Annual Report
1979-80

The Planning and Management of California's Coastal Resources

University of Southern California
Sea Grant Institutional Program

UNIVERSITY OF SOUTHERN CALIFORNIA
Institute for Marine and Coastal Studies
University Park • Los Angeles, California 90007

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Contents

Introduction

This is a report of the University of Southern California's tenth year of participation in the national Sea Grant program. The Sea Grant program, funded by the National Oceanic and Atmospheric Administration, supports marine research, education, and advisory services at several universities in coastal and Great Lakes regions. Sea Grant research is primarily applied research, and USC, like every Sea Grant program, has a commitment to work with representatives of the public and industry to solve marine and coastal problems of importance to the region. The theme of our program and the title of this report, "The Planning and Management of California's Coastal Resources," reflects that commitment.

At USC, Sea Grant researchers can draw on substantial facilities and a long tradition of excellence in marine research. The Sea Grant program is one of several marine programs within the University's Institute for Marine and Coastal Studies, founded in 1975. The Institute administers a marine science center and a conference center on Catalina Island; a major research vessel, the VELERO IV, and other research ships; a Marine and Freshwater Biomedical Center; a Center for Marine Transportation Studies; a research laboratory on the harbor waterfront; and other facilities. Individual academic units at USC, particularly the Allan Hancock Foundation, have been active in marine research since the early 1900s.

As a measure of the emphasis on state and local problem-solving in carrying out the research, each Sea Grant program is required to match the federal grant with half again as much funding from private, state, or local sources. In California, the state government annually provides $500,000 for matching Sea Grant funds, which amount we share with the University of California; and cash or in-kind services which have also been contributed by USC itself, local radio and television stations, a utility company, city and county government agencies, private foundations, and other sources. Their interest makes our work possible and keeps it relevant.

Sea Grant projects have to run a rather extensive course of review before funding is awarded. A technical advisory panel makes recommendations to the program managers; academic peer reviewers comment on the professional quality of the work; a panel of state agency representatives comments on the worth of the projects to the state; and a team of scholars and administrators from

around the country makes an on-site inspection of the entire program. The members of the IMCS Technical Advisory Panel and of the state advisory panel are listed at the end of this report.

Each year the USC Sea Grant program supports one or more projects in each of the following areas: socio-economic systems, living marine resources, non-living marine resources, coastal engineering, marine education, and advisory services. In 1979-80, the USC program supported the following projects:

Heterotrophic Metabolism of Marine Dinoflagellates

Second of three years. The data so far support the hypothesis that these marine organisms can metabolize organic compounds in seawater, such as those generated by urban wastes. The results are significant for understanding water quality generally and for understanding the origins of "red tide" blooms caused by the dinoflagellates.

The Role of Natural Populations of Microheterotrophs in Carbon Cycling in Southern California

Second of two years. The results of this project spotlight the important role of microorganisms in metabolizing complex organic compounds in seawater, such as those from water treatment plants. The results indicate that small particles (less than 1 micrometer) are responsible for more than half of the metabolic uptake in the experiments, that the compounds are taken up rapidly, and that the microorganisms themselves are consumed by larger organisms quite rapidly.

Ecology of a Small Tidal Lagoon Under the Influence of Urban Recreational Use

Second of two years. This study of a tidal lagoon in Long Beach, California, has produced data and computer models concerning the relationships between urban runoff patterns and the organisms growing in the lagoon. The results are significant for the management of this particular lagoon and for understanding other small marine ecosystems heavily affected by urbanization.

Southern California's Nearshore Environment: A Significant Fish Nursery

Second of three years. This project has complemented the well-established sampling work of the California Cooperative Fisheries Investigations further inshore, and it has already revealed interesting features of the distribution of fish larvae in the nearshore environment. Nearshore areas are relatively more productive than areas further offshore, and different ichthyoplankton dominate the nearshore area. The results are significant for understanding the effects of marine pollution on the ecosystem and for assessing coastal fishery stocks.

Sediment Accumulation and the History of Pollutant Accumulation in San Francisco Bay

Second of two years. Pollutants entering the sea may become attached to suspended particles and eventually buried in sediments after the particles settle. This pathway was studied in San Francisco Bay using naturally occurring radioactive tracers as pollutant analogs. These results suggest that pollutants take approximately a day to attach to suspended particles, that particles settle to the bottom in eight to eleven days, and that particles may be resuspended ten to twenty times before they are deeply buried. Thus, pollutants may be rapidly transferred to the sediments but remain available for resuspension for several decades.

Offshore Sand and Gravel Resources, Orange County, California

One year. Two areas off of Orange County, California, were examined for potential sand and gravel deposits. The first segment, offshore from Huntington Beach, contains two possible sand and gravel sites. The first contains material suitable for aggregate purposes. The second site contains material suitable for use in beach replenishment. The other general area, between Dana Point and San Mateo Point, does not appear to have deposits suitable for either purpose.

The Port Authority as a Public Enterprise

First of two years. This project is an analysis of how ports respond to the conflicting pressures on them to both generate revenue, like a private firm, and to act in the public interest, like a public agency. Particular emphasis is placed on the administrative structures chosen by the ports as modes of coping with these problems. The research to date has established an analytic framework based on a side-by-side study of Los Angeles and Long Beach Harbors.

Problems of Harbor Modeling

Second of two years. This project completed improvements upon earlier models of how a harbor responds to wave and tidal motions. In particular, the project developed equations and computer models that include nonlinear effects and dissipative effects that occur at resonance frequencies. Previous models had overestimated the wave amplitudes by not including such factors.

Program Development

Continuing. During every year some projects are initiated apart from the regular funding cycle, for various practical reasons, at the director's discretion. During 1979-80 these projects included a demographic study of the Pacific Islands, a

study of wave behavior in steep channels, and a study of using egg production in marine worms as a pollution indicator.

Marine Education and Training

Continuing. The education program developed curriculum materials for K-12 teachers, assisted public schools in actual classroom work, conducted marine education programs for several groups outside the school system, and continued the Sea Grant Trainee Program. Highlights included beach trips and classwork for visually impaired students, initiation of marine education efforts in several Latin American countries, and completion of the translation of the curricular materials into Spanish for bilingual classrooms.

In a separate project, curriculum materials were developed for a series of courses at the graduate level on port and harbor management, and the first course in the series was taught in the spring semester of 1980.

The Graduate Student Trainee Program provides financial support for selected graduate students to work on Sea Grant funded projects related to their dissertations.

Marine Advisory Services

Continuing. The advisory services program has as its job maintaining a two-way liaison between marine researchers and marine resource users. Highlights of the work for 1979-80 included a booklet and flow chart describing the coastal permitting process in California, a documentary film on a beach cleanup effort, a conference on marine energy sources, and assistance to several faculty research projects.

1979-80 Budget Summary

	Sea Grant Funds	State/Local Match
Socioeconomic Program		
The Port Authority as a Public Enterprise (R/CM-12)	19,886	16,154
Living Marine Resources Program		
Heterotrophic Metabolism of Marine Dinoflagellates (R/EQ-18)	32,460	18,300
The Role of Natural Populations of Microheterotrophs in Carbon Cycling in Southern California Coastal Waters (R/EQ-19)	27,745	21,000
Ecology of a Small Tidal Lagoon Under the Influence of Urban Recreational Use (R/EQ-20)	17,005	11,965
Southern California's Nearshore Environment: A Significant Fish Nursery (R/RD-6)	55,087	130,198
Non-Living Marine Resources Program		
Sediment Accumulation and the History of Pollutant Accumulation in San Francisco Bay (R/EQ-22)	23,793	11,967
Offshore Sand and Gravel Resources, Orange County, California (R/RD-9)	15,749	44,982
Coastal Engineering Program		
Problems of Harbor Modelling (R/CE-4)	33,162	22,481
Program Development	18,000	10,000

1979-80 Budget Summary (continued)

	Sea Grant Funds	State/Local Match
Marine Education and Training		
Marine Education in California (E/E-1)	58,517	20,494
Sea Grant Graduate Student Trainee Program (E/M-1)	57,500	5,000
Evaluation of a Master's of Public Administration Curriculum Specialization in Port/Harbor Management (E/CD-2)	35,820	20,275
Marine Advisory Services	102,266	133,833
Program Management	78,010	66,546
TOTAL	$575,000	$533,195

Heterotrophic Metabolism of Marine Dinoflagellates

Bernard C. Abbott, Chairman and Professor, Biological Sciences
Maria R. Ross, Hancock Fellow, Allan Hancock Foundation

Introduction

The accepted view of sincere conservationists has been that effluent other than natural runoff is potentially damaging to the marine ecosystem and must therefore be eliminated. We believe that not all waste materials are harmful and that if these are discharged under supervised conditions they can enhance the natural resources.

Abbott et al.(1976) had shown that in the presence of the nutrient waste materials from local fisheries in the Los Angeles-Long Beach Harbor the levels of standing crops of dinoflagellates, zooplankton, and ichthyoplankton were enriched above the corresponding open coastal waters.

Dinoflagellates are a common cause of phytoplankton blooms in enriched areas. The majority of blooms observed in the Los Angeles-Long Beach Harbor are often below the visible discoloration level and are evidenced only by taking cell counts or oxygen measurements of water samples. These blooms have been predominated by some one species of dinoflagellates. While the causes of dinoflagellate blooms leading to red tide outbreaks are not sufficiently clear, among the more important factors seems to be nutrient enrichment in the sea.

Though the dinoflagellates are primarily autotrophic in their metabolism, and derive most of their energy for metabolic processes photosynthetically from sunlight, many are known to be heterotrophic; yet, research concerning causes of blooms has only focused on inorganic nutrients and/or physical conditions. Consideration of these factors alone has proven insufficient to explain these blooms. We therefore proposed to investigate organic compounds as an additional important factor for the growth of dinoflagellates, because these organisms form an important component in the productivity of the ocean. As Lasker (1975) showed, bloom conditions in coastal waters are essential to the successful survival of fish larvae.

To assess metabolic activities of the marine dinoflagellates in their natural habitat is difficult. The chemistry of the sea is complex, and the occurrence and cycling of organic matter in sea water is still an unsolved puzzle. It is imperative that we study the heterotrophic metabolism of the marine dinoflagellates in the laboratory as axenic cultures and learn of their capabilities to exist under various conditions which may or may not simulate precisely their marine environment. We will test our hypothesis that

some of the nutrient cannery effluent materials are utilized by the organisms which produce blooms. By use of radioactively labeled substrates we shall examine the effectiveness of the dinoflagellate heterotrophic capabilities under conditions of illumination such that photosynthesis is proceeding and also in the dark where incorporation responds to different conditions.

We realize that it is probable that much of the organic material as well as dead test detritus is processed through bacteria present in harbor waters. While recognizing the important role played by the bacteria, we are deliberately emphasizing the study of the dinoflagellate heterotrophy. We believe that these organisms are capable of utilizing the nutrient organic compounds of the harbor waters. Evidence from culture studies indicates strongly that certain vitamins and organic substances have to be added in order to maintain successful axenic cultures of many phytoplankton. Not only was this demonstrated by Provasolli (1963) and Provasolli and McLaughlin (1963), it was reconfirmed at the ASLO conference by Herold and Sullivan (1980) with vitamin B12 uptake studies. And in fact some recent work from two schools, Wheeler et al. (1977) in Grover Stevens Laboratory and Khailov et al. (1978) from the Ukrainian Academy of Sciences, USSR, suggest strongly that the uptake of organic materials may be greater in the phytoplankton than in small bacteria.

Our study is concerned with the utilization of dissolved organic material in sea water derived from urban runoff and effluent wastes. More specifically, our studies are concerned with the basic question of dinoflagellate heterotrophy. Are marine dinoflagellates able to switch from autotrophic to heterotrophic metabolism when challenged with organic substrates?

When organisms are challenged with substrates they will utilize them immediately, adapt to the challenging condition, and after a lag period take up the substrates, or not utilize them at all because of the absence of necessary enzymatic pathways. Positive results will open up a whole world of investigations.

The overall goals of the project are being pursued at present. The study of heterotrophic metabolism and the kinetics of incorporation of amino acids is now in progress with all three experimental species, as well as the incorporation of carbohydrates and fatty acids.

Methods and Materials

The experimental organisms, *Gonyaulax polyedra*, *Scrippsiella trochoidea* , *Gymnodinium soupninium*, were isolated from bloom conditions in Los Angeles-Long Beach Harbor by Morey-Gaines (1976). Each was identified as the dominant species of the particular bloom condition. The unialgal cultures were made axenic by antibiotic treatment (Droop, 1967) as modified by Ross (1979). The axenic unialgal cultures are maintained in our laboratory and are continuously

monitored for bacterial contamination. The incubation temperature was 18° which simulates in situ conditions (Morey-Gaines, 1976). Sea water enriched with F/2 metals and vitamins is used as the growth medium (Guillard and Ryther, 1962). Cultures for the experiments are used 18 hours after inoculation (young culture). Total volume for experimental cultures is 25 milliliters. Labeled substrates used are 4,5 ^{3}H-leucine and ^{14}C-phenylalanine which are added to the cultures at a final concentration of 2.15 x 10^{-7}M; 0.1 µci/ml of medium; specific activity 460 µci/µmole.

Time of incubation and illumination conditions are varied for the three species of dinoflagellates.

One-milliliter samples are removed for cell counting with a Coulter Counter Model B-100µ window (Richar & Breakell, 1959), for protein determination (Lowry, et al., 1951) using bovine serum albumin as a standard and for incorporation measurement (Byfield & Scherbaum, 1966) as modified by Ross (1970) on Whatman glass fiber (GF/A) filters to be counted in a Beckman scintillation counter model LS 100, using the external standard ratio method.

Results are expressed as cpm/cell as a function of incubation time in hours.

Results

This progress report will deal with (1) the effect of antibiotic treatment on the experimental organisms; and (2) incorporation of the amino acids phenylalanine and leucine by the red tide dinoflagellate *Scrippsiella trochoidea*.

1. Effects of antibiotic treatment on the experimental organisms

Although the experimental cultures are axenic and unialgal after treatment with proper antibiotics, there are no reports dealing with the problem of permanent alteration, if any, of the dinoflagellates. Droop (1967) alludes to the fact that algal cells exposed to antibiotics may be altered. The effects of antibiotics on the growth studies with *Gonyaulax polyedra*, *Gymnodinium sanguinium*, and *Scrippsiella trochoidea* nontreated (Figures 1a, 2a, and 3a) and antibiotic treated (Figures 1b, 2b, and 3b), respectively, are represented. Unfortunately, the starting number of cells in both experiments cannot be made more equal. The larger number of cells per milliliter in the antibiotic treated cultures is necessary. When a study of the effects of antibiotics on the dinoflagellate species is initiated, one of the hazards encountered is the nonsurvival of the experimental organisms due to the antibiotic treatment as shown in Table II and Table III. In order to determine which antibiotics would be effective in eliminating the bacterial symbionts normally present in cultures isolated from oceanic sea water samples, the isolation, identification, and sensitivity to antibiotics of the bacterial species was a most important study to be completed (Table I). From the results obtained, we were able to proceed with the

specific antibiotic treatment of each of the experimental dinoflagellate unialgal species. To be completely certain that our cultures are axenic and remain axenic after the antibiotics are diluted out to an asymptotic zero level, the sterility tests are performed with nutrient broth at 18°, which is the normal growth incubation temperature and at 30° which accelerates the proliferation of the bacterial contaminant. We have demonstrated that cultures which proved to be bacteria-free when nutrient broth sterility tests incubated at 18° remained clear for many weeks, were shown not to be free of bacterial contamination when a duplicate set of sterility tests were incubated at 30°. Although our cultures are always incubated at 18°, we must be certain that no bacteria are present under any circumstance during growth studies, incorporation studies, and enzyme studies (enzyme extractions and enzyme kinetics). Our data could be altered if bacteria are present. Bacteria can contribute to any and all of the above segments of the study of heterotrophy by the red tide dinoflagellates. From growth studies of the dinoflagellates at 18° and 30°, our results clearly show no growth at 30°; however, this does not relieve us of the necessity and obligation to prove that our cultures are bacteria-free at any temperature. We have, therefore, adopted the regime of testing for bacterial contamination at both temperatures and when the sterility tests at 18° as well as those at 30° remain clear indefinitely, those cultures are claimed to be axenic.

2. Incorporation of amino acids phenylalanine and leucine by *Scrippsiella trochoidea*

The incorporation of two amino acids, phenylalanine and leucine, by *Scrippsiella trochoidea* was examined. Phenylalanine was examined because it is directly incorporated into protein; it equilibrates rapidly with the intracellular pool and is not converted to other amino acids (Morgan, et al., 1971). Leucine, while it is readily incorporated for protein synthesis, is also readily metabolized into other fractions of the cell. We have only measured that portion which is incorporated into the TCA precipitable and ether-ethanol insoluble fractions. The experiments were carried out at varied illuminating conditions--constant illumination, constant dark incubation, and light-dark cycles of 3 hr duration. The experimental cultures (Table IV) consisted of:

1. Control non-treated cells
2. Cultures with antibiotics present during incorporation
3. Axenic cultures after antibiotic dilution to asymptotic zero concentration

The results of the incorporation of ^{3}H-leucine are summarized in Table V (Figures 4a and 4b) and of ^{14}C-phenylalanine in Table VI(Figures 5a and 5b).

From the data obtained under all illuminating conditions, our hypothesis of dinoflagellate heterotrophy is again confirmed. The results with *S. trochoidea* for ^{3}H-leucine incorporation (Figures 4a and 4b) and for ^{14}C-phenylalanine (Figures 5a and 5b) suggest that the cultures incorporate the amino acids to a much lesser degree in the presence of the antibiotics ampicillin and gentamicin, irrespective of illuminating conditions. This indeed is in agreement with the fact that bacterial cell wall protein synthesis is inhibited by these antibiotics. When the experimental cultures are completely axenic and the antibiotics are at zero concentrations, the incorporation of the amino acids resumes at a higher rate. This is an indication that perhaps the inhibition observed with the antibiotics present may be temporary since it is relieved when the antibiotic concentration is diluted to zero. Although ampicillin is known to be specific against bacterial systems, only the gentamicin may affect both the bacterial cells and dinoflagellate cells. The incorporation with the nontreated cultures is always higher, as expected, because both bacterial and dinoflagellate incorporations are additive.

The data so far support our original hypothesis of heterotrophic metabolism by the red tide dinoflagellates *G. polyedra*, *G. sanguinium*, *S. trochoidea*. We have further shown the effects of antibiotics on the incorporation of amino acids--protein synthesis--in the experimental organism *S. trochoidea* which also support the original hypothesis. Due to the results from the antibiotic studies we have adopted more stringent criteria for axenicity of our experimental cultures.

Specific benefits derived from this project are numerous. The disposal of biological waste material both from food processing plants and from sewage plants presents a major problem for all cities and for all developing countries. Methods of handling waste materials must be studied intensively and extensively. It is imperative that systems of waste disposal be studied. We believe that controlled discharge of organic wastes can be handled by receiving ocean waters to give bioenhancement and to increase the regional productivity. In our local situation, the value of nutrient waste from the fish canneries is a specific target for evaluation.

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Project Communications

1. A paper entitled "Heterotrophic Metabolism of the Marine Red Tide Dinoflagellates," was presented at the American Society of Limnology and Oceanography meetings February 1980, at the University of Southern California, Los Angeles.

2. A paper entitled "Incorporation of ^{3}H-leucine and ^{14}C-phenylalanine by the Red Tide Dinoflagellates Gonyaulax polyedra, Scrippsiella trochoidea, Gymnodinium sanguinium" is in preparation for publication in the Journal of Limnology and Oceanography.

3. A paper on the effects of antibiotics on the red tide dinoflagellates is in preparation for publication. Credit is given to the University of Southern California Sea Grant program.

4. A paper on "Growth and Reproduction of Scrippsiella trochoidea Cultures Supplemented with Amino Acids" was presented by Laurence Ng, a high school student who is again this year working on our project as part of the CAST program. The program is funded by the National Science Foundation, and Larry's ongoing project is the protein content of S. trochoidea over the cell cycle.

5. A report entitled "Isolation of Marine Dinoflagellates in Pure Cultures" was submitted to USC Sea Grant in 1978.

6. Theses and Dissertations:

   Mohammad Yazdandoust completed his master's thesis on "Dinoflagellates as Food Source for (Cancer anthonyi) the Crab Larvae," in 1979. His doctoral dissertation is in progress, dealing with the efficiency of dinoflagellates as a food source for larval development of the Yellow Rock Crab (C. anthonyi).

   Alexander Andrasi's dissertation project is "Molecular Biology of the Marine Dinoflagellates." A research project was undertaken on cycle regulation and gamete and zygote ultrastructures.

Gonyaulax polyedra

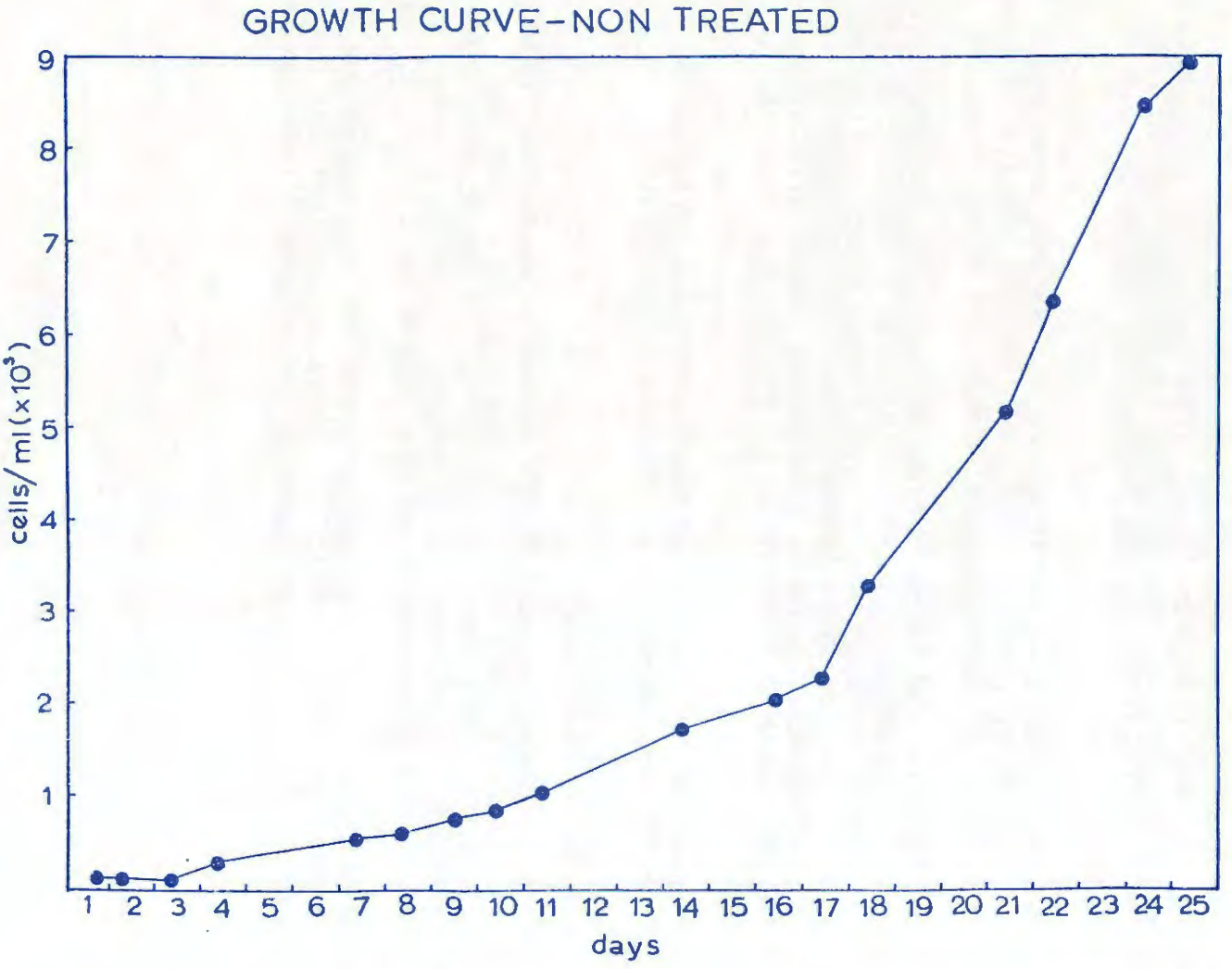


Fig. 1a

Gonyaulax polyedra

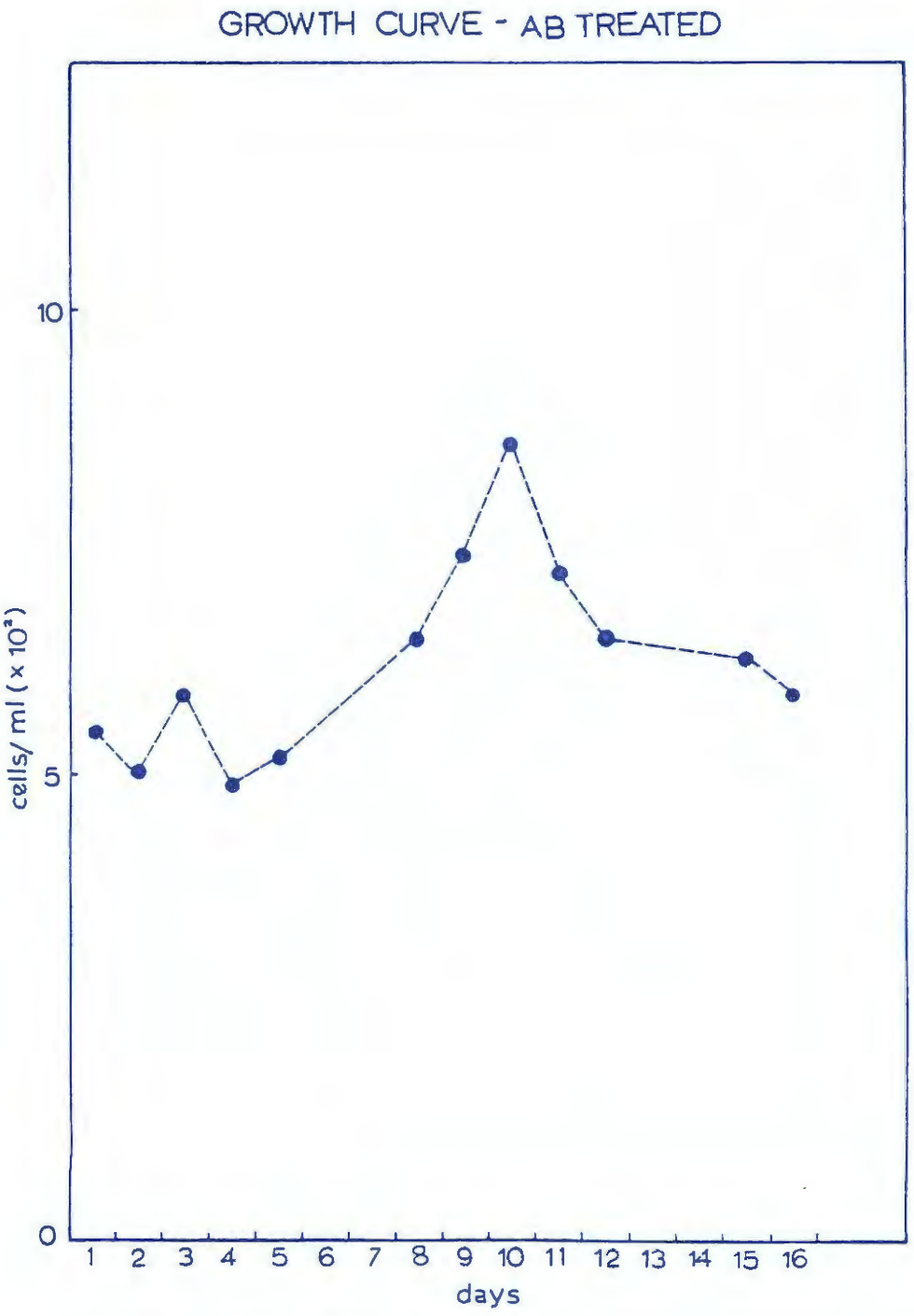


Fig. 1b Antibiotics: Gentamicin-Ampicillin
30 µg/ml each

Gymnodinium sanguinium

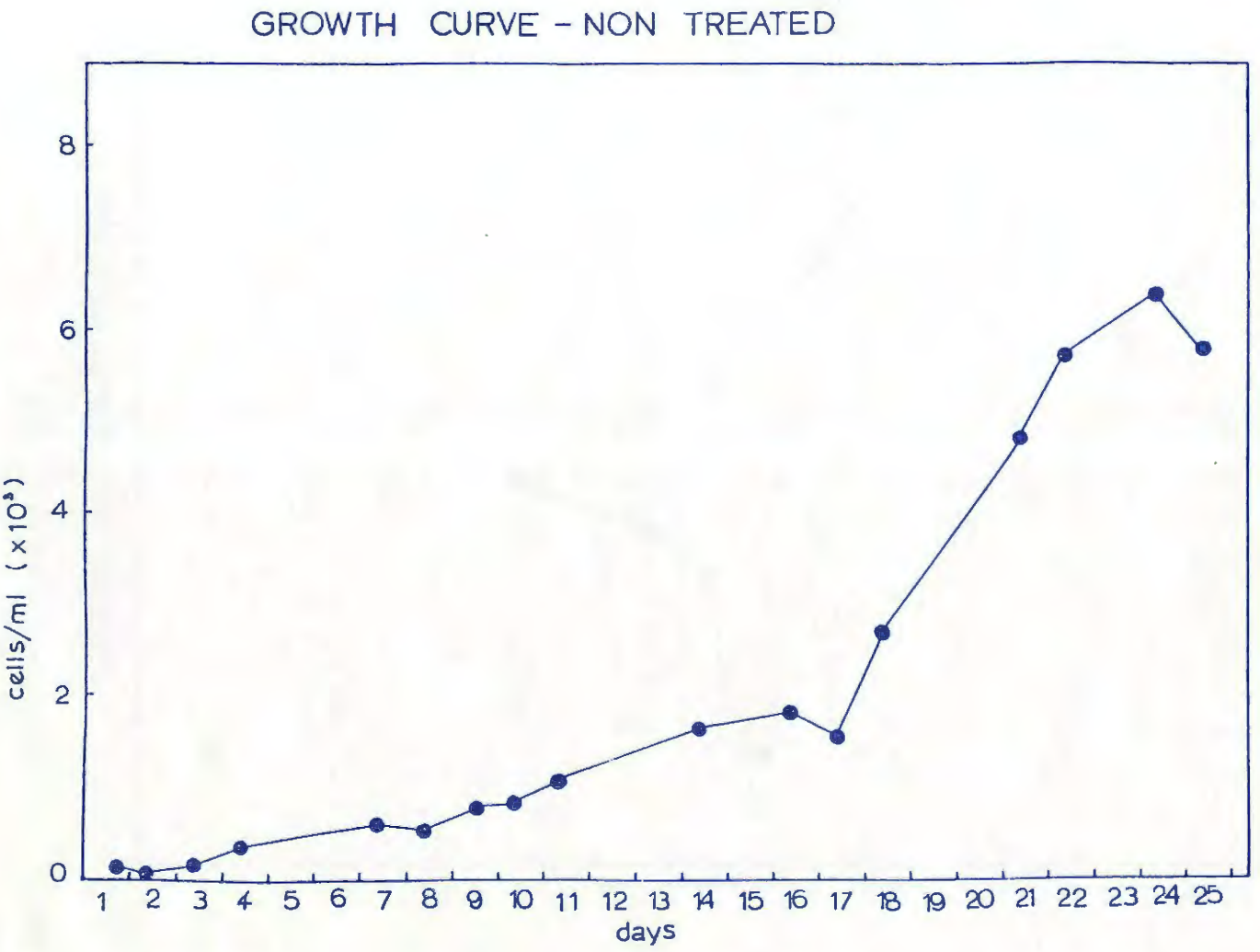


Fig. 2a

Gymnodinium sanguinium

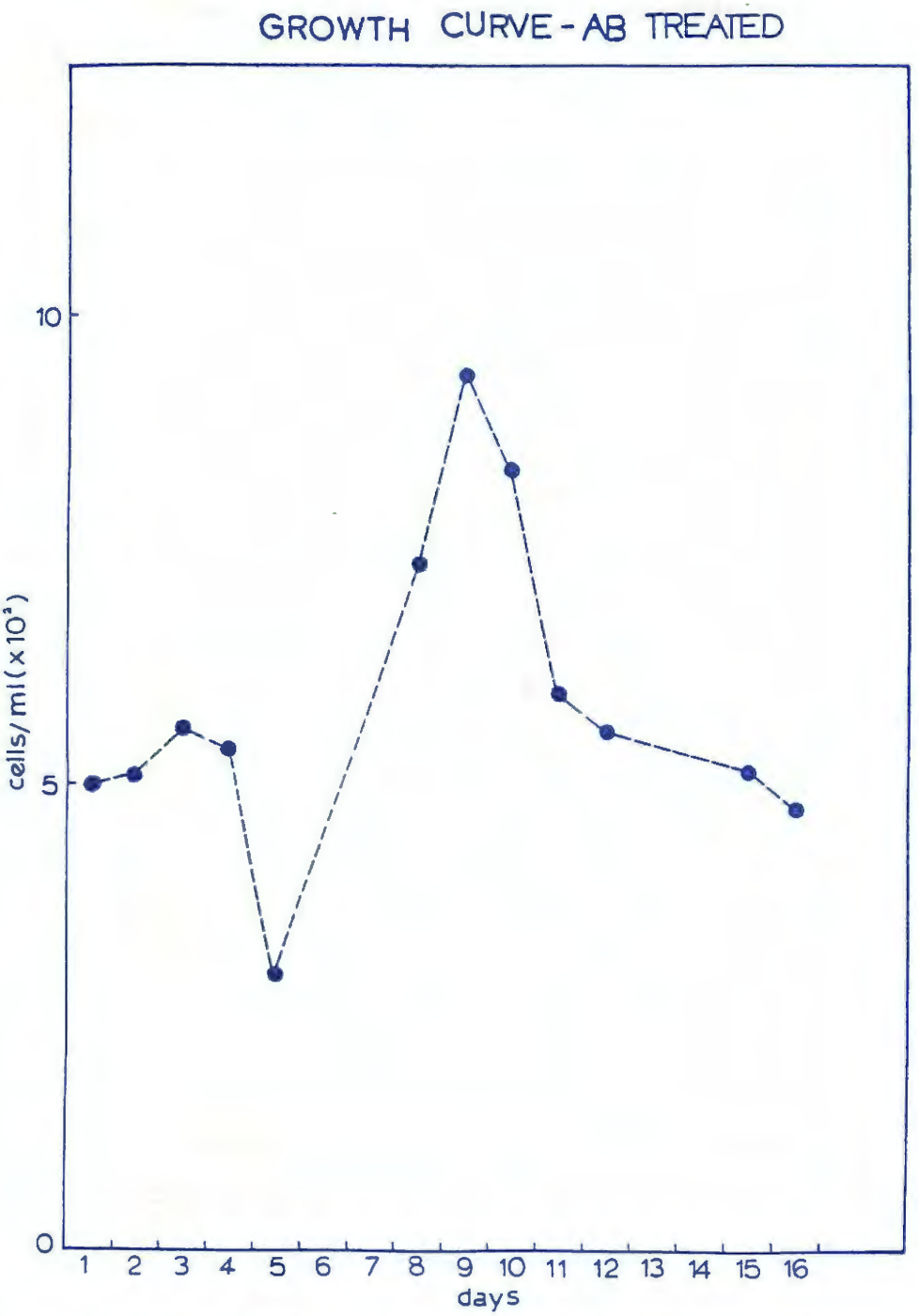


Fig. 2b Antibiotics: Gentamicin-Ampicillin
1.5 µg/ml each

Scrippsiella trochoidea

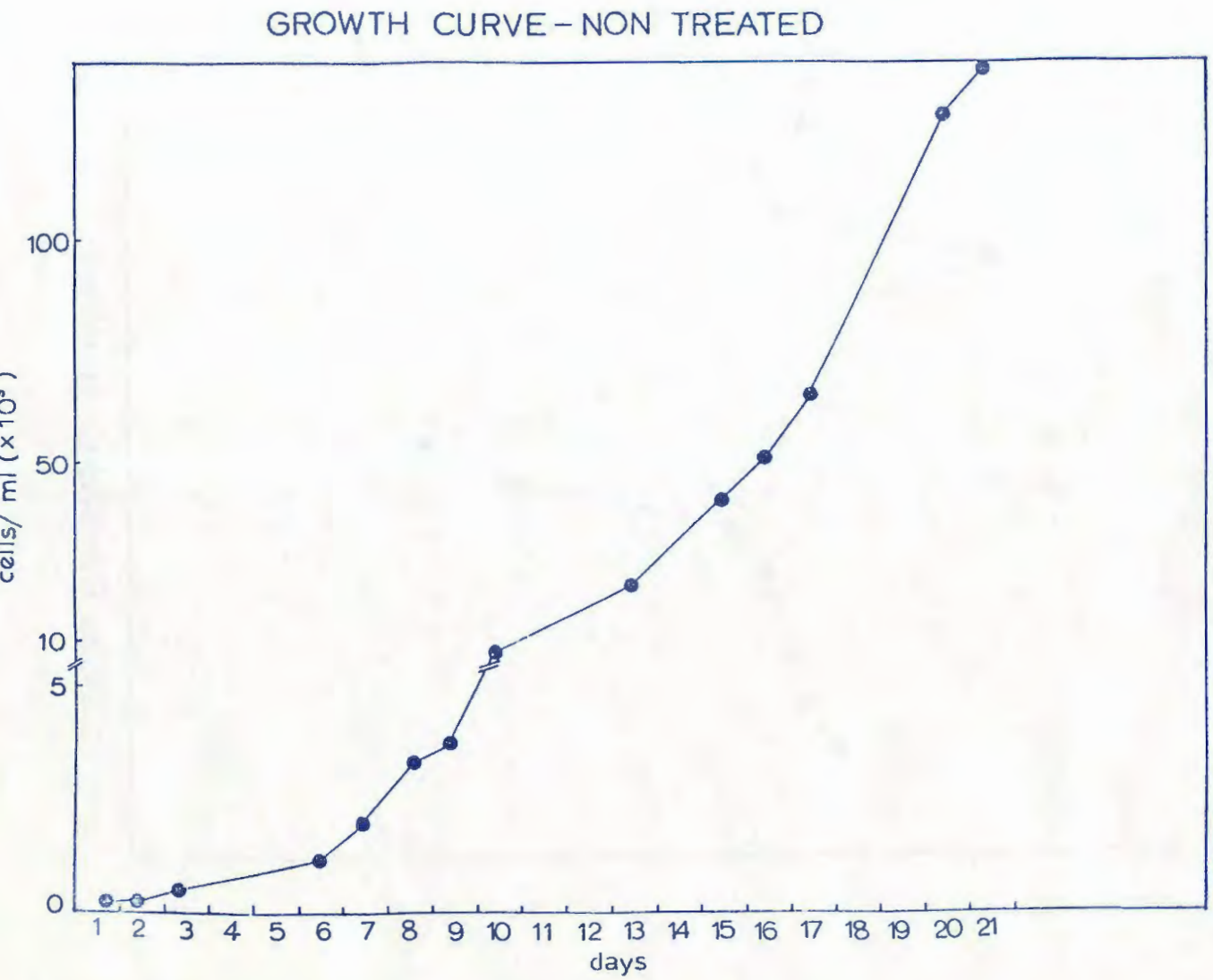


Fig. 3a

Scrippsiella trochoidea

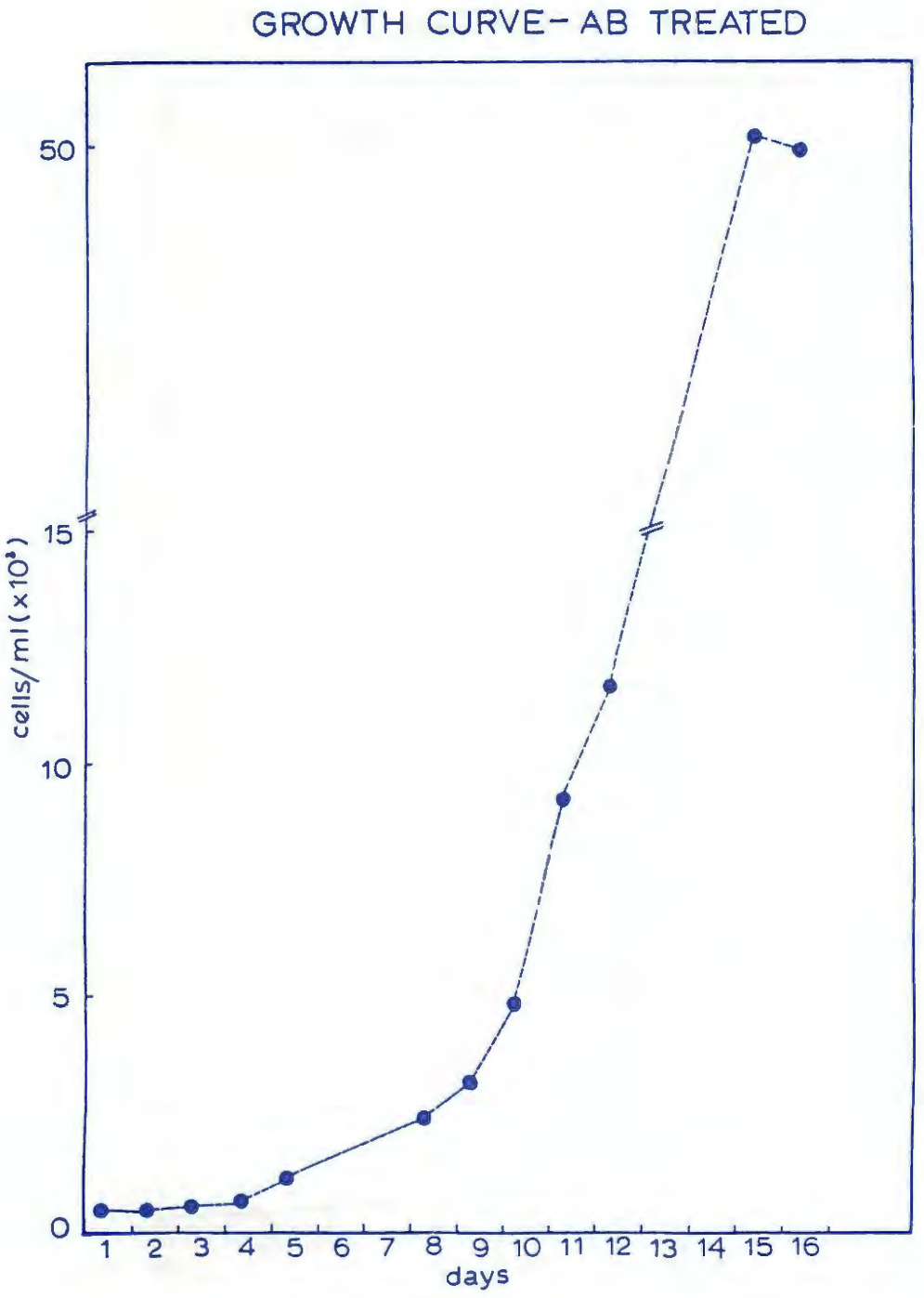


Fig. 3b Antibiotics: Gentamicin-Ampicillin
30 µg/ml each

Scrippsiella trochoidea

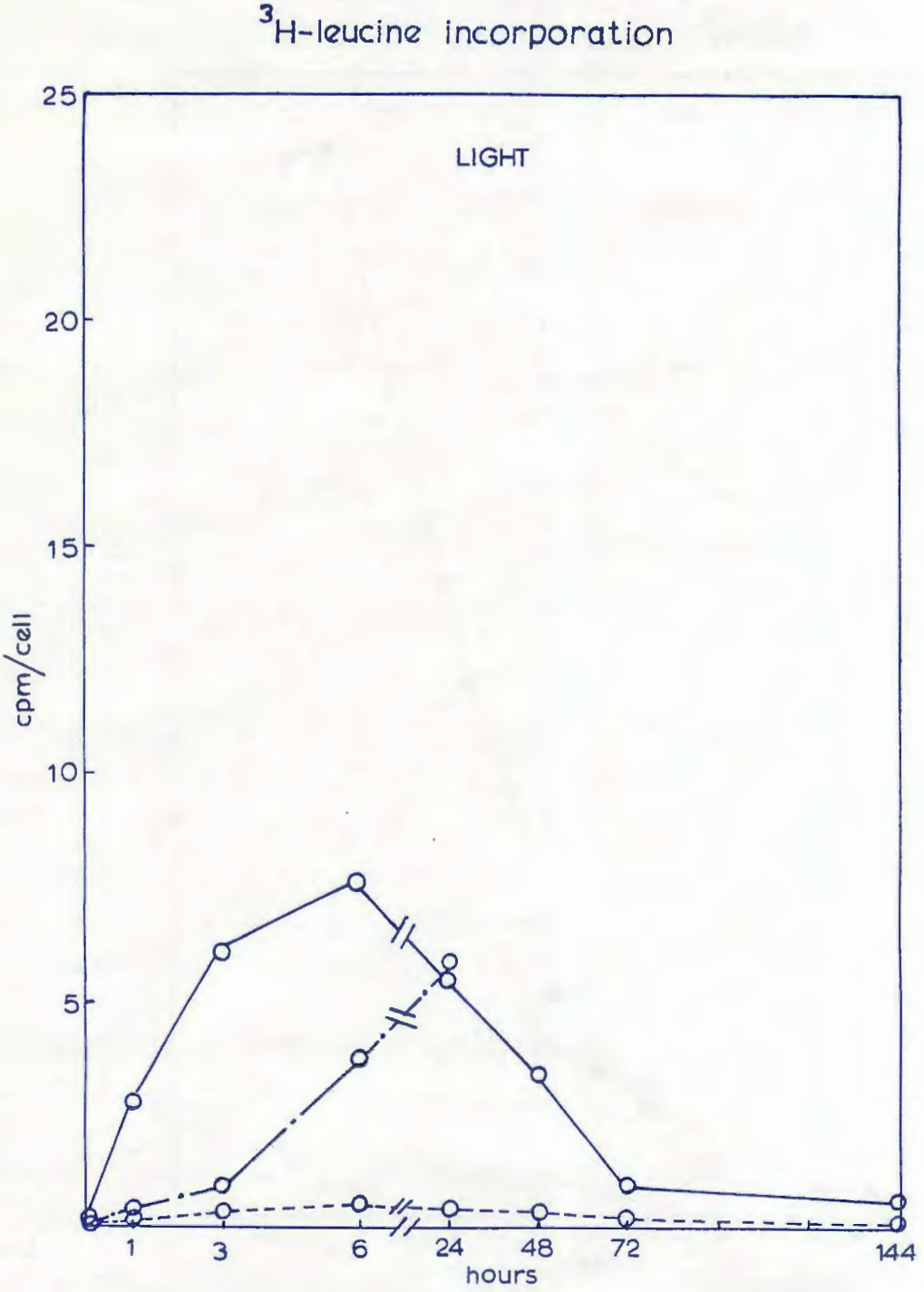


Fig. 4a · 0.1 µci/ml medium (sea water-F/2 enrichment)
Specific activity 460 µci/µmole - 2.17×10^{-7} M

(———) nonaxenic culture
(- - - - - -) antibiotic treated culture
(——·——) axenic culture

Scrippsiella trochoidea

^{3}H-leucine incorporation

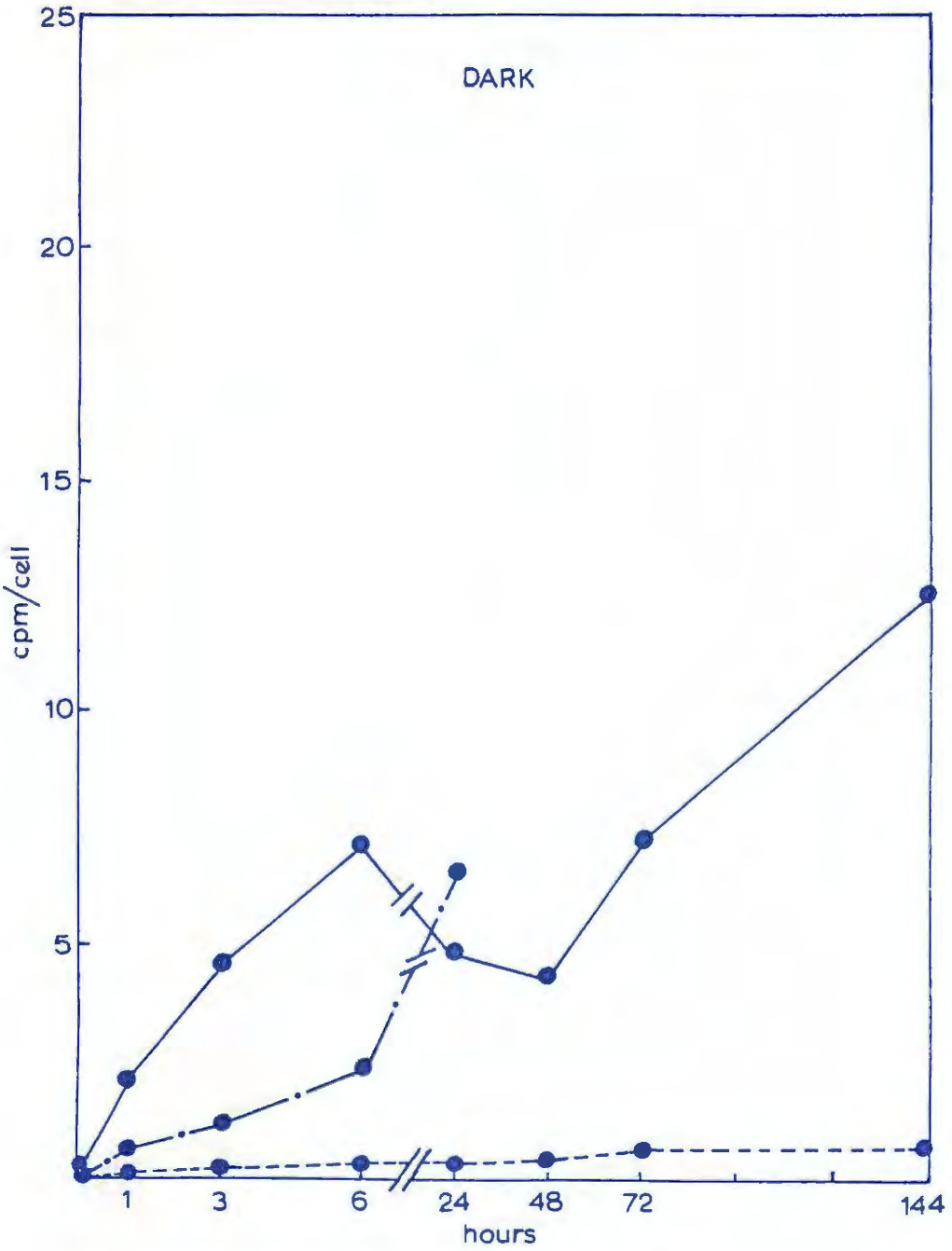


Fig. 4b 0.1 µci/ml medium (sea water-F/2 enrichment)
Specific activity 460 µci/µmole - 2.17×10^{-7} M

(———) nonaxenic culture
(- - - - -) antibiotic treated culture
(——·——) axenic culture

Scrippsiella trochoidea

^{14}C-phenylalanine incorporation

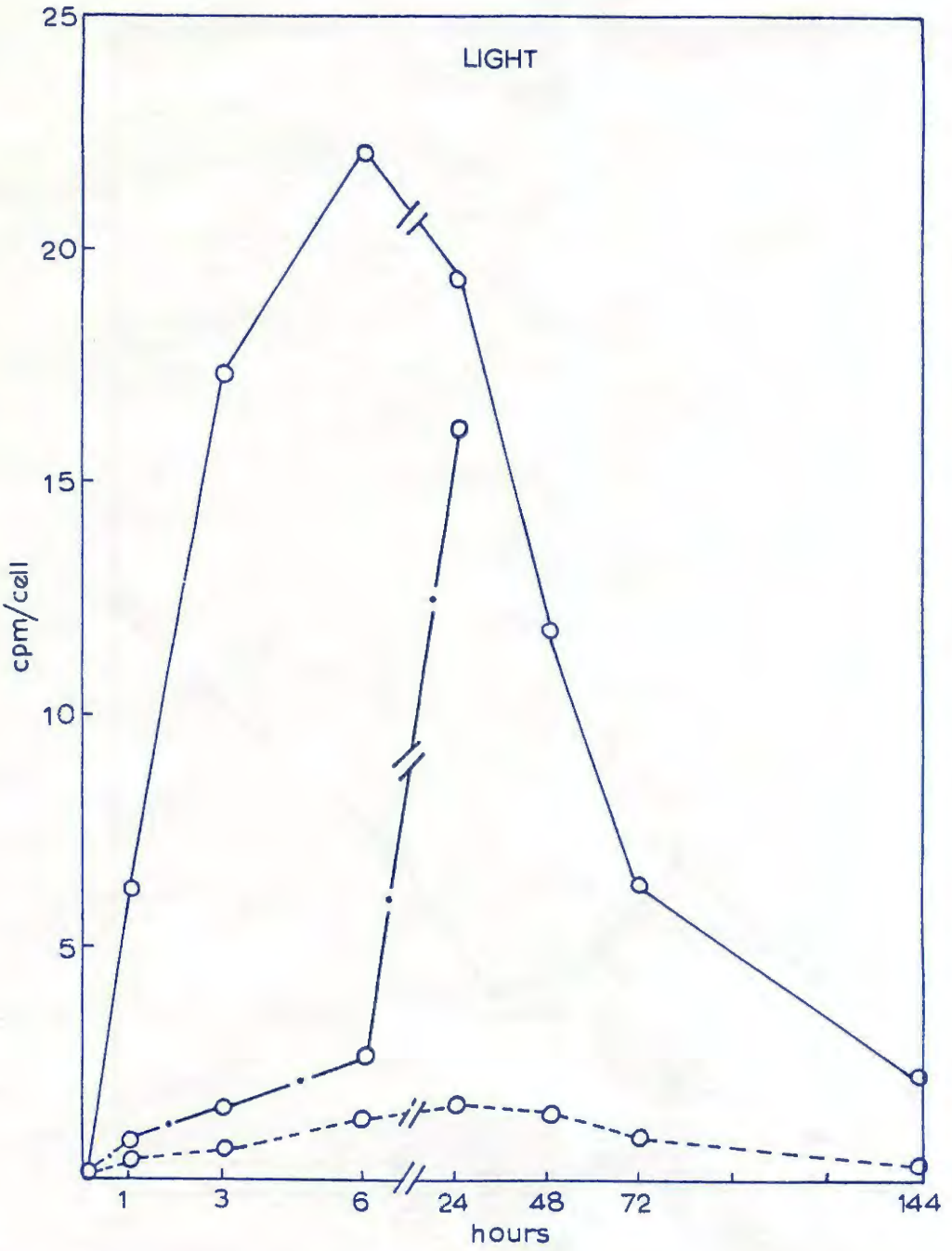


Fig. 5a 0.1 µci/ml medium (sea water-F/2 enrichment)
Specific activity 460 µci/µmole - 2.17×10^{-7} M

(———) nonaxenic culture
(- - - - -) antibiotic treated culture
(——·——) axenic culture

Scrippsiella trochoidea

^{14}C-phenylalanine incorporation

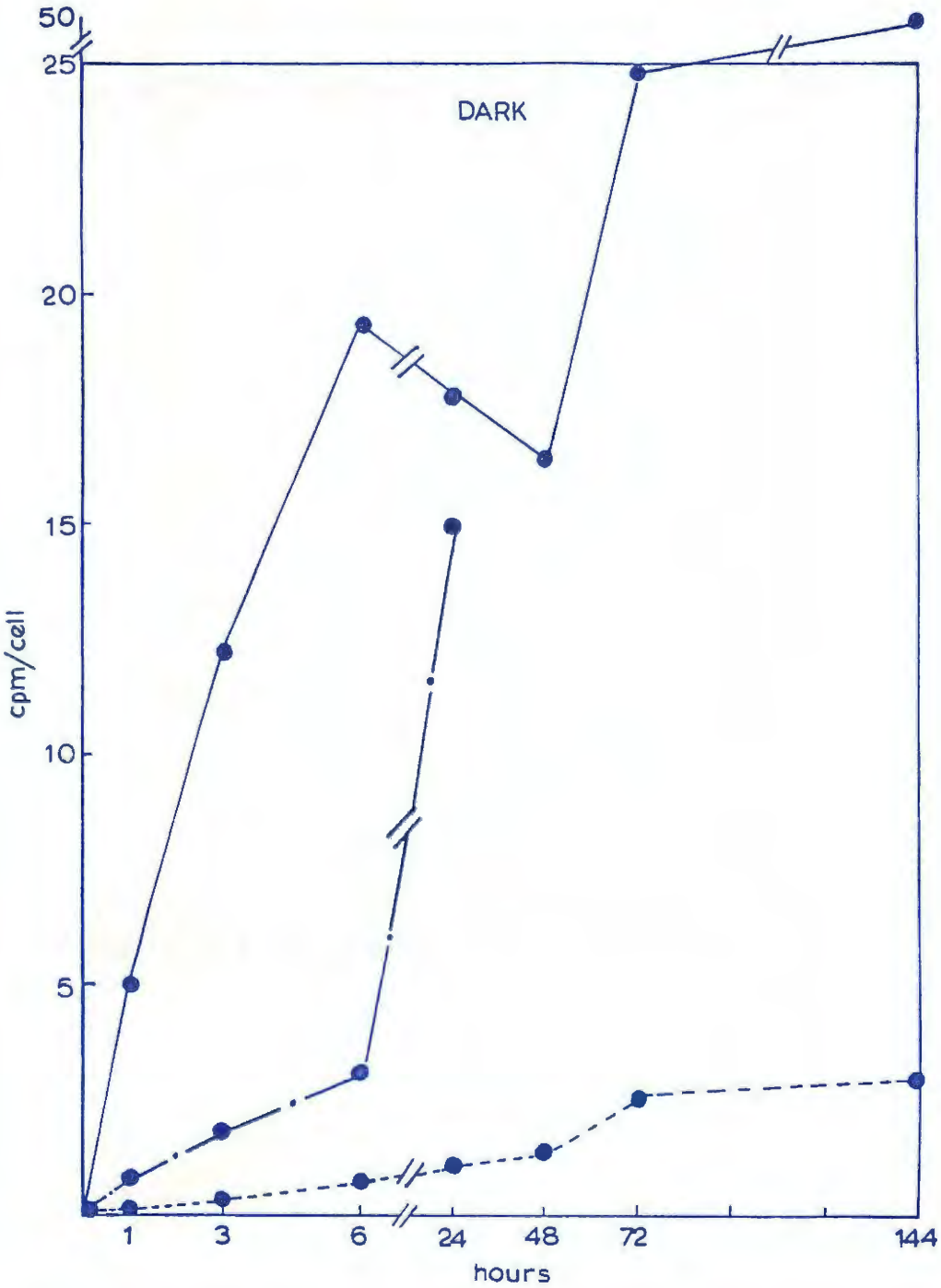


Fig. 5b 0.1 µci/ml medium (sea water-F/2 enrichment)
Specific activity 460 µci/µmole - 2.17×10^{-7} M

(———) nonaxenic culture
(- - - - -) antibiotic treated culture
(——·——) axenic culture

TABLE I. THE ANTIBIOTIC DISC SENSITIVITY OF THE BACTERIA ISOLATED FROM THE THREE DINOFLAGELLATES

ANTIBIOTIC DISC	CULTURES AND ISOLATED NUMBERS					
	GONYAULAX POLYEDRA		GYMNODINIUM SANGUINIUM		SCRIPPSIELLA TROCHOIDEA	
	*1	*2	*1	*2	*1	*2
CHLOROMYCETIN	-	+5	-	-	+11	+8
ERYTHROMYCIN	-	+6	+5	+6	+1	+10
KANAMYCIN	-	-	-	-	-	-
NEOMYCIN	-	-	+3	+1	-	-
NOVOBIOCIN	-	-	+4	+3	+3	+8
PENICILLIN	-	-	-	-	+10	+3
STREPTOMYCIN	-	-	-	+2.5	-	-
TETRACYCLINE	-	-	-	-	-	-
AMPICILLIN	-	-	-	-	+14	+3
BACITRACIN	+1	-	-	-	-	-
VANOMYCIN	-	-	-	-	-	+2.5

*TYPES OF BACTERIAL COLONIES ISOLATED ON NUTRIENT AGAR PLATES FROM EACH SPECIES OF ALGA AND FROM THE NUTRIENT BROTH STERILITY TESTS PLOTTED ON NUTRIENT AGAR PLATES.

+NUMBERS - NO SENSITIVITY

+ - SENSITIVITY DISTANCE IN MM FROM DISC

TABLE II. CONCENTRATIONS OF ANTIBIOTICS (µG/ML) PRESENT IN CULTURES OF:

(A) *GONYAULAX POLYEDRA*
(B) *GYMNODINIUM SANGUINIUM*
(C) *SCRIPPSIELLA TROCHOIDA*

SERIES	ANTIBIOTIC	DILUTION TUBE A	B	C	D	E
1	NEOMYCIN AND	1000	500	250	125	62.5
	KANAMYCIN	1000	500	250	125	62.5
2	KANAMYCIN	100	50	25	12.5	
3	NEOMYCIN	100	50	25	12.5	
4	NOVOBIOCIN	100	50	25	12.5	
5	GENTAMICIN	800	600	400	200	100
6	ERYTHROMYCIN	800	600	400	200	100
7	AMPICILLIN	800	400	200	100	50
8	AMPICILLIN AND	800	400	200	100	50
	ERYTHROMYCIN	25	25	25	25	25
9	GENTAMICIN	800	400	200	100	50
10	GENTAMICIN AND	800	400	200	100	50
	ERYTHROMYCIN	25	25	25	25	25
11	GENTAMICIN AND	800	400	200	100	50
	AMPICILLIN	25	25	25	25	25
12	GENTAMICIN AND	500	300	175	100	50
	AMPICILLIN	500	300	175	100	50
13	GENTAMICIN AND	1000	800	600	400	
	AMPICILLIN	1000	800	600	400	
14	GENTAMICIN AND	800	600	400		
	AMPICILLIN	800	600	400		
*15	GENTAMICIN AND	200	150	100		
	AMPICILLIN	200	150	100		

*SERIES 15 DILUTION FROM SERIES 14

TABLE III. ANTIBIOTIC TREATMENTS OF THREE DINOFLAGELLATES AND RESULTS OF STERILITY TESTS WITH NUTRIENT BROTH AND MICROSCOPICAL OBSERVATIONS OF ALGAL GROWTH

			CULTURES					
			G. POLYEDRA		G. SANGUINIUM		S. TROCHOIDEA	
SERIES	ANTIBIOTIC	DILUTION TUBE	BACT.	ALGAE	BACT.	ALGAE	BACT.	ALGAE
1	NEOMYCIN AND KANAMYCIN							
2	KANAMYCIN		NO ALGAL GROWTH OBSERVED. ALL DOSES					
3	NEOMYCIN		LETHAL.					
4	NOVOBIOCIN							
5	GENTAMICIN	A	+	+	+	+	+	+
		B	+	+	+	++	+	+++
		C	+	++	+	+++	+	+++
		D	+	+++	+	+++	+	++++
		E	+	+++	+	++++	+	++++
6	ERYTHROMYCIN	A	+	-	+	-	+	-
		B	+	-	+	-	+	-
		C	+	-	+	-	+	-
		D	+	-	+	-	+	-
		E	+	-	+	-	+	-
7	AMPICILLIN	A	+	+	+	+	+	+
		B	+	+	+	+	+	+
		C	+	+	+	+	+	+
		D	+	+	+	+	+	+
		E	+	+	+	+	+	+
8	AMPICILLIN AND ERYTHROMYCIN	A	-	-	+	-	+	-
		B	-	-	+	-	+	-
		C	-	-	+	-	+	-
		D	-	-	+	-	+	-
		E	-	-	+	-	+	-
9	GENTAMICIN	A	+	+	+	+	+	+
		B	+	+	+	+	+	++
		C	+	+	+	++	+	+++
		D	+	+	+	+++	+	+++
		E	+	+	+	+++	+	++++
10	GENTAMICIN AND ERYTHROMYCIN	A	-	-	-	-	-	-
		B	-	-	-	-	-	-
		C	-	-	-	-	-	-
		D	-	-	-	-	-	-
		E	-	-	-	-	-	-
11	GENTAMICIN AND AMPICILLIN	A	+	+	+	+	+	+
		B	+	+	+	+	+	+
		C	+	+	+	+	+	+
		D	+	+	+	+	+	+
		E	+	+	+	+	+	+
12	GENTAMICIN AND AMPICILLIN	A	-	+	-	+	-	+
		B	+	+	+	+	+	+
		C	+	+	+	++	+	++
		D	+	+	+	++	+	+++
		E	+	+	+	++	+	+++
13	GENTAMICIN AND AMPICILLIN	A	-	-	-	-	-	-
		B	-	+	-	+	-	+++
		C	-	+	-	+	-	+++
		D	-	+	-	+	-	+++
14	GENTAMICIN AND AMPICILLIN	A	-	++	-	++	-	+++
		B	-	++	-	++	-	+++
		C	-	++	-	++	-	+++
15	GENTAMICIN AND AMPICILLIN	A	-	++	-	++	-	+++
		B	-	++	-	++	-	+++
		C	-	++	-	++	-	+++

BACTERIA - NUTRIENT BROTH - INCUBATION 30°C

\- NO BACTERIAL CONTAMINATION

\+ BACTERIAL CONTAMINATION

ALGAL CULTURES - INCUBATION 18°C

\- NO GROWTH

\+ SOME GROWTH

++ LARGE NUMBERS OF CELLS

+++ VERY GOOD GROWTH

++++ NORMAL GROWTH WITH REFERENCE TO CONTROL

REFER TO TABLE II FOR ANTIBIOTIC CONCENTRATIONS IN µG/ML.

TABLE IV. *SCRIPPSIELLA TROCHOIDEA* GROWTH IN STERILE FILTERED SEA WATER WITH F/2 ENRICHMENT (CELLS/ML)

	DAY	1	2	3	4	5	8
	TIME	3:00 PM	3:00 PM	9:00 AM	10:00 AM	9:00 AM	9:00 AM
LIGHT							
C		580	820	1040	2280	2420	9960
AA		620	785	1000	1640	2480	8820
C_{AB}		520	970	1340	2380	3880	21040
AA_{AB}		760	1038	1690	2460	4240	19790
DARK							
C		620	720	960	800	680	400
AA		630	860	1000	1100	740	340
C_{AB}		480	930	1300	1220	1180	1560
AA_{AB}		580	1008	1370	1240	1080	570
LIGHT-DARK							
C		580	820	1040	2280	2420	9960
AA		730	780	1100	1160	1670	5480
C_{AB}		520	910	1360	2020	3040	11200
AA_{AB}		620	968	1290	2300	2990	10180

C - CONTROL CULTURE

AA - AMINO ACIDS ADDED 2.17×10^{-7} M - LEUCINE AND PHENYLALANINE

AB - ANTIBIOTIC TREATED CULTURES 3.2 µG/ML EACH - GENTAMICIN AND AMPICILLIN

TABLE V. SCRIPPSIELLA TROCHOIDEA ^{3}H-LEUCINE INCORPORATION
CPM/10^{3} CELLS

HOURS	0	1	3	6	24	48	72	144
C_L	189	2762	6100	7641	5499	3383	910	567
AB_L	124	198	281	421	391	282	172	43
C_D	190	2124	4582	7171	4880	4427	7255	12553
AB_D	4	26	78	188	219	269	511	594
C_{L-D}	2	1749	3762	8826	4125	4390	3137	873
AB_{L-D}	30	143	307	524	688	668	453	111

AB - ANTIBIOTIC CONCENTRATION 3.2 UG/ML EACH GENTAMICIN AND AMPICILLIN

AA - AMINO ACID ^{3}H-LEUCINE 2.17×10^{-7} M
0.1 µCI/ML SPECIFIC ACTIVITY 460 µCI/µMOLE

INCUBATION AT 18°C

CONDITIONS: LIGHT
DARK
LIGHT-DARK

TABLE VI. SCRIPPSIELLA TROCHOIDEA ^{14}C-PHENYLALANINE INCORPORATION
CPM/10^3 CELLS

HOURS	0	1	3	6	24	48	72	144
C_L	278	6380	17322	22122	19411	11821	7335	2212
AB_L	115	298	571	1285	1587	1387	866	254
C_D	235	5007	12299	19284	17878	16451	24986	45394
AB_D	22	95	288	737	1101	1350	2534	2882
C_{L-D}	42	3890	9365	23625	16391	19345	13022	3596
AB_{L-D}	56	260	720	1445	2597	2594	1871	506

AB - ANTIBIOTICS - GENTAMICIN AND AMPICILLIN 3.2 µG/ML EACH

AA - AMINO ACID ^{14}C-PHENYLALANINE 2.17×10^{-7} M
0.1 µCI/ML SPECIFIC ACTIVITY 460 µCI/µMOLE

INCUBATION AT 18°C

CONDITIONS: LIGHT
DARK
LIGHT-DARK

Ecology of a Small Tidal Lagoon under the Influence of Urban Recreational Use

James N. Kremer, Assistant Professor, Biological Sciences
Patricia Kremer, Hancock Fellow, Allan Hancock Foundation

Introduction

Colorado Lagoon is situated in suburban Long Beach, and it is constantly under direct human influence. Several storm drains deliver street runoff, and seasonal recreation use is intensive. The lagoon seems to be vigorous ecologically, but it is unclear whether this is in spite of or because of the urban influence. Enhanced primary productivity of the phytoplankton under the influence of external nutrient inputs and controlled tidal exchange may be important, but previous to this study there had been no measurements of critical ecological rates such as primary production, nutrient cycling, or ingestion by the benthos. In addition, the success of the hard clam Mercenaria mercenaria in Colorado Lagoon is a question of basic scientific interest. Reportedly introduced elsewhere in the Long Beach system of canals and causeways, M. mercenaria has appeared and flourished only in the lagoon.

Our overall goal was to identify and quantify important interactions between the lagoon biota and the urban environmental influences. Of specific interest are the reasons for the apparently unique success of the hard clam. To these ends, we proposed to measure primary production and community respiration for the total system and, in particular, for the plankton and for the benthos. In addition, since nutrients are potentially an important key to interpreting these rates, we have been determining the major storages and fluxes of the dissolved and particulate, organic and inorganic fractions of nutrients. These objectives require careful definition of the physical characteristics of the lagoon, including the flushing rates as controlled by the tide gates.

During the first year (1979), our efforts were directed toward an initial rather detailed description of seasonal patterns of important variables in the lagoon system. During the second year, we continued these measurements, in some cases with reduced detail, and shifted our emphasis to certain processes identified as especially important. In particular, our goals during the 1980 year of field work included: (a) a more complete measurement of the nutrient impact of storm runoff into the lagoon; (b) measurement of the amount of fresh water entering the lagoon during the rainy season; (c) description for a second year of the annual cycle of total system metabolism; (d) estimation of scales of variability in metabolic rates for different areas of the lagoon benthos; (3) measurement of the functional response of benthic primary production to incident solar radiation; (f) description of the relative

response of benthic primary production to incident solar radiation; (f) description of the relative rates of turbulent mixing during the tidal cycle and when the tide gates are closed; (g) experimentally determining the relative quality of water samples taken over the annual cycle by bioassay with phytoplankton cultures using froze, whole-water samples.

All of these goals have been realized. Data have not been completely analyzed, but some of our results and important conclusions are discussed below.

Results

The goals of our study of the Colorado Lagoon are broad in scope, spanning many aspects of the ecosystem structure and function (Table 1). While conceptually straightforward in comparison to the other parts of our study, the description of annual patterns of key environmental factors and biological and chemical constitutents (Table 1, part I) has been logistically difficult yet absolutely essential to the success of our work. We have sampled on a regular basis over two years, producing a clear picture of the patterns of response of the plankton macroalgae, and organic and inorganic chemical nutrients (NH_4, NO_3, PH_4, organic P, organic N) over the annual cycle (Figures 1-7).

Of special interest and importance with respect to our goal of documenting the impact of the suburban setting on the lagoon is the dramatic influence of street runoff during the rainy season on the chemical nutrients and on the macroalgae. Levels of nutrients in fresh rain were not dramatically above pre-rain levels in the lagoon. Yet mixing curves, such as the one in Figure 5, demonstrate that large amounts of ecologically important nutrients are carried into the lagoon in rainwater with concentrations elevated during the drainage process. We have also quantified the amount of fresh water entering the lagoon during certain storms. We anticipate deriving a relationship allowing us to estimate total runoff for any storm from U. S. weather bureau data (e.g., preliminarily, a rainfall of 1 inch raises the water level of the lagoon by 1 meter or 13500 m^3). Taken together, these results allow us to calculate with unusual precision the nutrient load entering the lagoon. We are thus able to relate quantitativelythis flux to the normal fluxes and standing stocks of the nutrient cycles in the lagoon.

An additional point is worth noting. The dominant primary producer shifts from macroalgae during the spring to phytoplankton during the summer Figure 6 vs. Figure 7). We feel that this shift in dominance results from the interactions of runoff enhanced nutrient availability and seasonal light levels. (This aspect of our study supports a graduate student, resulting so far in a scientific presentation and a master's thesis; Siegal, 1980).

Despite the importance of the seasonal patterns in characterizing the ecosystem, the real thrust of our study concerned direct assessment of major ecological fluxes of oxygen and nutrients. During the first year, we used the diel curve method to document the daily amplitude of oxygen (Figure 8). We continued with abbreviated dawn-dusk measurements monthly during the second year. Analysis of these dsta will generate estimates of total ecosystem metabolism (Table 1, part II), allowing comparison with important external factors (temperature, light, rainfall, summer recreational use, etc.) But at least as important, these estimates, which are made with no perturbation or manipulation of the intact total system, will allow comparisons with measurements of certain component fluxes (Table 1, part III).

In our previous annual report, we presented in some detail the results of our measurements of plankton production and respiration. We have continued to analyze this data, and have documented physiological changes in the photosynthesis-light response of phytoplankton over short time intervals (Figure 9). These detailed results allow the contribution of the plankton to the system oxygen budget to be assessed. Substantial computation is required, however, and this phase is still in progress.

To supplement the routine monthly measurements of benthic metabolism reported last year, we expanded the scope of our field work to determine the functional response of the benthos to light (Figure 10). In addition, calculations using the substantial base of benthic metabolism data and clam densities have allowed the role of M. mercenaria population in benthic metabolism to be assessed (Figure 11). These results we presented at a scientific meeting (Murphy, 1980), and they will be part of a doctoral dissertation on factors related to the unique success of the clam in Colorado Lagoon that will be completed in the next year.

The final aspect of our study, and the one that is just now starting to be realized, is the synthesis of the rather substantial body of data we have gathered successfully (Table 1, part IV). Considerable reduction of the data remains, and computer programs to assist in this are in various stages of development. One example of this kind of analysis was a numerical simulation mode of oxygen stratification in the lagoon (Kremer, 1980). Based on the direct measurement of the various fluxes believed to be most important (Figure 12), a dynamic budget was simulated and compared to a 4-day time series of oxygen profiles taken in the lagoon (Figure 13). There are important strengths and weaknesses in these results. It is encouraging that both the surface and bottom values are in good agreement with the observed profiles. The shape of the simulated profiles however are not realistic. The weakness responsible for this discrepancy is in the turbulent eddy diffusivity part of the model. And we are able to use the model to suggest reasonable profiles for this very difficult to measure variable.

Further, we have used the model to investigate the relative importance of various factors in creating the alarming anoxic conditions we discovered in the lagoon. Sensitivity analyses of the model results to changes in the coefficients indicate that one of the most important factors is water depth. This has important implications because the staff at the lagoon control the power tide gates to maintain a high water level for recreational swimming. The direct management of tidal flushing reduces turbulent mixing and reduces light penetration, thus contributing to the important events of benthic anoxia.

Project Communications

1. Murphy, R.C., and J. N. Kremer. 1980. Oxygen consumption in a shallow subtidal community. Paper presented at American Society of Limnology and Oceanography (ASLO), Los Angeles, California, January 31 - February 4 1980.

2. Kremer, J. N. 1980. A model of transient anoxic conditions in the benthic waters of a tidal lagoon. ASLO meeting, January 31 - February 4 1980, Los Angeles, California.

3. Kremer, J. N., and P. Kremer. 1981. Ecology of a small tidal lagoon. Manuscript in preparation; to be submitted to Ecological Monographs, summer 1981.

4. Siegal, J. 1980. Factors controlling the seasonal pattern of Enteromorpha intestinalis in Colorado Lagoon, Long Beach, California. Master's theses manuscript, Department of Biological Sciences, University of Southern California, Los Angeles, California.

5. Siegal, J., and J. N. Kremer. 1980. Role of nitrogen in the blooming of the green alga Enteromorpha in Colorado Lagoon. ASLO meeting, Los Angeles, California, January 31 - February 4 1980.

TABLE 1

COLORADO LAGOON ECOSYSTEM STUDY
STRATEGY AND GOALS

I. Describe annual patterns

A. Environmental factors

1. Temperature
2. Solar radiation, extinction coefficient
3. Rainfall

B. Standing stocks

1. Nutrients
2. Plankton
3. Microalgae

II. Quantify total system metabolism

A. Diel free-water oxygen cycles, and seasonally

B. Vertical stratification problem

C. Air-sea diffusion problem

III. Quantify metabolism of the component parts

A. Plankton production and respiration

1. Production vs. depth, and dielly
2. Seasonal patterns (vs. Lt, T, Nutr.)

B. Benthos (oxygen and nutrients)

1. Seasonal patterns of respiration
2. Spatial variability
3. Role of clams
4. Production vs. light

IV. Synthesis

A. Total system vs. sum of parts?

B. Seasonal shifts in dominance

C. Diel oxygen model

D. Role of runoff in nutrient budget

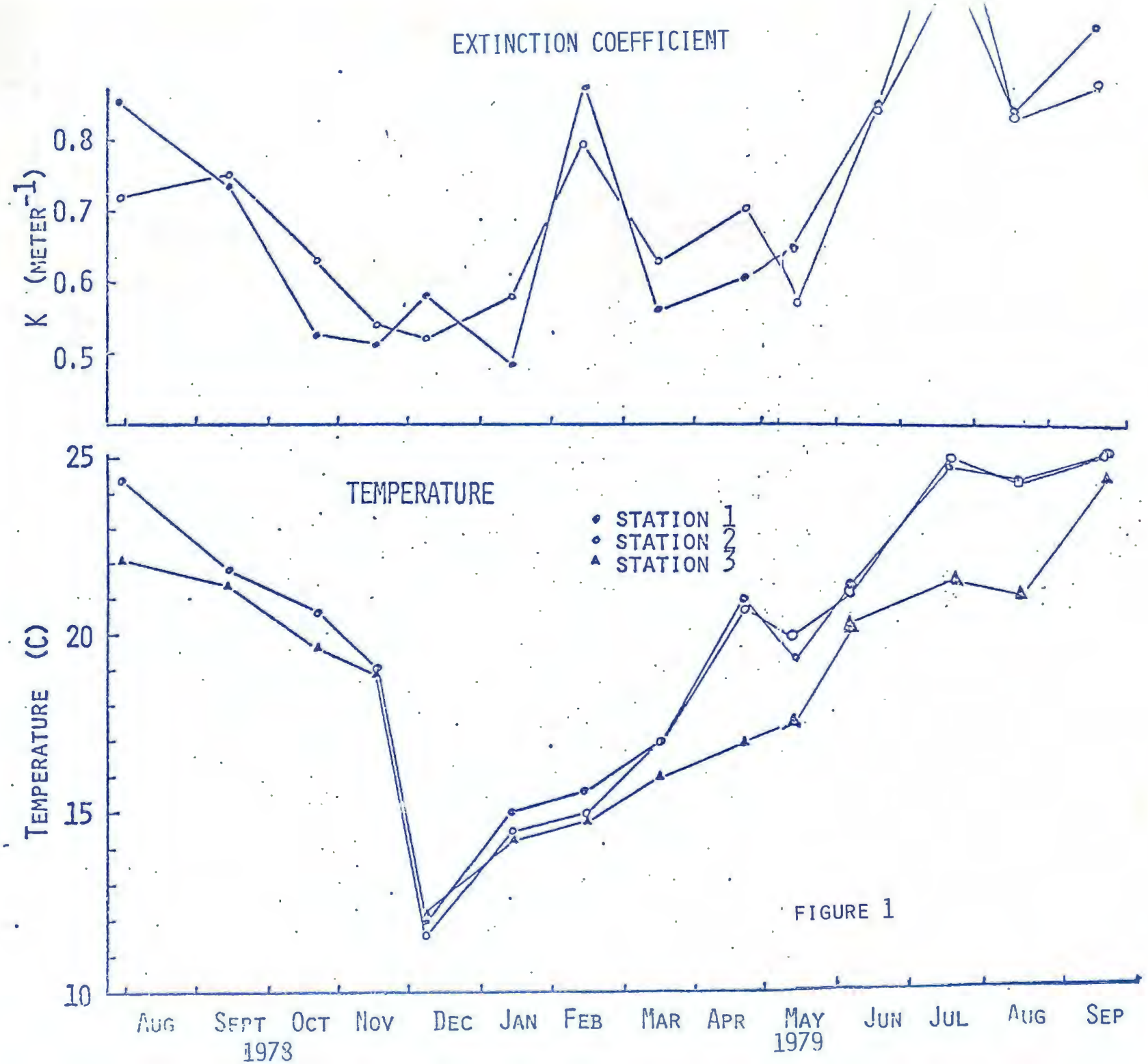
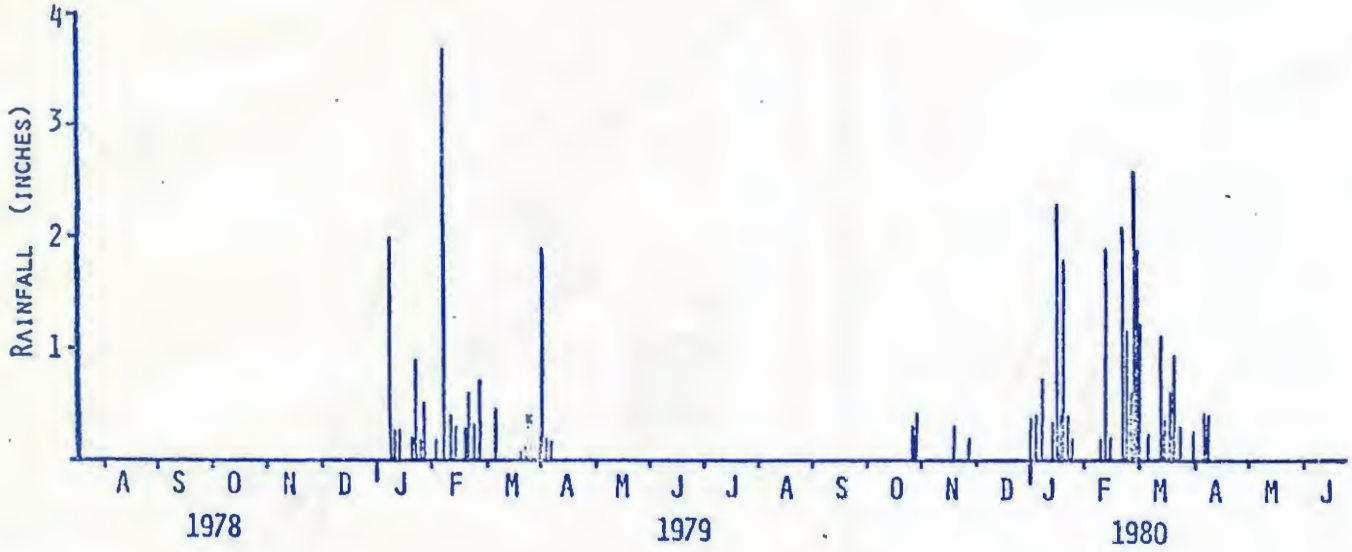
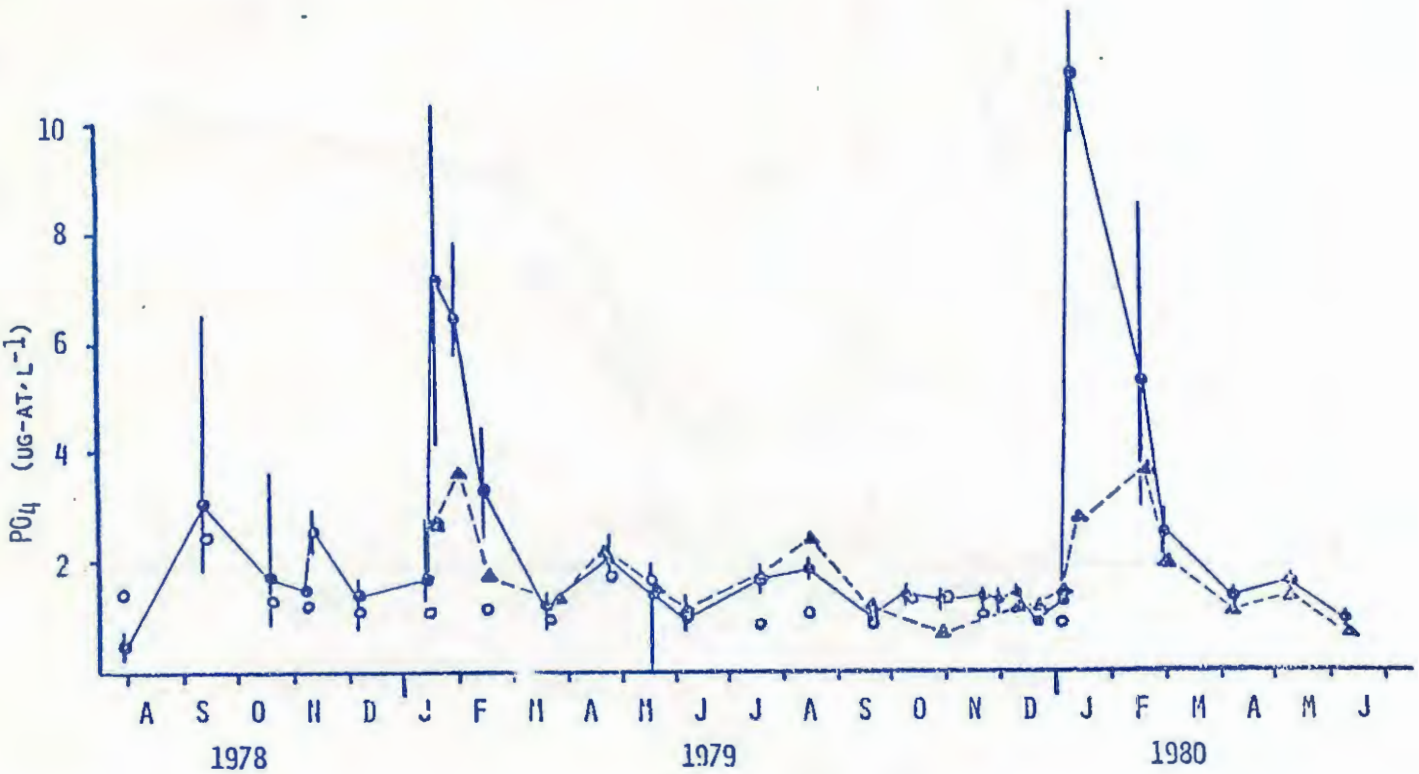

EXTINCTION COEFFICIENT
K (METER-1)
0.8
0.7
0.6
0.5
TEMPERATURE
STATION 1
STATION 2
STATION 3
TEMPERATURE (C)
25
20
15
10
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1978
1979

FIGURE 1

Figure 2


RAINFALL (INCHES)
4
3
2
1
A S O N D J F M A M J J A S O N D J F M A M J
1978
1979
1980


PO_4 (UG-AT·L^{-1})
10
8
6
4
2
A S O N D J F M A M J J A S O N D J F M A M J
1978
1979
1980

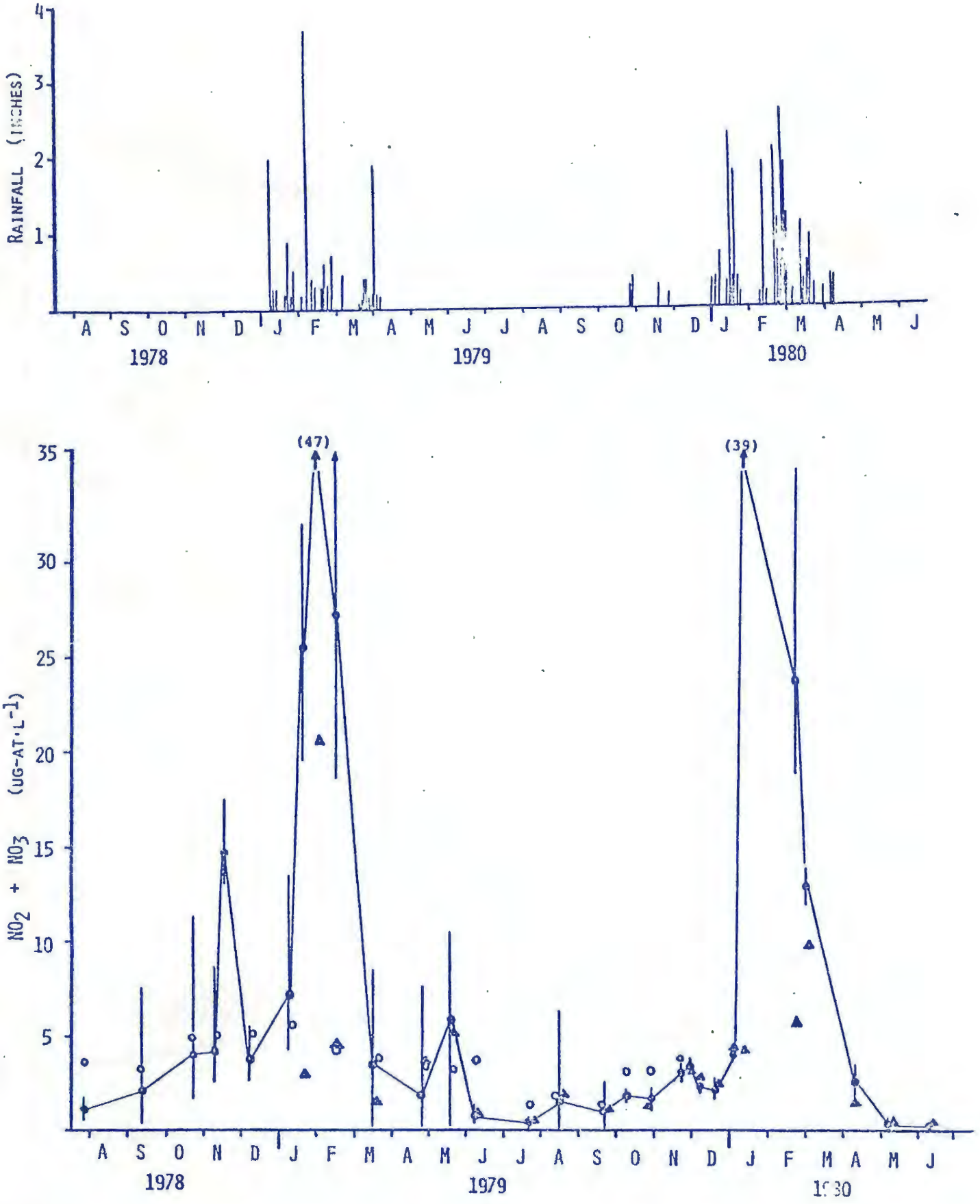

RAINFALL (INCHES)
4
3
2
1
A S O N D J F M A M J J A S O N D J F M A M J
1978
1979
1980
(47)
(39)
$NO_2 + NO_3$ (UG-AT·L^{-1})
35
30
25
20
15
10
5
A S O N D J F M A M J J A S O N D J F M A M J
1978
1979
1980

Figure 3

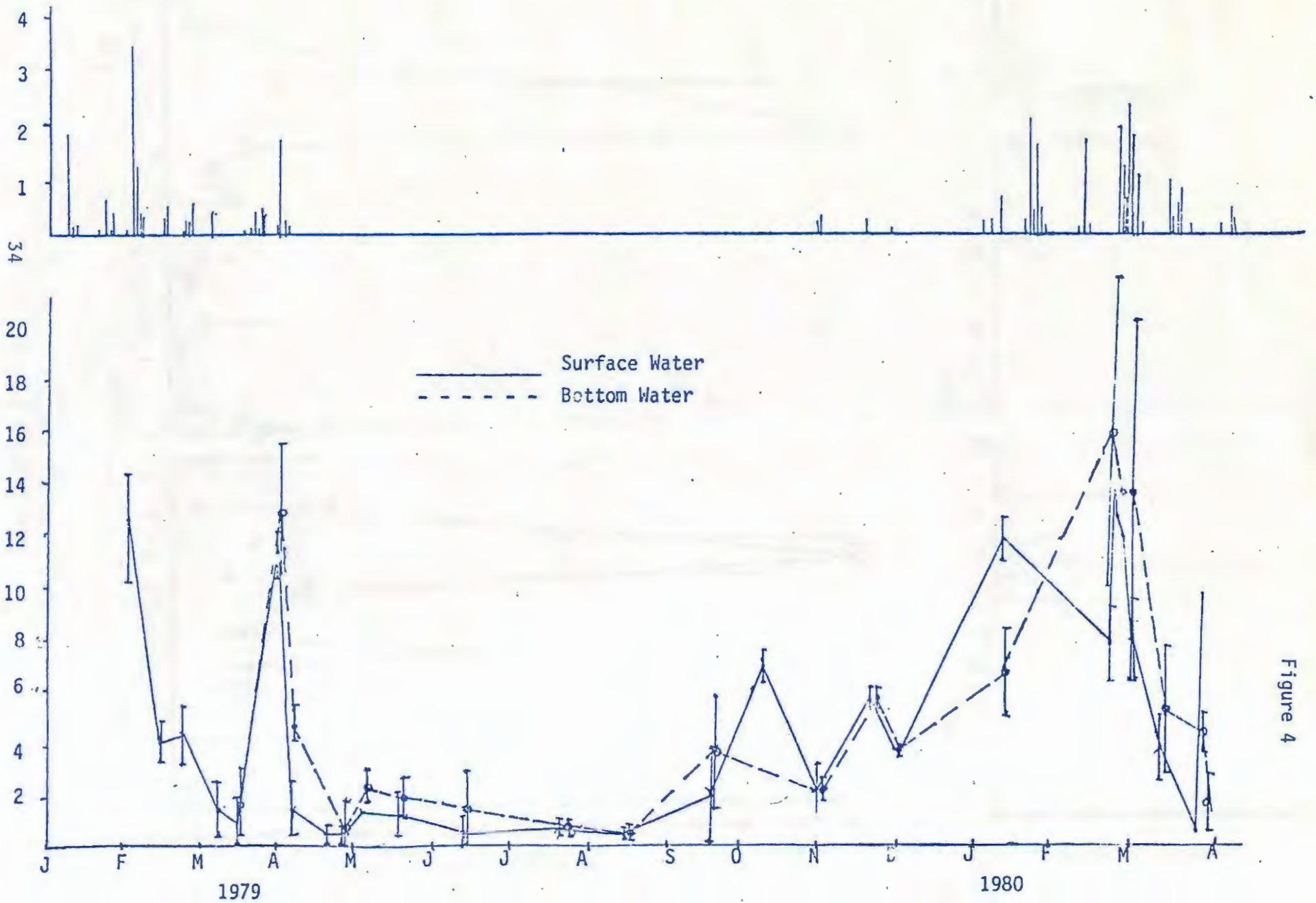

4
3
2
1
34
20
18
16
14
12
10
8
6
4
2
Surface Water
Bottom Water
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
1979
1980

Figure 4

NUTRIENTS vs. SALINITY
IMMEDIATELY FOLLOWING A RAINSTORM
16 JANUARY 1979

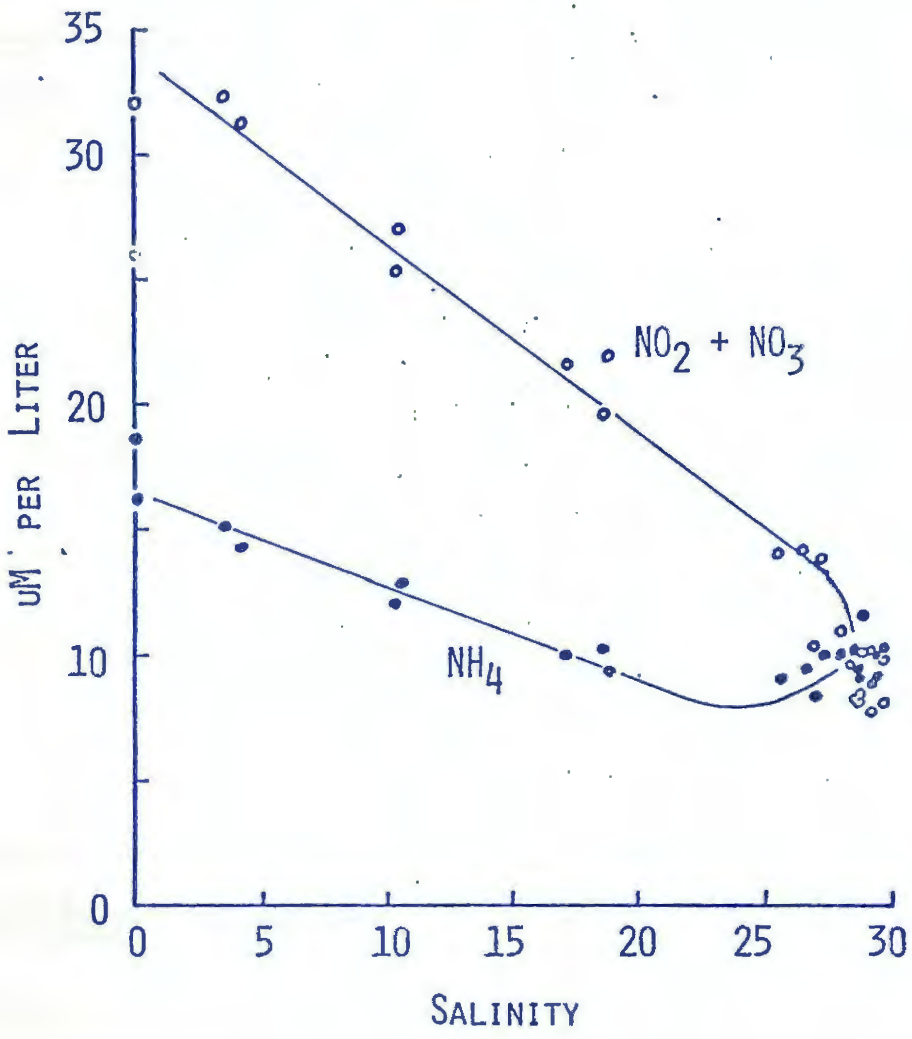


Figure 5

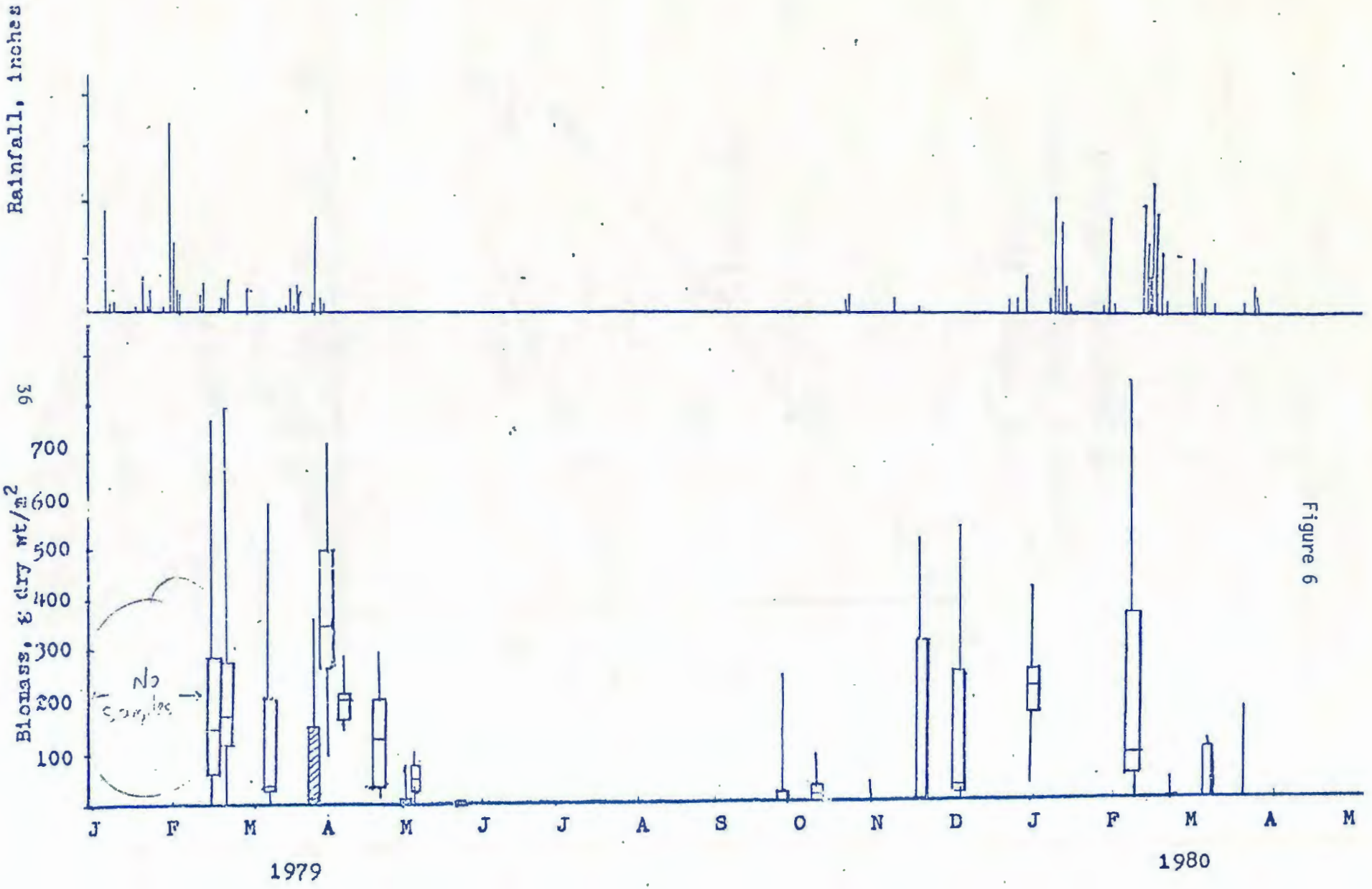

Rainfall, inches
Biomass, g dry wt/m2
100
200
300
400
500
600
700
No samples
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
1979
1980

Figure 6

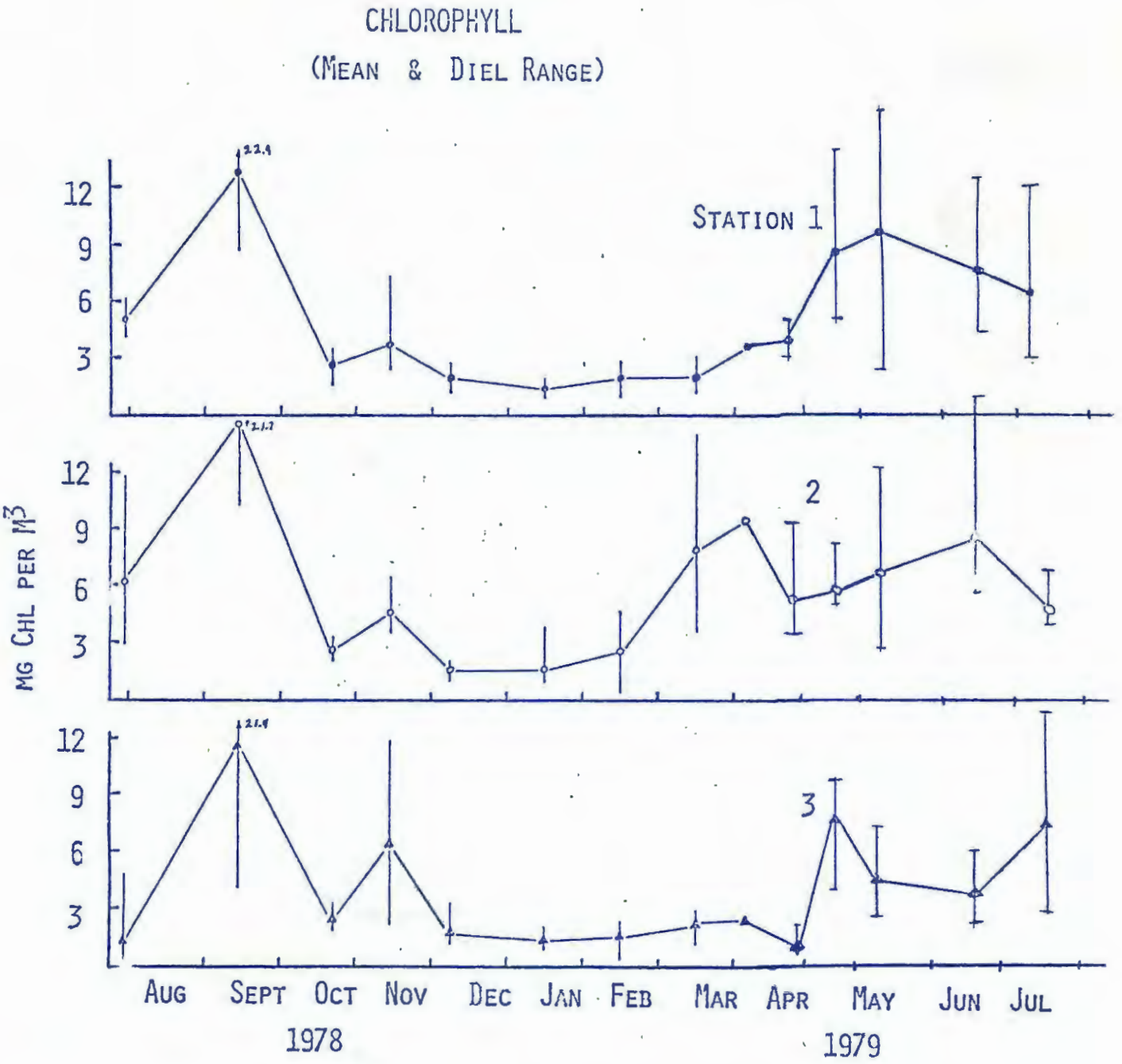

CHLOROPHYLL
(MEAN & DIEL RANGE)
STATION 1
2
3
MG CHL PER M3
12
9
6
3
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
1978
1979

Figure 7

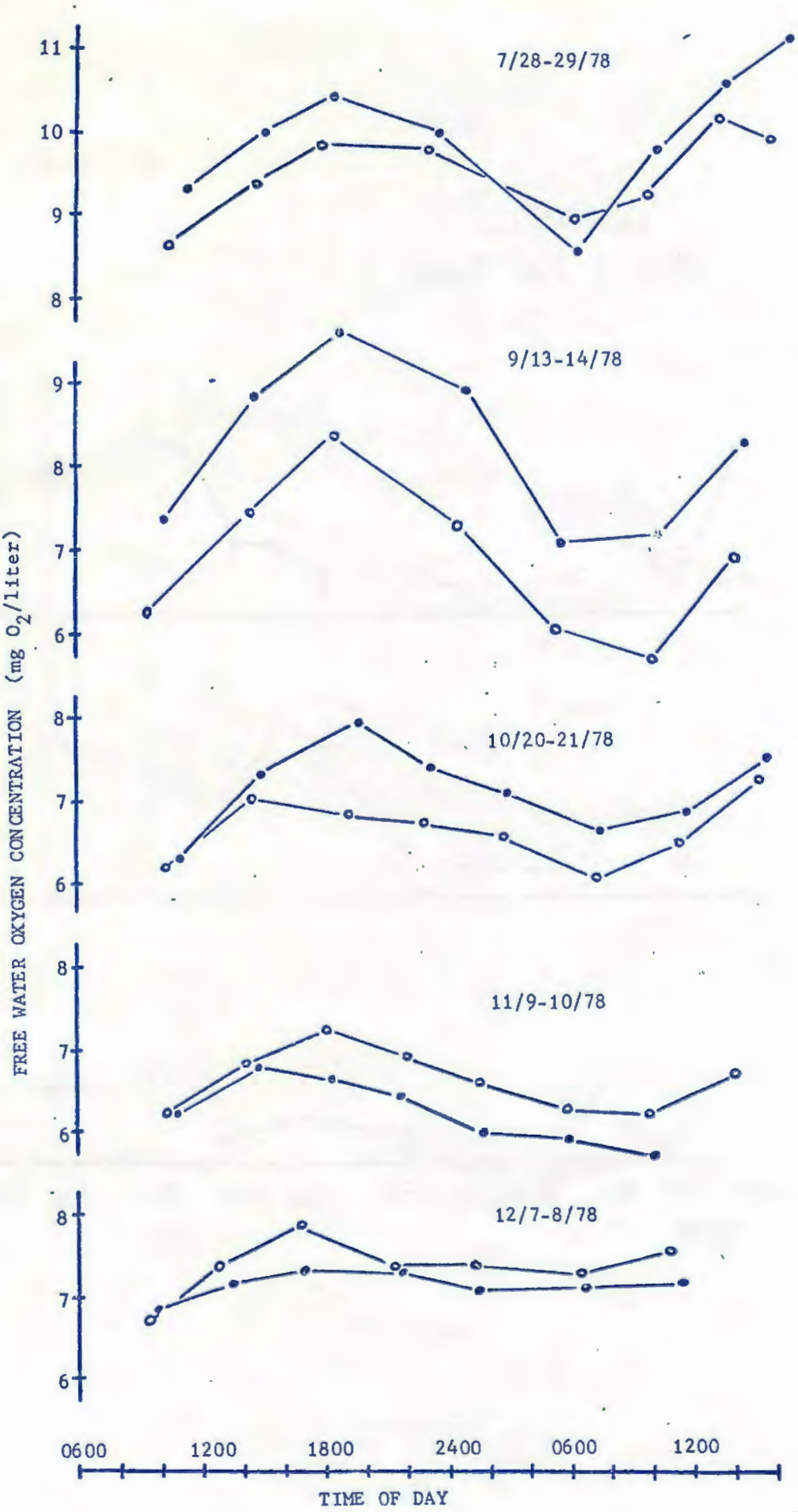
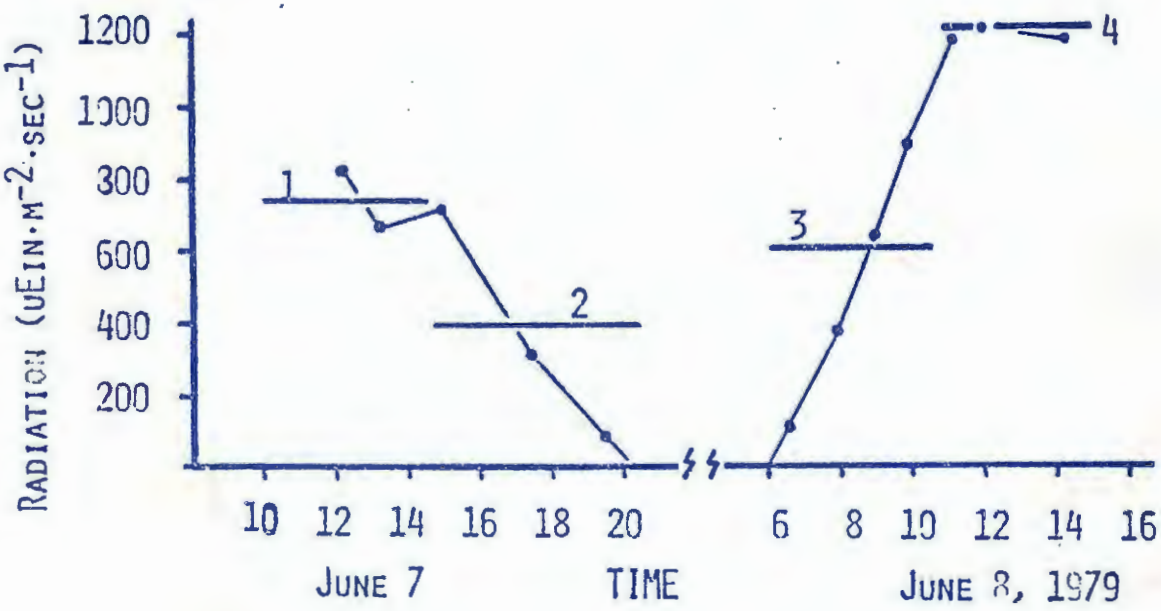

7/28-29/78
9/13-14/78
10/20-21/78
11/9-10/78
12/7-8/78
FREE WATER OXYGEN CONCENTRATION (mg O_2/liter)
TIME OF DAY
0600
1200
1800
2400
0600
1200

Figure 8


RADIATION (uEIN·M⁻²·SEC⁻¹)
1200
1000
300
600
400
200
1
2
3
4
10 12 14 16 18 20
6 8 10 12 14 16
JUNE 7
TIME
JUNE 8, 1979

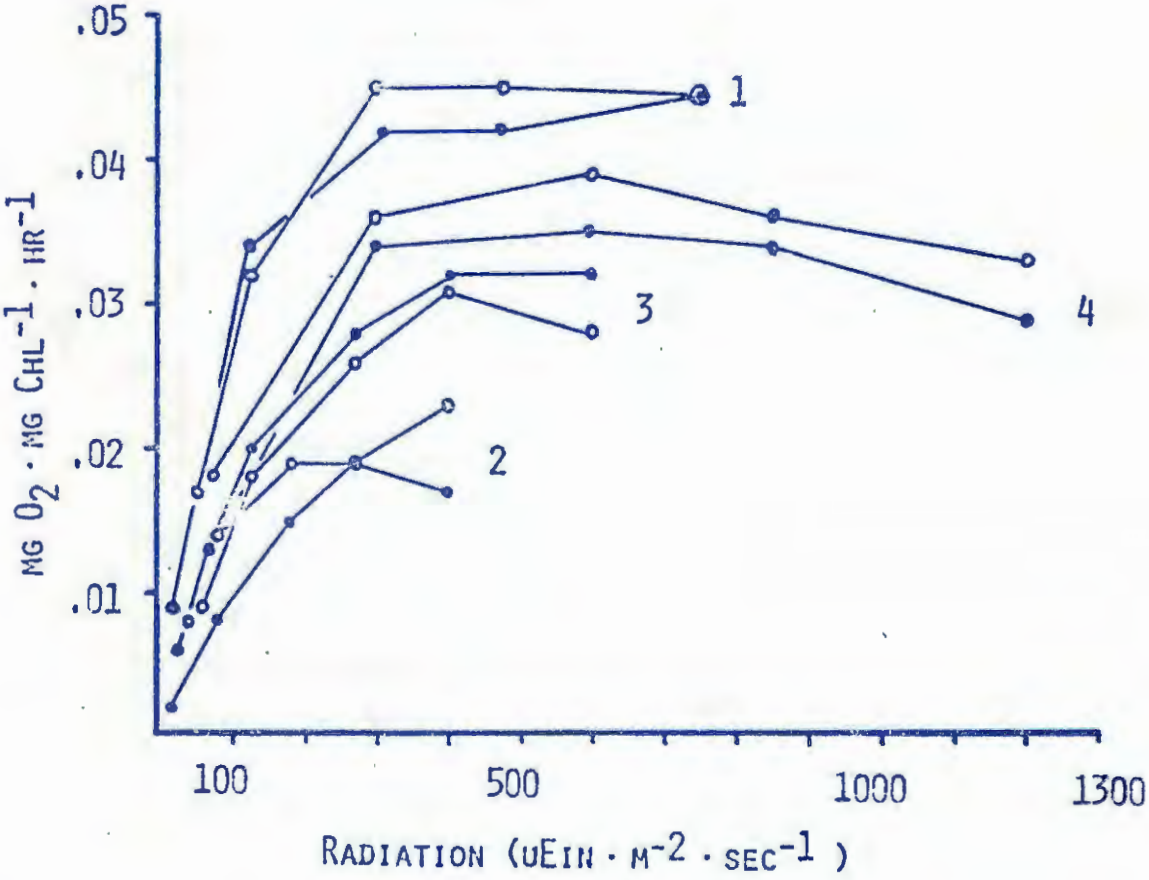

.05
.04
.03
.02
.01
MG O2 · MG CHL⁻¹ · HR⁻¹
1
2
3
4
100
500
1000
1300
RADIATION (uEIN · M⁻² · SEC⁻¹)

Figure 9

Figure 10

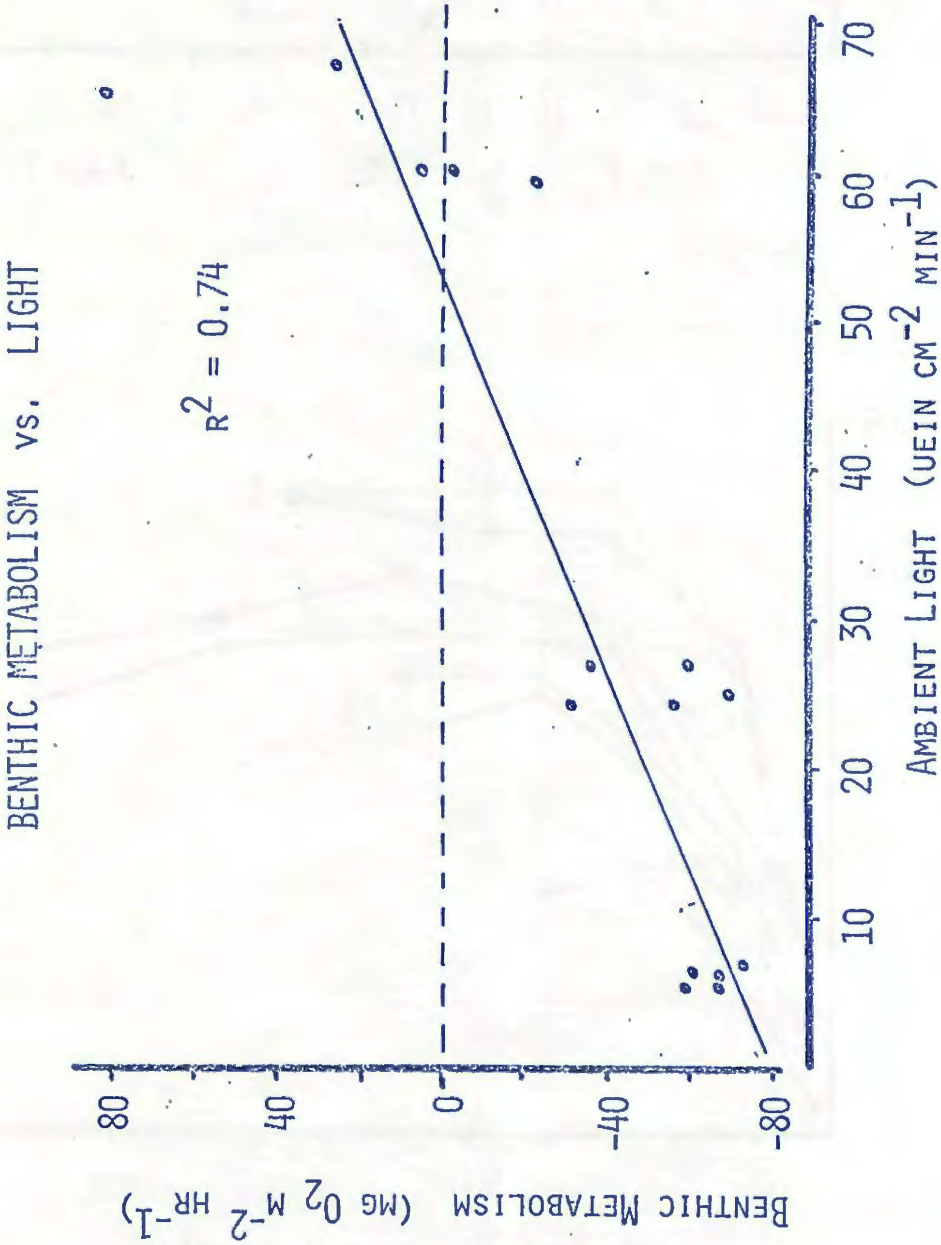
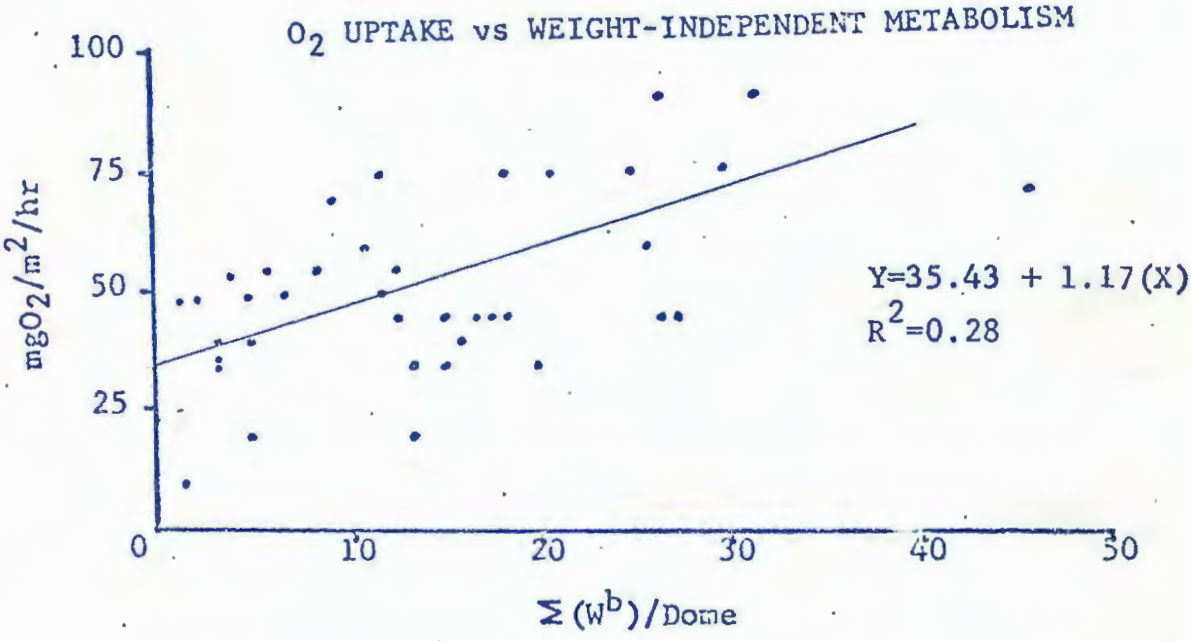

BENTHIC METABOLISM vs. LIGHT
$R^2 = 0.74$
BENTHIC METABOLISM (MG O_2 M^{-2} HR^{-1})
80
40
0
-40
-80
10
20
30
40
50
60
70
AMBIENT LIGHT (UEIN CM^{-2} MIN^{-1})

Figure 11


O_2 UPTAKE vs WEIGHT-INDEPENDENT METABOLISM
100
75
50
25
0
10
20
30
40
50
$mgO_2/m^2/hr$
$\Sigma (W^b)$/Dome
Y=35.43 + 1.17(X)
R^2=0.28

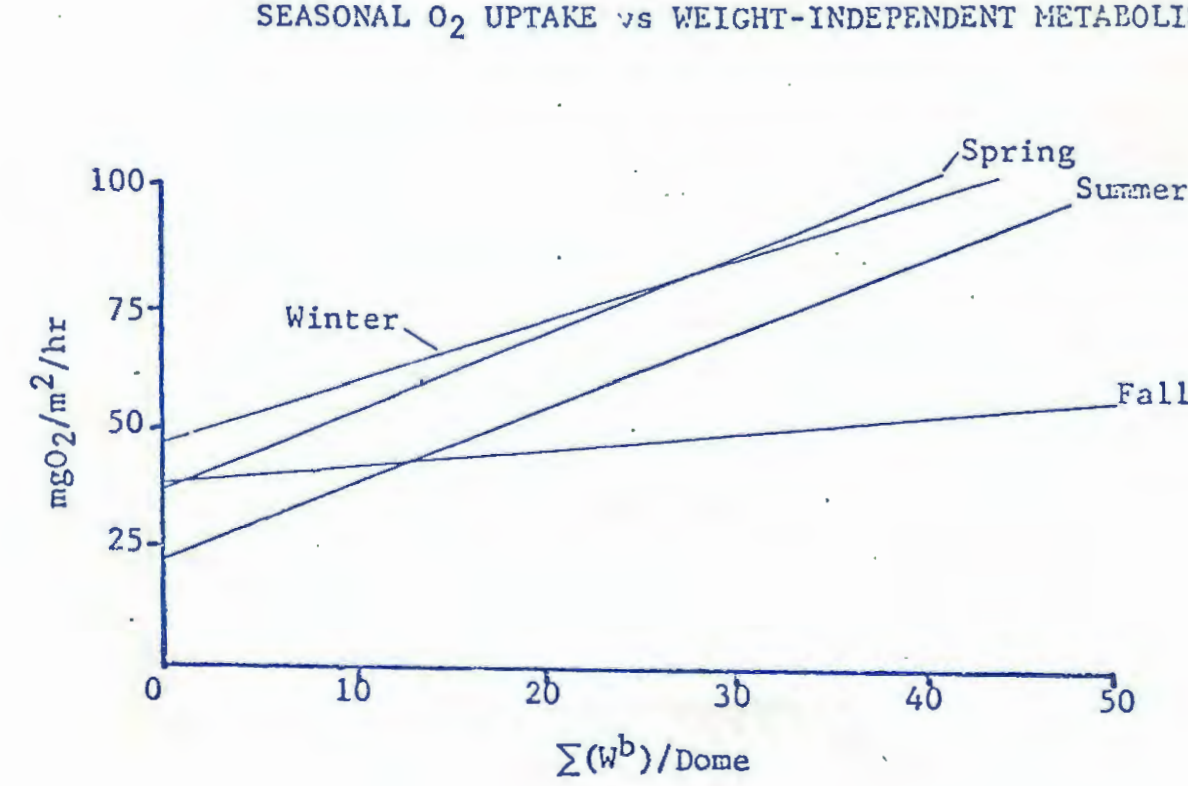
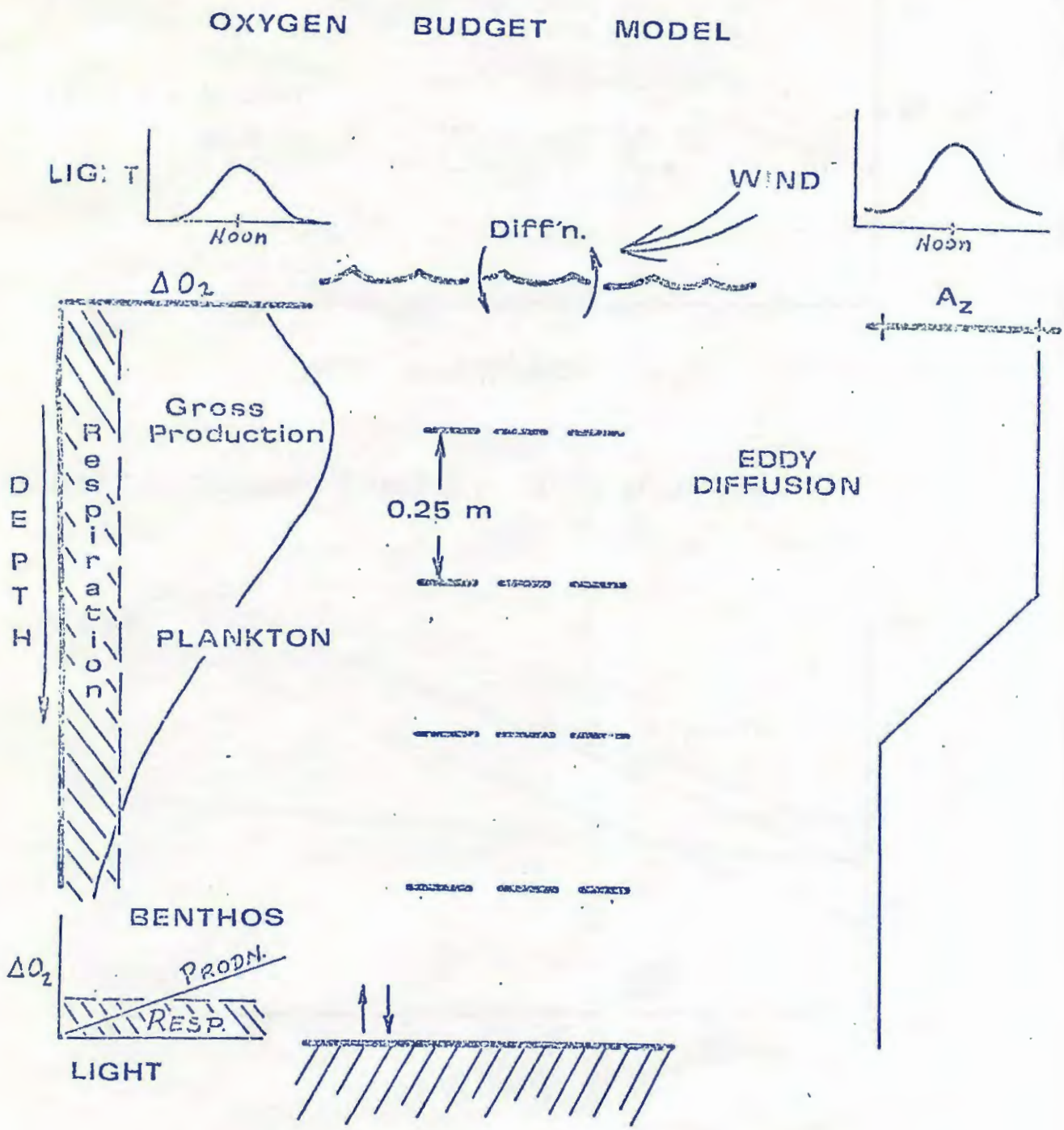

SEASONAL O_2 UPTAKE vs WEIGHT-INDEPENDENT METABOLISM
Spring
Summer
Winter
Fall
100
75
50
25
0
10
20
30
40
50
$mgO_2/m^2/hr$
$\Sigma (W^b)$/Dome

Figure 12


OXYGEN BUDGET MODEL
LIGHT
Noon
WIND
Noon
Diff'n.
ΔO_2
A_z
Gross Production
Respiration
DEPTH
0.25 m
EDDY DIFFUSION
PLANKTON
BENTHOS
ΔO_2
PRODN.
RESP.
LIGHT

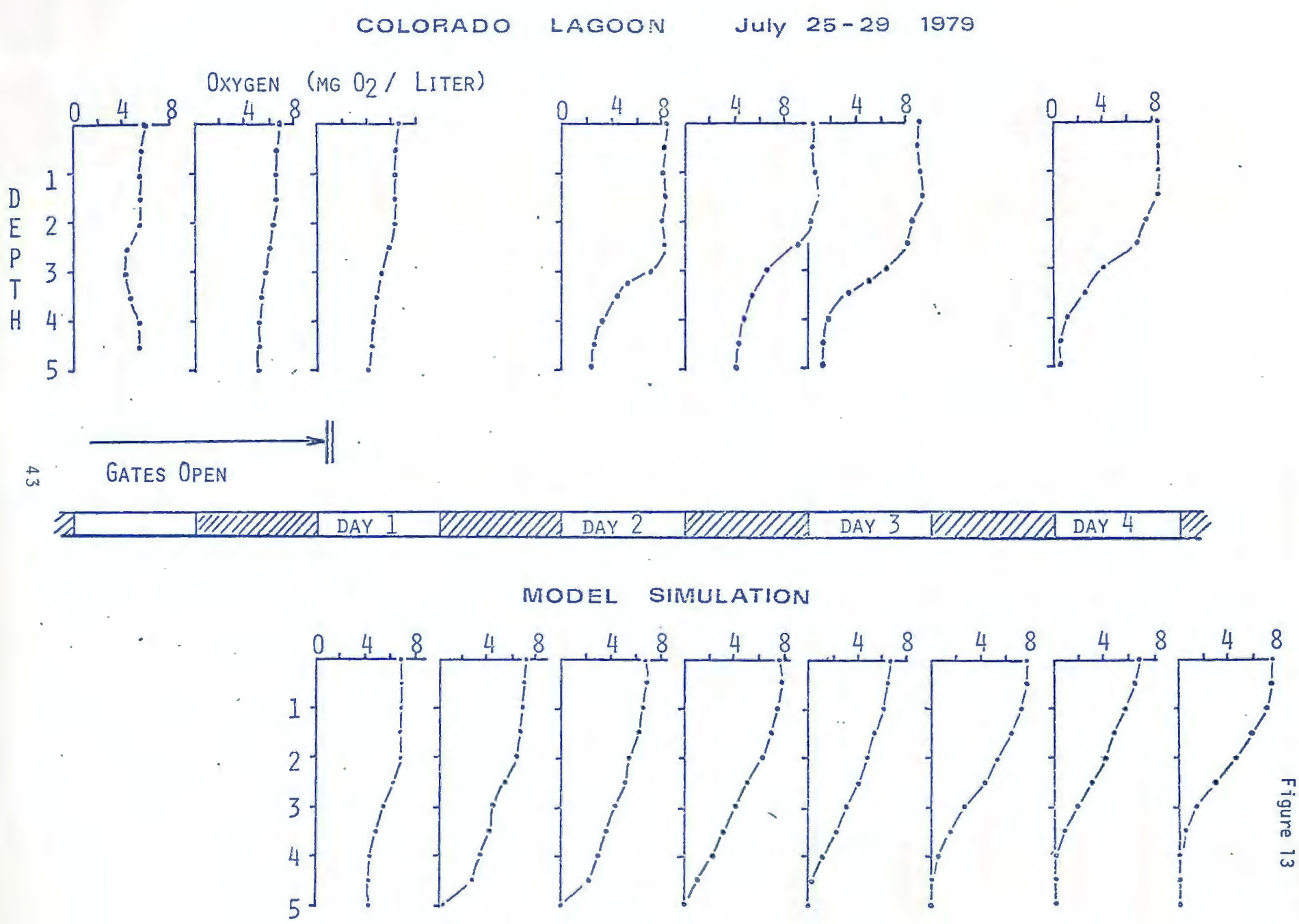

COLORADO LAGOON July 25-29 1979
OXYGEN (MG O_2 / LITER)
0 4 8
4 8
DEPTH
1
2
3
4
5
GATES OPEN
DAY 1
DAY 2
DAY 3
DAY 4
MODEL SIMULATION

Figure 13

The Role of Natural Populations of Microheterotrophs in Carbon Cycling in Southern California Coastal Waters

Cornelius W. Sullivan, Assistant Professor, Biological Sciences

Introduction

The basis of the cycling of carbon in marine ecosystems is considered to be one of the major themes of marine microbiology, a special case of biogeochemical cycles. Fortunately, in studies of organic cycling, the major questions being asked in applied research are similar if not identical to those asked in basic research; thus the work outlined here serves both ends.

With respect to applied research, microbiological studies have been identified by two agencies as essential (and previously lacking) components of Environmental Impact Report (EIR) for projects which the Environmental Protection Agency (EPA) and State Water Resource Control Board (SWRCB) evaluated for the potential for water quality enhancement. The two projects of greatest concern to the study area are the Terminal Island Effluent Proposal, Project No. C-06-1202, and the Tuna Canneries Association disposal problems.

In correspondence forwarded by Raymond Hertel of the Regional Water Quality Control Board, the Environmental Analysis Section (EAS) Critique, through Raymond Walsh, has stated:

> APPENDIX E, part II. In the marine environment, the utilization of dissolved organics by microorganisms, through consumer heterotrophic pathways, could be important to nutrient recycling and detrital food webs.

And Appendix C, part II, in reference to proteins and amino acids in effluent:

> Work is necessary to determine how much of this total protein is actually available to marine organisms and after determining how much is available, work is necessary to determine how much of the available protein, if any, is actually utilized.

I agree with both statements, and this proposed investigation addresses both of these ideas and several others.

Results

Our progress has been excellent; we have been able to keep pace with our projected goals and time schedules and in some cases surpass them. Our field experimental findings have resulted in the presentation of six abstracts at national and international meetings, and we currently have three papers in review or in press in referreed journals. In reviewing our progress, it is essential

to keep in mind the major hypotheses which we are attempting to test and the six basic questions which we believe must be answered in order to properly test them. The hypotheses are included here from the original proposal: (1) that organic enrichment of the coastal waters results in elevated standing stock of microheterotrophs; (2) that the assimilation capacity of coastal waters is directly related to standing stocks of microheterotrophs and their metabolic activity; (3) that the microheterotrophs provide a potential food source for organisms at higher levels.

Six basic questions must be answered to test these hypotheses:

1. What is the standing stock or biomass of marine microheterotrophs in coastal waters?

2. At what rates do microheterotrophs cycle the available organic nutrients?

3. Which organic compounds are being utilized by the natural microbial populations?

4. What is the turnover time of the nutrients?

5. What is the turnover time of the microbial community?

6. Are marine microheterotrophs potential or real food sources for organisms at higher trophic levels; if so, at what rates are they utilized?

Our efforts to answer these questions through our research in Los Angeles Harbor and southern California coastal waters with a battery of modern techniques have demonstrated several remarkable features of the microplankton community, particularly with regard to their dynamic catalytic nature:

1. Organisms which pass through a 1 μm pore size membrane filter (Nuclepore) account for approximately 20% of the microplankton (ATP) biomass.

2. This size fraction (1 μm) contains 18% of the chlorophyll a but more than 80% of the bacteria in the water column.

3. This bacterial-enriched fraction is responsible for the uptake of 50 to 95% of the radiotracer molecules which are added directly to the seawater samples and incubated under simulated in situ conditions.

4. The uptake of these radiochemical compounds is biologically mediated and requires ongoing energy metabolism by the microplankton.

5. The radiochemical compounds are taken up and efficiently concentrated even when present at extremely low concontrations 10^{-6} to 10^{-12} mole/liter; concentration factors range from 1840 to 92,000-X.

6. These particular compounds are taken up and metabolized very rapidly. Turnover times generally are on the order of 2 to 24 hr.

7. The organisms responsible for the uptake of the radiolabelled compounds themselves enter the food web rapidly as a result of grazing by bactivorous and phytoplanktivorous plankton at higher trophic levels.

In addition to the detailed characterization of the metabolic capabilities of the microplankton in these waters, we have examined the larger picture of microplankton cycling of carbon by analyzing our cumulative data base in relation to the total volume of effluent output and monthly mean biochemical oxygen demand (BOD) output from the Terminal Island Treatment Plant as reported to the City of Los Angeles in: Terminal Island Treatment Plant, Annual Reports 1978-79, NPDES Permit No. CA0053856 (File No. 2171). This data is presented in Figure 1, and it illustrates the dynamic relationship between one of the carbon nutrient input sources (TITP) and one carbon-nutrient sink bacterioplankton and phytoplankton for the Los Angeles Harbor during two successive years. The most notable feature of this data is the consistent rise of phytoplankton and bacterioplankton standing stocks which closely follow large but transient episodes of waters with high BOD which occur in each of the two years that samples were taken. It would, however, be premature to conclude a tightly coupled cause and effect relationship between the release of these effluents and the dramatic rise in microplankton standing stocks. This is especially true because of the relative time scale of these events; samples were taken at monthly intervals. Since response of bacterioplankton growth rates would be expected on a time scale of hours or days and for phytoplankton days or weeks, I believe a more detailed evaluation of these parameters, say on a daily basis for a week or a month, would allow us to establish a more sound cause and effect relationship of these notable features of the Los Angeles Harbor ecosystem.

I propose to investigate this relationship during the upcoming year of Sea Grant support.

Project Communications

1. G. Taylor and C. W. Sullivan. 1979. The ingestion and utilization of ^{14}C-labeled marine bacteria by bactivorous plankton from Los Angeles Harbor and Southern California coastal waters. Am. Soc. of Limn. and Ocean., 42nd ann. mtg., Stony Brook, N.Y. June 18-21.

2. S. McGrath and C. W. Sullivan. 1979. Community metabolism of total adenylates by the microorganisms of the Los Angeles Harbor and southern California coastal waters. Am. Soc. Limn. and Ocean., 42nd ann. mtg. Stony Brook, N.Y., June 18-21.

3. L. Herold and C. W. Sullivan. 1980. The uptake of vitamin B12 by natural marine plankton populations. Am. Soc. Limn. and Ocean. Winter mtg., Los Angeles, Ca. Jan. 31-Feb. 4.

4. D. W. Krempin and C. W. Sullivan. 1980. The assimilation of phosphate by microplankton of southern California coastal waters. Am. Soc. Limn. and Ocean. Winter mtg., Los Angeles, Ca., Jan. 31 - Feb. 4.

5. A. C. Palmisano and C. W. Sullivan. 1980. The fate of $^{51}Cr(III)$ in sea water: Uptake by microorganisms and molecular filtration of the dissolved fraction. Am. Soc. Limn. and Ocean. Winter mtg., Los Angeles, Ca. Jan.31 - Feb. 4.

6. S. McGrath and C. W. Sullivan. 1981. Community metabolism of adenylates by microheterotrophs from the Los Angeles Harbor and southern California coastal waters. Marine Biology (in press).

7. D. Krempin, S. McGrath, J. SooHoo, and C. W. Sullivan. 1981. Orthophosphate uptake by bacterioplankton and phytoplankton from the Los Angeles Harbor and southern California coastal waters. Marine Biology (in press).

8. C. W. Sullivan, L. Herold, D. Krempin, S. McGrath, A. Palmisano, and J. SooHoo. 1980. The flux of dissolved materials into marine microbial plankton on southern California coastal waters. Int. Symp. of Microb. Ecol., Univ. of Warwick, England. September 7-12 1980.

9. G. Taylor and C. W. Sullivan. 1981. Ingestion and utilization of ^{14}C-labeled marine bacteria by higher trophic organisms from Los Angeles Harbor and southern California coastal waters. Marine Biology (in preparation).

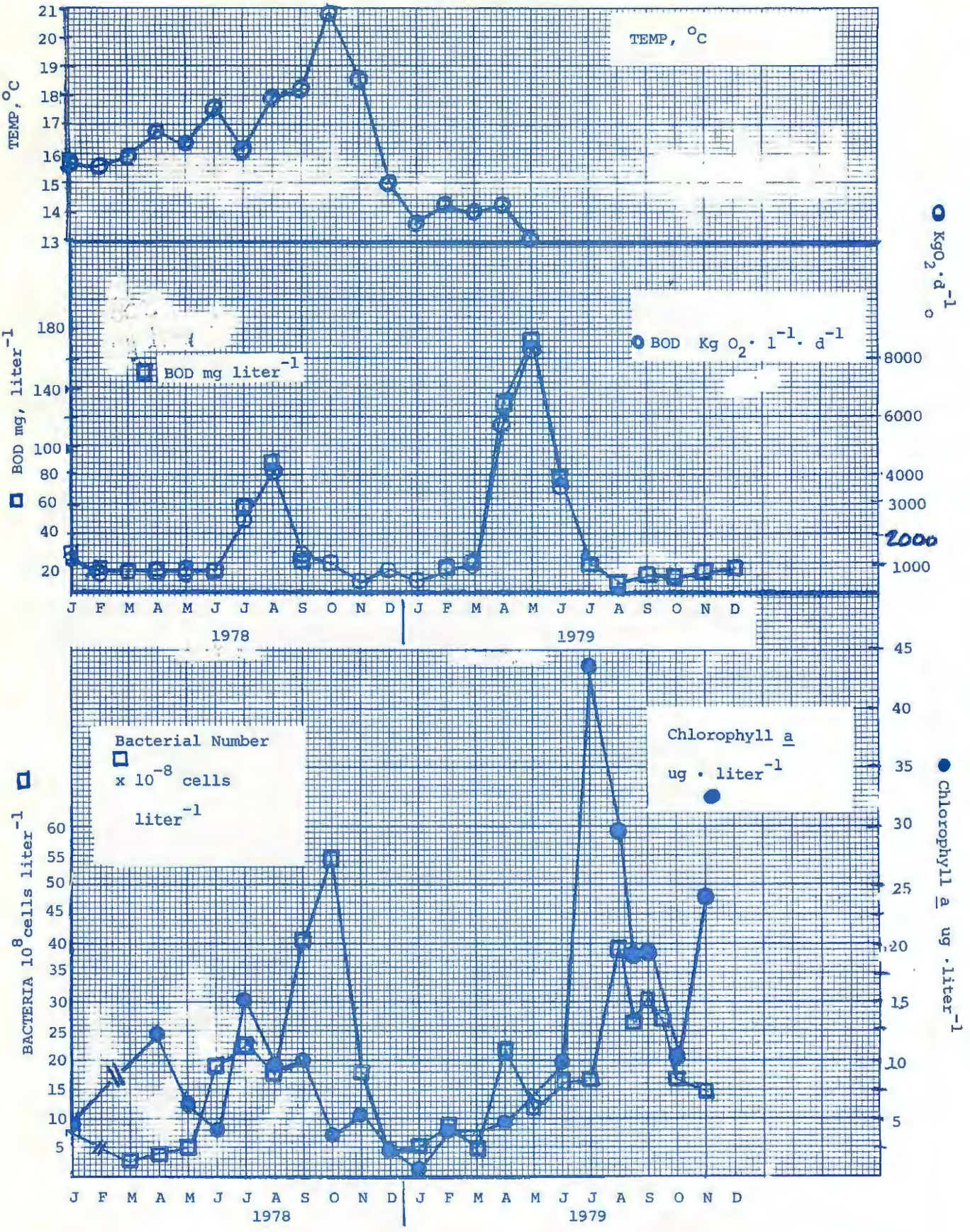

TEMP, °C
TEMP, °C
BOD mg liter⁻¹
BOD Kg O₂ · l⁻¹ · d⁻¹
Kg O₂ · d⁻¹
J F M A M J J A S O N D J F M A M J J A S O N D
1978
1979
Bacterial Number
x 10⁻⁸ cells
liter⁻¹
Chlorophyll a
ug · liter⁻¹
BACTERIA 10⁸ cells liter⁻¹
Chlorophyll a ug · liter⁻¹

Figure 1

Southern California's Nearshore Environment: A Significant Fish Nursery

Gary Brewer, Senior Research Scientist, Institute of Marine and Coastal Studies; Robert J. Lavenberg, Curator, Section of Ichthyology, Los Angeles County Museum of Natural History, and Adjunct Associate Professor, Biological Sciences

Introduction

The marine environment off southern California is unique among Pacific coast regions of the United States because of its recreational and commercial fisheries and its potentially conflicting use as a major repository of waste from adjoining industrial and population centers. The impacts of thermal and chemical wastes on these fisheries and potential problems of ichthyoplankton entrainment by 15 existing electrical generating plants and a proposed liquified natural gas (LNG) vaporization facility cannot be assessed without understanding the relative contribution of nearshore habitats as spawning and nursery areas.

The information needed to make such assessments includes data on the species composition, abundance, and the spatial and temporal distribution of fish eggs and larvae in shallow waters.

The Ichthyoplankton Coastal and Harbor Studies (ICHS) program adopted a sampling scheme beginning in June 1978 that would provide a broad perspective of ichthyoplankton dynamics in the nearshore southern California bight (Figure 1). The value of such surveys from a fishery biologist's perspective can be gleaned from the widely held premise that "There is no better technique for fishery resource evaluation than systematic larval surveys" (Ahlstrom,1965). To these ends, the sampling techniques adopted by ICHS were patterned after procedures used by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) in their surveys for eggs and larvae (Kremer et al., 1972; Smith and Richardson, 1977). In fact, a goal in the design of our sampling strategy and data management objectives was compatibility and information integration between the ICHS nearshore surveys and the offshore CalCOFI data.

Our overall goal has been to assess the importance of developed and undeveloped nearshore habitats in southern California as resources for the larvae of coastal marine fishes. In order to achieve this goal, each year's objectives have included efforts to: (1) sample monthly along transects over shallow bottom depths between Point Conception and San Diego with plankton nets towed obliquely (i.e., throughout the water column) and at discrete depths (neuston, mid-depth, and epibenthic); (2) record abiotic parameters (including temperature, salinity, pH, and dissolved oxygen) and measure chlorophyll a at each station; (3) identify and enumerate ichthyoplankton from all oblique tows and from representative discrete depth tows; (4) update and revise our computer data entry and retrieval system; (5) reevaluate objectives, performance of each type of sampling gear, and each sampling technique, and make adjustments as necessary or desirable.

Results

After 26 consecutive monthly sampling periods, ICHS completed its final bightwide cruise during July 1980. Since June 1978, we have collected and preserved more than 3,500 plankton samples, processed several hundred water samples for nutrient analysis, analyzed thousands of samples for chlorophyll a, and recorded tens of thousands of abiotic parameters. This unprecedented sampling record of the nearshore southern California bight is not only providing information on fish spawning and nursery functions but on general oceanographic phenomena as well.

Our efforts during the past Sea Grant year have been concentrated on collecting and analyzing data for the months of August 1979 - July 1980. During that 12-month period, 1,536 plankton tows were completed on board the Sea Watch. While the plankton samples from each month differ in required processing time because of variable plankton volumes, as of October 1980 our sorting-identification laboratory is completing well over 100 samples per month.

Major improvements in our techniques for storing and retrieving data were made during this past year. Data from each monthly cruise is now verified, compiled, and summarized on printouts within one week of sample completion for each cruise. Table 1 is an example of such a printout and includes scaled estimates of taxa per unit volume, unit area, and census estimates in "blocks" surrounding each station. We are experimenting with a variety of ways to graphically depict ichthyoplankton distribution and abundance, including three-dimensional plots (Figures 2 and 3).

We recently presented a paper at the annual CalCOFI Conference that summarizes the results of our nearshore studies to date. The paper is summarized below:

Monthly surveys between June 1979 and July 1980 revealed salient oceanographic features of the region between Point Conception and San Diego that included significant changes in the thermal structure of nearshore waters over bottom depths from 8 m to 36 m.

Warming and thermal stratification were characteristic of summer months with surface to bottom temperature differentials sometimes exceeding 10°C. From October through February, surface temperatures generally decreased while bottom temperatures remained relatively constant. By January, surface to bottom temperatures throughout the bight were virtually uniform at 15 + 1°C. A rapid decline in bottom water temperatures (to 10.2°C) during March and continuing through June, and corresponding increases in nitrate, chlorophyll a, and zooplankton concentrations indicated major upwelling events occurred during this period.

Highest densities of chlorophyll a and zooplankton along with higher temperatures were generally associated with stations over the shallower bottom depths.

During summer and fall months, highest densities of fish eggs and larvae occurred at stations over shallow bottom depths. During winter and spring, higher concentrations of ichthyoplankters were found over deeper stations. These differences reflected changes in the taxa represented and perhaps offshore transport of nearshore surface waters.

Ichthyoplankton in nearshore bight waters was dominated by northern anchovy (*Engraulis mordax*). Northern anchovy were least abundant during the late summer and fall when temperatures were highest and declining. Maximum numbers of *Engraulis* eggs and larvae occurred during the isothermal phase and up to and including the initiation of upwelling. White croaker (*Genyonemus lineatus*) and the rockfishes (*Sebastes* spp.) showed similar seasonal trends in relative abundance.

Queenfish (*Seriphus politus*), the basses (*Paralabrax* spp.), Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symetricus*), barracuda (*Sphyraena argentea*), and butterfish (*Peprilus simillimus*) were abundant during periods when *Engraulis* spawning was minimal. Data on other taxa including California halibut (*Paralichthys californicus*) and hornyhead turbot (*Pleuronichthys verticalis*) suggest two or more modal peaks in larval abundance.

An interesting feature of our analyses to date is the rank order abundance of the nearshore ichthyoplankton taxa (Table 2). While only the months of August - April are represented, comparison to 1975 CalCOFI data for the southern California zone show only one taxa is common to the top ten rankings of both surveys (date from V. Loeb, 1980 CalCOFI Conference). The differences exemplify our premise that the icthyofauna of the coastal zone is distinctive from that of offshore waters.

It is clear that the shallow southern California bight is relatively more productive (chlorophyll and zooplankton volumes) than offshore waters, and that the nearshore offers certain conditions for spawning and survival of fishes that are not available in deeper waters. Whether these conditions are simply the availability of shallow bottom substrate in which or on which to deposit eggs (as in the clinids, atherinids, cottids, and blennids) or whether prey availability (certain phytoplankters and microzooplankters) or predatory pressure (from larger invertebrates and fish) are more favorable is not known. Certain taxa that spawn planktonic eggs such as some sciaenids seem to be restricted to shallow waters. Other taxa that spawn planktonic eggs are wide-ranging offshore as adults, but still spawn during all seasons (i.e., *Engraulis mrodax*) or one season (*Scomber japonicus* and *Sphyraena argentea*) in nearshore areas. We hope to determine if those individuals spawned in the nearshore waters have distinct survival advantage over other individuals of the same taxa that are spawned offshore.

Despite the distinctive environmental conditions and resulting fish fauna that are found in the nearshore waters, it is obvious from the ICHS temperature, nutrient, and chlorophyll data that shallow waters to the 8-m isobath, at least, are still very much a product of the major oceanographic and meterological processes that operate well beyond the area surveyed by ICHS. Hence, the dynamics of these nearshore waters can be understood only by relating our data to phenomena that occur within the entire California Current System.

Project Communications

Publications:

Brewer, G. and D. Cooksey. 1979. The biology of the northern anchovy in relation to its biomass utilization. Biosources Digest 1(2):115-129.

Reports:

Brewer, G., R. Lavenberg and G. McGowen. 1979. Abundance and vertical distribution of fish eggs and larvae in the southern California bight: June and October 1978. Report to Southern California Edison, Research and Development Series: 79-RD-20.

Meetings:

California Cooperative Oceanic Fisheries Investigations: annual meeting 31 October - 2 November 1978.

Brewer, G., R. Lavenberg, G. McGowen. The University of Southern California's Ichthyoplankton Coastal and Harbor Studies (ICHS): Techniques and Preliminary Observations.

International Symposium on the Early Life History of Fishes - International Council for the Exploration of the Sea, Marine Biological Laboratory, Woods Hole, Mass., 2-5 April 1979.

Brewer, G., R. Lavenberg, and G. McGowen. Abundance and vertical distribution of fish eggs and larvae in the southern California Bight: June and October 1978.

McGowen, G. Composition, distribution, and seasonality of ichthyoplankton populations near an electricity generating station in south San Diego Bay, California.

Southern California Academy of Sciences, Annual Meeting, California State University Northridge, 11-12 May 1979.

Ninos, M. Distinguishing characters of the late pelagic larvae of *Hypsoblennius* in southern California.

California Cooperative Oceanic Fisheries Investigations; Annual Meeting, 22-25 October 1979.

Brewer, G., G. McGowen, and R. Lavenberg. Nearshore distribution of ichthyoplankton in the southern California bight.

Watson, W.,and G. McGowen. Identification of the atherinid larvae in the southern California bight.

California Cooperative Oceanic Fisheries Investigations: Annual Meeting, 20-23 October 1980.

Brewer, G., G. McGowen, and R. Lavenberg. Oceanographic features and associated ichthyoplankton distribution in the shallow southern California bight.

American Society of Zoologists: Annual Meeting, Seattle, Washington, 27-30 December 1980.

Brewer, G., R. Lavenberg, and G. McGowen. Fish reproduction in the nearshore southern California bight.

Dissertations:

Ninos, M. Larval distribution, settlement, and associated morphological and behavioral changes in three co-occurring species of the genus *Hypsoblennius* (in preparation).

Literature Cited

Ahlstrom, E. 1965. Kinds and abundance of fishes in the California Current region based on egg and larval surveys. Calif. Coop. Oceanic Fish. Invest., Rept. 10:31-52.

Kramer, D., M. Kalin, E. Stevens, J. Thrailkill, and J. Zweifel. 1972. Collecting and processing data on fish eggs and larvae in the California Current Region. NOAA Technical Report NMFS Circ. 370, 38 p.

Smith, P. and S. Richardson. 1977. Standard techniques for pelagic fish egg and larva surveys. FAO Fish. Tech. Pap. (175), 100 p.

Table 1. Example of computer print-out of station data with scaled estimates of ichthyoplankton abundance.

22/10/80

ICHS IDENTIFICATION VERIFICATION

Oblique Bongo 024 — 80 — 08 — 08 — 03

Haul fact: 0.688 Vol. strained: 116.32 Collection Date: 22/05/80 Time: 00:01

TAXON		est. # in sample	# per 1000 cu. m.	# per 10 sq. m.	# in area (millions)
Displacement volume	(ml.)	20.	171.94	13.75	23.3
Total Eggs (0104860000000)	Eggs	3,488.	29,986.24	2,398.70	4,057.5
Engraulis mordax (0104020203010)	Eggs	8.	68.78	5.50	9.3
Unknown eggs (0104980000000)	Eggs	3,480.	29,917.47	2,393.20	4,048.2
Total Larvae (0104880000000)	Larvae	116.	997.25	79.77	134.9
Atherinopsis californiensis (0104060502010)	Larvae	4.	34.39	2.75	4.7
Engraulis mordax (0104020203010)	Larvae	12.	103.16	8.25	14.0
Gobiidae-Type A (0104091294000)	Larvae	8.	68.78	5.50	9.3
Hypsoblennius (0104091101000)	Larvae	16.	137.55	11.00	18.6
Oxyjulis californica (0104090802010)	Yolk-sac	4.	34.39	2.75	4.7
Seriphus politus (0104090407010)	Larvae	60.	515.82	41.26	69.8
Typhlogobius californiensis (0104091213010)	Larvae	12.	103.16	8.25	14.0

* * * *

Table 2. Rank abundance of larval taxa based on monthly bightwide estimates to the 29-m isobath (August 1979-April 1980 only).

August-April Overall Rank	Sum of monthly bightwide estimates to 29-m depth (x 10^6)	Percent of total
Engraulis mordax (northern anchovy)	853,651	61.3
Genyonemus lineatus (white croaker)	312,200	22.4
Seriphus politus (queenfish)	25,362	1.8
Paralichthys californicus (California halibut)	15,218	1.1
Gobiidae type A/C (gobies)	13,357	1.0
Sardinops sagax caeruleus (Pacific sardine)	11,509	0.8
Peprilus simillimus (Pacific butterfish)	8,802	0.6
Paralabrax (sea basses)	7,322	0.5
Gobiidae type D (goby)	6,127	0.4
Hypsoblennius (blennies)	5,155	0.4
Citharichthys (sanddabs)	3,320	0.2
Pleuronichthys verticalis (hornyhead turbot)	2,919	0.2
Sebastes (rockfishes)	2,798	0.2
Chromis punctipinnis (blacksmith)	2,050	0.1
Scomber japonicus (Pacific mackerel)	2,043	0.1
Triphoturus mexicanus (Mexican lampfish)	1,794	0.1
Pleuronichthys ritteri (spotted turbot)	1,715	0.1
Hypsopsetta guttulata (diamond turbot)	1,499	0.1
Parophrys vetulus (English sole)	1,443	0.1
Sphyraena argentea (California barracuda)	1,375	0.1

Figure 1. Locations of ICHS transects and additional stations in the Los Angeles Harbor and San Diego Bay that have been sampled for ichthyoplankton.

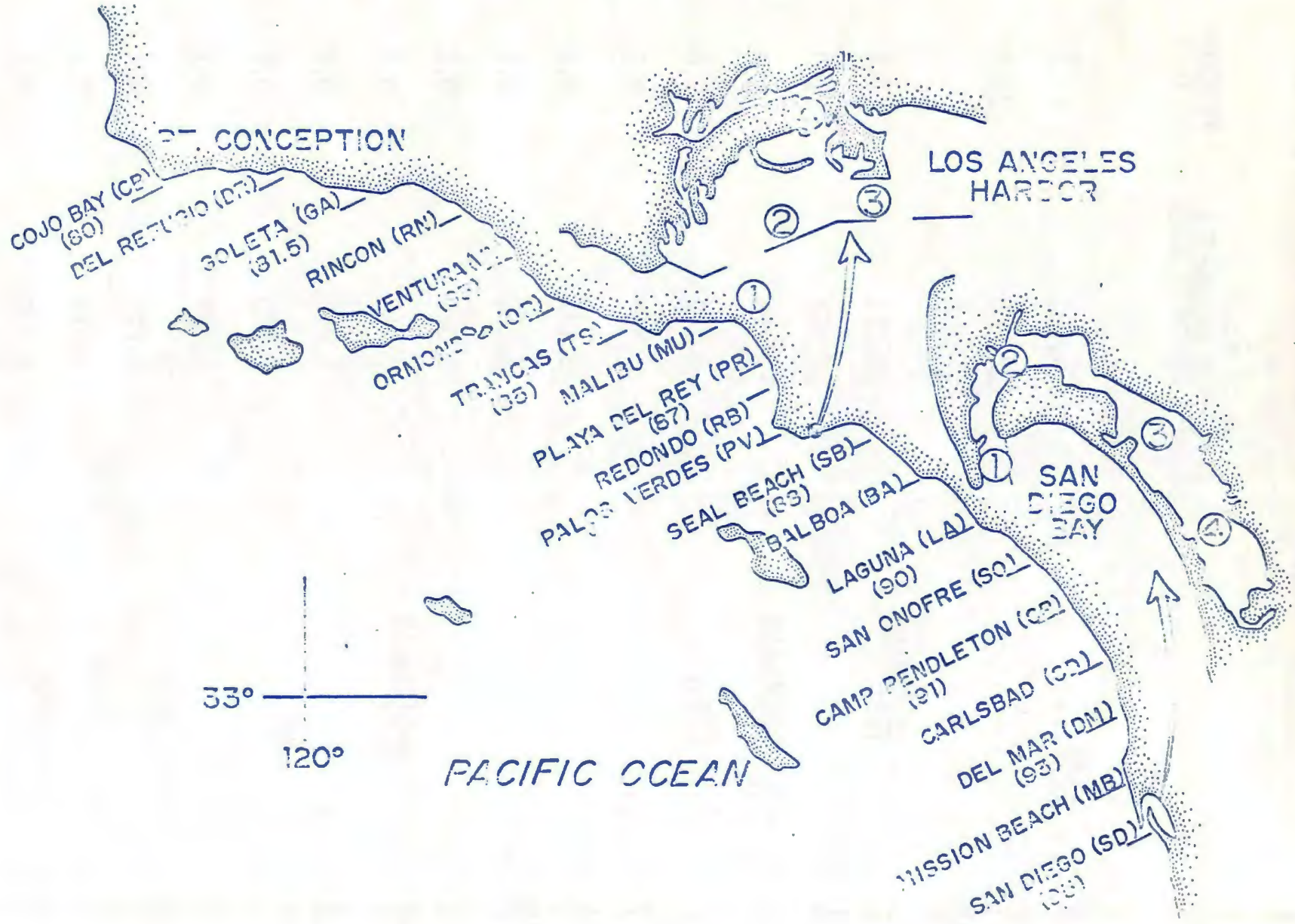


Figure 2. Example of three-dimensional computer graphic of ichthyoplankton abundance by transect and month (northern anchovy eggs).

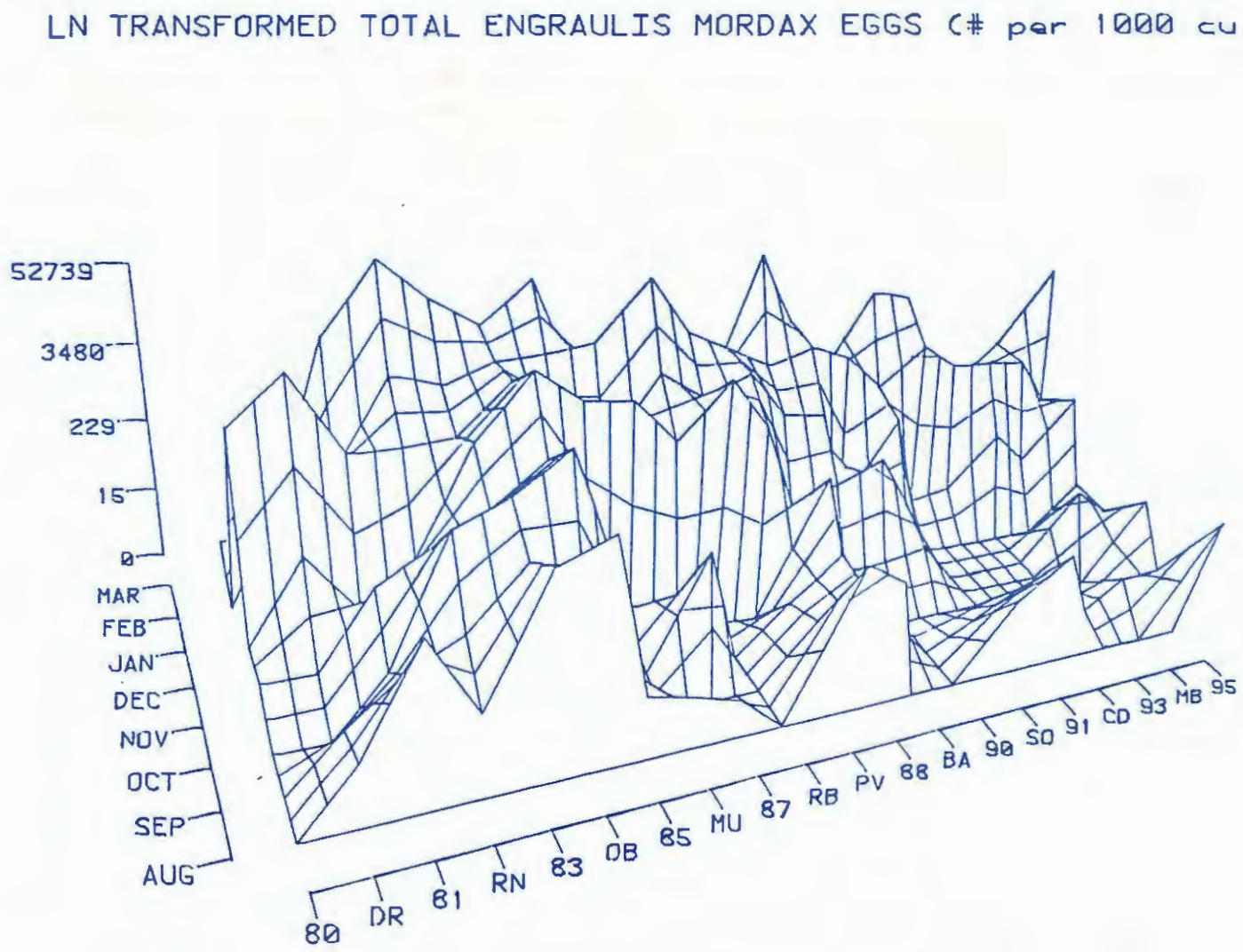
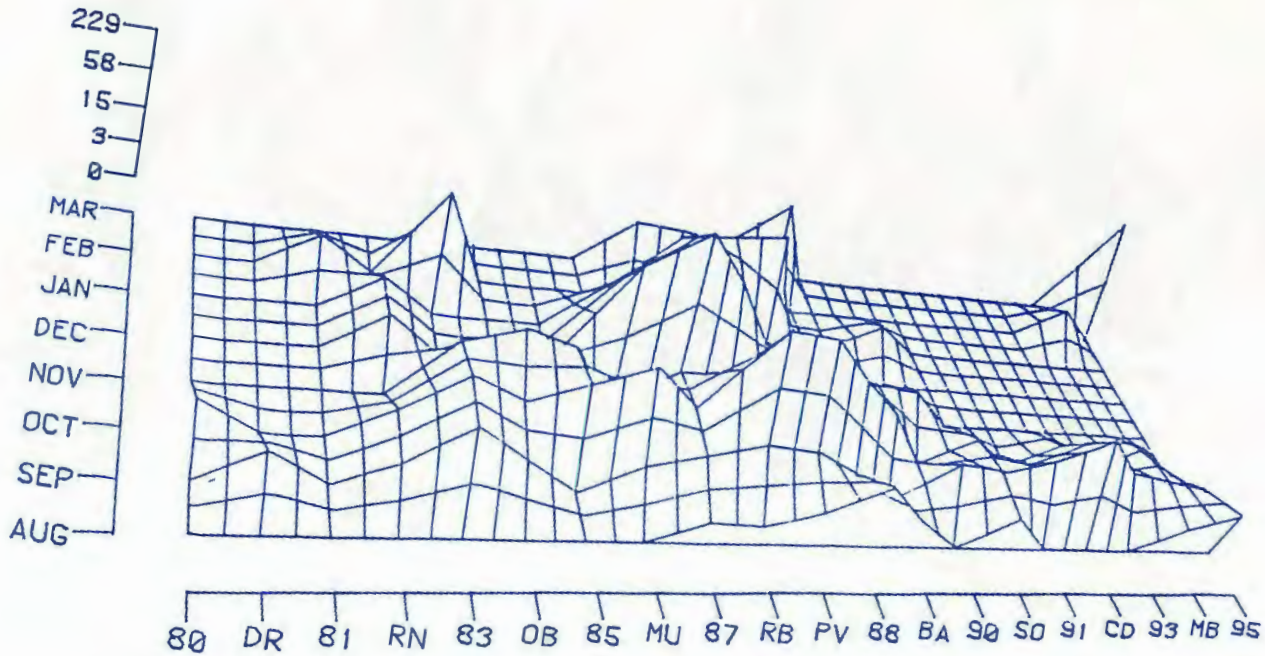


Figure 3. Example of three-dimensional computer graphic of ichthyoplankton abundance by transect and month (Pacific sardine larvae).



Sediment Accumulation and the History of Pollutant Accumulation in San Francisco Bay

Douglas Hammond, Assistant Professor, Geological Sciences

Introduction

The welfare of southern California is dependent in many ways on the management of water resources in the San Joaquin-Sacramento River drainage basin. At present this system provides a significant fraction of the water necessary for agricultural and municipal use in southern California. As California's share of Colorado River water is reduced in the coming decade, this system will become an increasingly important source of water for southern California. This diversion of water from its natural drainage basin in likely to impact San Francisco Bay in several ways which will affect the management of pollutant releases in this drainage basin. However, the impacts of water diversion can only be predicted by understanding the operation of the system at present. This project has focused on studying the dynamics of particles in San Francisco Bay and their role in removing pollutants from the water column.

The overall goals of this project are: (1) to determine the residence time of particulates and their associated pollutants in the water column; (2) to determine the rate at which particulates are added to and resuspended from the bottom; (3) to identify patterns and rates of recent sediment accumulation; (4) to construct a budget for suspended sediments in the bay as a whole, including dredge material; and (5) to determine the importance of bay sediments as a repository for chlorinated hydrocarbons applied in the Sacramento-San Joaquin drainage basin. During the past year, we have primarily focused on the first three of these goals, which are necessary for accomplishing the last two. Our approach has been to utilize naturally occurring radioisotopes and artificial radioisotopes from weapons testing to determine rates of particle movement. We will briefly outline each of these techniques and illustrate our results in subsequent paragraphs. Atlhough our field work for this project has been completed, our radiochemical measurements are not yet completed because of the large amount of counting time these analyses require.

Results

Water Column: Uranium is quite soluble in sea water, while thorium is relatively insoluble and has a great affinity for attaching to particle surfaces, as do many heavy metals and chlorinated hydrocarbons. Thus, when dissolved U-238 decays to

Th-234, the thorium daughter ($t_{1/2}$ = 24 days) attaches rapidly to particulates. The rate constant for attachment can be calculated by constructing a mass balance for dissolved Th-234.

$$[U]_d = [Th]_d \left(1 + \frac{\lambda_c}{\lambda_{th}}\right) \qquad \text{(eq. 1)}$$

where the square brackets subscripted d represent dissolved activity, $_{Th}$ represents the rate constant for decay of Th-234, and λ_c represents the rate constant for attachment of thorium to particulate surfaces. The residence time of reactive pollutants in the dissolved phases (before attachment to particle surfaces) is the inverse of the rate constant λ_c, assuming that reactive pollutants behave like thorium. The residence time of this reactive substance in the water column is then controlled by the residence time of particles in the water column which can be calculated by constructing a balance for Th-234 in the particulate phase,

$$\frac{\lambda_c}{\lambda_{Th}} [Th]_d = [P] (Th)_p \left(1 + \frac{\lambda_p}{\lambda_{Th}}\right) \qquad \text{(eq. 2)}$$

where P represents the concentration of suspended matter, $(Th)_p$ is the activity of excess Th-234 per gram of suspended matter, and λ_p is the rate constant for particle removal from the water column. The residence time of particles in the water column is the inverse of λ_p.

During the past two years, six trips to San Francisco Bay (Figure 1) have been made to collect samples for thorium and uranium analysis. The average of 12 measurements of $[Th]_d$ is 0.04 $\pm$ 0.01 dpm/l. The uncertainty represents

$$\left[\sigma^2/(n-1)\right]^{1/2}$$

where σ^2 is the variance of the measurements and n is the number of analyses. At present there is some additional systematic uncertainty in the number due to the Th-234 blank used for this calculation. The average $[U]_d$ is 2.1 $\pm$ 0.1 dpm/l and thus λ_c is 1.5 $\pm$ 0.6 day^{-1}. This rate constant indicates that 0.7 $\pm$ 0.3 days are required for reactive pollutants to attach to particles. No seasonal or geographic trends were observed in this data.

The residence time of particles has been calculated from equations 1 and 2, the average dissolved concentration of thorium, and the measured total thorium concentration in samples collected on five expeditions. The average of these measurements, based on 28 analyses in South San Francisco Bay and 10 analyses in San Pablo Bay, is shown in Table 1. The error represents $\left[\sigma^2/(n-1)\right]^{1/2}$ where σ^2 is the variance of the measurements and n is the number of analyses. These results are somewhat greater than those published for two other estuaries. This may be due to the shallow depth and to the high winds which prevail in South San Francisco Bay. These factors act to keep sediment in suspension.

Sedimentation and Resuspension Rates of Bottom Sediments

Lead 210 is a naturally occurring radioisotope ($t_{1/2}$ = 22 years) that is produced by the decay of atmospheric radon-222. Lead-210 is deposited in the bay by wet and dry fallout and is subsequently scavenged onto particulates. This results in an excess of lead-210 over its precursors in the particle. The rate of sediment accumulation at a given site can be estimated by constructing a mass balance for Pb-210 in the sediment column

$$\lambda_{Pb} J_{pb} = S(Pb)_p \qquad \text{(eq. 3)}$$

where J_{Pb} = excess Pb-210 activity in the sediment column integrated over depth, $(Pb)_p$ = excess Pb-210 activity in water column particulates, S = net sedimentation rate, and λ_{Pb} = lead-210 decay constant. Data in Figure 2 can be used to illustrate this calculation. Integration of the Pb-210 excess indicates P_{Pb} = 37 dpm/cm^2. Assuming that $(Pb)_p$ = 2.7 dpm/g (the value at the top of the core) yields S = 0.73 g/cm^2/yr. Note that bioturbation has homogenized the upper 15 cm of this core.

This calculation yields only an upper limit for the rate of sedimentation at this site because it neglects resuspension scour and due to the activity of benthic deposit feeders. The rate of resuspension can be estimated by constructing a balance for excess Th-234 in the sediment column,

$$\lambda_{Th} J_{Th} = (S + R)(Th)_p - R(Th)_s \qquad \text{(eq. 4)}$$

where J_{Th} = excess Th-234 activity integrated over depth in the sediment column, $(Th)_s$ = activity of excess Th-234 in resuspended sediment, and R = rate of resuspension. From data in Figure 2, J_{Th} = 16 dpm/cm^2, taking S = 0.7 g/cm^2/yr, $(Th)_p$ = 15 dpm/g, and $(Th)_s$ = 2 dpm/g yields R = 12 g/cm^2/yr. Thus particles at

this site are resuspended at least 15 times before final burial. In shoal areas the resuspension rates may be somewhat different. When measurements of Pb-210 in the suspended particles are completed, it may be possible to refine this model by correcting the Pb-210 balance for resuspension and obtain the true sedimentation rate, rather than an upper limit.

Chlorinated Hydrocarbons

One core has been completely analyzed for DDT, DDD, DDE, PCB 1254, PCB 1242, and chlordane by Dr. Richard Bopp of Columbia University. Two others are in progress. The results for the completed core (RB-2 in Figure 1) show that chlordane is low in the upper 20 cm and high below 20 cm. This probably reflects the relatively recent ban on use of this pollutant and the rapid reworking of the sediment column. DDT is primarily degraded into DDD and DDE, and a decrease in the DDD/DDE ratio with increasing depth suggests that DDD may also be slowly degraded. Budget calculations will be done when the additional cores are analyzed.

Summary

Although the analytical work for this project is not yet completed and final material balance calculations cannot yet be done, the following picture of the bay is emerging. Sediment accumulation occurs primarily in channel areas and near physical obstructions. Shoal areas accumulate sediment very slowly or not at all. Reactive pollutants will attach to suspended particles on the time scale of a day. Suspended particles reside in the water column for 8 to 11 days before deposition. This material may be resuspended and redeposited 15 or more times before finally being buried. Bioturbation to 20 cm or more will dilute transient injections of pollutants with older sediment but will also leave these pollutants available for resuspension in the water column for several decades.

Project Communications

1. Informal discussions with USGS Estuarine Studies Group, Menlo Park, Ca.; Dr. H. J. Simpson and Dr. Richard Bopp, Columbia University.

2. Publications: Hammond, D. E., and C. Fuller, 1979. The use of radon-222 to estimate benthic exchange and atmospheric exchange rates in San Francisco Bay, in, Conomos, T.J., San Francisco Bay: The Urbanized Estuary, AAAS. San Francisco, pp. 213-23; and Hartman, B., and D. E. Hammond.1981. The use of carbon and sulfur isotopes as correlation parameters for the source identification of beach tar in the southern California borderland. Geochemica and Cosmochimica Acta (in press).

Table 1

Comparison of Pollutant Residence Times (days) in Several Systems Determined from Th-234

Location	T_c	T_p	Mean Depth (25)	Reference
San Francisco Bay	0.7 ± 3		4	This work
South Bay		11 ± 3		This work
San Pablo		8 ± 3		This work
Narragansett Bay	4 ± 2	4 ± 2	10	Santschi et al. (1979)
Long Island Sound		1.4	20	Aller & Cochran (1976)
New York Bight, Continental Shelf		11.4		Li et al. (1979)

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Offshore Sand and Gravel Resources, Orange County, California

Robert H. Osborne, Associate Professor, Geological Sciences

Introduction

As part of a series of offshore sand and gravel investigations by personnel of the Sedimentary Petrology Laboratory at the University of Southern California, this report details findings for offshore Orange County, California. The areas studied included part of southeastern San Pedro Bay and the offshore area from southeast of Dana Point to San Mateo Point (Figure 1). The area between these two locations, i.e., southeast of Newport Submarine Canyon to Dana Point, was not studied because of the narrowness of the shelf, the marked decrease of sediment volume as compared with San Pedro Bay to the northwest, and the occurrence of numerous kelp stands. The San Pedro Bay shelf segment is much broader with a sediment volume estimate of 2750 x 10^6 cubic meters (Fischer et al.,1980).

Methods

Sediment samples for the areas of concern were obtained by vibracoring. The cores for this study were taken in October 1979 aboard the crane barge Geromino, with Meridian Ocean Systems, Inc., acting as contractor.

Core locations for the southeastern San Pedro Bay segment were chosen in a previously unexplored area offshore of Huntington Beach, just northwest of the Santa Ana River outfall. This area includes cores H-1 through H-9 (see Figure 2). These core sites are located between sand and gravel sites A-I and A-II of Osborne et al. (1979). It was anticipated that these cores would help to extend and better define these known sand and gravel deposits.

Vibracore locations for the shelf segment southeast of Dana Point were selected with the aid of a Holocene sediment isopach map prepared by Fischer et al. (in preparation). Locations were chosen where the Holocene sediment cover was absent or relatively thin. Where cores were taken in Holocene cover, it was done with the purpose of comparing recent sediment with underlying strata. Figure 3 shows the vibracore locations for the Dana Point study segment.

The average recovery for the vibracores was 2.03 m for the Huntington Beach segment and 2.60 m for the Dana Point samples. Upon collection of the vibracores, they were delivered to the laboratory, split lengthwise, logged, and photographed. Subsamples from each core were taken at discrete intervals or every 50 cm if the character of the sediment was fairly uniform. The samples were then dried in an oven and statistically split with half the sample being archived. After splitting, the samples were dispersed in Calgon solution for 12 hours. The mud fraction (0.063 mm) was then wet-sieved, dried, and weighed. The remainder of the sample was treated with an 8% solution of hydrogen peroxide to rid the sample of organic tissue. After rinsing with distilled water and oven drying, the coarser sediment samples (0.063 mm) were sieved at 1/2-phi intervals, and the sample in each fraction was weighed for later statistical analysis. In samples where there was an adequate amount of medium sand, a portion of it was used to make grain thin sections for petrographic modal analysis to determine the mineral composition. The thin sections were point-counted to obtain statistically accurate percentages for each component. A total of 17 samples from the Huntington Beach area were analyzed and only 2 from the Dana Point segment because of the apparent lack of medium and coarse grained sand.

Results

In the Dana Point shelf segment, where the Holocene cover is either absent or completely penetrated by the vibracores, dense, friable sandstone was encountered. In core D-1, the vibracore unit could only penetrate this material about 20 cm before stopping. This sandstone is thought to represent the Vaqueros Formation, which is Miocene in age. This condition contrasts sharply with the San Pedro Bay Holocene boundary below which coarse-grained Pleistocene deposits occur. This is especially evident in core H-5 in San Pedro Bay where a muddy, sandy gravel was encountered 110 cm below the surface. Clasts as large as 3 cm occur in this segment of core H-5. Compositionally, these clasts consist of syenite, quartzite, and basalt; the matrix of this interval is generally medium- to coarse-grained sand.

With the absence of Pleistocene sand and gravel packages along the Dana Point shelf segment, the only possible source is in the Holocene package. The character of the Holocene cover does not, however, appear promising. The sediment is typically an olive-gray (5Y3/2), micaceous, silty, very fine- to fine-grained sand. There are laminae of mud and clayey silt expressed as thin darker strata within the vibracores. The fine-grained character of the Holocene sediment in the Dana Point shelf segment probably reflects the relatively lower energy, sheltered environment of this inner shelf area (Fischer, et al., 1980).

The sediment of the Dana Point shelf segment is not deemed suitable for beach nourishment or construction aggregate. The average grain size diameter of the sand fraction within 54 subsamples is 3.47 phi or 0.10 mm. This puts the average grain size in the very fine sand category. This average grain size does not include any portion of the sample smaller than 0.063 mm (4 phi) or larger than 2.00 mm (-1 phi). By weight percent, the average amount of sample greater than 2.00 mm (-1 phi) is 0.81%. The average amount smaller than 0.063 mm (4 phi) is 41.5%.

There were occasional intervals of medium sand encountered within the Dana Point cores, but these were generally very thin (6 - 15 cm), thus making them difficult for mining purposes.

Some suitable sand and gravel packages were encountered in the Huntington Beach area. Acceptable grain size values for beach nourishment range from 0.177 to 0.710 mm or 0.5 to 2.5 (Coastal Engineering Research Center, personal communication).

Cores H-5 and H-7 penetrated sand and gravel intervals. Core H-5 is mostly a silty very fine to fine sand at the surface, but it contains pebbly intervals, and a muddy sandy gravel was recovered at 110 cm. Core H-7 consists mostly of suitable fine to medium sand, except the top 27 cm which is a silty very fine to fine sand.

The average grain size for the sand fraction of 40 subsamples for this area is 0.17 mm or 2.82 phi. This falls in the very fine sand category (classification according to Folk, 1974). Core H-7 has an average grain size for its samples of 0.225 mm or 2.18 phi. This value places these samples in the upper range of the fine sand class. The gravel interval penetrated in core H-5 has an average of its sand fraction of 0.394 mm or 1.34 phi, which may be suitable for aggregate because of the large clast content. In computing sand and gravel volume for this site, the maximum area is projected to the 5-fathom limit, the lower limit for dredging operations. The gravel unit penetrated in core H-5 is similar to a probable Pleistocene gravel unit penetrated in core V-29, from previous vibracoring in San Pedro Bay (Figure 2). A tentative new site, therefore, has been outlined connecting core locations H-5 and V-29. For the purposes of volumetric calculations, it is assumed that there is an average 10-ft thickness of material. It must be stressed that the material at this site does not appear to be good beach nourishment material but rather for aggregate. The site connecting cores V-29 and H-5 is estimated to contain 14.8×10^6 yd^3 of material. This calculation was obtained by planimetering around the proposed site to obtain the area and then multiplying by 20 ft (3.3 yd) to obtain a volume.

As mentioned, core H-7 contains usable beach nourishment material. This core is 215 cm long. Seismic lines show the surface layer here to be about 4 meters thick, so a conservative estimate of 10 ft thickness will be used for computational purposes. A line demarcating the minimum area of usable material has been drawn around core H-7, extending outward on the shelf to the 15 fathom limit. Based on this area, there is a minimum of 8.5×10^6 yd^3 of material suitable for beach nourishment. If this boundary line is extended outward (Figure 2) there is a minimum of 28.5×10^6 yd^3 of usable material.

Summary

Two areas of offshore Orange County, California, were examined for potential sand and gravel deposits. The first segment, offshore of the Huntington Beach area, contains two possible sand and gravel sites. The first site, connecting cores V-29 and H-5 has coarse material of use for aggregate purposes. Estimated volume for this site is 14.8×10^6 yd^3 of material. The second site, located seaward, has material of suitable beach nourishment quality. Volume for this site is estimated to be between 8.5 and 10^6 and 28.5×10^6 yd^3 of material.

It does not appear as if the shelf segment between Dana Point and San Mateo Point will yield deposits suitable for beach nourishment or aggregate. The Holocene sediment is a silty, very fine to fine sand and overlies a dense, friable sandstone.

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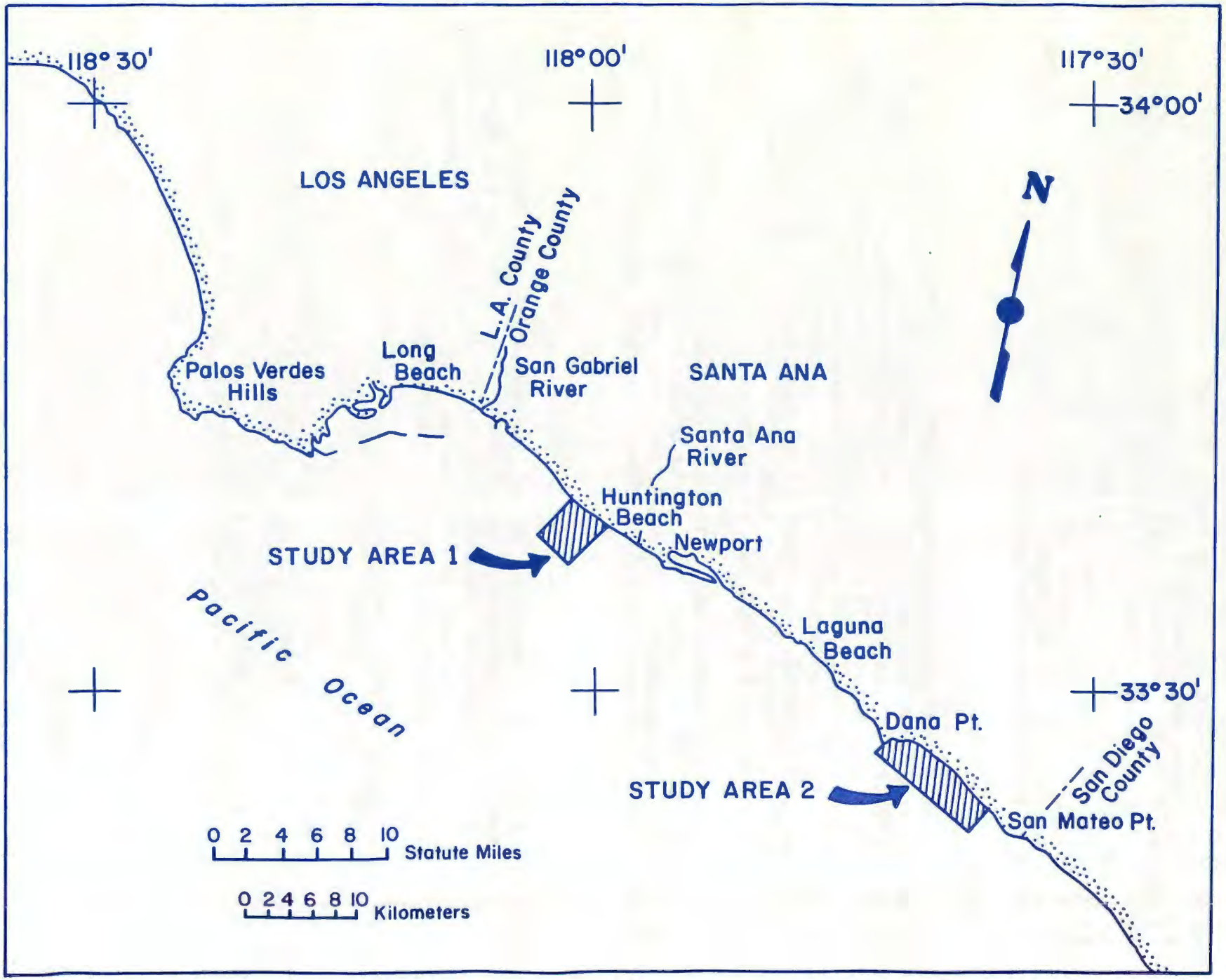
FIGURE 1. LOCATION MAP OF ORANGE COUNTY STUDY AREAS



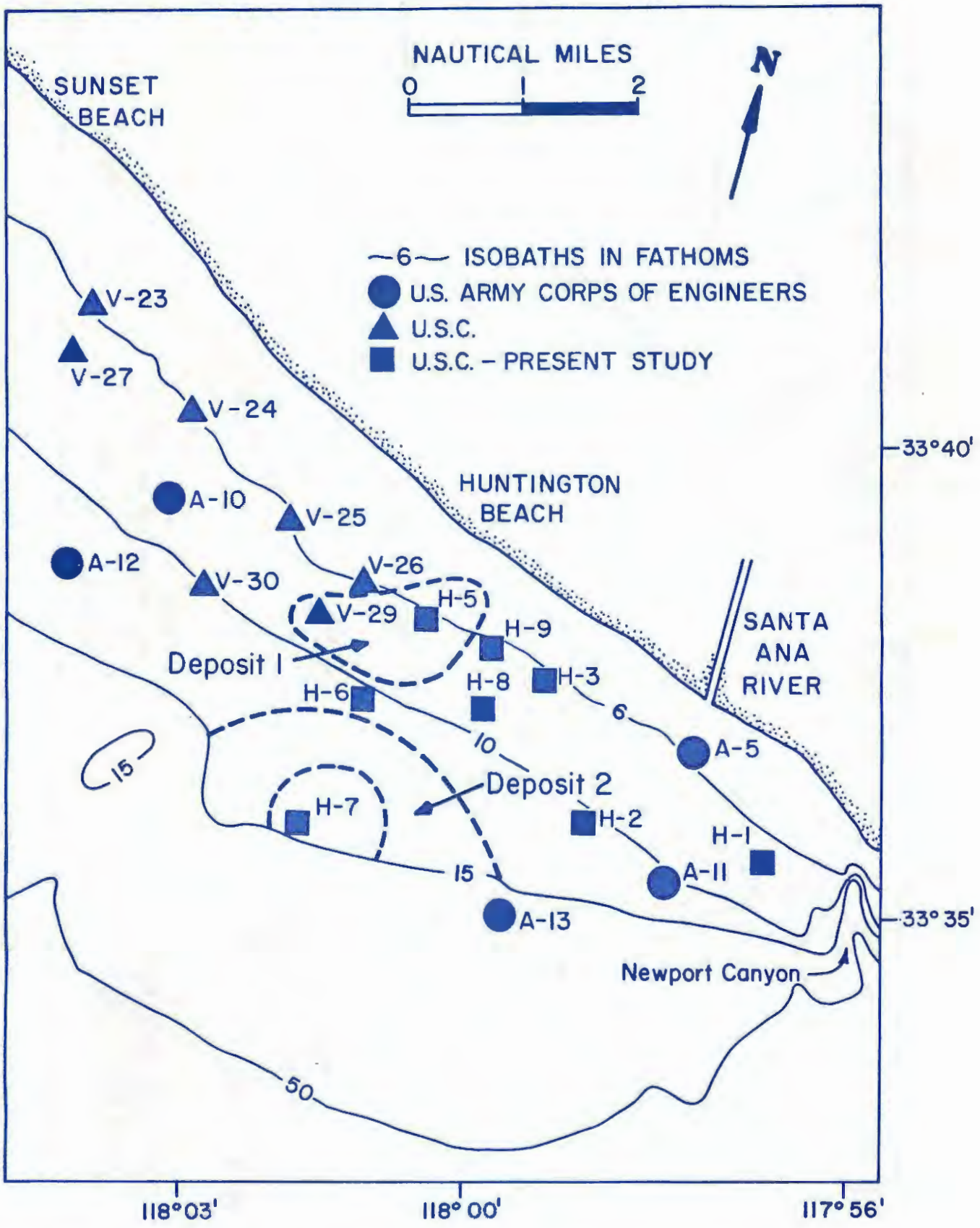


FIGURE 2. LOCATION MAP OF HUNTINGTON BEACH CORES WITH SAND AND GRAVEL SITES OUTLINED

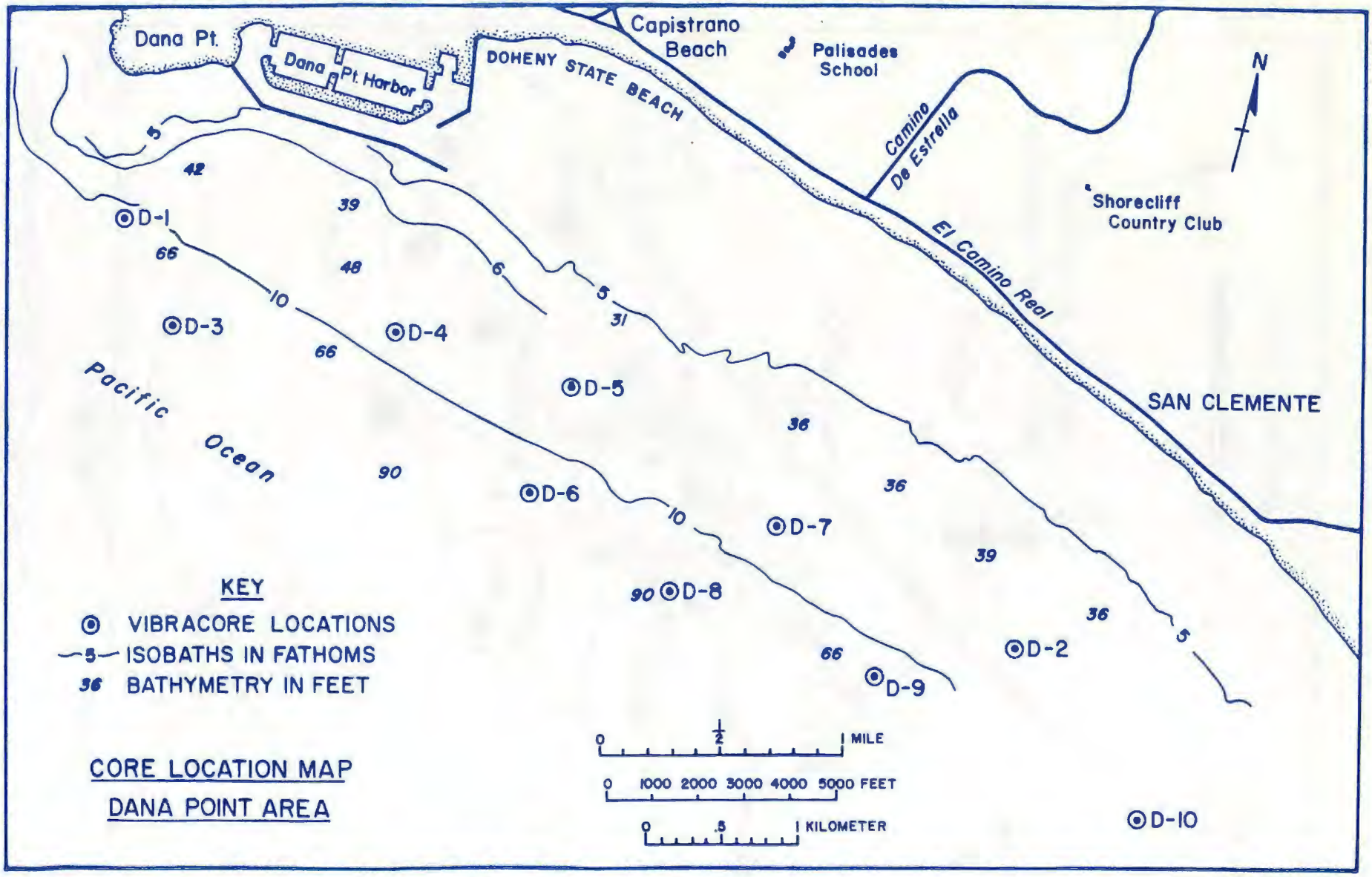


FIGURE 3. LOCATION MAP OF DANA POINT VIBRACORES

The Port Authority as a Public Enterprise

Herman L. Boschken, Assistant Professor, USC Sacramento Public Affairs Center; Louis F. Wechsler, Professor and Director, USC Sacramento Public Affairs Center

Introduction

Historically, ports and harbors have acted as critical transshipment points for the economic allocation of goods and services. With increased interdependence of regional, national, and international economies, port authorities have felt enormous pressures to maintain and support economic development values. Moreover, acting as a semi-autonomous enterprise similar to a private firm, the good ports have traditionally provided: (a) an enlarged tax base, (b) economic development opportunities, and (3) quasi-profit-oriented fiscally independent public agencies. With renewed China trade on the west coast, these development activities are likely to become more intense.

Over the last decade, however, equally important public demands for environmental quality and social planning have been imposed on port authorities. A central organizational problem emerges as to whether the structure of port authorities can handle multiple goal implementation or whether organizational adjustments can be made to manage the conflict in goals and still meet the traditional expectations of success as a development-oriented public enterprise.

The idea for this project came from an emerging focus on maritime port activities over the last five years. Competition over containerization facilities, LNG terminal decisions, the promise of trade with China, Alaskan oil, and other developments seems to imply numerous economic benefits for the future, but also raises problems of environmental quality. Ongoing USC Sea Grant research, notably that by Bakus on harbor transport pollution and that by Price on the need for port management training, indicate to us a problem of administration.

Hence, this study is of port authorities and their changing role in the regional economy and environmental setting in which they are placed. The goal is to make a comparative examination and analysis of port authority policies, patterns of administration, levels of effectiveness regarding multiple goal attainment, causes for administrative failure, and potential avenues for improvement. Specific inquiry is devoted to the legal mandates, authorities, and roles of port authorities; policy formation and implementation; and port operations within an intergovernmental setting.

RESULTS

A variety of works have been addressed to port management. Yet few seem to address the issues of interest to us: alternative decision-making processes, considerations of organization structure, and the interdependency of environmental factors, administrative tasks, and output. Our approach is different to the extent that we raise new concerns that come from the fields of political economy and organizational systems. These fields specifically provide a frame for analyzing the contingencies and constraints implied by maritime and coastal resources on the administration of harbor development.

Our tentative hypothesis is that successful management of ports for both economic development and environmental quality is associated with appropriate adminstrative structure. This interdependency suggests the following questions:

1. To what degree can the port authority as a public enterprise accommodate the conflicting regional demands for economic development, environmental quality, and diverse social planning needs?

2. Are appropriate intra- and inter-agency adjustment mechanisms utilized or available to allow port authorities to adapt to these changing regional realities?

3. Which authorities have proven most effective and under what circumstances?

4. What tradeoffs are made by the public enterprise regarding continued financial and economic success versus achievement of environmental quality and the internalization of adverse externalities?

The last 12 months have been used to develop the analytical frame in the context of Los Angeles and Long Beach harbors as a side-by-side study, and Oakland as a regional comparison. During this phase of the study, careful attention has been given to documenting, defining, and developing means for identifying and measuring port "behavior" as perceived by the port and by its external community which, for this study, largely consists of federal, state, and local agencies, and organized interest groups.

To date, the research strategy has: (1) undertaken background reading sufficient for understanding of the organizational, legal, economic, and environmental issues facing port authorities in the United States; (2) undertaken a documentary search for statutes, regulations, municipal ordinances, and state court decisions which impact port policy and operations in California; (4) undertaken extensive review and analysis of port master plans, public relations material, etc.; (5) undertaken further specification of the research design; and (6) devised appropriate tools for describing and cataloging port activities.

Port activities of interest to this study include the following:

1. Dredging: Ports schedule dredging activities, define how deep or how much draft capacity needs to be established or maintained, and determine or contract out what is to be done with the dredged materials.

2. Utilizing fill: Land fill or dredged materials can be used to generate more dock areas. The ports plan for dock expansion, secure financing, determine source of fill material, schedule activities, and implement or monitor the development of the docks.

3. Managing Hazardous Cargoes in Port: Ports are recipients and holding areas for a number of hazardous chemicals, explosive materials (e.g. oil), and radioactive substances. Consequently, they need to develop structural devices to assure the safe transport of dangerous materials and to respond to emergency situations automatically when they do occur. This can require establishing open buffer zones around industrial uses of these materials, providing fire-fighting and rescue equipment, and developing an emergency plan in sufficient detail so that emergencies are handled immediately and endangered areas are reached and secured quickly.

These actions jointly affect the port's economic position and its natural environment. The issue of dredging serves to illustrate this interaction. The size of cargo ships has been steadily increasing, and today ports are seeking to accommodate containerized ships and neobulk cargo vessels. In addition to the problems of traffic control among large ships, e.g., close passing tolerances, timing for favorable high tides, etc., ports need to be concerned with the deeper draft vessels requiring deeper channels and harbor accommodations. While the size of a vessel is not limitless, it is clear that the existing ships already require deeper water closer to shore, wider channels, and so forth. The port's shipping or economic interest does not necessarily merge with environmental responsibilities. Dredging and fill operations can result in significant losses of fish food (biomass), feeding grounds, living space for fish and fauna, and nursery areas. While this may be obvious, managing these environmental concerns against the objectives of servicing larger vessels is not obvious. In theory, the environmental considerations and laws are intended to influence dredging behavior by establishing appropriate: (1) times during the year for dredging; (2) schedules and/or parameters for frequency; (3) depth and/or closeness to shore; and (4) utilization of dredged materials.

A port's expression of how these two interests merge is frequently manifested in master plans, capital development plans, newsletters, etc. While theory suggests that the environmental laws

serve as a filter or constraint on port behavior, this may be an oversimplification of the situation. Ports are often autonomous, self-contained legal and financial entities having to respond competitively to market demands. As a consequence, ports in a few instances tend to keep disclosures about their actual operations vague, broad, and generalized rather than specific, focused, and quantifiable. Moreoever, we have found that when interacting with other agencies (i.e., Coastal Commission, Federal Fish and Wildlife Service, Corps of Engineers, etc.) and the public, different ports adopt different strategies.

For example, Long Beach and Oakland tend to be more open, facilitative, and well organized when collaborating with environmental agencies. Los Angeles tends to be less adaptive and sophisticated in this respect. In part, this is due to the way the administration is structured and controlled. Los Angeles is dominated by the politics of the city council and mayor while Long Beach and Oakland have evidence of a professional authority decentralized into project department specializations. We have more analysis to do, but the evidence suggests a relationship between organization structure, behavior, and successful adaptation to conflicting public goals and demands.

Project Communications

1. Herman L. Boschken, participant in Research Forum for Marine Transportation and Port Management and Development, April 8, 1980, Sea Grant College, University of California, La Jolla.

2. Sandra Emerson; dissertation in progress on "Ports as Public Enterprises."

3. John Thorson has served as a Sea Grant trainee on this project for 1979-80.

Problems of Harbor Modeling

Jiin-Jen Lee, Associate Professor of Civil Engineering; L. C. Wellford, Associate Professor of Civil Engineering

In the completed research project, improved models for the prediction of the hydrodynamic behavior of harbors were developed. The development of these models was necessary because the previously used techniques (Lee, 1971) failed to realistically represent the conditions in harbors at resonance. At resonance, the wave amplitudes in harbors have their largest values; however, dissipative and nonlinear effects act to reduce the size of these large-amplitude waves. These effects were not included in the previously used procedures, and thus the previous methods overestimated the wave heights in harbors. The new techniques introduced in this research project should allow for more economical harbor designs since they will provide a more accurate estimate for the wave heights within the harbor.

The overall goal of this project was to develop and test predictive computer models for the determination of the response of irregular shape, variable depth harbors to incident ocean wave systems. In these models, the effect of viscous dissipation at the bottom and harbor boundaries were to be included. In addition, the models were to consider nonlinear effects at resonance. In particular, the following goals were defined for the research project:

1. Determination of the physical laws and equations governing dissipation and nonlinearity in the problem of harbor resonance.

2. Development of a set of physical equations which account for energy dissipation as well as nonlinear effects at resonance.

3. Development of a computer model, using finite element methods, to define the response of an irregular-shape, variable-depth harbor to incident waves. The computer model was to consider dissipation . Comparison of the computer results with experimental measurements and the calculations of other investigators.

4. Development of a computer model, using finite element methods, capable of accounting for nonlinear effects in the problem.

In completing the first of the primary goals of the research project, it was necessary to decide upon a set of physical laws and equations governing dissipation and nonlinearity in the problem of harbor resonance. Two approaches were available. Either the analysis could be based on experimentally derived relationships for the dissipation mechanism, or the analysis could be carried out employing the basic fluid mechanical momentum and continuity equations for the fluid in the harbor. In this research project, the latter approach was employed. It was felt that by employing this method the parameters of the physical problem (bottom roughness. varying depths, etc.) could be more easily brought into play

in the solution. The analysis was based on the following turbulent flow version of the Navier-Stokes equations and continuity equation (defined in terms of the velocities u and v in the direction of the planar coordinates x and y and the velocity w in the direction of the depthwise coordinate z):

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z} = -\frac{1}{\rho}\frac{\partial P}{\partial x} + \frac{\partial}{\partial z}\left[(\nu + \varepsilon_x)\right]\frac{\partial u}{\partial z}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z} = -\frac{1}{\rho}\frac{\partial P}{\partial y} + \frac{\partial}{\partial z}\left[(\nu + \varepsilon_y)\right]\frac{\partial v}{\partial z} \qquad (1)$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

In addition to the convective nonlinear effects occuring in this system of equations, nonlinear terms in the free surface boundary conditions were considered.

In order to define the equation of motion for the fluid in the harbor, approximate versions of the physical equation (1) were developed. A Galerkin method, through the depth of the harbor, and a finite element technique of matched asymptotic expansions were employed in the development. In the matched asymptotic expansion method, two solutions were proposed for each velocity component u and v. An outer solution, valid away from the harbor bottom, and an inner solution of boundary layer type, valid at the harbor bottom, were proposed. These solutions were defined and matched by requiring that the Navier-Stokes equations $(1)_1$ and $(1)_2$ be satisfied in the Galerkin sense through the depth for each finite element of the harbor. Finally, a depth-averaged version of continuity equation $(1)_3$ was introduced to replace the velocity components u and v by the free surface elevation η. The resulting equation took the form of a nonlinear Helmholtz equation in the free surface height η. If this equation is linearized and dissipative effects are eliminated, the standard Helmholtz equation, valid for the inviscid problem, is obtained. Thus, the formulation is a natural extension of previous models.

The computer program developed as a part of this project is extremely general. It incorporates isoparametric quadrilateral and triangular finite elements, automatic mesh generation, and graphics capabilities. It should be an extremely useful tool for ocean engineers involved in harbor design.

As an example of the problems which can be solved using this program, the wave amplitudes in a rectangular harbor and the wave amplitudes in a near rectangular harbor were defined. The harbor depth was 1 unit. An inviscid version of the rectangular basin problem has been solved by several investigators (see Lee, 1971, for example). In Figures 1 and 2, the two finite element models for the rectangular and near rectangular harbors are pictured. In

Figure 3, the inviscid and viscous wave amplitudes at a specific point in the rectangular harbor are plotted versus wave number. In Figure 4, the inviscid response of the nonuniform harbor is plotted versus wave number. These results seem to correlate well with previously defined inviscid solutions and represent a reasonable solution to the viscous problem.

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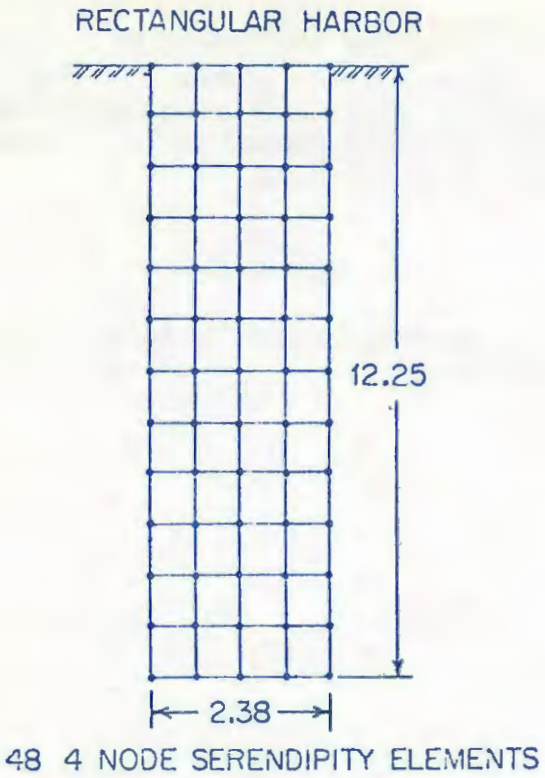

Figure 1. Rectangular Harbor

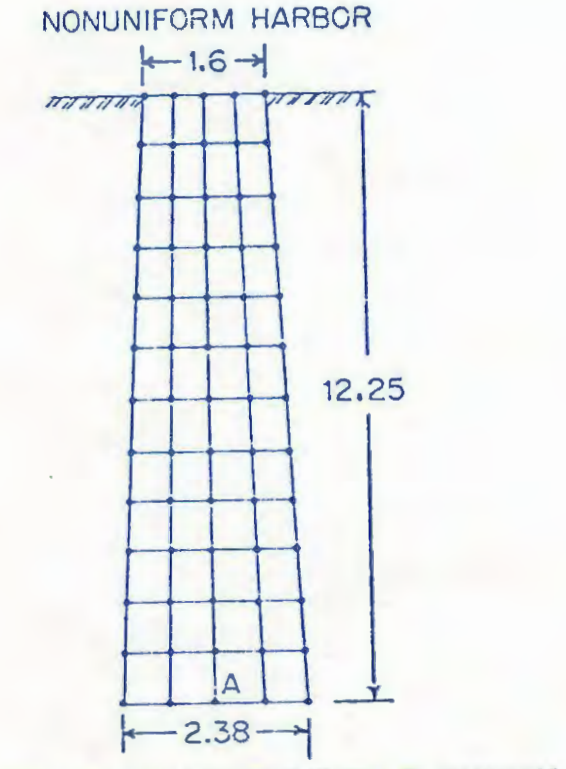

Figure 2. Nonuniform Harbor

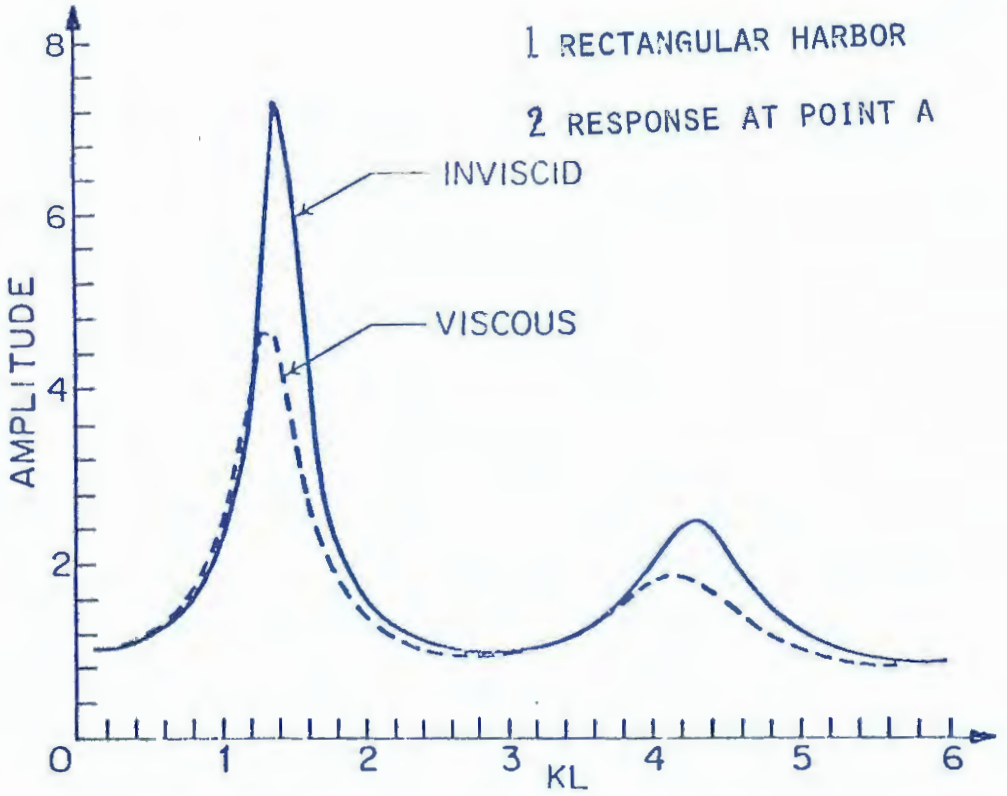

Figure 3. Response of Rectangular Harbor

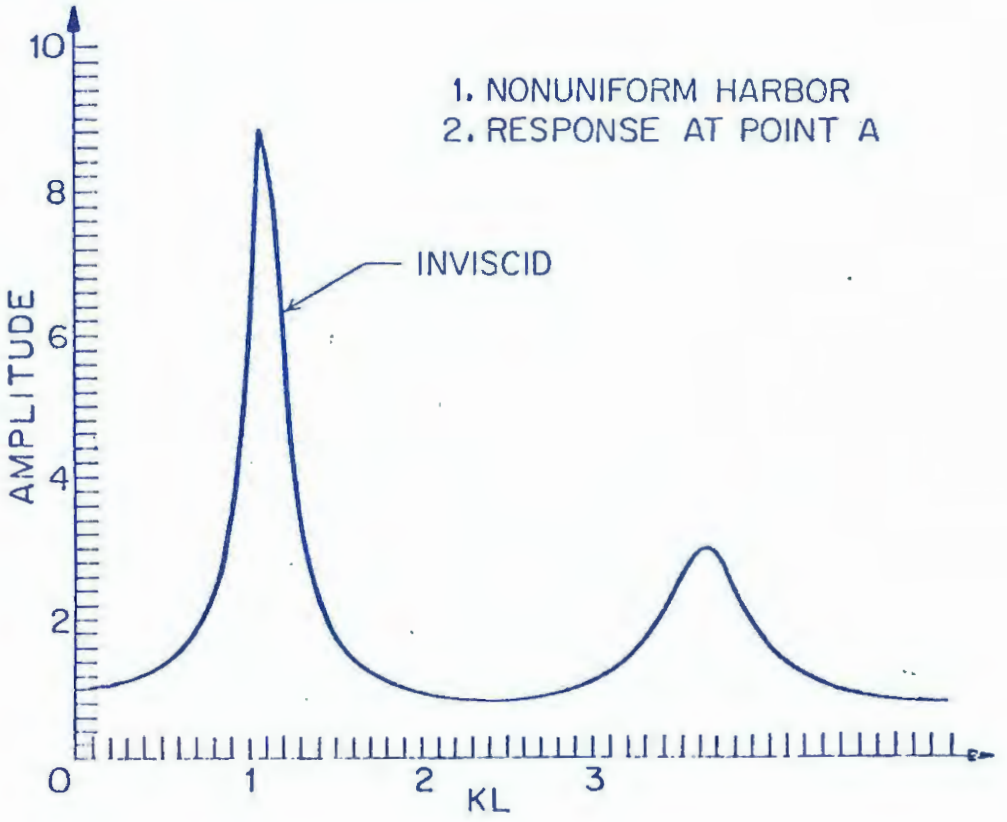

Figure 4. Response of Nonuniform Harbor

Program Development

Donald L. Keach, Director, and D. Patrick Hartney, Assistant Director, USC Sea Grant Institutional Program

Sea Grant projects usually require a lead time of about one year from submission of the proposal to startup. However, there are times during a given fiscal year when new or urgent research needs emerge which cannot or should not be delayed until the next budget cycle. New oil and tar seeps and fish kills are examples of time-critical research subjects.

Quick-response funding enables the Sea Grant Program to provide:

1. An interim source of funding for initiating short-term research projects during the course of the Sea Grant fiscal year in response to articulated needs from state and federal agencies, as well as from private-sector, industry-wide problems with coastal resource management and development.

2. Startup funding and background research for longer term research projects

3. Supplementary funds to be used for one-time advisory visits

During 1979-80, program development funds were used to support the research projects described subsequently.

DEMOGRAPHIC CHANGE AND ECONOMIC DEVELOPMENT IN THE PACIFIC ISLANDS FROM AN OCEANOGRAPHIC STANDPOINT

Kingsley Davis, Distinguished Professor, Department of Sociology, and USC Population Research Laboratory

To what extent has development in the Pacific Islands been impeded by their oceanic location, and how can the special disadvantages be overcome or turned into advantages? To what extent are the current demographic circumstances and future prospects of the islands also due to locational factors, and how might these effects be changed in the future?

Because the amount originally requested from Sea Grant was not available, we were not able to accomplish all that we had originally hoped to do on this project. For instance, because of budget and time limitations, we decided to omit Papua, New Guinea, from the study. For the rest of the region, we succeeded in getting the basic task done--that is, to develop a set of comparative data for all of the political units in the region for the period after World War II up to 1977. In many instances, this required that we prepare estimates to fill in the gaps when data were missing or to correct the given data when it was, according to various tests, clearly inaccurate. It was this process of estimation that took a great deal of time, because each unit had to be treated as a unique case. Different sources and different kinds of data had to be balanced off against one another. But the final result of this basic-data part of the project was that we now have a body of statistical information on this unique and neglected region which is not available anywhere else. The information can be readily added to to keep it up to date. It can be used for various kinds of analysis, depending on the kinds of questions one wishes to raise.

Fortunately, on the analytical side, we had time at least to make a start. Two term papers in a seminar on population were presented based on the data set, and certainly one and possibly two empirical papers (a requirement for the master of arts in the Department of Sociology) will be written. There is also a good possibility that a Ph.D. dissertation will be prepared which will include our data from the Pacific region, comparing it with other regions with respect to the selective factors in migration.

The basic data include, for every unit and for each year, births and birth rates, deaths and death rates, estimated internation net migration, and natural increase and population growth. For selected years, there are also figures on immigration and emigration, urban and rural population, the proportion of the labor force in agriculture, the labor force participation of women, the

age-sex structure of the population, the marital status and household composition of the population, and the level of educational achievement. In addition to compiling and estimating these figures for each political unit in the region, we summarized the data for the entire region, allowing comparisons to be made with other regions in the world.

There is no doubt that in this vast region, embracing more of the earth's surface than any other region of the world, the people located on the small dots of land amidst the endless ocean include some of the earth's poorest inhabitants. This is true despite the fact that they have, for an underdeveloped area, rather high level of schooling and some islands of considerable prosperity. Since it has generally been found that education, especially female education, is one of the main factors in lowering the birth rate, we might expect the schooling in the Pacific Island region to reflect itself in low fertility and hence less population growth than in other regions, such as Africa and South Asia, where economic backwardness is about equal to that of our region. However, only part of this expectation is fulfilled. The birth rate has been lower, at least in recent years, than in Africa and the Middle East, but the difference is much smaller than in the death rate. As a result of having death rates well below those for Africa and the Middle East, the Pacific Islands, despite their lower fertility, have had a very high rate of natural increase. This can be seen in Table 1, which shows that the Pacific Island region has recently had the lowest crude death rate of any less-developed region. It also has had one of the lowest crude birth rates, but not low enough, given the miniscule death rate, to avoid a rate of natural increase that is quite comparable to those in Africa, Asia, and Latin America.

The demographic situation in the region is about what one would expect in underdeveloped countries with a relatively high level of education, a low degree of urbanization, a high dependence on agriculture and fishing, and a rather low level of economic development. The same forces that have brought education have improved public health to a striking degree, but as yet they have not exercised a commensurate influence on the birth rate. As a result, the potential for population growth is quite large. This potential is not being fully realized, however, because the resources and economic activity of the region as a whole cannot easily absorb the population increase. As a result, two things are happening: (1) despite the long distances and costs, there is a considerable net migration out of the region; (2) there is downward pressure on the birth rate, especially in the more developed parts of the region, such as Fiji.

Currently, we estimate that net out-migration is taking about 6 percent of the natural increase. In view of the high rate of natural increase, this is not enough out-migration. It does little to cut the rate of population growth to a reasonable figure, and it is not enough to boost the economy much by way of remittances. The

downward movement of the birth rate is not enough, either, to stem the rate of population growth significantly. In view of the prevailing deficiency in registration statistics in the area, we have relied on our estimates of population by age to indicate changes in fertility. According to the child-woman ratios calculated from the age-sex distributions, fertility was rising in the region from 1950 to 1960. It reached a peak in 1960 and then began to fall. However, the decline was not dramatic. In 1978, the index stood at 86 percent of what it had been in 1960. A more rapid drop in fertility could take place in the future, but to obtain such a change either the pace of economic development will have to be stepped up or special policies designed to give people real incentives for having small families will have to be adopted. In view of the very high transportation costs of doing business in this region, both economic policies and population policies will have to be more vigorous than they have been so far.

These are merely some of the highlights growing out of the study. As mentioned already, most of our work was with the individual political units in the area, and was concerned with estimates so as to get data as complete as possible for the region. How necessary this work is can be seen from any compendium of basic statistics for the world's countries. In these compendia, the Pacific Island region is more likely than any other world region to be represented by blanks or figures in italics (for dubious reliability). As soon as the analytical papers growing out of the study and utilizing the estimated data are completed, they will be forwarded as addenda to this report.

TABLE 1

BIRTH, DEATH, AND NATURAL INCREASE RATES, 1970-1975
IN LESS DEVELOPED REGIONS

	Birth Rate	Death Rate	Natural Increase
West Africa	49	21	28
East Africa	48	20	28
North Africa	43	16	27
Middle Africa	45	22	23
Tropical South America	37	10	27
Middle America	43	9	34
Caribbean	32	9	23
South Asia	41	16	25
Pacific Island Region*	33	7	26

*These data refer to the period 1970-1974 instead of 1970-1975 as in the rest of the table.

SOURCES: Except for the Pacific Island Region, the data are taken from United Nations Demographic Yearbook 1978, p. 95. For the Pacific area, the data are based on compilations and estimates made on the present project.

VARIATIONS IN OOCYTE VOLUMES AS AN INDICATOR OF ENVIRONM STRESS IN OPPORTUNISTIC SPECIES

Jerry D. Kudenov, Assistant Professor, Biological

Introduction

An understanding of the reproductive ecology of opportunistic marine indicator species may lead to the development of an in situ bioassay technique to monitor the "health" of polluted habitats. This is particularly important since such species usually represent a final metazoan trophic link in stressed or polluted habitats, and changes in the reproductive cycle precede population fluctuations.

It has generally been considered that egg sizes in polychaetous annelids do not vary significantly. While this is true for certain families of worms, it has been found that egg sizes vary considerably in other groups like the Spionidae, and that this variability may reflect prevailing environmental and biotic conditions.

Thus, the overall goal of this project is to develop a simple, reliable, and rapid method to assess the in situ "health" of a particular opportunistic marine pollution indicator species. Such a technique will enable various state and federal agencies to monitor the environmental health of outfall areas and to deal with problems associated with waste treatment, toxicity, and the degradation of water quality.

Major goals for the previous six months have been:

1. How do selected reproductive parameters such as oocyte volume, fecundity, and rates of oogenesis vary in relation to controlled physical and chemical factors such as temperature, salinity, dissolved oxygen, and food quality?

2. How do these reproductive parameters vary in nature?

Results

The species under study is the spionid polychaete, Polydora nuchalis. A large amount of effort has been expended to characterize the amount of natural variation in egg sizes and number of larvae present in four worm populations in southern California. The four sites are San Gabriel River, Santa Catalina Island, Huntington

Harbor, and Malibu Lagoon. The first site is undoubtedly the most stressful in that temperatures are nearly always elevated as a result of a thermal outfall located upstream of the study area, while the last site (Malibu Lagoon) is the most enriched organically. Egg sizes are smallest at San Gabriel River and largest at Malibu Lagoon; they are of intermediate sizes at the other two sites. Significantly more larvae are produced by female P. nuchalis at Malibu Lagoon than at the other three sites.

A tentative conclusion is that organic enrichment in a particular habitat populated by P. nuchalis results in the increased production of larvae and large eggs. If the habitat experiences elevated temperature for prolonged periods, reproductive output will be suppressed. This species is also capable of exploiting variable salinities, although there does appear to be a lower limit to its tolerance (about 10 ppt).

A preliminary implication, therefore, is that egg volumes and the number of larvae produced by P. Nuchalis in the study areas are, in fact, reflective of prevailing environmental conditions. This is potentially extremely important since P. Nuchalis is typically abundant in estuarine habitats which (a) are common along the southern California coastline, and (b) receive domestic wastes and urban runoff. The ability of this species to reproduce under these conditions appears to vary according to existing temperature and salinity regimes and to the amount of available food. Obviously, there are many other physical and biotic factors, foremost among which are toxicant levels (which are also elevated in the San Gabriel River).

A pilot study to determine the influence of temperature, salinity, and food quantity on the reproduction of P.nuchalis in the laboratory commenced on 13 March 1980. Salinities of 15, 25, and 35 ppt, and temperatures of 15, 20, and 25°C are being tested on a total of 156 specimens (26 worms per treatment). It appears that growth rates are highly variable, and for the purposes of this experiment, food levels are not limiting. The largest worms in culture are exhibiting the presence of sperm in their coelomic cavities.

Once these data are accumulated and evaluated as to the reproductive response of the species to tested variables, the next step will be to increase sample sizes and treatments, and to manipulate food levels. Once the optimal reproductive activity is characterized in terms of temperature, salinity, and food, additional experiments will be conducted to determine how toxicants (heavy metals) influence reproduction.

ROLL WAVE DEVELOPMENTS ON CHANNELS OF DIFFERENT SLOPE

Jiin-Jen Lee, Associate Professor of Civil Engineering

Introduction

Experience has shown that when water flows down a long and sufficiently steep open channel, the water depth is not uniform. The flow usually consists of a series of surges or shocks that extend across the width of the channel and propagate downstream. These are called "roll waves." Generally such roll waves are undesirable, since the maximum depth of flow in roll wave trains is greater than the normal depth. If a channel is designed to convey a design discharge, then the channel depth must be significantly larger than the normal depth in order to avoid "spill of water" over the confines of the channel. Moreover, there will be excessive intermittent pressures and stresses due to the non-uniform water depth flow.

The amplitude of the roll wave could reach a very significant level (say 200% of the normal depth) at the channel outlet near the coastline. A possible way of reducing the amplitude of the roll wave is to change the slope of the channel at some strategic location in the hope that such changes in the channel slopes would diffuse the overtaking of the roll waves. Therefore, the amplitude of the roll waves could be reduced as they reach the coastal region.

A pilot study was undertaken during 1980 (through Sea Grant Program Development Funds) consisting of the following items:

1. Construction of a laboratory model to investigate the effect of the changes in channel slopes on the development of roll waves

2. Use of the constructed model to perform certain preliminary qualitative observations on the development of roll waves.

Model Construction

A hydraulic model to simulate the development of roll waves was constructed in the USC hydraulic laboratory. The model consisted of a 54-ft-long aluminum rectangular channel with width 4-5/8 in. and depth 1-13/16 in. The first 32 ft of the flume was constructed in a steeper slope so that the Froude number of the flow, defined as the mean flow velocity divided by $\sqrt{gh_n}$ was

greater than 2. The next 22 ft of the flume was constructed in a less steep slope so that the Froude number of the flow was between 1 and 2. The slope of the flume can be adjusted by adjusting the height of the support structure.

The support structure constructed of equipto-triangles were placed at 5-ft intervals and bolted to the laboratory concrete floor. As the water ran down the channel, the water was discharged to a storage tank constructed of plexiglas. A pump was used to pump the water from the storage tank to the inlet of the channel. The discharge of the flow was adjusted through a specially designed pipe branching system. For small discharge, some water returned to the storage tank before reaching the inlet of the steep channel. In this manner, the flow discharge can be effectively controlled.

A small paddle-type wave generator constructed at the inlet area was designed to generate the permanent type roll waves for the purpose of facilitating the early development of the roll waves. The period could be adjusted by a motor speed control.

Preliminary Observations

Quantitative measurements have not been made; however, qualitative observations have been made by recording the flow development through a video tape recorder as well as by actual observation. The following is a brief summary of the observations:

1. Reasonably well defined roll waves can be developed in the steep channel region although the length is not sufficiently long to permit the complete development of permanent-type roll waves.

2. The changes in the channel slope definitely affect the development process of roll waves. At the junction of the slope changes, the wave length decreases first and then increases downstream; thus the amplitude of the roll wave is gradually decreased.

3. Surface disturbance is strongly affected by the channel roughness; some of this can be attributed to the joints of channel sections.

Figure 1. An overall view of the channel structure supported by the support structure at 5-ft interval (no water flow present)

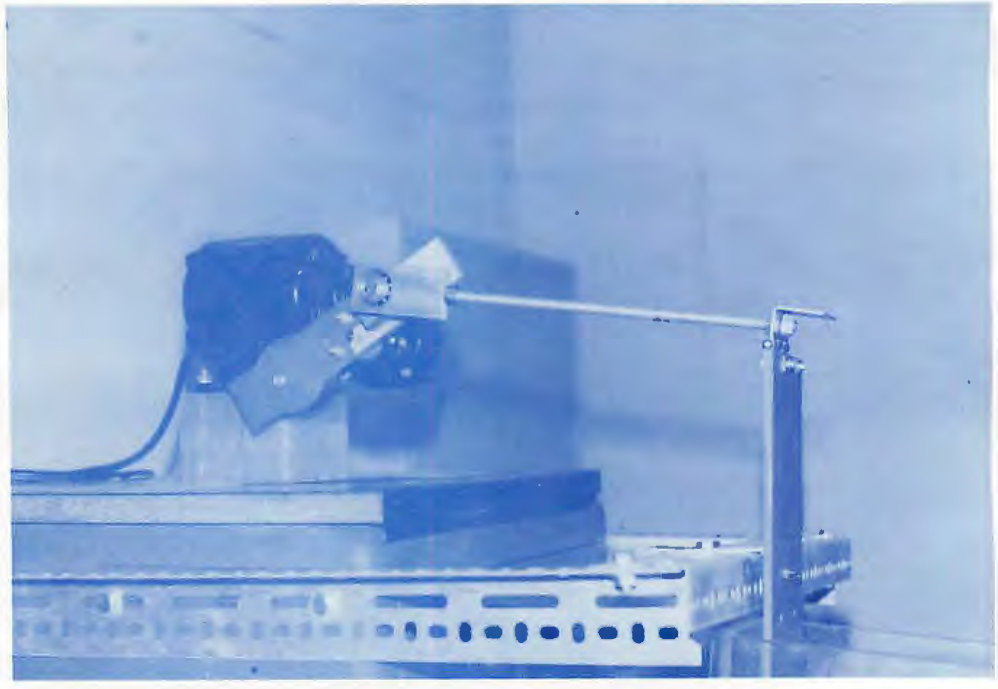

Figure 2. Paddle type wave generator at the inlet of the channel (strokes and periods are adjustable)

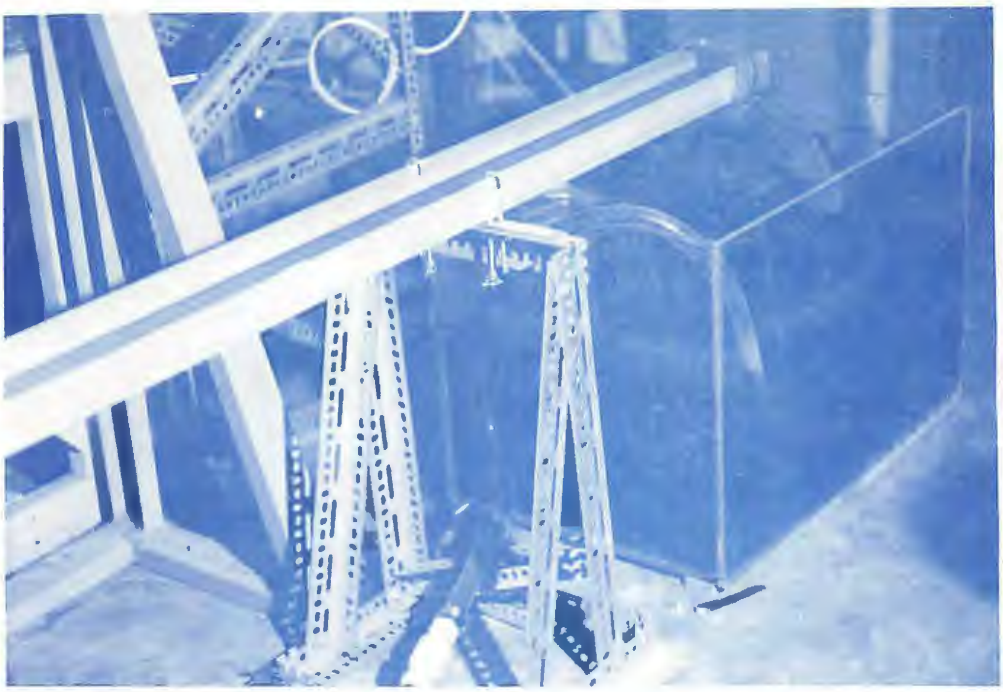

Figure 3. Storage tank at one end of the channel (water is pumped into the inlet through the flexible tubes)

Figure 4. Overall view of the development of roll waves in channel (red dyes are used to add visualization)

Marine Education

Dorothy M. Bjur, Director, Marine Education, Institute for Marine and Coastal Studies

The continuing goal of the Marine Education Program is to assist the citizenry of California in attaining an increased sensitivity toward the world of water and their responsibility to use its resources wisely.

To accomplish this goal, we have chosen to integrate marine concepts into many subjects and many levels of education. This has involved the development of multidisciplinary marine education materials, workshops, and special programs for the public school student, grade K-12; an educational program for public school students involving University undergraduates; a trainee program for graduate students; and extension programs for adults.

The three education projects funded by National Sea Grant and included in this report are: (1) California and the Oceans; (2) the Graduate Student Trainee Program, and (3) evaluation of a master of public administration curriculum specialization in port/harbor management.

Since 1977, the Marine Education Program has experienced a natural development of cohesive programs as a direct result of the multidisciplinary curriculum materials prepared and pilot-tested in preceding years. These materials have become the basis for both public school assistance and outreach programs. The curriculum materials include a Supplementary Multidisciplinary Teacher Guide, two Marine Studies Idea Books, and a book in braille and large letters for younger children with visual impairments.

With the support of the Sea Grant Director, a number of successful programs were conducted this year using the above-mentioned materials. A more detailed account is given in the California and the Oceans report; however, we would like to mention three exciting programs here: the Bilingual Program; the Marine Studies for the Visually Impaired Students, and the International Program.

The first year of the bilingual program produced a core of excellent teachers who have worked with the program this past school year and have been trained to instruct others in methods and techniques for teaching marine education. These teachers also developed a series of student materials to be used in conjunction with the Teacher Guide, "Wet and Wild." We naticipate translating

a Marine Studies Idea Book to provide teachers with a greater selection of marine education materials for the classroom.

The Program for the Visually Impaired students (V.I.) included three pilot programs which were documented on film. This film will be edited and produced into a 20-30 minute documentary film which will be made available to the public. Participating schools were enthusiastic with the results and are seeking funding to continue the project in their schools.

The International Program centered around the Marine Education Workshop held in Los Angeles in January 1980. The impact on the participants has been considerable. Costa Rica produced three sets of marine education curriculum materials, modeled after those from USC, and held a week-long workshop for 42 educators. Brazil also roduced a Teacher Guide in Portuguese and conducted a workshop for 200 educators. Argentina, not part of the original workshop, has expressed interest in a marine education program and will be working closely with this program in the future.

The Graduate Student Trainee Program has been active in producing necessary research for the Sea Grant Program. Students for this program are selected for their outstanding academic qualifications and their ability to conduct marine-related research. Participating students must work within the confines of the Sea Grant goals and objectives and be responsible each to a Sea Grant principal investigator. The trainees contribute to the high quality of research being produced by the USC Sea Grant Program.

Finally, through the efforts of Dr. Willard Price, graduate-level courses on port/harbor management have been developed. Two new courses have been taught and another is planned. Several sets of teaching materials have also been produced.

CALIFORNIA AND THE OCEANS

Dorothy M. Bjur, IMCS, Director of Marine Education
Jacqueline B. Rojas, IMCS, Assistant Director of Marine Education

Introduction

A knowledgeable concern for and understanding of the marine environment is pertinent to the future well-being of California. This understanding is an educational process which is most effective when begun at an early age.

It became evident several years ago that California, with its more than 1,200 miles of coastline, had neglected to place emphasis on marine education in the public school system. Marine education was thought of as marine science, and was confined to a few pages in a biology book or an hour or so of study in a high school science class. With so little formal education in the marine environment, young Californians were growing up with the limited understanding of the marine environment as a recreational haven but not as their source of future livelihood.

The Marine Education Program at USC, taking this into consideration, made its first endeavor toward educating public school children in marine concepts by developing a series of curriculum materials. These materials were designed to be both multidisciplinary and supplementary in approach.

These marine education written materials serve as a solid basis from which to build a variety of interesting programs for both the public school assistance and outreach programs.

During this past year, a concerted effort was made to expand the regular classroom activities and at the aame time expanded our horizon to other groups of both children and adults, otherwise neglected by marine education programs. Public school students have been our primary target, but we have not restricted our ideas and efforts to this one group. Rather, from the curriculum materials we have generated a variety of programs for handicapped students, diving clubs, community forums, and other audiences. Our progress has involved the formation of an integral relationship between our Public School Assistance program for bilingual schools and our Outreach Program for Latin America. These materials and techniques originating from each of these programs strengthens the other.

Objectives

The goals and objectives of the Marine Education Program in California for 1979-80 were divided into three categories:

(1) To complete the design of the curriculum materials and seek funding for their publication, and to translate at least one set of them into Spanish.

(2) To assist public schools in developing new programs by introducing the written materials into the California school system, and by working more closely with the State Environmental Education Department in fulfilling the goals for California as established at workshops sponsored by the Pacific Sea Grant Advisory Program (PASGAP).

(3) To expand the Outreach Program by assisting ongoing programs and developing new programs.

Progress

Objective 1: Curriculum Materials

During the past year the supplementary guide for teachers, entitled "Wet and Wild," was translated into Spanish. This translation was edited by professionals from nine Latin American countries. Both the English and Spanish versions are camera-ready for publication. At this time, the National Dissemination and Assessment Center for Bilingual Education and the National Marine Technology Society are both considering the guide for publication.

The two Marine Studies Idea Books continue to be used extensively in the inner-city program with the Joint Educational Program (JEP), as well as other educators. The second edition of the high school Idea Book, along with a description of the structural framework, has been prepared and sent with letters to eight publishers. We intend to translate this book into Spanish.

Other instructional materials include: (1) an illustrated book in large print and braille for visually impaired youngsters; (2) a teachers' manual compiled for the Model Marine Studies Program for the Visually Impaired; (3) a completed slide presentation with written narrative to accompany the English version of "Wet and Wild." (This instructional package was developed by Richard Murphy, a Sea Grant Trainee who has worked closely with this marine education program.)(4) English and Spanish student followup materials on "Wet and Wild" for kindergarten, grades 1-3 and grades 4-6, developed by a task force of bilingual teachers; and (5) preliminary efforts on the development of a Teacher Training Manual for Marine Educators. Information and materials were compiled through a special session at the National Marine Education Association Meeting in Salem, Massachusetts (August 1980).

Objective 2: Public School Assistance

(a) In order to fulfill the major goal of the PASGAP Workshop (to introduce marine education to all 58 counties of California and to affect 50 percent of all students enrolled in California

public schools, grades K-12 within a three-year period), we have worked closely with Mr. Schafer, the Director of Environmental Education in California (also the Coordinator of Marine Education for the State of California) as a member of the Task Force for developing a statewide Environmental Education Packet. We were appointed as representatives of the Coastal Commission. Our input will assure the inclusion of marine environmental aspects, along with land-related issues, in the final package.

(b) The pilot Bilingual Program in the Lennox School District resulted in a task force of teachers who developed a package of student-related materials to be used in conjunction with the Teachers' Guide developed by Sea Grant, "Wet and Wild." Of the fifteen specially selected teachers who attended the monthly in-service training classes, one from each of the five participating schools will now continue as a trainer for other teachers in the school district.

The Lennox School District also enjoyed the participation of the International Workshop participants as they both observed a bilingual class in session and contributed to the enrichment of the class by teaching a marine-related activity.

(c) The six-year plan of study developed for the 32nd Street Magnet School in Marine Studies was assisted through monthly in-service training sessions. By following this plan, the students will have learned concepts from the six units of the teacher guide, "Wet and Wild," by grade 7.

(d) The Marine Studies Program in the Inner City Schools continues to attract University students from all departments to preare and present marine-related classes to public school students attending a participating inner-city school. This past year there were 18 USC students from 11 disciplines who contributed 200 hours teaching marine studies to 400 students, grades K-12. This program has benefited greatly from the Marine Education Resource Library.

The resource library has been useful to the USC students in preparing lesson plans for the inner-city program. During the school year there are four to eight students each day using the library. It is also used by local teachers, visitors from summer camps, YMCA, marine labs, and even Sunday School leaders. One USC graduate student used the library in writing her master's project.

New materials have been acquired for the library including a slide duplicator and a copy stand (for creative graphics), specimen boxes, tapes and recorders, filmstrip projector, books, audio visual materials, etc., many of which were donated by participants in the International Workshop.

Objective 3: Outreach Program

During this past year, two outreach programs were of special interest. The International Workshop took place in January, and the Handicapped Program ran from April through June. Both of these programs were enthusiastically accepted.

(a) International Program. Nine countries were represented by eighteen participants at the workshop in Los Angeles. The two-week workshop, funded by the Tinker Foundation of New York, was the beginning of the new International Marine Education Association.

The agenda for the workshop included guest speakersfor background information, concepts in institution building and teacher training, methodology and materials for elementary and high schools levels, field trips, and classroom observation and participation.

Not only have we received letters from all of the participants establishing the relevance of the workshop, but in each of these nine countries a program is being started. Chile has formed an agreement between university scientists and the Ministry of Education which has approved a two-year plan and appropriated funds for the first year. They are writing a proposal to host an International seminar for countries in the southern region of South America.

The three participants from Costa Rica returned home and within six months had developed three sets of materials, modeled on the USC Guides and Idea Books but indigenous to Costa Rica. They organized and conducted a national workshop with 42 teachers in attendance from all over the country. The National Committee for Research in Science and Technology (CONICYT) paid for the workshop, including expenses for the USC team to come to Costa Rica and participate in the workshop. The weeklong training session was patterned after the international workshop held in Los Angeles. Costa Rica has developed a three-year follow-up plan, and marine education is quickly being integrated into the national school system.

(b) Handicapped Program. Three pilot Marine Studies Programs for the visually impaired youngster were funded by the Department of Health, Education, and Welfare. Working with the Los Angeles County superintendent of schools and the Braille Institute, the program mainstreamed visually impaired students with their sighted peers.

Prior to actual implementation, a three-day teacher-training course was held, plus orientation meetings for both parents and students.

In conjunction with the classroom activities and the field trips, several innovative techniques were developed to intensify the learning experience, especially for the visually imapired student. Specimen kits were constructed, tapes were made, recorders were provided for listening pruposes, and a book in braille and large letters was written and illustrated.

A formal evaluation was conducted with demonstrated positive responses. Next year we will endeavor to adapt this model to other handicapped programs locally and nationally while continuing to work with the teachers from this year's pilot programs.

(c) Other Outreach Activities. These included: (1) cooperating with the USC School of Education in their Marine Education Program and Bilingual Methodology courses; (2) givien presentations for the National Marine Education Association, Southern California School Administrators' conference, the Coastal Studies Institute at California State Fullerton, Southern California Workshop for Junior High Mentally Gifted Minors, the National Football League Summer Camp for Inner City High School Students; and several local diving clubs; (3) appearing in three television programs and writing one magazine article; (4) participating on the board of directors and speaking at Community Forum meetings for the Black Student Science Education in America (SEA) Program. (SEA is a USC program funded by NSF that encourages black students to pursue careers in science by involving them with black professionals from the community); (5) co-sponsoring with the Los Angeles County Museum another Underwater Film Festival, with nearly 1,000 persons attending. These festivals have proven to be effective in acquainting the adult audience with the marine environment.

Conclusion

According to a special report entitled, "Crisis in the Science Classroom " (Science 80, September/October 1980, pp. 17-22, by Efthalia and John Walsh), the problem in science education in America today may be summed up as follows:

> The trouble comes in the underrepresentation of women and minority students in this select group (of young people being prepared for careers in science) and with the low level of competency in science and math among the overwhelming majority of students.

The article cites "serious problems with student motivation" as a major explanation for this situation in high schools, and states that most elementary school teachers "have little science training and many are intimidated by it."

The USC Marine Education Program is responding to the need for an exciting approach to science by providing multidisciplinary curriculum materials that are scientifically sound, pedagogically creative, and graphically stimulating. Written in a language understood by laymen, they are easily implemented by even the non-science-oriented educator. Through workshops and presentations, we have aroused interest in the ocean and inspired new commitments to the use and preservation of the marine environment on the part of regular classroom teachers as well as other educators and community leaders. They have, in turn, been able to relate their enthusiasm and new knowledge to students and youth groups that have often been excluded from quality education.

Since USC is located in an area of high minority population, we have built a variety of programs to meet the needs of black and hispanic students by working with the black community and the inner city schools and by translating materials into Spanish and training bilingual teachers. Beyond the public schools, our outreach programs have included handicapped students and Latin American countries. Feedback from all of these diverse user groups has documented the growing interest in our materials and programs not only locally in California but nationally and internationally as well. Recognizing this accelerating potential for marine education, we commit our human and material resources to developing new projects and strengthening and extending existing programs toward the essential goal of creating a society of citizens conscious of the marine environment.

GRADUATE STUDENT TRAINEE PROGRAM

Dorothy M. Bjur, Director, Marine Education

The Graduate Student Trainee Program is a continuing program within the Sea Grant Program at USC. Candidates for this program are selected from many disciplines, and each is expected to pursue Sea Grant related research.

A specially appointed Selection Committee is responsible for selecting students of the highest qualification. Members of this committee represent different departments on campus, The Graduate School, and the Directors of Sea Grant and the Institute for Marine and Coastal Studies.

Students interested in participating in the program must submit an application, accompanied by at least three letters of recommendation, a typewritten statement of intent, and a copy of both the GPA and their GRE scores.

The research accomplished by the trainee provides the necessary element for receiving a University degree and at the same time assists the principal investigator in his/her Sea Grant research req-irements. Working closely with knowledgeable profes-sionals, the students have the optimum environment for broadening their intellectual scope as well as preparing them as specialists who can deal effectively with a broad range of social, economic, and scientific problems. Their interaction with the Advisory Services staff and Sea Grant professionals gives them an opportunity to become familiar with the needs of the ultimate recipient of this research---the public. Sea Grant's applicability to the citizen user is certainly enhanced through the endeavors of the trainee.

Thirteen graduate students participated in the Trainee Program during 1979-80. They represented six departments on campus: international relations, biological sciences, medicine, public administration, geological sciences, and engineering. Four of these thirteen have been accepted for another year of traineeship with Sea Grant, four have taken and passed their written and oral examinations for their Ph.D. and are presently writing their dissertations, and one is taking his internship at USC Medical Center for his M.D.

During this past year, monthly meetings were conducted at which time the trainees had the opportunity to interact with Sea Grant directors and principal investigators, and with the other trainees. Two or three trainees presented verbal reports of their research work at each of these meetings. All of the trainees sug-gested that this program continue next year. They considered these meetings invaluable for becoming more intimately involved in Sea

Grant, for keeping abreast of Sea Grant research, and for keeping the communications open between Sea Grant administrators and the students. The following graduate students participated in the 1979-80 trainee program:

Robert Bowen, Ph.D., International Relations, "The Impact upon California of World Ocean Decisions."

Keith L. Duncan, Ph.D., Pathology, "Benzo(a)pyrene Induction of Tumors in Flatfish."

William T. Gorham, Ph.D., Biological Sciences, "Heterotrophic Metabolism of Marine Dinoflagellates."

Blayne Hartman, Ph.D., Geological Sciences, "Gas Exchange Across the Air-Water Interface."

Joel Kabolkoff, Master's candidate, Geological Sciences, "Quaternary Stratigraphy and Sedimentology of San Pedro Bay of Southern California."

David Krempin, Ph.D., Biological Sciences, "The Role of Natural Populations of Microheterotrophs in Carbon Cycling in Southern California Coastal Waters."

Sarah McGrath, Ph.D., Biological Sciences, "The Role of Natural Populations of Microheterotrophs in Carbon Cycling in Southern California Coastal Waters."

Richard C. Murphy, Ph.D., Biological Sciences, Marine Education Program, and Ecology of a Small Tidal Lagoon under the Influence of Urban Recreational Use."

Marianne Ninos, Ph.D., Biological Sciences, "Settlement and Metamorphosis of Three Species of Hypsoblennius in Southern California."

Seyed Sobhani, Ph.D., Civil Engineering, "Hydraulics in Ocean Engineering."

John E. Thorson, Ph.D., Public Administration, "The Port Authority as a Public Enterprise: Organizational Adjustment to the Conflicting Demands for Economic vs. Environmental Quality Goals."

William E. Westermeyer, Ph.D., Ocean Policy, "Evaluating Alternative Management Regimes for the Development of the Mineral Resources of Antarctica."

Joseph Wible, Ph.D., Biological Sciences, "The Influence of Heavy Metals on Oocyte Volumes of Opportunistic Marine Pollution Indicator Species."

EVALUATION OF A MASTERS OF PUBLIC ADMINISTRATION CURRICULUM SPECIALIZATION IN PORT/HARBOR MANAGEMENT

Willard Price, Associate Professor, Public Administration;
Gilbert Siegel, Professor of Public Administration

Introduction

This project is concerned with the development of a curriculum in seaport management and the offering of coursework within the graduate program at the School of Public Administration. Currently, there is a lack of coursework in this area, and the general intent of this project is to design, test, and evaluate such a curriculum. The project is motivated by seaport practitioners who lack coursework focused in their field, by academics who believe sports represent important public enterprises which have significant impact on the economics and environment of the community, and by the need for development of attention to marine transportation in the IMCS. In the 1978-79 year, a basic concept of the field, an initial curriculum, and certain teaching materials were developed. In this year, 1979-80, we tested two courses, recruited students, evaluated these offerings, and completed additional teaching materials. We expect ultimately that the seaport courses will become part of the regular School of Public Administration curriculum and that new research topics will emerge during the coursework.

Results

During 1979-80, the curriculum became active with two course offerings and participation by students from the practicing community of seaport managers and existing students at the university. This allowed the testing of the curriculum design into the classroom and resulted in useful evaluations for the expected adaptation of this developing curriculum.

Specifically, the outputs of this year included:

1. A complete syllabus for: PA 501a, Introduction to Port Policy and Management; and PA 501b, Port Financial Management.

2. Course offerings at the graduate level:

   PA 501a: Taught by Dr. Willard Price, spring semester 1980, attended by seven students, including regularly enroll university students and seaport managers.

   PA 501b: Taught by Dr. Robert Waters, Professor of Engineering Management, George Washington University, fall semester 1980, attended by 13 students, including a significant group of practitioners from Seattle, Portland, and the Los Angeles-Long Beach area.

An evaluation was requested from students enrolled in both courses. These evaluations support the curriculum and suggested shifts of balance of curriculum, which is to be expected as a result of initial course offerings. In addition, it has been quite clear that the optional format of 2 or 4 units which was used in the 501b section is very helpful in allowing practitioners from outside the Los Angeles area to attend the courses. Further, a 2-unit course, while it cannot transmit as much content, does lessen the annual cost for seaports who support students. Those students who want 4 units of credit for degree purposes or for a certificate for completion of a specialization series can obtain the additional credit by independent study (used in 501b for 4 students) or by another 4-day class session (planned for 501c during the spring semester 1981).

Additional teaching materials were also produced, including:

1. Public Access: An Issue for Seaport Planning

2. Seaport Dredging and Environmental Mitigation: The Case of Coos Bay

3. Environmental Mediation: An Alternative to Litigation

4. Seaport Planning and Risk Management

5. Intermodal Transportation and Seaports

During August 1980, the principal investigator attended a workshop of the New England River Basin Commission in Boston. That conference discussed regionalization of seaports and included several important seaport academics. The result of that conference is a new attention by this research to focus on the regionalization question in 1980-81 in cooperation with Dr. David Olson, professor of political science at the University of Washington.

Project Communications

Willard Price, "Seaports as Public Enterprises: Some Policy Implications." In Making Ocean Policy, Hoole, et al., eds. Westview Press, 1981 (in press).

Willard Price, "Seaport Management: A Research Frame and Agenda," Coastal Zone Management Journal (in press). 1981).

A paper entitled "Regulation for Seaports - Selected Concepts with an Example from California," was presented by Dr. Price at the New England River Basin Commission Workshop in August 1980.

To date, a network of academics and professionals who interact on this subject has been established. Key individuals include: Jack Knecht, MARAD, San Francisco; David Olson, University of Washington; Herman Boschken, Sacramento Public Affairs Center, University of Southern California; Marc Hershman, University of Washington; Henry Marcus, Massachusetts Institute of Technology; Roger Richmond, Old Dominion University; Robert Waters, George Washington University.

These individuals, as well as all west coast practitioners, are now receiving copies of all materials produced by this research.

Marine Advisory Services

Stuart A. Ross, Director; James A. Fawcett, Coastal Planning Specialist; Shirley J. Hudgins, Communications Specialist

The goal of Marine Advisory Services is to deliver information and expertise needed to help people solve marine resources management and development problems. It seeks to be the link between on-campus researchers and the communities of California -- channeling the ideas and research needs of the community to the researchers and delivering the results of research to the appropriate users of that information.

For 1979-80, three programs were emphasized. One program was in coastal planning: California has more multiple-use problems along the coast and more ambitious attempts to deal with the problems than most other coastal states. An additional program was in mass communications: increasing marine awareness and information generally among the public facilitates appropriate public and private decisions about marine resources, and Los Angeles is a world center for the mass communications industry. A third program, newer than the others, concerns marine energy. With regard to renewable and non-renewable marine sources, specialist assistance is needed by both public and private groups.

Although the programs are reported separately for purposes of indicating that each person has concentrated primarily on one area, it should be emphasized that the three staff members, in fact, work in close daily contact with one another. Each made substantial contributions in time, energy, and expertise to the work of the others. This cooperation makes the advisory services staff very flexible and resourceful in responding to the needs of outside groups.

Advisory services moved into new quarters in October 1980, in a new laboratory building constructed for the Institute for Marine and Coastal Studies. The building, on the waterfront in an area known as Fish Harbor, provides MAS with opportunities for new interactions with IMCS research groups and with marine user groups.

Coastal Planning in California

James Fawcett

During the 1979-80 project year, the work of the specialist was concentrated on three techniques which offered the best promise for disussing the California coastal planning process with the citizens of California. Those general techniques are:

individual consultations, publications, and public appearances. The choice of activities undertaken during the year is a reflection of the context in which the services of the specialist are delivered, i.e., that approximately 80% of California's 20 million residents live near enough to the coast to utilize it as a recreational or commercial resource during the year, and that there is but one Sea Grant coastal planning specialist in the state.

Individual consultations

The traditional means of communication for Sea Grant agents and specialists has been personal contact with individuals who need assistance. There is a constant flow of requests for information and assistance on the California coastal management program -- on the order of 10 requests for information per week, or an average of two per day. Some of these requests can be handled within a few minutes by relating information at hand or by conducting a minor amount of research and providing information within the same day.

For example, a caller contemplating building a structure along the coast will inquire whether coastal commission development guidelines would prevent him from building according to his initial plans. By consulting my own library of coastal development guidelines for the state, I can give the caller an estimate of his chances within a few minutes. While my information is only advisory and not a legal determination, as I make clear, such clients are usually only looking for such estimates at the start of their planning.

Although this kind of quick assistance is commonly given to a wide range of citizens, there are three groups of clients with whom I have had more extensive contact during the past year: fishermen, planners, and university researchers.

During the year I continued an ongoing relationship with the United Fishermen's Organization (UFO) of Southern California. That group has been actively involved in attempting to improve docking and support facilities for a part of the commerical fishing fleet located in the Fish Harbor section of Los Angeles Harbor. In last year's annual report I noted that with my assistance, the UFO had been able to develop an initial list of capital improvement needs for Fish Harbor. Armed with this statement of needs (the first ever produced by this group of fishermen) the Los Angeles Harbor Department made some immediate changes in the support facilities, such as increasing the number of trash receptacles and the number of public toilets. During the past year, my efforts have been directed at helping the fishermen work with the Los Angeles Harbor Department to implement more of the fishermen's recommendations. In that connection, I have advised members of the UFO board of directors concerning their participation in the citizens advisory committee set up under the auspices of the Los Angeles Harbor Department and the California Coastal Commission to develop a plan for the future of Fish Harbor. As of this writing (October 1980), the draft plan has been made public and the fishermen feel

that they are well represented in the outcome of the plan.

A second group of clients with whom I deal on a personal level are planners, especially in the southern California area. I maintain close relations with planners from the City of Los Angeles as they develop a local coastal plan (LCP) for the Venice community of Los Angeles. Venice presents some difficult planning problems for the city planners since the community contains some of the last stocks of low income housing along the California coast. The interest of the city in maintaining these stocks of low income housing was a strong impetus for Professor Phillip Emmi of the USC School of Planning to undertake a project to explore strategies for maintaining such stocks of housing in the coastal zone. A senior planner for the city and I talked with Professor Emmi at some length explaining the nature of the problem at which point he wrote the proposal (R/CM-17) which was funded by Sea Grant for the 1980-81 fiscal year.

I am also involved with four different planning groups in the preparation of a local coastal plan for Santa Catalina Island, 26 miles off the Los Angeles coastline. The island is a part of Los Angeles County, thus the county planning department has had the responsibility for developing the Catalina local coastal plan. However, the island is owned by the Santa Catalina Island Company, which has hired an independent planning consulting firm, EDAW, to develop a prototype local coastal plan for use by the island company and the county in developing an "official" LCP for the island. Other planning interests are involved as well; the county planning department has formed a citizens advisory committee and a technical advisory committee for the purpose of obtaining citizen input and technical input into the planning process. I am a member of the technical advisory committee and I have advised members of the citizens advisory committee on various aspects of the plan. In dealing with the Los Angeles County Planning Department, the Santa Catalina Island Technical Advisory Committee and EDAW, I have been mainly an informational resource. When dealing with one member in particular of the citizens advisory committee and with the Catalina Island Company my role has been to provide information on the coastal planning process and to advise on the specific process through which the Catalina LCP is being prepared. Although the plan document is not yet complete, the real result of my participation is already evident -- that these clients better understand the planning process.

Finally, I have had fruitful interaction with the faculty of the university during the past year. Two-thirds of the preliminary proposals submitted to Sea Grant this year in the socio-economic category were a direct result of marine advisory service contacts. In addition to encouraging Professor Emmi to submit a proposal entitled "Residential Resources in the Coastal Zone: The Planning and Regulation of Housing Opportunities for Low- and Moderate-Income Households," currently funded by Sea Grant, I was also active in assisting Professor Harlan Hahn of the USC Department of Political Science to prepare a proposal entitled, "Access to Coastal Recreational Facilities for Physically Disabled Persons:

A Comparative Study of Public Policies." That project is of direct and immediate interest to the California Coastal Commission, as they must coordinate guidelines for coastal cities with the requirements of the Rehabilitation Act of 1973. Professor Hahn's project has been funded by USC Sea Grant through its Program Development activities. I am also a co-principal investigator with Professor Lowdon Wingo of the School of Urban and Regional Planning on a project for 1980-81 entitled, "The Impact of Major Interest Conflicts on the Evolution of the Coastal Planning 'Partnership' Between the Coastal Commission and Local Government." The Coastal Commission is very concerned about the organizational dynamics of their interaction with the 68 local governments which are the ultimate implementors of the California Coastal Act of 1976, and our research will give insights into how this collaborative planning process has developed.

Publications

Four major publications were written and distributed by the coastal planning program during the year, and work has begun on another document which will be published during the 1980-81 fiscal year. A monograph describing the process by which a coastal development permit is obtained from the California Coastal Commission was completed in October, 1979. The monograph was written with Barbara Katz of the University of California Sea Grant program and published jointly by both universities. The first printing of 2,000 copies was quickly distributed and a second printing of 3,000 copies, is also nearly gone at this time. The 24-page narrative discusses a process of some 52 steps which might be encountered by an applicant for a permit. The document includes a pull-out flow diagram which may be removed for posting on a wall. Aside from the evidence of usefulness indicated by the large distribution of this rather technical document, the chief of the permit section of the coastal commission has told us that she uses the monograph to teach planners new to the commission about the permit process.

Three professional papers have been produced by the specialist during the past year. The first, entitled "The Impact of the California Coastal Management Program on State-Local Conflicts in Planning Development" was co-authored with Professor Lowdon Wingo and was delivered at a conference on land use and the law sponsored by USC's School of Law, the USC School of Urban and Regional Planning and the Lincoln Institute of Land Policy. The paper has been published in a proceedings by the Lincoln Institute. The second paper, entitled "Coastal Zone Integration of State and Local Plans," also co-authored with Professor Wingo, will be presented at the Coastal Zone '80 conference sponsored by the American Society of Civil Engineers in late November 1980. Also to be presented at that conference is a paper on Sea Grant/state coastal management agency relations entitled "Enhancement of Public Participation Through Process Delineation." The focus of the latter paper is a description of how the coastal development permit process was explained to the public in the most effective manner by a cooperative effort by both Sea Grant programs in the state working in

conjunction with the staff of the state coastal commission. Both conferences were designed for practitioners as well as academics.

The Marine Advisory Services of the University of Southern California and the University of California jointly sponsored a conference on recreational access to the coast in the spring of 1979, with support from the Pacific Area Sea Grant Advisory Programs. At the close of this fiscal year, we are about one month away from publishing the proceedings of that conference. The book, edited by Andrew Manus, formerly with the University of California and now with the University of Delaware, Jens Sorenson of the University of California Sea Grant Program, and the USC coastal planning specialist, will contain 25 papers delivered at the conference. The speakers included journalists, lawyers, planners, citizen activists and academicians. This will be the first book-length discussion of recreational access to the coastline to be published, and we anticipate interest in it from a wide audience including academicians, legislative staffs, agency representatives and the general public.

Public Appearances

It has been particularly rewarding to discuss California's coastal management progress in public forums. The efforts of the communications specialist, Shirley Hudgins, have been essential in generating these opportunities, and the events at which I have appeared have been joint ventures with her in content as well as coordination. Two major speaking engagements were the result of our cooperative effort.

In June, I was asked to give the keynote address at a conference on coastal monitoring sponsored by the Los Angeles chapter of the Oceanic Society. About 100 persons attended the all-day conference to discuss technical and socio-political monitoring of the coastal environment. I addressed the broader issue of monitoring and encouraged each member of this enthusiastic audience to become a monitor of his or her own proximate coastal environment. The address was well received, and the opportunity to speak broadened my own perspective on the whole subject of monitoring.

The communications specialist arranged for me to discuss the coastal development permit process in a half-hour television program on the major public television outlet in Los Angeles, station KCET. Designated by KCET as producer of the program, the communications specialist asked an attorney from the Coastal Commission and a moderator to join me in discussing the process by which a person obtains a permit to build in the coastal zone. The television station expressed the view that the program was an excellent use of available air time, and the show was exceptionally well received by the public, as manifested by at least 200 requests for the monograph which was the focus of the discussion and a number of letters at least two of which expressed the view that the show was the best public affairs show that KCET had ever aired.

Conclusion

There are no simple or even easily explained answers to guide action in the planning and management of the California coastline. The agency which has been designed to fulfill that function is vigorously going about its tasks, but the public does not have a clear idea of the process through which their coastline is being planned. My activities have been focused on explaining the process to a large and diverse set of audiences. For people with immediate problems, engaged in or contemplating a permit application, I assist them on an individual basis. For the public with a general interest in the coastal planning process, I have made information available through publications, speaking appearances, and a television program. Finally, for the professional and academic audiences, I have written more detailed pieces on the implications of managing the coastline in the way we do. The favorable response of my clientele has validated my choice of approach.

Marine Information and Communications

Shirley Hudgins

The communications component of USC Marine Advisory Services is charged with expanding USC Sea Grant's community effectiveness within southern California through selected modes of mass communications. Los Angeles is the mass media capital of the world in the largest population concentration in California. These characteristics give the USC Communications effort unique opportunities to: (1) disseminate Sea Grant-generated research to the appropriate user communities in the most useful form; (2) develop a true multimedia program for expanded Sea Grant visibility in southern California; and (3) assist in the development of a "marine awareness" within the southern California region, the state, and, when possible, the nation.

Radio: This was the seventh year for Sea Grant's successful "Marine Recreational Watch" weather program on KNX-AM (CBS) News Radio. The use of Communications' bilingual marine fillers as copy for a radio show called "Curiosidades" on KLVE-FM, the leading Spanish broadcasting radio station in Los Angeles, was initiated this year.

Acting in the capacity of Public Relations Officer for the Los Angeles Region Section of the Marine Technology Society and the Los Angeles Chapter of the Oceanic Society, the Communications Specialist wrote monthly Public Service Announcements for radio airing on the activities and meetings of these societies.

Unfortunately, Communications was not able to meet its goal of establishing a continual radio show feed to KPFK-FM that it had initiated with some success earlier, but we are confident that it will become a viable program during the next fiscal year.

Newspapers and Magazines: Communications has continued to

write news releases based on Sea Grant and IMCS research and activities. The bilingual marine filler material was also continued this past year, being sent to 50 local newspapers. They were also included as part of suggested educational materials distributed to participants of the International Marine Education Workshop. Two articles were written for Sea Grant Today, spotlighting the ichthyoplankton research of Dr. Gary Brewer and the International Workshop in Marine Education conducted by Dorothy Bjur.

The effort by Communications to distribute Sea Grant-generated recipes in the Los Angeles area newspapers this year was a success. After the initial publicity efforts, over 2,000 requests for information were received in a month or so. Now, in a more settled pattern, new recipes are distributed to 19 local papers, home economic departments in Junior High and High Schools, and private health organizations on a continuing basis. These recipes and cooking hints have been well-used and well-received.

Television: Efforts in this area were most fruitful this past year. Recognizing the interest in and importance of understanding the coastal permitting process by a wide variety of southern Californians, KCET-TV provided Sea Grant with a unique opportunity. Working with KCET-TV, Communications produced a half-hour special show based on the Permit Flowchart that USC and UC Marine Advisory Services had generated. The show aired twice in July, with very good community response.

The Communications specialist also introduced marine programming into a television show produced by KCET-TV for elementary school children, called "Summer Faire." An entire day's show was devoted to marine science. Both the Communicator and the Director of the Catalina Marine Science Center appeared live on this show, along with taped segments of a field trip to an intertidal area conducted for the Braille Institute of America by USC Sea Grant's Marine Education Coordinator, Dorothy Bjur.

Communications was also able to augment Ms. Bjur's International Workshop in Marine Education by contacting KMEX-TV, the largest Spanish broadcasting television station in the Los Angeles area. They televised an interview with Ms. Bjur and her assistant about the workshop and other aspects of the USC Sea Grant bilingual marine education effort. In anticipation of further involvement in television, the Communications specialist is taking a course in the Principles of Television Production in the USC School of Broadcast Journalism.

Film: With funding from IMCS, Communications was able to secure an assistant who has been instrumental in initiating a film program for Sea Grant. Under the direction of that assistant, Mr. Peter Brosnan, Communications' assistant and media consultant, a ten-minute film documenting the Oceanic Society's clean up effort of Malibu Lagoon was completed and distributed. Requests for use of the film have come in from the U.S. Fish and Wildlife Service, local colleges, other chapters of the Oceanic Society, dive clubs, and the Science Screen Report (New York City). The Coca-Cola

Bottling Company of Los Angeles donated $600, and $500 was received from Actuality Films, Ltd., of New York for the film's completion. Shot in Super-8 and transferred to 16mm, this film broke new ground in Super-8 sound post-production with eight different sound tracks to mix.

A proposal has been submitted to the California Council for the Humanities Public Policy to fund a one-hour documentary study of policy issues that the California Coastal Commission faces in its management of the state's coastal resources. Extensive research, interviews and location scouting have already been done. Letters of support have come in from KCET-TV (Los Angeles), KOCE-TV (Huntington Beach), and KQED-TV (San Francisco), all stating that they would be most interested in airing our final product. The current proposal is for a $5,000 scripting grant, and Communications is, at this time, searching for funding sources for the bulk of the production costs. The Catherine M. Davis Foundation, of St. Paul Minnesota, has generously donated $5,000 which has been spent on scripting and location scouting.

Communications was also active in a very successful Education project, "Wet and Wild." This project, aimed at teaching marine education to the visually-impaired child, was carried out this year by Ms. Bjur. Trips to tide pools, in-class activities, and trips on floating labs were all filmed on Super-8. This fiscal year we will edit the footage to create a half-hour documentary film of the project. KCET-TV has expressed interest in airing the final product, and the Los Angeles Press Club, whose Educational Foundation endorsed the project, has agreed to schedule a special Press Club showing of the film.

Communications also served as a script advisor for the production of a marine resources film developed by Handel Film Productions of Los Angeles.

Publications: Under the direction of the Institute for Marine and Coastal Studies' (IMCS) editor, Sea Grant's publications effort was strengthened again this year. Both the Reprint and Theses/Dissertation series were continued, with three documents generated under each category. Also, our Technical Report series got underway with three publications. Advisory Services reprinted one document, the monograph on the coastal permitting process (see report by James Fawcett, below), and published a new document, entitled "Shoreline Appearance and Design." That booklet, based on earlier Sea Grant research at USC, summarizes the techniques and problems associated with evaluating the visual appearance of shoreline settings. It has already been used in classes on urban and regional planning and has been requested by groups ranging from local architects to other states' environmental agencies.

We are pleased to report also that advisory publications from previous years enjoyed continued popularity, particularly those dealing with marine recreation. During 1979-1980 over 2,000 copies of the booklet "Weather to Go Boating" have been sent out, to the National Weather Service and other audiences; and over 50 copies

of Recreation: Marine Promise have been requested, including a request for use as a class text from a professor in British Columbia.

Finally, work continued on the compilation of a nation wide Sea Grant document tentatively titled, A Reporter's Director to Sea Grant Marine Research. This listing is in the final review and update process, and the final document will be ready for distribution by the end of the 1980 calendar year.

In addition, the Communications Specialist has been called on to provide advice and assistance to other groups on their communications programs.

A Public Information Council was created from among the Public Relations officers on the USC campus. The Sea Grant Communicator was chosen as a member of this council and has co-chaired a meeting/lecture with the USC News Service's broadcasting specialist on developing television and radio spots. Communications also continues to draw on -- when possible -- the talent of broadcast journalism students to help with its regular marine weather programming on KNX News Radio.

As a member of the Executive Committee for the "Year of the Coast" coalition, hosted by Los Angeles County Supervisor Yvonne Burke, the Communicator worked with ARCO's Teleproduction Services to produce four 30-second "Year of the Coast" Public Service Announcements for television, which have been aired locally.

Communications also initiated a joint research effort between Occidental College, the Oceanic Society, Sea Grant, and IMCS to investigate the environmental health of the Malibu Lagoon. The Oceanic Society began this as a low-level monitoring program, and with these institutions' joint efforts, a worthwhile baseline data study will result.

The Communicator arranged and carried out a Press Club tour of the USC Catalina Marine Science Center in June. The trip was quite a success and received some very nice coverage in the Press Club's newletter, The 8-Ball.

Marine Energy

Stuart Ross

A specialization in marine energy sources was proposed as a role for the MAS director in the revised version of the 1979-80 proposal to Sea Grant. However, the gradual assumption of the additional duties of Assistant Director of Sea Grant has meant and will mean that this specialty will not be as large a project as originally planned.

To increase the information available to the interested public about renewable ocean energy sources, USC MAS cosponsored a conference on the subject, held on the USC campus on May 30. The cosponsor

was the Los Angeles Regional Section of the Marine Technology Society. Technical presentations in the morning explained the technologies, and policy presentations in the afternoon explored how the technologies might be assessed. Speakers included representatives from the Coastal Commission, General Electric, TRW, Scripps, and USC. The intended audience was the educated public -- students, professionals, and interested citizens, and several of each -- some 70 in all -- attended. A computer-general bibliography on ocean energy prepared by Mr. Robert Bowen, a Sea Grant trainee, was distributed to all attendees at the conference.

The specialist also carried out several smaller activities on marine energy: evaluating an application for program development funds to compare the California and the Scottish OCS experiences, addressing the Coast Guard officers' club on marine energy, supplying information to individual requests generated by the May conference, and attending a hearing on OCS Lease Sale No. 53 in San Luis Obispo.

Program Coordination and Management

Management efforts are necessary to facilitate the work of the existing specialists and to provide resources that are generally responsive to the region's marine information needs. The director has worked in the following areas:

Staff: In addition to daily or weekly contact with the specialists on an individual basis, formal staff meetings have been held once a month to ensure coordinated planning and information.

Plans have been made and presented to the National Office of Sea Grant for the addition of another MAS specialist to the staff in the area of ports and marine transportation. The IMCS proposed that it would underwrite the costs of this position for the first year at least, from external funds provided for its Center for Marine Transportation Studies. As of October 1980, these funds were not yet in hand; we estimate now that the position can be filled by the spring of 1981.

Sea Grant Management: MAS management has provided the Sea Grant Director with quarterly summaries of MAS activities, and copies of these reports have been sent to the National Office of Sea Grant and to the University of California MAS program. Furthermore, beginning in November 1980, the Director of Advisory Services will also serve as Assistant Director for the Sea Grant program.

User Groups: Some time is allocated for attending a variety of meetings for the purpose of learning about additional marine-related audiences and problems; these visits prove productive for the MAS program either in projects initiated or in establishing contacts and visibility that may be Useful later. Groups contacted in this manner included the "Year of the Coast" coalition, the Los Angeles Chamber of Commerce Maritime and Harbor Affairs Committee, the citizen's advisory committee for planning Fish Harbor, and other groups.

Sea Grant Network: In December and January, Dr. Bruce Wilkins of the New York Sea Grant program visited with our program for a total of four weeks, consulting with the MAS director on all aspects of the MAS program. His visit was supported by the Institute for Marine and Coastal Studies for the MAS program. His personal discussions with each specialist provided many useful suggestions for specific activities, and two all-day sessions with the entire MAS staff proved extremely valuable in formulating, evaluting, and integrating the objectives and activities of the MAS programs.

In August 1980, the director served as logistics coordinator for the annual meeting of the Advisory Service leaders from around the country, held in San Diego. In this role he was helped considerably by Mr. Arthur Flechsig, Area Marine Advisor for San Diego County for the University of California, and he worked closely with Mr. David Veal, Advisory Service leader for Mississippi, who was program coordinator.

USC Faculty: The MAS director received an adjunct faculty appointment to the School of Public Administration. This appointment provides the Sea Grant program with access to and recognition by faculty networks, through participation in the faculty Committee on Environmental Management and through teaching a one-semester course on marine policy.

Personal contacts have also been established with faculty in political science, engineering, biology, and humanities -- contacts which have in each case provided additional faculty awareness of MAS and additional information useful for the MAS program. A political science professor identified companies most likely to be helpful in establishing a conference on marine energy, for example, and a humanities professor provided further contacts with USC faculty interested in energy policy.

Information Services: MAS management has devoted a small but continuing amount of time and effort to maintaining and improving a wide base of information materials. The MAS has a library of its own, approximately 1,000 volumes, with emphasis on offshore oil, coastal zone management, and marine recreation. MAS subscribes to two computer search services and has provided literature searches on swordfish, shark liver oil, roll waves, marine energy, local ocean-related corporations, and other marine topics. These services have proven effective as an additional resource for both faculty and user groups.

In addition, the director answers outsiders' requests for information if the requests are not in the fields of the other two specialists. These have included a resident of Newport Beach interested in aquaria, two commercial divers interested in new technologies for cleaning hulls, and a cargo company executive seeking information on the effects of edible oils spilled in the marine environment. When there was not adequate expertise at USC, the questions were referred to the specialists or advisors in the University of California program.

IMCS TECHNICAL ADVISORY PANEL

Collectively and individually, these persons provide valuable counsel on the programs of the IMCS. One of their principal functions is to review the Sea Grant proposals each year.

Victor Adorian, Director
Los Angeles County
Department of Small Craft Harbors

Gary L. Bane
General Manager
Ocean Engineering Department
Interstate Electronics

Richard A. Geyer
Professor Emeritus
Texas A&M University

Captain Jack Boller
Executive Director
Marine Board
National Research Council

Colonel Ted Gillenwaters
Attorney
Newport First Investment Services

George Hatchett
President
Hydro Products

Robert Kleist
Director of Trade Development
Port of Los Angeles

Robert Krueger, Esq.
Nossaman, Krueger & Marsh

Captain William C. Lynch
Professor
California Western School of Law

George Mueller
President
Systems Data Corporation

Wheeler J. North
Department of Environmental Science
California Institute of Technology

Richard J. Seymour
State of California
Department of Boating and Waterways

Howard Talkington
Head
Ocean Technology Department
Naval Oceans Systems Center

Captain T. K. Treadwell
Professor
Department of Oceanography
Texas A&M University

O. D. Waters, Jr.
Rear Admiral USN (Ret.)

Donald E. Wilson
Director
Teacher Education
University of Southern California

Donald B. Bright
Donald B. Bright & Associates

Ex Officio Member

Don Walsh
Director
Institute for Marine & Coastal Studies
University of Southern California

CALIFORNIA STATE SEA GRANT ADVISORY PANEL

Name	Representation
E. C. Fullerton Chairman	Director, Department of Fish and Game, representing that department
Tom Tobin	Representing the California Coastal Commission
Jeffrey D. Frautschy Assistant Director Scripps Institute of Oceanography	Representing the University of California
Tom Gay Chief Deputy State Geologist	Representing the Department of Conservation
Wilbur M. Thompson Manager, Long Beach Operation California State Lands Commission	Representing the California State Lands Commission
Don Walsh, Director Institute for Marine & Coastal Studies	Representing the private institutions participating in the National Sea Grant Program
Richard Ridenhour Humboldt State University	Representing the California State University and Colleges
Marty Mercado Director Department of Boating & Waterways	Representing the Department of Boating and Waterways
Elmer Wheaton Vice President (Ret.) Lockheed California Corp.	Representing the ocean engineering industry
Rob Ross Northern California Seafood Institute	Representing the fishing industry

Journal or Book Contributions

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