SEA GRANT
BIOLOGICAL SCIENCES
GEOLOGICAL SCIENCES
SOCIO-ECONOMICS
ACADEMIC PROGRAMS
ADVISORY SERVICES
FACILITIES
PUBLICATIONS

MARINE RESEARCH AT USC 1982-1983

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Published by
Institute for Marine
and Coastal Studies
University of Southern California

The **INSTITUTE FOR MARINE AND COASTAL STUDIES (IMCS)** was established by the University of Southern California in 1975 to be the institutional framework for its marine programs, many of which had been in operation since the early 1900's. A part of the Division of Natural Sciences and Mathematics of the College of Letters, Arts, and Sciences, the Institute promotes basic and applied marine research as well as training in marine studies; sponsors workshops, conferences, and extension courses; and produces reports and publications based on Institute-sponsored research. The work of the Institute takes place throughout the southern California region—at USC's University Park campus, on several research vessels, at research facilities located in the Los Angeles Harbor, and at the Catalina Marine Science Center and Mt. Ada Marine Conference Center on Santa Catalina Island.

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SEA GRANT

SEA GRANT

One of the features that distinguishes Sea Grant from other large federal research programs is the delegation of significant funding and review responsibilities to an on-site program director and staff. This means that the many individual projects in research, education and advisory services are coordinated with one another to make maximum use of the available resources to meet the marine-related needs and problems of the Los Angeles area.

USC Sea Grant management, therefore, must integrate the resources and concerns of community groups, university researchers, funding agencies and other Sea Grant programs.

FY 82-83 was the 13th year of the University of Southern California's participation in the National Sea Grant College Program. 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 programs within the university's Institute for Marine and Coastal Studies, founded in 1975.

Like other Sea Grant programs, USC is required by the Congress to match federal funding with half again as much from non-federal sources. We are happy to acknowledge the receipt of $84,925 from the State of California's Resources Agency, more than $200,000 from other USC departments and more than $70,000 in services-in-kind from other sources. The support expressed by these institutions and companies makes our work possible and keeps it relevant.

Sea Grant projects run an extensive course of review before funding is awarded. A technical advisory panel makes recommendations to the program's management; academic peer reviewers from around the country 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 appointed by the federal government makes an on-site inspection of the entire program. The members of the IMCS Technical Advisory Panel and the Resources Agency Sea Grant Advisory Panel are listed elsewhere in this report.

In 1982-83, the USC Sea Grant Program supported the following projects: (These are discussed in detail on subsequent pages.)

- Nitrogen Transformations Associated with the Discharge of the Terminal Island Treatment Plant.
- Microbially Mediated Entry of Pollutants into Marine Food Webs.
- Problems in Paralytic Shellfish Poisoning.
- Capital Development Decision-Making by Seaports: A Survey of West Coast Ports and Their Responses to the "Rediscovery" of Coal.
- Scientific Information and the Valuation of Ecological Resources: The Case of California Coastal Wetlands.
- Factors Affecting the Survival of Nearshore Larval Fishes.
- Aspects of the Biology of the Sea Cucumber, Parastichopus parvimensis: A Developing Commercial Fishery.
- Food Availability, Feeding and Potential Competition for Food Between Larval Northern Anchovies and Adult Copepods.
- Wave Uplift Pressures on Horizontal Platforms.

In addition, each year Sea Grant sets aside limited funds for discretionary allocation to activities other than those that pass through the annual review cycle.

Projects that meet emergencies, ideas that are interesting but not yet fully developed, projects that must begin early or end late, and other discretionary situations can be covered by program development funds if they promise sufficient contribution to the Sea Grant Program. In 1982-83, program development funds went primarily to three projects.

1. A national workshop on seaport management and related marine transportation issues. The workshop, sponsored by USC at the request of the Council of Sea Grant Directors, was designed to arrive at a research agenda to guide scholars, managers and funding agencies concerned with research into seaport management. Further details on the workshop are included elsewhere in this report.

2. Travel funds for Dr. Bernard Abbott to attend a national workshop on "Natural Toxins and Human Pathogens in the Marine Environment." The workshop, sponsored by the Maryland Sea Grant Program in November 1982, addressed the barriers to seafood utilization posed by natural toxins, the information needed to overcome these barriers, and the aspects of research most appropriate for university effort. Workshop attendance obviously complemented Dr. Abbott's Sea Grant research project (R/EQ-31) on the problems of paralytic shellfish poisoning, but funds had not been anticipated in the original proposal budget.

3. In July 1983, Alex Andrasi, a Sea Grant trainee with Dr. Abbott, won a Sea Grant Association Award for the quality and importance of his dissertation research; program development funds were spent to further his research.

Nitrogen Transformations Associated with the Discharge of the Terminal Island Treatment Plant, Los Angeles Harbor (R/EQ-24)

Richard C. Dugdale, Professor, Biological Sciences, University of Southern California
Dale A. Kiefer, Assistant Professor, Biological Sciences, University of Southern California

The major goal of this project is to acquire the knowledge necessary for scientific management of primary nutrient-containing effluent flow into the Los Angeles Harbor.

The waters surrounding the discharge of the Terminal Island Treatment Plant (TITP) contain high concentrations of nitrogenous compounds, including organic nitrogen, nitrate, nitrite and ammonia. Concentrations of such compounds are several orders of magnitude higher than those of the coastal waters of the southern California Bight. Studies have shown that the effluent from the local tuna canneries provides a major nutrient input to the Los Angeles-Long Beach harbors (Allan Hancock Foundation, 1976).

Recently, secondary treatment of sewage from the tuna canneries has been instituted. This conversion from primary to secondary treatment has dramatically altered the forms of nitrogen within the discharge: Concentrations of organic nitrogen and ammonia have dropped in surrounding waters, and concentrations of nitrite and nitrate have increased. Such changes in the form of nitrogen discharged may affect the stock of both phytoplankton and bacteria. In effect, secondary treatment has made nitrogen more available to phytoplankton populations so blooms are more likely. Particularly important blooms of phytoplankton in the harbor are those provided by dinoflagellates. Red-tide-forming dinoflagellates, although beneficial as food to higher trophic levels, become a problem when they are: (1) present at low concentrations and are of a toxic variety or in a toxic phase, or (2) present in such large concentrations that they are unsightly and can deplete the oxygen of the enclosed harbor water. Secondary treatment will likely lower heterotrophic populations of bacteria because of decreased organic nitrogen. On the other hand, the conditions for bacteria that can use nitrate for respiratory purposes (for electron acceptors) are improved. The nitrate produced during secondary treatment may be converted to nitrite or ammonia or to volatile nitrogen compounds.

The other primary phytoplankton nutrients, phosphorous and silicon, also are supplied in the discharge of the treatment plant, and the final nutrient environment results from mixing concentrations of primary nutrients in the discharge. In the receiving waters, the response of the phytoplankton depends largely on the resulting concentration of the primary nutrients in the euphotic zone, on the preexisting phytoplankton population, and on the advective regime of the harbor.

Observations of the harbor, made by a continuous mapping technique since the activation of secondary treatment, show that the dominant form of nitrogen has changed from ammonia to nitrate. A map from February 1982 showed nitrate concentrations of greater than 30 μg-at/l near the outfall. Ammonium concentrations, while still high relative to most ocean waters, were at most 5 μg-at/l, and the highest concentration was in the western harbor, away from the outfall.

Toward the end of the summer in September 1982, the general patterns of nitrate and ammonia distributions were similar to February. However, the relative concentrations were lower except directly at the outfall. A sharp frontal area existed to the east of the outfall, possibly due to the winds. Very low nutrient concentrations ($NO3 < 0.1$ μg-at/l and $NH4 < 0.25$ μg-at/l) were observed to the east. This is likely to be water from Long Beach Harbor blown to the west by easterly (Santa Ana) winds.

A hydrographic transect was also sampled from the outfall to the sea buoy beyond the breakwater.

The location of the breakwater is at about 3 kilometers from the boil. Within the harbor a strong, vertical temperature gradient existed (dT) > =2°C over depth of about 6 m). Within 1 kilometer of the boil the highest nitrate concentrations were at surface. The presence of high nutrient concentrations near the surface with the associated strong stratification provide the opportunity for the phytoplankton to shift up to optimal rates of photosynthesis and nutrient uptake. This may account for the lower overall nutrient concentrations observed in September. The combination of less available solar radiation and more wind induced mixing in winter may result in suboptimal rates of photosynthesis and nutrient uptake.

Thus, for at least a portion of the year, the harbor conditions appear to be favorable for the phytoplankton to become a significant sink for the influx of inorganic nitrogen from the TITP outfall.

Measurements of nitrate and ammonium uptake/assimilation using 15N have shown: (1) "normal" Michaelis-Menten kinetics in regions of the plume somewhat removed from the boil; (2) strong inhibition of nitrate uptake near the boil, to be expected from the presence of high ammonium concentrations; and (3) some inhibition also of ammonium uptake near the outfall, presumably due to inhibitory materials as seen at the Whites Point outfall in previous work.

Microbially Mediated Entry of Pollutants into Marine Food Webs (R/EQ-28)

Dr. Cornelius W. Sullivan, Associate Professor, Biological Sciences, University of Southern California
Dr. Donal Manahan, Assistant Professor, Biological Sciences, University of Southern California
Dr. Gordon T. Taylor, Research Associate, Department of Oceanography, University of Hawaii

As originally proposed, this project was designed to investigate the uptake of toxic trace metals by plankton in the bacterial size fraction, which was an extension of an earlier Sea Grant project (R/EQ-19, "The Role of Natural Populations of Microheterotrophs in Carbon Cycling in Southern California Waters"). The earlier project established that the bacterial size fraction of the microplankton was very important in the uptake and assimilation of organic compounds.

By December 1982, however, the researchers had established that the trace metals, cadmium (Cd) and cobalt (Co), are accumulated only moderately by the phytoplankton-enriched fraction of the microplankton. The bacterial enriched fraction appeared to accumulate little or no Cd or Co. These observations were contrary to all previous observations of the behavior of these organisms with respect to organic compounds that enter the coastal zone through natural and anthropogenic processes. Continuation of investigations of inorganic metals would require more extensive instrumentation and, apparently, would not reveal a major metal pathway through the food web via microplankton.

Aware of this information, the Office of Sea Grant agreed to redirect the project to investigate the uptake of organic nitrogen compounds (amino acids and proteins) by the bacterial fraction of the microplankton. The redirection was guided by several factors: (1) The researchers acquired a High Performance Liquid Chromatograph (HPLC) apparatus capable of measuring amino acids and proteins at natural seawater concentrations; (2) The organic nitrogen compounds in natural seawater are known to be a major nutrient source for marine food webs; and (3) The project already was being conducted in conjunction with Dr. Richard E. Dugdale's project on nitrogen transformations (R/EQ-24), sharing shiptime on transects of the Terminal Island Treatment Plant (TITP) outfall plume.

For field experiments, a 1 liter sample of Los Angeles Harbor subsurface seawater was collected in a sterile flask and incubated at 20°C for 6 hours in the dark to minimize free amino acid production by phytoplankton. At 0, 4 and 6 hours 2 ml samples were removed and passed through a 0.2 μm membrane filter (Nuclepore) to remove most particles. Using standard techniques, the filtrate was prepared for analysis on a Beckman Series 340 HPLC.

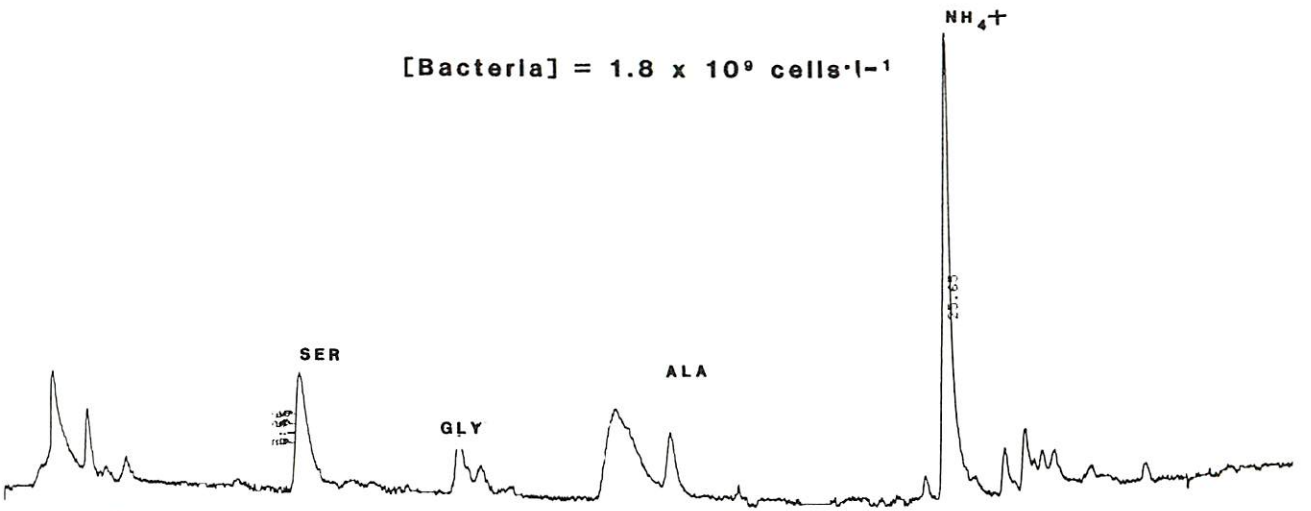
Figure 1 presents the concentrations of the amino acids, serine (SER), glycine (GLY), alanine (ALA) and ammonium ions (NH4+) in the harbor sample immediately after collection. Serine, glycine, and alanine were present in this sample at the following concentrations: 43.4, 39.6, and 18.4 nM, respectively. After a 4-hour incubation with the natural microplankton assemblage, concentrations of serine, glycine, and alanine were reduced to 19.8, 24.1, and 6.3 nM. After a 6-hour incubation period, serine, glycine, and alanine concentrations were further reduced to 14.1, 14.2, and 5.9 nM. Ammonium ion concentrations displayed no obvious trends.

Decline in amino acid concentrations during this 6-hour dark incubation with microplankton is attributed to bacterial utilization. Current studies using radiolabeled amino acids are expected to verify the fate of dissolved amino acids. Measured rates of dissolved amino acids disappearance represents turnover times of serine, glycine, and, alanine of 8.9, 9.4, and 8.9 hours, respectively.

To date, this study has demonstrated that the highly sensitive HPLC is an effective tool for measuring ambient free amino acid concentrations in the harbor system and changes in their concentrations due to microheterotrophic utilization.

Our studies are expected to provide a better understanding of the nature of organic input into the Los Angeles Harbor system, its variability within the harbor and coastal systems, and its interactions with the microplanktonic community. The anticipated results will be especially relevant to understanding the nitrogen economy of the harbor waters and complement concurrent studies by other investigators.

Figure 1. HPLC tracing of ambient dissolved amino acid in subsurface Los Angeles Harbor sample at time of collection (0 h). SER = serine, GLY = glycine, ALA = alanine, NH4+ = ammonium ion



Problems in Paralytic Shellfish Poisoning—(R/EQ-31)

Bernard C. Abbott, Professor, Biological Sciences, University of Southern California
Maria R. Ross, Hancock Fellow, University of Southern California
Alvin Siger, Ph.D., Director of Research, Foundation for Cardiovascular Research

Paralytic shellfish toxin is an ever-present threat to the entire fishing industry and, most importantly, to the populace of coastal states.

The danger posed to human health by the consumption of toxic shellfish is on the increase. In recent years, poisonings have resulted from consumption of both commercially and recreationally harvested shellfish. As the profile of the population is changing due to a tremendous influx of individuals from countries where the main diet consists of seafood, collecting and eating of bivalve molluscs is at an all-time high.

Because of the hazard to human life, regular monitoring of the levels of toxin in commercially harvested shellfish is mandated by the California Department of Health. If a threshold of 80 μg/100 g of shellfish tissue is exceeded, the sale of shellfish is banned. Although the majority of shellfish are harvested by commercial organizations that regularly supply samples for analysis, there exist long lengths of shoreline where native shellfish populations are harvested recreationally. The unavoidable publicity when fatal or near fatal incidents occur affects the entire fishing industry—at times with disastrous results.

It is important to protect the human population and the seafood industry by management procedures because control of the dinoflagellate organism, which produces the paralytic shellfish toxin, is unlikely. There is a great deal that is still unknown concerning the processes involved in the phenomenon of paralytic shellfish toxin production.

The only assay permissible by Food and Drug Administration (FDA) regulations is the Mouse Mean Death Time test. This test gives estimates that are significantly too small at low levels of toxin due to a 'salt' effect. The assay also is too complex and cumbersome to be used in the field.

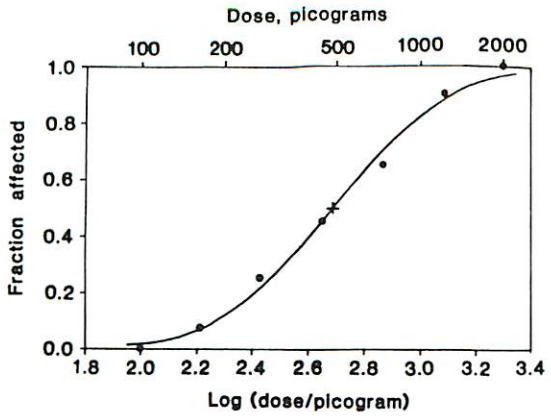


Figure 1

Research in this project has involved developing a sensitive, inexpensive and rapid bioassay that counters the many disadvantages of the present mouse bioassay. The new test animal is the species of common domestic fly, *Musca domestica*.

Calibration studies with the standard saxitoxin supplied by the FDA were carried out and the results are shown in Figure 1. The ED 50 (50% effective dose) is shown to be 490 picograms when 1 μl of the toxin solution is injected into the fly.

The researchers participated in a 1982 toxic clam PSP split sample used for the quality assurance program. Two extractions each of shellfish samples "A" and "B" were prepared and analyzed by the fly bioassay method and compared with results obtained in 19 laboratories with the mouse bioassay method. The toxin contents of both samples estimated by the fly method were higher by more than a factor of two than the values estimated by the official

mouse method. This is as expected since Schantz et al. (1959) showed that in this range the values obtained by the mouse method should be affected by about the same factor.

Extracts of non-toxic clam tissue have also been examined. This extract affected 5% of the flies (Figure 2). The extract was further tested. Known concentrations of the FDA saxitoxin standard were added to a constant volume of the extract. Dilution series were then prepared from each of the above using 0.18N HCl pH 3.3. The results from these experiments suggest that a saxitoxin-like material may be present in the ('non-toxic') clam extract, which affects the fly.

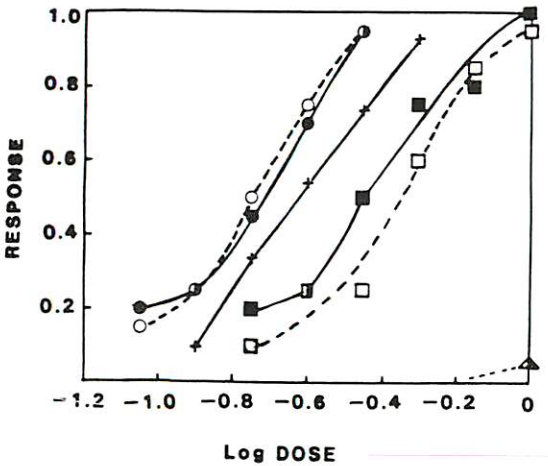


Figure 2

A similar study with non-toxic mussel (*Mytilus edulis*) extract was carried out by Alex Andrasi. The dose-response curve was obtained with known concentrations of saxitoxin added to the non-toxic mussel extract and compared with that of the saxitoxin standard diluted with 0.18N HCl pH 3.3. Again the results (Figure 3) demonstrate an elevated effect on the fly with the non-toxic mussel extract.

The preliminary results from the collaborative studies with the Department of Health Services scientists at Berkeley confirm the Schantz "salt" effect. The collaborative studies with samples from the Department of Marine Resources in Maine are inconclusive because the samples we received had observable mold growths. The fly bioassay was performed with each of the ten samples in duplicate; however, the results cannot be analyzed or compared with those of the mouse bioassay. The existence of toxin in each sample may have been affected either positively or negatively by the molds. Some molds produce toxin themselves which in turn may elevate the level of toxins that the fly is exposed to. On the other hand, molds may degrade the existing paralytic toxin in the sample, thus leading to an erroneously low level being detected with the fly bioassay. These studies are being repeated at present.

At the present time, we have successful unialgal cultures of two species of Gonyaulax, which produce toxin: *Gonyaulax catenella* from the West Coast (two isolates), one from British Columbia and one from Washington; and *Gonyaulax tamarensis* from the East Coast, State of Maine. The organism from the Los Angeles Harbor has been sent to Dr. Balech in Argentina for identification. All these cultures will be used for further studies during this funding year.

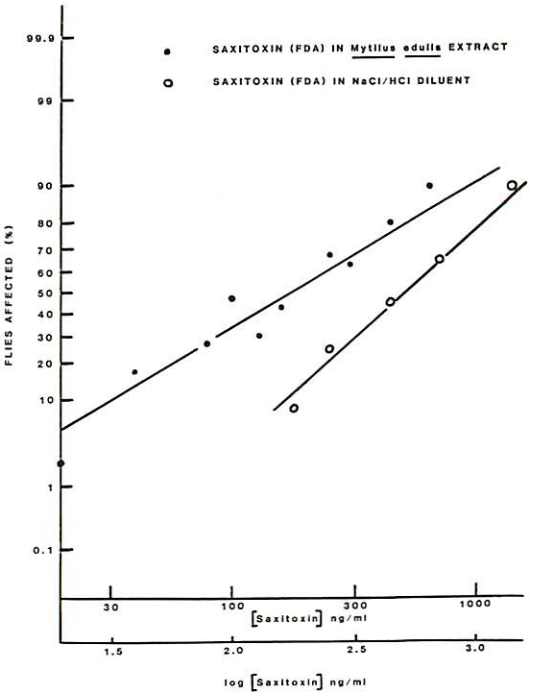


Figure 3

Decision-Making by Seaports: West Coast Ports and the "Rediscovery" of Coal (R/CM-20)

Willard Price, Associate Professor, School of Business and Public Administration, University of the Pacific

In 1980-81, increased international interest in the movement of supplies of coal as a source of energy led to the expectation of large increases in coal shipments through West Coast seaports by the end of the 1980s. About 20 ports in Washington, Oregon, and California, as well as in Alaska and in Vancouver, B.C., were approached by shippers looking for ports willing to engage in capital development projects to significantly increase their capacity to export coal.

This interest created an excellent data base of ports who began the process of a major development decision. Given the magnitude of the increment of cargo forecasted and the opportunity to study major development projects, Dr. Price proposed an effort to examine the response of West Coast ports to the "rediscovery of coal."

One of the most prevalent policy issues for ports is capital development because such decisions:

1. Involve large capital expenditures
2. Suggest financial risk for the port and/or the private developer and terminal operator
3. Create significant environmental implications for air quality, water quality, transportation congestion, noise and aesthetic impacts, and possible risks of hazardous cargos.
4. Offer an opportunity to study seaport decision-making

The study began in the fall of 1982, with about 15 West Coast ports involved in coal development projects. However, by the fall of 1983 few ports had new facilities for increased capacity completed; very little coal had been moved. In effect, predicted increases in coal exports had not materialized because of the worldwide recession and the decrease in crude oil prices.

Nonetheless, several ports have begun coal development projects, and each has progressed to different stages of development. In some cases, important decisions are still pending; in other ports, projects will be delayed in the hope that coal shipping will reach the anticipated level.

As a result, only a long-term study over several years can truly examine these development decisions regarding coal. However, the current study is not intended to be a longitudinal one, and some conclusions will be drawn and presented in the final report, scheduled for completion in mid-1984.

Within the life cycle of port development, there are several critical decision points at which the port must decide to continue, place the project on hold or cancel further development action. These include:

1. Commit to project plan and environmental impact assessment
2. Commit to engineering design and environmental permits
3. Commit to project construction
4. Commit to facility operation and maintenance

This study attempts to not only observe actual commitments by the ports in the data base, but also to examine the nature of those decisions and to identify the characteristics of such decisions as identified in social science models of decision-making.

For instance, one model of decision making is established by Kast and Rosenzweig (Organization and Management: A Systems and Contingency Approach, Third edition, 1981). They examine decisions across three continua:

- Open vs. closed decisions
- Quantitative vs. judgmental decisions
- Comprehensive vs. incremental decisions

No normative position will be taken by this study as to the quality of these decisions, but rather the intent is to better understand the nature of seaport development decisions.

The final report for this study will also examine the details of each project and will attempt to explain the factors that contributed to the development decisions.

For this annual report, some highlights of the study results are presented:

1. One overriding result is that less than 10 million tons of coal per year are being exported from West Coast U.S. ports, with an additional 10 million tons of Canadian coal being moved through Vancouver, B.C.
2. In general, the ports that committed to coal development projects were seeking private investment to minimize the port's risk in what turned out to be an uncertain market.
3. The question of whether ports can avoid such risk was demonstrated by the financial difficulties at Portland. Essentially, the private developers withdrew their financial support for construction. After litigation, the developer renegotiated his agreement with the port, decreasing the revenues for the port, but apparently ensuring the completion of the project construction.
4. The total coal capacity available in the short term (by 1985) will be substantially less than the amount initially proposed, say 20-25 million tons per year. That capacity may only achieve 50%-60% utilization unless the coal market increases.
5. The environmental disputes have been minimal in the existing development projects. Project approvals/permits came surprisingly easily and cooperatively in Vancouver, B.C., Portland and Stockton. More serious debate over transportation congestion and air pollution is likely if a major new coal terminal is actually developed in the Long Beach or Los Angeles area.
6. Coal is viewed as a desirable cargo by most ports, particularly where long term and large export agreements are made. With little risk, ports may well be able to generate substantial revenues in a time of an international recession with decreased demand for other land uses and cargo movements.
7. While the broader public has had opportunities to contribute to coal decisions, most of these development actions received little public debate. The Ports of Los Angeles and Long Beach are an exception to these conclusions with their environmental reviews.
8. The role of analytical decision models, like benefit-cost analysis, appear to receive only minimal attention. Certainly cash flows are predicted and decisions support minimum needed revenues for debt recovery, but the calculation of specific risk equations seems neglected.
9. Coal development decisions are clearly comprehensive because they represent such significant development actions and must consider all land use, land fill, transportation connections, traffic congestion and air and water environmental implications.

The Port of Los Angeles is one of the major ports under study in anticipation of the "rediscovery" of coal.

Valuation of California Coastal Wetlands (R/CM-22)

Lowdon Wingo, Professor, School of Urban and Regional Planning, University of Southern California

A very difficult problem in making decisions about—and policy for—such natural areas as coastal wetlands is the imputation of value to the biological and ecological services rendered by them. Such services can be distinguished from those contributing to the production of market goods, from amenity services directly enjoyed by the general public, and from collective services, such as the dispersal of flood waters, which would otherwise have to be provided through public works or programs. Unlike these, biological and ecological services have no direct—and, at best, tenuous indirect—market reflections.

Nevertheless, a major justification at all levels of government for legislation dealing with natural environments has been the intense public concern with the preservation of these resources. At the same time, proposals for the conversion of some coastal wetlands have challenged such policies by contending that the social values promised by the development of such areas would exceed their values in their natural state. The difficulty of specifying the value of the ecological services has made the answer uncertain and raised the possibility that such conflicts will be resolved with more easily specified market values overriding the actual social value of such areas. There is, accordingly, a serious need for a credible basis for the evaluation of such resources.

Scientists—the primary sources of information about such values—can take one or more of the following roles in policy formation: 1) Some may be primarily concerned with research to advance knowledge about wetland biology or ecology; 2) Some work for policy making bodies in relating scientific knowledge about wetlands to public policy purposes; 3) Some may act as scientific consultants to the private sector activities confronting government environmental policy; and 4) At one time or another, all may act as scientifically well-informed citizens in advocating policies of interest to them.

This project focuses on the first three roles and seeks to discover some of the propositions that underlie the judgments of wetland scientists in their public policy discourse about the valuation of wetland services.

The core of this project is a Delphi inquiry covering a wide set of topics associated with coastal wetlands and policy making for them. Three "expert" panels of scientists and technical personnel involved in wetland policy were established: a panel of academic biologists; a panel of consultants to the private sector; and a panel of government officials from agencies involved in the formulation or administration of coastal wetland policies. We began with 9-12 members on each panel. During the summer, we asked each panelist for approximately 2,000 separate judgments on wetland matters in a six-installment survey.

As of the date of this report, approximately 22 panelists completed the entire first round of the inquiry. This arduous exercise took its toll: Seven remained on the academic panel; Three members of the panel of ten of the government officials saw it through to the end.

In the middle of November, we initiated the first resurvey, the characteristic feature of the Delphi procedure. This involved informing panelists of the summary statistics of their panel and their own original answer and then asking if the individual's original answer should be reconsidered. Included in the resurvey were approximately 20% of the original questions, which reflected a high degree of dissensus as measured by the standard deviation of that panel's answers to the questions.*

A first look at the data from the initial survey suggests a rather surprising degree of consensus within and between panels. The typical question asked the panelist to choose the best response from a numbered rating scale offering eleven possible responses. Of the 2,000 judgments made by each of the 22 panelists, the standard deviation was less than 2. This suggests that roughly 31,500 judgments entered by the panelists fell within two points of the mean values question-by-question.

The greatest differences between the panels shows up on questions that depart from scientific judgment, and there the differences seem to be largely in emphasis rather than in perception. Academic panelists, for example, stressed biological productivity as an indicator of wetland "health" much more so than did their government counterparts, who emphasized diversity of species. Academic panelists were about 20% more concerned about the impact of water pollution on the viability of wetlands than were government panelists. Academics seemed to have greater faith in the efficacy of human intervention to protect wetland areas than did the government officials, probably reflecting the greater awareness of officials of the limitations of public policy.

In general, there seems to be good support for the notion that academic scientists are more narrowly focused in their views and more tentative in their conclusions about substantive issues. They are sensitive to hidden assumptions and have greater difficulty dealing with questions requiring judgments under uncertainty or which go beyond the scientific format. In contrast, scientists in government find it easier to compromise on scientific propositions, assert stronger views than academics (as measured by "polar scores"), and challenge assumptions and accepted norms less frequently. Such differences may lie at the root of many conflicts between the scientific community and the governmental establishment charged with responsibility for natural environments.

These are at best casual findings at this point. Detailed analysis of the data now underway will throw more light on how policy needs for coastal wetlands are affected by differing perceptions of the wetland "problem." The high degree of consensus we have discovered suggests that if and where such difficulties are to be found, they will be in the dissensual areas of the survey now being recycled to our panelists.

*Since the summary statistics for the consultants panel would have been meaningless, consultants were provided with summary statistics for one of the other panels.

Factors Affecting the Survival of Nearshore Larval Fishes (R/RD-13)

Gary D. Brewer, Research Scientist, Institute for Marine and Coastal Studies
Gary S. Kleppel, Adjunct Research Scientist, Institute for Marine and Coastal Studies

Few fishes survive past their first month of life. Typically, mortality is greater than 99% for the egg and larval stages of fishes that produce planktonic offspring. Those rare individuals that survive to the juvenile and adult stages co-occur with environmental conditions that include adequate densities of appropriate foods, relatively few predators or parasites, and the absence of pollutants.

Of these factors, starvation and predation are believed to be the overwhelming causes of mortality of the early life history stages. Yet, basic information on how starvation and predation of fish larvae varies in space and time has been gathered only recenlty, and only for a few commercially important taxa. There are large gaps in our knowledge of the feeding ecology and predator/prey interactions of larval fishes of most coastal species of economic or ecological importance.

This Sea Grant-sponsored research is designed to sample and evaluate factors that influence starvation and predation of fish eggs and larvae over shallow isobaths of southern California. Numerous species, including taxa with commercial and recreational fishery importance, spawn heavily in nearshore waters, including northern anchovy *(Engraulis mordax)*, white croaker *(Genyonemus lineatus)*, queenfish *(Seriphus politus)*, California halibut *(Paralichthys californicus)* and several flatfishes (family pleuronectidae).

These taxa require detailed information on the ecology of their early life history stages before their stocks can be managed effectively. Although an extensive literature exists on the biology of northern anchovy larvae in offshore waters, almost nothing has been published on the feeding ecology and predators of the other taxa mentioned. Moreover, studies over shallow isobaths (i.e., less than 50-meter depths) have been neglected for all taxa, including northern anchovy.

Direct observation of feeding and predation of ichthyoplankton is limited by the relatively small size or low density of ichthyoplankton, their foods and potential predators. Hence, our approach to the problem has been to identify apparent predator/prey interactions by capturing (and preserving quickly) ichthyoplankton, as well as all phytoplankton, invertebrates and fishes that co-occur. Stated simply, after collection all preserved material is returned to the laboratory to determine what the fish larvae were eating and what animals were eating the fish eggs and larvae.

Studies of nearshore predator-prey relationships of ichthyoplankton during the first two Sea Grant years have included winter (January 1982), summer (August-September 1982), and spring (April 1983) cruises in Santa Monica Bay. The three seasonal sampling periods were designed to encompass distinctly different oceanographic periods ranging from cool, well-mixed waters of winter, through the spring upwelling period when Santa Monica Bay is broadly influenced by nutrient rich subsurface and/or advected northern water masses, to the warm summer months when thermal stratification is a dominant feature. Different ichthyoplankton taxa dominate these seasonal periods.

The study area encompasses about 48 km^2 over isobaths between 8 and 40 meters in Santa Monica Bay. Routine surveys included bongo samples (0.335 mm mesh) for ichthyoplankton and macrozooplankton, pump samples for microzooplankton (organisms passing through 0.335 mm mesh but retained on 0.035 mm mesh) and phytoplankton. Three to five depths were sampled at each station. Salinity-temperature-depth (STD) casts and vertical profiles of in vivo chlorophyll (and phaeopigments) fluorescence were taken throughout the study area.

The kinds of data that have been generated from this field work during each seasonal cruise are exemplified in Figure 1. The results are exciting and provocative. The feeding habits of certain coastal fish larvae have proven to differ significantly from species studied previously, and previously undescribed predators on fish larvae have been found.

Work on the feeding ecology of coastal fishes has concentrated on the most abundant ichthyoplankton taxa including northern anchovy, white croaker and queenfish. These three species comprise 85%-90% of the fish larvae on an annual basis in nearshore waters of Southern California.

Surprisingly, bivalve larvae (pelecypod veligers) comprise the major identifiable fraction of food items in the digestive tracts of both white croaker and queenfish. Similarly, the stomachs of other members of the same family (Sciaenidae) have often been full of bivalve larvae. Mollusc veligers have been reported as food for some larval fishes, but only in small proportion in relation to major food items, which are the eggs, nauplii and copepodite stages of copepods. The high incidence of feeding on bivalve larvae is puzzling, given the low abundance of bivalves in the water column (Figure 1). Future plans are to evaluate the possibility that small dense patches of bivalve larvae exist and that such patches are thereby exploited by the croakers.

It is interesting that in the same samples that contained white croaker larvae with their stomachs filled with bivalve larvae, most northern anchovy larvae had empty stomachs. Those anchovy larvae that had identifiable foods generally contained copepod eggs and nauplii. The low incidence of feeding by northern anchovy may be due, in part, to the voiding of gut contents, associated with the trauma of capture and preservation. Northern anchovy larvae have a straight tubular gut, unlike the croakers that have a coiled gut. Previous investigators have suggested that larvae with straight guts are

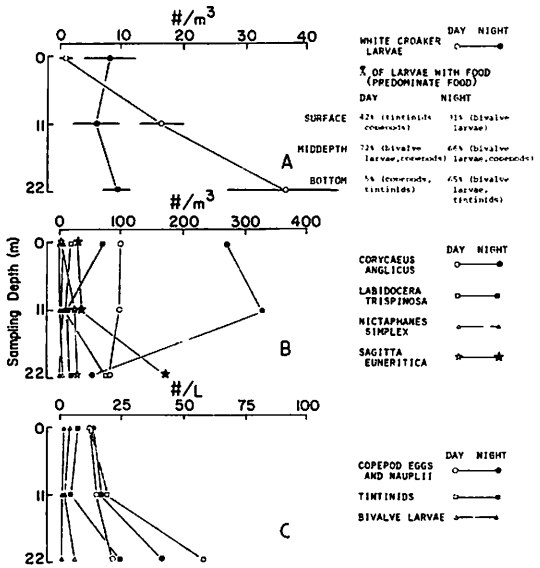


Figure 1. Examples of data generated from field work on factors affecting the survival of nearshore larval fishes

more susceptible to gut clearance during collection.

At least six taxa of predacious zooplankton have been found attached to fish larvae in preserved plankton samples. These apparent predators include *Corycaeus anglicus*, *Labidoera trispinosa*, *Tortanus discaudatus* (copepoda), *Sagitta euneritica* (chaetognatha), *Monoculoides* (amphipoda) and an unidentified decapod larvae. As many as 23% of the fish larvae in one sample had attached zooplankton predators. Overall, about 5% of the white croaker larvae and 2% of the northern anchovy larvae had attached zooplankton predators during our winter cruise. Fish larvae with attached zooplankton predators were relatively small.

Low numbers of fish eggs or larvae were found within the digestive tracts of juvenile-adult queenfish, white croaker, roughback sculpin *(Chitonotus pugetensis)*, thornback *(Platyrhinoids triseriata)* and fantail sole *(Xystruerys liolepis)*. No evidence has been found of ichthyoplankton predation in 25 other taxa examined for food contents. Demersal fishes may be a significant factor in nearshore ichthyoplankton mortality because the larvae ingested by the juvenile-adult fishes were relatively large (i.e., one large larvae has more significance in terms of future recruitment than many younger larvae or embryos because mortality is very high for the youngest stages and decreases as the larvae grow).

In summary, during the first two Sea Grant years, organisms that play important roles in the predator/prey interactions of nearshore larval fishes have been identified; their seasonal variability has been evaluated, and the diel abundance determined over small vertical and horizontal scales. Complementary studies now underway (year three) will help refine and supplement these findings, including analyses of micro-scale variability in relation to rates of feeding and predation of selected taxa.

Aspects of the Biology of the Sea Cucumber Parastichopus parvimensis: A Developing Commercial Fishery (R/RD-14)

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Dr. Ann Muscat, Assistant Director, Catalina Marine Science Center, University of Southern California

A new commercial fishery has recently developed in southern California centered around the sea cucumber *Parastichopus parvimensis*. Although this species is common in many shallow subtidal habitats, there is little known about its natural history, behavior or population interactions. Information on population dynamics is of special importance in establishing guidelines for utilization of this unique marine resource, and as of now there are not sufficient data upon which to base any intelligent management decisions. Furthermore, little is known about the basic biology of holothurians in temperate waters and their role in the communities of which they are often a conspicuous part.

A study of this newly exploited population offers a rare opportunity to accrue information of theoretical interest to marine ecologists as well as supplying needed information on an economically important species. Discussions with commercial fishermen, seafood brokers, and California Department of Fish and Game representatives indicate a great deal of interest in any information that results from the project.

The distribution and abundance patterns of *P. parvimensis* show a strong seasonal component. Each year, from August through November, most of the individuals in depths less than 13 m migrate downslope into the deeper, colder waters below the seasonal thermocline. Those remaining in shallower water are found principally on the surfaces and under sides of rocks and show little activity. Sea cucumbers are up to ten times more abundant on rock substrates than on soft sediments in Big Fisherman Cove and are about two-thirds less active. This is correlated with the increased amount of organic matter found on the rocks. Within the entirety of Big Fisherman Cove on Catalina Island, the dispersion patterns of *P. parvimensis* show clumping on the available rock surfaces. In the sand-dominated habitat, the sea cucumbers also aggregate on and around isolated rock patches, and in rocky areas they either distribute randomly or clump as if in response to local substrate heterogeneity. The mean proportion of recaptures for tagged sea cucumbers was greater in rock populations, another indication of less movement. Overall survival rate was high and was not significantly different between sand and rock populations. Immigration accounts for most of the population gains; emigration for most of the losses. The mean number of gains and losses was not significantly different between rock and sand.

The size of individual sea cucumbers varies with season. Regardless of depth or substrate, sea cucumbers are largest during winter and spring and get significantly smaller during late summer and fall. Juvenile (0.5-2.0 cm) *P. parvimensis* recruit into kelp holdfasts; subadults (2.0-6.0 cm) are found under rocks. Intermediate (8.0-12.0 cm) adults live on and under rocks, while large adults (12.0-20.0 cm) occur on sand. What maintains this separation of the two adult size classes is not clear. Recruitment occurs from October through December. The individuals in kelp holdfasts, on rocks and on the sand represent different year classes. Juvenile sea cucumbers (2.5 cm or less) are prey for several fishes common in the area, which may account for their cryptic behavior. Crustaceans occasionally encounter juveniles but do not eat them, and neither fish nor crustaceans prey upon healthy adults. Periodically, a microbial infection may kill both adults and juveniles, but its impact varies from year to year.

Spawning occurs in May and June, probably in response to increasing water temperatures. The gonads are completely resorbed by September and October, followed by maturation and growth from November through April. As many as 40% of the sea cucumbers examined between August and December had no viscera, but the data do not indicate if this is due to evisceration or resorption. There were no differences in size, reproductive potential, behavior or distribution patterns between sexes or between shallow and deep populations. The stability, from year to year, of the size-frequency distributions and of the population density suggest the *P. parvimensis* is slow-growing and long-lived. Large individuals on the sand are at least five years old.

Feeding rates varied throughout the year and were significantly higher for sand- vs. rock-dwelling sea cucumbers. The period of maximum feeding coincides with the period of gonadal growth and maximum total body weight. From August through November, deposit-feeding pressure from holothurians is greatly reduced in waters less than 13 m deep, due to migration and the loss of the digestive system. The caging experiment demonstrated that the deposit-feeding activities of *P. parvimensis* do not affect the distribution or abundance of the invertebrate infaunal populations in the soft sediments of Big Fisherman Cove. There is also no apparent direct effect of sea cucumber feeding on the distribution or abundance of the algae associated with soft sediments in Big Fisherman Cove.

Food Availability, Feeding and the Potential Competition for Food Between Larval Anchovies and Adult Copepods (R/RD-16)

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The goal of this project was to discern, through laboratory and field investigations, the nature and significance of the feeding interactions between female (adult) copepods and larval anchovies. Primary consideration was given to the relative importance of food in the 45-55 μm phytoplankton and 64-333 μm microzooplankton categories. The basic question, therefore, was: To what extent do the diets of adult copepods and larval anchovies overlap, and what is the result of this interaction?

It is believed that the highest mortality for most fishes occurs during the larval stage. During this period, mortality is thought to result from starvation and/or predation. While much data exists on the kinds and amounts of food required for successful feeding in larval fishes and efforts are being made to identify predators on fish larvae, the possible impact of competition between fish larvae and other zooplankton (e.g., adult copepods) for the same food resources has rarely been considered.

Successful feeding and growth of the larvae depend on the availability of threshold levels of specific types of food. For example, off Southern California, larval northern anchovy (*Engraulis mordax*) are thought to feed on both phytoplankton and zooplankton. Anchovy larvae have been reared in the laboratory on crustacean nauplii, molluscan larvae, rotifers and naked dinoflagellates. Laboratory, field and modelling studies, however, have suggested that only small particles (45-55 μm) of certain types (specifically, some naked dinoflagellates) are abundant enough in the sea to provide sufficient energy to support the anchovy larvae during their early life history.

Accurate predictions of the potential recruitment of larval fishes into the adult stocks is necessary for fisheries managers to better determine fishing quotas.

Laboratory feeding and competition experiments:

Laboratory feeding studies were conducted on larvae of the slough anchovy *(Anchoa delicatissima)*, the female copepod *Acartia tonsa*, and mixtures of the two potential competitors. Food in the experiments was either the naked dinoflagellate *Gymnodinium splendens* (0, 3, 30, 300 cells•ml^{-1}) or the rotifer *Brachionus* spp. (0, 0.03, 0.3, 3 animals•ml^{-1}).

Copepod egg production, both with and without the presence of fish larvae, grew with increased concentrations of phytoplankton. In containers with *G. splendens* concentrations of 30 and 300 cells•ml^{-1}, egg production was significantly higher when the fish larvae were absent than when larvae were present. At food concentrations of 0 and 3 *G. splendens*•ml^{-1}, mean egg production without fish larvae was not significantly different from values when larvae were present. Thus, the presence of the anchovy larvae did reduce egg production in *A. tonsa*.

Mean survival of larval anchovies fed on *G. splendens* was low in all experiments. Experiments with the larvae alone (no copepods present) showed maximum survival at food concentrations of 30 cells•ml^{-1}. Survival of the larvae at this food concentration in the presence of copepods was significantly lower than in the absence of copepods. Low survival both with and without copepods presence was observed at 300 cells•ml^{-1}. Reduced survival of the anchovy larvae, and therefore competition, is indicated at the lower two *Gymnodinium* concentrations. The low survival of larvae at all phytoplankton concentrations, however, requires caution in the conclusions drawn above.

Fish larvae and copepods fed on the rotifer *Brachionus* spp. showed less significant results. Copepod egg production increased with rotifer concentrations both with and without the presence of fish larvae in the experimental containers. Mean values of egg production were low and never exceeded 7 eggs•female^{-1}•day^{-1} (values similar to egg production in the *Gymnodinium* experiments at 3 cells•ml^{-1}). Similarly, larval fish survival was very low, and the survival at all rotifer concentrations was not significantly different from the controls. Thus, the rotifer concentrations used in the experiments were probably below threshold for successful feeding of the larvae and were a marginal food supply for the copepods.

Field studies:

Oceanographic cruises were conducted on February 22 and March 3, 1983 during the period of peak spawning of the nothern anchovy to determine the abundance of fish larvae, copepods and their potential foods (microzooplankton and phytoplankton). Samples were collected during the day (0730-1600 h) because fish larvae are thought to be visual feeders. Two stations, one on the coastal shelf and one on the shelf-slope were sampled.

At each station, discrete vertical samples were collected with a submersible pumping system for microzooplankton and phytoplankton enumeration, and for chlorophyll and carotenoid pigment analyses. Oblique, Bongo net (333 μm mesh) tows were conducted to collect the zooplankton (including fish larvae) near the surface (5 m to the surface) and over the complete water column (near-bottom to the surface). Zooplankton were later identified and counted in the laboratory, and the gut contents of the abundant copepod species were analyzed by gut fluorescence (chlorophyll) and by High Pressure

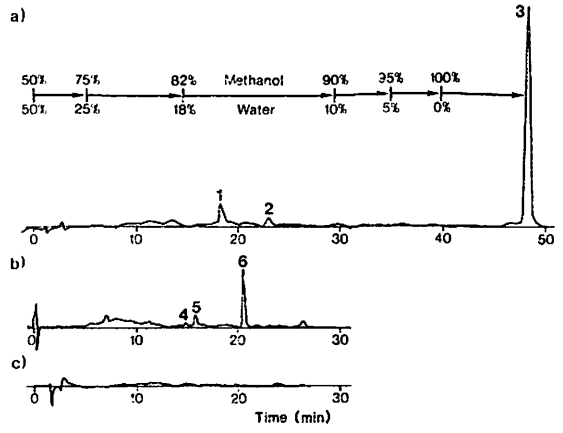

Figure 1. Chromatograms of phytoplankton pigments in the gut contents of the copepod* Paracalanus parvus.** ***a) Sample collected off San Onofre, Ca., June 1982. b) Sample collected in Los Angeles Harbor. c) Sample from copepods starved 24-h; no pigments detected. Pigments are 1, Peridinin 2, Diadinoxanthin 3, Chlorophyll a 4, Unidentified xanthophyll 5, Neoxanthin 6, Fucoxanthin

Liquid Chromatography (HPLC). The HPLC technique was developed, in part, during this project as a means of determining feeding activity, and an example of HPLC results is shown in Figure 1.

The results of the field work show that concentrations of chlorophyll-a, an indication of phytoplankton biomass, varied from 0 to 9.5 μg•l^{-1}. Shelf stations showed a near-surface chlorophyll maximum, while slope stations evidenced less structure. In February, near-surface chlorophyll concentrations on the shelf were higher than on the slope, while the opposite was true in March. The

phytoplankton biomass was dominated by diatoms and dinoflagellates. In only one case (February, slope station, 5 m) did the abundance of large, naked dinoflagellates (thought to be a primary food source of first-feeding anchovy larvae) approach the threshold concentration ($30 \cdot ml^{-1}$) considered to be necessary for successful feeding and growth. The dinoflagellate community, in cases where abundance was high, was dominated by *Prorocentrum micans*, a species that will not support the growth of anchovy larvae.

Diatoms were frequently numerous (up to $140 \cdot ml^{-1}$), and were generally dominated by chain forming centric species (*thalassiosira* spp., *Chaetoceros* spp. and *Skeletonema costatum*). Diatoms are not eaten by anchovy larvae, but both diatoms and dinoflagellates are consumed by copepods. The microzooplankton samples were dominated by copepod naupli, but concentrations were always less than $0.03 \cdot ml^{-1}$. Such concentrations are far below those considered adequate for anchovy feeding and growth (adequate levels $> 3.0 \cdot ml^{-1}$).

In this study it was observed that food was below threshold levels for successful feeding and growth of the anchovy larvae. However, the predatory copepod, *C. anglicus*, was present in high numbers at all stations. These observations indicate that an anchovy growth and, therefore, recruitment would be low during our cruises due to inadequate food and the high potential for predation. With the exception of the March slope station, potential copepod competitors did not appear to be feeding. The lack of food in the environment could be due to prior feeding by other organisms (including a possible competitor) or to environmental conditions.

Wave Uplift Pressure on Horizontal Platforms (R/CE-6)

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Landon C. Wellford, Professor, Civil Engineering, University of Southern California

In the winter of 1982-83, a high tide and large wave environment occurred along the coast of California. During this period, piers were knocked down, breakwaters were damaged and platforms were destroyed. The destruction of many of these coastal structures occurred because of wave impact and resulting uplift pressure on the structures. Prior to the situation of this research project, there was no analytical method to define the forces acting on coastal structures, such as piers, during large amplitude wave impact. Thus, it was impossible for the design engineer to determine the factors of safety inherent in a design.

Through the results of this research project, the pressures, external forces acting on the structure, and internal force acting in the structure can now be determined. Thus, the design engineer can now with confidence define the structural configuration best suited for an application.

The ultimate goal of the research project was to determine the uplift pressure on a horizontal platform as incident waves strike. In order to gain favorable agreement between the theoretical predictions and experimental data, new types of experimental and theoretical investigations were proposed and implemented.

These include:

1. An experimental procedure for the measurement of the water particle velocities in the horizontal and vertical directions has been developed and utilized. This method has used laser-Doppler velocimeter (LDV) techniques. Good experimental data has been obtained and the technique has proved reliable even during the period of rapid velocity variation at impact.

2. An analytical proccdurc using computer methods and finite element techniques has been developed. The method proved to be reasonably economical and extremely accurate. The procedure involved the solutions of the governing equations of motion to obtain fluid velocity and wave elevation time histories. These results were compared to the experimental results obtained using the LDV method. The comparison was very good. The free surface elevations at particular times for a certain platform-wave configuration, and horizontal velocities at particular points in the fluid region were determined. (Figures 1 and 2 are examples.)
3. The analytical procedure to determine fluid particle velocities was extended so as to define fluid pressures. The fluid pressures were computed and found to compare favorably with those obtained by experiment. The pressure time histories at particular points on the platform were determined analytically and by experiment. (Figure 3 is typical.) These pressures are extremely useful in engineering as they can be utilized in the calculation of the total force and moment acting on the platform.
4. Finally, design curves which are useful in engineering practice were prepared. These curves involved the determination of the variation with time of the total force applied to a platform. Such a graph for a particular platform configuration is shown in Figure 4.

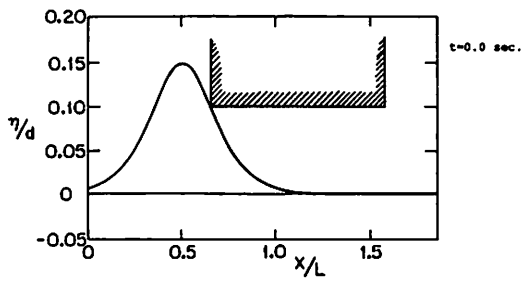


Figure 1. Wave striking the paltform, $d = 30.48$ cm, $H/d = 0.15$, $S/d = 0.1$

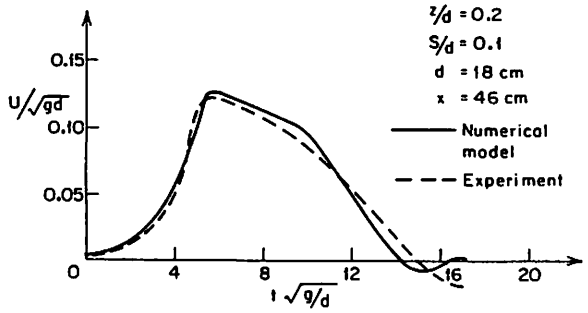


Figure 2. Horizontal water particle velocity for $\epsilon = 0.15$, $S/d = 0.1$ at $x = 46$ cm, and $z/d = 0.2$

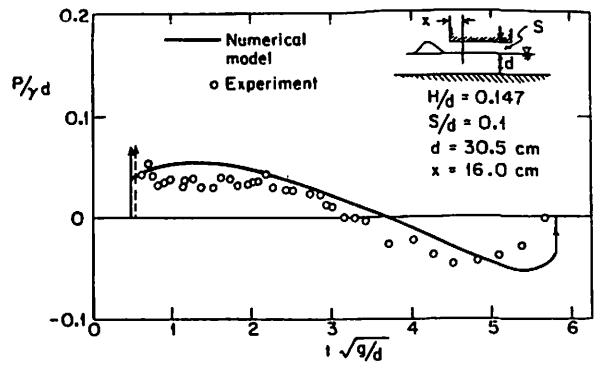


Figure 3. Pressure as a function of time for $\epsilon = 0.147$, and $S/d = 0.1$, at $x/d = 0.522$

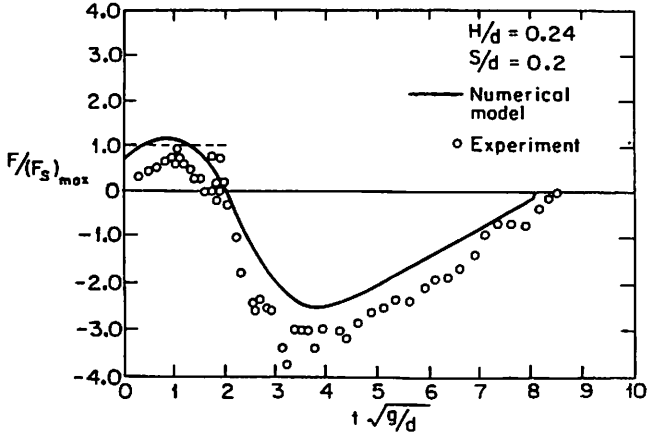


Figure 4. Normalized uplift pressure per unit width, for $d = 38.1$ cm, $L/d = 4.0$

BIOLOGICAL SCIENCES

Indo-U.S. Marine Bioactive Substances Program

Gerald Bakus, Associate Professor, Biological Sciences; Adjunct Research Associate, Institute for Marine and Coastal Studies, University of Southern California

USC will be participating in a three-year, $2-million program involving cooperating institutions from the United States and India to seek chemicals of medical and pharmacological importance from the Indian Ocean. Dr. Gerald Bakus, professor of biological sciences and adjunct research associate with the IMCS will be the principal investigator representing USC, and will work with representatives from the Central Drug Research Institute, Lucknow, India, the National Institute of Oceanography, Goa, India, the Bose Institute, Calcutta, India, the Office of Naval Research, Stevens Institute of Technology, and the New York Aquarium.

The program, beginning in May 1984, will include initial training of scientists from India at USC, featuring lectures on oceanography, marine ecology, marine bioactive substances, and bioassay techniques. Emphasis will be on sampling, preservation, and data recording techniques, and on the taxonomic characteristics of selected marine taxa. The scientists will also be trained in data analysis and computer techniques.

Two weeks will be spent in the Caribbean working on marine specimen collecting and coral reef research techniques.

From September to December 1984, Dr. Bakus and one of his graduate students will be in India working with the Indian scientists who had been trained at USC; two marine collection and distribution centers will be established and sites will be selected from detailed field studies.

Animals and plants will be sent to the Central Drug Research Institute where each species will be screened by approximately 100 medical and pharmacological tests, using a large variety of animals. The Bose Institute will study novel compounds. The National Institute of Oceanography will conduct preliminary bioassays and maintain voucher collections of marine specimens. Those marine species showing interesting properties will be recollected for further study. Specimens will be sent to specialists in India and elsewhere for final identification.

The Indian scientists are particularly interested in discovering bioactive substances with antifertility and antiparasite properties, in addition to antibiotics, antitumorals, and novel organic compounds. The Office of Naval Research is interested in antifouling and shark repellents, in conjunction with the coral reef studies. The Stevens Institute of Technology and the New York Aquarium will study the chemistry and biological activity of selected species.

Environmental Science and Management

Dr. Dorothy Soule, Director
Harbor Environmental Projects
Institute for Marine and Coastal Studies

The biological resources of urban coastal areas are impacted by a variety of stresses imposed due to the activities of some eleven million people living in the southern California megalopolis. Use of beaches, shoreline, and nearshore waters for recreation and development, commercial and recreational fishing, oil drilling and transport, and disposal of domestic and industrial wastes all exact a toll from the natural ecological systems. Resources must be properly inventoried, and impacts must be tested scientifically if management and planning are to preserve, protect, restore, and enhance the environment.

In the Pacific Islands, our oceanic community, populations are small, but coastal land area is also limited and urban pressures can be severe. Island economies range from the underdeveloped in remote areas like American and Western Samoa to the hyperdeveloped of Waikiki. Through information developed on the mainland, the principles evoked can lead to problem-solving in both near and remote areas.

Harbors Environmental Projects, established in 1970 to provide multidisciplinary environmental investigations, has developed information used in over $2 billion of proposed capital projects and has supplied regulatory agencies and industry with independent research on which to base decision-making. Several of these important areas of research are discussed below.

Fish Processing Wastes

Harbors Environmental Projects (HEP) has been carrying out extensive investigations of the role of fish processing wastes in harbor and coastal marine environments. In Los Angeles and Long Beach harbors, an extensive information base was developed on the ecosystem, on the relationship of the food web to wastes, and on the assimilative capacity of harbor waters. There is potential for management of wastes to minimize impacts and to benefit the ecology. Use of the ocean for disposal of non-toxic wastes has been limited in the last decades by the assumptions inherent in federal regulations that all reductions of waste loads to the sea are beneficial, without regard to nutrient flow or the existence of feasible land-based alternatives. Growing ecological, economic, and public health problems require reevaluation of these assumptions, but concomitant research is needed to develop new regulatory criteria for protection of the sea.

The first EPA permit granted to Star-Kist foods and Van Camp Seafoods for ocean disposal of fish processing wastes was issued in Pago Pago, American Samoa, on the basis of bioassay studies done by HEP at the IMCS Harbors Research Laboratory. Ocean monitoring of disposal off American Samoa has been carried out by Dr. Dorothy Soule and Mikihiko Oguri and their associates under a grant from NOAA, (Department of Commerce) and funds from the processors. In American Samoa there is no land available for safe, odor-free and pest-free disposal, while ocean depths reach 600 fathoms within three miles of shore. It is hoped that the wastes will provide food for existing but scarce coastal fish species in the nutrient-poor environment.

Ocean disposal studies carried out south of Los Angeles Harbor provided a baseline for an EPA permit application by Star-Kist Foods while developing a more detailed assessment of the behavior and effects of the wastes than is possible in more remote American Samoa. World Bank plans with Star-Kist for a new cannery in Papua, New Guinea, have already been influenced by the HEP advice based on a decade of studies carried out here and will be affected by the current research prospects. Puerto Rico processors may be forced to adopt ocean disposal as landfill sites become less available. Costs of ocean disposal are greater than land disposal costs in American Samoa, but ocean disposal is much less expensive than land disposal in Los Angeles and Puerto Rico.

Off the coast of American Samoa; the vessel pictured above is moving in a required 1-mile-diameter circle dumping fish processing wastes. USC researchers follow the dump boat and take samples.

Urban Wastes

The city of Los Angeles requested HEP to provide marine baseline data and environmental impact evaluation for the Terminal Island Treatment Plant effluent in Los Angeles harbor before and after the plant was converted to secondary waste treatment and the fish processing wastes incorporated as sewage in 1978. Some recurrent problems have occurred with the handling of the mixed wastes, leading to citations for exceeding effluent limitations. Meanwhile, the EPA permit must be renewed. The city requested that HEP restudy the impact of the wastes to determine whether the city is still in compliance with the *Bays and Estuaries Policy* of the *Water Quality Control Plan for Ocean Waters of California* and whether release of some untreated cannery wastes mixed with the secondary effluent would be feasible or advisable. Research showed that the productivity of the harbor was reduced under secondary treatment and has remained reduced since conversion in 1978. These studies on the urban wastes have resulted in publications on the nature of a detrital food web that is not based on an extensive natural estuary system. The studies have also been used in the federal secondary waiver program (301h) for coastal POTW's (publically owned treatment works) and the federal waiver program on ocean dumping restrictions for untreated seafood wastes.

Toxicity Studies

The IMCS Fish Harbor research laboratory has been utilized by HEP for a number of projects that determine the toxicity of materials to be disposed of at sea, such as dredged material and oil production wastes. Equipment at the Fish Harbor laboratory, including running seawater and advanced filtration, sterilization, and temperature control equipment, make it possible to carry out toxicity tests pursuant to EPA and Corps of Engineers regulations. Collaboration with the USC Environmental Engineering Program has resulted in improved chemical analysis and valuable interactions with staff and students.

An example of particular importance locally was related to the development of the new ARCO terminal in the Port of Long Beach. Routine bioassays suggested that problems of cadmium contamination might exist. HEP carried out extensive vibracoring from RV SEA WATCH to determine the actual distribution and concentration of cadmium at the site in sediments to be dredged; box coring was done from the VELERO IV to find ambient levels of cadmium at the EPA dumpsite off Point Fermin, while bioassays and bioaccumulation studies were performed at the harbor laboratory. Histological studies and scanning microscopy were done on the USC main campus, and ion probe investigations

were made at laboratories in Palo Alto. Problems were solved to the satisfaction of concerned agencies, and a $200 million terminal designed for increased safety in transport and delivery was allowed to proceed.

As oil exploration and development proceed into deeper water areas and density of platforms increases, questions of the effects on indigenous organisms increases. Research, funded in part by gifts from Aminoil USA, has been instituted to search for test species that occur naturally in deeper waters that would be appropriate for performing the toxicity tests required by regulatory agencies. More exact control of testing protocols is also necessary to insure that results, which can have great influence on permitting, are valid or are due to artifacts.

Oil and Dispersants

Studies of the effects of oil on ecosystems have included the investigation of the impacts of the explosion of the tanker *Sansinena* and the consequent spill of Bunker C fuel in Los Angeles harbor. Because of the extensive HEP baseline, it was the only study worldwide wherein it was possible to characterize the time and nature of recovery from the Bunker C spill. Subsequently, this research was used in consultations in Roscoff, France, where the impacts of the AMOCO CADIZ spill were being studied at the CNRS laboratory where Drs. John and Dorothy Soule had previously conducted research on local fauna.

Plans for containment and cleanup of spills involve the use of dispersants. Effects of dispersants were evaluated under contracts with the American Petroleum Institute, based on data collected by HEP in fieldwork off Long Island, New York and in southern California. The industry-funded organizations responsible for emergency spill response, along with the U.S. Coast Guard, need accurate, quantitative information on the negative effects of dispersant use as well as on the positive effects, and more precise protocols for determining when dispersants should or should not be used.

Baseline Monitoring

A good data base is essential to development of conceptual or quantitative models and to the use of information gained for planning and management. Long-term studies in Los Angeles-Long Beach Harbors sponsored by a number of agencies and industries led to physical, assimilation capacity, and oxygen budget models and thence to evaluating impacts of projects and planning of mitigation measures. Similarly, long-term studies in Marina del Rey led to conceptual models and to the discovery that storm drainage was carrying pollutants into the marina. The information developed was utilized in the local coastal plan (LCP). Updating of the baseline is being initiated so that the effects of planned future development can be predicated upon accurate, timely information.

Catalina Squid Program

Multi-Institution Programs at the Catalina Marine Science Center

The nervous system of the squid has been proven to be extremely valuable in understanding the cellular and molecular processes underlying neuronal function. For example, much of what is known about nerve excitation was first established at the squid giant axon, and the squid giant synapse has proven equally valuable in elucidating mechanisms of synaptic transmission. One measure of the contribution of squid toward such studies is that Nobel Prizes have been awarded to three individuals who worked upon squid nerve cells.

For the last five winters the squid *Loligo opalescens* has been collected and maintained at the Catalina Marine Science Center. This supply of squid is particularly valuable because it is the only reliable wintertime source of squid in the United States. The Catalina Squid Program has not only provided a valuable source of squid for neurobiological research, but has also yielded some valuable insights into squid population dynamics and laboratory culture techniques.

Investigators from several laboratories have participated in the Catalina Squid Program. The research efforts of these laboratories are briefly summarized below:

G. Augustine (University of Southern California): Role of calcium ions in neurotransmitter release at the squid giant synapse.

F. Benzanilla (University of California, Los Angeles): Measurement of unitary ionic currents from squid giant axons.

R. Eckert (University of California, Los Angeles): Presynaptic calcium currents at the squid giant synapse.

M. Montal (University of California, San Diego): Cyclic nucleotide enzymology in squid photoreceptors.

R. Zucker (University of California, Berkeley): Voltage clamp of squid giant synapse.

Investigators from several laboratories are participating in neurobiological research on squid at the Catalina Marine Science Center.

Natural History and Physiology of Demersal Sharks

Greg Pittenger, Laboratory Manager,
Catalina Marine Science Center
Dr. Perry Gilbert, Professor Emeritus,
Cornell University

This current research has evolved from research, also done at Santa Catalina Island, on the movement patterns, population dynamics, growth, and feeding of the pacific angel shark, *Squatina californica*. Although the angel shark is a common resident of the southern California marine environment, much of its basic biology was unknown or poorly understood prior to this study. The angel shark is commonly caught in commercial fishermen's nets, and until recently was regarded as a nuisance. Because of new fileting techniques and a public acceptance of shark meat as a food source, the Pacific angel shark is rapidly becoming an important fishery species.

The results of previous research efforts indicate that the angel shark is a year-round resident of the waters adjacent to Santa Catalina Island, but distribution and diet varies seasonally. During the late spring summer, and early fall, the sharks are found near the rock-sand interface at the base of reefs and feed primarily on fishes. In late fall, winter, and early spring, they are found in flat sandy areas away from the reef and feed on squid which have come inshore to spawn. All movement was found to take place at night, and the growth rate of the sharks was surprisingly slow.

Research is being done on the role of angel, swell and horned sharks as predators in southern California benthic systems. Annual food requirements are being estimated for each species from standard and active metabolic rates and oxygen consumption determinations. The effect of hyposic conditions on the behavior, metabolic rate, and blood chemistry of the sharks is also being studied in order to understand unusual diving patterns in species of sharks too difficult to maintain in captivity. The investigators, Greg Pittenger, Laboratory Manager at the Catalina Marine Science Center, and Dr. Perry Gilbert, Professor Emeritus from Cornell University, are being funded by a grant from a member of the Institute for Marine and Coastal Studies Oceanographic Associates.

Channel Islands Research Program

Dr. John M. Engle, Director of Research, The Tatman Foundation, St. Louis, Mo.

The Channel Islands contain the majority of the "pristine" marine communities that remain in southern California. In addition, the biota of the Channel Islands is extremely important to the understanding of the biogeography of Eastern Pacific marine species; however, largely due to their relative inaccessibility, the islands have received remarkably little scientific attention. Since 1980, the Channel Islands Research Program (CIRP) has been conducting scientific surveys around the eight islands in the Southern California Bight. This unique research program is sponsored by a private foundation, The Tatman Foundation, which operates in cooperation with the Institute for Marine and Coastal Studies Catalina Marine Science Center. The primary goals of CIRP are (1) to gather basic biological information about the distribution, abundance, natural history, and ecology of marine plant and animal species inhabiting the nearshore waters of the California Islands; and (2) to cooperate with other Channel Island research projects. The major emphasis of the program is on scuba diving surveys of subtidal ecosystems.

CIRP investigations are carried out using the 65 ft. research vessel CORMORANT, operated by the Tatman Foundation. Twenty-seven major cruises have taken place during the past four years. Cruise participants include volunteer scientists, students, underwater photographers, and buddy divers affiliated with various universities, governmental agencies, marine laboratories, and environmental companies throughout California. Coordination of CIRP projects and participants is carried out by Dr. John M. Engle, Director of Research for The Tatman Foundation, at the Catalina Marine Science Center.

Channel Islands Research Program projects conducted during 1983 include the following:

(1) Reconnaissance diving surveys around all eight Channel Islands. Results include subtidal habitat descriptions, relative abundance data for several hundred marine species, and a growing collection of voucher specimens and documentary photographs.

(2) Quantitative subtidal surveys in cooperation with the National Park Service, which has undertaken a long-term study to monitor the population dynamics of key marine resources within the five islands comprising the Channel Islands National Park.

(3) Detailed investigation of the structure and dynamics of a curious biological system at Anacapa Island. This habitat once supported extensive giant kelp beds, but now contains a barren-appearing assemblage of organisms dominated by three species of sea urchins.

(4) Continued monitoring of biologically important phenomena, including an epidemic disease which is killing off shallow-water sea stars, sea cucumbers, and brittle stars throughout southern California; exotic *Sargassum* weed which is expanding its range around the Channel Islands; unusual concentrations of small sea cucumbers which literally carpet the sea bottom, but only in certain locations; and unique populations of orangethroat pikeplennies which live in worm tubes on stable sand habitats at Santa Catalina and San Clemente Islands.

(5) Completion of field studies for the National Park Service evaluating the impact of visitors on Channel Islands tidepools. The effects of collecting organisms, overturning rocks, and trampling were determined for intertidal habitats at Anacapa and Catalina Islands. Results will be used to direct resource management programs.

Marine Ecosystems and Biogeography

Dr. Richard Brusca, Associate Professor, Biological Sciences, University of Southern California

Dr. Richard Brusca, Associate Professor of Biological Sciences and Curator of Crustacea for the Allan Hancock Foundation, is involved in several research projects in marine biology.

Dr. Brusca is publishing a series of monographs on the eastern Pacific isopod crustaceans, as well as selected studies on the fauna of temperate North American shores.

His research also includes investigations of the biogeography of marine invertebrates, including both ecological and historical approaches to biogeography, such as phylogenetic biogeography, biogeography and experimental studies examining the role of predator-prey interactions in regulating species distributions.

Studies of the ecology of shallow-water tropical and subtropical ecosystems includes extensive field work in western Mexico and Central America. The role of biological interactions in regulation of community structure and studies of rocky shore and mangrove lagoon systems are being examined.

Professor Brusca has authored two books, one on the marine fauna of northern California and another on the Gulf of California (Mexico). He is currently working on a text on invertebrate zoology for Macmillan.

Influence of Light on Development and Growth of Sea-Ice Microbial Communities in the Antarctic

Dr. Cornelius W. Sullivan, Associate Professor, Biological Sciences, University of Southern California

One of the largest amounts of biomass in the world grows in a zone beneath the 7-foot-thick blanket of ice in the area of McMurdo sound in the Antarctic. A team of USC researchers, headed by Dr. Cornelius W. Sullivan, have been investigating the growth of this biomass since 1980 in an ongoing program, sponsored by the National Science Foundation Division of Polar Programs.

A blanket of single-cell creatures—diatoms and algae—grows in a zone as much as six feet thick, attached to the bottom of the floating sea ice, despite the fact that the ice filters out all but 1 percent of the incoming light, and that sea water temperature is 2 degrees below zero Celsius. Furthermore, while light is continuous during the summer months, the photosynthetic diatoms are subjected to almost 6 months of continual darkness during the winter.

On successive field trips to the Antarctic, the USC researchers have studied the "annual spring bloom" of the microbial communities, measuring the distribution, production, and strategy for survival, using core sampling and measurements by scuba divers of under-ice irradiance. Samples for biomass analysis were taken by collecting cores with ice augers, and *in situ* incubated experiments were conducted using scuba to measure metabolic rate processes such as primary productivity, DNA synthesis, and heterotrophy.

The biomass being studied is the bottom layer of the Antarctic food chain. At the end of summer, melting sea ice releases a surge of these physiologically active micro-organisms into the water column and provides the basis for the subsequent phytoplankton blooms and a rich source of protein for pelagic grazers. One indication of the richness of the environment is the Antarctic krill which serve as food for whales and other creatures. The findings of the study will be applicable in future attempts to evaluate the carbon and energy flow through polar ecosystems.

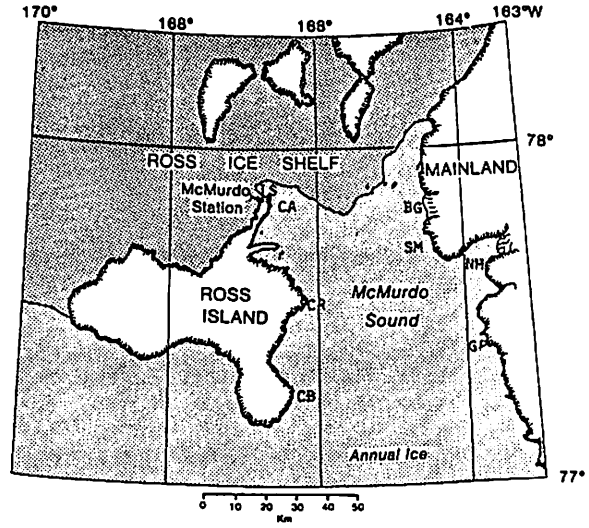


Figure 1. Sample locations for sea ice microbial community studies conducted during 1981 in McMurdo Sound, Ross Sea. Abbreviations: IS, Ross Ice Shelf; CA, Cape Armitage; TR, Turtle Rock; CR, Cape Royds; CB, Cape Bird; GP, Gneiss Point; NH, New Harbor; SM, Strand Moraines; BG, Blue Glacier.

Studies of Ocean Volume Reverberation at High Acoustic Frequencies

Dr. Richard E. Pieper, Research Scientist,
Institute for Marine and Coastal Studies, and
Research Associate Professor, Biological Sciences,
University of Southern California
D. Van Holliday, Director, San Diego Laboratory,
Tracor, Inc.

For several years, USC and Tracor, Inc., of San Diego have been involved in the use of acoustics to quantitatively measure small-scale plankton distributions and to develop models to describe and predict the ecological interrelationships of plankton in the open ocean. The objective of the research is a detailed understanding of the observed heterogeneous vertical and horizontal distribution of plankton.

Distributional heterogeneity is of major importance in understanding the dynamics of plankton and fish populations, but definition of the distribution and abundance of zooplankters on scales much less than tens of meters is difficult, if not impossible, with traditional net sampling programs.

This project is developing instrumentation techniques using very-high-frequency underwater acoustics to complement and supplement conventional methods of biological sampling in the ocean.

Acoustic methods offer a means of rapidly obtaining information on the distributions of organisms with high spatial resolution. The remote nature of the sampling also minimizes avoidance biases.

The Office of Naval Research and the National Science Foundation are joint sponsors of this research program. In the first phase of the work, it was demonstrated that acoustic reverbation at very high acoustic frequencies (500 kHz to 3 MHz) was primarily due to small (0.1-10 mm) crustaceans, mostly copepods. A quantitative relationship was developed between acoustic backscattering at each of four frequencies and the zooplankton biomass. This phase of the work also revealed major fine-scale structure in the vertical and horizontal abaundance of small zooplankton.

The objective of the second phase was to estimate the size-abundance distribution of small zooplankton from measurements of acoustic volume scattering strength. In this, the range of acoustic frequencies was extended to cover a band from 100 kHz to 10 MHz in 21 discrete steps. Acoustic sensors configured to the underwater unit permitted data collection while towing, as well as use in a vertical cast mode. Ability to tow the sensor package allowed an increase in spatial coverage of measurements while maintaining relatively high resolution.

At-sea tests of the new system were conducted and collection of comprehensive acoustic and biological data in the southern California Bight began in 1982.

During the current phase of the project, data are being processed and analyzed, and the technical and biological implications of that data will be examined intensively prior to proceeding with further at-sea applications.

Acoustic Applications to Ocean Productivity Instrument Development and Testing

Dr. Richard E. Pieper, Research Scientist,
Institute for Marine and Coastal Studies, and
Research Associate Professor, Biological Sciences,
University of Southern California

This project provides biological and oceanographic advice and support to the experimental design and testing of the Jet Propulsion Laboratory (JPL) Chirp sonar for use in measuring zooplankton distributions in the ocean.

During the first year of the two-year study, USC researchers Dr. Richard E. Pieper of USC and Donald J. Collins of JPL, tested the chirp sonar system off USC's dock and aboard ship. The next phase of the project includes a detailed study in Saanich Inlet, B.C., Canada, with Canadian Investigators from the Institute of Ocean Sciences.

Specific objectives of the project are:

1. Experimental design and testing of the chirp sonar to be used to measure scattering from zooplankton
2. Field experiments
3. To sample and identify the zooplankton as close as possible to the acoustically insonified volume
4. Comparing the *in situ* acoustic measurements to predicted scattering levels using the biological samples and acoustic scattering models
5. To utilize, when possible, the developed acoustic instrument in ocean productivity measurements

Most of the world's fisheries are restricted to the upper waters of the ocean, usually over the continental shelf or associated with near-shore upwelling plumes. Remote scientific measurements (satellites and aircraft) can provide synoptic maps of both sea-surface temperature and the distribution of chlorophyll. This information should provide scientists with a better understanding of the potential levels, variability, and distribution of those factors which control the levels of fish available for commercial use. The eventual use and success of such remote measurements depends on both calibration of these sensors and knowledge of what measurements imply relative to overall biological production in the sea.

Underwater acoustics offers a valuable technique for determining *in situ* zooplankton distributions. Techniques presently exist for estimating chlorophyll (phytoplankton) biomass. These can be used to calibrate the large-scale chlorophyll maps derived from satellite sensors. The chlorophyll measurements, however, represent only that portion of the phytoplankton biomass which remains after zooplankton grazing. In order to determine the levels of oceanic productivity, we also need to estimate the levels and impact of the zooplankton.

The major value of this technique is the rapid (millisecond) acquisition of large amounts of information on zooplankton distributions in real time. Such information is needed to provide information on interaction between the physical ocean, the phytoplankton, the zooplankton, and fishes of commercial or scientific interest. Additionally, an adequate data base will be acquired for mapping distributions over the large areas covered by airborne remote sensors.

This project is being funded by the National Aeronautics and Space Administration Oceanic Processes Branch.

Organization of Persistent Upwelling Structures (OPUS) Program

A Multi-Institution Program Coordinated Through the Allan Hancock Foundation, University of Southern California, Richard C. Dugdale, Director

Coastal upwelling is a major oceanographic process occurring especially along the eastern boundaries of the oceans. It is a process whereby deeper waters, which are cooler than surface waters and contain nutrients necessary for plant growth, are brought to the surface layer and into the lighted zone of the ocean (Figure 1). The process is often caused by winds blowing towards the equator and accelerating the surface currents in the same direction. This acceleration of the surface water toward the equator combined with the rotation of the earth (Coriolis effect) results in an offshore component to the flow at the surface. Hence, water is drawn away from the coast with a deeper (100-200 meters) compensating flow onshore and towards the surface. The introduction of the colder, nutrient rich, deeper water into the lighted layer of the ocean enables the plants to undergo rapid growth. Aspects of this production cycle are schematicized in Figure 2. This new plant production forms the base for a very productive food chain, available for harvesting by man and other carnivores.

The great contribution of coastal upwelling regions to worldwide fish catches is well known, as are some of the physical aspects of upwelling. Further, it appears that a fraction of the locally produced phytoplankton biomass eventually sinks and can lead, over geological time scales, to formation of petroleum deposits. There is, however, a good deal that is unknown about the mechanisms which link the physical processes of upwelling to high productivity. Specifically, biological development takes place in a physical environment which is highly variable in space and time, and it is not well known exactly how the various links in the biological chain are affected by physical phenomena.

Centers of coastal upwelling are frequent along the California coast and are associated with major coastal capes as well as some smaller capes. Several

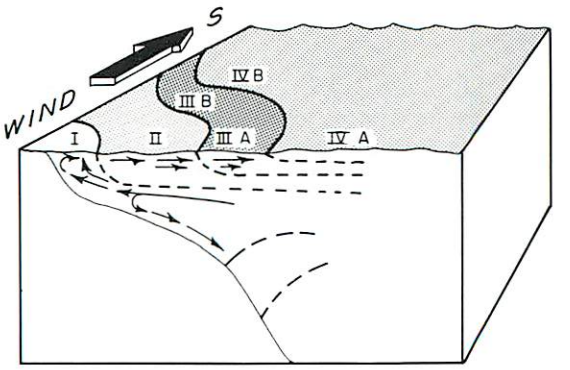


Figure 1

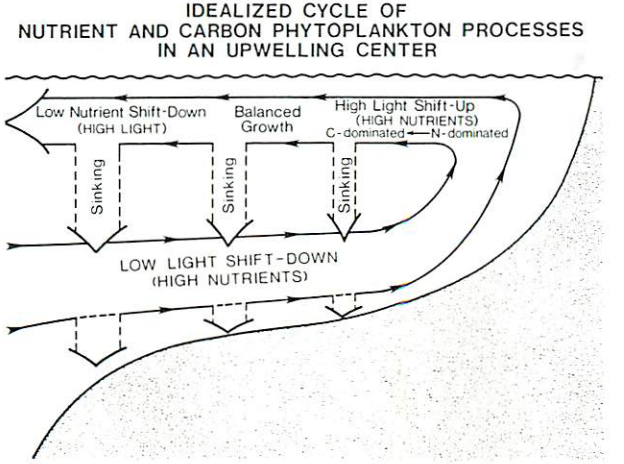


Figure 2

of these centers can be seen in the satellite image in Figure 3. Colder water, indicative of upwelling, is shown by the lighter shades in the image. This image shows the most frequently observed upwelling centers off Point Conception, Point Piedras Blancas, and off Point Sur. Smaller features are observable as well.

The Organization of Persistent Upwelling Structures (OPUS) program, funded by the National Science Foundation, has been established to study such structures with the following objectives:

1. To establish the important forcing mechanisms which create and maintain the three-dimensional characteristics of the upwelling structure.
2. To investigate the roles of advection and fronts in the near-surface dynamics of the upwelling structure.
3. To define the time and space patterns of the bacterioplankton, phytoplankton and zooplankton distributions relative to each other and to the physically and chemically defined features of the structure.
4. To establish the time and space patterns of phytoplankton processes in relation to environmental variations.
5. To integrate observed physical and biological distributions, along with biological rate measurements, to achieve a quantitative understanding of the ecosystem dynamics.

To accomplish these goals, OPUS, under the coordination of Richard Dugdale of the Allan Hancock Foundation, has gathered together groups of physical and biological oceanographers, from USC and other institutions, who each contribute a particular facet to the understanding of these upwelling centers. The investigators include:

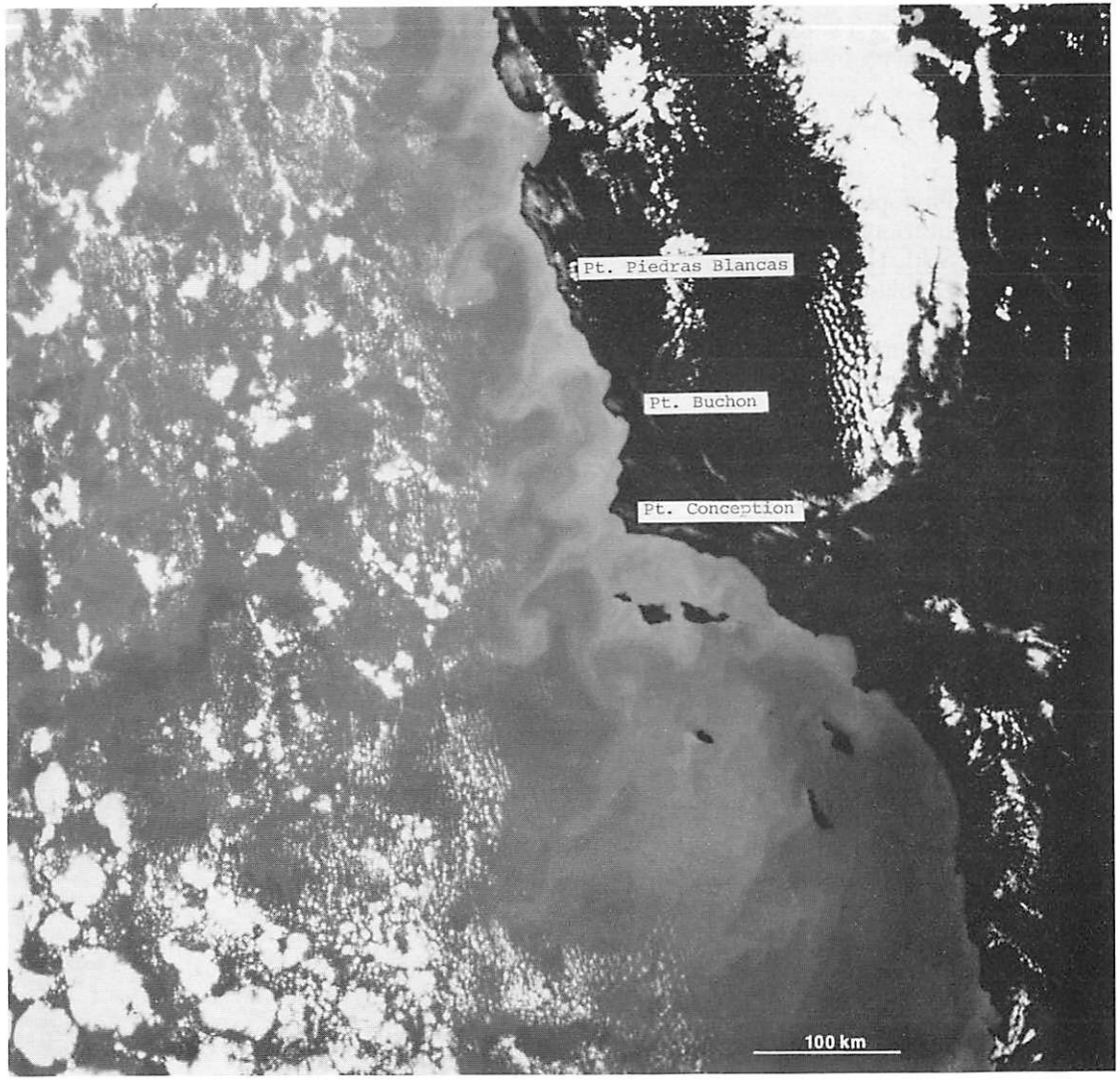


Figure 3

Richard C. Dugdale, Janice SooHoo and Frances Wilkerson Allan Hancock Foundation	Nitrogen and carbon primary productivity
Burton H. Jones Allan Hancock Foundation	Phytoplankton and nutrient distributions (with L. Atkinson and D. Blasco)
Cornelius W. Sullivan and Rodolfo Iturriaga Department of Biological Sciences	Bacterial distribution and productivity
James N. Kremer and Richard Zimmerman Department of Biological Sciences	Modeling of plankton dynamics
Tony Maxworthy Department of Mechanical Engineering	Laboratory modeling of physical dynamics

Investigators from other institutions

Larry Atkinson Skidaway Institute of Oceanography Savannah, Georgia	Hydrographic distributions (with Jones and Blasco)
Paul Bienfang Oceanic Institute Waimanalo, Hawaii	Phytoplankton losses due to sinking and spore formation
Dolors Blasco Bigelow Laboratory Ocean Sciences W. Boothbay Harbor, Maine	Phytoplankton distributions distributions (with Atkinson and Jones)
Kenneth Brink Woods Hole Oceanographic Institute Woods Hole, Massachusetts	Current observations
Dudley Chelton Oregon State University Corvallis, Oregon	Statistical analysis of physical space and time scales
Russ Davis Scripps Institution of Oceanography La Jolla, California	Current following drifters
Sharon Smith Brookhaven Laboratory Upton, New York	Zooplankton population dynamics
Dave Stuart Florida State University Tallahassee, Florida	Meteorological and Aircraft Support

The OPUS program collaborates closely with other ongoing efforts in the region. A major collaboration is with the Santa Barbara Channel circulation study carried out by investigators from Science Applications, Inc., Seattle, and Dynalysis, Princeton. This project is funded by the U.S. Minerals Management Service. Additional collaborations involve the California Cooperative Fisheries Investigations (CALCOFI) with investigators from NOAA Southwest Fisheries Laboratory and Scripps Institution of Oceanography.

It is expected that the results of the program will be beneficial first of all to a fundamental understanding of how these features function physically and interact with the surrounding ocean and how the biological processes are dependent upon and interact with the physical processes of coastal upwelling centers.

In addition, these results will be valuable to fisheries biologists seeking to understand and predict the variability of fish populations. The results may also be integrated into geological models of the development of oil formations off the coast of California.

GEOLOGICAL SCIENCES

Physical Oceanography

Dr. Tommy D. Dickey, Assistant Professor,
Geological Sciences
University of Southern California

The general impetus of research in physical oceanography at USC is to improve prediction of distributions of physical, optical, chemical, and biological properties of the ocean. One of the characteristic aspects of Dr. Dickey's research is the study of the physical processes by utilizing interdisciplinary data sets. General study topics have included turbulence, internal gravity waves, equatorial waves, air-sea interaction, upper ocean dynamics and mixing, mesoscale oceanic eddies, bottom boundary layers, and dispersion.

Turbulence and Gas Exchange

The relationships between fluid turbulence, molecular diffusivity, and gas exchange have been investigated, in which unique, high-quality measurements of turbulence parameters have been enabled by a streak photographic method developed in the course of this and previous research. Using this technique and gas exchange measurements, fundamental questions concerning turbulent and molecular parameters in the vicinty of the air-water interface have been answered. The near-surface molecular processes, which are most difficult to probe, have been elucidated by utilizing gases of varying molecular diffusivity. One of the applications of this work is the prediction of gas transfer rates which bear upon ecological and climatic questions.

Future plans call for coupling a numerical model of turbulence to a molecular boundary layer model in order to improve prediction of exchanges of heat, gases, etc. across the air-sea interface. Laboratory and field experiments will be used to test this model.

Collaborators have included Dr. Douglas Hammond, Department of Geological Sciences and Dr. James N. Kremer, Department of Biological Sciences.

Upper Ocean Structure

Much of the work in this area has concerned the development and application of numerical models of the upper ocean. From the physical aspect, a turbulence closure model (Mellor-Yamada) has been modified to account for the penetration of solar radiation into the ocean. It has been demonstrated that upper ocean structure (e.g., temperature, currents, etc.) is sensitive to water's light absorption characteristics and hence that biological and/or geological processes can in fact modify physical processes. In addition, simulations of diurnal heating cycles have indicated that variations in diurnal upper ocean structures can be modified by the optical properties of water. Another study has demonstrated that time variability of wind direction may be as significant to upper ocean structure as wind stress magnitude under certain conditions. Thus, improved sampling of wind direction appears to be necessary in order to advance our predictive capability. These studies have been utilized in the development of a numerical model of optical variability of the upper ocean as part of the Optical Dynamics Experiment (ODEX). ODEX is a 3-year Office of Naval Research (ONR) program which focuses upon the Navy's goal of predicting the optical properties of the upper ocean in response to atmospheric forcing. The model, which is still evolving, will couple physical, biological, and optical components (Figure 1). As a principal investigator, Dr. Dickey was involved in the planning and execution of a 45-day field experiment in the central Pacific which was conducted as part of ODEX. Data taken from the study is currently being analyzed and will then be used to test and generalize the numerical model.

ODEX collaborators have included: Dr. R. Zaneveld, Oregon State University, Dr. R. Smith, University of California, Santa Barbara, Dr. J. Mueller, Naval Post-graduate School, Dr. H. Gordon, University of Miami, Dr. J. Simpson, University of California, San Diego, and Dr. D. Kiefer, University of Southern California.

An Eddy in the California Current

The subject of the study is an eddy located approximately 400 to 500 km off the California coast (Point Conception). Satellite infrared imagery was used to locate and track the warm core eddy, which was approximately 150 km in diameter. While eddies in western boundary currents have been studied in great detail, no intense study of an eastern boundary current eddy had been undertaken. The two current regimes, eastern boundary current (e.g., California Current) and western boundary current (e.g., Gulf Stream), are quite distinct. Consequently, the eddy genesis and dynamics are presumably quite different. This eddy along with others which seem to be semi-permanent features must affect not only the distributions of physically relevant parameters (e.g., temperature structure, currents, etc.) but also those of biological, chemical, and geological parameters as well. This work was done jointly with Scripps investigators.

Bottom Boundary Layers

The study of current structure near the ocean bottom has been motivated by physical, geological, and biological questions. For example, one location of high dissipation of ocean energy is the region near the ocean bottom. Work in this area has centered on the numerical simulation of a unique data set provided by a collaborator on the project, Professor John Van Leer of Miami, taken off the coast of Peru (Figure 2). These data are in good agreement with the researcher's numerical predictions (Figure 3).

Future studies will entail long-term currentmeter, temperature, and salinity profiling near the bottom. Plans are to utilize a cyclesonde-bottom tripod mooring to extend the measurements into the logarithmic layer. Of interest also is the study of the interaction between internal waves and the bottom boundary layer.

Dispersion

This research has involved development of a model to evaluate the sensitivity of dispersion to atmospheric forcing, currents, stratification, and discharge depth.

Presently, a long term set of observations of physical, chemical, and biological parameters taken in the vicinity of an outfall near Los Angeles, is being analyzed by a USC biologist, Dr. Burt Jones, and Dr. Dickey. These and future data will enable ecological simulations.

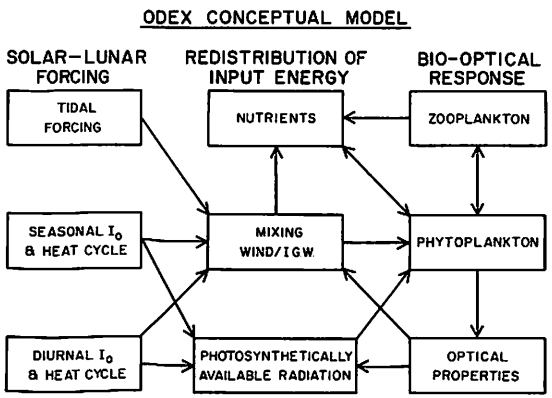


Figure 1

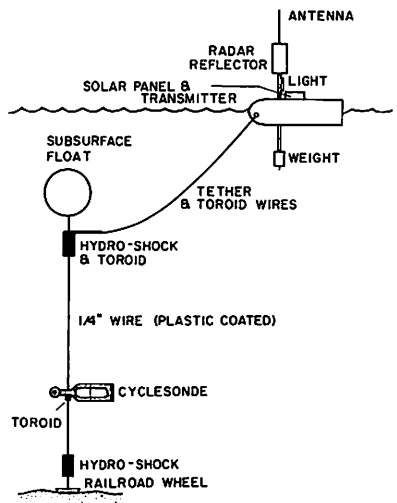


Figure 2

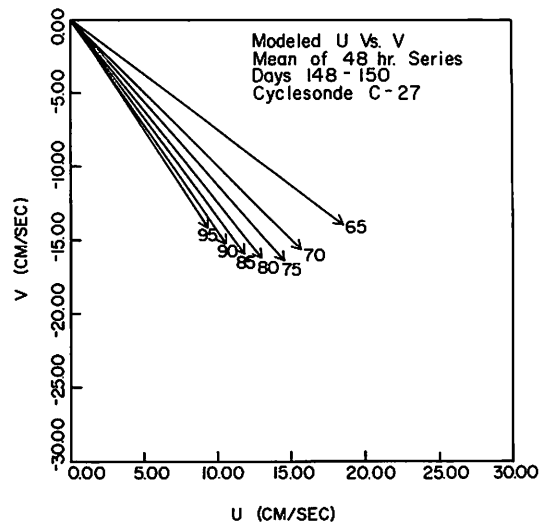


Figure 3

Fluid Motions in the Upper Atmosphere

Alan Bratkovich, Research Scientist, Physical Oceanography, Geological Sciences, University of Southern California

Dr. Bratkovich's present research interests concern the measurement, statistical analysis and dynamical interpretation of fluid motions in the upper ocean and along coastal boundaries. Studies of rotating, stratified fluid flows are conducted *in situ* using moored instrumentation deployed from oceanographic vessels. The scope of this research includes a number of unique measurement problems as well as the development of statistical tools specifically adapted to the analysis of geophysical fluid flows. These studies are motivated by a number of basic scientific questions and a broad range of resource management and defense related problems.

Over the past few years, Dr. Bratkovich has participated in several experiments sited on the California continental shelf, including the Coastal Ocean Dynamic Experiment (CODE). He is specifically interested in the dynamics and energetics of the internal wave field as observed near coastlines. Other interests include processes associated with the mixing environment and water mass formation in coastal waters.

Dr. Bratkovich has authored or co-authored publications on temperature and current on the southern California shelf, tidal variability in current and temperature fields on the southern California continental shelf, and near inertial accelerations on the California shelf and slope.

Micropaleontology and Paleoecology

Dr. Robert G. Douglas, Professor and Chairman, Geological Sciences, University of Southern California

Professor Douglas' principal research focus is foraminiferal paleoecology, biostratigraphy and paleoceanography of Mesozoic and Cenozoic sediments. He is involved with reconstructing the depositional environments of deep-sea and continental margin facies and the history of their development. A parallel interest is the ecology and biogeography of benthic and planktonic foraminifera in modern depositional systems and the development of analog models useful in interpreting ancient deposits.

Current research projects include a cooperative program with Dr. Samuel Savin of Case Western Reserve University on the thermal history and deep circulation in the Late Cretaceous ocean based on faunal and isotopic analysis of microfossils recovered from DSDP cores in the Atlantic and Pacific oceans. Together with his students, he is investigating late Cretaceous active margin paleoenvironments along the Pacific Coast with an emphasis upon the integration of microfossil evidence with that gained from stratigraphic and sedimentological studies and, a study of the Holocene and late Pleistocene depositional environments of the California borderland emphasizing the environmental response of foraminifera to the changing modes and rates of sedimentation that resulted from the change in sea level, climate and oceanography of the past 50,000 years. The research in the borderlands is a cooperative program with Dr. Donn Gorsline.

A secondary interest is a study of the foraminiferal biofacies associated with the anoxic environments present in some borderland basins and the oceanographic conditions which control the development of anoxia.

Professor Douglas' publications include works on slope and basin benthic foraminifers of the California borderland, Pleistocene occurrence of Melonis pompilioides in the California borderland and its implication for foraminiferal paleoecology, and response of deep sea benthic foraminifera to Miocene paleoclimatic events.

Marine Geology and Sedimentary Processes

Dr. Donn S. Gorsline, Professor, Geological Sciences, University of Southern California

Professor Gorsline's interests primarily deal with recent marine sediments, sedimentary processes, and the relationship between sedimentary deposits and climatic and oceanographic conditions at the time of deposition. Much of his work has been in the basins of the California Continental Borderland. His earlier work established the influence of both conventional fan development and mass movement processes in transporting sediments to basin floors.

More recently, Dr. Gorsline's interests have centered on the record of fine continental margin sedimentation. This work is of increasing interest for providing continuous records of the cyclic changes in climate. As climatic cycles interact with tectonism, a spectrum of sedimentary facies are formed in the basin system. The general problem of identification of the dominant factor in a given facies has been the thread connecting much of Dr. Gorsline's work and that of his students. His students' work has ranged from studies of interior alluvial systems to polar deep ocean sedimentation. Some have worked on individual borderland basins including seismic stratigraphic studies and geotechnical properties.

In 1983, Dr. Gorsline received the Francis P. Shepard Medal for Excellence in Marine Geology, commending him for "outstanding research and inspirational leadership and teaching in marine geology."

Among Dr. Gorsline's publications are those on the anatomy of margin basins, deep-water sedimentologic conditions and models, and a review of fine-grained sediment origins, characteristics, transport, and deposition.

Isotope Geochemistry and Chemical Oceanography

Dr. Douglas E. Hammond, Associate Professor, Geological Sciences, University of Southern California

As a marine geochemist, Dr. Hammond's interests have focused on utilizing radioactive and stable isotopes for understanding a variety of geochemical processes. Much of his research has been interdisciplinary, and involves collaboration with sedimentologists, physical oceanographers, biologists, and geophysicists.

During his doctoral research at Columbia University, Professor Hammond developed an interest in estuarine systems, particularly the distribution of nutrients from sewage wastes in the Hudson River estuary and the impacts that estuarine circulation, exchange of gases at the air-water interface, and benthic exchange have on this distribution. At USC, he and several of his students have extended these interests and have worked closely with the estuarine studies group at the USGS in Menlo Park on San Francisco Bay and on the Potomac River estuary, elucidating the process which effect sediment diagenesis, benthic exchange of nutrients, sedimentation and sediment resuspension, and exchange of gases across the air-sea interface in these systems. The gas exchange work has led to development of a series of laboratory experiments conducted jointly with Professor Tommy Dickey, designed to define the relationship between gas exchange and fluid turbulence.

Professor Hammond and his students have been developing techniques to study sediment diagenesis, benthic exchange, and mixing in basins of the Southern California Borderland. One of the principal aspects of this program is the development of a remote benthic lander which can be deployed in deep water for periods of several days and used to measure benthic fluxes of nutrients, radioisotopes, and the *in situ* rate of dissolution of silica and carbonate. These measurements have great importance for understanding the biogeochemical cycling of several elements and for modeling the response of ocean chemistry to perturbations generated by man. The research in sediment diagenesis is a joint project with the geophysics group to explore the relationship between magnetic mineralogy and diagensis. Other projects in which Professor Hammond has been involved include the use of groundwater chemistry for earthquake prediction, identifying sources of coastal beach tars, and the geochemistry of closed-basin saline lakes.

His publications have included articles on the use of Radon-222 to estimate benthic exchange and atmospheric exchange rates in San Francisco Bay; and a search for covariance among seismicity, groundwater chemistry, and groundwater Radon in southern California.

SOCIAL SCIENCES

Arctic Policy Forum

Dr. Robert L. Friedheim, Associate Director, Marine Policy, Institute for Marine and Coastal Studies, and Professor of International Relations
Dr. Michael C. Fry, Director, School of International Relations, and Professor of International Relations
University of Southern California

Through a grant from the William H. Donner Foundation, a U.S.-Canada Arctic Policy Forum will be established at the University. The grant was awarded by the foundation to the Institute for Marine and Coastal Studies and the School of International Relations. The objective of the forum will be to examine Arctic policy options on problems significant to both the United States and Canada.

The forum will bring together Arctic experts from both countries to identify the problems, to compare the range of policy options available, and to recommend acceptable options.

Dr. Robert L. Friedheim, Associate Director of Marine Policy for the Institute for Marine and Coastal Studies, and Dr. Michael C. Fry, Director of the School of International Relations, are co-principal investigators for the forum.

Dr. James H. Zumberge, the president of USC and a distinguished polar scientist, will be the American co-chairman of a binational advisory group that will help guide the forum.

Earthquake Mitigation for Harbors and Ports

Gilbert B. Siegel, Professor, School of Public Administration, University of Southern California
Dorothy M. Bjur, Director of Education and Training, Institute for Marine and Coastal Studies, University of Southern California

In 1984, USC researchers will begin a 12-month study aimed at providing information on impacts, problems, and mitigations of the effects of earthquakes and tsunamis on ports and harbors. The work is under the sponsorship of the National Science Foundation.

Many seaports and harbors in the United States are vulnerable to earthquakes. The potential disruption to society following a major seismic event can have repercussions far beyond the confines of the harbor/port itself, extending to associated urban centers.

Significant in the current research problem is identifying ports and harbors around the world that have experienced major damage or destruction during an earthquake or tsunami. By studying different ports and harbors, the areas of vulnerability and hence problems worthy of indepth study to mitigate potential destruction are identified.

The research project will initially involve such identification by studying documentation of incidents of extensive damage to major seaports/harbors in the world resulting from earthquakes and tsunamis. Based on this study, case studies will be compiled for each major incident, emphasizing the nature and extent of damage. The conceptual framework will be utilized to organize a problems-and-issues workshop in which case events will be evaluated in terms of efficacy, omissions, ignored consequences, and other factors.

The outcome of the research will be a systematized set of guidelines for port and harbor management that can be applied before, during, and after a major earthquake or tsunami.

Law of the Sea

An ongoing emphasis in marine policy work at USC has been on the evolution of the Law of the Sea Treaty.

Dr. Robert Friedheim, IMCS Associate Director for Marine Policy and Dr. Jay Kadane, Chairman of the Statistics Department at Carnegie Mellon University, were involved in the mid-1970s with a project at the Center for Naval Analysis which dealt with modelling and forecasting the outcomes of the United Nations Conference on Law of the Sea (UNCLOS). The project will be completed at IMCS under a grant from the Office of Naval Research. The research involved developing an innovative method for forecasting the probable positions of nation-states on individual issues, and the tradeoffs accompanying large-scale multilateral negotiations.

This work is of particular relevance now because multilateral negotiations seem likely to occur with increasing frequency in the enactment of future U.S. foreign policy.

Law of the Sea issues have been the subjects of several recent Ph.D. dissertations in the field of international relations. Dr. Arvid Pardo and Dr. Robert L. Friedheim, both of whom are professors of international relations, are active participants on dissertation committees of students whose research centers on the Law of the Sea.

Dr. Pardo, who as ambassador of Malta to the United Nations first introduced the concept of a Law of the Sea Treaty, was recently honored by the Third World Foundation with its annual Third World Prize, recognizing his pioneer work in the Law of the Sea.

ACADEMIC PROGRAMS

Present marine-related academic programs at USC involve approximately 35 faculty members, 50 professional staff and 12 academic units. These include the IMCS, Geological Sciences, Biological Sciences, Economics, Political Science, Medicine, Public Administration, Law, International Relations, Engineering, Urban and Regional Planning, and Business.

Graduate courses are focused in the IMCS (Master of Marine Affairs Program), Geology (through the Ph.D. level in marine geology), Biology (through the Ph.D. level in marine biology) and Engineering (through the M.S. level in ocean engineering and environmental engineering). There are currently approximately 70 full-time students registered in these programs.

Ph.D. Studies in Marine-Related Fields

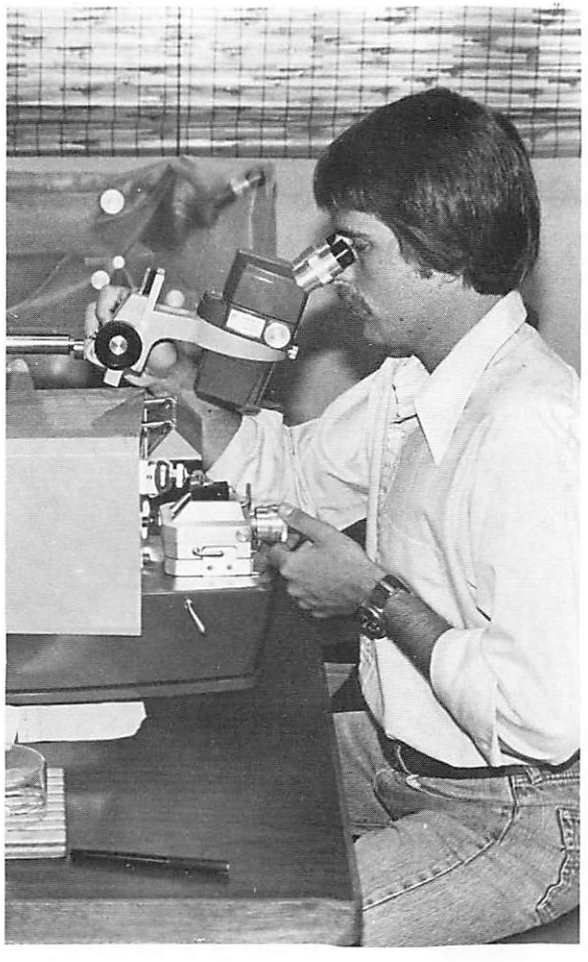
Areas of emphasis in marine studies are available at the Ph.D. level in the Department of Geological Sciences, the Department of Biological Sciences, and the Schools of International Relations and Urban Planning.

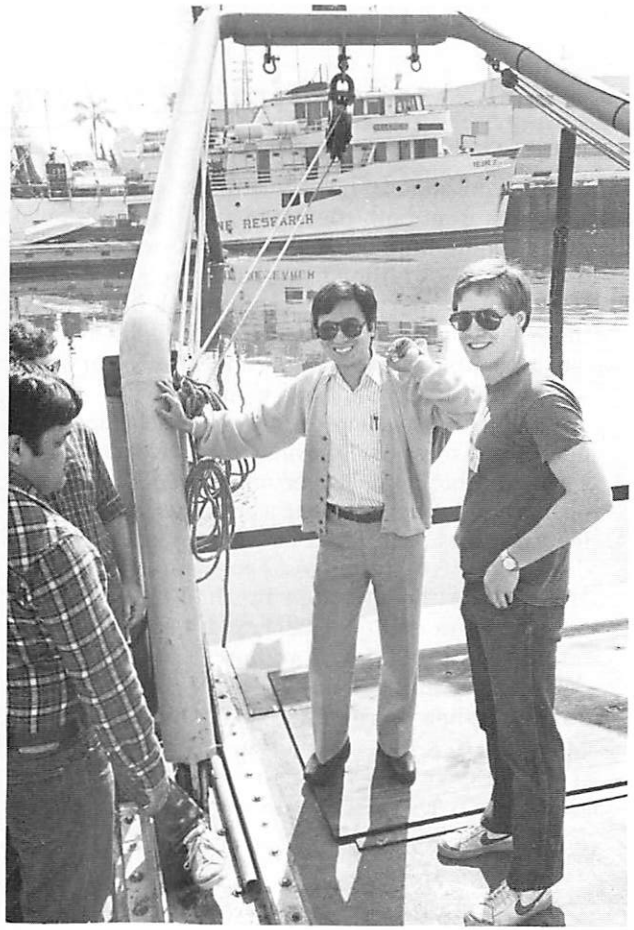
Through the university's system of interdisciplinary study, joint faculty appointments, and shared facilities, students interested in marine science and marine policy at the Ph.D. level can select programs tailored to meet these interests.

In geological sciences, biological sciences, and engineering, the University's Catalina Marine Science Center, Fish Harbor Marine Laboratory, and research vessels are examples of facilities available for marine study, and some faculty from several schools are associated in research and teaching capacities with the Institute for Marine and Coastal Studies. In the Schools of International Relations and Urban Planning, the marine policy emphasis is possible within the Ph.D. degree.

Indicative of doctoral level work in these fields in the recent past are dissertations prepared on such subjects as aspects of the biology of the sea cucumber, wave uplift pressures on horizontal platforms, scientific information and the valuation of ecological resources in the coastal wetlands, a minerals regime for the Antarctic, processes controlling gas exchange across the air-water interface, and state and local conflict in California coastal planning.

Details of these programs and requirements for admission are available from the individual schools and in the Bulletin of The Graduate School of the University of Southern California.





Master of Marine Affairs

Marine policy is a multidisciplinary field of study of the effective management of the ocean and maritime enterprises. These enterprises include such activities as resources management, protection of the environment, ports and harbors management, and the onshore impact of a variety of offshore activities.

Improved technology and a change in the traditional concepts of the Law of the Sea are only two factors which significantly affect maritime activities. The world enclosure movement, in which nation-states are claiming areas out to 200 miles as national territory, is a worldwide phenomenon. As a result, many countries are now seeking to create coherent national ocean policies.

In anticipation of a critical need for managers who can deal effectively with the changing aspects of uses and abuses of the oceans, the Institute for Marine and Coastal Studies offers the graduate degree program Master of Marine Affairs.

The Master of Marine Affairs is a graduate degree program in marine policy. Students can select from three areas of emphasis within a framework of core courses and prerequisites. The combination provides sound training in management and a thorough grounding in basic concepts in the marine sciences. Two different degree options are available, depending on a student's academic preparation and work experience.

The three areas of emphasis are:

- Marine policy
- Marine law
- Marine economics

The degree plans are described below. A series of core courses totalling 20 credit units is required for both degree plans.

Degree Plan I: Requires 28 credit hours. To qualify, a student must have an undergraduate degree and at least two years of experience in a field related to ocean mangement or resource analysis. No thesis is required, but students must pass a comprehensive examination.

Degree Plan II: Requires 36 credit hours. This plan is for the student with an undergraduate degree but no relevant experience. These students can acquire the additional units in one of three ways: (1) additional course work and a comprehensive examination; (2) additional course work and 4 units of thesis; (3) additional course work and an internship in an ocean-related organization.

Intensive Courses

An effective format for presenting graduate-level courses has proved to be the intensive course—taught day-long for several consecutive days rather than distributed on an hourly basis throughout a semester.

In conjunction with the Master of Marine Affairs degree, the IMCS has offered three such intensives so far—in the subject area of marine transportation and in seaport management.

This format allows the University to call on prestigious faculty members from other universities as well as from within USC, and also allows working professionals to concentrate academic study either for degree application or professional advancement within a short time frame.

M.M.A. Internships

An important part of the training of graduate students can be through participation in an organization that is actively engaged in marine affairs activities. An internship program developed within the Master of Marine Affairs program placed six students in internships.

The most recent group of M.M.A. interns and their projects were:

Greg Packard: research, compile information, and prepare a written report on the specific underwater tasks of divers for exploration, construction, production, and maintenance phases of offshore oil production; Oceaneering, Wilmington, Ca.

Joseph Onorato: preparing documents to be used by oil and gas field personnel promoting compliance with E.P.A. and U.S. Coast Guard regulations in all aspects of oil exploration, recovery, and distribution; with Union Oil of California.

Steven Hill: determine a clear alternative in Environmental Impact Statement process utilizing the Computer Aided Operating Research Facility (CAORF) as a planning tool; with U.S. Maritime Administration (MARAD), Washington, D.C.

Penelope Jones: identify both revenue-producing and non-revenue-producing assets and their estimated return on investment; with the Port of Long Beach.

Enrique Manzanilla: investigating U.S.-Mexico fisheries policies; with the Delegacion Federal de Pescan, Ensenada, Mexico.

Masahisa Takeo: prepare reports on the current socio-economic situation of the South Pacific countries and Japan's aid policies toward the region; with the Institute of Developing Economies, Tokyo, Japan.

Seminar Series

The IMCS sponsors a seminar series featuring speakers from the USC marine community and from off-campus on subjects in marine policy and marine science. Recent seminars and speakers have included:

"Chinese Attitudes Toward the Law of the Sea," Professor Wang Teiya, Faculty of Law, Peking University.

"The New Law of the Sea and the Development of Tuna Fisheries in Kiribati," Roniti Teiwaki, University of the South Pacific, Suva.

"The Endangered Species Act and Biological Conservation," Edwin M. Smith, Assistant Professor of Law, USC, and Research Fellow, Institute for Marine and Coastal Studies.

"Law of the Sea Issues and Antarctica," Doug Hengel, International Economist, U.S. State Department.

"International Politics of Antarctica," Charles W. M. Swithinbank, Earth Sciences Division of the British Antarctic Survey, Cambridge, England.

"Law of the Sea Questions and Relations Between Mexico and the United States," Jorje A. Vargas, Visiting Research Fellow, University of California, San Diego, and former Ambassador from Mexico to the U.N. Law of the Sea Conference.

"Fisheries Economics," Dr. Daniel D. Huppert, U. S. Department of Commerce/NOAA, National Marine Fisheries Service, Southwest Fisheries Division.

"Workshop on Fisheries Economics," Daniel F. Spulber, Department of Economics, USC, and Institute for Marine and Coastal Studies.

"The Great Fish War: A Cooperative Solution," Professor Tracy Lewis, University of British Columbia and Visiting Professor, California Institute of Technology.

"Short-Run Behavior of a Commercial Fishery: An Economic Perspective," Michael Phillips, Assistant Professor, Department of Finance and Business Economics, School of Business.

Visiting Scholars

IMCS frequently hosts visiting scholars and researchers from both the national and international marine communities for periods of residence at the university. In addition to pursuing their own scholarship or research activities with colleagues at USC, these visiting experts teach classes, deliver seminars, or author publications, and interact in other ways with the USC marine community.

Among the more recent visiting scholars have been three from Asia during the past year. Paul C. Yuan, a prominent lawyer and expert on China's offshore oil policies, spent a semester with IMCS lecturing and writing on his country's activities in developing its oil resources. From Korea, Dr. Chun Ho Park has been hosted by the IMCS and the School of International Relations. Dr. Park is also interested in offshore oil resource policy.

Currently in residence at IMCS is Mr. Shinichi Takagawa, here under the sponsorship of the Japan Marine Science and Technology Center (JAMSTEC). Mr. Takagawa is associated with JAMSTEC's Deepsea Technology Department.

ADVISORY SERVICES, EDUCATION, AND PROFESSIONAL TRAINING

Advisory Services and Education (AE-1)

Stuart A. Ross, Director of Marine Advisory Services, USC Sea Grant Program;
Dorothy M. Bjur, Director of Marine Education, USC Sea Grant Program;
James A. Fawcett, Coastal Planning Specialist, USC Sea Grant Program;
Jacqueline B. Rojas, Assistant Director of Marine Education, USC Sea Grant Program

An essential part of every Sea Grant program is the effort to make information about the oceans, including recent research and policy developments, more broadly available to the public and to specific groups that use or rely on the ocean.

These activities at USC were carried out by a staff of four professionals, located on campus and in the Los Angeles/Long Beach harbor area.

Efforts have been primarily in five areas: general marine education, marine recreation, coastal zone management, commercial fishing and marine transportation. Additionally, the staff participates in general presentations to civic groups and classes, staff meetings with local marine agencies, computer literature searches for investigators, maintenance of two marine-oriented libraries, and participation in regional activities with other Sea Grant advisory programs.

Marine Education

The Sea Grant Marine Education project, through a series of written curriculum materials and special programs, is a means by which students, as well as the adult populace in California, can become sensitized to their marine environment and knowledgeable about the present and future impact of the ocean on their lives. The overall goal of this project has been to create a marine-conscious and marine-knowledgeable society in California.

Objectives of the project are:

1. Distribution of exemplary, scientifically sound curriculum materials in marine education to teachers and students;
2. Provision of teacher training workshops;
3. Development of special programs around the written materials, to be used as models for other educators;
4. Provision of adult education programs;
5. Creation of a network of local and state support groups interested in California's marine resources to assure long-term effects of the marine-consciousness-raising program.

The following objectives were accomplished:

1. Eleven teacher workshops, with more than 200 teachers in attendance. Two district-wide workshops had present representatives from nearly all the school districts in Los Angeles.
2. Coordination and formal presentations for conferences held by the California Association of Bilingual Teachers, the National Energy Foundation, the National Marine Education Association, and the Los Angeles Teachers Association.
3. Developed special programs for two elementary schools and one high school, the latter which won a state award.
4. Worked with the Department of Education on its Bilingual Program, Teacher Science Centers, Environmental Education Program, and a state supported marine program at California State University, Long Beach; worked with the County Superintendent of Schools and the Marina Foundation to establish a first-ever prize for marine science projects at the Los Angeles County Science Fair.
5. Produced and published the statewide quarterly Marine Education Newsletter, in cooperation with the California Sea Grant College marine advisory program.
6. Coordinated a three-day program for inner-city high school students and held meetings with their parents at the Sea Grant facility on the USC campus.

7. Provided speakers for monthly meetings of the Los Angeles Town Hall and served as chair for the Marine Resources Committee.
8. Conducted two four-day programs for retired adults at Catalina with 60 participants, and assisted the Handicapped Scuba Association with education programs.
9. Taught two courses with the USC Master of Marine Affairs Program—one on policy analysis for marine topics and one on coastal zone management.

Coastal Zone Management

James Fawcett's work on a project with Professor Lowdon Wingo (Project R/CM-15) led to two major presentations during the 1982-83 year. The first, entitled "State-Local Conflict and the Management of California's Coastal Waters," was delivered in November 1982 at a three-day symposium sponsored by the California Coastal Commission. The meeting was directed at clarifying the most appropriate policy directions for the Coastal Commission to take in pursuing its interests in the offshore portion of the California coastal zone. The paper demonstrated the extent of issue conflict with local government that the commission would probably experience in extending its concerns more aggressively into the marine side of the coastal zone.

The second paper, also co-authored with Professor Wingo, was entitled "The Intergovernmental Politics of Coastal Planning." The paper addressed the progress of the California coastal planning effort, and was presented at Coastal Zone '83 in San Diego. Because the California coastal planning process has been in the vanguard of coastal zone management in the nation for more than ten years, and because the style of coastal management in California relies upon a unique application of sub-state federalism, the thrust of the presentation was upon assessing the nature and sources of that approach.

In addition to research and writing projects, time is spent advising various individuals and groups about coastal zone management in all of its various manifestations. Coastal planning situations vary widely, and individual contacts have proven to be the most effective way of helping people. For instance, the staff of the Coastal Commission called on Sea Grant Advisory Services to help obtain information on the impact of brine effluent from coastal desalinization plants, advised the regional office of a federal agency on the relationship between state and federal requirements for notices to fishermen of geophysical surveying activities, and secured information on California policies on coastal protection structures for an out-of-state Sea Grant program. Approximately one third of the coastal planning specialist's time has been invested in such advisory contacts.

Marine Recreation

Sea Grant continues to distribute thousands of copies of the popular booklet on marine weather, entitled "Weather to Go Boating." Funding for publication of additional reprinting came from The Marina Foundation, based in Marina del Rey.

Since 1972, Sea Grant has provided marine weather information by broadcasting 26 thirty-second reports each weekend to listeners of the CBS news station in Los Angeles, KNX-AM. Five reporters and one alternate, coordinated by James Fawcett, prepared and broadcast these reports—more than 1,300 each year.

Sea Grant also provides a telephone weather service for the near offshore area via telephone answering machines in the West Los Angeles office of the National Weather Service, which records weather updates on them every three hours.

Fishing

Through IMCS' Fish Harbor Marine Laboratory, Sea Grant maintains contact with the fishing industry, primarily through assistance with their "landside" problems. Sea Grant distributes notices of geophysical exploration by oil companies to help fishermen avoid loss of gear, and has distributed IRS instruction booklets for fishermen and advised them on their participation in the planning process within the Port of Los Angeles.

Marine Transportation

In March 1983, USC Sea Grant sponsored a national two-day workshop on seaport management. Approximately 50 practitioners and academics met in the Port of Los Angeles administrative building to develop a research agenda for the study of management problems in the large commercial ports of the United States. Dr. Willard Price was the leader of the conference effort, which included discussion sections on eight major topic areas: technology and productivity, computers and management, personnel development, international trade, financing, regional planning, environmental planning and land transportation.

The agenda developed from the eight summary papers was edited by Dr. Price, Robert Friedheim and Stuart Ross. It was published in December 1983 and is now being distributed. A second workshop, on smaller maritime ports, is planned for 1984.

Sea Grant Graduate Student Trainee Program (E/M-1)

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

The USC Sea Grant Graduate Student Trainee Program offers students the opportunity to apply classroom knowledge to actual working situations, with students assigned to marine-related research under the direction of faculty members on selected Sea Grant projects.

This program accomplishes several objectives: (1) It provides qualified students with the opportunity to work under the direction of experienced faculty members. (2) It provides students with marine research projects that fulfill graduate research requirements for their degrees. (3) It provides Sea Grant principal investigators with qualified students who will substantively contribute to the research results. (4) It provides students with experience in their chosen fields to help prepare them for leadership roles in the research and development of marine-related topics.

An important measure of the success of the trainee program is shown by the percentage of students who successfully finish their research projects and receive their graduate degrees.

Of the eight Sea Grant trainees for 1982-83, three received their doctoral degrees in the spring of 1983: Kamran Iradjpanah, Engineering, is now a project engineer with a firm in Naples Florida; Seyed Mehdi Sobhani, Engineering, is an assistant professor at Northrop University in Inglewood, California; and Ann Marie Muscat, Biology, is assistant director of the USC Catalina Marine Science Center.

The remaining five students are expected to finish their programs in 1984.

A highlight of the year was the selection of Alexander Andrasi as USC's first recipient of the national Sea Grant Association Award for his research on the development of an assay method for paralytic shellfish poisoning.

Throughout the year at monthly luncheons for the trainees, their principal investigators, and the Master of Marine Affairs students at USC, trainees presented their research progress, helping to keep students, researchers and others abreast of the various Sea Grant projects.

1982-83 USC Sea Grant Graduate Student Trainees were:

Alexander Andrasi, Biological Sciences, doctoral candidate. "Problems of Paralytic Shellfish Poisoning," R/EQ-31. Principal Investigators: B. Abbott, M. Ross, G. Kleppel and A. Siger.

Mary Bergen, Biological Sciences, doctoral candidate. "Scientific Information and the Valuation of Ecological Resources in the Coastal Wetlands," R/CM-22. Principal Investigator: L. Wingo.

John H. Costello, Biological Sciences, doctoral candidate. "Food Availability, Feeding and the Potential Competition for Food Between Larval Northern Anchovies and Adult Copepods," R/RD-16. Principal Investigators: R. Pieper and G. Kleppel.

Mary E. Dempsey, Institute for Marine and Coastal Studies, master's candidate in Marine Affairs. "Factors Affecting the Survival of Nearshore Larval Fishes," R/RD-13. Principal Investigators: G. Brewer and G. Kleppel.

Kamran Iradjpanah, Civil Engineering, doctoral candidate in Hydraulics. "Wave Uplift Pressures on Horizontal Platforms," R/CE-7. Principal Investigators: J-J Lee and L. Wellford.

Ann Marie Muscat, Biological Sciences, doctoral candidate. "Aspects of the Biology of the Sea Cucumber, Parastichopus parvimensis, A Developing Commercial Fishery," R/RD-14. Principal Investigator: J. Kastendiek.

Seyed Mehdi Sobhani, Civil Engineering, doctoral candidate. "Wave Uplift Pressures on Horizontal Platforms," R/CE-7. Principal Investigators: J-J Lee and L. Wellford.

James Yumeji, Urban Planning, doctoral candidate. "Scientific Information and the Valuation of Ecological Resources in the Coastal Wetlands," R/CM-22. Principal Investigator: L. Wingo.

Adult Education Programs

A marine-knowledgeable citizentry is imperative to assure wise use of our limited ocean resources and to preserve those resources that are non-renewable for future generations. The IMCS Adult Education Program is an important element in that objective.

During 1982-83, the IMCS adult education programs reached groups spanning in age from young adults to retired adults.

For those people whose leisure-time is spent in ocean-related sports, a series of evening and weekend lectures and demonstrations were conducted over a two-month period. Approximately 500 adults heard from scientists, medical doctors, paramedics, master scuba divers and underwater photographers, to name a few, on how to make the marine environment a safer and healthier place.

For the busy professional who is interested in the marine environment, monthly luncheon speakers were provided for the Los Angeles Town Hall meetings. Groups of 20 to 40 business people heard speakers on subjects such as marine geology, the Antarctic, the China Sea, marine research, and other informative marine subjects. Dorothy Bjur, director of training for IMCS, served as chairperson for the Marine Environmental Section of Town Hall and coordinated 18 luncheon speakers.

For retired persons, the Catalina Marine Science Center hosted four 4-day educational workshops. With 30 participants in each session—and a waiting list as long—these energetic adults listened to scientists, took field trips, visited research laboratories and came away with a much clearer picture of their marine environment. These workshops were conducted in cooperation with The Elderhostel Foundation. There will be four more workshops in 1984.

Hyperbaric Chamber Operation and Diving Physiology

The hyperbaric chamber at the Catalina Marine Science Center is the site of a number of training courses in various aspects of hyperbaric chamber operation and diving physiology.

The chamber staff offers ongoing courses during the year to train individuals in operating the chamber. At the option of the student, tuition for these courses is waived in return for an internship as a member of the chamber crew in the treatment of emergency diving accidents.

A course in emergency management of diving accidents offered last year for nurses, was successful to the extent that two more courses are being offered during 1984. In these courses, offered in conjunction with the Institute of Continuing Education for Nurses of the Los Angeles County-USC Medical Center Department of Nursing, critical care and emergency room nurses are instructed in current treatment practices for decompression sickness, air embolism, and other diseases in which hyperbaric physiology is a factor.

Educators in the diving profession learn the rules and standards that govern the complex decompression tables and procedures available for compressed gas diving in a course entitled "Taming the Tables," offered twice in 1984 at the CMSC chamber.

A second course in emergency management of diving accidents, aimed at diving professionals, involves coordination with and instruction from personnel in some of the most experienced rescue agencies on the west coast in the assessment, handling, transport, and treatment of diving accident victims.

Marine Literacy in Latin America

International marine literacy is the goal of a joint project conducted by the university and the Tinker Foundation of New York.

Since 1980, the Tinker Foundation has supported "Marine Literacy for Latin America," conducted by Dorothy M. Bjur, director of training for the Institute for Marine and Coastal Studies, and Dr. Wesley E. Bjur, assistant professor of Public Administration at USC.

The first phase of the project brought scientists and educators from nine Latin American countries to Los Angeles in 1980. These professionals were introduced to the bilingual marine education materials developed through the USC Sea Grant Marine Education Program. They were then encouraged to adapt the materials to their countries' flora and fauna and to develop further materials that would be indigenous to their environment.

As a result of the 1980 workshop, the Tinker Foundation provided funding for the second phase of this international marine education program in which Dr. and Mrs. Bjur have conducted marine advisory services and education workshops in Chile, Argentina and Brazil. Another workshop is scheduled in Venezuela, and the Ecuadorian government will receive assistance in developing a marine education program for the Galapagos Islands and the continent.

Workshops

Sea Grant Workshop on Seaport Management and Transportation Issues

Over the last two decades, a relatively small group of researchers has gradually advanced our understanding of seaport management and related marine transportation issues. During the last several years, Sea Grant programs around the country have taken an increasingly active interest in the issues.

In 1983, the Sea Grant Program at USC, at the request of the National Sea Grant Directors, sponsored a national forum that brought together experts from industry, from public management bodies, and from the academic community focusing on the problems of large, multifunction maritime ports. The workshop produced recommendations for eight areas of interest:

- International Trade and Seaport Demand
- Technology and Productivity in Seaports and Marine Transportation
- Regional Seaport Planning
- Environmental Goals and Seaport Planning
- Land Transportation and Seaports
- Seaport Management Systems
- Seaport Personnel and Professional Development
- Seaport Finance

"A Research Agenda for Seaport Management and Related Marine Transportation Issues," which was published as a result of the national workshop, contains a general framework for understanding seaport management and priority levels for research recommendations.

In April 1984, USC Sea Grant will sponsor a second national workshop—this one addressing the problems of ports that have an uphill struggle to attract maritime business. A summary of that workshop, in the form of a research agenda, will also be published.

Marine Resource Development in the Yellow and East China Seas

International and national experts gathered on the USC campus in late 1983 to discuss "Problems of Marine Resource Development in the Yellow and East China Seas."

The workshop was sponsored by IMCS in association with the Korean Ocean Research and Development Institute. Participants, including Korean, Japanese, and Chinese scholars who were in the United States, as well as American scholars and government officials with Asian research experience, surveyed the scientific, environmental, developmental, legal and political issues that will accompany efforts at exploiting the Asian natural resources.

The workshop dealt with a set of very controversial issues that are generated by multiple conflicting claims to control of fisheries, offshore oil and gas, and sovereignty.

The theme of the workshop was in keeping with USC President James C. Zumberge's desire for university involvement in the problems of the Pacific Basin.

Sessions during the workshop discussed the problems of differing legal standards and the needs for regional cooperation and an examination of the various techniques that modern social science can contribute to conflict resolution.

A summary of the workshop proceedings will be published in 1984.

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Executive Vice President
Evergreen Marine Corporation
San Pedro, CA

Robert Krueger
Finley, Kumble, Wagner, Heine,
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FACILITIES

In addition to classrooms, laboratories, and computer facilities on the main campus, the University of Southern California maintains a number of specialized facilities for use in marine studies.

On the main campus, some of the unique facilities include geological sciences' sedimentation laboratory, and wave-tanks for use by engineers studying wave uplift pressures and the impact of waves on coastal structures. The Allan Hancock Foundation is the respository of one of the most extensive collections of marine vertebrates and algae on the Pacific Coast. The Allan Hancock Library, built around a collection of rare books on natural history acquired by Captain G. Allan Hancock from the Boston Museum of Natural History, contains more than 90,000 volumes, some of which are extremely rare books, and 100,000 reprints and pamphlets.

Some of the specialized off-campus facilities are discussed below. These facilities are administered through the Institute for Marine and Coastal Studies.

Catalina Marine Science Center

The Catalina Marine Science Center (CMSC) is the main research facility of the Institute for Marine and Coastal Studies. The Center supports undergraduate and graduate teaching programs, and graduate students and visiting scientists take advantage of the Center for a wide range of research projects.

Located on the sheltered side of Santa Catalina Island, 22 miles from Los Angeles, the lab occupies 45 acres fronting on Big Fisherman Cove. It consists of a laboratory and an administration building, a dormitory-apartment-cafeteria complex, a waterfront facility, and assorted outbuildings and storage areas.

The 30,000-square-foot laboratory building was built to house about 60 students and researchers. It contains a lecture hall, library, zoological museum and herbarium, nine research and teaching laboratories, machine shop, stockroom and computer room. The waterfront area includes a pier and moorings for boats, an FAA-approved helicopter pad and a diving locker.

As originally conceived, the Catalina Marine Science Center serves as a regional marine laboratory, offering a program of research and teaching, with formal emphasis on field and laboratory work. Classes in marine biology are taught at the undergraduate level by the University of Southern California, the University of California at Los Angeles and Carleton College in Minnesota. During the summer months, USC offers courses at the graduate level. A program of continuing education courses for secondary teachers in the sciences is offered, as well as natural history courses for the sport diver. In addition to faculty and graduate students from USC, scientists from the University of California and California State Universities conduct research at CMSC. Numerous studies have been done in the area of neurobiological research, utilizing the squid *Loligo opalescens*, which is common during the winter months at Catalina. A number of research projects have also centered around the island's easily accessible kelp beds. The Tatman Foundation of St. Louis, Missouri, supports the Channel Islands Research Program out of CMSC, which involves extensive marine biological research throughout the chain of southern California islands. In addition, researchers from other academic institutions across the country and from industry utilize the lab's facilities. The Center has frequently been used for field-testing such prototype equipment as offshore drilling platforms and submersible vehicles.

The Center is the location for two unique facilities—the Catalina Hyperbaric Chamber and the National Undersea Research Program.

The hyperbaric chamber, which is the only facility of its kind in the southwestern United States, serves not only as an educational and research facility, but, under contract with the County of Los Angeles, is a 24-hour, year-round emergency treatment facility for diving accidents.

During 1980, the National Oceanic and Atmospheric Administration designated USC as one of five institutions in the nation to initiate manned underwater research programs. The program will allow marine scientists to live and work in an underwater habitat for missions from five to seven days. The system will take approximately two years to design and fabricate, and the habitat should be in full operation by early 1986.

The Catalina Marine Science Center is a fully equipped marine field station located 22 miles from the Los Angeles mainland.

The NOAA National Undersea Research Program at the University Of Southern California

The National Oceanic and Atmospheric Administration (NOAA) has a legislative mandate to establish programs for the assessment, protection, development, and utilization of U.S. coastal zone resources. NOAA's Office of Undersea Research has established the National Undersea Research Program to address those problems through use of such state-of-the-art technology as manned and unmanned submersibles, saturation diving, surface-supplied umbilical diving, and conventional scuba. state-of-the-art technology in systems such as manned and unmanned submersibles, saturation diving, surface-supplied umbilical diving, and conventional scuba.

As a part of the national program, the Institute for Marine and Coastal Studies of the University of Southern California has designed a movable habitat-based saturation diving program to be located initially at the Catalina Marine Science Center, 22 miles off the coast of southern California on Santa Catalina Island. Construction of the habitat is due to begin in 1984, with the first scientific mission scheduled for early 1986.

Actually one of the five programs within NOAA's National Undersea Research Program, the USC/NUR project is designed to support scientific studies at depths of 40-130 FSW, using saturation diving techniques. This will be the first such system to routinely support undersea research in temperate waters, and the first time that this important scientific technology will be available on a university campus, enabling aquanaut-scientists to work in an academic atmosphere under an established, ongoing, fully operational marine science program.

The USC/NUR project lends itself particularly well to research requiring the presence of the scientist at a study site for long periods of time. More particularly, saturation diving lends itself to long-term observations of behavior, movement, reaction to disturbance, etc., and to conducting experiments requiring extensive manipulation of organisms or gear.

Proposals to participate in this unique program will be evaluated by a national peer-review panel, with high priority being given to projects that address these basic NOAA Undersea mission goals:

1. *Fisheries*—ecosystem assessment and dynamics, habitat degradation and enhancement, harvesting impact, animal behavior and gear development.
2. *Pollution*—manner and physical effects of waste disposal; behavioral, biochemical and physiological responses of marine organisms to pollutants.
3. *Sea floor properties and processes*—geological, geochemical, and geophysical aspects including gradients in the water column near the sea floor, sediment transport, stability, fluxes, mineral resources.
4. *Ocean technology and services*—marine sanctuary monitoring, engineering, equipment testing and recovery, medical and diving physiology, archaeology.

The underwater laboratory system will consist of the habitat itself, a ballasted baseplate secured to the ocean bottom, a life support barge moored over the site, a personnel transfer capsule, satellite "way stations" (similar to wet bells) for emergency shelter and to extend excursion range, and a surface decompression chamber. The overall dimensions of

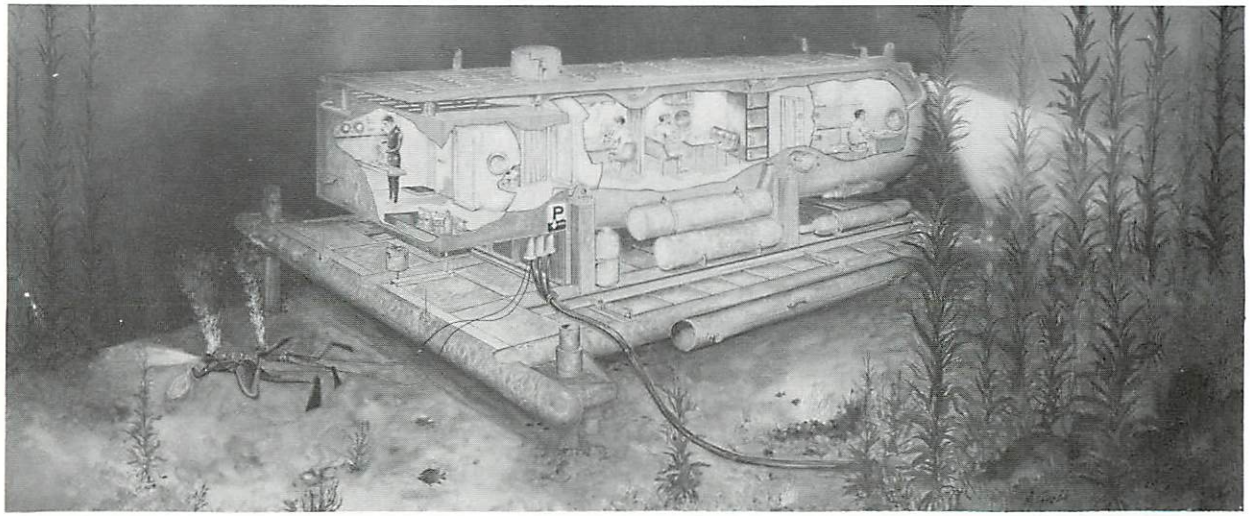
the habitat are 9 ft. diameter chamber, 12 ft. wide, 16½ ft. high and 40 ft. long. It will always be positively bouyant and will be winched down and secured to the baseplate. It will have the capability of being surface-towed to a new location.

The internal pressure rating of the habitat is 230 FSW. Normal operating storage (saturation) depth is between 50 and 120 FSW. Excursion diving (using scuba or tethered) from the habitat will initially be limited to 130 FSW. With demonstrated safety and scientific need, this limit may be extended in the future.

The habitat is designed to house six aquanauts (five scientists and one staff technician). An anticipated average saturation duration is 7 to 10 days. However, longer times are possible if the scientific need exists. The life support barge will be moored above the habitat and will supply electrical power and life support functions to the habitat via umbilical connections. There will be an operational monitoring capability on the barge. Fresh water, waste disposal and electrical connections will exist from the shore to the barge when available.

The personnel transfer capsule will normally be positioned adjacent to the habitat on the ocean bottom. It will be used for emergency pressurized evacuation of aquanauts to the surface chamber and for decompression of staff divers.

The habitat interior will have environmental control to create a comfortable "shirt-sleeve" condition. The habitat breathing gas will be nitrox (reduced oxygen mixture). The excursion diving will be on air. Nitrox will be used to reduce the possibility of pulmonary oxygen toxicity with the long exposures. The reduced oxygen atmosphere also essentially eliminates fire hazard during saturation. However, the increased percentage of nitrogen modifies decompression and nitrogen narcosis.



Artist's conception of the manned undersea research lab to be located at the Catalina Marine Science Center

Hyperbaric Chamber Operations

The hyperbaric chamber, located at the Catalina Marine Science Center, is unique in the Pacific southwest as one of the larger chambers available to the public for the treatment of diving accidents. This chamber has been a major facility for the diving community of southern California, not only as one of the most active treatment facilities in the world for decompression sickness and air embolism, but also as a research, testing, and training facility.

Treatment

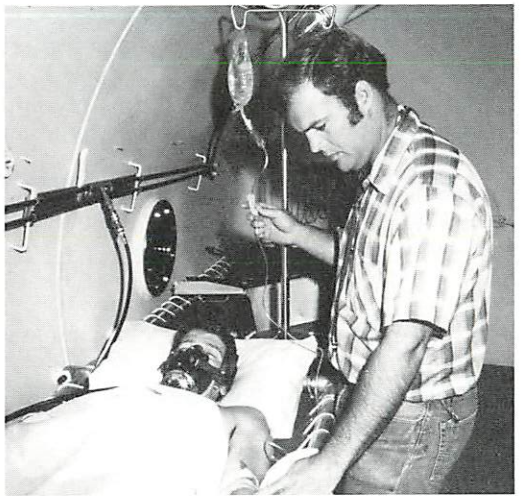
Southern California and the lee side of Catalina is one of the most heavily dived areas in the world. Because the prognosis of diver's decompression sickness and air embolism is so time-to-chamber dependent, the location of the chamber is ideal for the treatment of diving-related ailments. A staff of trained professionals is on call 24 hours a day to handle emergencies. The treatment of diving accidents is a cooperative effort of the CMSC staff, the Department of Emergency Medicine of the USC School of Medicine, the Los Angeles County Sheriff's Department, and the Search and Rescue Units of the U.S. Coast Guard, Navy, and Marine Corps.

Research and Testing

Catalina's temperate climate, abundant underwater research sites, and the hyperbaric chamber offer a diverse set of conditions in which to carry out scientific, commercial and military investigations. In the past, studies have ranged from research on basic tissue nitrogen uptake under pressure, testing of underwater welding equipment in a helium atmosphere, and human testing of underwater decompression devices. In addition, the size of the chamber provides the capability to conduct clinical research in hyperbaric medicine.

Training

The staff of the hyperbaric chamber has a longstanding commitment to training and further education in the area of diving physiology and medicine, chamber operations, and diving accident prevention and management. The CMSC chamber has received numerous requests to provide continuing education for medical and paramedical personnel, diving instructors, state and federal agencies and international institutions. In response to these requests, the staff has developed a variety of flexible and practical training courses. These courses range from 2-hour lectures to several days of study, providing experience with actual decompression exposures.



The IMCS hyperbaric chamber is the location for teaching, training, and research as well as a facility for treatment of emergency diving accidents.

The Mount Ada Marine Conference Center is a modern conference center located in the former summer home of the Wrigley family on Catalina Island

Mount Ada Marine Conference Center

The Mount Ada Marine Conference Center, overlooking Avalon Bay on Catalina Island, is a unique conference center in an island setting.

The Center, which is the former island home of the William Wrigley, Jr., family, was built in 1921. In renovating the house and grounds for use as a conference center, the Institute has carefully preserved the gracious interior decor and architectural details of the house, while augmenting them with the modern conveniences necessary for a successful conference.

The house is virtually encircled by a spacious veranda that provides a panoramic view of the island and the Pacific ocean. The foyer can be used as a reception area and leads to the L-shaped living room which serves as the principal meeting room. The billiard room, sun room, and dining room can be used for meetings or for informal discussions. A circular stairway leads to six additional meeting rooms on the second floor. These rooms can each accommodate between eight and fifteen persons.

A professional conference planning staff is available to discuss specific conference plans, reserve dates, develop fee schedules, or design a complete conference package. They also assist with arrangements for transportation, hotels, and sightseeing.

Research Vessels

USC's marine research vessels are capable of conducting a wide variety of sampling and research at sea. The fleet includes two major vessels and a number of small boats for harbor studies and nearshore collections.

The two major vessels are:

The VELERO IV—at 110 ft is the largest and most versatile. Characteristics include sophisticated navigation equipment, a range of 7,000 nautical miles, a heavy trawl winch with a 20,000-ft ½-inch wire rope, an articulating A-frame, a hydraulic crane and smaller hydrographic winch, ample storage and work space, and accommodations for 12 scientists.

The SEA WATCH is a 65-ft wood hull sportfishing vessel modified for oceanographic research. This boat provides an excellent platform for classroom demonstrations for as many as 45 students, or it can accommodate 16 scientists for projects of about 6 days duration.

Fish Harbor Marine Laboratory

This new facility provides scientists from USC and other academic and private institutions with a mainland facility located on the waterfront.

FHML consists of a 5500 sq ft building with laboratories, offices, and storage space.

Due to the lab's unique location, it boasts both immediate access to the open ocean for sampling, and a sophisticated wet lab (800 sq ft) containing a majority of the lab's aquaria and tanks. This wet lab is flexible enough to meet the needs of virtually any marine scientist.

Facilities at FHML include:

- A 475 liter/minute capacity circulating seawanter system that provides water to
- An 800-sq-ft wet laboratory, numerous outdoor tanks and pools, and a mobile environment bioassay facility

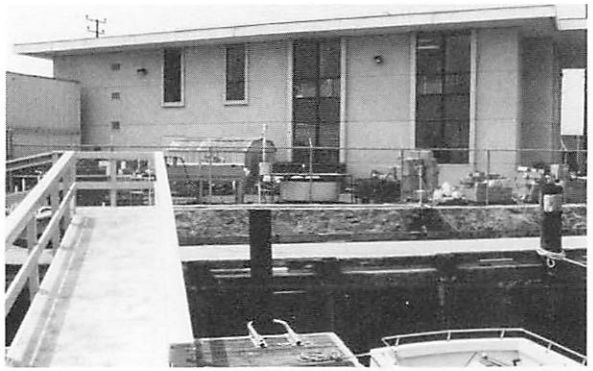
In addition to standard instrumentation and sampling gear necessary for biological and biochemical research, the laboratory has:

- A complete culture room
- An analytical chemistry laboratory
- A high-performance liquid chromatography system
- A scanning spectrophotometer
- Fluorometers
- A freeze drier
- A reverse osmosis purification system
- Osmometers

Computing facilities include in-house microprocessors and links to the USC campus mainframe systems.

The USC Sea Grant library of satellite sea surface temperature imagery, enhanced to evaluate small-mesoscale variability in southern California coastal ocean features, is located at FHML.

Scientists from the USC campus and FHML staff scientists conduct 60 to 70% of research work at the laboratory. Between 30 and 40% of the research at FHML is done by visiting scientists, faculty, and graduate students from other academic institutions and from the private sector.



The Fish Harbor Marine Laboratory and the University's research vessels are major components of the IMCS waterfront facilities in the Port of Los Angeles

SUPPORT GROUPS

SUPPORT GROUPS

Marine programs at USC benefit from support—in the form of funds, scholarships, and professional expertise—of a number of local, regional, and national groups.

Through the IMCS, two support groups, the Oceanographic Associates and the Corporate Associates, support marine programs at USC. In addition, several facilities and specific programs have their own advisory groups made up of prominent individuals from within the University and from the marine community, who lend their expertise to long-range planning and advisement.

Scholarships and Endowments

Scholarship and fellowship assistance is provided both by the University as a whole and by individual schools and departments.

In the Institute for Marine and Coastal Studies, financial aid has been in the form of both direct scholarship assistance and traineeships through the Sea Grant Institutional Program (NOAA), the Oceanographic Associates (a support group of donors to IMCS), and the ARCS (Achievement Rewards for College Scientists) Foundation, and Mr. and Mrs. Albert Vignolo, Jr.

The Wilford and Daris Zinsmeyer Chair in Marine Studies was established in 1977 in the amount of $1 million; several hundred thousand dollars has been raised to date for the Captain G. Allan Hancock-USC Associates Chair in marine Science; and late in 1980 a nationwide campaign by government, industry, and labor leaders was launched to fund a $1 million endowment in memory of union leader Paul Hall, "The Paul Hall Memorial Chair."

Oceanographic Associates

The Oceanographic Associates is the support group for all of USC's marine studies programs. Members include individuals and families who have a serious and broad interest in marine affairs.

The Associates maintain a scholarship program for graduate students and have contributed and raised money for facilities and equipment for the Institute.

Associates participate in special dinners four times a year, at which well known speakers present lectures, slides, and films on marine-related topics. Special events are also staged, such as the annual weekend at the Catalina Marine Science Center, which features tours, demonstrations, and lectures to keep them informed of the Institute's activities.

Donations and Gifts

The IMSC has an ongoing boat donation program in which said and power boats donated to the University are used to support student activities and marine research, respectively, or are eventually sold at their market value to support programs. The Institute also accept gifts-in-kind that can be utilized in support of marine research. Donors to the IMCS are affored the maximum tax benefits allowable by law. These marine programs are well founded, and the "related use" aspect for donated equipment is fully substantiated.

Corporate Associates

The IMCS works closely through its Corporate Associates Program with industrial firms and business organizations involved with the oceans of the world.

The Corporate Associates support marine research at USC, and, in return have access to research facilities and data, and to University faculty, libraries, and other facilities.

Corporate Associates currently include Ameron, Aminoil USA, Inc., Bechtel Power Corporation, Chevron USA, Inc., Crowley Maritime, Exxon Company, USA, Fluor Drilling, Hydril, Oceaneering International, StarKist Foods, SWECO, TRW, and Union Oil.

APPENDIX: PUBLICATIONS/ COMMITTEES

MARINE ADVISORY SERVICES

Weather to Go Boating: Hints on Coastal Boating in Southern California. Published in cooperation with the Southern California Boating Safety Advisory Group, National Weather Service, U.S. Coast Guard and the California Department of Boating and Waterways. Second edition. Fifth reprinting by the Marina Foundation of Marina del Rey. 16 pp. pamphlet. (Free). USCS6-AS-01-83 (formerly USCSG-AS-04-81).

The California State Coastal Conservancy: A Guide for Planners. Muretta, Peri A. A booklet summarizing the activities of the California State Coastal Conservancy. USCSG-AS-01-82.

MARINE EDUCATION

Marine Education Newsletter. A quarterly publication for marine educators in California. A joint project by the University of California and the University of Southern California Sea Grant Marine Education Programs.

Marine Education: Five Program Evaluations. Bjur, Dorothy M., and Jacqueline B. Rojas. USCSG-ME-09-82.

Wet and Wild. A 10-minute documentary on the marine studies classroom and field programs for visually impaired children (in color and with sound). USCSG-ME-08-82.

On the Waterfront: Teaching Seaport Management. Cashman, Jenny. Reprinted from Sea Grant Today. USCSG-R-09-82.

Dimensions of the Sea: Marine Education Slide Presentations With Narratives: Grades K—Graduate Level. (a) The Physical Ocean; (b) Ocean Management; (c) Ocean Research; (d) The Biological Ocean; (e) The Economic Sea; (f) Marine Ecology. Each set contains 35mm color slides on the marine community and environment, USCSG-ME-04-82.

Mini-Information Booklets (Bilingual). (a) Tidepool Animals/Los Animales que viven in las pozas de la marea; (b) Sharks and Other Sea Creatures/Los tiburones y otros animales marinos; (c) Fantastic Marine Animals/Fantasticos animales marinos. Each booklet contains approximately 50 mini-articles, USCSG-ME-02-82.

Marine Studies Idea Book: For Teachers, Grades K—6. A resource book of ideas and activities for the development of lesson plans by teachers, available in either English or Spanish for use in bilingual and international programs. USCSG-ME-01-82.

Teaching Materials Prepared for a Curriculum Development Research Study to Support an Academic Field in Harbor Port Management: "A Cry for Independence: A Case Study of the Port of Los Angeles." USCSG-ME-07-82. SPM-GV-1. "Seaport Data Analysis." USCSG-ME-06-82. SPM-MG-2. "Intergovernmental Relations and Seaports." USCSG-ME-05-82. SPM-FI-1.

COASTAL ENGINEERING

Simulation of Large-Scale Circulation in Harbors. Chiang, Wen-Li, and Jiin-Jen Lee. Reprinted from *Journal of the Waterway, Port, Coastal and Ocean Division*, Proceedings of the American Society of Civil Engineers (ASCE) Conference, Vol. 108, No. WWI, pp. 17-31, 1981. USCSG-R-06-82.

Wave Propagation over a Rectangular Trench. Jiin-Jen, Lee, and Robert M. Ayer. Reprinted from *Journal of Fluid Mechanics* 110:335-347, 1981. USCSG-R-03-82.

Interactions of Waves with Submarine Trenches. Lee, Jiin-Jen, Robert M. Ayer and Wen-Li Chiang. Reprinted from *Proceedings of the 17th International Coastal Engineering Conference*, ASCE, Sydney, Australia, March 23-28, 1980, pp. 812-822. USCSG-R-02-82.

LIVING MARINE RESOURCES

Waste Disposal in the Oceans: Maximizing Benefits, Minimizing Impacts. Soule, Dorothy, and Don Walsh (eds.). Includes chapters by the two editors and by Dr. Richard E. Pieper and Dr. Gary Kleppel of IMCS, along with others contributing as the result of a symposium sponsored by the Southern California Academy of Sciences. Boulder, Colo.: Westview Press. 1983.

Nearshore Production of Young Anchovy. Hewitt, Roger P., and Gary D. Brewer. Reprinted from *California Cooperative Oceanic Fisheries Investigations* (CalCOFI) Reports, Vol. XXIV, October 1983, pp. 235-244. USCSG-R-06-83.

Northern Anchovy and Pacific Sardine Spawning Off Southern California During Spring 1978-80; Preliminary Observations on the Importance of the Nearshore Coastal Region. Brewer, Gary D., and Paul E. Smith. Reprinted from *California Cooperative Oceanic Fisheries Investigations*, Vol. XXIII, 1982, pp. 160-171. USCSG-R-12-82.

Abundance and Vertical Distibution of Fish Eggs and Larvae in the Southern California Bight: June and October 1978. Brewer, Gary D., Robert J. Lavenberg and Gerald E. McGowen. Reprinted from the *Proceedings of the International Council for the Exploration of the Sea, Reports et Procesverbaux des Reunions.* P. Rapp (ed.), Woods Hole, Massachusetts: Woods Hole Oceanographic Institution, 1981, pp. 165-167. USCSG-R-05-82.

The Demands of Conflicting Change on Public Enterprise: West Coast Seaport Development and Environmental Regulation. Boschken, Herman. Reprinted from *Public Administration Review*, May/June 1982, American Society for Public Administration. USCSG-R-10-82

The Seasonal Abundance, Vertical Distribution and Relative Microbial Biomass of Chroococcoid Cyanobacteria at a Station in Southern California Coastal Waters. Krempin, David W., and Cornelius W. Sullivan. Reprinted from *Canadian Journal of Microbiology* 27(12):1341-1344, 1981. USCSG-R-04-82.

NON-LIVING MARINE RESOURCES

Alternative Regimes for Mineral Resource Development in Antarctica. Westermeyer, William E. Foreword by USC President, Dr. James Zumberge. Based on Dr. Westermeyer's doctoral dissertation, completed under the chairmanship of Dr. Robert L. Freidheim. Boulder, Colo.: Westview Press, 1983.

Point-Slope Approach for Reservoir Flood Routing. Butler, Stanley S. Reprinted from the *Journal of Hydraulics Division*, Proceedings of the American Society of Civil Engineers 108(HY10):1102-1113, 1982. USCSG-R-11-82.

Potential Offshore Sand & Gravel Resources of the Inner Shelf of Southern California. Appendix A: Vibracore Logs & Sediment Descriptions;. pp. 1-222. Appendix B: Results of Sediment Grain-Size Analysis, pp. 1A-978. Appendix C: Cumulative Frequency Curves for Sediment Samples, C-1, Area 1, Santa Monica Bay, pp. 1-385; C-2, Area 2, San Pedro Bay, pp. 386-772; C-3, Area 3-8, Dana Point-San Diego Bay, pp. 773-1000. Appendix D: Results of Petro-Graphic Model Analysis, pp. 148. Osborne, Robert H. 1982. USCSG-TR-03-82.

"Observations and Simulation of a Bottom Ekman Layer on a Continental Shelf," *Journal of Geophysical Research*, 89, 1983-1988. T. D. Dickey and J. Van Leer.

"The Influence of Optical Water Type on the Diurnal Response of the Upper Ocean," *Tellus* 35:142-151, 1983. T. D. Dickey and J. J. Simpson.

"Measurement of Fluid Flow Using Streak Photography," *American Journal of Physics*, in press. T. D. Dickey, B. Hartman, E. Hurst, and S. Isenogle.

"A Laboratory Technique for Investigating the Relationship Between Gas Transfer and Fluid Turbulence," T. D. Dickey, B. Hartman, D. Hammond, and E. Hurst, in *Gas Transfer at Water Surfaces*, eds. W. H. Brutsaert and G. H. Jirka. Dordrecht, Holland: D. Reidel Publishing Co., 1984, pp. 93-100.

"An Offshore Eddy in the California Current System: Part I, Interior Dynamics," Progress in Oceanography, 13:5-50, 1984. J. J. Simpson, T.D. Dickey, and C. J. Koblinsky.

"An Offshore Eddy in the California Current System: Part II, Surface Manifestation," *Progress in Oceanography*, 13:51-70, 1984. C. J. Koblinsky, J. J. Simpson, and T. D. Dickey

SOCIO-ECONOMICS

Japan and the New Ocean Regime. Friedheim, Robert L. (International Relations, USC); Dr. George O. Totten III (chairman, Political Science, USC); Dr. Tsuneo Akaha (Bowling Green University); Dr. Haruhiro Fukui (Political Science, University of California-Santa Barbara); Professor Mamoru Koga (Aichi Prefectural University of the Arts, Aichi, Japan); Professor Masayuki Takeyama (West Kyushu University, Japan) and Mr. Hiroyuki Nakahara (Research Institute for Ocean Economics, Tokyo). Boulder, Colo.: Westview Press. 1983. 384 pp.

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Newsletter

The *Oceanographic Associates* is a quarterly newsletter distributed for the IMCS support group and for friends and colleagues of the Institute.

Directories

Sea Grant published a program directory that lists all the research projects and principal investigators for the 1983-84 funding year. In addition, a catalog of publications produced by Sea Grant was completed and distributed.

Annual Reports

Results of research for all projects was included in the 1980-81 and 1981-82 annual reports by the Sea Grant Program. In addition, trainees who worked on research projects compiled a 1981-82 annual report detailing their contributions to the Sea Grant work.

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