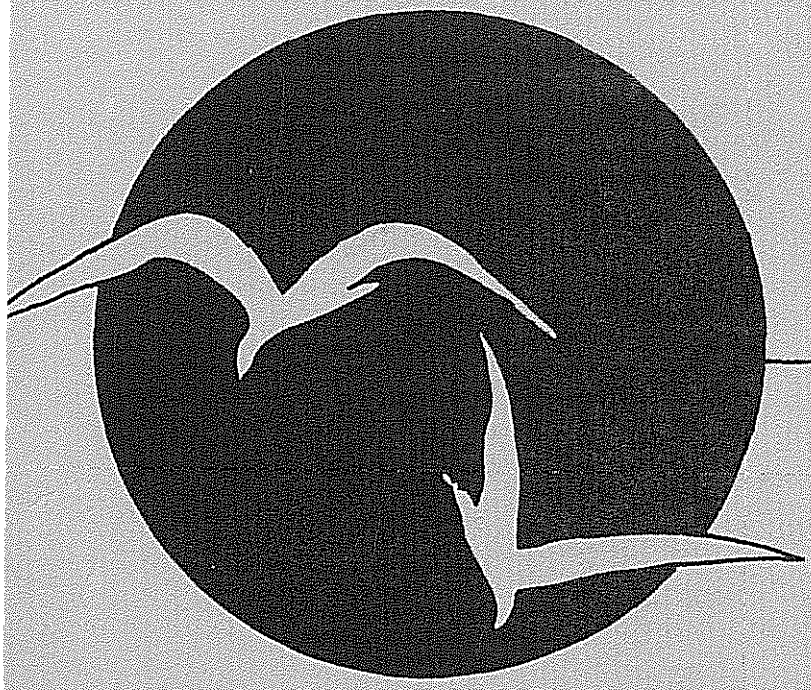

Moss Landing Marine Laboratories

ENVIRONMENTAL STUDIES OF MONTEREY BAY
AND THE CENTRAL CALIFORNIA COASTAL ZONE

Progress Report:
First Half of 2nd. Year of Operation--July 1971-February 1972

A NATIONAL SEA GRANT PROJECT

Supported by the
OFFICE OF SEA GRANT PROGRAMS
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
DEPARTMENT OF COMMERCE

Sea Grant 2-35137

by
Robert E. Arnal
Sea Grant Project Coordinator

MOSS LANDING MARINE LABORATORIES
of the
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TABLE OF CONTENTS

FIGURES

TABLE OF CONTENTS

(CONTINUED)

TABLE OF CONTENTS

(CONTINUED)

I. INTRODUCTORY REMARKS

R. E. Arnal, Project Coordinator

At the mid point of this three-year project, the Sea Grant Faculty and Staff wish to present a summary of progress in the different activities of the Sea Grant Program conducted at the Moss Landing Marine Laboratories. The environmental data collection and research projects in Monterey Bay have been underway for more than a year, and function efficiently as the routine work is well developed. Emphasis in the collection of environmental data is to provide the decision makers of Monterey Bay comunities with the information needed following the suggestions of the Regional Advisory Committee.

As it will be stated in several occasions in the following pages, the coordination of the Sea Grant Project and the Association of Monterey Bay Area Governments (AMBAG) oceanographic study has allowed a much greater detail and better coverage in the collection of environmental data. Also, it has made possible the collection of entirely new data such as surface current studies by release of drift cards. Several sections in Chapter Two of this report give details of work in progress in the plankton studies, the hydrographic work, the benthic survey, the productivity of fishes and sand transport in Monterey Bay. The next chapter explains the progress to date in providing additional education in the marine sciences for interested persons as well as information for the general public and public services for the communities of Monterey Bay.

Most students taking classes at the Moss Landing Marine Laboratories benefit directly from the education provided through the Sea Grant Program. These students may call for advice or information on any of the persons listed below with their Sea Grant responsibilities.

FACULTY AND STAFF AND SEA GRANT RESPONSIBILITIES

Mr. Patrick Albin	Diving Captain
Dr. Robert Arnal	Sedimentology - Project Coordinator
Mrs. Doris Baron	Librarian - Public Information
Mrs. Jeri Boechler	Moss Landing Marine Laboratories Secretary
Dr. William Broenkow	Chemical - Physical Oceanography
Mr. Patrick Clark	Bivalve Molluscs
Mr. Eric Dittmer	Sand Transport
Dr. Jon Galehouse	Marine Geology
Mr. David Garrison	Phytoplankton Data
Mrs. Judith Hansen	Phytoplankton Identification
Mr. Alfred Hodgson	Polychaete Worms
Dr. James Jensen	Algology
Mr. Gary Kukowski	Fishes
Mr. Larry Leopold	Advisory Committee Work
Miss Valerie Loeb	Coliform Bacteria
Mr. Scott McKain	Oceanographic Technician
Dr. Victor Morejohn	Marine Mammals
Dr. James Nybakken	Marine Invertebrates
Mr. Robert Read	Meteorology

Mr. David Seielstad	Plankton Technician
Dr. Mary Silver	Plankton and Productivity
Mr. Richard Smith	Computer Programs
Mr. William Smethie	Hydrographic Data
Mrs. Deirdre Stevenson	Sea Grant Secretary
Mr. Barry Turner	Benthic Organisms
Mr. Daniel Varoujean	"Orca" Boat Operator
Mr. Russell Weidelich	Equipment Technician

In addition to benefiting the students and the public, the financial support from the Sea Grant Program has made it possible to improve the operations of the Laboratories. New equipment items, a small computer purchased with Sea Grant funds, and support for additional personnel have allowed greater versatility and efficiency. All this would not have been possible without the help provided by the Sea Grant Program. Gratefully, we acknowledge this support.

II. PROGRESS IN ENVIRONMENTAL DATA COLLECTION AND RESEARCH PROJECTS

PLANKTON STUDIES IN MONTEREY BAY

M. W. Silver, D. B. Seielstad and D. L. Garrison

Phytoplankton and zooplankton of nearshore Monterey Bay are being studied under the sponsorship of the Sea Grant Program. Special emphasis has been given to the phytoplankton study, since these organisms are the basic producers for the food chain of open waters and are important indicators of hydrographic conditions. The phytoplankton study consists of collection of phytoplankton for identification, measurement of standing stock and measurement of growth rate. The zooplankton study consists of collection of zooplankton for identification and measurement of zooplankton biomass.

Plankton samples are taken monthly in conjunction with the hydrographic studies (see report by W. Broenkow). Stations in the north and central areas of the bay have been occupied for plankton studies since March and stations in the south bay since September. The methods used in the major portions of the plankton study have been presented in the annual data report to Sea Grant (July 1971) and thus will be reviewed only briefly. Nine months of plankton data have been processed, some aspects only partially, and eleven months of data have been collected.

The results of the plankton program already have provided insight into the seasons of the inner bay, have given students an opportunity to participate in the collection and interpretation of oceanographic data, have led to a number of student research projects, and have

allowed the author to assist in consulting with a regional planning agency concerned with the future development of the Monterey Bay area.

PHYTOPLANKTON STUDIES

1. Species Composition. One hundred milliliter water samples are drawn from Niskin bottles at all standard depths on hydrographic casts (see report by W. Broenkow). Samples are preserved in Lugol's solution for identification under an inverted phase contrast microscope. Non-quantitative phytoplankton samples also are taken at all stations using 0.25 m mouth opening, 35 μm mesh net in a vertical haul from 15 m to the surface. A record is being kept of the dominant genera, or species where possible, encountered each month at stations where phytoplankton biomass is highest in the bay. An atlas of phytoplankton species of the nearshore bay area is being assembled from these samples using photography and line drawings.

2. Biomass. A) Describe Sampling Program: Five hundred milliliter samples are drawn from Niskin bottles at all standard depths on hydrographic casts. Water samples are filtered through 0.3 μm pore size filters and frozen on board ship. In the laboratory pigments are extracted in acetone from the filters and fluorescence of chlorophyll a determined on a fluorometer. The biomass of chlorophyll a and its detrital derivative, phaeophytin a, are expressed for all depths as mg/m^3 and the standing stock of chlorophyll a in the water column calculated at mg/m^2 for all stations. B) Continuous Sampling Program: Estimates of average biomass are difficult to obtain since phytoplankton are not evenly distributed throughout the bay. The distribution of plankton is known

to be remarkably "patchy" and thus imprecisely measured by discrete sampling methods. Thus a continuous profiling system has been set up to monitor in vivo fluorescence of phytoplankton by pumping sea water through a flow-through door on the fluorometer (Lorenzen, 1966). The fluorometer and filters are those used for the analysis of discrete samples, with a flow-through door and cuvette replacing the standard items. A strip chart recorder with a chart speed of approximately 2 cm/min gives a continuous record of the fluorometer output. Units of in vivo fluorescence are standardized to chlorophyll a concentration by collecting samples from the fluorometer discharge and extracting the plant pigments using the discrete methods outlined above. Since in vivo fluorescence is affected by a number of variables, standardization is carried out on every cruise.

Continuous measurements of surface fluorescence will be made on all future hydrographic cruises. Water for the measurement is taken through the ship's hull fitting at a depth of approximately 1 m and water is monitored continuously while the ship is underway at a speed of 7-9 knots. Such horizontal profiles will be made while the ship is underway between the standard hydrographic stations.

Continuous vertical profiles of chlorophyll a also will be obtained using a submersible pump at all hydrographic stations. The pump is lowered to a depth of 10-75 m, the depth depending on the water depth at the station, and raised at a constant rate to the surface. The profiles are then compared with the discrete samples taken simultaneously at the station.

The continuous profiling system should indicate whether the average biomass obtained from the discrete sampling method is indeed a reasonable value. The discrete methods give a more accurate value for chlorophyll concentration than the continuous method, since the continuous method does not separate out fluorescence due to detrital pigments (as the discrete method does) and does not measure chlorophyll concentrations as accurately (the pigments are not extracted and thus readings are affected by cell geometry). Thus the best estimates of the true concentrations of phytoplankton can be obtained by a combination of continuous and discrete sampling programs in a three dimensional sampling grid.

3. Productivity. Since December 1971, phytoplankton growth has been measured using carbon-14 techniques. In December, productivity was measured by in situ incubation techniques, and in the future deckboard incubation techniques will be used (Strickland and Parsons, 1968; Doty and Oguri, 1958). Water samples are obtained in Niskin bottles from depths corresponding approximately to the 100%, 50%, 25%, 10%, and 1% light levels as indicated by a submarine photometer or a Secchi disk. Samples of 125 ml are drawn into flint glass bottles and innoculated with 2-4 μc of $Na_2{}^{14}CO_3$. The bottles then are either returned in an anchored incubation rack to the depth from which they were obtained (in situ method), or retained on board in an incubator maintained at sea surface temperature and fitted with neutral density filters corresponding to light levels at depth (incubator method). Two light and one dark bottle are incubated from each depth for one-half of a light-day

(dawn to noon or noon to dusk). At the end of incubation, samples are filtered through HA Millepore filters (0.45 μm pore size) and placed on planchettes in a desiccator for storage. Each filter is counted for a minimum of 25,000 counts and carbon fixation calculated from the formulas given by Strickland and Parsons (1968).

Chlorophyll samples are drawn simultaneously with incubation samples. Chlorophyll a content is determined from these samples using standard fluorometric methods. Carbon uptake by the phytoplankton is expressed as carbon fixation per unit chlorophyll, mg C/m^3/day/mg chl a. Integrated productivity for the water column is expressed as C/m^2/day/mg chl a.

Comparisons of the 1% light depth and the depth of the mixed layer must be made in order to properly interpret incubation data. If the mixed layer is very deep with respect to the depth of the euphotic zone, phytoplankton may be carried into regions where there is net consumption, not fixation, of carbon. Therefore, the depth of the mixed layer is being measured by a bathythermograph at the time of the productivity experiment. The depth of the top of the thermocline will give the depth of the mixed layer in most cases, since density structure in the area is determined chiefly by the water temperature (W. Broenkow, personal communication).

ZOOPLANKTON STUDIES

1. Species Composition. Zooplankton are obtained in a half-meter net with a mesh size of 500 μm. Tows are made at 30 m/min with 15 m wire out. Zooplankton are examined in the laboratory under a

dissection microscope and identification made to the lowest possible taxa. Line drawings or photographs of the common species are being made and assembled into an atlas for the bay.

2. Biomass. Since October, the zooplankton tows have been metered and thus the volume filtered is known. In the laboratory zooplankton are drained of surrounding preservative for 5 min and the displacement of the organisms measured. The zooplankton biomass is expressed as ml/m^3.

TWENTY-FOUR HOUR PLANKTON STUDY

A special study was conducted to determine the effect of tides on plankton biomass over the Submarine Canyon. Stations 1103 and 1108 were occupied for 26 hours on 7 August 1971 and phytoplankton biomass measured using the standard methods presented above. The cruise description is presented in the report by W. Broenkow.

RESULTS

Analysis of samples collected on Sea Grant cruises is still in progress, but some preliminary results may be presented. Phytoplankton biomass was not significantly higher or lower at any station over the year as compared with other stations. However, significant variations in phytoplankton biomass for the bay as a whole were noted over the sampling period (Figure 1). Highest standing crops were encountered in March and averaged 6.0 mg. chl a/m^3 in the upper 10 meters for the bay. Chain forming diatoms dominated: Skeletonema costatum, Thalassiosira

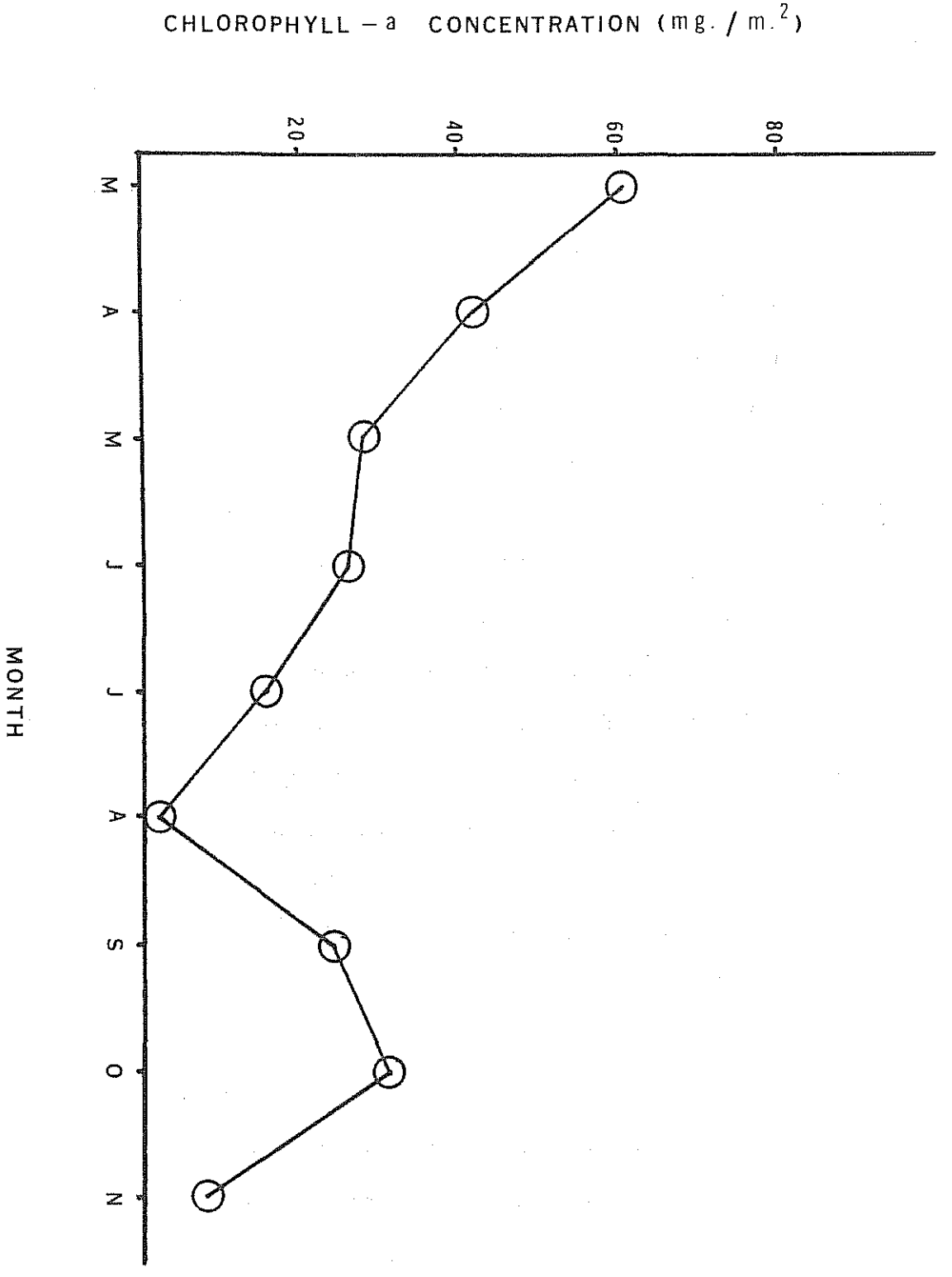

Fig. 1. Chlorophyll a standing stock in the upper 10 m from March to November 1971. Values are averages for all stations.

spp., Chaetoceros spp. and many others. The phytoplankton crops declined steadily from March until the summer minimum in August, biomass averaged 0.2 mg chl a/m^3 in the upper 10 m over the bay. During the "oceanic" hydrographic season in the bay plant crops increased due to the blooming of a red tide assemblage dominated by species of Gonyaulax and Ceratium. The red tide reached its peak at the hydrographic stations in October and stocks of 17 mg chl a/m^3 were found in the upper 10 m at a station in the north bay. Phytoplankton biomass dropped again to low levels in November. Standing crops were, as expected, highly variable in the bay and varied as much as six-fold between stations during the "upwelling" season (March to August) in the upper 10 m. During the period of red tide the crops were even more variable, with the standing crops in the upper 10 meters differing by as much as fifty-five fold between stations.

Nutrient enrichment in the bay can be expected to enhance growth rates and thus increase phytoplankton standing stocks. If water movements are slow enough, the stocks would be expected to increase near areas of such nutrient enrichment. Nutrient enrichment can be expected over Monterey Submarine Canyon, a known source of upwelled water (W. Broenkow). Nutrient enrichment might also be expected in the northern and southern ends of the bay, where domestic sewage discharges are greatest. Nutrient enrichment of surface waters might also be brought about by mixing processes in shallow water: nutrients are regenerated in the benthos and readily returned here, and river

discharges and land runoff from fertile adjacent agricultural lands provide natural and agricultural growth stimulants.

Figure 2 indicates the relative standing crops found in the major sectors of the bay, and Figure 3 contrasts stocks in the inshore and offshore areas of the bay. Figure 4 compares phytoplankton standing stocks in areas near sewage enrichment. The standing stocks do not appear to vary as a function of any of these sources of enrichment. This apparent "homogeneity" of the bay may be due to the rapid mixing or advection rates of water in the bay. Future growth studies in the bay (to be carried out in the coming year in the Sea Grant Program) may indicate that stocks in these areas are growing more rapidly than in less-enriched areas. If indeed stocks are growing more rapidly than here, the homogeneity of crops may implicate advection or mixing processes or grazing control of phytoplankton stocks. The apparent homogeneity might also be an artifact of averaging highly variable data: the plant stocks are high "patchy" in the bay. Future continuous profiling studies may be more sensitive to biomass distribution and indicate that differences, not shown by the insensitive discrete sampling methods, do actually exist in enriched va. non-enriched areas. Alternatively, nutrient control of phytoplankton populations may not occur or occur only in certain areas of Monterey Bay. Future continuous profiling studies of the bay may indicate much more precisely the areas of high stocks in the bay. The configuration of patches in the bay hopefully may implicate the variables that control the distribution of phytoplankton populations in the bay.

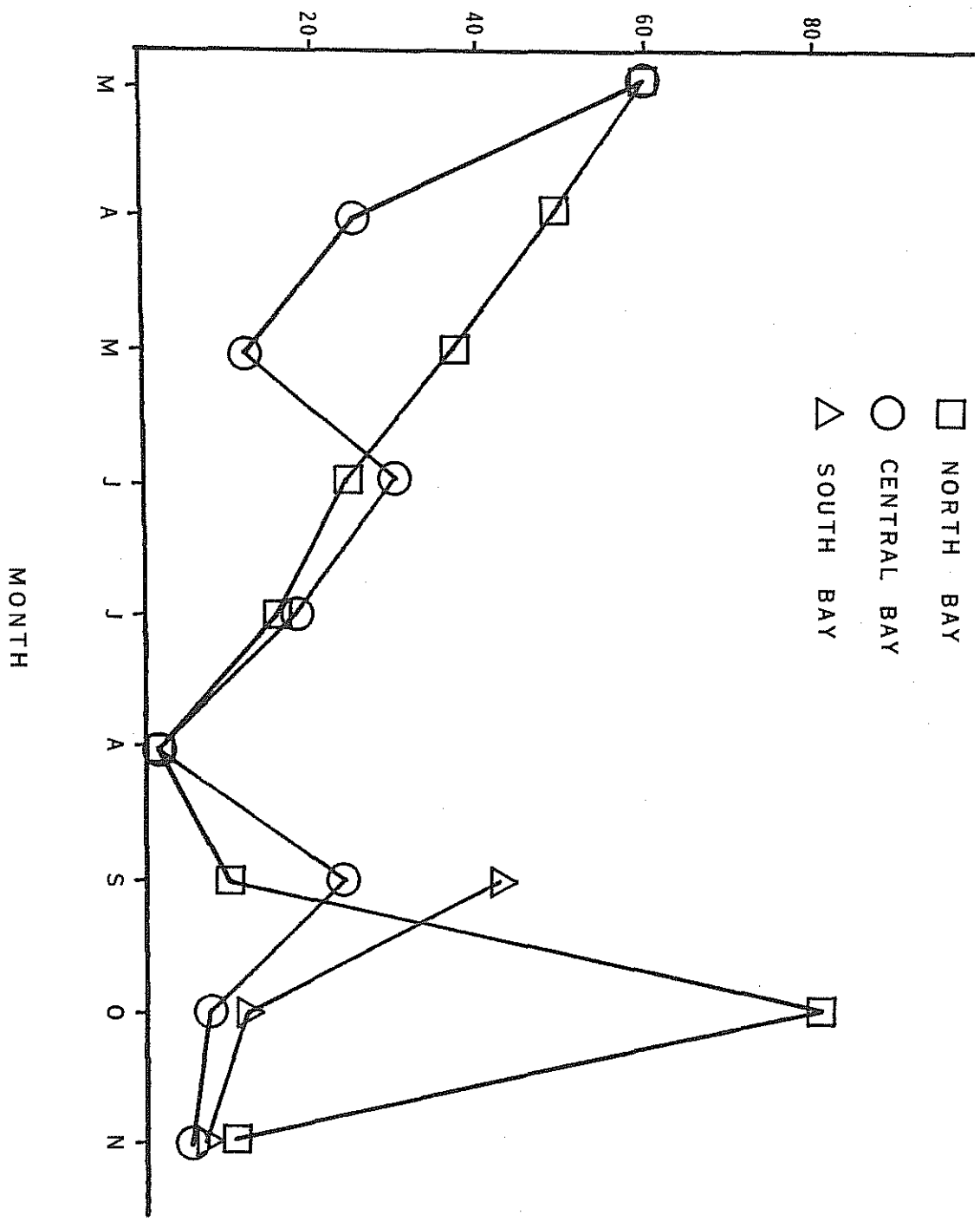

Fig. 2. Chlorophyll a standing stock in the upper 10 m from March to November 1971 in north, central and south sectors of Monterey Bay. The north sector includes stations north of the Pajaro River, the south sector includes stations south of the Salinas River, and the central sector consists of all other stations. Values are averages for all stations in the sector. (South Bay stations were occupied starting September 1971)

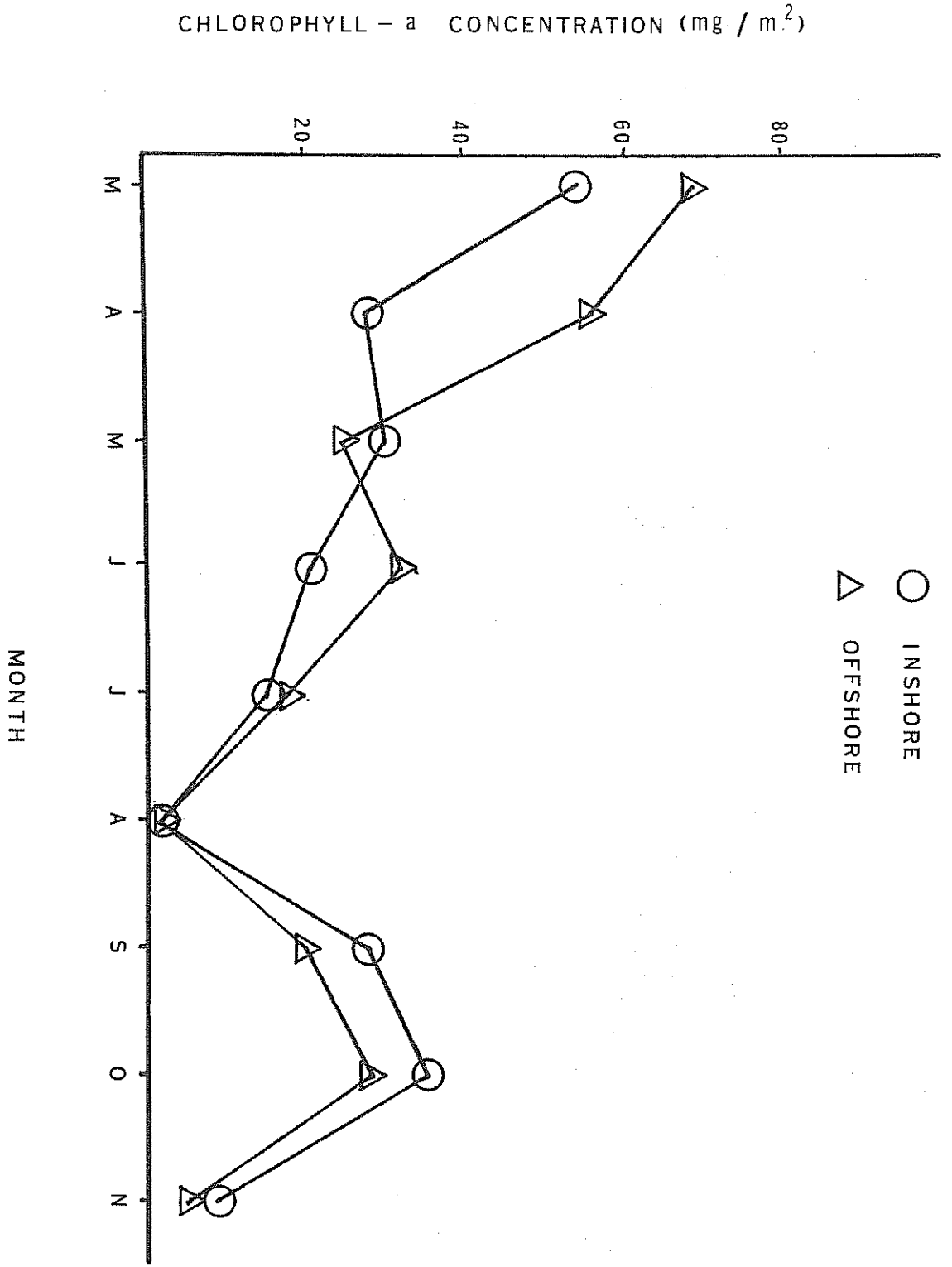

Fig. 3. Chlorophyll a standing stock in the upper 10 m from March to November 1971 at inshore and offshore stations. Inshore stations are stations within two nautical miles of shore, and offshore stations are all other stations. Values are averages for stations.

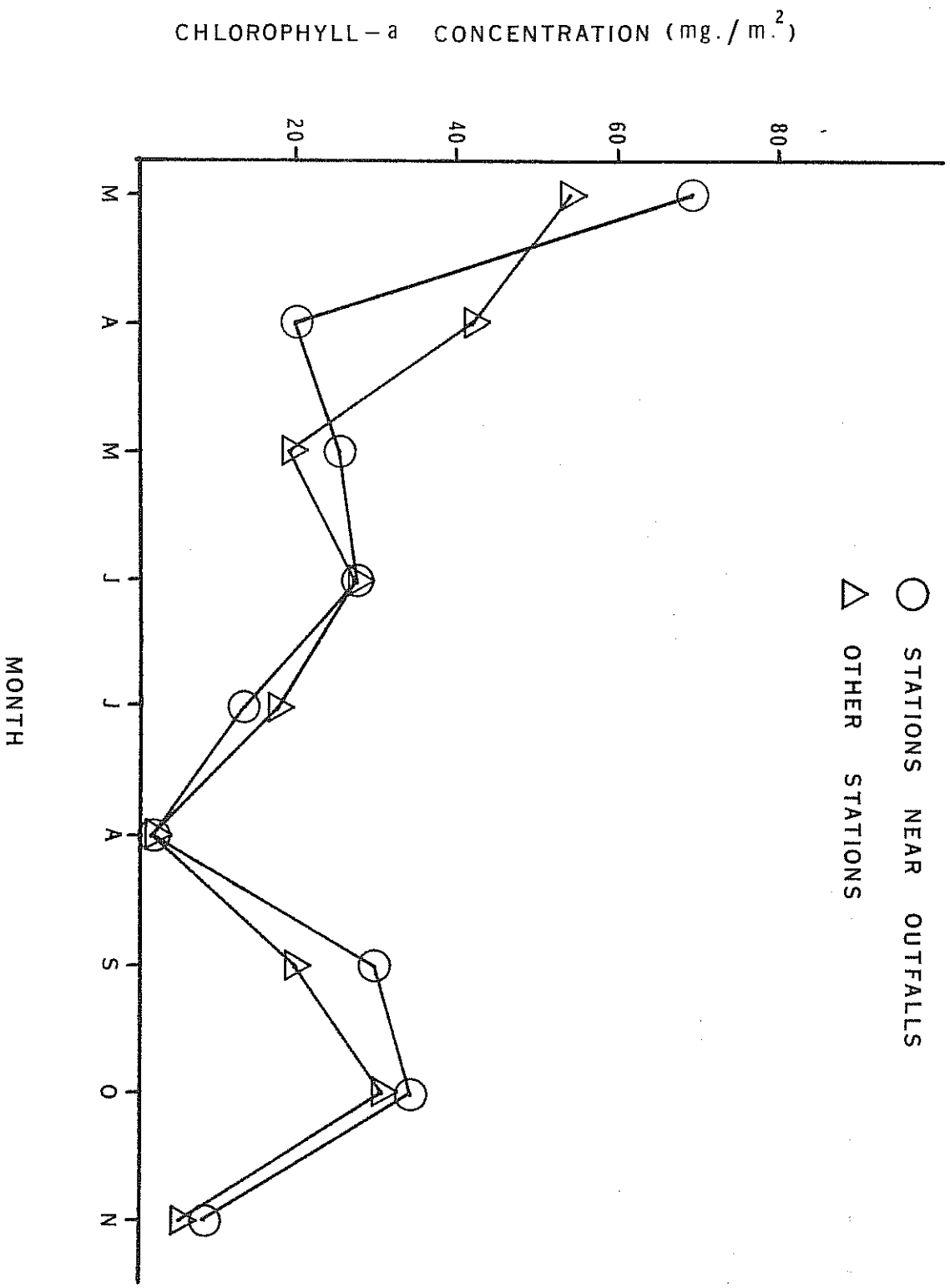

Fig. 4. Chlorophyll a standing stock in the upper 10 m from March to November 1971 in regions near outfalls and areas away from such discharges. Stations within two nautical miles of a discharge point or of a river that is discharging such materials are considered stations near outfalls. Values are averages for all the appropriate stations.

The 24 hour study over Monterey Submarine Canyon investigated the effect of tidal influences on phytoplankton biomass. The total biomass in the water column varied by a factor as high as 4 between high and low tides. Maximum standing crops were found at high tide, when surface-like waters occurred at greater depths than during the low tide period (Figure 5). The "base" of the phytoplankton layer, as defined by the depth of the 0.5 mg chl $\underline{a}/m^3$ appeared to move as much as 120 m over the head of the Canyon (Sta 1103) and as much as 85 m at the outer station (1108) between successive low and high tides (Figure 6). The movement of the phytoplankton layer was correlated with the movement of hydrographic properties measured simultaneously (see report by W. Broenkow). Because of the magnitude of these short term variations in phytoplankton biomass, the measurement obtained at any given time has only limited value as a representation of daily, weekly, or monthly trends over the submarine canyon. Tidal influences were expected to be maximal at these two stations because of the topography of the canyon; stations in other areas probably will not be so strongly influenced by tides.

LITERATURE CITED

DOTY, M. S., AND M. OGURI. 1958 Selected features of the isotopic carbon primary productivity technique, p. 47-55. In: Measurements of primary production in the sea. Rapport et Proces-Verbaux des Reunions, 144.

LORENZEN, C. J. 1966. A method for the continuous measurement of *in vivo* chlorophyll concentration. Deep-Sea Res. 13:223-227.

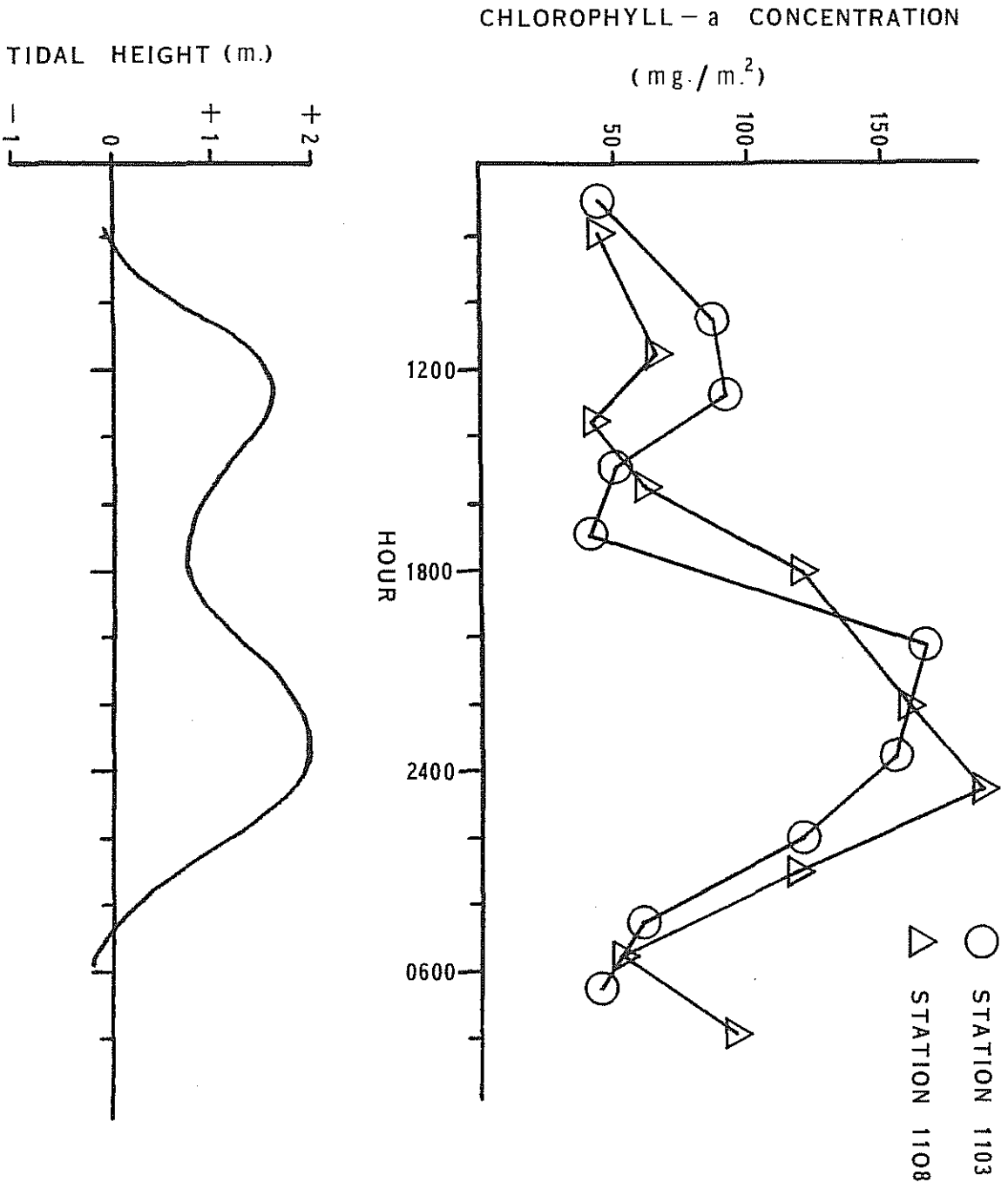

Fig. 5. Chlorophyll a standing stock in the water column at two stations over two tidal cycles. Station 1103 is located over the head of Monterey Submarine Canyon in 110 m water approximately 1 nautical mile from shore. Station 1108 is located over Monterey Canyon in 240 m water, approximately 2 nautical miles from shore. Standing crops at Station 1103 are measured over the upper 100 m and crops at Station 1108 over the upper 150 m.

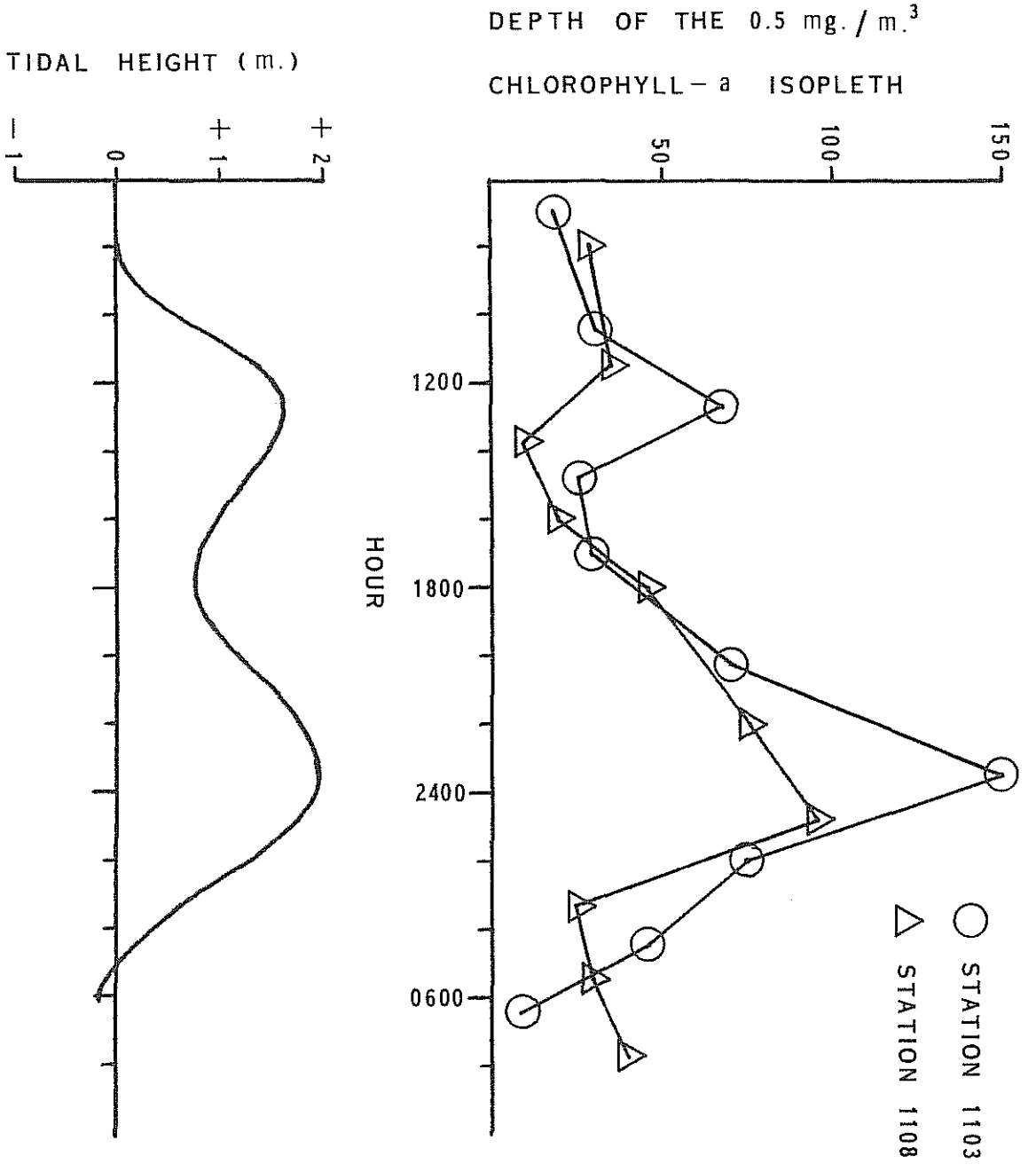

Fig. 6. Depth of the surface phytoplankton populations at two stations over the two tidal cycles. The depth of the 0.5 mg. chlorophyll a concentration has been chosen arbitrarily to define the "bottom" of the phytoplankton population.

STRICKLAND, J. D. H., AND T. R. PARSONS. 1968. A practical handbook of seawater analysis. Fish. Res. Bd. Canada Bull. 157, 311 p.

CHEMICAL AND PHYSICAL OCEANOGRAPHY OF MONTEREY BAY, ELKHORN SLOUGH AND MOSS LANDING HARBOR

W. W. Broenkow, W. M. Smithie and R. E. Smith

During the past year, our oceanographic studies have provided the first full year's detailed hydrographic data for Monterey Bay, Elkhorn Slough and Moss Landing Harbor.

The need for these data is apparent during this period of increased public environmental awareness. In August 1971, the Association of Monterey Bay Area Governments (AMBAG) provided additional support to Moss Landing Marine Laboratories to increase our oceanographic sampling program in Monterey Bay from the 13 stations, which were supported under the Sea Grant Program, to the present 21 stations (Figure 7). Before August our work was limited to the northern and central areas of the bay. Now under the joint Sea Grant - AMBAG study it is assured that oceanographic conditions in the whole bay will be well documented for at least a one year period.

These data are needed to determine the observable effects of the nine domestic sewage outfalls that discharge into Monterey Bay and to test computer models of proposed changes in sewage discharge facilities. Without Moss Landing's Sea Grant Program that has provided the initial oceanographic equipment and data processing facilities, it is doubtful that we would have been able to assist AMBAG in this important public service.

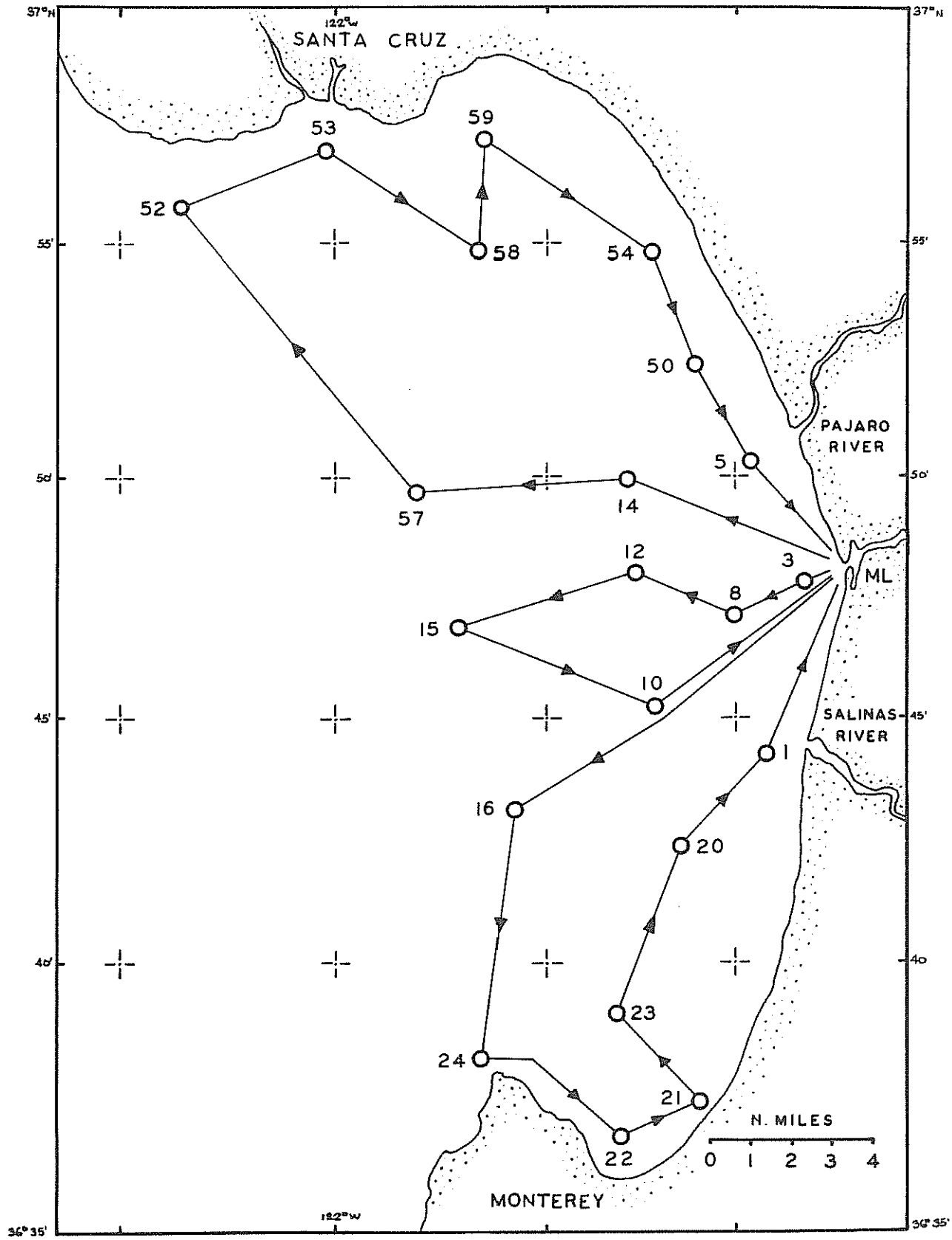

Fig. 7. Moss Landing Marine Laboratories Monterey Bay hydrographic stations.

The Moss Landing Harbor-Elkhorn Slough study, supported solely by the Sea Grant Program, will also be of public benefit. The Moss Landing Harbor Commission recently proposed an ordinance to prohibit living aboard vessels in the harbor to eliminate one source of harbor pollution. Our data will be used to identify sources of pollutants to the harbor and to investigate the flushing mechanism of the slough-harbor system. This study also provides baseline data for future biological studies and for evaluating future development of the area by local governments.

MONTEREY BAY

Monthly hydrographic sampling was begun in February 1971 at 13 stations in northern and central Monterey Bay. These stations were occupied during two days of the same week by the oceanographic technician, the graduate teaching assistants, and undergraduates enrolled in the Sea Grant research participation courses. With increased sampling experience, we were able to expand our program to 16 stations in July and August, and with additional support from AMBAG we further expanded our hydrographic sampling in September to three days each month and included stations in southern Monterey Bay.

At these 21 stations water samples are obtained, where depth allows, at 0, 10, 20, 30, 50, 75, 100, 150, 200, 250, 300, 400 and also at 5 m at shallow stations. These samples are analyzed by our technicians, graduate teaching assistants and undergraduates in the research participation classes for: temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, ammonia and silica. Concurrently

analyses are made for chlorophyll at all sampling depths (Dr. Silver). Analytical methods and other details were given in our 1971 Sea Grant Annual Report.

From February to June 1971 an average of 64 depths were sampled monthly, and presently we sample at 111 depths each month. A summary of data obtained in 1971 is given in Table 1. We arranged our station positions to eliminate overlap with the 6 Monterey Bay stations that are regularly occupied by Hopkins Marine Station. As part of the AMBAG study each month we perform nutrient analyses on 95 water samples taken by Hopkins Marine Station from their stations in Monterey Bay and the nearshore Pacific Ocean. To perform these additional analyses, we have a full time oceanographic technician supported from the AMBAG funds.

A data report for the 1971 Monterey Bay hydrographic observations is in preparation. A sample of these data showing the Wang computer data format and the parameters we routinely measure is given in Table 2. These data are the basis for a Master's thesis (W. Smethie), and some preliminary conclusions can be made from them.

Table 3 summarizes changes in temperature, salinity and nutrients betwen the upwelling season (March through June 1971) and the non-upwelling season (August through December 1971) for both the northern and central areas of the bay. These average values show small and probably insignificant differences between the two areas during the non-upwelling season, but larger and perhaps significant differences during the upwelling season. The higher phosphate and nitrate concentrations and the lower temperatures in the central bay near Monterey

TABLE 1

MONTEREY BAY HYDROGRAPHIC OBSERVATIONS, 1971*

Monthly Sampling Periods	11
Sampling Days	26
Stations Occupied	182
Depths Sampled	960
Temperature	943
Salinity	959
Dissolved Oxygen	954
Phosphate	938
Nitrate	938
Nitrite	939
Ammonia	938
Silica	939

* Excludes 25-hour study in August.

TABLE 2

MONTEREY BAY HYDROGRAPHIC STATION DATA

CRUISE	STATION	DATE	HOUR	N LATITUDE	W LONGITUDE
ML 17	1108	30 SEP 1971	8.5	36^{o} 47.4'	121^{o} 50.5'

TRANSP	WAVES			WIND		BAROM	AIR TEMP ^{o}C		WEATH	CLOUDS		VISIB
m	dir	ht	p	dir	speed	mb	dry	wet		typ	amt	
8	29	2	2	30	4	1013.9	12.8	10.6	2	3	1	9

DEPTH	TEMP	SALINITY	SIGMA T	OXYGEN	AOU	SAT	PHOSPHATE	NITRATE	NITRITE	AMMONIA	SILICA	CHL-a	PHAEO
m	^{o}C	ppt		ml/l	µg-at/l	%	µg-atoms/liter					µg/l	
0	15.20	33.428	24.74	7.58	-181	137	.31	.8	.02	.10	5	2.36	1.34
10	12.52	33.544	25.38	4.97	79	85	.70	.3	.04	.05	10	.68	.51
20	11.37	33.586	25.63	4.47	137	75	1.28	.4	.51	1.13	14		
30	10.24	33.671	25.89	3.72	217	61	1.74	19.2	.46	.28	22	.04	.18
50	9.64	33.764	26.07	2.17*	362	35	1.85	26.1	.15	.00	26	2.15	11.2
75	9.32	33.816	26.16	2.99	293	48	2.02	24.1	.23	.19	31	.04	.11
100	9.14	33.857	26.22	2.89	304	46	2.08	26.3	.15	.10	32	.04	.09
150	8.44	33.985	26.43	2.34	362	37	2.35	29.8	.13	.02	40	.02	.11

* Indicates questionable data

TABLE 3

AVERAGE VALUES IN UPPER 10 M IN NORTHERN MONTEREY BAY (7 STATIONS) AND CENTRAL MONTEREY BAY (5 STATIONS), DURING UPWELLING (MARCH - JUNE) AND NON-UPWELLING (AUGUST - DECEMBER) PERIODS, 1971

	NORTH BAY		CENTRAL BAY	
	Mar.-Jun.	Aug.-Dec.	Mar.-Jun.	Aug.-Dec.
Temperature, ^{o}C	11.08	13.29	10.57	13.17
Salinity, $^{o}/oo$	33.758	33.565	33.769	33.551
Phosphate, µg-at/l	1.01	.65	1.35	.60
Nitrate, µg-at/l	8.3	3.1	13.2	3.0
Nitrite, µg-at/l	0.17	0.13	0.14	0.09
Ammonia, µg-at/l	0.5	0.5	0.6	0.5
Silica, µg-at/l	17	11	19	6

Submarine Canyon are evidence that the upwelling process is concentrated in the area of the canyon.

During the non-upwelling season, only the silicate concentration appears to differ between the northern and central bay. The reason for this is not clear. When examining these averages, no apparent phosphate enrichment from sewage effluent entering the northern bay is found. Some nearshore stations occasionally show markedly higher phosphate, nitrate and ammonia concentration in the surface waters, but no widespread effect of the sewage discharge is noticeable.

The seasonal trends (Figure 8) show the expected cooler, higher salinity, nutrient-rich surface waters during the March to June upwelling period. During the oceanic period (August to October) only inorganic dissolved nitrogen (mainly as nitrate) approached concentrations that might be limiting to phytoplankton growth for short periods in some areas of the bay. Generally, however, all nutrients are found in concentrations sufficient to support phytoplankton growth. During 1971, the oceanic period, which is the time of highest surface water temperatures, occurred about 2 months earlier than usual. The Davidson Current period (normally from about November to February) was also anomalous in 1971 with only light southerly winds and little rain. Thus, it is probable that conditions observed during the fall and winter of 1971 are not representative of a normal year.

During the first few months of our hydrographic sampling program, it became apparent that tidal changes with a 12 hour period might significantly affect the interpretation of data taken over a three day

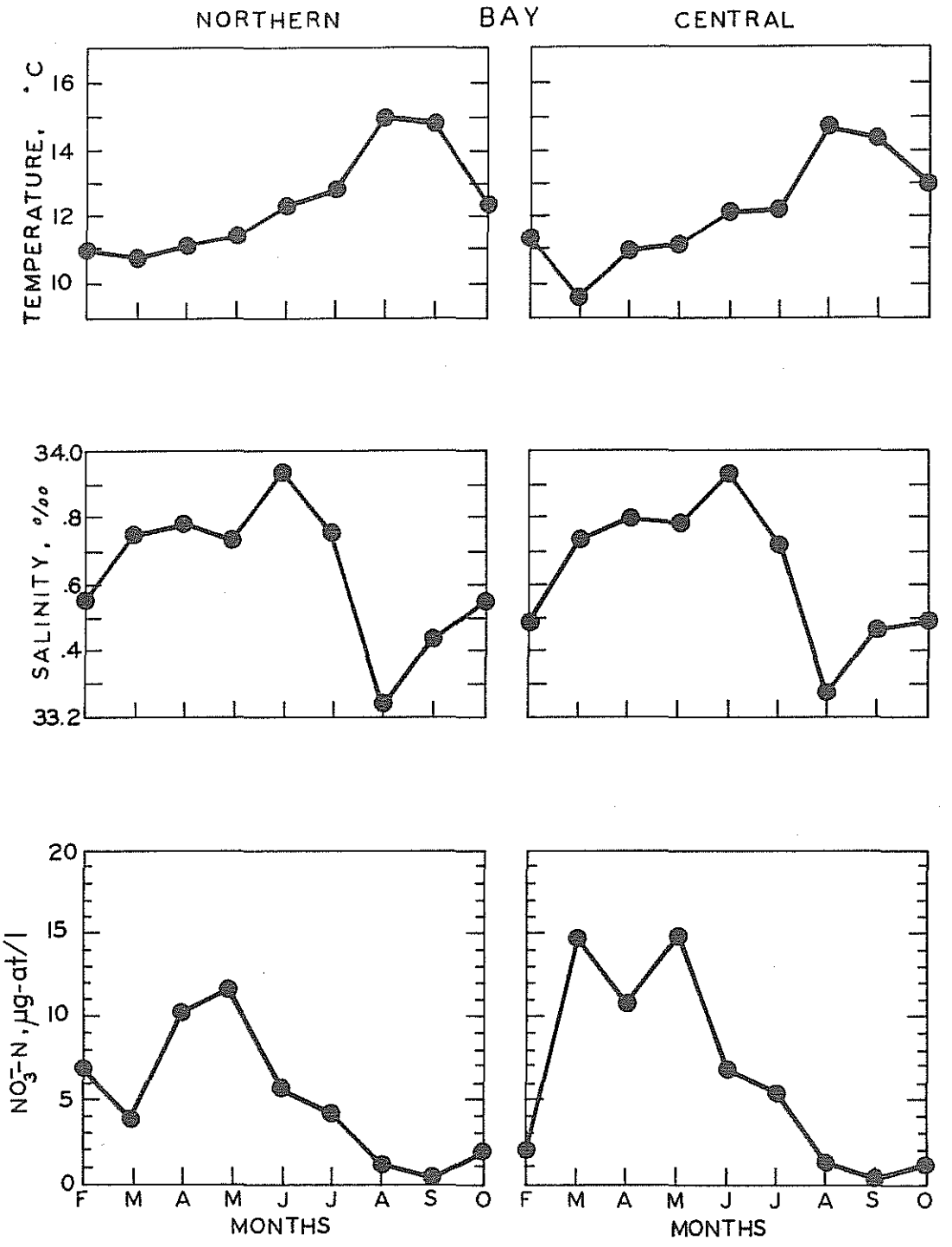

Fig. 8. Seasonal changes in temperature, salinity and nitrate in the upper 10 m in northern Monterey Bay and in the central bay over Monterey Submarine Canyon, 1971.

period. To determine the magnitude of these changes, the graduate teaching assistants and students in the research participation classes conducted a 25-hour study at two stations located at the head of Monterey Submarine Canyon. These stations were sampled 10 times each during 7-8 August 1971.

Large tidally induced changes were observed for all parameters routinely measured during the regular hydrographic surveys. These changes are caused by deep water ascending in Monterey Submarine Canyon during ebbing tides and descending during flooding tides. The magnitude of the changes is indicated in Figure 9, which shows the ratio of the total range of the measurements over the tidal day to the total vertical range of the measured values from the surface to 150 m. Thus, in an area where large vertical changes in all properties are found, the tidal range is between 20% and 75% of the vertical range. The maximum tidal variation occurs in the thermocline, decreases slightly just below the thermocline, and gradually increases to the bottom. Figure 10 shows that the isopleths oscillated vertically by as much as 80 m where the water depth was about 130 m. It is not possible to extrapolate these observations to other areas of the bay, because of the obvious and pronounced effect of the funneling of tidal waters in the submarine canyon. We would expect tidal variations to be smaller in the flatter areas of the bay north and south of the canyon. We propose to investigate these changes during the summer of 1972.

We have modified our original sampling sequence to occupy the stations over the canyon as closely in time as possible. Even still,

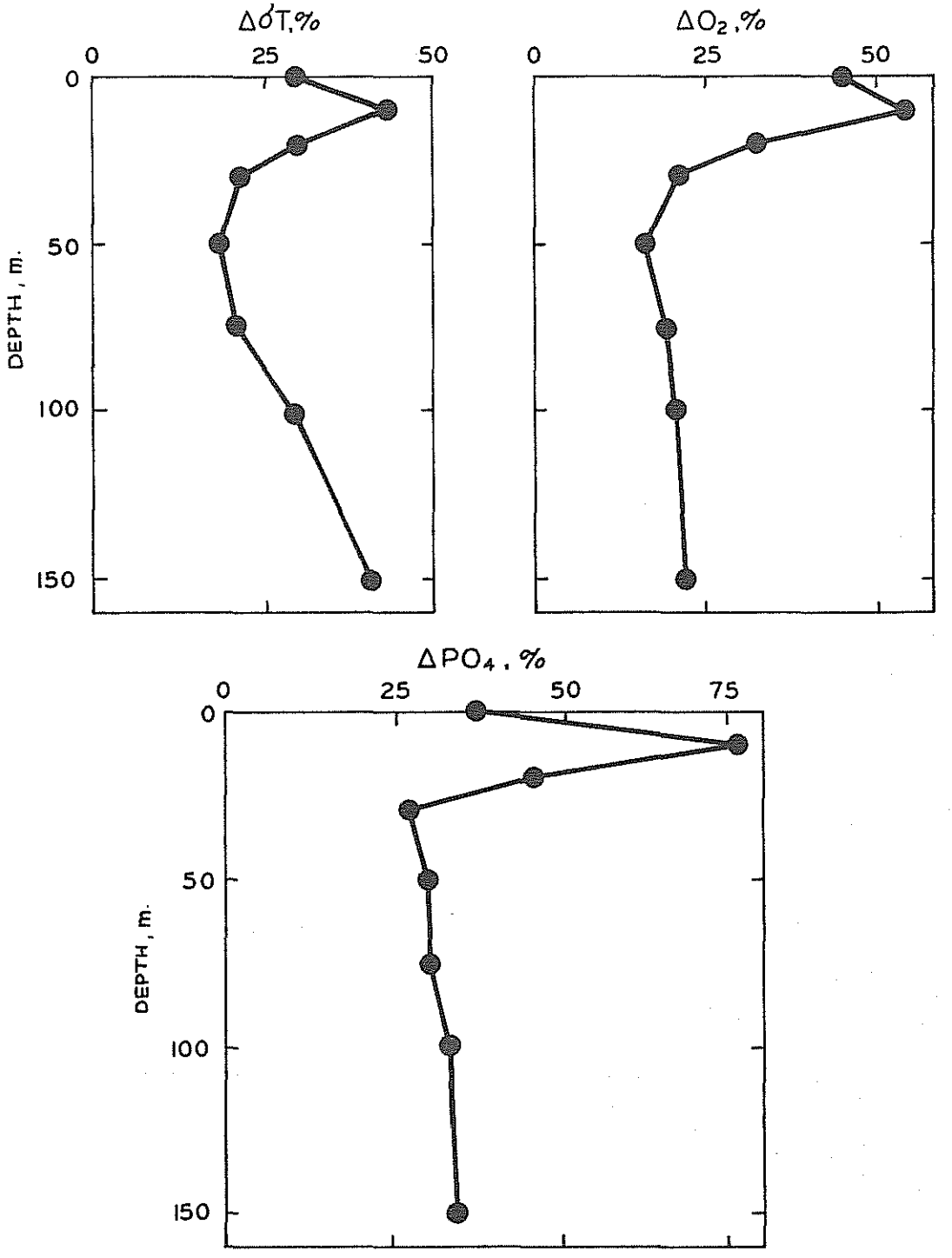

Fig. 9. Percent daily ranges of σ_T, dissolved oxygen and inorganic phosphate relative to their average vertical differences between 0 and 150 m, Station 1108, 7-8 August 1971.

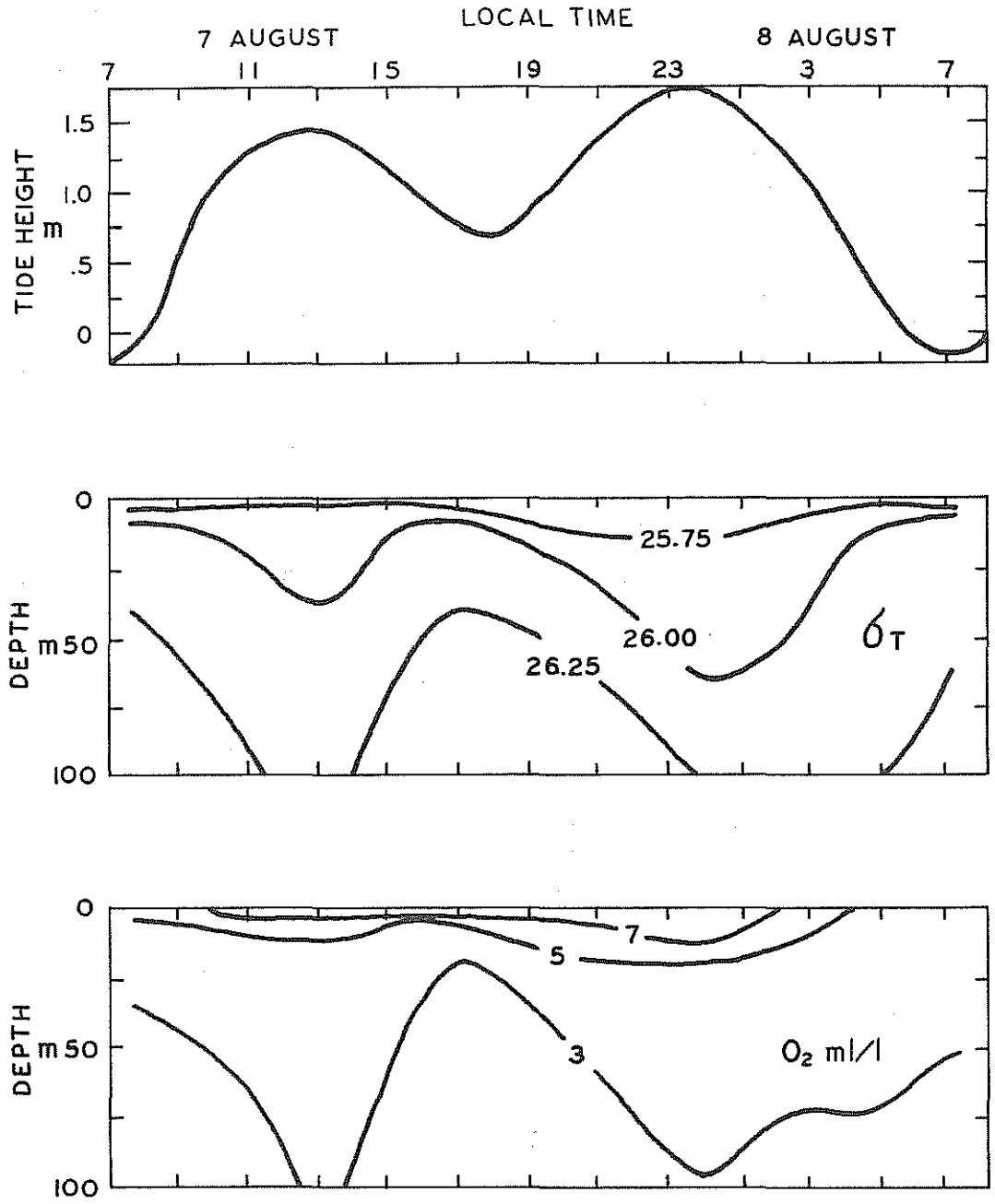

Fig. 10. Vertical variations in σ_T and dissolved oxygen at Station 1103 in Monterey Submarine Canyon, 7-8 August 1971.

it may be difficult to differentiate between the small scale effects of upwelling and the effects of the tide.

ELKHORN SLOUGH AND MOSS LANDING HARBOR

Data similar to those from Monterey Bay have been collected in Elkhorn Slough and Moss Landing Harbor from October 1970 to the present. Water samples were obtained each month from 3 depths at 9 stations in the 3 m deep, 10 km long slough-harbor system (Figure 11). Analyses were made for temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, ammonia and silica, and a resume of these observations is given in Table 4. Sampling details and analytical methods are explained in more detail in the 1971 Sea Grant Annual Report.

Tidal effects in the slough and harbor were presumed to be large, and sampling has been carried out within 1 hour of high tide. To determine the magnitude of the tidal changes, hourly samples were taken at 3 stations in the slough and harbor for periods of 26 hours in March during the wet season and again in August during the dry season. Approximately 20 undergraduate students enrolled in the research participation or marine science techniques classes plus graduate students interested in special aspects of the program carried out the field observations and laboratory analyses.

Analysis of these data is incomplete, and they will be incorporated into a Master's thesis describing the seasonal and tidal changes in the slough-harbor system (R. Smith). Preliminary analysis shows the large yearly range in properties and the large differences between

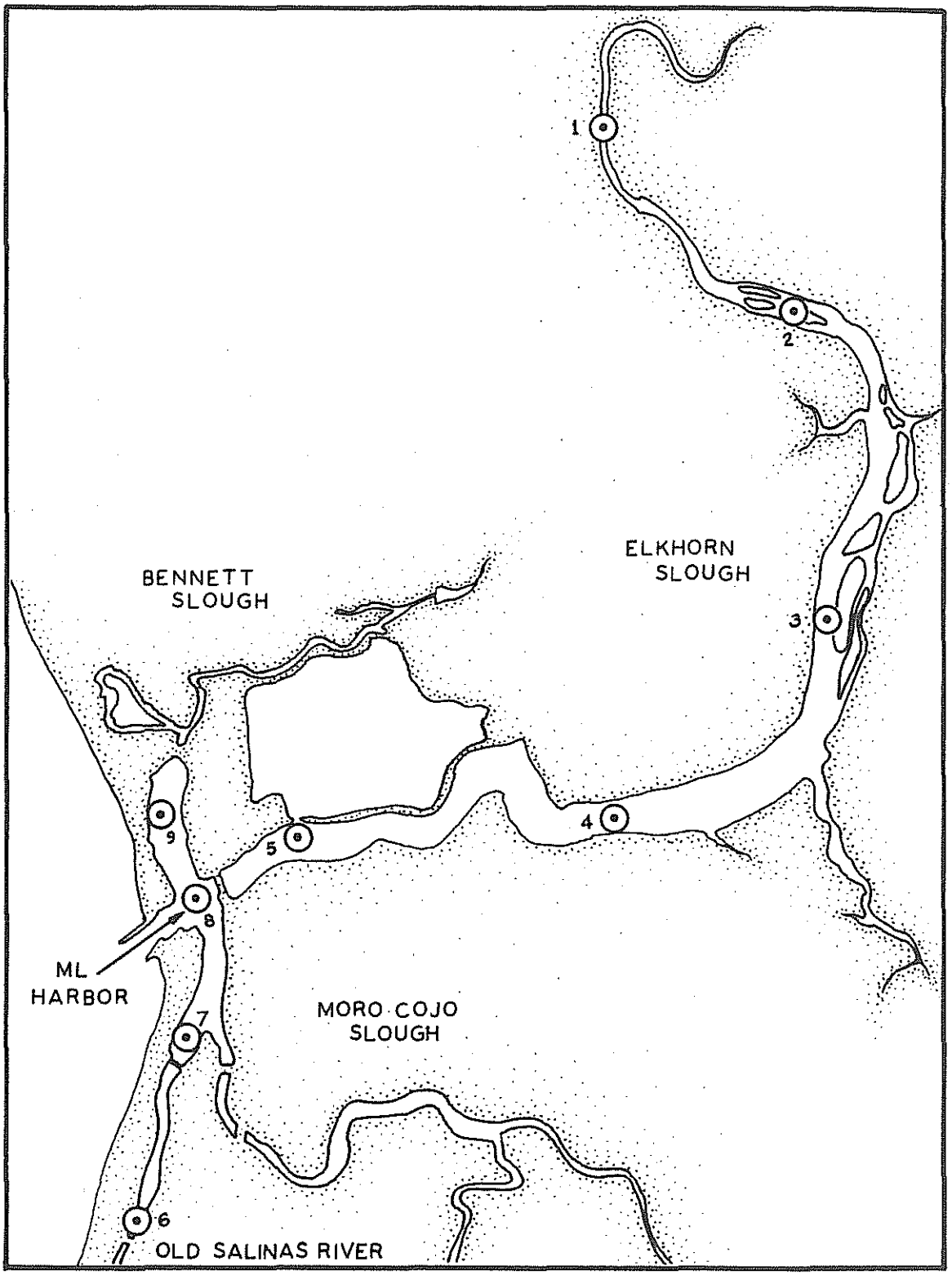

Fig. 11. Station locations in Elkhorn Slough and Moss Landing Harbor.

TABLE 4

ELKHORN SLOUGH AND MOSS LANDING HARBOR

HYDROGRAPHIC OBSERVATIONS, OCTOBER 1970 - NOVEMBER 1971*

Monthly Sampling Periods	13
Stations Occupied	115
Depths Sampled	316
Temperature	312
Salinity	316
Dissolved Oxygen	315
Phosphate	308
Nitrate	300
Nitrite	307
Ammonia	290
Silica	308

* Excludes tidal studies in March and August.

the three arms of the embayment (Table 5). These data show that fresh water enters the harbor primarily through the old Salinas River channel (Stations 6 and 7) and Tembladero Slough. Salinities greater than offshore surface seawater are observed in upper Elkhorn Slough (Stations 1 and 2) during the dry season (August to October). High nutrient concentrations are found in both upper Elkhorn Slough and in the old Salinas River channel showing the influence of both agricultural drainage and domestic sewage waters received in the system.

The independent behavior of the upper slough, the old Salinas River channel and harbor entrance waters is shown in Figure 12. There is an indication that phosphate concentrations increase in the harbor and slough during the dry season when the offshore phosphate concentration is decreasing. Conversely the nitrate concentration in the slough decreases during the dry season and suddenly increases with the beginning of winter rains.

A review of the data has shown that, for the most part, a single sample at 1 m is adequate to define the major seasonal and lateral variations in water chemistry. Therefore, we plan to continue monitoring the chemistry of the slough-harbor system on a reduced scale by sampling at a single depth at 11 stations. We are also asking the Monterey County Health Department to coordinate their coliform bacteria sampling program with our surveys.

DRIFT CARD CURRENT STUDY

In August 1971 we began to release numbered post cards sealed in plastic bags at the Monterey Bay hydrographic stations during our regular

TABLE 5

YEARLY AVERAGE WATER COLUMN VALUES

FOR DIFFERENT AREAS IN ELKHORN SLOUGH AND

MOSS LANDING HARBOR, OCTOBER 1970 - NOVEMBER 1971

	Upper Slough Stations 1 & 2	Slough Mouth Stations 5 & 8	Old Salinas River Channel Stations 6 & 7
Temperature, ^{o}C	15	13	13
Salinity, $^{o}/oo$	32.8	33.3	29.7
Oxygen, ml/l	4.6	5.5	4.6
Phosphate, µg-at/l	3.0	1.5	7.5
Nitrate, µg-at/l	7	11	25
Nitrite, µg-at/l	0.5	0.3	3.1
Ammonia, µg-at/l	4.6	2.3	12
Silica, µg-at/l	29	17	48

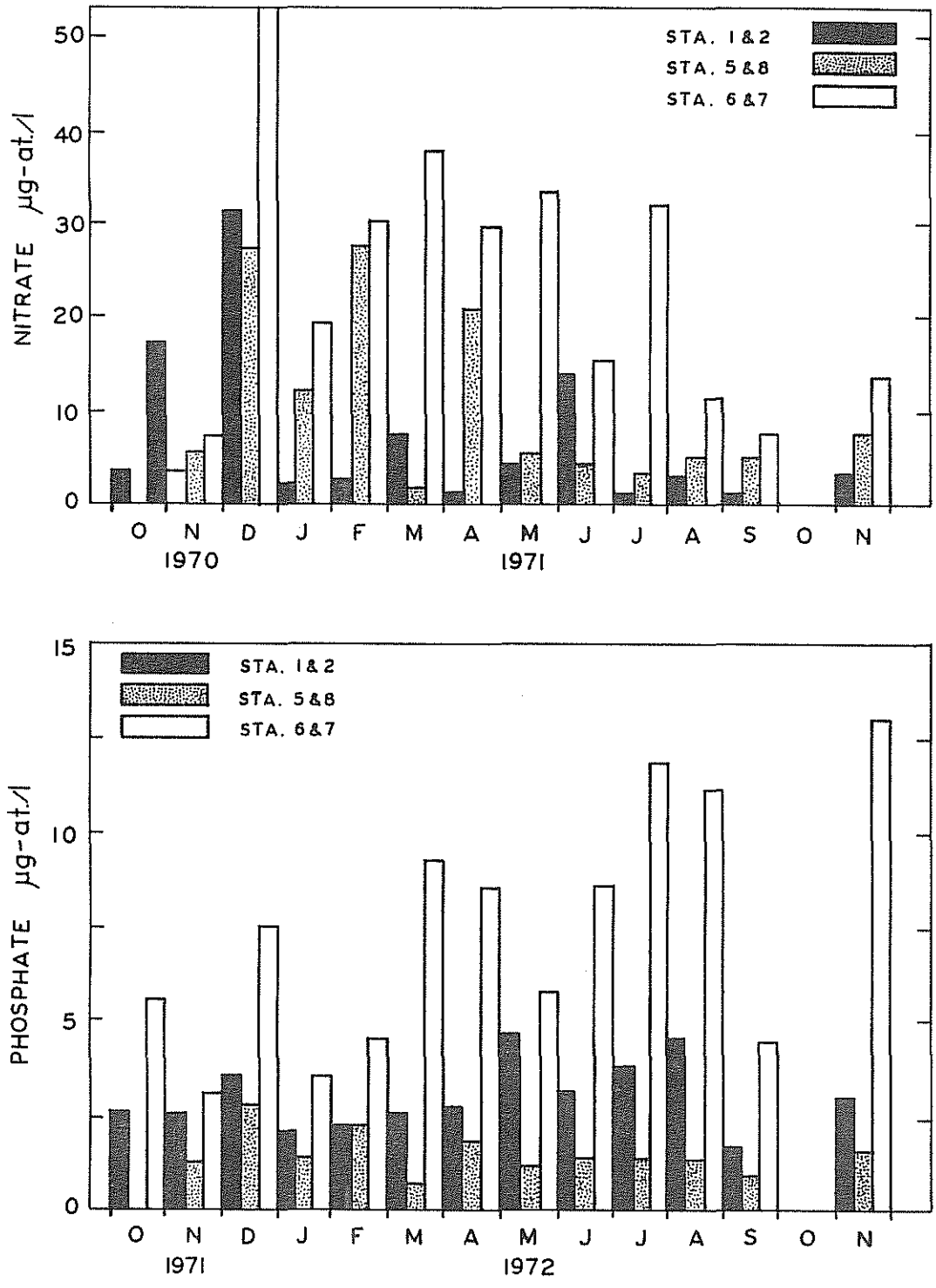

Fig. 12. Seasonal variations in dissolved nitrate and phosphate in Elkhorn Slough and Moss Landing Harbor, October 1970 to November 1971.

monthly sampling. The purpose of this study is to define the drift of surface waters within the bay and the adjacent Pacific Ocean. These data will aid in the placement of sewage outfalls and will help to define small scale pecularities in the nearshore surface currents that would be too costly to determine more precisely with current meters.

Approximately 580 cards are released each month, and about 10% are returned. The plastic bags are apparently either difficult to seal or puncture easily. The recovery rate is about half that expected. The net drift of the cards corresponds well with the direction of the prevailing winds, drifting generally to the southeast during periods of northwesterly winds (Figure 13) and to the north during the Davidson Current period of southerly winds (Figure 14).

Though it is too early to assess the validity of the results, it appears that we should continue with the program for the remainder of the year in spite of the technical difficulties with the plastic bags. We have made periodic changes in the number of cards released and the release points as we were best able to judge by hindsight.

One unexpected result is public response to the drift card project. Because the success of the project depends upon public cooperation, we have made several press releases to the local newspapers and to radio and television stations. Because the drift cards are something everyone can see and understand, public support has been very good. A number of cards have been returned with wishes of good luck in the program, and some have been returned by high school students doing their own drift card studies.

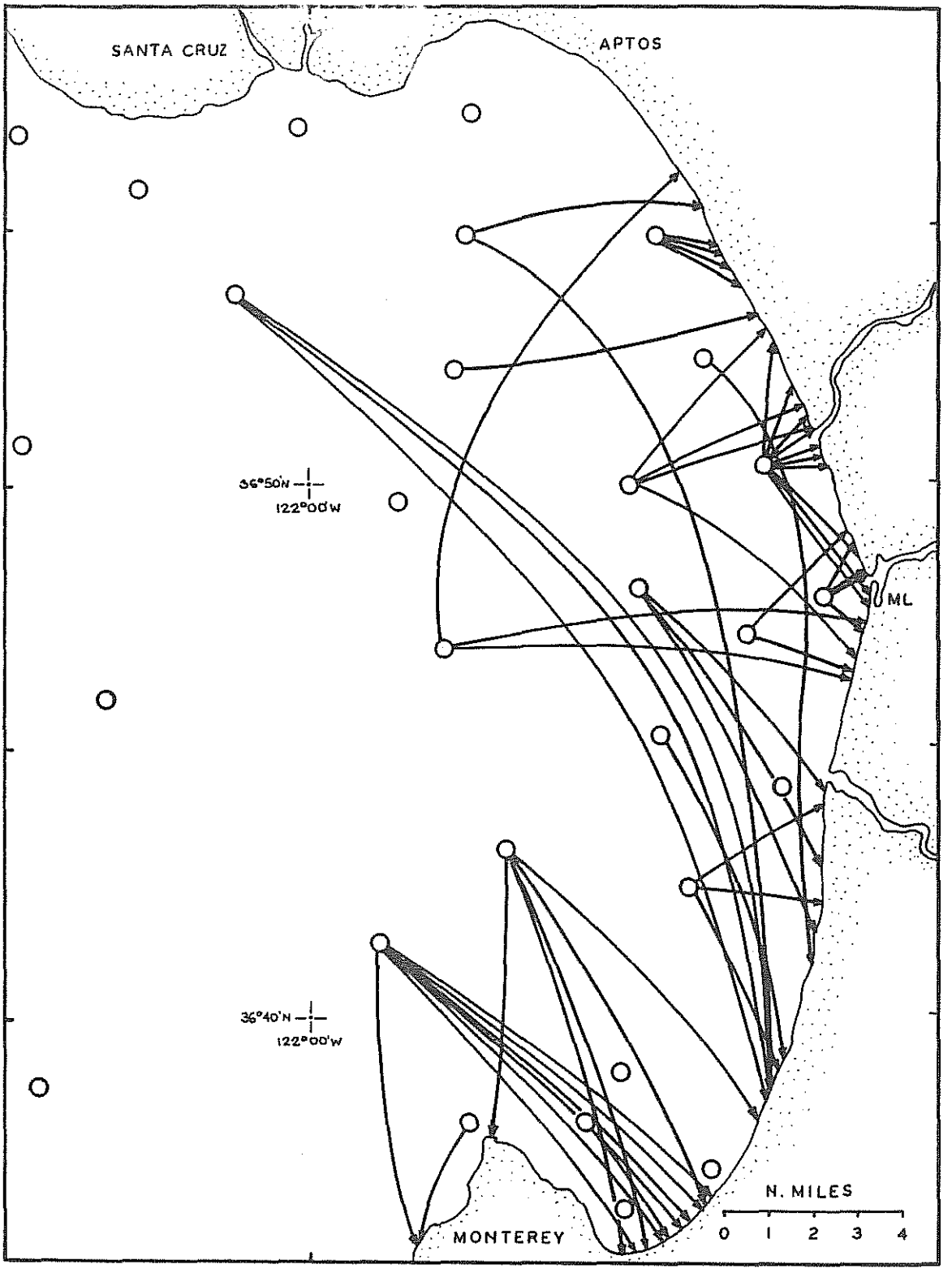

Fig. 13. Drift card returns during a period of northwesterly winds, October 1971. Release points ○

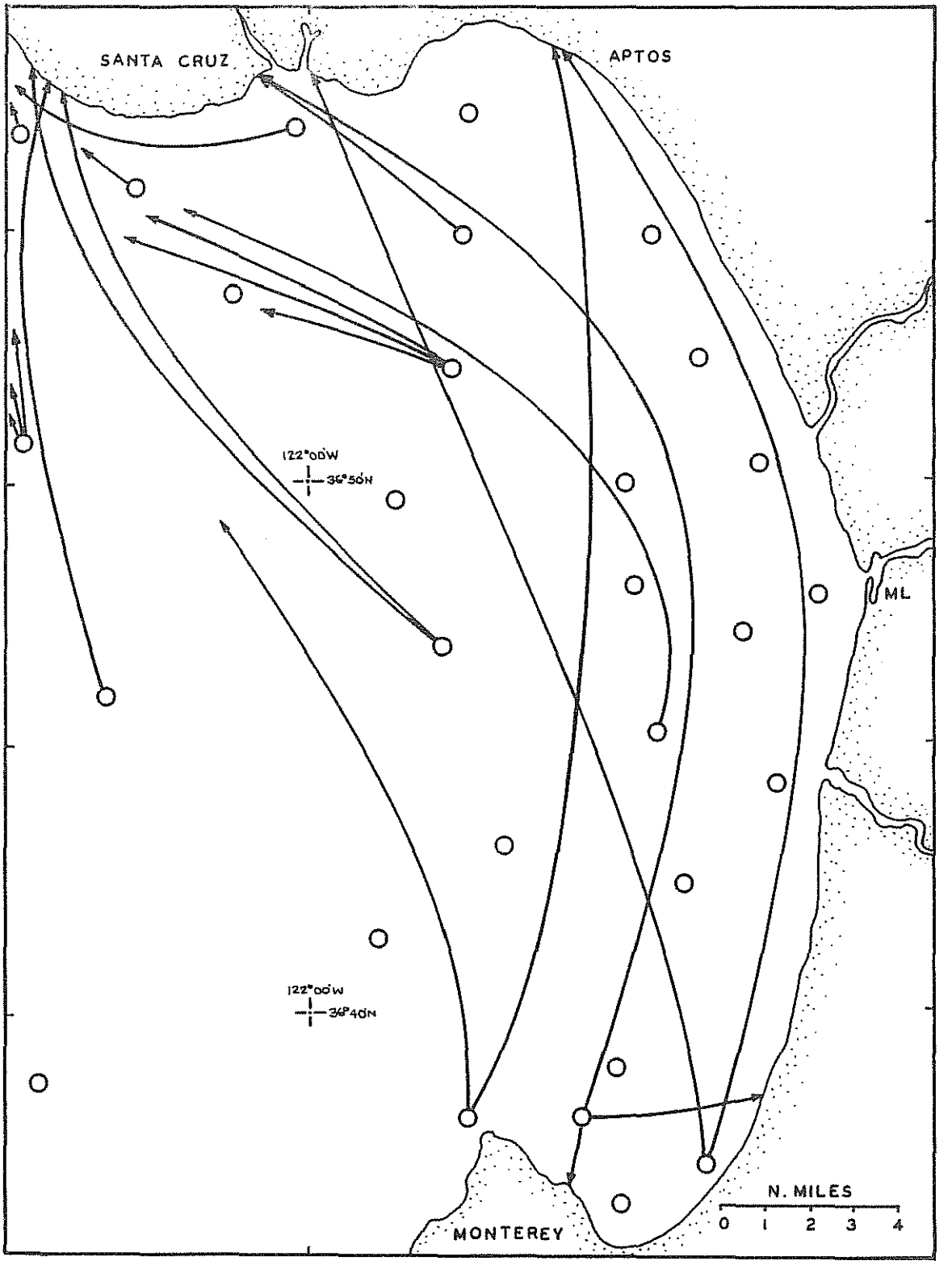

Fig. 14. Drift card returns during the Davidson Current period, December 1971. Release points ○

WANG COMPUTER

In September 1971, we received a Wang Model 700B desktop computer and a Wang Model 701 output writer and have recently received the Model 714 mark sense card reader. These major equipment items purchased from Sea Grant funds have expanded our data processing capacity tenfold, and perhaps more importantly have given us the facilities at Moss Landing to use the small computer in our instructional program. Soon after receiving the computer, a short course on computing techniques was given to the Sea Grant teaching assistants and technicians who wished to participate. They in turn have given instruction to other graduate and undergraduate students. The computer is now in operation about 30 hours per week, and as more students learn its use, it will be in use almost constantly.

In the first two months of the computer's operation, we have written the following programs for routine oceanographic data processing:

1. Calculation of nutrient concentrations from spectrophotometer readings.
2. Oceanographic reversing thermometer corrections and thermometric depth calculations.
3. Calculation of salinity from precision salinometer readings.
4. Calculation of dissolved oxygen concentrations from titration values.
5. Oxygen saturation and seawater density calculations from observed temperature, salinity, and dissolved oxygen concentrations.
6. Calculation of chlorophyll *a* standing stock from fluorometer readings.

7. Calculation of primary productivity rate using the ^{14}C method.

8. Shannon-Weiner species diversity index.

9. Offshore hydrographic data format.

10. Elkhorn Slough-Moss Landing Harbor hydrographic data format.

11. Determination of light levels from Secchi disk depths.

Since receiving the Wang computer, all oceanographic and chemical data obtained since the beginning of the Sea Grant Program have been recalculated. Eleven months' data (February to December 1971) have been reduced and checked and will be issued as a data report by May 1972.

BENTHIC SURVEY IN NORTHERN MONTEREY BAY

J. W. Nybakken, A. T. Hodgson and P. C. Clark

Accomplishments on the Sea Grant Program this year can be divided into two areas: the basic environmental data collection from benthic stations in Monterey Bay and the results of the pilot research project on the reproductive cycle and growth rates of gaper clams (Tresus nuttalli) in Elkhorn Slough.

The benthic study in Monterey Bay has been greatly aided through additional support from the Association of Monterey Bay Area Governments (AMBAG). This substantial support has allowed to increase the number of stations occupied last year from 5 to 11 and to employ a full time technician to work up and identify the organisms. Similarly, the gaper clam pilot research project has been aided through supplemental funds provided by the California Department of Fish and Game.

The continuing project involving the attempt to gain baseline information relative to the community composition of the benthos of the shallow waters of Monterey Bay was initiated in this second year of Sea Grant support in August when 8 replicate samples were taken at each of 10 stations in the northern half of the bay. Analysis of the August samples suggested that 6 replicates would be adequate to assess the variance, and thus at the second sampling period in November, six replicates were taken and an additional station was established to bring the total to 11. These stations are listed on Table 6.

The sampling gear was also changed this year. A Smith-McIntyre

TABLE 6

LIST OF STATIONS FOR THE

SEA GRANT - AMBAG BENTHIC SURVEY

AS OF 18 NOVEMBER 1971

STATION NUMBER	LATITUDE N	LONGITUDE W
1105	36° 51.0'	121° 49.8'
1154	36° 55.5'	121° 52.6'
1159	36° 57.1'	121° 56.2'
1158	36° 55.1'	121° 56.7'
1156	36° 53.0'	121° 55.0'
1157	36° 50.2'	121° 50.2'
1153	36° 56.7'	121° 59.2'
1152	36° 54.8'	122° 01.0'
1176	36° 52.3'	121° 59.8'
1177	36° 53.6'	121° 57.5'
1155	36° 50.8'	121° 53.6'

grab was selected as the instrument to use because of its great reliability in taking consistent samples and because one of the other institutions on the bay, Hopkins Marine Station, uses this gear exclusively for its sampling of the southern half of the bay. Use of the Smith-McIntyre thus allows us to make direct comparisons with the Hopkins results.

Sampling will continue quarterly. A three month intervals allows us to sample in each of the main marine seasons and still is spaced sufficiently far apart to allow time to process the samples.

At this time each of the 11 stations has been occupied three times (August, November, February) and six replicates taken at each station during each sampling period (8 replicates for August) or a total of 212 individual samples have been taken. All have been screened and rough sorted to phylum. The August samples have had the molluscs identified to species and the polychaetes to genus. These two groups comprise the bulk of the organisms in the samples. Presently, the species names of the polychaetes and molluscs of the November samples are searched through the literature; at the present rate of progression, species identification, analysis of community structure and variation will be completed sometime in late summer or early fall of 1972.

This benthic project has employed 6 graduate students and has led some of them to develop sub-projects involved with community analysis which may become the basis of their Master's degree research. For example, P. Clark has worked with the bivalve molluscs and has recently completed a recurrent group analysis to sort out the various

co-occurring species. A. Hodgson has analyzed the polychaete worms in a similar fashion and D. Shonman the gastropod molluscs.

Eight undergraduate students also are involved in this project, primarily in rough sorting the samples and in assisting on the ship in the working of the grab.

The pilot research project on the reproductive cycle and growth rate of the gaper clam (Tresus nuttalli) has been very productive this year. To elucidate the reproductive cycle a minimum of six and a maximum of ten adult clams were collected each month during 1970-71, preserved and the gonads sectioned. Inspection of these monthly samples has given proof that at least some of the clams are breeding every month of the year, but that peaks in spawning occur in late winter and in late spring.

The growth rate of the juvenile clams has been obtained through individual marking of the juveniles and then returning them to large sand filled buckets placed in the Slough. These buckets have been retrieved at various time intervals during the year and the juveniles re-measured. Results of this study have shown that the juvenile clams from 2.0 to 20.0 mm in shell length grow at the very rapid rate of about .25 mm per day in shell length. This rate of growth declines in larger specimens such that in animals of the 30 to 50 mm shell length class, the rate is only .14 mm per day and in those of 50 to 60 mm the rate is down to .08 mm per day. At these rates of growth and knowing that the clams reach sexual maturity at around 70 mm in shell length, we feel that newly settled clams would be of breeding size in about one year.

Thus, it appears that the gaper clam population maintains itself in Elkhorn Slough under intense fishing pressure because of the rapid growth rate of the young clams, their rapid maturity and their ability to breed all year thus providing constant recruitment to the fishery.

A STUDY OF SEAL AND BIRD ROOKERIES IN RELATION TO PRODUCTIVITY OF FISHES OF ECONOMIC IMPORTANCE

G. V. Morejohn, V. J. Loeb, G. E. Kukowski,
E. C. Shumaker and D. Watson

Studies of the effects of seal excreta on marine life adjacent to seal rookeries are underway in the vicinity of Ano Nuevo Island north of Monterey Bay, California (Figure 15).

Five studies have been conducted in the field and at the Laboratories. Field work has largely consisted of sample collections of sea water, foraminifera, and fishes. Analysis of samples has been conducted in the Laboratories and is still underway. Sample collections will continue for the next few months.

WATER NUTRIENT STUDY

Water samples were taken from the Ano Nuevo Point and Pigeon Point areas and analyzed for nutrient concentrations to determine whether significant differences exist in the nutrient levels of the onshore waters of the two areas. Correlations with numbers of pinnipeds present on the island throughout the year will be made to determine their influence on concentrations of various water nutrients.

Sampling was done bi-monthly at low tidal levels. There were six sample stations established in the Ano Nuevo Point area and two in the control Pigeon Point area (Figures 16 & 17). The sample stations established in the Ano Nuevo area were at the point, the northern and

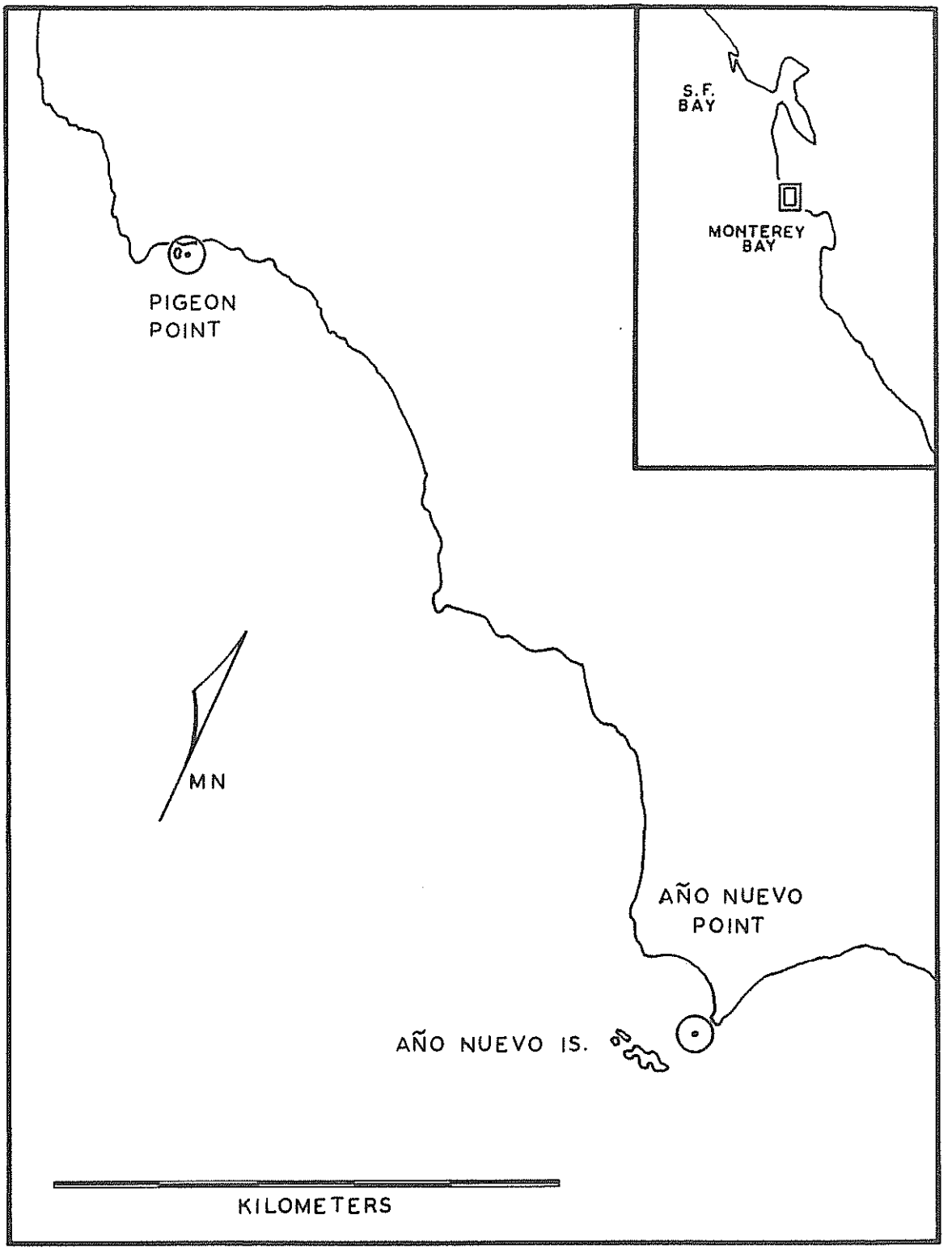

Fig. 15. The two sampling sites shown in relation to their location in central California.

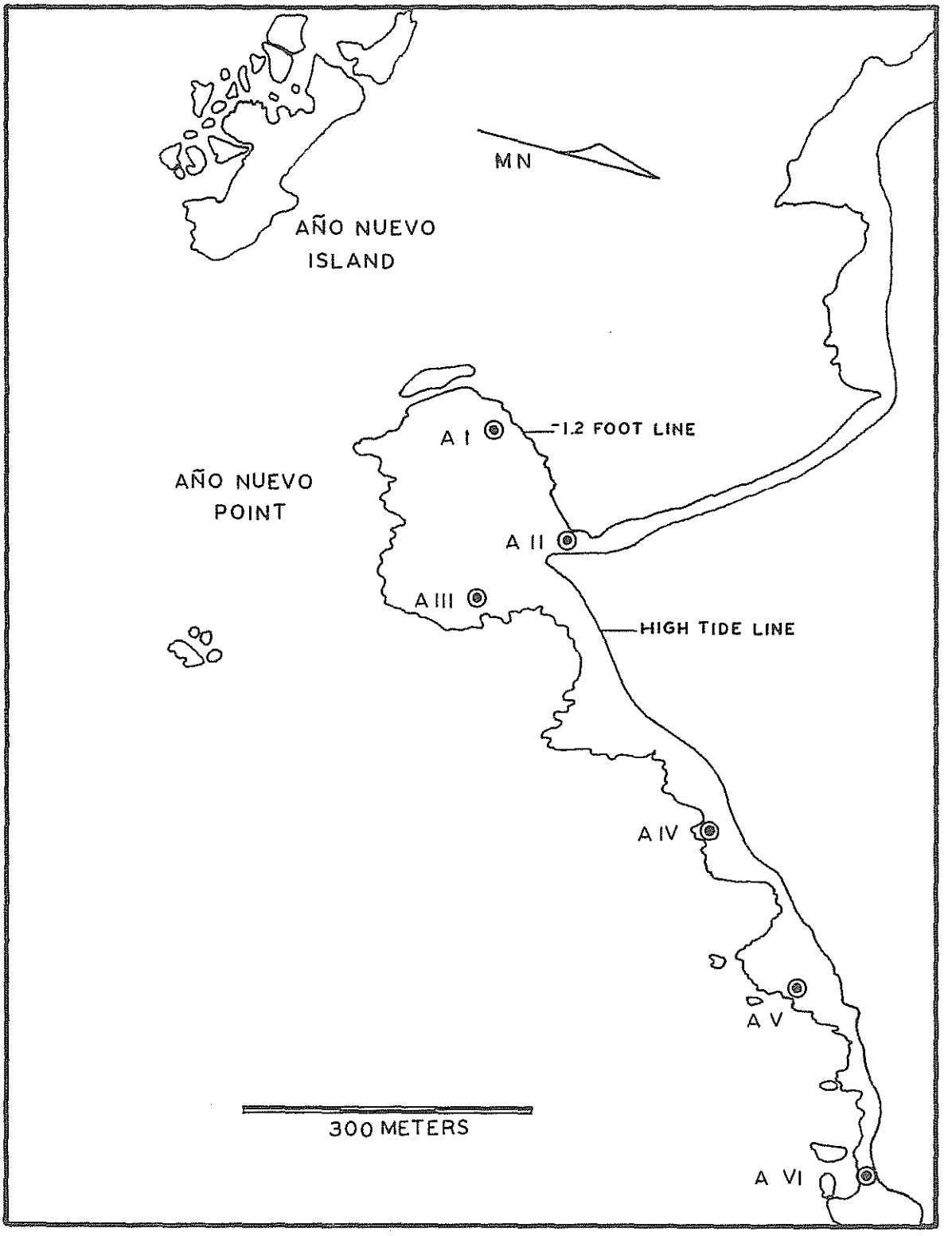

Fig. 16. The six collecting stations along Ano Nuevo Point.

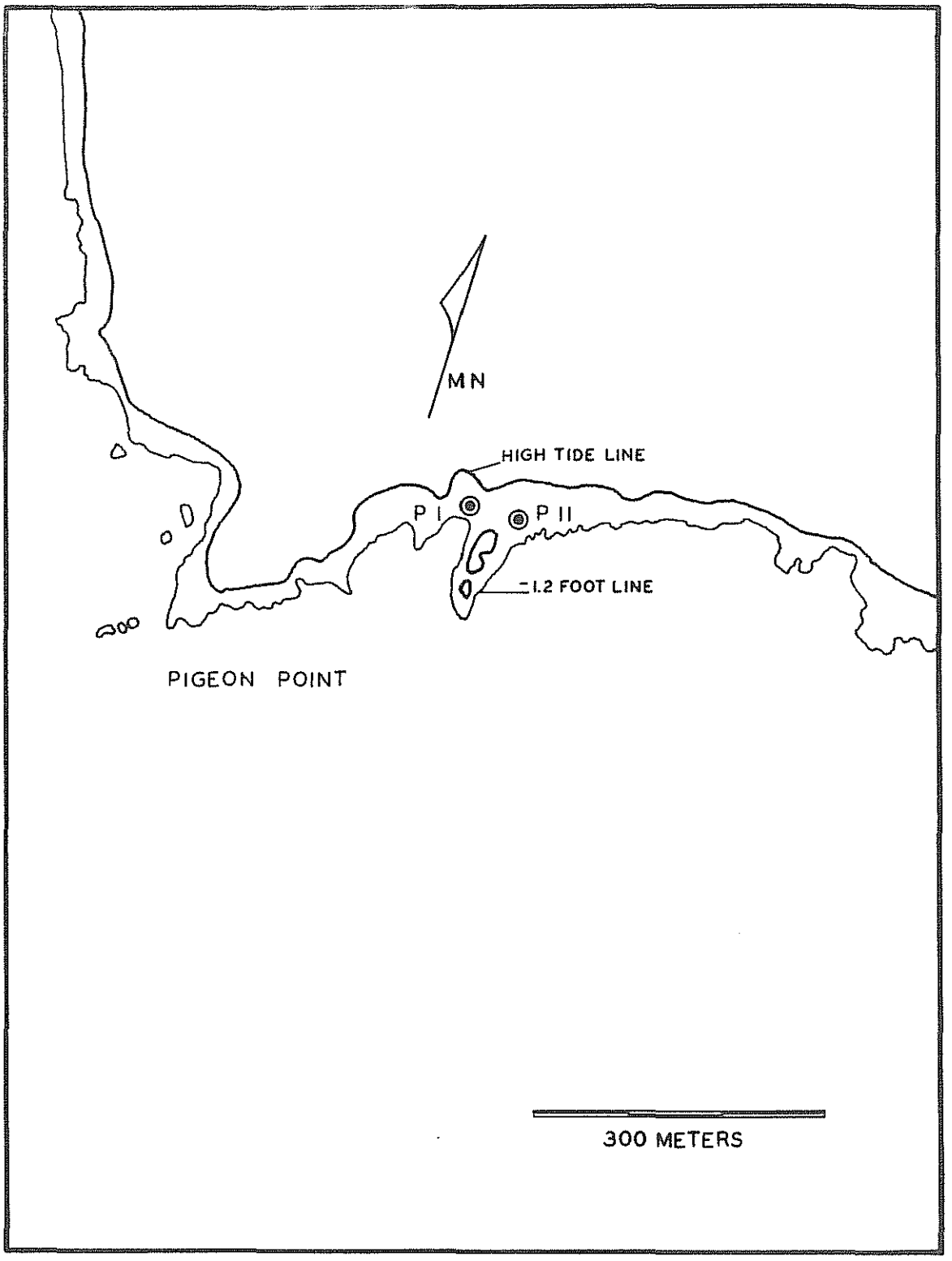

Fig. 17. The two sampling stations along Pigeon Point.

southern bases of the point, and on the southern limits of the three consecutive bays south of Ano Nuevo Point. The last station was approximately 3/4 mile from Ano Nuevo Point. The Pigeon Point stations were established at the northern and southern bases of a small outcropping just south of Pigeon Point. Water samples were taken in 500 ml polyethylene bottles and were frozen immediately in dry ice and isopropyl alcohol bath. They were kept frozen until they were chemically analyzed. Nutrients tested were nitrate, nitrite, phosphate, and ammonia (Table 7). The methods utilized for their analysis were those described in the Moss Landing Marine Laboratories Sea Grant Annual Report for 1971.

To date, it appears that the only nutrient tested which shows any significant difference between the Ano Nuevo and Pigeon Point areas was ammonia, and this nutrient seems to be generally higher along the southeastern edge of Ano Nuevo Point and increasing to a higher concentration at Station V (Figure 16).

COLIFORM BACTERIA STUDY

Coliform counts were made of water samples from the Ano Nuevo and Pigeon Point areas to serve as an indication of the relative amounts of fecal material in the onshore waters. It was assumed that the Pigeon Point area would be free of measurable amounts of Coliform bacteria, due to its distance from the Ano Nuevo rookeries and its lack of pinnipeds.

Coliform samples were collected once a month, starting in December 1971, from the eight sampling stations described for the water nutrient study. Water was collected in 250 ml sterilized jars and kept at sea

TABLE 7

NUTRIENT ANALYSES (ug-at/1) AND COLIFORM COUNTS (MPN)

FOR SAMPLE STATIONS AT ANO NUEVO POINT AND PIGEON POINT

SAMPLE SITE	5 OCT	21 OCT	2 NOV	17 NOV	30 NOV	16 DEC	30 DEC	12 JAN	25 JAN
A-I									
Phosphate	.77	.54	.77	.47	.71	1.61	1.11	1.34	1.10
Nitrate	.50	1.4	2.9	2.0	4.8	13.2	6.0	7.7	4.8
Nitrite	.21	.10	.19	.15	.21	.37	.36	.54	.34
Ammonia	1.60	1.00	1.95	1.66	.65	- .19	.04	2.93	.54
Coliform MPN /100 ml						0		4	
A-II									
Phosphate	.88	.48	.81		1.45	1.60	1.37	1.64	1.18
Nitrate	.7	1.1	2.5		8.4	16.3	8.5	7.1	5.3
Nitrite	.09	.09	.25		.37	.47	.40	.42	.36
Ammonia	2.00	1.23	2.00		2.86	3.58	.15	5.38	.31
Coliform MPN /100 ml						1,100		23	
A-III									
Phosphate	1.14	.48	2.14	2.26	1.99	1.75	1.22	1.32	1.40
Nitrate	2.4	1.1	5.6	2.6	10.9	17.5	8.1	8.6	7.8
Nitrite	.49	.09	.34	.20	.26	.42	.36	.49	.47
Ammonia	4.10	1.23	10.18	7.39	3.16	.84	.29	1.52	.00
Coliform MPN /100 ml						2,400		0	

TABLE 7 (CONTINUED)

SAMPLE SITE	5 OCT	21 OCT	2 NOV	17 NOV	30 NOV	16 DEC	30 DEC	12 JAN	25 JAN
A-IV									
Phosphate	1.05	.88	1.27	1.26	1.69	1.84	1.36	1.92	1.34
Nitrate	2.7	1.2	6.6	4.3	6.0	17.9	8.4	10.3	6.1
Nitrite	.30	.16	.24	.27	.30	.45	.40	.57	.49
Ammonia	1.30	2.04	3.06	1.51	1.42	.65	1.22	.24	.31
Coliform MPN /100 ml						0		0	
A-V									
Phosphate	.61	.82	.87	.79	1.71	1.28	1.70	1.74	1.37
Nitrate	.20	.8	.54	3.4	7.4	8.9	10.1	10.5	9.3
Nitrite	.18	.12	.18	.18	.34	.25	.47	.57	.41
Ammonia	.73	1.33	15.39	1.42	2.02	.33	1.00	.46	.88
Coliform MPN /100 ml						0		23	
A-VI									
Phosphate			1.13	.64	1.71	1.71	1.45	1.60	1.48
Nitrate			7.1	3.7	7.8	16.7	10.0	11.2	5.6
Nitrite			.36	.19	.37	.44	.38	.55	.46
Ammonia			1.33	1.13	2.18	.35	.33	.40	1.15
Coliform MPN /100 ml						4		9	
P-I									
Phosphate	.76	.71	2.88	1.01	1.26	1.70	1.34	1.60	1.42
Nitrate	1.6	1.8	6.1	4.5	9.2	13.3	7.1	7.7	7.6
Nitrite	.26	.18	.25	.22	.31	.35	.33	.44	.22
Ammonia	1.43	1.00	1.74	2.01	1.91	.81	.39	.29	.60
Coliform MPN /100 ml						0		0	

TABLE 7 (CONTINUED)

SAMPLE SITE	5 OCT	21 OCT	2 NOV	17 NOV	30 NOV	16 DEC	30 DEC	12 JAN	25 JAN
P-II									
Phosphate	1.01	.76	4.47	.93	1.70	1.79	1.56	1.96	1.42
Nitrate	6.1	1.6	11.9	4.1	14.0	13.5	7.3	10.5	9.0
Nitrite	.31	.19	.41	.28	.47	.35	.39	.43	.44
Ammonia	1.59	.83	- .95	2.81	1.32	.77	.31	.12	.13
Coliform MPN /100 ml						0		0	

water temperature in a styrofoam ice chest until serial dilutions could be made in prepared Hach lactose broth fermentation tubes. Triplicate dilutions of 1:10, 1:100 and 1:1000 were made for each sample, and these were incubated at 35 C for 48 hours. The tubes were then checked for gas formation, indicative of a positive coliform count. Those samples showing positive signs were then used to innoculated Hach prepared brilliant green bile broth tubes, which were incubated for another 48 hours, for confirmation of coliform bacteria. A most probable number value (MPN) of coliform bacteria was assigned to each positive sample based on the MPN Index and 95% confidence limits for multiple tube fermentation, as appears in Orland (1969).

Coliform bacteria were found in the greatest numbers at the stations closest to Ano Nuevo Island. The presence of coliform bacteria in the more distant stations is probably related to currents moving from Ano Point northeast toward Station VI (Figure 16).

FORAMINIFERA STUDY

The purpose of the foraminiferal investigation is to determine the influence of pinniped fecal matter on distribution of foram populations at the Ano Nuevo and Pigeon Point areas.

Monthly at low tide approximately 300 ml samples of sediment are scooped from six intertidal locations at the Ano Nuevo point area and two locations at the Pigeon Point area. The samples are preserved in 40% isopropyl alcohol and stained with Rose Bengal. After a period of at least a week (to insure good staining), the samples are dried and separated equally (by weight) into three jars for organic carbon

and carbonate carbon analyses, sediment size analysis, and foraminifera classification.

Five months of samples have been taken, preserved and stained, dried and sorted into jars. Organic carbon (total carbon) and carbonate carbon analyses will be made at completion of a 10 month sampling period. Foram classification and particle size analysis of sediments are underway.

BENTHIC ALGAL PRODUCTIVITY

Benthic algae, Ulva Linza and Enteromorpha intestinalis, were cultured in light and dark bottles. Some bottles contained filtered sea water while others were filled with sea water enriched by California sea lion (Zalophus californianus) feces. These algae were cultured in several concentrations of the nutrient mixture. Productivity was determined by the Winkler oxygen technique. Also, uptake of nutrients (PO_4, NO_3, NO_2, and NH_3) was noted by taking samples of the culture water before and after a full day of incubation in the ocean.

Nutrients which seemed to be taken up most readily by the algae were ammonia and phosphate. Nitrate showed dubious uptake in several bottles and inconsistency in the rest. Concentrations of nitrite increased slightly during incubation, indicating that it was not being absorbed by the algae. These increases may result from the oxidation of nitrogenous compounds.

Productivity of algae in the filtered sea water was higher than that in the two concentrations of enriched water. This may be due to inhibition of algal growth by over-concentrated nutrients, or it may be

an indication that the carbon to oxygen ratio is higher in the enriched water. More investigation is necessary.

FISH STUDY

A study of the fishes present at Ano Nuevo Point was initiated in October 1971. The purpose of this study was to provide data on the species of fish present in the area and on their feeding habits.

Approximately once a month a fishing effort was made in the Ano Nuevo area. A small skiff was launched from a beach, with an easy road access, several miles south of the point, and was motored to the study site. The methods used for fishing were long lines, with 40 hooks each, dip nets for intertidal fishes, and gill nets, as described in the Moss Landing Marine Laboratories Sea Grant Annual Report for 1971. The area of study was in the sheltered area southeast of Ano Nuevo Point (Figure 16)

The fish collected were identified and measured for total length, and then their stomachs were removed, tagged, wrapped in cheese cloth bags, and preserved in 10% formalin until contents could be identified.

The rugged nature of the Ano Nuevo area has been the greatest deterrent to the study of this area. Various methods of launching the fishing skiff have been tried, but none has been found to be successful in any but the most calm weather conditions. New techniques are being planned for a more intense fishing study in the future. Among these is the plan to tow the fishing skiff

from Monterey to the study area behind a larger vessel, plus the utilization of a team of skin divers to set gill nets and fish taps.

LITERATURE CITED

ORLAND, H. P. (Ed.) 1965. Standard Methods for the Examination of Water and Wastewater. 12 ed., Boyd Printing Co., Albany, N. Y. 769 pp.

SEDIMENTOLOGICAL STUDIES

R. E. Arnal and E. R. Dittmer

SAND TRANSPORT

Sand is an important natural resource in Monterey Bay. Several sand mining comparnies are located around the Monterey Peninsula. The sand produced is used in construction, glass making and for landscape gardening. This resource should not be overexploited, hence a sand budget is desirable. In order to evaluate the sand budget for Monterey Bay, it is necessary to have an estimate of the tonnage removed from the system by natural means in addition to removal by dredging.

To evaluate the amount of sand in longshore transport, seven permanent beach transect stations were established along the shoreline and data have been collected almost monthly over a period of eleven months. In addition, particle size analysis and organic content were run on samples collected in conjunction with the profiling of the beaches. Techniques for beach configuration studies were described in the Moss Landing Marine Laboratories Annual Report for the 1971 Sea Grant Project. Data collected so far were plotted for general interpretation; however, this winter season has been characterized by an absence of major storms and the past 12 months represent an unusual yearly cycle. We must continue the accumulation of data for another year to obtain beach configuration for a typical winter season. Conclusions at the end of this study will be based on 24 months of data and will represent better the average conditions in Monterey Bay.

DREDGE SPOIL STUDIES

Disposal of dredge spoil at shallow depth on the ocean floor provides an unusual way to study the effect of rapid introduction of fairly large quantities of sediment at the dumping site. To determine the effect of dumping on the benthic environment, a pre-dumping survey of the conditions on the substratum should be made. When spoil dumping has been completed, a re-survey will point out differences. Such study was made in the vicinity of Santa Cruz Harbor in late 1970 and early 1971; an open-file report giving the details of this study will be incorporated in the 1972 Sea Grant Annual Report for the Moss Landing Marine Laboratories. Preliminary results show that: 1) the benthic fauna at the dumping site was made up of more than 50% polychaetes, 25% mollusca and the remainder crustacea, echinoderms, bryozoa and others. 2) there was a high biomass value at the disposal site and surrounding area. 3) sediments from the dredge site had a very high organic content regardless of grain size and would create a high oxygen demand at the time of dumping.

Another similar study is under way to investigate the fate of dredge spoil dumped near the head of the Monterey Canyon (see published abstract by R. E. Arnal, Second National Coastal and Shallow Water Conference, Chapter III of this report). It has been stated repeatedly through the literature that the head of the Monterey Submarine Canyon acts as a barrier between the northern and southern parts of Monterey Bay because of its close proximity to the shoreline. The intent of our study is to find out whether sand deposited in shallow water near the

head is transported or not down the slope of the submarine canyon. Fluorescent tagged sand has been introduced during the summer of 1971 mixed with harbor dredge spoil. Repeated sampling down canyon from the dumping site has not yet revealed any movement to greater depth. Furthermore, divers making routine observations to depth of 100 feet report no change in the accumulation of spoil material. Perhaps the absence of major storms this winter has prevented any movement that might normally be initiated during the winter. Sampling down the slope will nevertheless be continued on a regular basis.

A recent experiment with fluorescent sand of a different color has provided exciting results. This experiment was conducted in mid March 1972. Fluorescent sand was introduced at the edge of the water at low tide north of the north jetty of Moss Landing Harbor. Three days later, many grains of the same fluorescent color were recovered south of the Moss Landing pier (Figure 18). The experiment does demonstrate that sand transport take place along shore across the region of the head of the Monterey Canyon. We intend to repeat this experiment at several stages of the tidal cycle and also along the shore south of the recovery area and north of the introduction point (Figure 18).

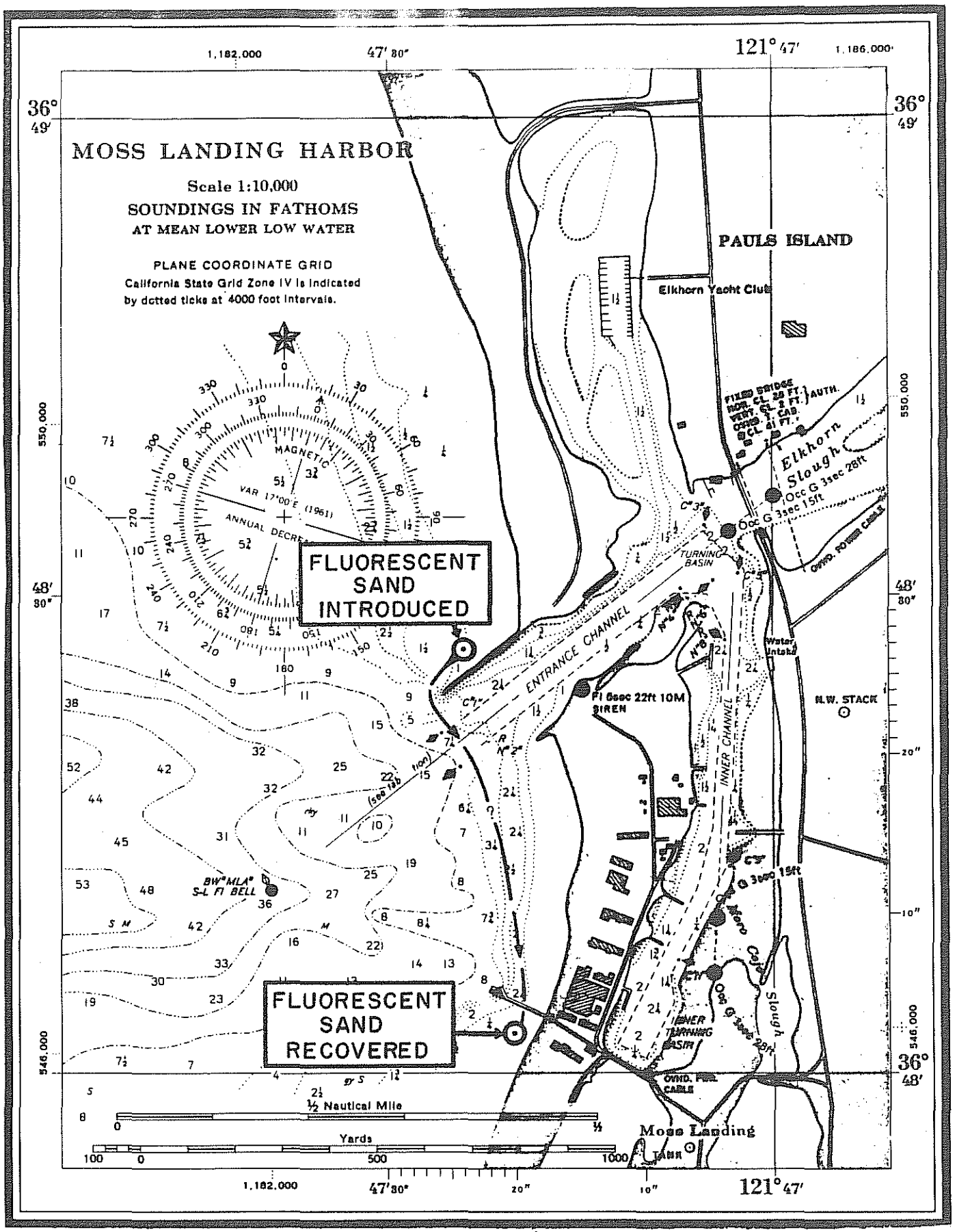

Fig. 18. Approximate track of fluorescent sand in mid March 1972 experiment.

III. PROGRESS IN EDUCATION, PUBLIC INFORMATION AND PUBLIC SERVICES

NEW EDUCATIONAL EXPERIENCES

M. W. Silver and W. W. Broenkow

Students at the Laboratories also have profited from the participation of the Laboratories in the Sea Grant Program. Students routinely aid in the data collection at sea, in the laboratory analysis of samples, and in the data reduction. Monthly meetings in ML 155a, the laboratory course for research participation, provide a forum for discussion of Sea Grant data during the semester. Faculty, student assistants, and students participate in these meetings and discuss problems of sampling, data interpretation, and the significance of the results. A number of local high school teachers have attended the research participation program and have expanded their understanding of marine techniques and the conduct of research. Their response to the Sea Grant Program has been enthusiastic. Graduate students also are involved through individual and group research projects in a course entitled Environmental Research in Monterey Bay, ML 255a. Research projects include studies on the plankton, hydrography, and benthic invertebrates of the bay: these studies are closely involved with related studies under the Sea Grant Program. Several Master's theses also are using the data provided by Sea Grant Programs or are working closely with the laboratory program.

Before the arrival of the Wang computer, students enrolled in the research participation classes devoted a large portion of their time to data reduction, and consequently had less time to participate in

field methods and laboratory analyses. Now data processing is less time consuming and more accurate.

In spring semester 1972 we began a new course, "Quantitative Marine Science", in which the students are taught statistical methods directly applicable to biological, chemical and physical data as gathered in the Sea Grant Program. During this course the students will learn to write their own simple computer programs to perform the statistical analyses. Student response to the course has been excellent.

SECOND SHALLOW WATER CONFERENCE

R. E. Arnal and D. E. Baron

The Moss Landing Marine Laboratories was well represented at the Second National Coastal and Shallow Water Research Conference sponsored by the Office of Naval Research, October 1971. Since the first conference was held a decade ago, this meeting was an especially important one. Participants representing the Moss Landing Marine Laboratories were Dr. Robert E. Arnal, Dr. William W. Broenkow, Dr. G. Victor Morejohn, Dr. James Nybakken, Dr. Mary Silver, and Mrs. Judith Hansen. Abstracts of their studies appear on the following pages.

Dr. Robert E. Arnal, Sea Grant Project Coordinator and Interim Director of the Moss Landing Marine Laboratories acted as Chairman of Section 1B: Beach, Estuarine and Bay Studies, at the conference.

The support given the Moss Landing Marine Laboratories through the National Sea Grant Program of the National Oceanic and Atmospheric Administration made possible the sharing of our research on the coastal zone and shallow water margin of the Central California Coast with other groups and individuals. At the same time, we were made more aware of the increased number of individuals investigating our coasts; we had an opportunity to meet many of them and learn about their prominent research interest.

ABSTRACT VOLUME

SECOND NATIONAL COASTAL AND
SHALLOW WATER RESEARCH CONFERENCE

Sponsored by Geography Programs, Office of Naval Research

15

SAND TRANSPORT IN CENTRAL MONTEREY BAY AS A FACTOR IN DETERMINING SAND BUDGET[1]

Robert E. Arnal
Moss Landing Marine Laboratories
Moss Landing, California 95039

In trying to evaluate the surplus or deficit nature of the sand budget in Monterey Bay, it is essential to know if losses take place by transport down the slope of the Monterey Submarine Canyon.

In dredging operations for the Moss Landing Harbor District, approximately 80,000 cubic yards of dredge spoil will be dumped at the head of the Monterey Canyon in water depth less than 10 fathoms. More than 10,000 pounds of tracer fluorescent sand has been prepared following a technique developed by the U.S. Geological Survey. The fluorescent tracer will be mixed regularly with the dredge spoil as dredging proceeds.

Previous experience (1968) has shown that 20,000 cubic yards of dredge spoil were readily dispersed after the occurrence of two winter storms; however, nothing is known of the nature or direction of the dispersal in the previous dumping operations. Sampling of the dumping site sediments in a closely spaced grid prior to dumping of the dredge spoil shows little background fluorescence, none in the fluorescence color of the tracer sand.

Post dumping sampling of the same site will be carried out immediately after the end of dumping operations and at regular intervals afterwards until the end of the period of winter storms. Hopefully, it will be possible to determine the main direction of dispersal of dredge spoil material.

[1] This study is supported by the U.S. Army Corps of Engineers, U.S. Department of Defense, the National Sea Grant Program, National Oceanic and Atmospheric Administration U.S. Department of Commerce.

ABSTRACT VOLUME
SECOND NATIONAL COASTAL AND
SHALLOW WATER RESEARCH CONFERENCE
Sponsored by Geography Programs, Office of Naval Research

30

HYDROGRAPHIC OBSERVATIONS IN MONTEREY BAY, CALIFORNIA[1]

William W. Broenkow
Moss Landing Marine Laboratories
Moss Landing, California 95039

Seasonal hydrographic conditions in Monterey Bay, California are being investigated by Moss Landing Marine Laboratories in a two-year study. Twenty hydrographic stations in nearshore Monterey Bay are occupied monthly for measurements of temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, ammonia, and silica. These data and phytoplankton standing stock measurements (M. Silver and J. Hansen) show small scale variations in their distributions, reflecting localized sources of the nutrient ions. These sources include 8 sewage outfalls, 3 streams, the Elkhorn Slough that empties into the bay and the upwelled deeper waters from Monterey Submarine Canyon.

Surface currents are being investigated by releasing drift cards at monthly intervals at 10 locations in the bay. The net surface drift closely corresponds to changes in the wind field.

Short term variations in hydrographic properties at the head of Monterey Submarine Canyon were studied during a 25-hour study at two stations. These relatively large magnitude changes are related to tidal and internal wave oscillations.

A year long study of the Hydrography of Elkhorn Slough (6 miles long, 3 meters deep) has shown that the slough receives substantial quantities of nitrogen compounds derived from farmland drainage. The flushing time of the slough is long compared with the rate at which these nitrogeneous compounds enter the slough. During the dry season (June to October), hypersaline conditions are observed in the upper slough. This and the markedly diurnal distributions of oxygen and phosphate in the tidally flushed slough demonstrate that tidal mixing of the upper slough waters is slow.

[1] This study is financed by the National Sea Grant Program, National Oceanic and Atmospheric Administration.

ABSTRACT VOLUME
SECOND NATIONAL COASTAL AND
SHALLOW WATER RESEARCH CONFERENCE
Sponsored by Geography Programs, Office of Naval Research

161

THE EFFECTS OF NUTRIENTS ON PRODUCTIVITY OF FISH AND ALGAL SPECIES IN WATERS SURROUNDING SEAL AND BIRD ROOKERIES[1]

G. Victor Morejohn
Moss Landing Marine Laboratories
Moss Landing, California 95039

Pilot studies conducted in 1968 and others underway indicate certain relationships of high nutrient levels, as provided by seal droppings, to high densities of certain species of fishes and algae adjacent to seal and marine bird rookeries. The stimulatory and/or inhibitory effects of marine mammal and avian fecal material on various species of marine algae are being determined experimentally.

Two study areas have been established: 1) surrounding waters adjacent to seal and bird rookeries on offshore rocks, and 2) surrounding waters adjacent to offshore rocks not serving as rookeries for seals or birds. These study areas are being compared through periodic study and sample collections to determine a) growth and diversity of algal species, b) molluscan and other invertebrate fauna feeding on algal species, c) fish species present, d) zooplankton diversity, e) water chemistry, and, f) coliform levels.

Identification of food items in stomachs of fishes, birds, and mammals of the area are being made. Metabolic studies are in progress on seals and birds to determine nutrient levels of foods eaten in relation to by-products or nutrients eliminated in fecal material. The study areas are north of Monterey Bay in the vicinity of Año Nuevo Island and Pigeon Point, California.

1 This study is supported by National Sea Grant Program, National Oceanic and Atmospheric Administration, United States Department Of Commerce.

ABSTRACT VOLUME
SECOND NATIONAL COASTAL AND
SHALLOW WATER RESEARCH CONFERENCE
Sponsored by Geography Programs, Office of Naval Research

REPRODUCTIVE CYCLE AND GROWTH RATES OF TRESUS NUTTALLI IN ELKHORN SLOUGH, CALIFORNIA

James Nybakken
Moss Landing Marine Laboratories
Box 223
Moss Landing, California 95039

Tresus nuttalli is an important clam in Elkhorn Slough where it receives considerable fishery pressure from sportsmen. This species remains, however, relatively unknown ecologically.

The present study is divided into two parts. The first part is concerned with the elucidation of the spawning cycle. In this phase of the study samples of 20 adult clams are taken each month and sacrificed for gonad sectioning. Observation of the gonad sections under the microscope is used to establish the stage of reproductive readiness and the approximate time of spawning. Results from a year and a half of this phase of the project indicate that Tresus nuttalli breeds at a low level almost all year but has two main peaks in the spawning cycle, one in winter and one in the spring. Small clams may be found year around.

The second phase of the study is concerned with the determination of the growth rate of the juvenile clams (those from 4 to 30 mm in shell length). This aspect of the study has been most successfully approached through the placing of measured, marked juveniles in containers, returning them to the slough, retrieving the container after 2 months and remeasuring the clams. The few data thus far available from this study suggest that the growth rate of the juveniles is very rapid, approaching 0.25 mm in shell length per day, for those clams in the size range of from 4 to 20 mm in shell length.

ABSTRACT VOLUME
SECOND NATIONAL COASTAL AND
SHALLOW WATER RESEARCH CONFERENCE
Sponsored by Geography Programs, Office of Naval Research

PLANKTON STUDIES IN NEARSHORE MONTEREY BAY[1]

Mary Silver and Judy Hansen
Moss Landing Marine Laboratories
Moss Landing, California 95039

Moss Landing Marine Laboratories has been sampling the plankton of nearshore areas of central and northern Monterey Bay since March 1971. The plankton sampling program is coordinated with hydrographic studies in the bay (W. Broenkow) as part of a continuing Sea Grant research program. We are concerned with the measurement of standing stock of phytoplankton and zooplankton and with the relationship between phytoplankton stocks and hydrographic events in the bay.

We are measuring chlorophyll a standing stock, zooplankton volumes, total and net phytoplankton, and light penetration at monthly intervals at eleven stations. In addition, we are investigating the variability of plant stocks over tidal and daily periods at two stations over the Monterey Submarine Canyon.

Preliminary results indicate that the standing stock of phytoplankton ininshore Monterey Bay varied from 30-480 mg chl a/m^2 during March and April. Average concentrations in the upper 10 m ranged from 1-10 mg chl a/m^3. These concentrations are within the range expected for fertile, coastal waters (Strickland, 1965, in Chemical Oceanography, ed. Riley and Skirrow, Academic Press, N.Y.). The chlorophyll concentrations in the north bay were generally higher than in the central bay. These higher concentrations in the north correspond to higher nutrient levels in this area, and may be related to sewage discharge (W. Broenkow, personal communication). The data also indicate that large quantities of phytoplankton occurred below the 1% light level in March, during the period of upwelling.

The variability in chlorophyll standing stock between successive days and over a tidal cycle appears quite large. Because of the magnitude of these short term variations, the measurement obtained in this coastal environment on any given day has only limited value as a representation of weekly or monthly trends in chlorophyll standing stock.

[1] This study is financed by the National Sea Grant Program, National Oceanic and Atmospheric Administration.

PUBLIC INFORMATION, NEWSPAPER ARTICLES, NEWSLETTER

R. E. Arnal, D. E. Baron, G. V. Morejohn, M. W. Silver

The studies of Monterey Bay sponsored by the Sea Grant Program are providing an invaluable fund of data for the community. The changes in the bay brought about by urban and industrial development may be recognized by comparison of data obtained from the Sea Grant Program with data from future similar studies. Already the Association of Monterey Bay Governments (AMBAG) is drawing heavily on the knowledge provided by the plankton program at Moss Landing Marine Laboratories for its studies. The plankton program sponsored by Sea Grant has provided background and direction for AMBAG investigations that will lead to a model for the bay; the model will identify sewage outfall sites that produce a minimum of damage to the bay biota. Faculty from the Laboratories, including the author, attend monthly meetings to advise the AMBAG participants on the basis of the present background provided by the Sea Grant and other research activities.

An atlas of the Monterey Bay plankton is being assembled from the samples collected on the Sea Grant cruises. The atlas should provide important reference material for identification of the bay biota and perhaps aid other workers conducting neritic studies in the central California region. The atlas will be available for examination by any interested person at Moss Landing Marine Laboratories and may receive wider circulation if found appropriate.

Similarly, an atlas of algae of Monterey Bay is being assembled by the Laboratories' Algologist, Dr. James Jensen, and new species described whenever necessary. This is available to any interested person.

Several newspaper releases were made to keep the public informed of the activities of our Laboratories. Samples are incorporated in the following pages with copies of the resulting articles published in local newspapers.

A newsletter series was started recently. It will be published on a bi-monthly basis. The editor, Dr. Morejohn, has completed the review of the first number that describes the recent news of our institution and the meeting of the Regional Advisory Committee to the Sea Grant Program held last November.

Moss Landing Marine Laboratories of the
CALIFORNIA STATE COLLEGES at Fresno, Hayward, Sacramento, San Francisco, San Jose
P.O. Box 223, Moss Landing, California 95039

Environmental Studies, Monterey Bay Region
National Sea Grant Program

FOR IMMEDIATE RELEASE 1 SEPTEMBER 1971

For centuries men have tossed note-filled bottles into the sea with thoughts of distant shores. Beginning in September this very simple method of communication is being used by researchers at Moss Landing Marine Laboratories to determine the pattern of surface currents in Monterey Bay.

Sealed plastic bags containing self-addressed post cards have been released by plane at approximately twenty locations within the bay. The bright yellow cards ask their finders for the time, date, and location where the drift cards were found. 500 cards were released August 31, 1971 in the hope that 50 to 100 of them will be returned by fishermen, surfers, and beachcombers.

The use of drift cards is not new in oceanography but unique to Monterey Bay, according to Dr. William Broenkow, Associate Professor of Oceanography at Moss Landing Marine Laboratories. Drift cards will be air dropped by student Stan Phillips of San Jose State College once a month for at least one year through funds made available from the National Sea Grant Office for oceanographic teaching and research.

The direction and speed of water moving in and around Monterey Bay is not now completely known. The results of the experiment are of value to basic oceanographic research now being performed at Moss Landing Marine Laboratories and also for studies that must preceed the design of sewage outfall.

The scientists at Moss Landing are depending on public cooperation to gather this information. Drift card finders are asked to fill out the cards and drop them in the nearest mail box. Their help is greatly appreciated.

William Broenkow
Associate Professor

San Leandro, Calif.
News
(Cir. D 9,055)

SEP 24 1971

Allen's P. C. B. Est. 1888

Moss Landing

'Bottled Notes' Used To Trace Currents

For centuries, men stranded on desert islands and others just looking for adventure have tossed note-filled bottles into the sea with thoughts of communicating with distant shores.

This month researchers at Moss Landing Marine Laboratories in Monterey have begun using this age-old method of communication to determine the pattern of surface currents in Monterey Bay.

About 500 bright yellow, self-addressed post cards have been sealed into plastic bags and released by plane at approximately 20 locations within the Bay. The cards ask their finders for the time, date and location where the drift cards were found. Researchers hope that 50 to 100 cards will be returned.

Drift cards will be dropped by a San Jose State College student once a month for at least one year. The project is being funded by the National Sea Grant Office for oceanographic teaching and research.

The direction and speed of water moving in and around Monterey Bay is not now completely known, explained Dr. William Broenkow, associate professor of oceanography at the Laboratories. The results of the experiment are of value to basic oceanographic research now being performed at Moss Landing and also for studiest that must preceed the design of sewage outfall, he said.

Moss Landing Marine Laboratories, the project of five California State Colleges, under the direction of SJSC, is designed to collect marine data from Monterey Bay while training students in oceanography, marine biology and related sciences.

San Jose, Calif.
East San Jose Sun
(Cir. 2xW 9,214 Fere 17,401)

SEP 2 4 1971

Allen's P. C. B. Est. 1888

At Moss Landing

Sea research all bottled up

3099

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Moss Landing Marine Laboratories of the
CALIFORNIA STATE COLLEGES at Fresno, Hayward, Sacramento, San Francisco, San Jose
P.O. Box 223, Moss Landing, California 95039

Environmental Studies, Monterey Bay Region
National Sea Grant Program

September 16, 1971

Attached is a copy of my report on the work that I have been doing on the Monterey Bay and Salinas Valley during 1970-1971 to date. May I suggest you read the conclusions and recommendations on page 56-57, which are self explanatory. I would be happy to get together with you to discuss the rest of the report and perhaps to explain some of the graphic work.

What is true in the Salinas Valley is also true in the Carmel Valley and it appears that both of these valleys are developing in the classical pattern in California, i.e. from coast to inland. I really think our county and state planners should begin to think about AIR ZONING which may be the ultimate answer to the dangers of air pollution and contamination.

Air zoning may be the best method for controlling pollution. Insofar as air pollution is concerned it is not the land that should be zoned but rather the atmosphere. Such zoning differs from the usual land zoning and does not necessarily lead to unconditional restrictions for the location of a pollution source in any desired area.

Air zoning could be based on an analysis of meteorological conditions and take into account the willingness of the population in some communities to tolerate contamination (air pollution) to a greater degree than a standard established for the state. In order to accomplish such zoning a pollution source might be given a choice on limitation of the manner and rate at which each pollutant could be emitted, collection or reduction of pollutant emission when weather conditions are not favorable, or complete interruption of pollutant emission under emergency conditions.

The possibility of selecting among alternate restrictions depending on location might permit an estimate of costs in investment and operation that would be required by the various choices.

Standards for air pollution tolerance based on their temporary and lasting effects would have to be established. These standards would not necessarily be rigid but could include some margin within which a departure from basic standards could be authorized. This might lead to the creation of giant "smoking lounges" where higher contamination tolerances would be accepted.

Authorization for a departure from basic standards could be given if the communities involved should decide that the benefits from pollution sources justified these departures. For example, if industry and heavy urbanization were to be located in the area, Soledad to King City, the meteorological conditions dictate a much more efficient atmospheric waste disposal than if industry and urbanization are placed in the area from the coast to Salinas.

Since it appears that both the mouth of the Carmel Valley and Salinas Valley are being rapidly urbanized it might be wise for people in the middle and upper parts of these valleys to seriously consider pushing for air zoning now because it will only be a matter of time before their own air becomes polluted from upstream pollution sources.

Sincerely,

Robert G. Read
Associate Professor

Smog Comes to Peninsula Area

The mid-September heat wave proved that, given a certain combination of atmospheric conditions, the Monterey Peninsula already has smog, according to Robert G. Read, associate professor of meteorology, San Jose State College.

It could be seen, it could be smelled, its acrid fumes could be breathed, and at any time when the temperature nears the 100-degree mark, it will be repeated, especially in Carmel Valley, Read predicted.

The concept of air conservation or "air zoning" must be given consideration now, if there is to be breathable air for our children, Read contends.

Crop Levels

In 1969 Read started work with his students at the Moss Landing Marine Laboratories, on an examination of wind and moisture data at crop levels between the coast and Soledad.

They have recently completed, as a National Sea Grant project for the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, a 93-page report on "Marine Air Penetration of the Monterey Bay Coastal Strip and Salinas Valley."

In the report's recommendations to the federal government, it is pointed out that "as coastal valleys in California have been developed from agricultural to urban usages, the pattern of development has been first near the coast and then inland. As a result, heavy industry, highway systems and residential patterns have concentrated near the coast and atmospheric waste disposal of pollutants has been a serious problem.

Inversion

"The field studies reported here indicate that an inversion may cap the valley air shed even though the synoptic situation would indicate strong flushing of the air shed. If the valley is to be urbanized and industry does settle here, it would be wise to locate some distance from the coast, i.e., between Soledad and King City, where conditions are favorable for more ventilation and spreading out in the vertical of the atmospheric waste.

"The problem will still be there, but the concentrations of pollutants would be much less than with development near the coast. The coastal plain and the flat wide section of the valley floor would be profitably utilized in agriculture, and well-planned residential areas could be placed on the slopes leading into the valley floor."

Carmel Valley, Read said, is now developing from its mouth or seaward and inland, and, with steep-sided hills on each side like the Salinas Valley, it will experience the identical situation. The only difference between the areas is that the Salinas Valley is about 100 miles long and Carmel Valley less than 20.

Last December, Reed said, measurements taken at the Carmel Valley airstrip showed a turbulent mixing inversion — a thoroughly mixed marine air layer capped by the inversion, which can be present even when strong winds come into the area. This inversion slopes upward as one progresses into the valley.

"It is possible that an inversion may be present over this air shed (Monterey Bay coastal strip and Salinas Valley) a large part of the year," the report declares.

Add Traffic

"Add a lot of traffic to the wind flow — and we're getting more traffic all the time — and you create one of the worst problems for atmospheric waste disposal," Read continued. "Everybody thinks the atmosphere is the cheapest way to dispose of waste. Maybe a charge should be made for it, like sewage and garbage disposal.

"I feel like a Don Quixote, tilting at windmills, but I really think our county and state planners should begin to think about air zoning which may be the ultimate answer to the dangers of air pollution and contamination.

"For example, you're a nonsmoker and you attend a theater which prohibits smoking in the center seats but permits it on the sides of the house. Supposedly, the people in the center don't have to put up with the smoke but to some degree it reaches them anyway. They just get less of it.

Air Zoning

"Air zoning would establish a place where smoke would be permitted, and this concept would have to be worked out after a series of tests, but somewhere in the middle of the valleys, dispersion of pollutants would be more efficient. The area should be one in which the most rapid diffusion takes place or where the effluent will do the least damage."

Air zoning, Read concedes, implies a permit to add pollutants to the atmosphere. The permit would only be issued, he said, where there is reason to believe that the added pollutants will not produce effects undesirable for the community.

"It could be based on an analysis of meteorological conditions and take into account the willingness of the population in some communities to tolerate air contamination to a greater degree than a standard established for the state.

"In order to accomplish such zoning, a pollution source might be given a choice on limitation of the manner and rate at which each pollutant could be emitted, collection or reduction of pollution emission when weather conditions are not favorable, or complete interruption of pollutant emission under emergency conditions.

"The possibility of selecting among alternate restrictions depending on location might permit an estimate of costs in investment and operation that would be required by the various choices."

Problems of air pollution will probably never be solved completely, Read admits, but if political, scientific and technological skills are brought to bear, "we may yet leave our children the blessing of clean air."

Standards

Standards for air pollution tolerance based on their temporary and lasting effects would have to be established, Read further declares.

"These standards would not necessarily be rigid but could in include some margin within which a departure from basic standards could be authorized. This might lead to the creation of giant 'smoking lounges' where higher contamination tolerances would be accepted.

"This is a very difficult problem involving knowledge of the possible sources of pollution, local geographic and weather conditions, chemical changes of pollutants in the atmosphere, the necessity for applying purification methods and many other factors.

Cooperation

"It certainly requires cooperation among the political structure of the community, the consuming general public, the scientific and technological community and the transportation and power industries.

Monterey Peninsula Herald
Saturday, Oct. 9, 1971. 13

SALINAS CALIFORNIAN Monday, September 20, 1971

Air Zoning Urged to Curb Pollution

A San Jose State College meteorologist who has just completed the first in-depth study of wind patterns of Monterey Bay and the Salinas Valley recommends air zoning to control a high air pollution potential.

Robert G. Read, associate professor of meteorology at San Jose State, made the study at the Moss Landing Marine Laboratory between May of 1970 and 1971.

The study released today was made as part of the environmental studies program supported by the Office of Sea Grant Programs, the National Oceanic and Atmospheric Administration, and the U.S. Department of Commerce.

Read made weather observations using evaporimeters, pilot balloons to measure wind currents, a helicopter to gauge temperature and humidity, and wet and dry bulb instruments.

The central focus of the study was the pattern of marine air from Monterey Bay and its influence on local weather systems.

Because of existing wind patterns and temperatures, it is possible that an inversion layer may be present in the area for a large portion of the year, the study concluded.

The effect of this phenomenon is to reduce atmospheric mixing and increase the potential for air pollution — especially in areas closer to the coastline.

Disposal a Problem

Since both Carmel Valley and the Salinas Valley are following the traditional pattern of development in California from the coastline inland, the proper disposal of atmospheric pollutants is a serious problem, Read found.

His study suggests that efforts to be made to locate heavy industry in the Salinas Valley some distance from the coast where the air circulation would promote better diffusion of waste materials.

The area between Soledad and King City, "where conditions are favorable for more ventilation and spreading out in the vertical of the atmospheric waste," was suggested as the best location for heavy industry.

"Air zoning may be the best method for controlling pollution," Read suggests. "Insofar as air pollution is concerned, it is not the land that should be zoned but rather the atmosphere."

Read suggests that air zoning could be accomplished taking into consideration a full analysis of meteorological conditions and the possible willingness of people in certain areas to tolerate a greater degree of air pollution than the standards set for the state would allow.

"A pollution source might be given a choice on limitation of the manner and rate at which each pollutant could be emitted, collection or reduction of pollutant emission when weather conditions are not favorable or complete interruption of pollutant emission under emergency conditions," Read suggested.

Air zoning would also entail the establishment of air pollution tolerance standards which could include a margin within which departures from basic standards could be permitted.

"Smoking Lounges"

The establishment of such an air zoning system with margins of tolerance could then lead to the creation of giant "smoking lounges" where higher concentrations of contaminants could be accepted, Read suggested.

By Bob Lyhne

Photos: Reg McGovern

Excerpts from: "Peninsula Living"
Supplement to PALO ALTO TIMES,
Saturday, January 29, 1972.

Cover Story by: Bob Lyhne
Photos: Reg McGovern

Briny Campus

Beyond the Breakers

The Marine Lab is located in an old sardine cannery, right on the beach at Moss Landing. The building, formerly owned by a privately-endowed research facility, came on the market and was acquired by the state in 1966. Not purchased, mind you. Acquired.

"Somebody from San Francisco State heard about it," Arnal recalled, "and we tried to get the state to buy it. But no. Finally, it was purchased with grants from the National Science Foundation and from the private foundations of the five colleges, and donated to the state." Today, there is a faculty of 15, some part time, from San Francisco, San Jose, Fresno, Hayward and Sacramento state colleges, and a student body of about 120 — primarily graduate students.

"We have a well-rounded program," Arnal went on — he sounds like somebody out of a Cousteau special — with geologists, chemists, a meteorologist — the physical sciences — represented as well as biological sciences.

"Research is very practical — mostly, problems that are brought to us, rather than things people just decide to work on."

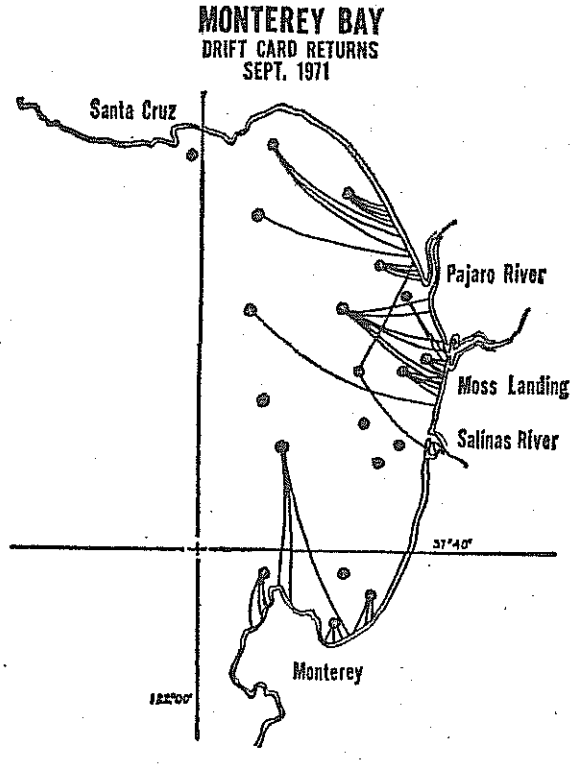
The practical problems often bring grants with them. One is the Sea Grant project, federal money for environmental data collection and training of students in marine science techniques. Another large project is for AMBAG, Association of Monterey Bay Area Governments, part of an extensive study of the bay concerned, among other things, with the location of sewer outfalls. Other work is done for such agencies as the State Department of Fish and Game, and Kaiser Industries. Kaiser, for example, has a refractory brick plant at Moss Landing that produces problematical calcium-rich wastewater.

Dear Finder: Where Am I?

"We do a lot of fairly obvious monitoring," explained William Broenkow, assistant professor of chemistry and oceanography. "But nobody has ever studied the bay this extensively before. We're establishing a base of information. Actually, we don't know what changes have occurred already. This all should have been done 10 years ago."

He described the extensive water sampling program. A boat — it's chartered — occupies various stations in the bay once a month. Up to 12 water samples will be taken at each station (at various depths) and subjected to nine tests. And for a deep station, the product is 108 numbers a month.

"It's really not very exciting work," Broenkow went on. We're not finding anything unexpected. We knew there was a certain amount of pollution, for example. But we're putting numbers to it.



As part of the water sampling work, 600 postcards in plastic bags are dropped into the bay each month, at the various stations. They drift, and the finders are asked to return them. "We're not sure whether it shows currents or not," Broenkow said, "but it shows gross direction of drift. And it's cheap. We get back about 80 cards a month. I think the rest sink. The plastic bags we're using are not too good."

Excerpts from: "Peninsula Living"
Supplement to PALO ALTO TIMES,
Saturday, January 29, 1972.

Cover Story by: Bob Lyhne
Photos: Reg McGovern

Seal and Fish Story: Where Does Fertilization Stop?

Man can most readily identify with the highest forms of marine life — the sea mammals. Studies involving them thus seem to be a particular interest, and because the mammals sometimes compete with man at the top of the food chain, they can even be of political interest.

Studies are going on concerning the diving adaptations of these animals, their dietary habits, reproductive processes and causes of death. The work is based on the study of specimens, mostly beach casts, according to G. Victor Morejohn, professor of biology, although he does have federal and state permits to collect some specimens.

"We've had students making beach runs, assessing the rates of death not only of mammals, but birds, and we've tied this in with weather conditions — fogs, winds, storms at sea, even oil slicks.

"Death causes vary from year to year," Morejohn went on. "Some are from bullet wounds. Some are fishhook fatalities. Some have net marks on them — obviously were caught underwater in nets and drowned.

"We've been coming up with some very interesting rates of death of marine birds from plastic six-pack beer can holders. The birds seem to think they're worms. The bird grabs one end and it flips over the back of the head. Then he struggles and gets a wing in; then he struggles some more, and finally gets a foot in."

The most significant finding of the past two years, Morejohn continued, concerns the relationship of fecal material from sea lions to the surrounding kelp beds. Two of his students have just qualified for their masto-rates working on this subject at Ano Nuevo Point.

"At Ano Nuevo Island, there may be as many at 14,000 seals hauled out of the ocean at a time. Pollution? It has been going on for centuries. Studies by the students showed that the growth of plant life, various planktonic forms, and marine algae, is greatly enhanced.

"For years, sports and commercial fishermen have been going there for the fish. The fishermen are always damning the seals, yet here's a specific case where the fish are there not in spite of the sea lions, but because of them."

The point, of course, is that there is a very fine line drawn between fertilization and pollution. The question is not what, but how much.

A scientific paper on the results will be published within a few months. No recommendations. "I'm not a wildlife manager," Morejohn said. It's up to Fish and Game to make decisions. The pressures on that department, he added, are great, interests ranging from the preservationists — who seem to think all the fishermen should become plumbers — to the fishermen — who think the sea lions are unfair competitors.

Not to speak of the Monterey County Health Department, which last year "came up to have a statement from me on pollution of Monterey Bay by seals."

Morejohn also has been doing work on the foetuses of gray whales, having obtained 13 of them when the Federal Bureau of Fisheries took some specimens over a period of years. "I believe we're the only ones in the world to have the complete skeletons of baby gray whales."

He has also done a study on waterflow patterns over the bodies of gray whales as they swim — based on the orientation of their barnacles. "No such study has ever been done on any kind of whale before."

And one of his students is completing a study of the anatomy of gray whale barnacles — a species that grows on the grays and nowhere else.

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Photos: Reg McGovern

The joint effort of five state colleges, Moss Landing Marine Laboratories is rapidly making its mark in the scientific world.

The horseneck clam has been studied for Fish and Game. "This is the most common large clam dug in Elkhorn Slough," explained James W. Nybakken, associate professor of biological sciences, "and we had to find out how the population was doing." (Elkhorn Slough is a waterway that enters the bay at Moss Landing.) "We've tried to determine when they reproduce, and how fast they grow. They seem to reproduce all year round, and they grow very fast indeed — a quarter millimeter a day in shell length. These two factors in combination probably explain how they sustain the fishing pressure."

The horseneck clam study will continue through 1972. Meanwhile, Nybakken said, another study is about to start on the Pismo clam. "This will be for the Corps of Engineers. They do a lot of dredging around here, and they're concerned about what dredging does."

Still another project, he went on, is a study of the benthic, or bottom, organisms in the northern part of Monterey Bay. "This is to see what's there, so that if something starts to happen, we'll be able to recognize it. The way it is right now, you could dump all the pollution in the world in there, and we couldn't prove any damage, because we don't know what was there to start with."

Nybakken here touched on what doubtless will be the greatest product of the Marine Labs' efforts: the establishment of a solid, statistical basis of information, a profile, of Monterey Bay.

Basic information on phytoplankton — microscopic plants — and zooplankton — the tiny animals that feed on them, is being collected under the supervision of Dr. Mary Silver, assistant professor of marine biology.

"They're the base of the food chain for all open-ocean communities. They support all oceanic life," she explained. "So if you want to know how much food is available to fish, you start by learning how much food is fixed by phytoplankton. We're really just starting, finding out how much is there in terms of plant material, how fast they grow, how much energy is available to the food chain, and what species there are. River and sewage discharges are being monitored, to determine their effect."

Next month, an experimental program of air surveys of plankton may be started. "I don't think it has been tried, over a period of time, any place in the world."

Man is forever changing his environment, and often it is unwittingly for the worse. With increasing urbanization coastal trees tend to be cut —and the result may be denser fogs.

A project just being started under the supervision of Robert G. Read, associate professor of meteorology, attempts to measure fog drip for the first time — by collecting the moisture on an instrument homemade of screen (many of the instruments must be invented and made in a shop at the Marine Lab).

"We think that two to three times as much water reaches the ground from fog drip as from rainfall," Read said. A whole ecology seems to be based on it. What we're doing is a pre-urbanization study. We think there will be more fog after the trees are cut. The Japanese have planted trees on Hokkaido to see if they will reduce fog."

REGIONAL ADVISORY COMMITTEE

R. E. Arnal and L. C. Leopold

A meeting of the Regional Advisory Committee for the Sea Grant Project was held at the Moss Landing Marine Laboratories to inform leading citizens of the nature of the project and invite their comments as to appropriate investigations to be conducted in the future.

Attached is a copy of the membership of that committee. Each person received a copy of the letter attached explaining the purpose of the meeting and the proposed meeting time.

From the reaction of the participants at the end of the afternoon, the meeting was a real success and very informative.

As a follow up to the meeting, a questionnaire (copy attached) was sent to the membership of the committee. The summary of their comments is detailed in the first issue of our Newsletter.

REGIONAL ADVISORY COMMITTEE MEMBERSHIP

Dr. Lester H. Lange, Dean
School of Natural Sciences and Mathematics
San Jose State College

Dr. John Hensill, Dean
School of Natural Sciences
San Francisco State College

Dr. Donald Fletcher
Associate Dean for Biological Science
School of Natural Sciences
San Francisco State College

Dr. Burke Zane, Acting Dean
School of Natural Sciences
Fresno State College

Dr. Leon Fisher, Dean
School of Natural Sciences
California State College, Hayward

Dr. John Livingston, Acting Dean
School of Arts and Sciences
Sacramento State College

Mrs. Ruth Andresen
Chairman, Board of Education
Salinas, California

Mr. H. Gary Greene
United States Geological Survey
Menlo Park, California

Mr. Welday, Marine Geologist
California Division of Mines and Geology
San Francisco, California

Mr. Malvern Gilmartin
Hopkins Marine Station of Stanford University
Pacific Grove, California

Mr. Paul Wilde
California State Department of Fish and Game
Monterey, California

Dr. Fred Schierer
Professor of Biology
Cabrillo Junior College

Capt. USN (Ret) Sidney Brooks
Council on Monterey Bay
Monterey, California

Mr. Walter Wong, Director
Monterey County Department of Public Health
Salinas, California

Mr. Richard Parrish
California State Department of Fish and Game
Monterey, California

Dr. James Heath
Chairman of Moss Landing Marine Laboratories Governing Board
San Jose State College

Dr. Mary Silver, Professor
Moss Landing Marine Laboratories

Dr. William Broenkow, Professor
Moss Landing Marine Laboratories

Dr. James Nybakken, Professor
Moss Landing Marine Laboratories

Dr. G. Victor Morejohn, Professor
Moss Landing Marine Laboratories

Mr. Pat Clark
Student Representative to Governing Board
Moss Landing Marine Laboratories

Mr. Eric Dittmer
Sea Grant Research Assistant
Moss Landing Marine Laboratories

Mr. Larry Leopold
Sea Grant Research Assistant
Moss Landing Marine Laboratories

Moss Landing Marine Laboratories of the
CALIFORNIA STATE COLLEGES at Fresno, Hayward, Sacramento, San Francisco, San Jose
P.O. Box 223, Moss Landing, California 95039

Environmental Studies, Monterey Bay Region
National Sea Grant Program

You are cordially invited to attend a luncheon and meeting at Moss Landing Marine Laboratories on Tuesday, November 30, 1971, from noon until 3:00 P. M. The purpose of the meeting is two-fold: First, to present to you the accomplished, current, and planned activities of the Sea Grant Program; second, to provide an opportunity for you to inform the Program Director as how best to guide and/or modify the Program to better serve your specific operations and goals.

You are to be the guests of Moss Landing Marine Laboratories for lunch at the Harbor Inn (Highway 1, just north of Elkhorn Slough) from noon until 1:00 P. M. After lunch, the participants will return to the Seminar Room at the Laboratories.

During the first hour of the meeting, Dr. Robert Arnal will present a more complete statement of the three-fold aims of the National Sea Grant Program: Instruction, Research, and Public Informational Services. He will also detail the present plans for future Institution-Community interaction. Following Dr. Arnal, three research personnel, working with-in the Sea Grant Program will briefly describe their present activities. (An abstract of this year's program is provided with this letter as further background material).

The second hour of the meeting is to enable you to respond informally and directly to the presentation with any recommendations you feel would guide the Program towards more effective service of your needs. A follow-up letter, in which you could fully state and formalize your critiqes and suggestions within two to three weeks of the meeting, would be greatly appreciated. The meeting will terminate at 3:00 P. M. Those who might wish to remain after the meeting for further discussions are encouraged to do so at their convenience.

Thank you for your consideration and help in making the Program of greater value to everyone.

Sincerely,

Lawrence C. Leopold
Sea Grant Assistant

R.S.V.P.

ABSTRACT

The Moss Landing Marine Laboratories of the California State Colleges is continuing its coordinated project of education, research, and advisory services for Monterey Bay and for the central Pacific Coastal region, under provisions of the National Sea Grant College and Program Act of 1966.

This program enlists the scientific and technical competencies of five major colleges that constitute the Moss Landing Marine Laboratories consortium. Educational and research functions have been coordinated into an environmental data collection and analysis program. Public services are provided through a bibliographic and data center, and by means of publications keyed to the public interest and need.

A. Education and research: environmental data collection and analysis.
   1. Biological, chemical, geological, and physical data are being collected from four major environmental subdivisions:
      a. Sea-air-land zones of contact.
      b. Shallow coastal embayment: Elkhorn Slough.
      c. Rivers and estuaries: Pajaro and Salinas Rivers.
      d. Shallow waters of Monterey Bay and head of Monterey Submarine Canyon.
   2. This program serves simultaneously the oceanic data needs of the surrounding communities and the educational needs of students at three levels:
      a. Graduate marine science students acting as teaching assistants responsible for data collection in one of the above environmental areas, or as research assistants for pilot research projects.
      b. Science teachers receiving practical field experience through summer or weekend participation in the data collection and analysis program.
      c. Upper division undergraduate marine science students engaged in a year-long field experience and research participation program under the direct supervision of the graduate teaching assistants.
   3. Pilot research programs have been chosen for their potential either to stimulate future sustained research by private industry and governmental agencies or to explore areas of significant resource development presently outside the scope of local public or private enterprise:
      a. Effects of marine air penetration on climate of the Salinas and Carmel Valleys;
      b. Hydrography and currents in Elkhorn Slough;
      c. Ecology of the Gaper and Washington clams in Elkhorn Slough;
      d. Seal and bird rookeries of Monterey Bay in relation to the productivity of fishes of economic importance;
      e. Thickness of soft sediments in Elkhorn Slough.

B. Public Information and Interpretation Services
   1. Library reference resources will include a systematic collection or scientific and technical papers and data reports relating to marine resources development. The annotated bibliography developed from these will be updated continually.
   2. Public information services will include a marine sciences newsletter series, progress reports in planning and research, and pertinent current news from science and industry.

Moss Landing Marine Laboratories of the
CALIFORNIA STATE COLLEGES at Fresno, Hayward, Sacramento, San Francisco, San Jose
P.O. Box 223, Moss Landing, California 95039

Environmental Studies, Monterey Bay Region
National Sea Grant Program

December 3, 1971

Thank you very much for spending your time with us on the 30th. As part of the follow-up requested by Dr. Arnal, we are providing you with a few questions to which you may respond. It is hoped your answers will reflect your own areas of expertise as well as a general approach.

1) What areas of our present program should we expand?

2) Are there any areas of interest or investigations that we are not now pursuing which we should?

3) What non-classroom programs should we expand or initiate to better serve the regional needs within the guidelines of the Sea Grant Program?

4) What should the Laboratories' role be as an active member institution of the Monterey Bay Region?

5) Please feel free to make any additional comments or recommendations that may not have been covered by the above questions.