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

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by
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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.

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

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.

(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

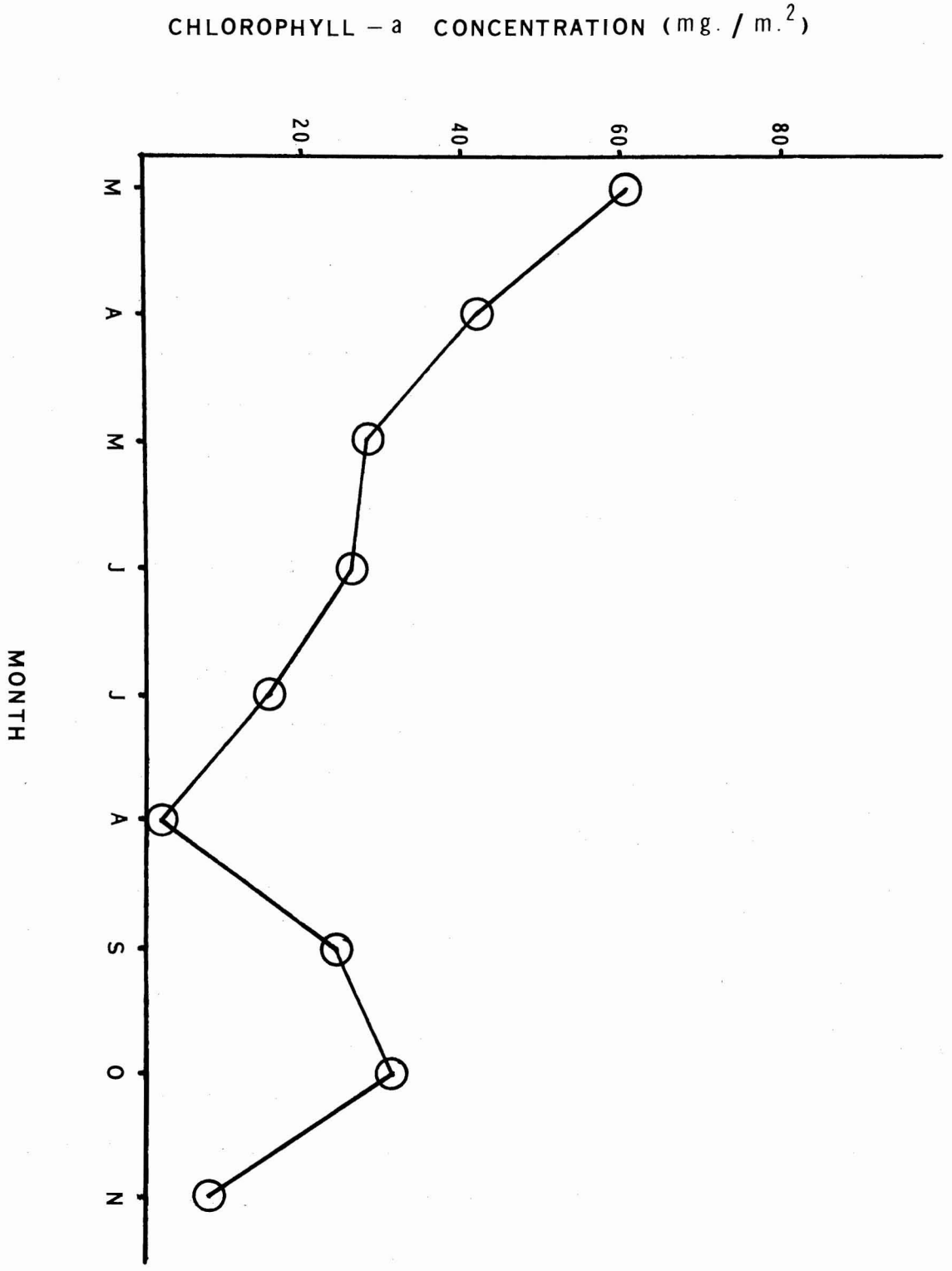

Fig. 1. Chlorophyll a standing stock in the upper 10 m from March to November 1971. Values are averages for all stations.

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.

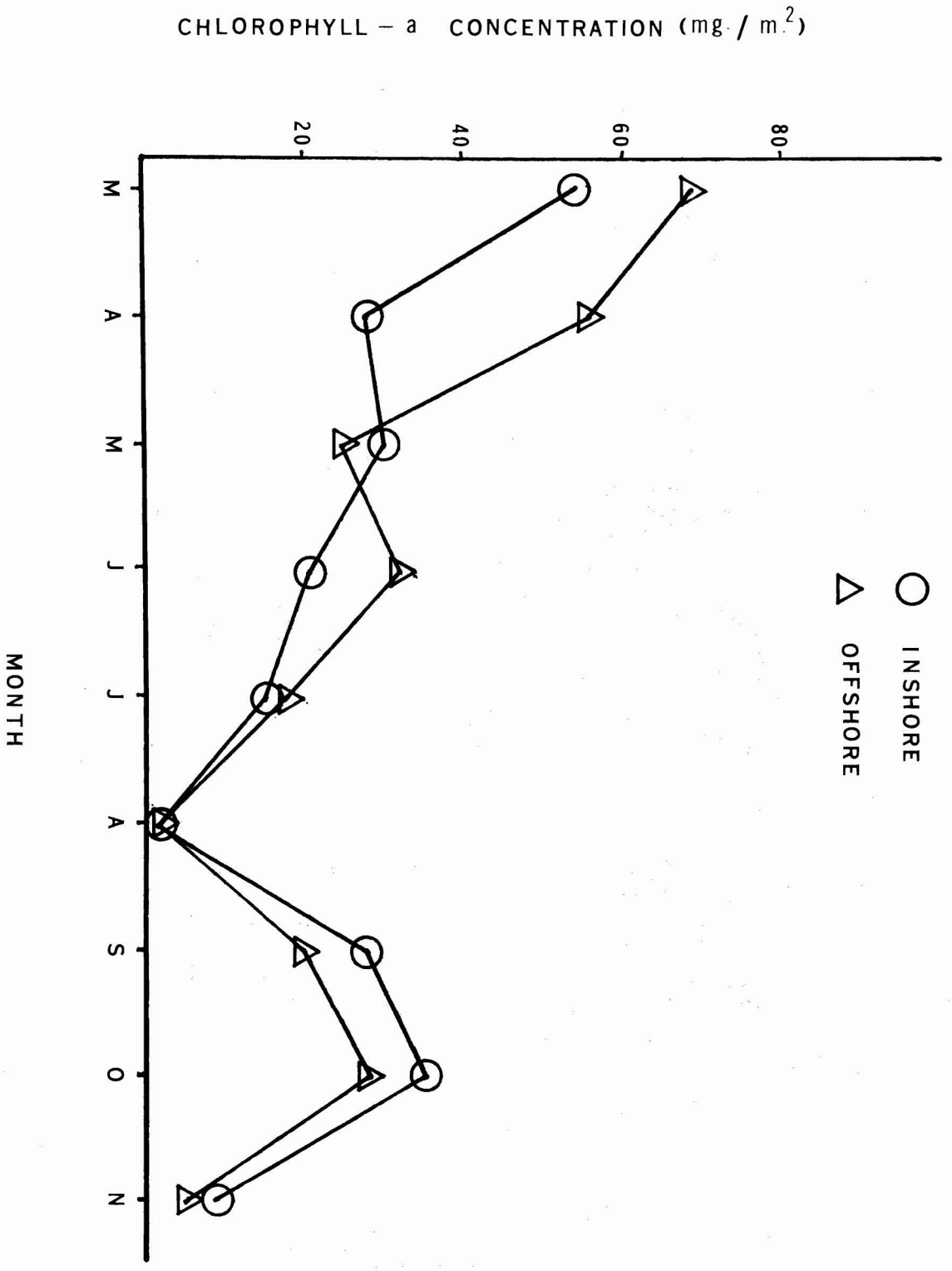

Fig. 3. Chlorophyll a standing stock in the upper 10 m from March to November 1971 at inshore and offshore stations. Inshore stations are stations within two nautical miles of shore, and offshore stations are all other stations. Values are averages for stations.

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 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.

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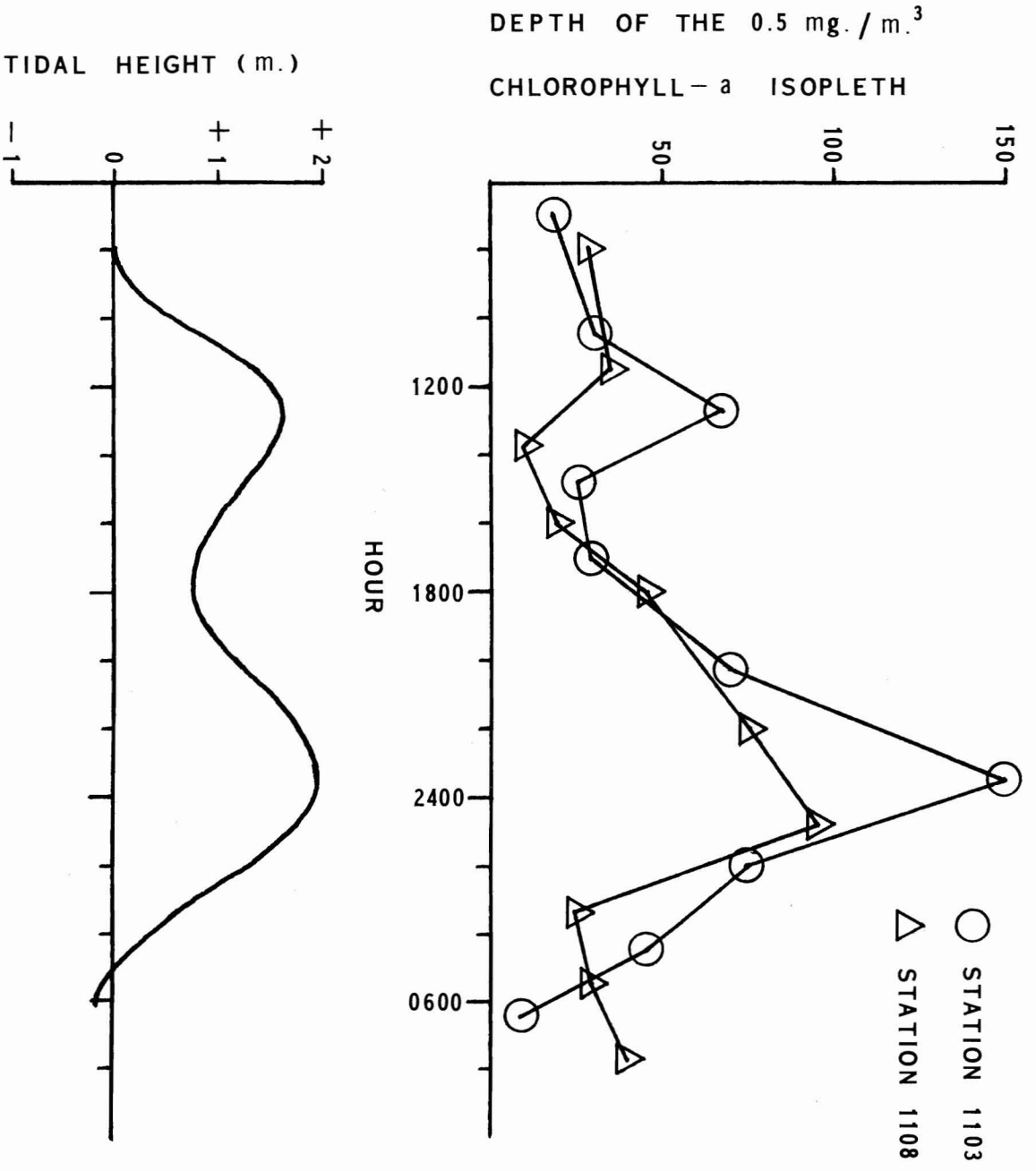

Fig. 6. Depth of the surface phytoplankton populations at two stations over the two tidal cycles. The depth of the 0.5 mg. chlorophyll *a* concentration has been chosen arbitrarily to define the "bottom" of the phytoplankton population.

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.

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

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 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

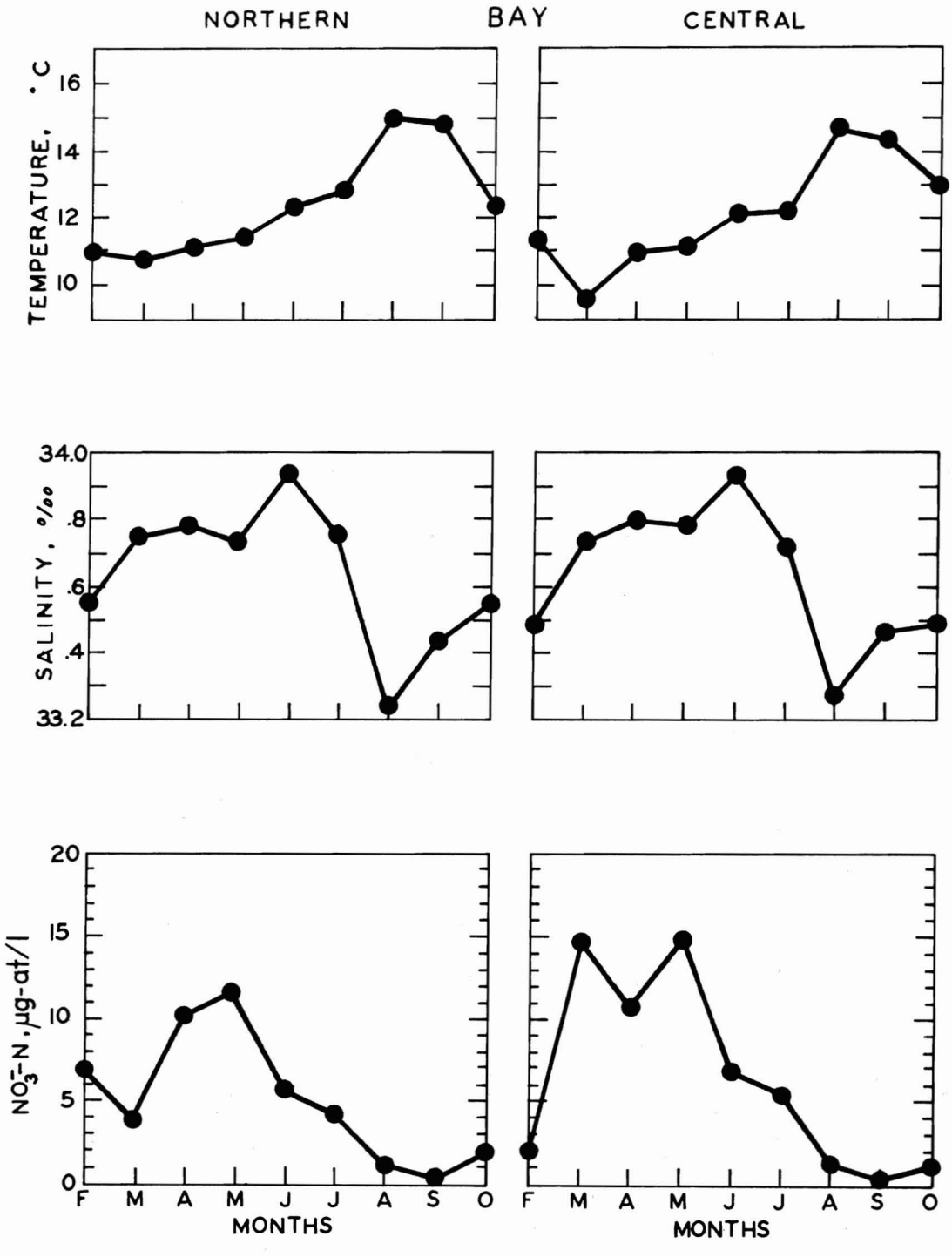

Fig. 8. Seasonal changes in temperature, salinity and nitrate in the upper 10 m in northern Monterey Bay and in the central bay over Monterey Submarine Canyon, 1971.

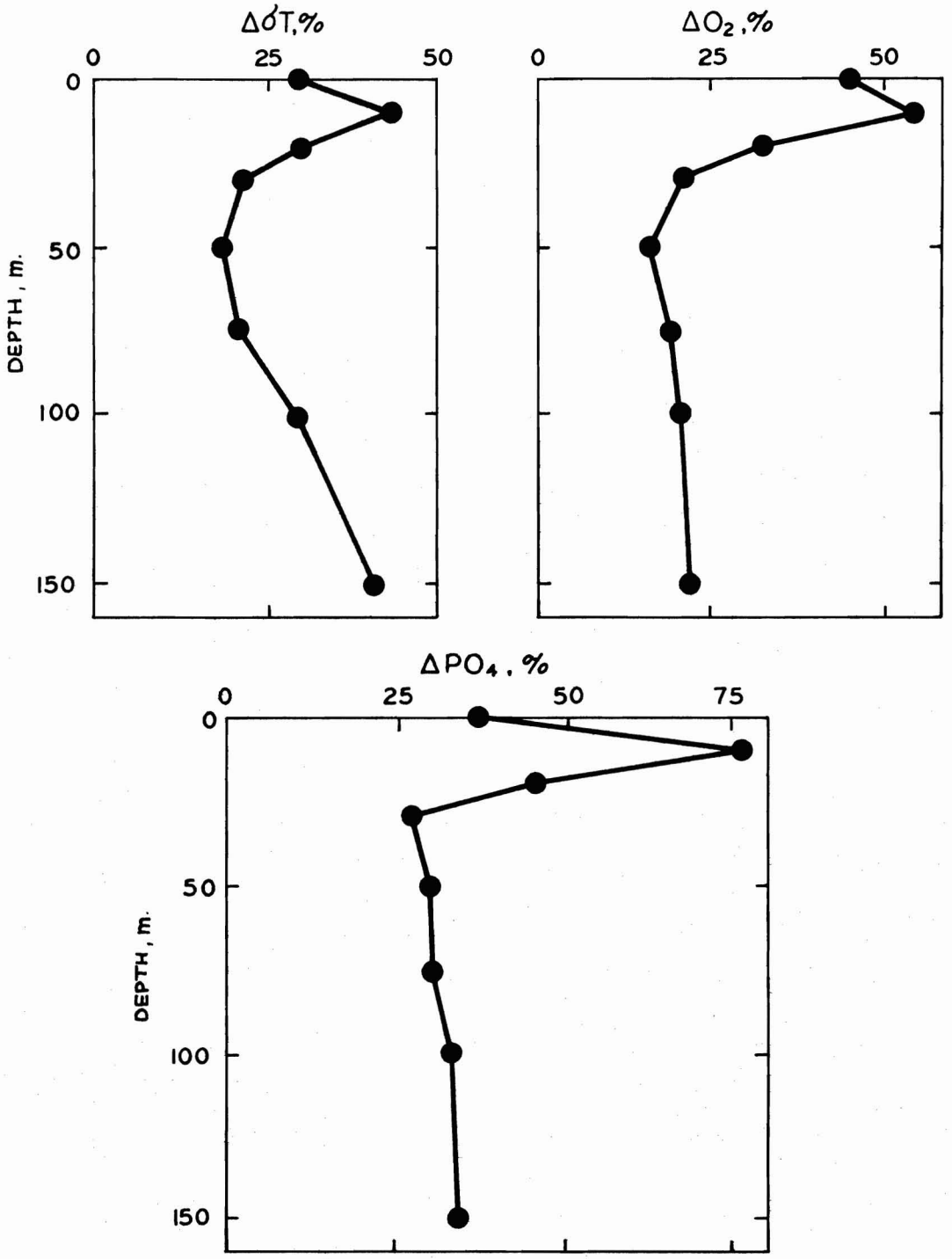

Fig. 9. Percent daily ranges of σ_T, dissolved oxygen and inorganic phosphate relative to their average vertical differences between 0 and 150 m, Station 1108, 7-8 August 1971.

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

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.

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

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.

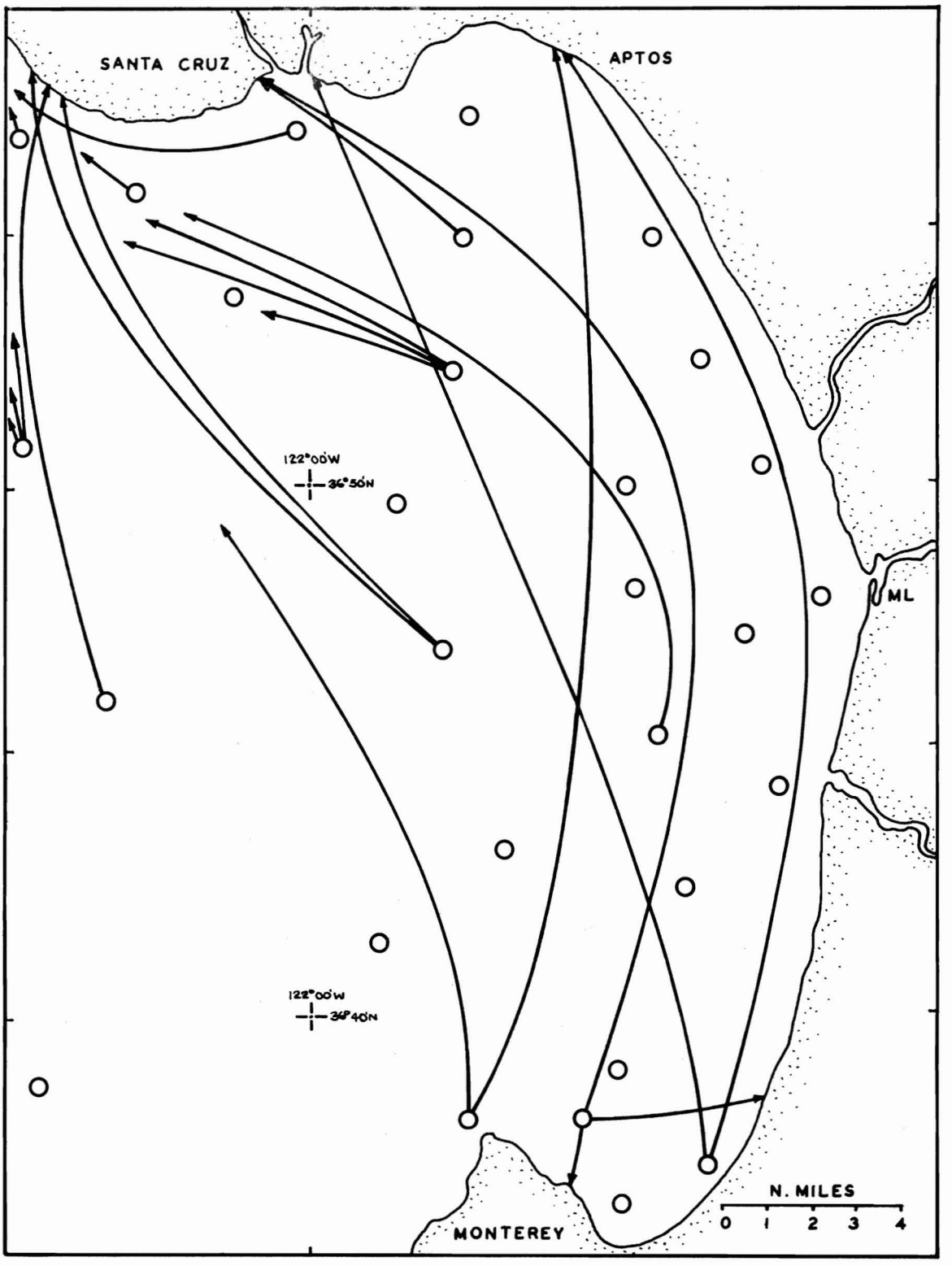

Fig. 14. Drift card returns during the Davidson Current period, December 1971. Release points ○

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.

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^{o} 51.0'	121^{o} 49.8'
1154	36^{o} 55.5'	121^{o} 52.6'
1159	36^{o} 57.1'	121^{o} 56.2'
1158	36^{o} 55.1'	121^{o} 56.7'
1156	36^{o} 53.0'	121^{o} 55.0'
1157	36^{o} 50.2'	121^{o} 50.2'
1153	36^{o} 56.7'	121^{o} 59.2'
1152	36^{o} 54.8'	122^{o} 01.0'
1176	36^{o} 52.3'	121^{o} 59.8'
1177	36^{o} 53.6'	121^{o} 57.5'
1155	36^{o} 50.8'	121^{o} 53.6'

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.

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

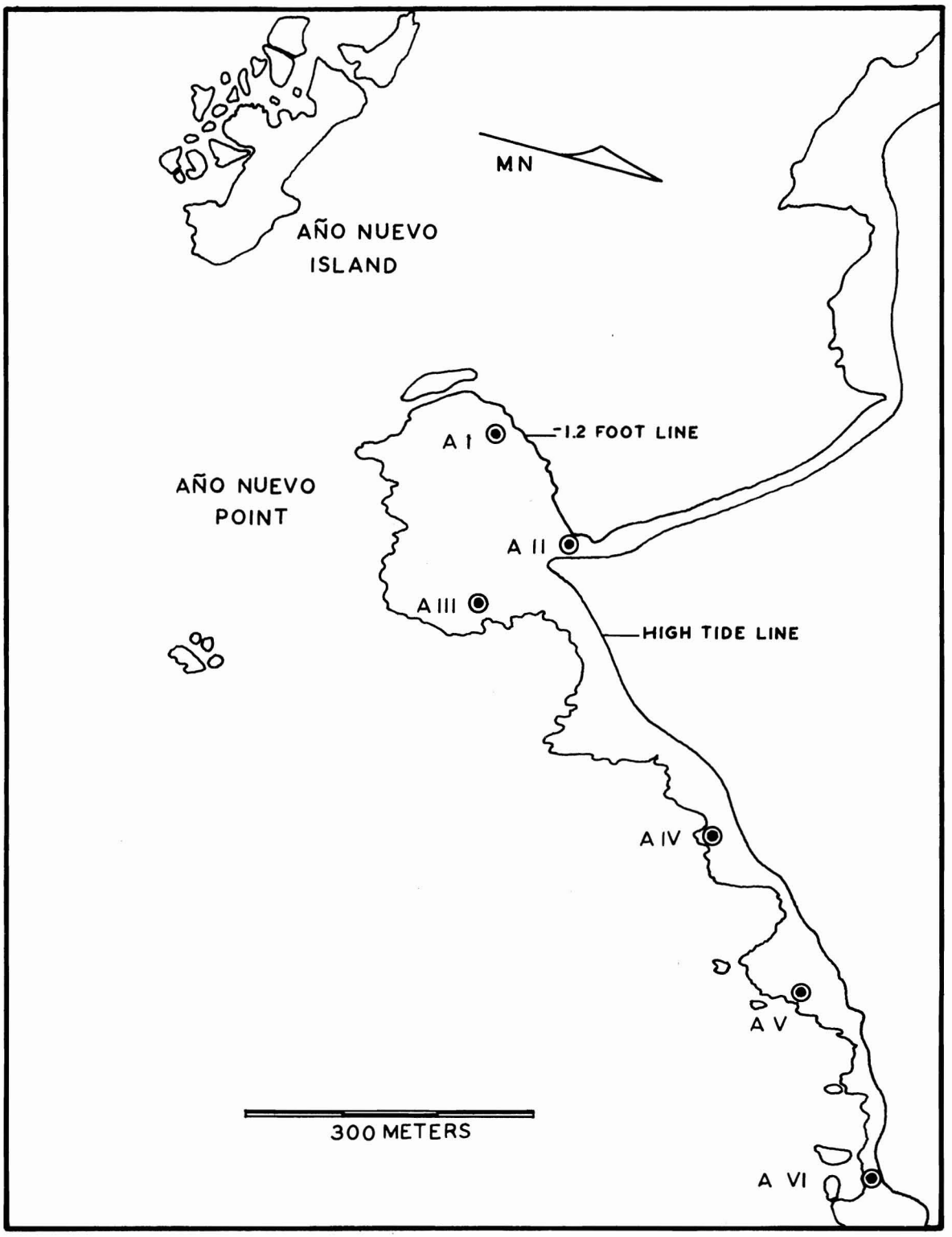

Fig. 16. The six collecting stations along Ano Nuevo Point.

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 (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	

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

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

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.

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).

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

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

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

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.

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.

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

SEP 2 4 1971

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At Moss Landing

Sea research all bottled up

3099

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 studies that must precede the design of sewage outfall, he said.

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

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

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"

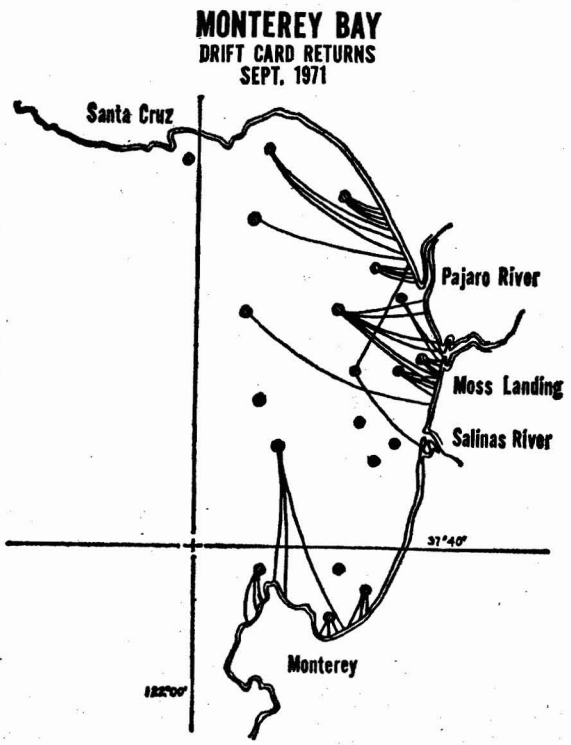
The establishment of such an air zoning system with margins of tolerance could then lead to the creation of giant "smoking lounges" where higher concentrations of contaminants could be accepted, Read suggested.

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

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

Cover story by: Bob Lyhne
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 MEMBERSHIP

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Monterey, California

Dr. Fred Schierer
Professor of Biology
Cabrillo Junior College

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.

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?