.5	0	0	5	1	2	27	7	13	2	3	6	66	13.4	61
12-29-69	1.5	2	0	4	1	7	0	4	1	0	1	4	24	2.2	13
1-26-70	1.5	1	1	5	1	0	22	6	8	0	2	13	57	6.3	70
2-25-70	1.5	1	0	1	0	0	8	14	3	1	0	14	42	3.4	54

Beach: Emma Wood DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
5-16-70	0	0	0	14	1	0	0	2	0	0	0	0	17	1.8	29
5-16-70	1.5	1	1	59	1	25	1	16	4	3	1	6	118	24.7	318
6-11-70	0	3	0	37	0	10	2	12	2	3	0	1	70	29.0	131
6-11-70	1.5	18	1	52	0	43	7	63	26	10	1	22	243	44.0	0
7-17-69	0	1	0	18	1	7	3	10	0	1	0	0	41	4.2	73
7-17-69	1.5	0	0	39	1	3	0	26	1	5	0	2	76	7.3	266
8-12-69	0	1	0	12	0	3	1	1	0	0	0	0	18	1.9	31
8-12-69	1.5	6	1	61	0	21	3	35	8	4	1	5	145	41.9	268
9-19-69	1.5	0	0	0	0	0	0	0	7	1	0	0	8	0.7	6
10-13-69	1.5	1	0	1	0	6	3	9	2	1	0	3	23	2.1	159
11- 4 -69	1.5	4	2	10	0	4	12	14	10	5	0	0	61	7.3	432

Beach: Hollywood DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna: Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4-11-69	0	0	0	1	0	1	0	0	0	0	0	0	2	0.2	5
4-11-69	1.5	0	0	2	0	23	1	0	0	1	0	4	31	1.7	65
5-9-69	0	0	0	1	0	0	2	0	0	0	0	0	3	0.5	9
5-9-69	1.5	1	0	6	0	0	0	1	0	0	0	0	8	3.5	22
6-11-69	0	0	0	4	0	2	0	1	0	0	0	0	7	0.9	17
6-11-69	1.5	0	0	8	0	2	0	0	0	0	0	2	12	1.5	43
7-17-69	0	0	0	4	0	3	0	0	0	0	0	1	8	19.0	23
7-17-69	1.5	0	0	10	0	1	0	16	1	1	0	0	29	2.9	27
8-14-69	0	0	0	0	0	1	1	0	1	0	0	0	3	0.3	4
8-14-69	1.5	0	0	1	0	10	0	0	0	1	0	0	12	0.9	30
9-19-69	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.0	4
10-13-69	1.5	1	1	3	0	25	0	1	3	0	0	3	37	7.8	194
11-4-69	1.5	0	0	0	0	2	0	0	1	0	0	2	5	0.3	10
12-23-69	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.0	4
1-28-70	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.0	2
2-24-70	1.5	0	0	1	0	3	1	0	0	0	0	2	7	0.5	21

Beach: Pt. Magu DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4-11-69	0	0	0	0	0	0	0	0	0	1	0	0	1	0.1	4
4-11-69	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1
5- 9 -69	0	0	0	0	0	3	0	1	0	0	0	0	4	2.3	8
5- 9 -69	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.0	2
6-11-69	0	0	0	1	0	4	0	0	1	1	0	0	7	0.6	30
6-11-69	1.5	0	0	0	0	2	0	0	0	0	0	0	2	0.2	5
7-17-69	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1
7-17-69	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0
8-14-69	0	0	0	0	0	0	0	0	0	1	0	0	1	0.1	3
8-14-69	1.5	0	0	0	0	1	0	0	1	0	0	1	3	0.2	14

Beach: Zuma DATE	Water Depth (meters)	Buccella tenerrima	Buliminella elegantissima	Fauna Cibicides fletcheri	Elphidium crispum	Elphidiella hannai	Rosalina globularis	Rotorbinella lomaensis	misc. elphidiids	misc. hyaline spp.	misc. agglut. spp.	miliolids	Total	foram. per 100 gm.	No. fossil foram.
4-11-69	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1
4-11-69	1.5	0	0	11	0	0	2	12	0	1	0	0	26	10.0	61
5- 9 -69	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1
5- 9 -69	1.5	0	0	2	0	0	0	1	0	0	0	0	3	2.0	8
6-20-69	0	0	0	7	0	0	0	4	0	0	0	0	11	1.3	5
6-20-69	1.5	0	0	7	0	1	1	16	3	1	0	0	29	2.3	26
7-17-69	0	0	0	1	0	0	0	0	0	0	0	0	1	0.1	4
7-17-69	1.5	0	0	0	0	0	0	1	0	0	0	0	1	0.0	16
8-14-69	0	0	0	0	0	0	3	0	0	0	0	0	3	0.3	1
8-14-69	1.5	0	0	3	0	0	3	12	3	2	0	2	25	2.8	17
9-23-69	1.5	0	0	2	0	1	3	7	3	2	0	1	19	1.9	7
10-13-69	1.5	0	1	4	0	0	5	7	2	1	0	1	21	1.9	17
11-26-69	1.5	0	0	16	0	2	8	26	5	5	0	11	73	6.8	27
12-23-69	1.5	0	0	1	0	0	4	6	1	0	0	1	13	1.2	0
1-28-70	1.5	0	0	0	0	0	0	1	0	0	0	0	1	0.1	2
2-24-70	1.5	1	0	2	0	0	2	1	3	0	0	1	10	1.8	10

APPENDIX 6

Nearshore foraminiferal values.

Sample Number	IIC		IID		IIIA		IIIB		IIIC		IIID		IVA		IVB		IVC		IVD		VIB		VIC		VID		VIIIA		VIIIB		VIIIC		VIIID		XA		XB		XC	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B. vaughani	2	0	0	4	0	2	0	0	1	14	0	0	1	0	1	3	2	1	0	1	0	0	0	0	0	2	1	2	1	1	1	1	0	3	0	0	2	4	0	1
Buccella frigida	0	2	3	8	0	2	1	4	7	15	5	6	0	0	0	1	1	1	5	7	1	5	2	10	2	13	0	0	3	2	1	9	2	26	0	1	0	2	0	20
Bulimina marginata denudata	3	13	2	21	0	0	0	1	0	15	1	18	0	0	0	0	1	7	3	22	2	3	3	13	7	45	0	1	0	5	1	7	3	59	0	0	0	2	1	16
Bulimina elegantissima	2	2	3	12	23	53	33	74	16	53	8	20	30	10	49	29	1	3	1	32	4	9	2	7	3	20	53	18	5	14	4	3	3	13	5	3	6	15	3	23
Cassidulina spp.	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	5
Cancris auricula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Cibicides fletcheri	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0
Elphidiella hannai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Epistominella bradyana	0	1	0	4	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Florilus scaphus basispinatus	0	6	0	2	0	6	0	2	1	10	0	7	0	1	0	2	1	1	0	12	0	5	2	12	4	20	0	3	0	11	0	8	2	15	0	1	0	6	2	5
Hopkinsina pacifica	0	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Nonionella miocenica stella	1	26	6	49	0	13	0	30	3	95	6	74	0	2	2	8	3	22	15	121	0	38	11	54	7	105	0	5	0	35	2	79	1	56	0	2	2	15	11	99
Rosalina globularis	0	6	0	4	0	2	0	3	0	3	0	1	1	28	1	19	0	6	0	0	0	0	0	1	0	2	0	8	0	6	0	5	0	1	0	16	0	6	0	3
Rotorbinella lomaensis	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	2	0	1	0	1
R. versiformis	0	10	0	3	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	4	0	6	0	0	0	0	0	5	0	11	0	0	0	1	0	3
Uvigerina juncea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. elphidiids	0	0	0	1	1	4	0	12	0	11	0	1	0	9	0	12	0	3	0	13	0	3	0	0	0	2	0	6	0	4	0	10	0	5	2	14	0	10	0	14
Misc. nonionids	0	9	1	7	0	0	0	1	0	7	1	10	0	0	0	0	0	3	9	18	0	2	2	12	1	18	0	2	1	3	5	12	0	12	0	0	0	3	0	3
Misc. calcareous hyaline	0	23	0	2	0	51	1	39	0	63	0	35	0	41	0	46	0	13	0	33	0	11	0	0	0	22	0	13	0	39	0	41	0	35	0	47	0	24	1	80
Misc. porcelaneous	0	4	0	2	6	109	7	92	0	37	1	51	3	60	2	43	0	7	0	5	0	0	0	5	0	1	0	12	0	10	0	4	0	1	10	38	0	11	0	3
Eggerella advena	0	6	1	23	0	10	0	6	0	184	0	0	0	2	0	2	0	11	1	97	1	49	0	6	0	29	0	1	2	10	1	20	2	56	0	0	0	1	0	43
Guadryina arenaria	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goesella flintii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides advenus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	7	0	0	0	0	0	3	0	8	0	0	0	0	0	0
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccammina atlantica	0	1	0	1	0	0	0	9	0	24	0	3	0	0	0	0	0	7	0	5	0	22	0	13	0	5	0	0	0	2	0	1	0	11	0	0	0	4	0	2
Textularia conica	0	7	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	1	0	0	0	2	0	5	0	0	0	0	0	0
T. earlandi	0	0	0	1	0	0	0	1	0	14	0	7	0	0	0	0	0	0	0	8	0	0	0	0	0	3	0	0	0	1	0	3	1	10	0	0	0	0	0	3
Trochammina pacifica	0	12	0	39	0	3	0	1	0	31	0	1	0	1	0	7	0	111	0	122	0	66	0	40	1	33	0	3	2	41	0	34	0	40	0	4	0	97	0	34
T. spp.	0	0	0	0	0	11	0	7	0	36	0	14	0	3	0	3	0	2	0	7	0	14	0	9	0	6	0	3	0	11	0	21	0	7	0	0	0	0	0	21
Misc. agglutinated	0	2	0	7	0	3	0	5	0	4	0	0	0	1	0	1	0	3	0	10	0	2	0	3	0	10	0	0	0	1	0	0	0	2	0	0	0	7	0	2
Total benthonic forams.	9	132	16	221	30	271	44	288	30	615	22	261	35	160	56	184	9	202	34	523	8	234	22	190	25	358	54	72	14	196	15	273	14	376	17	130	10	237	18	384
Planktonics	0	90	0	48	0	10	0	31	0	5	0	21	0	70	0	25	0	15	0	49	0	13	0	59	0	59	0	19	0	17	0	62	0	27	0	28	0	16	0	43
Foraminifera/gram	179.4		43.2		19.8		22.7		73.1		35.3		24.8		85.5		30.0		59.4		16.7		25.6		24.6		39.2		37.2		25.9		71.9		23.3		18.2		32.0	
Benthonic/gram	109.3		35.9		19.2		20.8		72.5		32.9		18.3		77.5		28.0		54.6		15.8		23.3		21.3		34.1		34.4		21.3		67.2		19.6		17.1		28.9	
Planktonic/gram	69.8		7.3		0.6		1.9		0.6		2.4		6.5		8.0		2.0		4.8		0.9		2.3		3.3		5.1		2.8		4.6		4.7		3.7		1.1		3.1	
Living/gram	7.0		2.4		1.9		2.8		3.4		2.6		3.3		18.1		1.2		3.3		0.5		2.4		1.4		14.6		2.3		1.1		2.4		2.3		0.7		1.3	
Dead/gram	102.3		33.5		17.3		18.0		69.1		30.3		15.0		59.4		26.8		51.3		15.3		20.9		19.9		19.5		32.1		20.2		64.8		17.3		16.4		27.6	
Planktonic/benthonic ratio	0.638		0.203		0.033		0.093		0.008		0.074		0.359		0.104		0.071		0.088		0.054		0.099		0.154		0.151		0.081		6.6		14.2		0.191		0.065		0	
Live-dead ratio	0.07		0.07		0.11		0.10		0.05		0.08		0.22		0.30		0.04		0.07		0.03		0.12		0.07		0.75		0.07		0.05		0.04		0.13		0.04		0.05	
% Hyaline / % Porc. + % Agglut. - Total	3		2		1		2		1		2		2		3		0.5		1		0.5		2		3		5		2		2		2		2		0.7		3	
" " - Living	100		16		4		5		100		19		10		24		100		32		7		100		24		100		2		13		4		0.7		100		100	
" " - Dead	3		2		1		1		0.9		2		1		2		0.4		1		0.5		1		3		3		2		2		2		2		0.7		3	
% Nonionidea - Total	29.8		27.4		6.3		10.0		17.8		34.6		1.5		5.4		14.2		31.4		18.6		43.8		40.5		8.0		23.8		36.8		22.0		2.0		1.1		29.9	
" - Living	11.1		43.7		0		0		13.3		31.8		0		3.6		44.5		70.7		0		68.2		48.0		0		7.2		46.7		21.4		0		20.0		72.3	
% B. elegantissima - Total	2.8		6.3		25.2		32.2		10.6		9.8		20.5		32.5		1.8		5.9		5.3		4.2		16.4		56.3		9.0		2.4		4.1		5.4		8.5		6.4	
" - Living	22.2		18.7		76.6		75.0		53.3		36.3		85.7		87.5		11.1		2.9		50.0		9.0		4.0		98.1		35.7		26.6		21.4		29.4		60.0		16.6	
E. advena + % T. pacifica - Total	14.1		26.5		4.3		2.1		33.3		18.7		1.5		3.7		57.8		39.4		47.9		21.6		6.0		3.1		26.1		19.0		25.1		2.7		43.7		19.1	
" " - Living	0		6.2		0		0		0		4.5		0		0		0		2.9		12.5		0		12.0		0		28.5		6.6		14.2		0		0		0	

Sample Number	XD		XIIA		XIIB		XIIC		XIID		XIVA		XIVB		XIVC		XIVD		XVIA		XVIB		XVIC		XVIIIA		XVIIIB		XVIIIC		XVIIID		XXB		XXC		XXD		XXIIB	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0
B. pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. vaughani	0	1	2	1	2	3	3	1	1	0	0	0	1	0	0	2	0	2	6	5	5	1	0	3	1	1	2	7	0	4	0	0	0	1	0	2	0	2	0	2
Buccella frigida	1	20	0	1	1	7	2	3	2	5	0	0	1	6	2	18	0	8	23	4	36	13	7	51	0	1	8	16	16	24	19	56	22	9	23	12	6	8	0	1
Bulimina marginata denudata	0	18	0	0	0	0	0	0	0	7	0	0	0	2	0	5	2	11	1	4	4	14	1	5	0	0	4	2	11	5	23	37	2	5	5	10	8	6	0	0
Buliminella elegantissima	1	18	57	58	38	49	27	21	14	15	9	4	2	16	2	17	4	11	14	23	11	9	7	4	15	29	8	18	11	10	7	3	16	20	18	5	13	13	12	4
Cassidulina spp.	0	1	0	2	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cancris auricula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cibicides fletcheri	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2	0	0	0	22	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Elphidiella hannai	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistominella bradyana	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Floritus scaphus basispinatus	2	15	0	1	0	6	6	6	2	1	0	0	0	4	2	5	0	5	0	0	0	3	1	2	0	0	1	2	3	8	8	11	0	1	3	11	0	5	0	0
Hopkinsina pacifica	0	0	0	0	0	0	0	1	1	1	0	0	0	0	3	1	0	3	0	4	1	11	2	5	0	0	2	2	2	4	0	0	1	0	1	3	0	0	1	0
Nonionella miocenica stella	4	79	1	3	2	5	43	90	36	50	0	1	0	1	16	97	4	5.	9	28	21	30	19	37	5	4	19	59	40	94	46	72	41	100	39	100	17	48	0	0
Rosalina globularis	0	0	1	16	0	1	0	1	0	0	2	56	0	24	0	2	0	1	2	37	0	0	0	11	0	15	0	3	0	0	0	0	0	5	0	0	0	0	0	15
Rotorbinella lomaensis	0	0	0	0	0	1	0	0	0	0	0	3	0	2	0	2	1	0	0	12	0	0	0	11	0	2	0	0	0	0	0	0	0	1	0	0	0	0.	0	3
R. versiformis	0	6	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uvigerina juncea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. elphidiids	0	2	0	9	1	16	0	3	0	1	5	14	0	22	0	36	0	6	1	7	1	10	0	12	1	8	0	7	0	0	0	0	0	22	0	1	0	0	1	18
Misc. nonionids	1	7	0	0	0	0	5	5	3	2	0	0	0	0	1	2	0	9	0	1	0	0	4	6	0	0	1	5	1	7	4	8	0	0	3	4	7	3	0	0
Misc. calcareous hyaline	0	40	0	55	1	35	1	44	1	16	0	100	0	77	0	203	0	44	0	39	0	21	0	118	0	13	1	27	0	30	0	13	0	18	0	4	1	7	0	18
Misc. porcelaneous	0	0	10	21	3	22	2	7	0	0	0	22	2	31	0	2	0	0	4	12	0	3	0	5	3	67	0	2	0	1	0	0	1	3	0	0	0	1	0	12
Eggerella advena	0	43	0	0	0	7	3	24	3	36	0	0	0	1	0	9	3	27	1	26	2	84	2	4	0	6	3	34	2	44	-	-	0	13	0	19	1	35	0	0
Guadryina arenaria	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goesella flintii	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Haplophragmoides advenus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	2	0	0	0	0	0	1	0	0
Recurvoides contortus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6	0	0
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccammina atlantica	0	1	0	1	0	5	0	3	0	0	0	0	0	0	0	4	0	2	0	0	0	5	0	1	0	0	0	12	0	2	0	1	0	0	0	1	0	0	0	0
Textularia conica	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. earlandi	0	2	0	0	0	0	0	6	0	0	0	0	0	0	0	2	1	2	0	3	0	2	0	1	0	0	0	1	0	6	0	0	0	3	0	0	0	20	0	0
Trochammina pacifica	0	5	1	6	0	0	0	4	0	1	0	0	0	7	0	7	0	1	0	4	0	11	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	26	0	1
T. spp.	0	3	0	2	0	3	0	3	0	3	1	3	0	8	0	11	0	5	0	21	0	1	0	2	0	13	0	0	0	0	0	0	0	3	0	2	0	0	0	2
Misc. agglutinated	0	6	0	1	0	0	1	1	0	7	0	1	0	2	0	1	0	3	0	24	0	5	0	4	0	17	0	25	0	3	0	0	0	7	0	3	0	4	0	0
Total benthonic forams.	9	270	72	179	40	161	93	222	63	148	17	205	6	206	26	428	14	192	62	257	81	228	43	317	25	182	49	225	87	246	107	206	83	211	92	177	54	185	14	77
Planktonics	0	22	0	31	0	16	0	21	0	10	0	83	0	101	0	177	0	24	0	24	0	5	0	106	0	8	0	10	0	1	0	0	0	20	0	0	0	2	0	53
Foraminifera/gram	40.7		68.9		48.9		140.1		27.7		234.6		66.6		175.3		115.0		88.0		73.0		637.5		69.4		78.9		196.5		92.0		196.3		134.5		22.9		59.9	
Benthonic/gram	37.7		61.3		45.4		131.3		26.4		170.8		45.1		126.1		103.0		81.8		71.8		490.3		66.8		76.1		195.9		92.0		183.8		134.5		22.7		37.9	
Planktonic/gram	3.0		7.6		3.5		8.8		1.3		63.8		21.5		49.2		12.0		6.2		1.2		147.2		2.6		2.8		0.6		0		12.5		0		0.2		22.0	
Living/gram	1.2		17.6		10.4		38.8		7.9		13.1		1.3		7.2		7.0		15.9		18.8		50.0		8.1		13.6		51.2		31.4		51.9		46.0		5.1		5.8	
Dead/gram	36.5		43.7		35.0		92.5		18.5		157.7		43.8		118.9		96.0		65.9		53.0		440.3		58.7		62.5		144.7		60.6		131.9		88.5		17.6		32.1	
Planktonic/benthonic ratio	0		0.124		0		3.2		4.7		0		0		0		0.117		1.6		0.016		0.300		0.039		0.036		0.003		0		0.068		0		0.008		0.582	
Live-dead ratio	0.03		0.40		0.30		0.42		0.43		0.08		0.03		0.06		0.07		0.24		0.36		0.11		0.14		0.22		0.35		0.52		0.39		0.52		0.29		0.18	
% Hyaline / % Forc. + % Agglut. - Total	4		5		4		5		3		7		3		12		4		2		2		12		1		2		4		99		9		10		2		5	
" " - Living	100		6		16		16		24		16		2		100		2		12		32		16		7		16		32		100		99		100		24		100	
" " - Dead	3		5		3		4		2		7		3		4		4		2		1		12		0.8		2		3		49		6		6		1		4	
% Nonionidae - Total	38.7		2.0		6.2		58.0		44.4		0.01		2.6		27.2		32.5		11.9		17.5		17.2		4.4		31.7		50.0		47.5		48.3		59.5		33.4		0	
" - Living	78.0		1.4		5.0		49.2		65.0		0		0		73.0		28.6		16.1		25.9		53.5		20.0		42.8		50.6		54.0		49.5		49.0		44.4		0	
% B. elegantissima - Total	6.8		45.8		41.6		15.2		13.7		5.8		8.4		4.1		7.2		11.5		6.4		2.7		21.2		9.4		6.3		3.1		12.2		8.5		10.8		17.5	
" - Living	11.1		79.1		79.1		29.0		22.2		52.9		33.3		7.6		28.5		22.5		13.5		16.2		60.0		16.3		12.6		6.5		19.2		19.5		24.0		85.7	
E. advena + % T. pacifica - Total	17.2		2.7		3.3		9.8		18.9		0		3.7		3.5		15.0		9.7		31.3		1.5		2.8		13.5		14.1		0		4.4		7.0		25.9		1.0	
" " - Living	0		1.3		0		3.2		4.7		0		0		0		21.4		1.6		2.4		4.6		0		6.1		2.2		0		0		0		1.8		0	

Sample Number	XXIIC		XXIID		XXIVA		XXIVB		XXIVC		XXIVD		12-9-26		12-9-27		12-9-28		12-9-33		12-9-34		12-9-35		12-9-36		12-9-41		12-9-42		12-9-43		12-9-44	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	8	0	0	0	0	0	1	0	0	0	0	0	1	0	2	3	7
B. pacifica	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	3	0	0	0	0	0	1	0	2	0	0	0	4	0	3	2	14
B. vaughani	1	1	0	2	0	0	2	3	1	1	0	1	6	3	0	5	0	2	8	2	1	3	1	4	0	3	6	5	0	2	1	1	0	1
Buccella frigida	2	16	5	3	0	1	1	1	5	17	1	17	6	9	5	6	8	12	2	6	5	9	6	9	12	5	1	0	6	8	1	14	8	14
Bulimina marginata denudata	0	5	0	0	0	0	0	0	2	3	1	5	1	15	4	29	12	47	3	1	2	24	8	35	3	27	0	1	5	43	2	61	6	24
Buliminella elegantissima	3	2	38	21	79	19	70	85	19	41	10	14	4	8	11	16	6	8	7	11	12	17	7	16	6	13	6	6	7	21	6	12	8	24
Cassidulina spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cancris auricula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cibicides fletcheri	0	6	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidiella hannai	0	16	0	2	0	5	0	3	0	4	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistominella bradyana	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	8	0	0	0	0	0	1	0	1	0	0	0	0	0	3	0	1
Florilus scaphus basispinatus	0	4	0	2	0	1	0	4	2	10	0	6	1	6	3	13	1	13	1	2	12	26	1	9	5	7	0	3	2	7	18	32	8	18
Hopkinsina pacifica	0	0	3	0	0	0	0	1	9	5	5	6	0	0	1	0	0	0	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Nonionella miocenica stella	1	4	1	11	0	0	0	8	37	121	3	60	15	52	6	54	3	38	0	8	46	50	5	32	5	21	7	17	14	44	3	25	3	21
Rosalina globularis	1	24	0	10	1	14	0	2	0	0	0	0	0	18	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	2	0	0	0	0
Rotorbinella lomaensis	0	18	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	1	0	0	0	0	0	0	0	0	0	0	0	7	0	1	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Uvigerina juncea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. elphidiids	2	21	0	13	0	10	0	5	2	4	0	5	0	11	0	0	0	0	3	4	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Misc. nonionids	0	0	1	0	0	0	0	0	0	3	1	0	7	8	2	6	2	3	0	0	8	13	2	7	7	6	1	1	5	11	1	5	4	3
Misc. calcareous hyalin'	0	31	0	8	0	52	0	26	0	28	0	24	0	42	1	59	0	41	0	27	0	21	1	21	0	16	0	76	0	22	0	14	0	27
Misc. porcelaneous	1	50	0	6	1	5	1	3	1	9	0	6	1	9	0	0	0	1	2	7	0	0	0	0	0	2	0	2	0	0	0	1	0	0
Eggerella advena	1	1	0	12	0	0	0	16	0	53	0	45	3	23	2	31	0	3	1	24	0	9	0	1	1	13	1	15	0	21	0	9	1	15
Guadryina arenaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
Gossella flintii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0	1	0	9	0	3
Haplophragmoides advenus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	8	0	4	0	2
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0
Saccammina atlantica	0	2	0	1	0	0	0	0	1	11	0	8	0	2	0	0	0	0	0	12	0	3	0	0	0	2	0	0	0	2	0	3	0	1
Textularia conica	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	1	0	5	0	0	0	1	0	0	0	2	0	0	0	4	0	0	0	0
T. earlandi	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	9	0	5	0	0	0	1	1	5	0	18	0	1	0	4	0	6	0	15
Trochammina pacifica	0	14	0	17	0	0	0	1	0	2	0	1	0	48	0	1	0	0	0	8	0	0	0	0	0	1	0	0	0	0	0	0	0	1
T. spp.	0	7	0	8	0	2	0	12	0	4	0	0	0	3	0	0	1	5	0	5	0	1	0	1	0	0	0	2	0	0	0	0	0	0
Misc. agglutinated	0	7	0	1	0	1	0	10	0	7	0	6	0	1	0	9	0	1	0	1	0	0	0	2	0	5	0	0	0	5	0	5	0	0
Total benthonic forams.	12	230	48	118	81	112	74	181	79	317	21	213	45	279	35	254	40	215	27	121	86	178	33	147	39	155	22	140	39	211	32	210	43	193
Planktonics	0	20	0	11	0	51	0	7	0	20	0	2	0	89	0	17	0	15	0	10	0	10	0	4	0	3	0	48	0	10	0	12	0	13
Foraminifera/gram	48.5		19.9		22.2		16.5		27.2		12.5		48.6		66.5		25.7		23.0		85.6		27.9		63.6		110.6		66.7		29.9		63.8	
Benthonic/gram	44.8		18.7		17.6		16.1		25.9		12.4		38.1		62.8		24.3		20.6		82.5		27.3		62.6		85.3		64.1		28.5		60.5	
Planktonic/gram	3.7		1.2		4.6		0.4		1.3		0.1		10.5		3.7		1.4		1.4		3.1		0.6		1.0		25.3		2.6		1.4		3.3	
Living/gram	2.2		5.4		7.4		4.7		5.2		1.1		5.3		7.6		3.8		3.8		26.9		5.0		12.6		11.6		10.0		3.8		11.0	
Dead/gram	42.6		13.3		10.2		11.4		20.7		11.3		32.8		55.2		20.5		16.8		55.6		22.3		50.0		73.7		54.1		24.7		49.5	
Planktonic/benthonic ratio	0.083		0.067		0.264		0.027		0.051		0.009		0.275		0.059		0.059		0.068		0.038		0.022		0.015		0.296		0.040		0.050		0.055	
Live-dead ratio	0.05		0.41		0.72		0.41		0.25		0.10		0.16		0.14		0.19		0.22		0.48		0.22		0.25		0.16		0.18		0.15		0.22	
% Forc. + % Agglut. / % Hyaline - Total	2		3		19		5		4		3		2		4		9		1		16		24		3		7		5		5		5	
" " - Living	5		100		99		99		32		100		8		16		49		8		100		32		32		19		100		100		49	
" " - Dead	2		2		13		3		3		2		2		4		8		1		10		12		2		6		4		5		4	
% Nonionidea - Total	3.7		9.0		1.0		43.7		29.9		29.9		27.5		29.0		25.9		7.4		58.7		20.0		26.3		17.9		33.6		34.7		24.2	
" - Living	8.3		4.2		0		49.3		20.0		20.0		51.0		31.4		15.0		3.7		76.8		24.2		43.5		36.4		54.0		88.8		34.9	
% B. elegantissima - Total	2.0		35.5		50.7		60.7		15.1		10.2		3.7		9.3		5.4		25.9		10.9		8.2		9.7		7.4		11.2		7.4		13.5	
" - Living	25.0		79.1		40.9		94.5		24.0		47.6		8.8		31.4		15.0		12.1		13.9		21.2		15.3		27.2		17.9		18.7		18.6	
E. advena + % T. pacifica - Total	6.6		17.4		0		6.0		13.6		19.6		22.8		11.7		1.1		22.2		3.4		0.3		7.7		9.8		10.0		3.7		7.2	
" " - Living	8.3		0		0		0		0		0		6.6		5.7		0		3.7		0		0		2.5		4.5		0		0		2.3	

APPENDIX 7

Offshore foraminiferal values.

Sample Number	12732		12733		12734		12741		12742		12743		12754		12755		12757		12758		12759		12761		12762		12763		12764		12765		12769		12770		12772		12796	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	1	5	13	3	6	27	3	0	15	2	52	13	3	5	0	5	8	13	12	41	1	10	2	6	3	10	2	23	8	5	2	3	2	1	1	3	0	0	0	10
B. argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	0	0	16	42	1	17	8	2	12	5	12	6	0	2	0	4	2	6	0	7	2	6	2	12	6	6	0	1	4	0	1	5	1	4	3	0	0	0	0	0
B. vaughani	0	1	1	3	0	6	0	0	21	3	0	3	1	6	3	1	0	3	0	4	1	4	5	5	2	2	2	2	0	2	0	0	1	3	2	1	0	0	0	0
B. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buccella frigida	1	15	1	6	11	14	0	2	13	10	6	1	20	65	0	0	2	46	8	17	12	47	28	101	6	147	6	69	9	143	18	160	21	81	2	24	2	9	4	75
Bulimina marginata denudata	5	21	32	110	7	30	9	7	45	15	16	21	24	0	25	68	25	59	22	71	13	54	6	16	5	33	44	202	34	51	9	29	6	34	1	8	0	0	20	305
Buliminella elegantissima	12	5	4	7	8	6	6	6	15	34	20	4	22	10	15	10	6	9	15	9	19	13	34	39	18	14	8	3	8	4	11	12	15	36	6	18	33	2	0	5
Cassidulina spp.	0	0	0	33	0	16	0	1	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	41	0	0	0	1	0	0	0	0	0	0
Cancris auricula	0	0	0	0	2	2	0	0	0	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cibicides fletcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidiella hannai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	12	0	5	0	5	0	0	0	0
Epistominella bradyana	0	2	2	16	0	9	0	0	0	0	0	18	0	5	1	1	0	7	0	0	0	0	0	0	1	3	0	19	1	6	0	3	1	4	0	0	0	0	0	3
Florilus scaphus baslespinatus	6	3	0	1	3	6	12	1	35	14	15	2	17	35	7	16	18	17	0	2	10	24	5	19	13	21	9	44	93	19	16	7	10	11	2	3	4	2	4	66
Hopkinsina pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	18	9	9	3	0	0	27	4	9	4	7	4	0	0	0	0	0	0
Nonionella miocenica stella	1	20	4	7	2	72	9	6	81	46	29	15	6	21	11	81	2	100	6	32	16	66	19	82	18	44	0	143	24	85	10	64	19	84	18	40	33	15	0	85
Rosalina globularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rotorbinella lomaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	0	0	0	0	3	0	0	0	1	0	0	2	15	0	0	0	2	2	1	1	0	0	0	0	0	0	2	0	2	0	0	0	2	0	0	0	0	0	0
Suggerunda eckisi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uvigerina juncea	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. elphidiids	0	0	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	10	0	22	0	6	1	11	0	0
Misc. nonionids	0	0	0	0	0	2	1	5	3	5	1	1	2	9	3	8	1	4	0	0	3	6	0	4	0	0	0	0	3	2	0	2	4	10	0	0	2	0	0	2
Misc. calcareous hyaline	0	19	0	138	1	264	5	16	9	19	4	54	4	104	2	42	1	57	0	74	4	44	5	58	1	46	0	30	2	3	0	28	0	42	3	42	0	7	0	29
Misc. porcelaneous	0	0	0	0	0	0	1	2	25	14	0	2	2	10	0	0	0	2	1	3	0	0	0	6	0	1	0	1	0	0	1	3	0	10	0	0	0	0	1	1
Eggerella advena	3	3	0	5	1	5	2	2	16	19	5	3	10	36	5	7	3	4	2	1	2	9	21	44	7	15	0	0	0	0	0	3	1	12	0	2	0	0	0	0
Gaudryina arenaria	0	0	0	0	2	7	0	0	0	0	1	1	1	33	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goesella flinti	3	4	0	0	0	0	0	0	84	16	4	1	3*	9	0	2	12	4	3	2	2	7	0	1	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	1
Haplophragmoides advenus	0	0	1	1	0	0	1	0	8	5	3	0	0	0	0	0	1	0	1	0	6	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0
Recurvoides contortus	1	1	0	0	3	3	5	4	14	7	3	3	1	10	0	6	3	6	0	3	0	0	0	0	0	0	0	3	0	3	0	1	2	2	0	0	0	0	0	1
Reophax scorpiurus	1	3	0	0	0	2	0	0	0	0	0	0	0	1	0	3	0	1	1	1	0	0	1	9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	6	0	0	0	6	0	0	8	8	0	0	0	3	2	2	3	3	0	0	0	0	0	0	2	2	0	1	1	0	1	3	0	5	0	0	0	0	0	0
Textularia conica	1	2	0	0	0	8	0	0	1	2	4	1	1	0	0	0	4	6	1	4	0	4	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0
T. earlandi	2	2	1	7	1	3	2	4	2	3	16	26	2	7	0	3	1	3	2	11	3	10	3	9	1	8	0	0	0	1	0	2	2	1	0	0	0	0	0	0
Trochammina pacifica	0	0	0	0	0	1	0	0	5	33	3	2	12	67	0	0	0	0	0	1	0	2	0	5	0	0	0	0	0	0	0	0	0	3	1	2	0	0	0	0
T. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miss. agglutinated	0	2	0	0	0	0	0	0	0	0	0	1	0	9	0	1	0	0	1	5	3	10	1	5	1	0	2	6	0	4	0	1	1	3	0	0	0	0	0	4
Total benthonic forams.	37	135	75	412	47	502	64	57	412	261	195	178	135	513	65	254	91	355	79	293	100	339	151	430	92	359	75	508	214	381	78	352	95	419	39	154	75	38	29	593
Planktonics	0	3	0	83	0	28	0	12	0	31	0	27	0	134	0	1	0	22	0	7	0	10	0	3	0	16	0	4	0	0	0	13	0	37	0	27	0	13	0	7
Foraminifera/gram	32.7		105.8		108.7		41.2		32.2		82.5		16.8		34.0		35.9		39.8		60.7		19.8		47.2		146.8		4.8		40.0		37.8		4.6		0.6		9.9	
Benthonic/gram	32.1		90.4		103.4		37.5		30.8		76.9		13.9		33.9		34.2		39.0		59.3		19.7		45.5		144.8		4.8		38.8		35.3		4.0		0.5		9.8	
Planktonic/gram	0.6		15.4		5.3		3.7		1.4		5.6		2.9		0.1		1.7		0.8		1.4		0.1		1.6		1.0		0		1.2		2.5		0.6		0.1		0.1	
Living/gram	6.9		13.9		8.9		19.8		18.8		40.2		2.9		6.9		7.0		8.5		13.5		5.1		9.3		18.8		1.7		7.1		6.5		0.8		0.3		0.5	
Dead/gram	25.2		76.5		94.5		17.7		12.0		36.7		11.0		27.0		27.2		30.5		45.8		14.6		36.2		126.0		3.1		31.7		28.8		3.2		0.2		9.3	
Planktonic/benthonic	0.017		0.17		0.51		0.099		0.046		0.072		0.207		0.003		0.049		0.019		0.023		0.005		0.035		0.007		0		0.030		0.072		0.140		0.115		0.011	
Live-dead ratio	0.27		0.18		0.09		1.12		1.56		1.09		0.26		0.25		0.25		0.26		0.29		0.35		0.25		0.15		0.57		0.22		0.22		0.25		1.97		0.048	
% Hyaline																																								
% Porc. + % Agglut. - Total	4		32		12		6		2		4		2		9		7		7		4		5		10		32		49		24		10		32		99		49	
" " - Living	2		32		6		5		2		4		3		7		2		5		5		5		7		99		99		49		12		32		100		32	
" " - Dead	5		32		13		4		1		3		2		9		10		7		4		4		12		32		32		24		10		32		32		49	
% Nonionidae - Total	17.4		2.4		15.4		28.0		27.5		16.8		13.8		39.4		31.8		10.7		28.4		22.2		21.2		33.6		37.9		23.0		26.8		32.6		49.5		25.2	
" - Living	18.9		5.3		10.6		34.3		28.8		23.0		18.5		32.3		23.0		7.5		29.0		15.8		33.6		12.0		56.0		44.8		34.7		51.2		52.0		13.7	
% B. m. denudata - Total	15.1		29.1		6.7		13.2		8.9		9.9		3.7		29.1		18.8		25.0		15.2		3.7		8.4		34.6		14.2		8.8		7.7		4.6		0		52.2	
" - Living	13.5		42.6		14.8		14.0		10.9		8.2		17.7		38.4		27.4		27.8		13.0		3.9		5.4		58.6		15.8		11.5		6.3		2.5		0		68.9	
% B. elegantissima - Total	9.8		2.2		2.5		9.9		7.3		6.4		4.9		7.8		3.3		6.4		7.2		12.5		7.0		1.8		2.0		5.3		9.9		12.4		30.9		0.7	
" - Living	32.4		5.3		20.0		9.3		3.6		10.2		16.2		23.0		6.5		18.9		19.0		22.5		19.5		10.6		3.7		14.1		15.7		15.3		44.0		0	

Sample Number	12800		12805		12806		12807		12808		12809		12810		12811		12814		12816		12817		12818		12819		12820		12822		12823		12824		12827		12828		12829	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	2	18	0	12	8	7	8	40	4	9	3	2	8	7	0	0	4	62	0	0	0	6	1	30	0	11	2	5	0	0	0	0	2	4	0	7	0	0	0	0
B. argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	3	12	1	21	10	29	8	42	5	14	1	5	5	8	0	1	0	2	0	1	0	0	0	2	0	0	2	1	0	1	0	0	4	8	8	11	7	3	0	2
B. vaughani	0	0	0	0	0	4	0	7	3	12	4	3	0	2	3	2	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	5	6	3	3
B. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buccella frigida	1	15	2	30	4	3	9	16	3	19	10	60	20	199	9	64	6	75	6	19	2	93	0	8	0	22	7	106	0	4	1	6	14	42	0	3	10	51	1	6
Buliminа marginata denudata	8	30	18	69	1	3	17	74	4	13	7	35	95	179	8	11	22	122	0	1	13	124	26	48	14	177	34	158	0	0	1	3	3	18	1	14	8	28	1	3
Buliminella elegantissima	6	5	7	48	10	6	12	13	8	61	3	16	10	22	8	24	1	12	0	2	0	1	1	6	0	2	0	5	5	12	1	8	5	35	0	3	27	151	2	6
Cassidulina spp.	0	3	0	2	0	0	0	13	0	8	0	6	0	15	0	1	0	5	0	3	0	0	0	4	0	3	0	0	0	0	0	3	0	2	0	27	0	4	0	0
Cancris auricula	1	0	0	0	0	0	1	3	0	1	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0
Cibicides fletcheri	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidiella hannai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	1	0	0	0	2	0	2	1	1	0	0	0	0	0	1	0	1
Epistominella bradyana	1	17	0	6	0	5	0	6	2	16	1	9	2	15	3	3	0	2	0	0	0	2	0	5	0	5	0	2	0	1	0	0	0	3	3	20	0	1	0	1
Florilus scaphus basispinatus	5	3	0	4	1	3	15	22	13	22	3	6	13	37	1	7	0	6	0	1	3	49	5	33	4	81	14	95	0	0	1	0	5	6	1	1	14	6	0	0
Hopkinsina pacifica	0	1	1	0	0	0	0	0	0	0	0	0	7	2	11	7	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	3	1	1	2	2
Nonionella miocenica stella	9	47	8	94	3	15	17	175	8	67	1	21	21	230	9	23	3	55	1	2	1	48	2	41	0	107	4	102	1	1	0	2	9	31	0	0	29	52	6	21
Rosalina globularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Rotorbinella lomanensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	1	0	2	0	0	1	0	0	1	0	7	0	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0
Suggerunda eckisi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uvigerina juncea	0	0	0	2	0	0	0	8	0	0	0	0	0	0	0	0	0	14	0	37	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Misc. alphidids	0	0	0	0	0	0	0	1	0	14	0	1	0	0	0	34	0	0	1	5	0	0	0	0	0	0	0	0	0	3	0	0	0	15	0	0	0	28	1	18
Misc. nonionids	0	3	2	23	0	1	5	8	1	3	0	4	14	41	1	8	0	0	0	0	0	4	0	2	0	3	2	14	0	0	1	0	3	2	1	3	9	17	1	2
Misc. calcareous hyaline	5	67	0	40	0	30	3	128	3	69	1	0	7	69	0	25	0	70	0	3	0	27	2	25	1	15	0	33	0	58	1	44	1	29	0	50	6	28	0	23
Misc. porcelaneous	0	2	0	1	0	1	0	0	0	2	1	1	0	0	0	0	0	1	0	6	0	4	0	1	0	2	0	10	0	0	0	0	0	4	0	0	5	18	1	7
Eggerella advena	1	3	0	22	1	17	2	12	9	16	9	40	5	14	15	128	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	9	0	0	19	61	0	5
Gaudryina arenaria	0	0	0	0	0	0	1	3	0	0	1	6	0	0	0	0	2	7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	33	0	0	0	0
Gossella flinti	4	7	1	75	0	7	0	5	1	1	0	4	0	3	0	0	0	15	0	0	0	1	0	6	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides advenus	1	0	0	3	7	4	0	1	2	1	0	1	2	0	0	1	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planidesimus	0	1	0	2	1	0	0	2	0	0	1	0	5	5	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	3	0	0
Recurveides contortus	1	12	0	7	0	8	1	13	1	3	1	12	2	23	0	0	0	6	0	0	0	4	0	3	0	1	0	7	0	0	0	0	0	4	0	0	2	0	0	0
Reophax scorpiurus	0	1	0	3	0	0	0	0	0	0	0	3	1	7	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	2	0	2	0	2	0	2	0	1	0	2	2	10	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	2	0	15	0	0
Textularia conica	4	7	0	2	0	2	0	9	1	2	0	2	1	1	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0
T. earlandi	1	17	0	40	3	19	2	20	2	5	2	18	2	14	0	3	0	0	0	0	0	1	0	3	0	0	1	1	0	0	0	0	0	3	0	4	0	16	0	2
Trochammina pacifica	0	0	0	2	0	1	0	4	1	21	0	13	0	2	0	2	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	6	23	0	0
T. spp.	0	0	0	0	1	1	0	0	0	0	0	5	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	1	0	0	0	0
Miss. agglutinated	0	4	0	13	1	7	0	7	0	4	0	13	1	10	0	3	0	0	0	16	0	4	0	7	0	1	0	5	0	1	0	0	0	1	0	0	0	3	0	1
Total benthonic forams.	53	278	39	525	52	175	102	634	71	386	49	295	233	877	68	378	39	459	8	233	19	378	37	224	19	433	67	554	7	89	7	72	49	223	18	199	150	518	18	103
Planktonics	0	13	0	17	0	9	0	26	0	27	0	23	0	16	0	17	0	21	0	18	0	3	0	16	0	2	0	113	0	27	0	34	0	81	0	145	0	30	0	34
Foraminifera/gram	75.3		48.1		35.4		104.3		78.5		41.0		64.1		32.7		49.4		3.8		20.2		14.6		30.4		3.9		6.1		3.7		21.7		36.4		54.4		12.3	
Benthonic/gram	72.5		46.7		34.0		100.7		74.1		38.4		63.2		31.5		47.4		3.5		20.0		13.8		30.0		3.3		4.8		2.6		16.7		21.8		52.1		9.6	
Planktonic/gram	2.8		1.4		1.4		3.6		4.4		2.6		0.9		1.2		2.0		0.3		0.2		0.8		0.4		0.6		1.3		1.1		5.0		14.6		2.3		2.7	
Living/gram	11.6		3.2		7.8		14.0		11.5		5.5		12.8		4.8		3.7		0.1		0.9		2.0		1.3		0.4		0.4		0.2		3.0		1.8		11.7		1.4	
Dead/gram	60.9		43.4		26.2		86.7		62.6		32.9		50.4		26.7		43.7		3.4		19.1		11.8		28.7		2.9		4.4		2.4		13.7		20.0		40.4		8.2	
Planktonic/benthonic	0.039		0.030		0.040		0.035		0.059		0.067		0.072		0.038		0.042		0.075		0.007		0.061		0.015		0.020		0.281		0.430		0.298		0.668		0.045		0.281	
Live-dead ratio	0.19		0.074		0.29		0.16		0.18		0.16		0.25		0.18		0.084		0.034		0.05		0.17		0.04		0.12		0.07		0.09		0.21		0.09		0.28		0.17	
% Hyaline / % Porc. + % Agglut. - Total	4		2		2		8		5		2		9		1		13		3		24		12		49		24		24		24		7		4		3		6	
" " - Living	3		32		3		16		3		2		9		4		16		100		100		100		100		99		100		6		24		5		3		16	
" " - Dead	4		2		1		7		6		1		9		1		3		13		24		10		49		24		24		32		6		4		3		6	
% Nonionidae - Total	20.2		23.1		10.1		32.8		24.9		10.1		32.3		10.9		12.8		1.6		26.2		31.8		43.1		37.1		2.0		5.0		20.5		2.7		19.0		24.7	
" - Living	26.4		25.6		7.6		36.2		30.9		8.1		21.5		16.1		7.6		12.5		16.6		18.9		21.0		29.8		14.2		14.2		34.6		5.5		34.6		38.8	
% B. m. denudata - Total	11.4		15.3		1.7		12.3		3.7		12.2		24.9		4.2		28.9		0.4		34.5		28.3		42.2		30.9		0		5.0		7.7		6.9		5.3		3.3	
" - Living	15.0		46.1		1.9		16.6		5.6		14.2		42.6		11.7		56.4		0		72.2		70.2		73.6		50.7		0		14.2		6.1		5.5		5.3		5.5	
% B. elegantissima - Total	3.3		9.7		7.0		3.3		15.0		5.5		2.9		7.1		2.6		0.8		0.2		2.6		0.4		0.8		17.7		11.3		14.7		1.3		26.6		6.6	
" - Living	11.3		17.9		19.2		11.7		11.2		6.1		4.4		11.7		2.5		0		0		2.7		0		0		71.4		14.2		10.2		0		18.0		11.1	

Sample Number	12831		12832		12833		12834		12835		12836		12838		12839		12859		12860		12861		12862		12863		12864		13865		12866		12868		12869		12870		12885	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	0	0	0	0	1	1	2	6	3	0	0	1	6	9	47	3	10	0	7	1	9	1	3	0	2	0	1	5	5	8	13	0	1	0	0	0	0	0	13
B. argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
B. pacifica	0	0	0	0	2	1	47	13	23	11	1	0	1	4	3	17	1	0	2	6	0	3	5	5	2	5	0	4	3	5	10	27	0	1	3	8	0	0	0	10
B. vaughani	0	0	3	0	11	5	1	1	0	1	8	2	2	5	0	4	0	0	1	1	0	1	1	2	0	1	3	1	1	0	0	6	0	1	0	0	2	0	0	0
B. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buccella frigida	2	4	6	27	5	61	0	3	0	6	6	38	6	41	1	17	7	87	2	96	5	58	7	34	2	57	7	34	2	10	4	23	1	1	1	6	1	3	0	0
Bulimina marginata denudata	0	1	1	2	2	19	0	0	0	3	2	14	12	33	25	76	26	82	39	101	13	70	7	37	11	46	2	22	4	17	1	25	2	0	4	2	1	3	5	41
Buliminella elegantissima	15	20	65	63	32	154	0	2	1	3	44	140	9	70	7	18	3	7	6	13	9	12	8	23	3	10	2	5	1	6	9	23	4	29	13	39	14	33	0	0
Cassidulina spp.	0	1	0	1	0	2	19	117	3	93	0	3	0	11	0	7	0	3	0	1	0	0	0	0	0	1	0	53	0	1	1	3	0	27	0	1	0	0	0	51
Cancris auricula	0	0	0	0	0	0	13	3	11	13	0	0	0	0	3	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	1
Cibicides fletcheri	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Elphidiella hannai	0	6	0	9	0	0	0	0	0	0	0	9	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	0	0
Epistominella bradyana	0	0	0	1	1	3	11	20	4	26	1	2	0	10	7	48	0	1	0	13	0	6	0	1	0	8	0	2	0	3	0	25	0	4	2	6	0	2	0	19
Florilus scaphus basispinatus	0	2	4	5	10	8	0	1	0	8	3	17	3	9	5	6	15	16	7	17	6	23	19	21	3	9	0	4	0	1	2	6	0	1	0	1	1	8	0	0
Hopkinsina pacifica	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	1	2	3	3	4	8	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Nonionella miocenica stella	0	0	14	9	29	79	0	2	2	3	22	47	14	50	2	37	1	52	13	101	4	73	36	80	1	56	0	15	7	28	26	82	1	9	7	38	3	8	0	5
Rosalina globularis	0	2	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	2	0	0
Rotorbinella lomaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	0	0	0	4	8	1	1	1	2	0	3	1	2	0	2	0	1	0	0	0	1	0	1	0	0	2	16	0	2	0	3	0	1	0	0	0	0	0	0
Suggerunda eckisi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uvigerina juncea	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13
Misc. elphidiids	6	11	6	22	0	32	0	4	0	1	4	52	0	18	0	0	0	0	1	2	0	0	0	3	0	0	0	0	0	0	0	0	0	8	1	14	0	9	0	3
Misc. nonionids	0	0	0	4	4	9	3	0	3	3	2	7	6	12	3	5	1	4	2	8	1	4	4	11	0	0	5	12	2	3	2	6	0	2	0	1	0	3	0	0
Misc. calcareous hyaline	0	0	2	9	0	26	7	130	5	146	2	26	4	66	3	74	0	20	3	45	2	16	4	35	1	18	0	60	0	20	5	56	2	30	9	47	1	21	1	90
Misc. porcelaneous	0	1	1	4	1	22	0	0	0	1	1	10	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	2	0	1
Eggerella advena	0	1	3	11	3	44	5	3	1	5	2	51	11	65	3	16	0	1	2	12	0	5	4	32	0	5	2	10	3	2	2	7	0	1	2	2	4	8	0	1
Gaudryina arenaria	0	0	0	0	0	0	1	14	3	129	0	0	0	0	8	28	0	0	0	0	0	0	0	0	0	0	1	66	1	2	0	3	0	0	0	0	0	0	0	4
Goesella flinti	0	0	0	0	0	1	0	0	0	1	0	2	2	5	1	0	0	1	0	1	0	4	0	0	0	6	1	1	5	32	5	8	0	0	0	0	0	0	0	0
Haplophragmoides advenus	0	0	0	2	0	3	1	2	0	0	1	7	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	2	0	0	0	0	2	0	0	0
H. planissimus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	0	0	1	0	0	0	0	0	0	0	5	3	2	0	2	2	1	0	9	0	6	2	4	0	5	1	9	2	17	0	1	0	0	0	0	0	0
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	2	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	1
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Saccammina atlantica	0	1	1	9	0	16	0	3	0	7	0	7	0	11	0	7	0	2	0	4	0	3	0	5	0	11	0	0	0	0	0	4	0	0	0	0	1	1	0	2
Textularia conica	0	0	0	0	1	0	0	2	0	2	0	0	1	4	0	3	0	1	1	1	0	2	0	0	0	0	0	4	2	3	1	4	0	0	0	0	0	0	0	0
T. earlandi	0	0	1	0	0	0	1	2	0	3	0	2	2	17	3	21	1	0	2	10	1	9	0	7	1	6	0	3	0	7	1	20	0	0	0	1	0	0	0	1
Trochammina pacifica	0	1	2	10	2	47	0	0	0	0	7	38	2	10	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4	19	0	0
T. spp.	0	0	0	0	0	0	7	18	0	4	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	17	0	1	0	3	0	0	0	4	0	0	0	3
Miss. agglutinated	0	0	0	0	0	4	1	2	0	9	1	2	0	2	0	2	0	2	0	5	0	6	0	1	0	1	0	5	0	4	0	15	0	0	0	0	0	1	0	2
Total benthonic forams.	23	48	110	186	107	549	114	349	63	493	107	434	79	463	94	465	58	291	84	346	45	318	100	237	28	250	23	331	37	167	80	384	12	121	42	172	36	124	6	296
Planktonics	0	5	0	14	0	61	0	532	0	254	0	51	0	44	0	45	0	4	0	15	0	4	0	2	0	8	0	90	0	8	0	21	0	59	0	62	0	21	0	276
Foraminifera/gram	4.3		28.9		47.2		28.7		115.4		68.2		152.6		109.8		62.5		112.6		62.8		63.7		47.8		18.0		23.5		45.2		15.1		35.8		13.9		1343.9	
Benthonic/gram	4.0		27.6		43.2		13.4		79.2		62.3		141.2		101.6		61.8		108.9		62.2		63.4		46.5		15.3		22.6		43.2		10.5		27.7		12.3		670.7	
Planktonic/gram	0.3		1.3		4.0		15.3		36.2		5.9		11.4		8.2		0.7		3.7		0.6		0.3		1.3		3.7		0.9		2.0		4.6		8.1		1.6		673.2	
Living/gram	1.3		10.2		7.0		3.3		9.0		12.3		20.6		17.1		10.3		21.3		7.7		18.7		4.7		1.6		4.1		7.5		1.1		5.5		2.8		14.6	
Dead/gram	2.7		17.4		36.2		10.1		70.2		50.0		120.6		84.5		51.5		87.6		54.5		44.7		41.8		13.7		18.5		35.8		9.5		22.3		9.5		656.1	
Planktonic/benthonic	0.070		0.047		0.093		1.149		0.457		0.094		0.081		0.081		0.011		0.035		0.011		0.006		0.029		0.254		0.039		0.045		0.444		0.290		0.131		1.004	
Live-dead ratio	0.47		0.59		0.19		0.32		0.12		0.24		0.17		0.20		0.19		0.24		0.14		0.42		0.11		0.11		0.22		0.20		0.10		0.24		0.29		0.02	
% Hyalins																																								
% Porc. + % Agglut. - Total	24		6		4		7		2		3		3		4		32		9		8		5		6		2		2		4		49		19		3		16	
" " - Living	100		16		13		6		16		8		3		4		49		12		49		24		6		4		2		6		12		19		2		100	
" " - Dead	16		4		3		7		2		3		3		5		24		9		7		4		6		2		2		4		49		19		3		16	
% Nonionidae - Total	2.8		12.1		21.1		1.2		3.5		18.1		17.3		10.3		25.5		34.4		30.5		50.4		24.7		9.3		20.0		26.7		9.7		21.9		9.3		1.8	
" - Living	0		16.3		40.1		2.6		7.9		25.2		29.1		10.6		29.3		26.1		24.4		59.0		14.2		8.6		24.3		37.5		8.3		16.6		11.1		0	
% B. m. denudata - Total	1.4		1.0		3.2		0		0.5		2.9		8.3		18.0		30.9		32.5		22.8		12.9		20.4		6.7		10.2		5.6		1.5		2.8		2.5		16.7	
" - Living	0		0.9		1.8		0		0		1.8		15.1		26.5		44.8		46.4		28.8		7.0		39.2		8.6		10.8		1.2		16.6		9.5		2.7		83.3	
% B. elegantissima - Total	49.2		43.2		28.3		0.4		0.7		34.0		14.5		4.4		2.8		4.4		5.7		9.1		4.6		1.9		3.4		6.8		24.8		24.2		29.3		0	
" - Living	65.2		59.0		29.9		0		1.5		41.1		11.3		7.4		5.1		7.1		20.0		8.0		10.8		8.6		2.7		11.2		33.3		30.9		38.8		0	

Sample Number	13118		13119		13120		13121		13122		13123		13124		13125		13126		13127		13128		13129		13130		13131		13132		13133		13134		13135		13136		13137	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	1	13	0	0	0	0	0	0	0	0	0	0	0	0	1	9	1	3	0	4	0	2	0	0	0	14	0	1	3	9	0	6	0	1	0	1	0	49	0	48
B. argentea	0	0	1	439	0	451	0	63	0	39	0	99	0	17	0	2	0	0	0	0	0	2	0	40	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	1	25	0	7	0	4	0	2	0	2	0	2	0	4	0	2	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
B. vaughani	0	1	0	0	0	7	0	0	0	1	0	2	0	1	0	4	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
B. spp.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	3	0	6	0	5	0	11	0	5	0	0	0	0	0	0	0	0	2	13
Buccella frigida	0	0	0	2	0	0	0	0	0	0	0	0	0	0	4	36	4	27	0	6	0	0	0	0	0	1	0	0	0	1	2	9	4	47	1	54	1	8	0	4
Bulimina marginata denudata	9	137	0	0	0	0	0	0	0	0	0	0	6	80	12	48	5	10	11	70	30	146	0	2	1	14	4	116	10	42	2	21	9	61	5	41	12	33	15	65
Buliminella elegantissima	7	3	0	0	0	0	0	0	0	0	0	0	0	0	7	8	1	5	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	10	0	7
Cassidulina spp.	0	7	0	2	0	0	0	3	0	7	0	0	0	0	0	6	0	0	0	0	0	5	0	0	0	11	0	8	0	13	0	7	0	1	0	0	0	1	0	17
Cancris auricula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Cibicides fletcheri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Elphidiella hannai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Epistominella bradyana	1	50	0	5	0	0	0	0	0	6	0	1	0	8	0	9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	5	0	0	0	0	0	0	0	53
Florilus scaphus basispinatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hopkinsina pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonionella miocenica stella	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	66	1	82	0	0	0	0	0	0	0	0	0	0	0	0	0	10	1	12	5	60	0	25	1	10
Rosalina globularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Rotorbinella lomaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
R. versiformis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Suggerunda eckisi	0	22	0	35	0	192	0	46	0	8	0	5	0	37	0	1	0	0	0	0	0	26	0	13	0	2	0	12	0	0	0	0	0	0	0	0	0	0	0	1
Uvigerina juncea	0	0	0	23	0	0	0	0	0	20	0	10	0	70	0	2	0	2	0	43	0	76	0	29	0	6	0	84	0	9	0	5	0	0	0	0	0	3	0	16
Misc. elphidiids	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Misc. nonionids	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. calcareous hyaline	0	30	1	93	0	346	0	97	0	39	0	34	0	14	0	58	0	41	0	124	0	41	0	14	0	73	0	62	1	51	0	36	0	38	1	36	0	48	0	202
Misc. porcelaneous	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Eggerella advena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaudryina arenaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	4	0	0	0	0	0	0	0	0	0	7
Goesella flinti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haplophragmoides advenus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccammina atlantica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Textularia conica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
T. earlandi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochammina pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
T. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miss. agglutinated	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	6	0	0	0	0	0	0	0	1	0	0	0	2	1	1	0	0	0	0	0	0	1	7
Total benthonic forams.	19	290	1	606	0	1000	0	211	0	123	0	154	6	235	28	282	7	96	28	487	32	387	1	425	4	195	2	226	16	147	4	66	18	125	6	188	18	273	30	646
Planktonics	0	50	0	124	0	2485	0	282	0	51	0	45	0	36	0	22	0	2	0	44	0	49	0	56	0	228	0	36	0	28	0	3	0	0	0	3	0	44	0	19
Foraminifera/gram	274.6		136.4		1244.6		1643.3		96.6		66.3		65.1		43.7		23.3		68.2		52.6		2410.0		1779.0		101.6		127.4		43.0		15.7		33.9		52.4		110.3	
Benthonic/gram	237.7		113.3		357.1		707.3		68.3		51.3		56.7		40.8		22.9		62.8		47.1		2310.0		829.0		87.7		108.7		41.2		15.7		33.4		45.5		107.3	
Planktonic/gram	36.9		23.1		887.5		940.0		28.3		15.0		8.4		2.9		0.4		5.4		5.5		280.0		950.0		13.9		18.7		1.8		0		0.5		6.9		3.0	
Living/gram	14.6		0.2		0		0		0		0		1.4		3.7		1.6		3.4		3.6		5.0		16.7		0.8		10.7		2.4		2.0		1.0		2.8		4.8	
Dead/gram	223.1		113.1		357.1		703.3		68.3		51.3		55.3		37.1		21.3		59.4		43.5		2125.0		812.5		86.9		98.0		38.8		13.7		32.4		42.7		102.5	
Planktonic/benthonic	0.155		0.204		2.485		1.336		0.415		0.292		0.149		0.071		0.019		0.085		0.117		0.131		1.146		0.158		0.172		0.043		0		0.015		0.151		0.028	
Live-dead ratio	0.12		0.00		0.00		0.00		0.00		0.00		0.00		0.10		0.07		0.05		0.08		0.00		0.02		0.01		0.10		0.05		0.14		0.03		0.07		0.04	
% Hyaline / % Porc. + % Agglut. - Total	100		100		100		100		100		100		100		16		19		99		100		100		99		100		19		19		100		99		99		95	
" " - Living	100		100		0		0		0		0		100		13		100		100		100		0		100		100		5		4		100		100		100		19	
" " - Dead	100		100		100		100		100		100		100		16		19		99		100		100		99		100		24		24		100		99		99		19	
% Nonionidae - Total	0		0.1		0		0		0.8		0		0.8		26.4		43.4		0		0		0		1.3		0		2.5		9.2		7.4		31.7		12.9		2.3	
" - Living	0		0		0		0		0		0		0		7.1		8.3		0		0		0		0		0		0		0		7.1		41.6		0		5.2	
% B. m. denudata - Total	47.2		0.3		0		0		0		0		35.6		19.3		16.2		28.2		53.1		1.9		10.0		38.0		33.1		21.2		40.2		22.4		23.3		16.8	
" - Living	47.3		0		0		0		0		0		100		42.8		33.3		100		100		0		100		100		66.6		40.0		64.2		41.6		92.3		78.9	
% B. elegantissima - Total	3.2		0		0		0		0		0		0		4.8		5.8		0		0		0.2		0.5		0		1.2		0		0		0		3.4		1.0	
" - Living	36.8		0		0		0		0		0		0		25.0		14.2		0		0		0		0		0		0		0		0		0		0		0		0	

* Lumped with Misc. calcareous hyaline.

Sample Number	13138		13142		13143		13144		13145		13221		13222		13223		13224		13225		13227		13228		13229		13230		13231		13232		13233		13234		13235		13236	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	1	0	5	0	1	0	0	0	0	5	16	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	8	0	0	0	0	0	2
B. argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	101	0	123	0	32	0	0	0	0	0	0	0	0	0	301	0	0	0	0	0	0	0	0	0	0
B. pacifica	*	*	*	*	*	*	*	*	*	*	1	15	0	14	0	0	0	0	0	0	0	5	0	0	1	3	0	10	0	3	0	0	0	8	0	2	0	2	0	4
B. vaughani	*	*	*	*	*	*	*	*	*	*	1	2	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1
B. spp.	0	0	0	0	0	4	0	3	0	6	0	0	0	0	0	83	0	227	0	148	0	81	0	11	0	56	0	35	0	30	0	79	0	4	0	31	0	90	0	0
Buccella frigida	0	0	1	0	3	51	5	22	6	22	17	18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	8
Bulimina marginata denudata	8	44	2	3	3	48	0	2	6	30	15	70	5	183	0	0	0	0	0	0	0	1	0	0	1	1	2	59	0	1	0	0	2	74	0	0	0	0	7	19
Buliminella elegantissima	0	0	0	0	0	5	1	9	3	71	29	28	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	4
Caseidulina spp.	0	5	0	3	0	3	1	0	0	5	0	3	0	0	0	0	0	0	0	0	0	3	0	0	0	28	0	119	0	3	0	0	0	2	0	0	0	0	0	1
Cancris auricula	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cibicides fletcheri	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elphidiella hannai	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistominella bradyana	0	7	0	0	0	2	0	7	0	2	0	8	0	13	0	0	0	0	0	0	0	4	0	0	0	0	0	37	0	0	0	0	0	13	0	0	0	0	0	1
Florilus scaphus basispinatus	*	*	*	*	*	*	*	*	*	*	12	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	10
Hopkinsina pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonionella miocenica stella	0	0	2	7	1	25	3	13	2	34	19	117	0	10	0	2	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	1	0	0	0	1	4	42
Rosalina globularis	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rotorbinella lomaensis	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	*	*	*	*	*	*	*	*	*	*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suggerunda eckisi	0	1	0	0	0	0	0	0	0	0	0	0	0	113	0	31	0	214	0	61	0	0	0	0	0	0	0	60	0	10	0	23	0	12	0	8	0	16	0	1
Uvigerina juncea	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	15	0	0	0	47	0	0	0	0	0	0
Misc. elphidiids	0	0	0	0	0	1	0	15	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Misc. nonionids	0	0	0	1	0	0	0	0	0	0	11	17	0	0	0	0	0	0	0	0	5	25	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	8
Misc. calcareous hyaline	0	11	0	7	1	10	0	22	2	46	0	38	0	36	0	32	0	12	0	1	0	161	0	106	0	126	0	99	0	4	0	4	0	8	0	5	0	33	0	9
Misc. porcelaneous	0	0	0	0	0	3	0	7	0	2	0	1	0	0	0	0	0	0	0	0	0	1	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eggerella advena	0	0	0	0	0	0	0	0	1	14	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Gaudryina arenaria	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gossella flinti	0	0	0	0	0	0	0	0	0	0	4	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
Haplophragmoides advenus	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	0	0	0	0	0	0	0	2	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	0	0	0	0	0	0	0	0	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia conica	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
T. earlandi	0	0	0	0	0	0	0	0	0	1	2	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Trochammina pacifica	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
T. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. agglutinated	0	0	1	1	0	0	0	0	0	5	0	15	0	1	0	0	0	0	0	0	0	1	0	10	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benthonic forams.	38	443	6	31	7	108	3	37	28	252	123	527	5	458	1	250	0	578	0	242	5	292	5	163	8	225	2	440	0	364	0	106	0	117	0	48	2	203	28	117
Planktonics	0	36	0	17	0	17	0	11	0	24	0	10	0	25	0	135	0	796	0	524	0	452	0	15	0	608	0	160	0	25	0	79	0	124	0	20	0	10	0	10
Foraminifera/gram	469.9		17.3		18.6		18.5		84.5		45.2		113.5		68.9		2328.9		1418.5		2496.7		10.9		977.9		1719.9		277.9		1423.1		1095.4		113.3		79.6		110.7	
Benthonic/gram	437.2		16.2		16.2		14.3		77.8		44.5		107.7		44.8		979.7		448.1		990.0		10.0		270.9		1262.8		260.0		815.4		531.8		80.0		75.9		103.6	
Planktonic/gram	32.7		1.1		2.4		4.2		6.7		0.7		5.8		24.1		1349.2		970.4		1506.7		0.9		707.0		457.1		17.9		607.7		563.6		33.0		3.7		7.1	
Living/gram	34.5		1.0		1.0		1.2		7.8		8.4		1.2		0.2		0.0		0.0		16.7		0.3		9.3		5.7		0		0		0		0		0.7		20.0	
Dead/gram	402.7		15.2		15.2		13.1		70.0		36.1		106.5		44.6		979.7		448.1		973.3		9.7		261.6		1257.1		260.0		815.4		536.8		80.0		75.2		83.6	
Planktonic/benthonic	0.075		0.459		0.148		0.297		0.086		0.015		0.054		0.538		1.377		2.165		1.522		0.089		2.609		0.362		0.069		0.745		1.060		0.417		0.042		0.069	
Live-dead ratio	0.09		0.19		0.06		0.09		1.11		0.23		0.01		0.00		0.00		0.00		0.02		0.03		0.04		0.00		0.00		0.00		0.00		0.00		0.10		0.24	
% Hyaline																																								
% Foro. + % Agglut. - Total	100		16		99		16		8		4		99		100		100		100		100		5		99		100		100		100		100		100		100		19	
" " - Living	100		7		100		100		19		9		100		100		0		0		100		0.3		100		100		0		0		100		0		0		100	
" " - Dead	100		24		49		13		7		3		99		100		100		100		100		6		99		100		100		100		100		100		100		16	
% Nonionidae - Total	0		37.5		16.3		14.2		13.1		38.1		2.1		0.7		0		0		0.3		0		0.8		13.8		0.2		0		0		0		37.0		17.9	
" - Living	0		25.0		12.5		30.0		10.0		34.1		0		0		0		0		0		0		12.5		100		0		0		0		0		100		25.0	
% B. m. denudata - Total	58.4		15.6		32.0		1.7		13.1		13.0		40.6		0		0		0		0.3		0		0.8		13.8		0.2		0		0		0		37.0		17.9	
" - Living	100.0		28.5		37.5		0		30.0		12.1		100.0		0		0		0		0		0		12.5		100		0		0		0		0		100		25.0	
% B. elegantissima - Total	0		0		4.3		8.0		27.1		8.7		0		0		0		0		0.6		0		0		0		0		0		0.8		0		0.4		4.8	
" - Living	0		0		0		10.0		15.0		23.5		0		0		0		0		0		0		0		0		0		0		0		0		0		10.7	

* Lumped with Misc. calcareous hyaline.

Sample Number	13237		13242		13250		13251		13253		13259		13260		13265		13269		13270		13271		13272		13273		13274		13338		13333		13337		13340		13341		13342	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	1	1	4	0	23	2	23	0	2	0	0	0	0	0	0	0	28	0	10	0	0	0	0	1	2	0	0	0	0	1	2	0	0	0	0	0	0	0	20
B. argentea	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	71	0	201	0	1	1	337	0	0	0	0	0	0
B. pacifica	0	8	0	6	0	4	0	9	0	0	0	0	0	2	0	0	0	49	0	1	0	0	0	0	0	0	0	34	0	0	0	2	0	0	0	0	0	0	0	5
B. vaughani	0	4	0	0	0	3	0	0	0	0	1	0	0	0	0	2	0	2	0	4	0	0	10	21	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0
B. spp.	0	2	0	0	0	10	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	4	0	0	0	69	2	28	1	26	0	17
Buccella frigida	0	0	0	5	2	34	11	19	3	8	2	9	0	0	0	0	0	9	6	29	0	3	35	22	3	12	0	2	0	0	6	0	0	0	0	0	0	0	0	13
Bulimina marginata denudata	1	8	1	4	1	66	4	31	18	37	0	8	0	2	0	1	0	8	16	86	0	0	14	35	9	102	0	2	0	0	11	30	0	0	0	0	0	1	0	6
Buliminella elegantissima	0	0	0	0	0	6	12	11	2	2	12	3	0	0	0	0	0	1	10	41	11	27	60	131	5	16	0	10	0	0	1	11	0	0	0	0	1	0	0	0
Cassidulina spp.	0	0	0	58	0	31	0	1	0	0	0	0	0	2	0	101	0	96	0	10	0	8	0	4	0	3	0	5	0	1	0	0	0	0	0	23	0	108	0	220
Cancris auricula	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6
Cibicides fletcheri	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	31	0	20
Elphidiella hannai	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistominella bradyana	0	2	0	0	1	22	0	4	0	2	0	0	0	0	0	1	0	0	0	12	0	0	0	1	0	5	0	1	0	0	0	2	0	0	0	0	0	0	0	3
Florilus scaphus bacispinatus	0	0	0	1	0	1	1	35	1	7	0	10	0	10	0	1	0	0	1	53	0	2	0	16	2	17	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Hopkinsina pacifica	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonionella miocenica stella	0	1	0	6	0	49	1	45	1	39	16	155	0	0	0	0	0	3	7	158	0	49	10	106	2	35	0	0	0	0	11	26	0	5	0	0	0	0	0	1
Rosalina globularis	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
Rotorbinella lomaensis	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	43	0	1
R. versiformis	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	4
Suggerunda eckisi	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	13	0	0	0	83	0	0	0	0	0	0
Uvigerina juncea	0	11	0	0	0	12	0	8	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	2	0	1	0	18	0	0	0	1	0	0	0	0	0	3
Misc. alphidids	0	0	0	7	0	16	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	6	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. nonionids	0	0	1	7	0	2	3	8	5	4	2	6	0	0	0	0	0	0	2	6	0	0	2	3	5	8	0	0	0	0	2	7	0	0	0	1	0	2	0	0
Misc. calcareous hyaline	0	7	0	127	0	92	1	47	0	2	0	2	0	2	2	148	0	226	0	85	0	9	1	25	0	38	0	15	0	10	0	11	0	22	1	93	0	181	0	211
Misc. porcelaneous	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	36	0	3	0	1	0	0	1	72	0	3	0	0	0	0	0	1	0	0	0	16	0	14	0	0
Eggerella advena	0	0	1	3	0	5	0	0	0	0	0	1	0	0	0	0	0	1	0	2	0	0	14	37	1	5	0	0	0	0	0	15	0	0	0	0	0	0	0	0
Gaudryina arenaria	0	0	0	0	0	6	0	3	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	1	20	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Goesella flinti	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	49	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Haplophragmoides advenus	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textularia conica	0	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T. earlandi	0	0	0	0	0	1	0	4	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	2	0	2	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Trochammina pacifica	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	47	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
T. spp.	0	1	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4	0	1	0	0
Miss. agglutinated	0	0	0	5	0	4	0	0	0	7	0	0	0	0	0	26	0	2	0	4	0	1	0	2	0	13	0	0	0	0	0	2	0	0	0	5	0	38	0	11
Total benthonic forams.	1	61	4	283	4	404	35	265	30	111	34	198	0	18	2	430	1	474	43	506	11	101	165	609	29	371	1	196	0	247	32	151	1	517	3	200	2	458	0	537
Planktonics	0	3	0	445	0	20	0	12	0	1	0	0	0	0	0	148	0	1306	0	15	0	2	0	31	0	16	0	23	0	0	0	6	0	243	0	59	0	264	0	845
Foraminifera/gram	40.0		3182.6		428.0		39.4		16.1		74.9		0.7		427.2		3634.6		108.5		18.9		196.3		126.3		64.7		0		45.0		1042.5		145.6		11,492.7		6580.9	
Benthonic/gram	38.1		1247.8		408.0		37.9		16.0		74.9		0.7		392.7		969.3		105.6		18.6		188.7		121.4		57.9		0		43.6		709.6		112.8		6666.6		2557.1	
Planktonic/gram	1.9		1934.8		20.0		1.5		0.1		0		0		34.5		2665.3		2.9		0.3		7.6		4.9		6.8		0		1.4		332.9		32.8		3826.1		4023.8	
Living/gram	0.6		17.4		4.0		4.4		3.4		11.0		0		1.8		2.0		8.3		1.8		40.2		8.8		0.3		0		7.6		1.4		1.7		28.9		0	
Dead/gram	37.5		1230.4		404.0		33.5		12.6		63.9		0.7		390.9		967.3		97.3		16.8		148.5		112.4		57.6		0		36.0		708.2		111.1		6637.7		2557.1	
Planktonic/benthonic	0.049		1.551		0.049		0.040		0.007		0		0		0.343		2.749		0.027		0.016		0.040		0.040		0.117		0		0.032		0.469		0.290		0.573		1.574	
Live-dead ratio	0.02		0.01		0.01		0.13		0.27		0.17		0		0		0		0.08		0.11		0.27		0.08		0.01		0		0.21		0		0.02		0		0	
% Hyaline / % Forc. + % Agglut. - Total	49		12		16		16		16		99		0		6		19		49		49		3		2		100		100		4		100		6		7		49	
" " - Living	100		3		100		100		100		100		0		100		100		100		100		5		9		100		0		100		100		100		100		0	
" " - Dead	49		12		16		13		13		99		0		6		19		49		49		3		2		100		100		3		100		6		7		49	
% Nonionides - Total	14.7		1.7		16.4		11.6		39.0		81.4		0		0.2		0.6		41.3		41.8		17.7		17.2		0		0		28.9		0.9		0.4		0.4		0.1	
" - Living	100.0		25.0		25.0		11.4		60.0		52.9		0		0		0		23.2		0		7.2		31.0		0		0		40.6		0		0		0		0	
% B. m. denudata - Total	14.7		1.7		16.4		11.6		39.0		3.4		11.1		0.2		1.6		18.5		0		6.3		27.5		1.0		0		22.4		0		0		0.2		1.1	
" - Living	100		25.0		25		11.4		60.0		0		0		0		0		37.2		0		8.4		27.5		0		0		34.3		0		0		0		0	
% B. elegantissima - Total	0		0		1.4		7.6		2.8		6.4		0		0		0.2		9.2		31.1		24.6		5.2		5.0		0		6.5		0		0		0.2		0	
" - Living	0		0		0		34.2		6.6		35.2		0		0		0		23.2		100.0		36.3		17.2		0		0		3.1		0		0		50.0		0	

Sample Number	13345		13346		13347		13351		13352		13353		13354		13355		13356		13357		13358		13359		13360		13364		13365		13366		13367		13368		13370		13371	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	3	0	41	0	1	0	0	0	4	0	6	2	30	0	3	0	1	0	0	0	3	0	0	2	0	0	0	0	0	0	1	0	2	1	0	0	0	0	0
B. argentea	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	0	3	0	1	0	1	0	0	0	3	0	0	0	7	2	51	0	2	0	0	0	8	0	2	11	92	1	27	0	3	1	1	0	0	1	12	1	3	0	4
B. vaughani	0	0	0	0	0	3	0	2	1	8	0	0	0	1	0	3	0	0	0	0	0	2	0	0	0	4	0	0	0	0	49	6	1	0	0	0	18	13	6	13
B. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	16	0	1	0	5	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buccella frigida	0	0	1	7	2	9	0	2	4	14	0	5	0	0	0	2	0	0	0	0	0	1	0	0	0	0	3	44	6	81	8	29	3	4	0	0	24	28	0	3
Bulimina marginata denudata	3	279	4	84	0	18	0	6	4	30	4	50	3	36	4	77	7	140	26	126	0	1	0	0	3	16	1	5	2	12	17	19	13	41	0	1	20	23	12	27
Buliminella elegantissima	0	0	0	1	3	18	50	215	5	27	0	1	0	3	2	5	0	2	0	1	0	0	0	0	2	12	3	4	7	22	9	32	0	7	0	1	28	76	12	45
Cassidulina spp.	0	15	0	32	0	1	0	1	0	23	0	33	0	7	0	11	0	5	0	1	0	61	0	35	0	6	0	0	0	0	5	6	1	11	0	28	0	3	0	0
Cancris auricula	0	2	0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	1	0	1	0	0	0	20	0	0	0	1	0	0	0	0	1	4	1	1	0	0
Cibicides fletcheri	0	0	0	1	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Elphidiella hannai	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	12	0	1	0	0	0	0	0	3	0	1
Epistominella bradyana	0	21	0	19	0	4	0	0	0	10	0	61	2	13	0	21	0	3	0	4	0	0	0	0	0	8	0	0	0	0	0	1	0	3	0	1	0	4	0	1
Florilus scaphus bacispinatus	0	0	0	0	0	2	0	0	0	1	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	8	1	7	2	11	0	1	1	11	0	0
Hopkinsina pacifica	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7	4	3	2	1	0	0	0	2	0	1	0
Nonionella miocenica stella	0	0	0	5	1	25	0	5	1	22	0	24	0	3	0	11	0	2	0	0	0	0	0	0	3	6	4	15	3	54	35	39	51	57	0	2	7	39	13	31
Rosalina globularis	0	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Rotorbinella lomaensis	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	2	0	0
Suggerunda eckisi	0	32	0	0	0	0	0	0	0	0	0	1	0	0	0	5	0	10	0	4	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Uvigerina juncea	0	148	0	16	0	0	0	0	0	0	0	0	0	52	0	15	0	62	0	26	0	0	0	0	0	31	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Misc. elphidids	0	0	0	0	0	0	0	68	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	11	0	2	0	0	0	11	1	10
Misc. nonionids	0	0	0	0	0	6	0	0	3	13	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	6	0	0	0	3	0	4	0	1	0	0	2	5	0	0
Misc. calcareous hyaline	0	52	0	21	0	15	0	101	0	29	0	14	0	206	0	73	0	5	0	12	0	143	0	21	1	71	1	14	1	22	1	22	0	10	0	33	1	0	0	18
Misc. porcelaneous	0	0	0	0	0	0	0	30	0	6	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	12	0	4	0	2	3	18	4	14
Eggerella advena	0	0	0	0	0	7	0	24	0	30	0	0	0	5	1	5	0	0	0	0	0	0	0	0	0	5	0	1	0	4	1	16	0	1	0	0	8	52	1	17
Gaudryina arenaria	0	2	0	6	0	0	0	0	0	4	0	0	0	18	0	2	0	0	0	0	0	1	0	0	0	4	0	0	0	0	1	0	0	0	1	50	0	0	0	0
Goesella flinti	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Haplophragmoides advenus	0	0	0	0	0	0	0	3	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	4	0	0	0	0	1	14	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recurvoides contortus	0	0	0	0	0	0	0	0	0	2	0	20	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	1	0	1	0	0
Reophax scorpiurus	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	0	0	0	0	0	0	4	0	4	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	8	0	0	0	1	0	2	0	1
Textularia conica	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
T. earlandi	0	0	0	0	0	1	0	3	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	0	1	0	1	0	5	0	0	0	0	0	10	0	6
Trochammina pacifica	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	0	0	0	1	2	32	1	5
T. spp.	0	0	0	0	0	2	0	28	0	21	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0
Miss. agglutinated	0	0	0	1	0	2	0	5	0	7	0	1	0	13	0	0	0	1	0	0	0	6	0	5	1	3	0	1	0	0	0	3	0	3	0	1	0	4	0	1
Total benthonic forams.	3	559	5	235	6	116	52	554	18	283	4	226	7	422	9	303	7	298	26	246	0	236	0	92	25	309	16	118	27	196	137	267	72	156	4	143	119	358	51	197
Planktonics	0	28	0	14	0	5	0	60	0	44	0	168	0	25	0	65	0	24	0	13	0	210	0	114	0	103	0	3	0	3	0	22	0	39	0	147	0	21	0	32
Foraminifera/gram	280.9		169.3		45.4		40.9		44.2		23.1		20.4		82.0		149.6		290.8		3185.7		515.0		48.1		105.4		31.0		49.5		54.5		19.8		85.8		444.5	
Benthonic/gram	267.6		160.0		43.5		37.2		38.6		14.3		19.3		67.9		138.7		277.5		1685.7		230.0		36.8		103.1		30.6		46.9		46.5		9.9		82.2		393.7	
Planktonic/gram	13.3		9.3		1.9		3.7		5.6		9.8		1.1		14.1		10.9		13.3		1500.0		285.0		11.3		2.3		0.4		2.6		8.0		9.9		3.6		50.8	
Living/gram	1.4		3.3		2.1		3.2		2.3		0.2		0.3		2.0		3.2		26.5		0		0		2.8		12.3		3.7		15.9		14.7		0.3		20.5		81.0	
Dead/gram	266.2		156.7		41.4		34.0		36.3		14.1		19.0		65.9		135.5		251.0		1685.7		230.0		34.0		90.8		26.9		31.0		31.8		9.6		61.7		312.7	
Planktonic/benthonic	0.050		0.058		0.040		0.099		0.146		0.730		0.058		0.208		0.078		0.047		0.889		1.239		0.308		0.022		0.013		0.054		0.171		1.000		0.044		0.129	
Live-dead ratio	0.1		0.21		0.05		0.09		0.06		0.02		0.02		0.03		0.02		0.11		0		0		0.08		0.14		0.14		0.51		0.46		0.03		0.33		0.26	
% Hyaline																																								
% Foro. + % Agglut. - Total	99		32		9		5		2		9		6		32		99		100		32		19		12		32		24		4		24		2		2		4	
" " - Living	100		100		100		100		100		100		100		8		100		100		0		0		12		100		100		24		100		3		7		7	
" " - Dead	99		32		9		5		2		9		6		24		99		100		32		16		12		32		19		2		19		1		2		4	
% Nonionidae - Total	0		2.1		27.8		0.8		13.2		14.3		0.6		4.8		0.9		0		0		0		4.4		17.1		30.4		21.2		49.1		2.0		11.5		17.7	
" - Living	0		0		16.6		0		22.2		0		0		0		0		0		0		0		12.0		31.2		14.8		26.2		23.2		0		8.4		25.4	
% B. m. denudata - Total	50.1		36.6		14.7		0.9		11.2		23.4		9.0		25.9		48.1		81.6		0.4		0		5.6		4.4		7.4		8.9		23.6		0.6		9.0		15.7	
" - Living	100		80.0		0		0		22.2		100.0		42.8		44.4		100.0		100.0		0		0		12.0		6.2		6.2		12.4		18.0		0		16.8		23.5	
% B. elegantissima - Total	0		0.4		17.2		43.7		10.6		0.4		0.6		2.2		0.6		0.3		0		0		4.1		5.2		13.0		10.1		3.0		0.6		21.8		22.9	
" - Living	0		0		50.0		96.1		27.7		0		0		22.0		0		0		0		0		8.0		18.7		25.9		6.5		0		0		23.5		23.5	

Sample Number	13374		13375		12-9-1		12-9-2		12-9-3		12-9-4		12-9-5		12-9-6		12-9-7		12-9-8		12-9-9		12-9-10		12-9-11		12-9-12		12-9-13		12-9-14		12-9-15		12-9-16		12-9-17		12-9-18	
Species	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	0	0	0	1	0	7	0	4	0	6	0	4	0	43	0	0	0	10	0	8	1	59	0	26	0	21	0	0	0	3	0	2	0	18	0	32	0	17	2	47
B. argentea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	0	0	0	4	0	0	0	0	0	3	0	0	0	2	0	6	0	2	0	0	0	4	0	0	0	3	0	0	0	3	0	3	0	14	0	4	0	7	0	2
B. vaughani	4	5	4	0	0	2	0	1	0	1	0	1	0	1	0	2	0	4	0	1	0	5	0	2	1	3	0	0	0	6	0	6	0	16	0	11	0	1	0	3
B. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buccella frigida	11	9	11	33	2	24	5	9	1	9	2	4	6	5	15	12	11	18	6	17	5	10	3	7	1	68	2	20	5	62	3	14	7	25	1	25	1	18	4	16
Bulimina marginata denudata	1	2	26	89	5	63	13	41	3	40	0	23	12	61	4	35	5	46	3	45	9	130	1	58	24	373	2	22	7	62	5	50	5	84	5	80	3	108	7	239
Buliminella elegantissima	249	97	15	94	3	10	2	10	2	6	4	8	24	13	22	40	17	7	6	12	5	8	1	6	5	22	1	3	2	6	14	16	6	42	2	10	2	14	2	18
Cassidulina spp.	0	0	0	2	0	2	0	0	0	7	0	5	0	4	0	0	0	0	0	1	0	21	0	4	0	0	0	20	0	67	0	8	0	4	0	2	0	5	0	4
Cancris auricula	0	0	0	0	0	0	0	0	0	1	0	4	0	1	0	1	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0
Cibicides fletcheri	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	14	0	0	0	1	0	1	0	0	0	0
Elphidiella hannai	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epistominella bradyana	0	1	0	9	0	1	0	2	0	5	0	1	0	8	0	5	0	2	0	4	0	12	0	12	0	7	0	0	0	9	0	8	0	15	0	17	0	0	0	3
Florilus scaphus basispinatus	0	5	2	13	0	21	0	7	0	7	1	7	1	10	0	22	0	33	0	10	0	2	0	0	0	76	0	1	0	2	0	4	2	15	0	8	0	5	0	4
Hopkinsina pacifica	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonionella miocenica stella	3	37	15	106	3	86	0	33	3	34	0	17	0	43	5	32	0	37	0	0	0	17	1	18	1	290	0	11	0	89	1	58	0	111	0	67	0	68	0	74
Rosalina globularis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	12	0	1	0	0	0	0	0	0	0	0
Rotorbinella lomaensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	0	0	3	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	3	0	10	0	7	0	4	0	3	0	1	0	2	0	1
Suggerunda eckisi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uvigerina juncea	0	0	0	0	0	1	0	1	0	11	0	8	0	17	0	0	0	5	0	3	0	52	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	13
Misc. elphidiids	2	19	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Misc. nonionids	0	4	18	28	0	2	0	5	0	4	0	3	0	3	4	14	0	14	0	4	0	1	0	0	0	7	1	7	0	9	0	2	1	16	0	2	0	0	0	0
Misc. calcareous hyaline	0	12	1	26	0	24	0	18	0	92	0	75	0	102	0	22	0	45	0	52	0	82	0	86	1	53	0	41	2	228	0	35	0	100	0	125	0	97	0	89
Misc. porcelaneous	1	9	2	8	0	0	0	0	0	0	0	1	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	8	0	5	0	0	0	0	0	0	0	0
Eggerella advena	2	15	0	8	0	1	0	1	0	2	0	1	0	9	1	11	0	5	0	4	0	5	0	0	0	0	0	5	0	7	0	8	0	4	1	3	0	1	0	0
Gaudryina arenaria	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	4	0	0	0	0	1	28	0	2	0	0	0	1	0	1	0	0	0	1
Goesella flinti	0	0	0	2	0	2	0	0	0	0	0	3	0	0	0	21	0	3	0	1	0	2	0	0	0	2	0	0	0	0	0	7	0	5	0	0	0	0	0	0
Haplophragmoides advenus	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0
H. planissimus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Recurvoides contortus	0	2	0	4	0	1	0	1	0	0	0	0	0	0	0	15	0	9	0	3	0	0	0	0	0	10	0	1	0	0	0	9	0	8	0	3	0	0	0	0
Reophax scorpiurus	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	3	0	1
Textularia conica	0	0	0	1	0	1	0	5	0	5	0	3	0	12	0	5	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	2	0	0
T. earlandi	0	0	0	1	0	1	0	0	0	2	0	8	0	4	0	10	0	7	0	10	0	3	0	0	0	0	0	1	0	4	1	19	0	16	0	2	0	2	0	1
Trochammina pacifica	1	7	2	9	0	0	0	0	0	0	0	0	0	1	0	2	0	1	0	2	0	1	0	0	0	0	0	25	0	2	0	1	0	1	0	1	0	2	0	1
T. spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	*	0	0	0	0	0	0	0	0	0	0
Misc. agglutinated	0	0	0	6	0	6	0	7	1	20	0	8	0	8	0	17	0	11	0	2	0	5	0	2	0	4	0	12	0	41	0	10	0	1	0	2	0	11	0	16
Total benthonic forams.	274	226	97	455	14	261	20	145	10	260	7	184	43	341	51	255	33	300	15	186	20	425	6	245	33	947	7	209	16	649	24	270	21	516	8	401	6	382	15	533
Planktonics	0	14	0	31	0	10	0	3	0	50	0	22	0	31	0	6	0	18	0	3	0	22	0	13	0	17	0	42	0	353	0	31	0	22	0	24	0	23	0	42
Foraminifera/gram	79.2		108.0		27.7		35.7		27.6		44.4		45.2		27.1		27.1		31.4		63.1		64.9		37.7		23.7		111.8		61.5		39.5		45.5		40.3		78.7	
Benthonic/gram	77.0		102.3		26.7		35.1		23.3		39.8		41.8		26.6		27.0		30.9		60.1		61.6		37.1		19.8		73.0		55.5		37.9		43.0		38.0		73.1	
Planktonic/gram	2.2		5.7		1.0		0.6		4.3		4.6		3.4		0.5		0.1		0.5		3.0		3.3		0.6		3.9		38.8		6.0		1.6		2.5		2.3		5.6	
Living/gram	42.2		18.0		1.1		3.8		0.7		0.6		2.1		2.6		1.4		1.4		2.4		1.3		1.2		0.6		1.5		2.3		1.2		0.8		0.5		2.0	
Dead/gram	34.8		84.3		25.6		31.3		22.6		39.2		39.7		24.0		25.6		29.5		57.7		60.3		35.9		19.2		71.5		53.2		36.7		42.2		37.5		71.1	
Planktonic/benthonic	0.028		0.056		0.036		0.018		0.185		0.115		0.081		0.020		0.060		0.015		0.049		0.053		0.017		0.194		0.531		0.105		0.041		0.059		0.059		0.077	
Live-dead ratio	1.21		0.21		0.05		0.14		0.04		0.04		0.13		0.20		0.12		0.08		0.04		0.02		0.03		0.3		0.02		0.09		0.04		0.02		0.02		0.02	
% Foro. + % Agglut. - Total	13		12		13		12		7		6		10		3		6		6		19		99		49		2		10		4		12		24		16		24	
" " - Living	49		24		100		100		9		100		100		49		100		100		100		100		100		6		100		24		100		7		100		100	
" " - Dead	6		10		13		9		7		6		9		2		5		6		19		99		32		2		10		4		10		24		16		24	
% Nonionidae - Total	9.8		32.9		42.9		27.2		18.1		14.6		14.8		25.1		28.0		6.9		4.0		7.5		38.1		9.2		15.0		22.1		28.5		18.8		17.5		14.2	
" - Living	1.0		36.0		21.4		0		30.0		14.2		2.3		17.6		0		0		0		16.6		3.0		14.2		0		4.1		5.2		0		0		0	
% B. m. denudata - Total	0.6		20.8		24.7		32.7		15.9		12.0		19.0		12.7		17.0		23.8		31.2		23.5		40.5		11.1		10.3		18.7		16.6		20.7		28.6		44.8	
" - Living	0.3		26.8		35.7		65.0		30.0		0		27.9		7.8		15.1		20.0		45.0		16.6		72.7		28.5		43.7		20.8		26.3		62.5		50.0		46.6	
% B. elegantissima - Total	69.2		19.7		4.7		7.2		2.9		6.2		9.6		20.2		8.0		8.9		2.9		2.7		2.7		1.8		1.2		10.2		8.9		2.9		4.1		3.6	
" - Living	90.8		15.4		21.4		10.0		20.0		57.1		55.8		43.1		51.5		40.0		25.0		16.6		15.1		14.2		12.5		58.3		31.5		25.0		33.3		13.3	

* Lumped with Misc. agglutinated.

Sample Number	12-9-19		12-9-20		12-9-21		12-9-22		12-9-23		12-9-24	
Species	L	D	L	D	L	D	L	D	L	D	L	D
Bolivina acuminata	1	22	1	6	1	9	0	12	0	3	0	11
B. argentea	0	0	0	0	0	0	0	0	0	0	0	0
B. pacifica	0	4	0	3	0	3	0	3	0	0	0	0
B. vaughani	0	1	0	1	0	2	0	10	0	0	0	4
B. spp.	0	0	0	0	0	0	0	0	0	0	0	0
Buccella frigida	5	9	1	17	4	40	6	60	1	31	0	42
Bulimina marginata denudata	1	9	2	27	7	46	7	99	10	104	5	182
Buliminella elegantissima	0	5	3	7	5	17	6	24	0	4	0	5
Cassidulina spp.	0	0	0	2	0	6	0	0	0	5	0	5
Cancris auricula	0	1	0	2	0	0	0	0	0	0	0	0
Cibicides fletcheri	0	0	0	0	0	0	0	1	0	0	0	0
Elphidiella hannai	0	0	0	0	0	0	0	0	0	0	0	0
Epistominella bradyana	0	2	0	10	0	7	0	10	0	12	0	3
Florilus scaphus basispinatus	1	17	0	0	1	7	0	28	1	45	2	69
Hopkinsina pacifica	0	0	0	0	0	0	0	0	0	0	0	0
Nonionella miocenica stella	0	18	3	66	7	72	1	127	0	36	0	60
Rosalina globularis	0	0	0	0	0	0	0	0	0	0	0	0
Rotorbinella lomaensis	0	0	0	0	0	0	0	0	0	0	0	0
R. versiformis	0	1	0	5	0	0	0	6	0	0	0	0
Suggerunda eckisi	0	0	0	0	0	0	0	0	0	0	0	0
Uvigerina juncea	0	2	0	0	0	1	0	0	0	0	0	0
Misc. elphidiids	0	0	0	0	0	0	0	0	0	0	0	0
Misc. nonionids	1	3	2	10	2	6	0	19	0	1	0	5
Misc. calcareous hyaline	0	27	0	75	0	49	0	64	0	21	0	29
Misc. porcelaneous	0	0	0	0	0	0	0	1	0	0	0	0
Eggerella advena	1	20	0	10	0	0	0	4	0	0	0	0
Gaudryina arenaria	0	2	0	0	0	0	0	0	0	0	0	0
Goesella flinti	0	10	0	1	0	1	0	1	0	0	0	0
Haplophragmoides advenus	0	2	0	0	0	0	0	0	0	0	0	0
H. planissimus	1	5	0	1	0	2	0	0	0	0	0	0
Recurvoides contortus	0	14	0	11	0	0	0	3	0	0	0	0
Reophax scorpiurus	0	0	0	0	0	4	0	0	0	0	0	0
Rhabdamina abyssorum	0	0	0	0	0	0	0	0	0	0	0	0
Saccamina atlantica	0	3	0	0	0	0	0	1	0	1	0	0
Texturalia conica	0	1	1	1	0	0	0	2	0	2	0	0
T. earlandi	0	20	0	6	0	3	0	4	0	0	0	0
Trochammina pacifica	0	3	0	2	0	1	0	1	0	0	0	0
T. spp.	0	0	0	0	0	0	0	0	0	0	0	0
Miss. agglutinated	0	9	0	8	0	1	0	5	0	0	0	1
Total benthonic forams.	10	201	13	279	27	278	20	495	12	267	7	416
Planktonics	0	5	0	18	0	12	0	23	0	2	0	3
Foraminifera/gram	22.2		25.2		31.7		103.5		28.6		24.9	
Benthonic/gram	21.7		23.7		30.5		99.1		28.4		24.7	
Planktonic/gram	0.5		1.5		1.2		4.4		0.2		0.2	
Living/gram	1.0		0.8		2.3		3.1		1.2		0.4	
Dead/gram	20.7		22.9		28.2		96.0		27.2		24.3	
Planktonic/benthonic	0.024		0.062		0.039		0.045		0.007		0.007	
Live-dead ratio	0.05		0.05		0.05		0.04		0.04		0.02	
% Hyaline												
% Porc. + % Agglut. - Total	1		6		24		24		99		99	
" " - Living	4		12		100		100		100		100	
" " - Dead	1		6		19		24		99		99	
% Nonionidae - Total	18.9		27.7		31.1		33.9		29.7		32.1	
" - Living	20.0		38.4		37.0		5.0		8.3		28.5	
% B. m. denudata - Total	4.7		9.9		17.3		20.5		40.8		44.2	
" - Living	10.0		15.3		25.9		35.0		83.3		71.4	
% B. elegantissima - Total	14.2		3.4		7.2		5.8		1.4		1.1	
" - Living	0		23.0		18.5		30.0		0		0	

APPENDIX 8

Nearshore sample station locations.

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
August, 1969					
I-a	26	1030	34°26'30"	119°58'14"	6
I-b	26	1040	34°26'16"	119°58'20"	12
I-c	26	1050	34°25'55"	119°58'29"	24
I-d	26	1055	34°25'22"	119°58'32"	55
II-a	26	1118	34°26'00"	119°57'32"	12
II-b	26	1125	34°25'27"	119°57'42"	24
II-c	26	1140	34°24'57"	119°57'47"	31
II-d	26	1150	34°24'42"	119°57'52"	37
III-a	26	1210	34°26'00"	119°56'43"	6
III-b	26	1220	34°25'37"	119°56'48"	12
III-c	26	1225	34°25'18"	119°56'49"	24
III-d	26	1230	34°24'52"	119°56'53"	37
IV-a	26	1245	34°25'48"	119°55'30"	6
IV-b	26	1255	34°25'18"	119°55'40"	12
IV-c	26	1300	34°24'40"	119°55'47"	24
IV-d	26	1310	34°24'05"	119°55'50"	37
V-a	26	1325	34°25'24"	119°54'32"	6
V-b	26	1330	34°25'00"	119°54'37"	12
V-c	26	1337	34°24'40"	119°54'40"	24
V-d	26	1342	34°24'11"	119°54'49"	37
VI-a	26	1350	34°24'41"	119°53'10"	12
VI-b	26	1358	34°24'25"	119°53'18"	24

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
VI-c	26	1403	34°24'09"	119°53'25"	31
VI-d	26	1409	34°23'42"	119°53'32"	37
VII-a	26	1415	34°24'26"	119°52'25"	12
VII-b	26	1425	34°24'01"	119°52'30"	24
VII-c	26	1430	34°23'38"	119°52'39"	31
VII-d	26	1435	34°23'18"	119°52'47"	37
VIII-a	26	1444	34°24'27"	119°51'23"	12
VIII-b	26	1452	34°24'08"	119°51'28"	24
VIII-c	26	1504	34°23'47"	119°51'35"	31
VIII-d	26	1510	34°23'20"	119°51'40"	37
IX-a	26	1525	34°24'09"	119°50'48"	12
IX-b	26	1537	34°23'47"	119°50'52"	24
IX-c	26	1545	34°23'26"	119°50'55"	37
X-a	26	1550	34°24'52"	119°49'56"	6
X-b	26	1555	34°24'33"	119°49'56"	12
X-c	26	1600	34°24'07"	119°49'55"	24
X-d	26	1605	34°23'35"	119°49'56'	37
XI-a	27	1430	34°24'56"	119°48'11"	15
XI-b	27	1438	34°24'39"	119°48'12"	30
XI-c	27	1450	34°24'18"	119°48'12"	39
XII-a	27	1350	34°24'30"	119°46'15"	14
XII-b	27	1354	34°24'13"	119°46'20"	18

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
XII-c	27	1400	34°24'00"	119°46'22"	30
XII-d	27	1409	34°23'30"	119°46'24"	38
XIII-a	27	1338	34°23'55"	119°44'25"	7
XIII-b	27	1330	34°23'42"	119°44'32"	11
XIII-c	27	1326	34°23'24"	119°44'33"	29
XIII-d	27	1310	34°22'58"	119°44'40"	48
XIV-a	27	0939	34°23'37"	119°42'29"	6
XIV-b	27	0946	34°23'22"	119°42'33"	12
XIV-c	27	0952	34°23'07"	119°42'33"	24
XIV-d	27	0957	34°22'42"	119°42'39"	37
XV-a	27	0837	34°24'12"	119°41'00"	6
XV-b	27	0846	34°23'50"	119°40'55"	12
XV-c	27	0914	34°23'18"	119°40'51"	31
XV-d	27	0920	34°22'55"	119°40'51"	37
XVI-a	27	0950	34°24'54"	119°39'46"	12
XVI-b	27	0958	34°24'25"	119°39'40"	15
XVI-c	27	1010	34°24'10"	119°39'35"	24
XVII-a	28	1015	34°25'02"	119°37'46"	13
XVII-b	28	1025	34°24'43"	119°37'44"	28
XVIII-a	28	1030	34°25'08"	119°36'02"	12
XVIII-b	28	1038	34°24'48"	119°36'04"	16
XVIII-c	28	1045	34°24'31"	119°36'04"	27

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
XVIII-d	28	1056	34°24'03"	119°36'00"	34
XIX-a	28	1130	34°24'47"	119°34'21"	8
XIX-b	28	1140	34°24'32"	119°34'22"	14
XIX-c	28	1155	34°24'15"	119°34'24"	27
XX-a	28	1300	34°23'50"	119°32'33"	9
XX-b	28	1400	34°23'28"	119°32'33"	17
XX-c	28	1420	34°23'12"	119°32'35"	37
XX-d	28	1445	34°22'47"	119°32'37"	35
XXI-a	28	1730	34°23'06"	119°30'32"	11
XXI-b	28	1725	34°22'47"	119°30'37"	18
XXI-c	28	1714	34°22'29"	119°30'40"	22
XXII-b	28	1655	34°22'20"	119°28'21"	11
XXII-c	28	1650	34°21'47"	119°28'23"	15
XXII-d	28	1640	34°21'20"	119°28'32"	18
XXIII-a	28	1625	34°20'30"	119°26'59"	18
XXIV-a	28	1612	34°20'43"	119°25'24"	7
XXIV-b	28	1605	34°20'30"	119°25'36"	12
XXIV-c	28	1600	34°20'15"	119°25'43"	18
XXIV-d	28	1610	34°19'49"	119°25'59"	22
October, 1969					
10-9-1	28	1035	34°23'42"	119°55'25"	-
10-9-2	28	1110	34°23'50"	119°53'00"	-

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
October, 1969					
10-9-3	28	1125	34°24'15"	119°52'55"	-
10-9-4	28	1305	34°20'10"	119°36'45"	-
10-9-5	29	0915	34°22'08"	119°49'55"	-
10-9-6	29	0945	34°18'35"	119°49'50"	-
10-9-7	29	1000	34°15'10"	119°49'35"	-
10-9-8	29	1030	34°11'20"	119°49'22"	-
10-9-9	29	1100	34°07'58"	119°49'10"	-
10-9-10	29	1130	34°07'30"	119°42'20"	-
10-9-11	29	1145	34°11'25"	119°42'43"	-
10-9-12	29	1200	34°15'18"	119°43'00"	-
10-9-13	29	1230	34°18'42"	119°43'18"	-
10-9-14	29	1300	34°21'55"	119°43'32"	-
10-9-15	30	1530	34°22'15"	119°37'25"	-
10-9-16	30	1330	34°18'32"	119°35'13"	-
10-9-17	30	1305	34°15'15"	119°36'55"	-
10-9-18	30	1100	34°10'42"	119°36'50"	-
10-9-19	30	1125	34°07'10"	119°36'38"	-
10-9-20	30	1200	34°08'10"	119°29'30"	-
10-9-21	30	1230	34°12'31"	119°29'44"	-
10-9-22	30	1410	34°17'07"	119°29'55"	-
10-9-23	30	1435	34°20'40"	119°30'05"	-

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
October, 1969					
10-9-24	30	1505	34°20'10"	119°36'45"	-
December, 1969					
12-9-1	9	-	34°22'35"	119°46'12"	59
12-9-2	9	-	34°22'18"	119°47'37"	64
12-9-3	9	-	34°22'04"	119°42'12"	82
12-9-4	10	-	34°21'47"	119°50'32"	88
12-9-5	10	-	34°21'26"	119°52'04"	128
12-9-6	10	-	34°23'15"	119°50'00"	62
12-9-7	10	-	34°22'35"	119°49'40"	73
12-9-8	10	-	34°21'25"	119°48'45"	88
12-9-9	10	-	34°20'35"	119°48'12"	137
12-9-10	10	-	34°19'02"	119°40'25"	90
12-9-11	11	-	34°22'20"	119°37'48"	53
12-9-12	11	-	34°21'33"	119°37'40"	48
12-9-13	11	-	34°20'47"	119°37'30"	48
12-9-14	11	-	34°20'03"	119°37'18"	59
12-9-15	11	-	34°19'15"	119°37'13"	68
12-9-16	11	-	34°18'26"	119°37'00"	86
12-9-17	11	-	34°17'38"	119°36'50"	93
12-9-18	11	-	34°16'55"	119°36'42"	97
12-9-19	11	-	34°19'08"	119°39'18"	71

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12-9-20	11	-	34°19'12"	119°38'12"	70
12-9-21	11	-	34°19'18"	119°36'00"	64
12-9-22	11	-	34°19'20"	119°34'55"	60
12-9-23	11	-	34°19'25"	119°33'54"	60
12-9-24	11	-	34°19'30"	119°32'42"	57
12-9-25	12	-	34°25'55"	119°57'50"	16
12-9-26	12	-	34°25'20"	119°57'55"	33
12-9-27	12	-	34°24'48"	119°58'12"	60
12-9-28	12	-	34°24'05"	119°58'27"	73
12-9-29	12	-	34°24'58"	120°00'18"	71
12-9-30	12	-	34°25'37"	119°59'45"	57
12-9-31	12	-	34°26'08"	119°59'30"	40
12-9-32	12	-	34°26'36"	119°59'12"	18
12-9-33	12	-	34°27'22"	120°00'55"	18
12-9-34	12	-	34°26'37"	120°00'58"	44
12-9-35	12	-	34°25'50"	120°01'07"	57
12-9-36	12	-	34°24'55"	120°01'12"	71
12-9-37	12	-	34°25'00"	120°02'35"	77
12-9-38	12	-	34°25'58"	120°02'33"	66
12-9-39	12	-	34°26'42"	120°02'27"	51
12-9-40	12	-	34°27'20"	120°02'25"	24

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12-9-41	12	-	34°27'15"	120°03'58"	27
12-9-42	12	-	34°26'32"	120°04'07"	55
12-9-43	12	-	34°25'57"	120°04'15"	71
12-9-44	12	-	34°25'12"	120°04'20"	82
January, 1970					
1-0-1	27	0900	34°23'42"	119°46'35"	-
1-0-2	27	0930	34°23'26"	119°52'54"	-
1-0-3	27	1000	34°24'50"	119°58'28"	-
1-0-4	27	1030	34°21'05"	119°58'04"	-
1-0-5	27	1100	34°18'44"	119°52'47"	-
1-0-6	27	1130	34°14'14"	119°52'33"	-
1-0-7	27	1200	34°10'05"	119°52'43"	-
1-0-8	27	1225	34°06'12"	119°52'37"	-
1-0-9	27	1300	34°06'18"	119°45'37"	-
1-0-10	27	1320	34°10'17"	119°45'55"	-
1-0-11	27	1400	34°14'35"	119°46'18"	-
1-0-12	27	1430	34°19'15"	119°46'24"	-
1-0-13	27	1510	34°21'05"	119°36'54"	-
1-0-14	28	0837	34°23'48"	119°39'17"	-
1-0-15	28	0905	34°20'35"	119°36'45"	-
1-0-16	28	0925	34°19'12"	119°39'12"	-

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
1-0-17	28	0955	34°14'30"	119°39'12"	-
1-0-18	28	1022	34°10'18"	119°39'05"	-
1-0-19	28	1050	34°06'20"	119°38'59"	-
1-0-20	28	1110	34°03'12"	119°39'24"	-
1-0-22	29	1103	34°07'17"	119°24'54"	-
1-0-23	28	1145	34°06'18"	119°32'10"	-
1-0-24	28	1237	34°10'18"	119°32'12"	-
1-0-25	28	1300	34°14'36"	119°32'38"	-
1-0-26	28	1320	34°16'27"	119°28'50"	-
1-0-27	28	1352	34°19'15"	119°32'40"	-
1-0-28	28	1415	34°21'05"	119°36'54"	-
1-0-29	29	0840	34°23'48"	119°33'37"	-
1-0-30	29	0855	34°21'49"	119°30'30"	-
1-0-31	29	0927	34°19'08"	119°26'12"	-
1-0-32	29	1000	34°14'29"	119°25'12"	-
1-0-33	29	1031	34°10'20"	119°25'11"	-
1-0-34	29	1140	34°11'12"	119°18'24"	-
1-0-36	29	1225	34°03'37"	119°14'12"	-
1-0-37	29	1255	34°06'18"	119°12'13"	-
1-0-38	29	1330	34°10'20"	119°18'17"	-
1-0-39	29	1350	34°14'30"	119°18'20"	-

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
1-0-40	29	1520	34°21'05"	119°36'54"	-
February, 1970					
2-0-1	11	0935	34°27'38"	120°05'51"	17
2-0-2	11	0955	34°27'13"	120°06'00"	44
2-0-3	11	1005	34°26'42"	120°06'09"	59
2-0-4	11	1013	34°26'12"	120°06'10"	70
2-0-5	11	1025	34°26'13"	120°07'23"	70
2-0-6	11	1040	34°26'48"	120°07'19"	57
2-0-7	11	1050	34°27'22"	120°07'15"	37
2-0-8	11	1101	34°27'57"	120°07'10"	17
2-0-9	11	1115	34°28'09"	120°08'42"	17
2-0-10	11	1125	34°27'41"	120°08'47"	40
2-0-11	11	1132	34°27'10"	120°08'48"	55
2-0-12	11	1145	34°26'23"	120°08'48"	70
2-0-13	11	1200	34°26'34"	120°10'44"	70
2-0-14	11	1210	34°27'03"	120°10'46"	60
2-0-15	11	1219	34°27'35"	120°10'47"	46
2-0-16	11	1225	34°28'07"	120°10'42"	17
2-0-17	11	1240	34°28'07"	120°12'06"	17
2-0-18	11	1250	34°27'30"	120°12'12"	57
2-0-19	11	1300	34°27'01"	120°12'12"	66

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
2-0-20	11	1312	34°26'30"	120°12'10"	70
2-0-21	11	1325	34°26'36"	120°13'40"	73
2-0-22	11	1335	34°27'06"	120°13'41"	57
2-0-23	11	1336	34°27'30"	120°13'40"	40
2-0-24	11	1350	34°27'49"	120°13'41"	15
2-0-25	11	1400	34°27'46"	120°15'18"	15
2-0-26	11	1410	34°27'18"	120°15'20"	22
2-0-27	11	1423	34°26'50"	120°15'20"	64
2-0-28	11	1433	34°26'18"	120°15'20"	68
2-0-29	11	1450	34°26'12"	120°17'13"	59
2-0-30	12	1034	34°26'53"	120°17'15"	26
2-0-31	12	1048	34°27'35"	120°17'17"	33
2-0-32	12	1055	34°28'00"	120°17'15"	13
2-0-33	12	1108	34°27'38"	120°19'16"	18
2-0-34	12	1115	34°27'05"	120°19'16"	33
2-0-35	12	1124	34°26'24"	120°19'15"	40
2-0-36	12	1132	34°25'50"	120°19'15"	55
2-0-37	12	1150	34°25'23"	120°21'16"	57
2-0-38	12	1200	34°26'08"	120°21'20"	38
2-0-39	12	1208	34°26'40"	120°21'21"	22
2-0-40	12	1221	34°27'12"	120°21'20"	18

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
2-0-41	12	1238	34°26'26"	120°23'21"	18
2-0-42	12	1252	34°25'42"	120°23'27"	57
2-0-43	12	1300	34°24'59"	120°23'29"	70
2-0-44	12	1314	34°25'07"	120°25'30"	75
2-0-45	12	1324	34°25'41"	120°25'29"	59
2-0-46	12	1333	34°26'11"	120°25'32"	37
2-0-47	12	1342	34°26'42"	120°25'27"	15
2-0-49	13	0935	34°18'30"	119°24'49"	27
2-0-50	13	0944	34°18'51"	119°24'34"	20
2-0-51	13	0952	34°19'17"	119°24'18"	15
2-0-52	13	0956	34°19'30"	119°24'08"	9
2-0-53	13	1014	34°17'25"	119°23'10"	26
2-0-54	13	1025	34°18'01"	119°22'49"	20
2-0-55	13	1031	34°18'21"	119°22'35"	9
2-0-58	13	1053	34°16'55"	119°20'48"	13
2-0-59	13	1100	34°16'41"	119°21'55"	20
2-0-60	13	1106	34°16'15"	119°21'17"	22
2-0-61	13	1120	34°14'56"	119°19'52"	20
2-0-62	13	1125	34°15'20"	119°19'32"	20
2-0-63	13	1135	34°15'45"	119°19'14"	18
2-0-64	13	1140	34°16'08"	119°18'50"	110

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
2-0-65	17	0950	34°13'19"	119°19'36"	20
2-0-66	17	1004	34°13'45"	119°18'46"	17
2-0-67	17	1011	34°14'10"	119°18'12"	17
2-0-68	17	1020	34°14'40"	119°17'40"	17
2-0-69	17	1030	34°14'37"	119°17'12"	17
2-0-72	17	1050	34°13'16"	119°17'37"	15
2-0-73	17	1100	34°13'00"	119°17'20"	-

APPENDIX 9

Offshore sample station locations.

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
January, 1969					
12600	20	1600	34°02'15"	119°21'00"	91
12601	20	1655	34°05'30"	119°18'20"	220
12602	20	1755	34°07'15"	119°17'13"	31
12603	20	1850	34°09'00"	119°17'15"	20
12604	20	1930	34°12'20"	119°17"15"	15
12605	20	2030	34°10'06"	119°19'08"	22
12606	20	2124	34°08'46"	119°20'00"	40
12607	20	2330	34°04'45"	119°33'36"	91
12608	21	0915	34°01'30"	119°37'15"	23
12609	21	1010	34°03'15"	119°40'00"	91
12610	21	1114	34°03'28"	119°44'30"	55
12611	21	1228	34°05'00"	119°49'00"	91
12612	21	1408	34°05'00"	119°59'00"	90
12613	22	0757	34°00'30"	119°29'13"	53
12614	22	1100	34°11'45"	119°54'29"	503
12615	22	1240	34°17'45"	120°09'50"	512
12616	22	1340	34°23'00"	120°13'00"	366
12617	22	1410	34°25'20"	120°13'00"	174
12618	22	1541	34°26'03"	120°26'00"	46
12619	22	1905	34°24'40"	120°21'10"	73
12620	22	1928	34°25'30"	120°21'10"	55
12621	22	1940	34°26'10"	120°21'10"	46

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12622	22	1950	34°26'45"	120°21'10"	37
12623	22	2010	34°26'15"	120°19'42"	46
12624	22	2020	34°25'38"	120°19'26"	51
12625	22	2044	34°27'08"	120°18'45"	24
12626	22	2103	34°26'28"	120°18'21"	38
12627	22	2113	34°26'04"	120°17'40"	42
12628	22	2140	34°25'30"	120°17'52"	110
12629	22	2155	34°26'09"	120°16'40"	73
12630	22	2208	34°26'48"	120°16'45"	24
12631	22	2220	34°26'45"	120°15'40"	18
12632	22	2228	34°26'27"	120°15'38"	59
12633	22	2238	34°25'43"	120°15'48"	88
12634	22	2253	34°25'41"	120°14'15"	106
12635	22	2307	34°26'38"	120°14'15"	73
12636	22	2317	34°27'21"	120°14'10"	23
12637	22	2343	34°27'09"	120°10'08"	55
12638	23	0025	34°27'00"	120°06'30"	62
12639	23	0113	34°26'40"	120°03'10"	64
12640	23	0147	34°26'20"	120°00'00"	46
12641	23	0228	34°24'50"	119°56'10"	59
12642	23	0335	34°24'10"	119°49'06"	40
12643	23	0419	34°23'30"	119°45'20"	44

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12644	23	0504	34°23'00"	119°40'00"	42
12645	23	0542	34°24'00"	119°36'00"	37
12646	23	0612	34°21'30"	119°37'00"	46
12647	23	0650	34°20'00"	119°34'10"	46
12648	23	0725	34°22'00"	119°33'00"	37
12649	23	0757	34°21'30"	119°30'15"	27
12650	23	0823	34°18'57"	119°31'13"	55
12651	23	0927	34°19'25"	119°26'45"	29
12652	23	0958	34°17'11"	119°28'22"	55
12653	23	1048	34°17'36"	119°23'56"	29
12654	23	1130	34°14'27"	119°26'20"	46
12655	23	1218	34°13'11"	119°23'15"	40
12656	23	1252	34°16'00"	119°21'15"	23
12657	23	1327	34°14'00"	119°19'00"	19
12658	23	1405	34°11'00"	119°21'15"	23
12659	23	1436	34°10'10"	119°19'00"	22
12660	23	1510	34°07'15"	119°19'40"	55
12661	23	1550	34°04'10"	119°20'00"	229
12662	23	2245	33°48'55" 33°48'30"	119°32'33" 119°33'00"	1756
12663	30	1940	34°24'10"	119°54'00"	42
12664	30	2028	34°21'34"	119°51'30"	110
12665	30	2100	34°24'12"	119°48'16"	40

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12666	30	2137	34°23'25"	119°45'14"	33
12667	30	2217	34°20'52"	119°42'54"	70
12668	30	2320	34°23'00"	119°40'00"	37
12669	30	2350	34°23'15"	119°37'52"	20
12670	31	0038	34°23'10"	119°33'00"	23
12671	31	0123	34°22'00	119°29'15"	20
12672	31	0740	34°20'10"	119°30'15"	42
12673	31	0853	34°15'07"	119°33'12"	110
12674	31	0942	34°12'35"	119°37'10"	174
12675	31	1032	34°11'33"	119°42'00"	293
12676	31	1150	34°05'40"	119°42'00"	110
12677	31	1233	34°03'30"	119°40'00"	91
12678	31	1333	34°08'15"	119°38'30"	293
12679	31	1439	34°11'20"	119°35'15"	165
12680	31	1555	34°10'00"	119°32'00"	202
12681	31	1640	34°07'20"	119°32'10"	238
12682	31	1755	34°04'40"	119°33'30"	88
12683	31	1900	34°07'20"	119°29'12"	234
12684	31	1954	34°10'00"	119°26'20"	101
12685	31	2036	34°08'00"	119°23'18"	174
12686	31	2130	34°05'00"	119°24'40"	229
12687	31	2228	34°02'25"	119°26'18"	91

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12688	31	2322	34°02'12"	119°20'50"	91
February, 1969					
12689	1	0007	34°05'10"	119°19'00"	238
12690	1	0117	34°07'45"	119°17'50"	27
12691	1	1241	34°13'10"	119°19'25"	18
12692	1	1315	34°12'50"	119°16'30"	14
12693	1	1330	34°12'15"	119°16'00"	14
12694	1	1400	34°10'20"	119°19'00"	18
12695	1	1425	34°09'29"	119°16'50"	14
12696	1	1452	34°07'45"	119°13'30"	18
12697	1	1525	34°06'46"	119°11'15"	18
March, 1969					
12732	5	0650	34°23'30"	119°49'30"	46
12733	5	0728	34°22'00"	119°49'20"	73
12734	5	0814	34°20'28"	119°49'20"	201
12735	5	0854	34°18'38"	119°49'15"	293
12736	5	0947	34°16'47"	119°48'12"	302
12737	5	1228	34°11'45"	119°49'10"	421
12738	5	1625	34°22'50"	119°38'10"	37
12739	5	1711	34°21'00"	119°42'00"	60
12740	5	1800	34°20'00"	119°39'40"	64
12741	5	2015	34°24'20"	119°54'10"	27

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12742	5	2102	34°23'48"	119°54'12"	46
12743	5	2148	34°22'18"	119°54'04"	119
12744	5	2325	34°22'40"	119°53'50"	110
12745	6	0005	34°22'45"	119°54'00"	110
12746	6	0920	34°23'32"	119°34'58"	18
12747	6	1022	34°20'51"	119°36'04"	42
12748	6	1210	34°18'55"	119°36'50"	91
12749	6	1335	34°23'40"	119°35'00"	18
12750	6	1400	34°23'45"	119°35'10"	18
12753	6	1704	34°20'45"	119°36'00"	42
12754	7	0829	34°21'17"	119°37'09"	42
12755	7	0900	34°22'48"	119°35'12"	35
12756	7	0933	34°21'28"	119°33'04"	37
12757	7	1024	34°20'00"	119°34'45"	55
12758	7	1110	34°17'43"	119°35'33"	88
12759	7	1250	34°19'00"	119°32'30"	46
12760	7	1340	34°21'00"	119°30'45"	37
12761	7	1355	34°21'00"	119°30'45"	37
12762	7	1412	34°22'00"	119°30'00"	27
12763	7	1420	34°22'00"	119°30'00"	27
12764	7	1440	34°21'00"	119°28'10"	27
12765	7	1449	34°21'00"	119°28'10"	27

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12766	7	1518	34°19'15"	119°30'00"	55
12767	7	1552	34°19'00"	119°26'55"	37
12768	7	1614	34°18'15"	119°24'30"	27
12769	7	1634	34°16'20"	119°24'30"	35
12770	7	1700	34°16'45"	119°21'30"	20
12771	7	1725	34°14'30"	119°22'40"	24
12772	7	1810	34°12'50"	119°17'50"	17
12792	20	0143	34°05'30"	119°10'25"	37
12793	20	0318	34°08'00"	119°18'30"	27
12794	20	0425	34°09'50"	119°18'15"	18
12795	20	0605	34°14'30"	119°29'45"	73
12796	20	0655	34°16'50"	119°26'15"	46
12797	20	1923	34°23'30"	119°35'00"	26
12798	20	2005	34°21'56"	119°35'08"	44
12799	20	2057	34°20'56"	119°36'12"	42
12800	20	2245	34°18'45"	119°36'28"	73
12801	21	0015	34°17'40"	119°36'30"	82
12802	21	0306	34°16'00"	119°37'15"	101
12803	21	0405	34°17'15"	119°28'30"	91
12804	21	2000	34°23'27"	119°40'58"	31
12805	21	2038	34°21'58"	119°40'56"	55
12806	21	2128	34°19'45"	119°41'00"	73

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12807	21	2230	34°18'27"	119°37'52"	86
12808	21	2342	34°19'00"	119°37'13"	73
12809	22	0222	34°21'00"	119°36'58"	49
12810	22	0306	34°22'00"	119°36'10"	42
12811	22	0520	34°23'45"	119°35'40"	20
12812	22	1922	34°22'15"	119°34'20"	37
12813	22	2057	34°20'00"	119°34'12"	44
12814	22	2230	34°16'55"	119°34'28"	91
12815	23	0012	34°18'30"	119°32'30"	68
12816	23	0205	34°21'45"	119°28'40"	18
12817	23	0355	34°19'15"	119°29'50"	40
12818	23	0500	34°16'20"	119°31'30"	82
12819	23	0813	34°17'20"	119°28'55"	59
12820	23	1001	34°18'00"	119°26'30"	37
12821	23	1238	34°18'45"	119°23'55"	18
12822	23	1830	34°16'50"	119°21'00"	17
12823	23	1903	34°14'30"	119°23'00"	24
12824	23	1935	34°12'15"	119°24'50"	40
12825	23	2015	34°09'40"	119°26'30"	183
12826	23	2111	34°07'12"	119°29'45"	229
12827	23	2157	34°07'11"	119°24'53"	227
12828	23	2257	34°10'42"	119°22'13"	31

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12829	23	2337	34°13'02"	119°20'00"	20
12830	24	0010	34°15'15"	119°18'00"	18
12831	24	0053	34°12'25"	119°16'30"	15
12832	24	0122	34°10'15"	119°18'30"	18
12833	24	0153	34°08'15"	119°20'00"	37
12834	24	0220	34°05'30"	119°22'20"	229
12835	24	0254	34°05'30"	119°18'20"	205
12836	24	0315	34°07'45"	119°16'40"	27
12837	24	0345	34°07'45"	119°15'00"	13
12838	24	0425	34°06'00"	119°11'45"	35
12839	24	0453	34°04'00"	119°12'45"	128
April, 1969					
12852	2	2145	34°04'30"	119°10'50"	46
12853	3	0738	34°23'18"	119°38'17"	37
12854	3	0901	34°23'18"	119°38'07"	37
12855	3	1052	34°24'18"	119°37'53"	38
12856	3	1245	34°23'12"	119°38'18"	42
12857	3	1428	34°23'08"	119°38'06"	42
12858	3	1605	34°23'08"	119°37'53"	42
12859	3	1727	34°22'58"	119°37'53"	44
12860	3	1916	34°22'58"	119°38'05"	42
12861	3	2106	34°22'58"	119°38'17"	42

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12862	3	2229	34°23'30"	119°37'20"	37
12863	4	0006	34°22'20"	119°37'36"	46
12864	4	0154	34°21'15"	119°38'00"	46
12865	4	0257	34°19'40"	119°38'30"	64
12866	4	0358	34°18'45"	119°39'05"	64
12867	4	0725	34°04'45"	119°14'15"	348
12868	4	0753	34°06'20"	119°13'45"	311
12869	4	0850	34°07'40"	119°13'15"	165
12870	4	0901	34°07'10"	119°12'11"	18
12881	14	0804	34°05'58"	119°14'10"	256
12882	14	0904	34°05'12"	119°15'50"	183
12883	14	1015	34°05'08"	119°16'21"	216
12884	14	1122	34°02'45"	119°17'10"	183
12885	15	0700	34°05'00"	119°25'30"	229
12886	15	0953	34°08'42"	119°29'29"	293
12887	15	1054	34°11'20"	119°44'48"	293
12888	15	1230	34°13'40"	119°50'20"	412
12889	15	1348	34°17'00"	119°56'00"	512
12890	15	1822	34°26'33"	120°19'29"	37
12891	16	0200	34°26'45"	120°16'30"	27
12892	16	0209	34°26'15"	120°16'20"	55
12893	16	0220	34°25'50"	120°16'15"	82

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12894	16	0231	34°25'30"	120°16'10"	137
12895	16	0245	34°25'10"	120°16'10"	174
12896	16	0305	34°24'50"	120°16'00"	201
12897	16	0340	34°24'25"	120°19'15"	183
12898	16	0358	34°24'45"	120°19'10"	137
12899	16	0414	34°25'25"	120°19'15"	82
12900	16	0429	34°26'00"	120°19'15"	42
12901	16	0447	34°26'45"	120°19'30"	37
12902	16	0500	34°26'45"	120°19'00"	37
12903	16	0512	34°27'00"	120°18'15"	27
12904	16	0524	34°27'00"	120°17'40"	22
12905	16	0538	34°26'15"	120°18'00"	29
12906	16	0550	34°25'50"	120°17'50"	91
12907	16	0559	34°25'28"	120°17'50"	146
12908	16	0610	34°25'02"	120°17'45"	164
12909	16	0806	34°26'36"	120°16'38"	55
12910	16	0845	34°26'03"	120°16'54"	101
12911	16	0924	34°25'29"	120°16'52"	146
12912	16	1030	34°25'02"	120°16'52"	183
12913	16	1119	34° 25'00"	120°18'31"	155
12914	16	1305	34°24'30"	120°19'30"	210
12915	16	1403	34°24'30"	120°16'40"	220

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12916	16	1545	34°24'05"	120°17'20"	229
12917	16	1625	34°23'25"	120°16'55"	265
12918	16	1818	34°22'25"	120°18'55"	265
12919	16	1910	34°22'13"	120°16'30"	293
12920	16	1952	34°22'07"	120°15'04"	338
12921	16	2145	34°23'00"	120°17'30"	265
12922	16	2248	34°19'00"	120°17'28"	375
12923	17	0005	34°14'45"	120°17'15"	466
12924	17	0118	34°10'45"	120°17'10"	476
12925	17	0230	34°14'15"	120°14'30"	494
12926	17	0357	34°17'30"	120°12'20"	457
12927	17	0514	34°20'10"	120°10'30"	485
12928	17	1230	34°25'00"	120°01'45"	73
12929	17	1319	34°22'00"	120°02'00"	439
12930	17	1412	34°18'20"	120°02'00"	558
12931	17	1507	34°15'00"	120°01'20"	567
12932	17	1553	34°11'30"	120°00'00"	567
12933	17	1645	34°09'00"	119°55'45"	421
12934	17	1907	34°12'40"	119°53'30"	494
12935	17	1950	34°15'40"	119°50'08"	439
12936	17	2039	34°08'36"	119°49'29"	284
12937	17	2122	34°21'28"	119°47'33"	88

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12938	17	2148	34°22'42"	119°46'45"	70
12939	17	2220	34°21'12"	119°44'36"	73
12940	17	2258	34°19'12"	119°43'16"	101
12941	17	2342	34°16'39"	119°41'25"	179
12942	18	0030	34°14'00"	119°38'56"	183
12943	18	0113	34°14'10"	119°36'00"	128
12944	18	0155	34°16'40"	119°33'50"	91
12945	18	0230	34°18'30"	119°32'30"	73
12946	18	0318	34°21'30"	119°30'20"	27
12947	18	0407	34°18'45"	119°27'45"	37
12948	18	0443	34°16'20"	119°27'15"	55
12949	18	1137	33°39'27"	118°26'56"	481
May, 1969					
12968	1	1300	34°25'20"	120°29'30"	91
12969	1	1448	34°26'00"	120°15'50"	73
12970	1	1840	34°22'00"	120°16'15"	320
12971	1	2124	34°18'09"	120°16'12"	402
12972	1	2400	34°14'00"	120°16'30"	476
12973	2	0332	34°10'00"	120°16'30"	457
12974	2	0605	34°05'50"	120°16'30"	91
12975	2	0833	34°01'25"	120°16'29"	35
12976	2	1235	33°57'00"	119°53'58"	229

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12977	2	1555	34°02'20"	119°58'05"	37
12978	2	1638	34°04'45"	120°03'50"	73
12979	2	1847	34°09'30"	120°03'45"	503
12980	2	2102	34°14'10"	120°03'39"	585
12981	3	0100	34°18'00"	120°03'40"	549
12982	3	0348	34°22'00"	120°03'35"	412
12983	3	0600	34°26'10"	120°03'45"	64
12984	3	0809	34°23'48"	119°49'09"	37
12985	3	0927	34°20'20"	119°49'10"	183
12986	3	1122	34°16'30"	119°49'15"	274
12987	3	1351	34°12'45"	119°49'00"	362
12988	4	0754	34°01'45"	119°30'16"	59
12989	4	0807	34°01'36"	119°29'18"	59
12990	4	0825	34°01'23"	119°28'27"	60
12991	4	0843	34°01'10"	119°27'26"	57
12992	4	0906	34°00"38"	119°27'22"	55
12993	4	0931	34°00'46"	119°28'22"	57
12994	4	0953	34°00'54"	119°29'23"	51
12995	4	1018	34°01'01"	119°30'16"	51
12996	4	1040	34°00'56"	119°31'32"	27
12997	4	1102	34°00'18"	119°31'18"	29
12998	4	1156	34°00'17"	119°30'21"	40

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
12999	4	1224	34°00'13"	119°29'20"	51
13000	4	1254	34°00'06"	119°28'15"	55
13001	4	1320	33°59'56"	119°27'06"	55
13002	4	1352	33°59'20"	119°26'19"	82
13003	4	1432	33°59'28"	119°28'35"	46
13004	4	1508	33°59'33"	119°30'05"	46
13005	4	1805	34°08'50"	119°48'50"	397
13006	4	2025	34°05'20"	119°48'34"	88
13007	4	2227	34°03'30"	119°36'48"	86
13008	5	0009	34°07'30"	119°36'30"	256
13009	5	0205	34°11'30"	119°36'30"	155
13010	5	0349	34°15'30"	119°36'28"	101
13011	5	0523	34°19'30"	119°36'30"	64
13012	5	0707	34°22'00"	119°42'30"	57
13013	5	0829	34°23'34"	119°36'25"	31
13014	5	1025	34°07'54"	119°24'03"	27
13015	5	1208	34°14'00"	119°24'15"	37
13016	5	1307	34°10'10"	119°24'00"	82
13017	5	1422	34°06'32"	119°24'15"	220
13018	5	1625	34°02'40"	119°23'55"	82
13019	5	1753	34°04'03"	119°20'27"	216
13020	5	1930	34°07'15"	119°19'15"	46

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13021	5	2035	34°10'20"	119°18'15"	18
13022	5	2154	34°08'20"	119°15'30"	22
13023	5	2248	34°05'38"	119°16'30"	183
13024	6	0037	34°03'05"	119°17'20"	183
13025	6	0850	34°21'50"	120°29'33"	274
13026	6	1058	34°17'57"	120°29'30"	444
13027	6	1352	34°14'00"	119°29'30"	201
13028	6	1545	34°10'00"	119°29'40"	110
13029	6	1808	34°02'30"	120°31'00"	101
13030	7	0050	34°21'24"	119°39'45"	55
13031	7	0230	34°22'22"	119°31'39"	27
13032	7	0339	34°20'00"	119°27'22"	33
13047	27	1527	34°19'52"	119°36'30"	73
13048	27	1905	34°21'40"	119°29'20"	22
13052	28	0800	34°13'30"	120°02'30"	567
13053	28	1150	34°15'00"	120°02'25"	549
13054	29	1158	34°19'00"	119°36'10"	64
		1300	34°21'40"	119°36'43"	46
June 1969					
13093	25	1450	34°23'30"	119°39'30"	27
13094	25	1845	34°23'30"	119°36'20"	33
13095	25	1934	34°19'20"	119°36'25"	64

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13096	25	2018	34°15'24"	119°36'29"	110
13097	25	2125	34°08'34"	119°32'38"	240
13098	25	2152	34°10'04"	119°30'23"	218
13099	25	2317	34°06'34"	119°23'29"	190
13100	25	2350	34°08'14"	119°15'22"	18
13101	26	0045	34°10'30"	119°21'30"	29
13102	26	0135	34°14'15"	119°21'30"	22
13103	26	0235	34°16'50"	119°27'55"	55
13104	26	0312	34°20'00"	119°27'50"	27
13106	26	2220	34°22'30"	119°56'08"	220
13107	26	2340	34°19'11"	119°57'12"	485
13108	27	1055	34°20'10"	119°36'29"	46
13110	27	1330	34°20'20"	119°36'30"	46
13111	27	1345	34°20'05"	119°36'30"	46
13112	27	1437	34°20'02"	119°36'30"	46
13113	27	1519	34°20'15"	119°36'30"	46
13114	27	1555	34°20'30"	119°36'30"	51
13115	27	1918	34°22'00"	119°29'10"	22
13116	27	2021	34°23'30"	119°34'54"	24
13117	27	2227	34°23'18"	119°38'17"	37
13118	28	1303	34°22'32"	119°56'00"	274
13119	28	1413	34°19'15"	119°57'20"	476

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13120	28	1535	34°15'40"	119°58'28"	549
13121	28	1912	34°10'30"	119°59'10"	549
13122	28	2040	34°10'21"	119°53'24"	476
13123	28	2220	34°14'52"	119°52'45"	494
13124	28	2347	34°18'56"	119°50'55"	329
13125	29	0112	34°22'40"	119°48'50"	64
13126	29	0625	34°22'00"	119°43'00"	64
13127	29	0715	34°18'15"	119°44'50"	192
13128	29	0820	34°13'40"	119°47'09"	274
13129	29	0925	34°08'34"	119°47'58"	366
13130	29	1045	34°06'20"	119°42'45"	174
13131	29	1203	34°10'50"	119°40'45"	293
13132	29	1312	34°14'45"	119°39'00"	137
13133	29	1350	34°18'30"	119°37'10"	59
13134	29	1433	34°22'00"	119°35'30"	37
13135	29	1519	34°20'15"	119°29'30"	33
13136	29	1608	34°16'10"	119°31'30"	77
13137	29	1650	34°12'50"	119°33'00"	128
13138	29	1805	34°08'50"	119°35'00"	247
13139	29	1913	34°04'50"	119°37'00"	101
13140	29	2013	34°04'45"	119°30'45"	119
13141	29	2058	34°08'30"	119°28'50"	229

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13142	29	2202	34°12'00"	119°26'50"	73
13143	29	2254	34°15'21"	119°25'23"	37
13144	30	0622	34°13'50"	119°20'15"	22
13145	30	0718	34°10'00"	119°21'50"	46
13146	30	0805	34°06'00"	119°23'34"	220
13147	30	0900	34°03'30"	119°19'07"	223
13148	30	0955	34°07'34"	119°17'15"	22
July, 1969					
13210	22	1835	34°05'30"	119°16'30"	192
13211	22	1907	34°08'15"	119°15'25"	22
13212	22	2019	34°10'25"	119°21'32"	29
13213	22	2058	34°14'12"	119°21'35"	22
13214	22	2202	34°20'00"	119°27'50"	27
13215	22	2231	34°16'45"	119°27'48"	55
13216	22	2322	34°10'00"	119°30'30"	201
13217	22	2347	34°08'39"	119°32'37"	229
13218	23	0105	34°15'30"	119°36'30"	101
13219	23	0135	34°19'30"	119°36'20"	64
13220	23	0218	34°23'36"	119°36'00"	22
13221	23	0520	34°26'36"	120°05'20"	64
13222	23	0555	34°23'30"	120°06'30"	274
13223	23	0635	34°20'25"	120°07'45"	494

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13224	23	0716	34°16'50"	120°09'25"	512
13225	23	0816	34°13'11"	120°11'00"	530
13226	23	0901	34°09'40"	120°12'23"	476
13227	23	0952	34°06'12"	120°13'40"	101
13228	23	1027	34°02'18"	120°15'13"	37
13229	23	1120	34°03'50"	120°07'10"	55
13230	23	1152	34°06'42"	120°07'10"	274
13231	23	1225	34°09'15"	120°06'10"	485
13232	23	1309	34°12'00"	120°06'30"	567
13233	23	1400	34°15'50"	120°04'00"	567
13234	23	1440	34°19'10"	120°02'36"	549
13235	23	1520	34°22'30"	120°01'30"	247
13236	23	1551	34°25'15"	119°59'30"	64
13237	23	1647	34°20'50"	119°53'15"	329
13238	23	1758	34°17'20"	119°55'00"	476
13239	23	1905	34°13'10"	119°56'20"	530
13240	23	1955	34°08'20"	119°57'20"	293
13241	23	2033	34°07'15"	120°01'10"	375
13242	23	2124	34°04'20"	120°01'54"	64
13243	23	2154	34°03'22"	119°57'45"	46
13244	23	2232	34°06'40"	119°54'38"	101
13245	23	2313	34°05'42"	119°49'00"	82

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13246	23	2348	34°07'45"	119°51'28"	165
13247	24	0045	34°12'30"	119°50'05"	430
13248	24	0200	34°10'00"	119°44'30"	357
13249	24	0300	34°14'55"	119°43'00"	210
13250	24	0357	34°16'45"	119°48'30"	274
13251	24	0455	34°21'15"	119°46'35"	73
13252	24	0546	34°18'50"	119°41'00"	91
13253	24	0618	34°21'50"	119°39'30"	51
13254	24	0912	34°20'15"	119°36'30"	55
13255	24	1055	34°19'31"	119°38'59"	68
13256	24	1245	34°19'10"	119°41'30"	91
13257	24	1452	34°20'00"	119°41'30"	73
13258	24	1650	34°21'30"	119°29'20"	22
13259	24	2103	34°21'46"	119°31'27"	31
13260	24	2155	34°16'24"	119°34'45"	95
13261	24	2225	34°12'22"	119°36'46"	155
13262	24	2310	34°08'36"	119°38'45"	274
13263	24	2359	34°03'28"	119°39'54"	88
13264	25	0045	34°04'30"	119°34'03"	82
13265	25	0125	34°02'05"	119°28'15"	68
13266	25	0154	33°58'30"	119°29'25"	247

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13267	25	0245	33°56'05"	119°25'12"	366
13268	25	0356	34°00'00"	119°20'00"	338
13269	25	0448	34°03'05"	119°22'30"	37
13270	25	0540	34°06'50"	119°19'45"	64
13271	25	0619	34°11'30"	119°17'30"	17
13272	25	0858	34°08'00"	119°14'21"	24
13273	25	0923	34°05'30"	119°15'57"	159
13274	25	1002	34°05'00"	119°12'09"	55
13275	25	1030	34°02'00"	119°13'30"	530
August, 1969					
13320	23	0045	34°25'30"	120°29'15"	82
13321	23	0320	34°22'12"	120°29'03"	274
13322	23	0600	34°18'00"	120°29'30"	421
13323	23	0912	34°14'22"	120°29'30"	375
13324	23	1215	34°10'15"	120°29'30"	119
13325	24	0820	34°00'39"	120°02'26"	9
13326	25	0808	34°00'38"	119°59'00"	27
13327	25	0925	34°04'35"	119°56'56"	55
13328	25	1034	34°02'58"	120°01'21"	33
13329	25	1152	34°09'50"	120°04'00"	521
13330	25	1617	34°14'25"	120°03'00"	567
13331	25	2206	34°18'03"	120°03'36"	540

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13332	26	0142	34°22'20"	120°03'30"	402
13333	26	0435	34°26'30"	120°03'45"	51
13334	26	0738	34°26'10"	120°15'50"	73
13335	26	0930	34°21'15"	120°15'56"	329
13336	26	1215	34°18'15"	120°16'00"	384
13337	26	1438	34°13'30"	120°16'00"	485
13338	26	1908	34°10'20"	120°16'30"	466
13339	26	2210	34°06'13"	120°16'30"	82
13340	26	2353	34°02'03"	120°16'15"	24
13341	27	0140	34°04'00"	120°04'02"	46
13342	27	0425	34°06'00"	119°49'10"	90
13343	27	0615	34°09'30"	119°49'10"	384
13344	27	0907	34°13'23"	119°48'45"	384
13345	27	1200	34°16'10"	119°49'15"	302
13346	27	1705	34°20'30"	119°49'00"	165
13347	27	1858	34°24'00"	119°49'00"	37
13348	27	2148	34°22'11"	119°42'24"	55
13349	27	2250	34°21'18"	119°39'26"	55
13350	28	0027	34°22'50"	119°31'45"	27
13351	28	0120	34°23'55"	119°36'15"	27
13352	28	0230	34°20'30"	119°36'30"	46
13353	28	0415	34°15'45"	119°36'30"	97

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13354	28	0625	34°12'00"	119°36'30"	168
13355	28	0902	34°10'03"	119°30'20"	192
13356	28	1108	34°08'34"	119°32'40"	229
13357	28	1352	34°07'55"	119°36'30"	265
13358	28	1547	34°04'05"	119°36'30"	88
13359	28	1815	34°03'15"	119°23'30"	101
13360	28	2030	34°07'00"	119°23'54"	220
13361	28	2314	34°08'34"	119°32'40"	229
13362	29	0105	34°10'00"	119°30'15"	174
13363	29	0255	34°16'36"	119°28'00"	55
13364	29	0348	34°20'00"	119°27'32"	29
13365	29	0510	34°18'15"	119°24'15"	24
13366	29	0817	34°15'30"	119°24'27"	27
13367	29	1048	34°10'34"	119°24'20"	73
13368	29	1414	34°04'30"	119°20'30"	238
13369	29	1638	34°03'30"	119°16'40"	229
13370	29	2010	34°07'40"	119°19'00"	33
13371	29	2130	34°10'34"	119°18'23"	18
13372	29	2258	34°14'15"	119°21'35"	27
13373	29	2330	34°10'30"	119°21'30"	29
13374	30	0030	34°08'45"	119°15'45"	16
13375	30	0149	34°06'10"	119°16'30"	110

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13376	30	0412	34°01'50"	119°27'00"	73
13377	30	0448	34°02'00"	119°28'30"	70
13378	30	0522	34°02'00"	119°30'00"	64
13379	30	0555	34°00'45"	119°31'00"	29
13380	30	0620	34°00'45"	119°29'00"	49
13381	30	0655	33°59'00"	119°31'00"	46
13382	30	0725	33°59'30"	119°28'40"	46
13383	30	0801	33°59'29"	119°26'25"	73
October, 1969					
13418	14	1945	34°23'00"	119°38'15"	40
13419	14	2030	34°23'00"	119°38'15"	40
13420	14	2127	34°23'00"	119°38'15"	40
13421	14	2253	34°21'00"	119°39'30"	44
13422	14	2341	34°21'00"	119°39'30"	44
13423	15	0028	34°21'00"	119°39'30"	44
13424	15	0128	34°19'15"	119°41'00"	77
13425	15	0237	34°22'20"	119°35'30"	40
13426	15	0435	34°22'20"	119°35'30"	40
13427	15	0545	34°22'20"	119°35'30"	40
13428	15	0728	34°20'30"	119°38'00"	46
13429	15	0812	34°20'30"	119°38'00"	46
13430	15	0856	34°20'30"	119°38'00"	46
13431	15	0956	34°18'20"	119°39'20"	91

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13432	15	1045	34°21'20"	119°34'40"	37
13433	15	1116	34°21'20"	119°34'40"	37
13434	15	1243	34°21'20"	119°34'40"	37
13435	15	1316	34°20'00"	119°35'55"	55
13436	15	1346	34°20'00"	119°35'55"	55
13437	15	1415	34°20'00"	119°35'55"	55
13438	15	1447	34°17'30"	119°37'00"	91
13439	15	1532	34°21'00"	119°33'00"	44
13440	15	1608	34°21'00"	119°33'00"	44
13441	15	1650	34°21'00"	119°33'00"	44
13442	15	1730	34°19'00"	119°34'15"	60
13443	15	1845	34°19'00"	119°34'15"	60
13444	15	1920	34°19'00"	119°34'15"	60
13445	15	2010	34°17'00"	119°35'30"	91
13446	16	0905	34°20'15"	119°36'38"	55
13447	16	1018	34°19'31"	119°38'56"	70
13448	16	1207	34°20'00"	119°41'30"	73
13449	16	1422	34°21'40"	119°29'20"	15
		1900	34°21'40"	119°29'20"	22
November, 1969					
13536	4	0929	34°25'30"	120°29'30"	84
13537	4	1121	34°21'52"	120°29'45"	274

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13538	4	1413	34°17'50"	120°29'30"	421
13539	4	1532	34°14'15"	120°29'40"	421
13540	4	1815	34°10'00"	120°30'00"	119
13541	4	2027	34°20'45"	120°26'13"	302
13542	4	2211	34°23'32"	120°26'12"	106
13543	4	2258	34°25'00"	120°23'26"	55
13544	5	0015	34°22'15"	120°23'30"	210
13545	5	0122	34°19'15"	120°21'45"	320
13546	5	0231	34°22'00"	120°19'56"	265
13547	5	0346	34°24'20"	120°20'15"	192
13548	5	0453	34°26'10"	120°16'00"	73
13549	5	0549	34°22'05"	120°16'00"	311
13550	5	0743	34°18'15"	120°16'15"	412
13551	5	0957	34°26'56"	120°04'00"	51
13552	5	1027	34°25'51"	120°03'58"	70
13553	5	1105	34°24'00"	120°04'00"	165
13554	5	1210	34°18'10"	120°03'50"	530
13555	5	1336	34°13'30"	120°03'45"	567
13556	5	1458	34°08'30"	120°03'45"	485
13557	5	1704	34°05'50"	119°49'00"	86
13558	5	1815	34°12'00"	119°49'15"	393
13559	5	1940	34°17'25"	119°49'10"	289

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13560	5	2046	34°21'25"	119°49'15"	88
13561	5	2117	34°22'24"	119°49'20"	70
13562	5	2151	34°23'42"	119°49'15"	46
13563	5	2306	34°21'50"	119°42'30"	59
13564	5	2344	34°20'28"	119°42'28"	70
13565	6	0035	34°19'00"	119°42'25"	91
13566	6	0128	34°16'00"	119°42'28"	201
13567	6	0310	34°14'32"	119°40'00"	192
13568	6	0415	34°16'30"	119°36'30"	101
13569	6	0520	34°21'05"	119°35'45"	42
13570	6	1225	34°21'28"	119°30'00"	22
13571	6	1308	34°18'20"	119°30'25"	55
13572	6	1346	34°16'15"	119°30'27"	70
13573	6	1439	34°14'12"	119°30'27"	81
13574	6	1505	34°12'45"	119°30'27"	81
13575	6	1620	34°18'20"	119°24'05"	20
13576	6	1657	34°16'12"	119°24'05"	31
13577	6	1730	34°14'00"	119°24'20"	51
13578	6	1843	34°12'00"	119°24'30"	46
13579	6	1922	34°09'30"	119°24'15	119
13580	6	2018	34°06'25"	119°24'26"	234
13581	6	2123	34°04'00"	119°20'25"	205

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13582	6	2228	34°07'50"	119°20'00"	37
13583	6	2253	34°09'10"	119°20'00"	24
13584	6	2317	34°11'15"	119°20'00"	22
13585	6	2346	34°13'50"	119°19'50"	18
13586	7	0014	34°15'45"	119°19'30"	17
13587	7	0048	34°14'00"	119°17'00"	12
13588	7	0114	34°11'58"	119°16'45"	8
13589	7	0146	34°10'15"	119°16'30"	13
13590	7	0212	34°08'10"	119°15'45"	27
13591	7	0239	34°06'15"	119°16'29"	64
13592	7	0315	34°02'30"	119°17'30"	210
13593	7	0427	34°06'50"	119°11'45"	18
13594	11	0900	34°19'00"	119°42'07"	86
13595	11	0929	34°20'00"	119°41'30"	70
13596	11	1232	34°19'31"	119°38'59"	70
13597	11	1344	34°19'52"	119°36'30"	59
13598	11	1527	34°21'40"	119°29'20"	23
13599	11	1905	34°23'40"	119°36'15"	33
13600	11	2000	34°19'30"	119°36'30"	64
13601	11	2037	34°15'25"	119°36'30"	99
13602	11	2152	34°08'33"	119°32'36"	229
13603	11	2221	34°10'05"	119°30'26"	177

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13604	11	2320	34°16'48"	119°27'45"	59
13605	12	0005	34°20'00"	119°27'30"	22
13606	12	0115	34°14'20"	119°21'30"	27
13607	12	0157	34°10'30"	119°21'30"	37
13608	12	0244	34°08'10"	119°15'30"	27
13609	12	0315	34°05'30"	119°16'28"	210
13610	12	1016	34°15'00"	120°02'25"	571
13611	12	1347	34°15'45"	119°56'10"	527
13612	12	1515	34°16'50"	119°51'00"	402
13613	12	1708	34°18'25"	119°44'30"	201
13618	13	1220	34°21'30"	119°36'43"	46
		1400	34°16'45"	119°35'43"	91
December, 1969					
13643	8	0914	34°19'00"	119°42'00"	91
13644	8	1005	34°20'00"	119°41'30"	70
13645	8	1233	34°19'31"	119°38'59"	70
13646	8	1450	34°20'03"	119°37'15"	51
13647	8	1640	34°21'30"	119°29'15"	22
13648	9	0810	34°25'30"	120°29'10"	81
13649	9	1045	34°22'00"	120°29'10"	265
13650	9	1347	34°18'00"	120°28'06"	421
13651	9	1805	34°26'06"	120°15'45"	73
13652	9	2038	34°21'17"	120°15'45"	326

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13653	9	2300	34°18'12"	120°16'00"	406
13654	10	0216	34°13'40"	120°16'00"	485
13655	10	0540	34°10'15"	120°16'30"	476
13656	11	0117	34°26'30"	120°04'00"	59
13657	11	0248	34°22'10"	120°03'30"	408
13658	11	0533	34°17'58"	120°03'30"	540
13659	11	0950	34°14'12"	120°29'20"	265
13660	11	1132	34°10'30"	120°29'30"	113
13661	11	1325	34°10'30"	120°16'30"	466
13662	11	1435	34°06'10"	120°16'45"	91
13663	11	1627	34°14'15"	120°23'30"	576
13664	11	1910	34°09'50"	120°03'40"	540
13665	11	2205	34°04'00"	120°03'30"	55
13666	11	2245	34°06'10"	120°00'00"	82
13667	11	2313	34°05'38"	119°56'28"	84
13668	12	0018	34°05'40"	119°49'00"	91
13669	12	0142	34°10'00"	119°49'15"	392
13670	12	0345	34°13'30"	119°48'15"	302
13671	12	0529	34°16'20"	119°48'46"	274
13672	12	0718	34°20'28"	119°49'00"	161
13673	12	0855	34°23'52"	119°48'57"	40
13674	12	1052	34°22'00"	119°42'26"	60

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13675	12	1144	34°21'07"	119°39'24"	46
13676	12	1434	34°04'15"	119°37'00"	82
13677	12	1559	34°02'50"	119°30'02"	82
13678	12	1711	34°06'45"	119°36'40"	247
13679	12	1928	34°11'45"	119°36'29"	146
13680	12	2108	34°08'22"	119°32'30"	229
13681	12	2142	34°10'10"	119°30'27"	110
13682	12	2240	34°10'15"	119°21'30"	31
13683	12	2332	34°14'00"	119°21'30"	22
13684	13	0020	34°16'45"	119°27'50"	46
13685	13	0055	34°20'00"	119°27'15"	27
13686	13	0205	34°15'34"	119°36'20"	91
13687	13	0335	34°19'15"	119°36'30"	64
13688	13	0525	34°23'30"	119°36'20"	22
13689	13	0947	34°18'03"	119°24'07"	26
13690	13	1048	34°14'15"	119°24'18"	27
13691	13	1155	34°10'55"	119°24'00"	53
13692	13	1307	34°07'00"	119°23'30"	223
13693	13	1455	34°03'00"	119°23'30"	141
13694	13	1700	34°03'15"	119°16'40"	265
13695	13	1946	34°06'00"	119°16'30"	137
13696	13	2137	34°07'56"	119°15'30"	18

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13697	13	2335	34°01'45"	119°03'27"	421
13698	14	0100	33°58'00"	119°05'10"	732
13699	14	0356	33°55'00"	119°06'50"	777
February, 1970					
13783	6	1830	34°05'30"	119°16'30"	220
13784	6	1915	34°08'05"	119°15'25"	20
13785	6	2013	34°10'28"	119°21'34"	27
13786	6	2058	34°14'15"	119°21'30"	24
13787	6	2209	34°20'00"	119°27'43"	33
13788	6	2247	34°16'45"	119°27'50"	53
13789	6	2341	34°10'09"	119°30'18"	183
13790	7	0035	34°08'40"	119°32'45"	229
13791	7	0136	34°15'30"	119°36'30"	119
13792	7	0217	34°19'30"	119°36'25"	62
13793	7	0307	34°23'30"	119°36'15"	33
13794	7	1116	34°16'50"	119°58'54"	567
13795	7	1249	34°15'45"	119°59'28"	567
13796	7	1326	34°15'30"	119°59'34"	567
13797	7	1415	34°15'25"	119°59'20"	567
13798	7	1713	34°20'15"	119°36'40"	49
13799	7	1815	34°21'40"	119°29'15"	26
13800	7	2150	34°22'28"	119°34'35"	37

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13801	7	2253	34°20'30"	119°34'45"	46
13802	7	2321	34°18'12"	119°34'45"	73
13803	7	2355	34°16'00"	119°34'40"	101
13804	8	0035	34°13'52"	119°31'45"	101
13805	8	0114	34°16'30"	119°31'55"	82
13806	8	0147	34°18'47"	119°31'45"	73
13807	8	0226	34°21'15"	119°31'30"	55
13808	8	0257	34°19'20"	119°26'30"	29
13809	8	0335	34°17'15"	119°26'30"	48
13810	8	0410	34°14'40"	119°26'30"	44
13811	8	0445	34°12'10"	119°26'25"	73
13812	8	0917	34°18'25"	119°44'30"	201
13813	8	1058	34°19'00"	119°42'07"	86
13814	8	1225	34°20'00"	119°41'30"	73
13815	8	1300	34°19'30"	119°38'59"	36
13816	8	1620	34°17'15"	119°51'20"	384
13817	8	2047	34°25'30"	119°43'01"	77
13818	8	2200	34°20'27"	119°49'09"	174
13819	8	2255	34°21'45"	119°53'26"	165
13820	8	2353	34°21'45"	119°58'25"	430
13821	9	0106	34°24'30"	120°01'00"	59
13822	9	0210	34°24'28"	120°07'00"	124

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13823	9	0310	34°23'40"	120°12'30"	238
13824	9	0405	34°26'00"	120°15'30"	64
13825	9	0500	34°25'20"	120°21'15"	49
13826	9	0516	34°26'00"	120°21'25"	46
13827	9	0550	34°25'00"	120°23'30"	62
13828	9	0607	34°25'30"	120°23'30"	48
13829	9	0634	34°23'50"	120°25'00"	91
13830	9	0720	34°25'00"	120°25'30"	64
13831	9	0734	34°25'30"	120°25'30"	55
13832	9	0803	34°25'30"	120°29'15"	81
13833	9	0855	34°30'18"	120°31'40"	37
13834	9	0940	34°28'54"	120°33'10"	60
13835	9	1027	34°26'57"	120°35'33"	110
13836	9	1149	34°22'08"	120°29'27"	265
13837	9	1602	34°04'10"	120°03'15"	55
13838	9	1653	34°07'30"	120°01'00"	220
13839	9	1815	34°07'12"	119°57'30"	101
13840	9	1900	34°10'00"	119°56'00"	466
13841	9	2018	34°09'30"	119°49'10"	384
13842	9	2110	34°05'50"	119°49'10"	77
13843	9	2158	34°06'31"	119°45'40"	192
13844	9	2241	34°09'03"	119°41'27"	338

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13845	10	0028	34°07'30"	119°36'40"	265
13846	10	0110	34°03'50"	119°36'30"	82
13847	10	0241	34°04'20"	119°29'30"	82
13848	10	0418	34°03'00"	119°23'45"	82
13849	10	0530	34°06'45"	119°24'00"	210
13850	10	0610	34°07'30"	119°27'00"	220
13851	10	0820	34°11'12"	119°32'45"	106
13852	10	0849	34°11'18"	119°36'30"	161
13853	10	1012	34°11'45"	119°41'40"	262
13854	10	1104	34°13'10"	119°49'00"	384
13855	10	1257	34°15'00"	119°55'28"	503
13856	10	1358	34°13'30"	119°58'20"	549
13857	10	1530	34°15'30"	119°59'28"	549
13858	10	1643	34°14'00"	120°03'30"	558
13859	10	2107	34°10'24"	120°29'30"	119
13860	10	2236	34°14'15"	120°29'30"	402
13861	11	0050	34°17'54"	120°29'22"	402
13862	11	0232	34°19'20"	120°24'40"	329
13863	11	0445	34°15'30"	120°25'00"	421
13864	11	0640	34°12'40"	120°25'00"	457
13865	11	0946	34°09'30"	120°25'15"	106
13866	11	1054	34°06'56"	120°20'40"	82

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13867	11	1203	34°09'54"	120°20'30"	366
13868	11	1340	34°13'20"	120°20'30"	448
13869	11	1520	34°17'03"	120°20'28"	375
13870	11	1704	34°20'45"	120°20'30"	274
13871	11	1953	34°23'25"	120°20'30"	165
13872	11	2130	34°21'18"	120°15'45"	329
13873	11	2242	34°18'13"	120°15'57"	402
13874	12	0025	34°13'50"	120°16'00"	476
13875	12	0242	34°10'15"	120°16'22"	457
13876	12	0440	34°06'15"	120°16'45"	95
13877	12	0546	34°05'15"	120°12'00"	71
13878	12	0654	34°04'50"	120°07'30"	86
13879	12	0825	34°08'00"	120°07'30"	448
13880	12	0935	34°09'50"	120°03'40"	521
13881	12	1858	34°22'00"	120°03'25"	466
13882	12	2133	34°20'40"	120°07'10"	503
13883	12	2324	34°19'12"	120°12'14"	439
13884	13	0110	34°15'15"	120°12'20"	485
13885	13	0258	34°12'00"	120°12'02"	494
13886	13	0515	34°09'25"	120°12'10"	439
13887	13	0730	34°12'00"	120°07'30"	549
13888	13	0901	34°15'52"	120°07'32"	549

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13889	13	1035	34°18'00"	120°03'33"	558
13890	13	1446	34°18'30"	119°54'00"	439
13891	13	1800	34°16'32"	119°49'10"	302
13892	13	1800	34°16'32"	119°49'10"	302
13893	13	2021	34°20'32"	119°44'18"	88
13894	13	2112	34°16'08"	119°45'07"	192
13895	13	2252	34°11'51"	119°45'08"	338
13896	14	0125	34°06'30"	119°46'30"	91
13897	14	0243	34°10'00"	119°56'00"	293
13898	14	0336	34°13'34"	119°58'10"	567
13899	14	0430	34°17'45"	119°57'50"	503
13900	14	0515	34°21'45"	119°58'20"	348
13901	14	0727	34°13'00"	119°39'40"	128
13902	14	0936	34°08'12"	119°32'24"	229
13903	14	1220	34°01'00"	119°18'15"	393
13904	14	1405	34°03'20"	119°16'45"	220
13905	14	1536	34°01'10"	119°11'30"	430
13906	14	1812	34°03'30"	119°10'30"	179
13907	14	1930	34°05'30"	119°10'00"	33
13908	14	2040	34°07'00"	119°13'50"	238
13909	14	2339	34°05'53"	119°16'39"	155
13910	15	0123	34°07'45"	119°17'10"	26

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13911	15	0212	34°09'45"	119°16'32"	18
13912	15	0312	34°08'20"	119°21'45"	51
13913	15	0358	34°11'32"	119°21'00"	27
13914	15	0455	34°10'30"	119°24'30"	91
13915	15	0608	34°11'45"	119°29'00"	101
13916	15	0737	34°14'15"	119°24'30"	37
13917	15	0841	34°14'00"	119°22'00"	22
13918	15	0935	34°15'00"	119°20'24"	19
13919	15	1052	34°16'14"	119°23'27"	26
13920	15	1150	34°17'57"	119°24'20"	26
13921	15	1359	34°17'40"	119°26'47"	46
13922	15	1459	34°15'45"	119°27'59"	59
13923	15	1618	34°14'50"	119°32'28"	86
13924	15	1755	34°15'30"	119°36'30"	95
13925	15	1902	34°16'50"	119°39'30"	123
13926	15	2010	34°19'30"	119°36'30"	64
13927	15	2102	34°21'23"	119°38'02"	46
13928	15	2151	34°23'45"	119°36'26"	27
13929	16	0133	34°18'32"	119°31'20"	64
13930	16	0317	34°05'28"	119°33'50"	183
13931	16	0654	34°03'40"	119°14'40"	448
13932	16	0910	34°05'25"	119°14'03"	357

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
13933	16	1117	34°06'25"	119°13'50"	289
13934	16	1420	34°01'40"	119°08'30"	476
13935	16	1543	34°01'50"	119°05'20"	567
13936	16	1820	34°01'35"	119°14'45"	476
13937	16	1955	34°04'20"	119°20'20"	238
13938	16	2048	34°06'15"	119°19'45"	73
13939	16	2125	34°09'56"	119°18'57"	18
13940	16	2205	34°11'57"	119°18'00"	18
13941	17	0042	34°04'00"	119°08'20"	274
13942	17	0340	34°03'20"	119°04'58"	494
13943	17	0450	34°04'45"	119°06'22"	311
March 31 - April, 1970					
14076	31	0044	34°08'50"	119°32'40"	229
14077	31	0148	34°15'30"	119°36'45"	101
14078	31	0228	34°19'30"	119°36'20"	82
14079	31	0328	34°23'40"	119°36'15"	37
14080	31	1105	34°15'00"	120°02'30"	567
14081	31	1205	34°14'58"	120°02'30"	567
14082	31	1257	34°15'30"	119°59'30"	567
14083	31	1352	34°16'00"	119°57'10"	539
14084	31	1433	34°16'00"	119°57'15"	539
14085	1	0915	34°21'40"	119°29'20"	22

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
14086	1	1055	34°19'52"	119°36'30"	55
14087	1	1310	34°20'02"	119°36'30"	55
14088	1	1420	34°19'58"	119°39'00"	70
14089	1	1426	34°19'45"	119°39'00"	70
14090	1	1455	34°20'00"	119°39'00"	70
14091	1	1557	34°20'00"	119°41'30"	73
14092	1	1708	34°19'00"	119°42'07"	86
14093	1	1830	34°18'25"	119°44'30"	192
14094	1	2158	34°23'39"	119°36'21"	27
14095	1	2239	34°19'30"	119°36'18"	60
June, 1970					
14192	4	2050	34°03'13"	119°16'36"	265
14193	4	2257	34°05'33"	119°20'40"	220
14194	4	2341	34°08'24"	119°18'42"	27
14195	5	0028	34°11'00"	119°17'00"	15
14196	5	0108	34°10'30"	119°23'00"	37
14197	5	0135	34°08'05"	119°25'00"	146
14198	5	0204	34°06'00"	119°27'30"	229
14199	5	0310	34°09'00"	119°30'48"	229
14200	5	0350	34°11'10"	119°27'15"	101
14201	5	0430	34°14'15"	119°25'00"	29
14202	5	0504	34°13'25"	119°28'50"	73

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
14203	5	0533	34°12'30"	119°32'00"	119
14204	5	0559	34°09'15"	119°34'30"	238
14205	5	0635	34°07'50"	119°36'00"	265
14206	5	0741	34°10'30"	119°38'30"	293
14207	5	0824	34°08'30"	119°43'00"	320
14208	5	0917	34°11'29"	119°46'40"	329
14209	5	0958	34°15'20"	119°46'53"	247
14210	5	1035	34°15'10"	119°51'27"	421
14211	5	1215	34°09'42"	120°03'50"	530
14212	5	1359	34°13'00"	120°06'45"	549
14213	5	1820	34°14'12"	120°03'28"	576
14214	5	2203	34°18'00"	120°03'41"	549
14215	5	2356	34°22'06"	120°03'30"	439
14216	6	0103	34°24'45"	120°01'15"	82
14217	6	0215	34°21'30"	119°51'45"	155
14218	6	0257	34°19'55"	119°47'05"	201
14219	6	0326	34°17'20"	119°47'10"	247
14220	6	0418	34°18'10"	119°43'00"	165
14221	6	0450	34°21'00"	119°43'00"	86
14222	6	0535	34°17'30"	119°38'45"	110
14223	6	0625	34°14'00"	119°42'25"	157
14224	6	0715	34°14'00"	119°38'30"	170

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
14225	6	0750	34°12'30"	119°35'45"	155
14226	6	0854	34°15'10"	119°34'00"	101
14227	6	1021	34°17'55"	119°33'53"	79
14228	6	1123	34°15'58"	119°30'30"	73
14229	6	1205	34°17'15"	119°26'30"	229
14230	6	1300	34°16'45"	119°22'30"	24
14231	6	1327	34°13'32"	119°20'30"	22
14232	6	1432	34°15'00"	119°30'45"	73
14233	6	1548	34°16'30"	119°35'50"	91
14234	7	0432	34°04'00"	119°43'15"	88
14235	7	0450	34°05'15"	119°43'00"	86
14236	7	0527	34°05'15"	119°47'45"	86
14237	7	0542	34°04'30"	119°48'10"	86
14238	7	0614	34°05'30"	119°52'35"	91
14239	7	0633	34°06'40"	119°52'20"	93
14240	7	0650	34°08'00"	119°52'00"	229
14241	7	0733	34°11'40"	119°51'15"	439
14242	7	1210	34°17'50"	120°00'45"	549
14243	7	1520	34°20'30"	120°10'40"	494
14244	7	1725	34°24'25"	120°10'45"	457
14245	7	1900	34°27'15"	120°10'45"	421
14246	8	0142	34°41'45"	120°38'00"	33

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
14247	8	0202	34°41'30"	120°43'02"	40
14249	8	0245	34°41'29"	120°43'00"	59
14250	8	0318	34°41'15"	120°46'00"	82
14251	8	0402	34°41'00"	120°49'00"	113
14252	8	0452	34°40'30"	120°51'45"	220
14253	8	0538	34°40'20"	120°55'30"	366
14254	8	0633	34°36'00"	120°51'30"	357
14255	8	0725	34°36'10"	120°48'25"	192
14256	8	0803	34°36'10"	120°46'00"	110
14257	8	0832	34°36'28"	120°34'09"	64
14258	8	0859	34°36'40"	120°40'21"	37
14259	8	1050	34°29'45"	120°43'48"	274
14260	8	1126	34°30'50"	120°41'00"	101
14261	8	1155	34°31'57"	120°38'30"	64
14262	8	1425	34°14'20"	120°38'25"	603
14263	8	1903	34°11'30"	120°27'15"	137
14264	8	1952	34°15'50"	120°27'15"	439
14265	8	2111	34°19'15"	120°27'10"	375
14266	8	2212	34°21'40"	120°27'13"	265
14267	8	2305	34°23'45"	120°27'12"	113
14268	8	2345	34°25'45"	120°27'15"	55
14269	9	0002	34°25'30"	120°26'00"	55

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
14270	10	0640	34°11'15"	119°42'30"	293
14271	10	0857	34°15'57"	119°42'54"	210
14272	11	0242	34°25'10"	120°23'30"	64
14273	11	0337	34°23'00"	120°23'30"	201
14274	11	0510	34°20'30"	120°23'50"	293
14275	11	0611	34°22'00"	120°18'30"	284
14276	11	0840	34°21'44"	120°17'29"	274
14277	11	0932	34°24'30"	120°18'32"	192
14278	11	1044	34°26'42"	120°10'57"	70
14279	11	1120	34°23'33"	120°10'57"	284
14280	11	1300	34°14'35"	120°04'50"	567
14281	11	2045	34°15'20"	119°36'45"	110
14282	11	2130	34°19'28"	119°36'30"	70
14283	11	2221	34°23'45"	119°36'26"	37
14284	11	2340	34°22'54"	119°44'38"	46
14285	12	0011	34°22'30"	119°52'28"	73
14286	12	0102	34°19'15"	119°56'32"	476
14287	12	0130	34°15'30"	119°56'32"	551
14288	12	0154	34°12'30"	119°56'32"	553
14289	12	0300	34°12'30"	120°06'40"	567
14290	12	0358	34°10'00"	120°09'40"	494
14291	12	0610	34°16'30"	120°06'45"	540

Station	Day	Time	Lat. (N)	Long. (W)	Depth (m)
14292	12	1342	34°19'30"	120°18'20"	349
14293	12	1445	34°20'30"	120°23'32"	302
14294	12	2303	34°19'58"	119°27'45"	33
14295	12	2336	34°16'45"	119°28'00"	48
14296	13	0025	34°14'15"	119°21'30"	24
14297	13	0100	34°10'30"	119°21'30"	37
14298	13	0141	34°08'00"	119°15'30"	20
14299	13	0214	34°05'20"	119°16'15"	201
14300	13	0400	34°08'32"	119°32'30"	238
14301	13	0445	34°10'00"	119°30'30"	165
14302	13	0932	34°21'30"	119°29'15"	22
14303	13	1035	34°19'52"	119°36'30"	51
14304	13	1242	34°19'31"	119°38'59"	70
14305	13	1335	34°20'00"	119°41'30"	73
14306	13	1555	34°19'05"	119°42'00"	91
14307	13	1645	34°18'30"	119°44'30"	165