USC Sea Grant Institutional Program

1981–82
ANNUAL REPORT

UNIVERSITY OF SOUTHERN CALIFORNIA
Institute for Marine and Coastal Studies
University Park, Los Angeles, CA 90089

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Introduction

Dr. Robert L. Friedheim, Director, USC Sea Grant Program

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

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

As a measure of the emphasis on state and local problem-solving in carrying out the research, each Sea Grant program is required to match the federal grant with half again as much funding from private, state or local sources. In California, the state government provided $250,000 in 1981-82 for matching Sea Grant funds, which amount we shared with the University of California Sea Grant College; and cash or in-kind services have also been contributed by USC itself, a local radio station, city and county government agencies and other sources. Their interest 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 managers; academic peer reviewers comment on the professional quality of the work; a panel of state agency representatives comments on the worth of the projects to the state; and a team of scholars and administrators from around the country makes an on-site inspection of the

entire program. Members of the IMCS Technical Advisory Panel and the California State Sea Grant Advisory Panel are listed at the end of this report.

Each year the USC Sea Grant program supports one or more projects in each of the following areas: socio-economic systems, living marine resources, non-living marine resources, coastal engineering, marine education and advisory services. In 1981-82, the USC Sea Grant Program supported the following projects:

Program Development

Continuing. Every year, at the director's discretion, some projects are initiated apart from the regular funding cycle, for various practical reasons. During 1981-82, Program Development provided an advance start for a 1982-83 project on understanding and management of dinoflagellate induced health and seafood problems, and financed some equipment purchases for experiments on gut contents analysis in copepods.

Advisory Services and Education

Continuing. This project seeks each year to make information about the ocean available to those who have specific ocean-related problem and to those who merely want to learn about the oceans. It also advises researchers on which problems need the most attention and how best to formulate the problems for purposes of doing the research. Efforts this year have been directed to the areas of recreation, coastal planning, seaports and shipping, fisheries, and education, including an extensive set of curriculum materials for the public schools.

In a separate project, curriculum materials were developed for a new university-level course in seaport management on the application of systems analysis and operations research.

Additionally, the Graduate Student Trainee Program provides financial support for selected students to work on Sea Grant funded projects related to their degree studies.

Nitrogen Transformations Associated with the Discharge of the Terminal Island Treatment Plant

Second of three years. This study traces the reactions and dispersal of certain compounds in a major outfall in the Los Angeles-Long Beach Harbor. The compounds studied include nitrates, phosphates and silicates, which are important nutrients for marine

microorganisms. The results are important for the design of outfalls.

Microbially-Mediated Entry of Pollutants into Marine Food Webs

First of three years. This project investigates how toxic metals in the marine environment are assimilated by marine microorganisms. This first step in the food web leading to man must be understood if we are to have a rational assessment of the metals' consequences for our ecosystem. The results suggest that marine bacteria play a minor role in the assimilation of toxic metals.

Factors Affecting the Survival of Nearshore Larval Fishes

First of three years. This project, which complements well-established work by the investigators, is producing data necessary for improved management of several sport and commercial fisheries. It is generally believed that the larval stage is the most critical for determining the success or failure of a year-class of fishes, but very little is known about the exact physical and biological interactions that occur in the natural setting. By intensive examination of a small nearshore area, the investigators are producing some of the initial answers.

Gas Exchange Rates at the Air-Sea Interface in Coastal Waters

Second of two years. This project explores the mechanisms governing the exchange of oxygen and other gases between the atmosphere and the ocean. Because dissolved oxygen is a critical component of overall water quality and because the atmosphere is a major source of dissolved gases, understanding the interactions will be important for environmental management.

Aspects of the Biology of the Sea Cucumber Parastichopus parvimensis: A Developing Commercial Fishery

First of two years. Changing ethnicity patterns and export markets have created a growing market for this previously nonutilized organism, but too little has been known about it to ensure appropriate management. This project is establishing basic information about the biology, behavior and distribution of the sea cucumber.

Waves and Currents in Regions of Sharply Changing Water Depth

Second of two years. This project builds on earlier Sea Grant projects by the same investigators, gradually expanding the range of wave and tidal effects near the coast that can be modeled mathematically. Focusing on the changes in wave patterns caused by abrupt changes in water depths, such as dredged channels, this project has shown, among other results, that some wave frequencies are not transmitted past such a channel.

Wave Uplift Pressure on Horizontal Platforms

First of two years. This project is utilizing new experimental techniques and complex mathematical models to establish more reliable predictions and guidelines for engineers to follow in estimating the uplift forces that their horizontal platforms will experience. The models and data are useful to municipalities, oil companies and others who build piers and platforms above the ocean surface.

Budget Summary

1981-82 Budget Summary

	Sea Grant Funds	State/Local Match
I. Program Management		
Administration and Management (M-1)	$ 87,095	$102,863
Program Development (M-2)	22,256	2,330
	109,351	105,193
II. Marine Advisory Services and Education		
Advisory Services/ Education (A/S-1 and E/E-1)	231,605	239,457
Sea Grant Graduate Student Trainee Program (E/M-1)	32,400	3,600
Systems Analysis and Operations Research: Applications to Seaports (E/CD-2)	15,368	7,563
	279,373	250,620
III. Living Marine Resources - Environmental Quality		
Nitrogen Transformations Associated with the Discharge of the Terminal Island Treatment Plant, Los Angeles Harbor (R/EQ-24)	52,948	24,437
Microbially-Mediated Entry of Pollutants into Marine Food (R/EQ-28)	27,638	22,433

Factors Affecting the Survival of Nearshore Larval Fishes (R/RD-13)	74,509	22,411
Aspects of the Biology of the Sea Cucumber Parastichopus parvimensis, a Developing Commercial Fishery (R/RD-14)	7,592	11,737
	162,687	81,018
IV. Non-Living Marine Resources-Environmental Quality		
Gas Exchange Rates at the Air-Sea Interface in Coastal Waters (R/EQ-26)	23,222	18,116
	23,222	18,116
V. Coastal Engineering		
Waves and Currents in Coastal Regions of Sharply Changing Water Depth (R/CE-6)	17,016	14,245
Wave Uplift Pressue on Horizontal Platforms (R/CE-7)	23,351	20,131
	40,367	34,376
TOTAL	$615,000	$489,323

Program Development

Administration and Management (M-1)

Dr. Robert L. Friedheim, Director, Sea Grant Program, University of Southern California.

Dr. Stuart A. Ross, Assistant Director, Sea Grant Program, University of Southern California.

The goals of the director, assistant director and staff of the USC Sea Grant Program are as follows:

1) To develop, coordinate and implement the USC Sea Grant Program and to exercise administrative and fiscal control.

2) To provide leadership to initiate an integrated program to assure that the general guidelines of the National Sea Grant Program will be met by current and projected programs.

3) To work with and assist agencies in California to explore and ultimately define resource management needs and to cooperatively investigate methods of satisfying these needs.

4) To act as a focal point of collaborative programs with other institutions of higher learning; with local, regional and state governments; and with the public.

5) To explore new applications of research, education, communications and advisory services.

No major changes in these goals, or in the management staff, occurred during 1981-82.

As indicated elsewhere in this report, the advisory services and education functions were merged more closely together, and the communications and publications function given separate recognition. These changes codify already developing patterns; they indicate no change in personnel or priorities.

The USC Sea Grant offices were moved across campus to a building with more floor space and in closer proximity to the Institute for Marine and Coastal Studies, USC Sea Grant's parent organization.

Our current address is: USC Sea Grant Program, Institute for Marine and Coastal Studies, University of Southern California, University Park, NBA-0341, Los Angeles, CA 90089-0341. Our telephone number remains: (213) 743-6068.

Program Development (M-2)

Dr. Robert L. Friedheim, Director, USC Sea Grant Program.

Each year Sea Grant sets aside limited funds for discretionary allocation to research projects other than those that pass through the annual review cycle. The purpose of the program development fund is to allow USC Sea Grant management sufficient flexibility to respond appropriately to circumstances that are not easily accommodated under the annual review cycle.

Projects to meet emergencies, project 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. Sizeable allocations are approved by the national Sea Grant office before execution.

In 1981-82, program development funds went primarily to these projects:

Understanding and Management of Dinoflagellate Induced Health and Seafood Problems (M-2/12.1).

Dr. Bernard C. Abbott, Professor, Biological Sciences; Director, Cellular Biology Section, University of Southern California.

Dr. Maria R. Ross, Hancock Fellow, Allan Hancock Foundation, University of Southern California.

One of the more serious problems of the shellfish industry is that of Paralytic Shellfish Poisoning (PSP). Some shellfish accumulate toxins derived from one of their food sources, microorganisms called dinoflagellates. The toxins, when ingested by humans, cause varying degrees of numbness, paralysis, and often death. The incidents occur to recreational gatherers of shellfish; commercial sources are protected by continuous monitoring programs. However, the industry suffers nonetheless -- from the costs of monitoring, from the publicity surrounding the occasional fatalities among recreational divers, and from the government-imposed periodic bans on shellfish harvesting at times when dinoflagellates blooms are likely.

The occurrence of the blooms, and hence the spread of PSP toxins, is a natural phenomenon not subject to our control, but a management and information program

could be of considerable help. More needs to be known about the development of toxic blooms, about the toxins and their actions in the shellfish and in humans, and about procedures for banning and monitoring shellfish harvests.

Through program development funds, a symposium was held to discuss a number of scientific questions concerning possible predictability of dinoflagellate blooms using satellite data; questions about bioassay techniques; and problems of ecology. The workshop explored management methods and allowed scientists to meet with representatives of government and industry to develop common objectives for reduction of the PSP problems. The three-day symposium, in March of 1982, included almost 40 scientists, educators, commercial managers, and government officials from around the country.

With the help of the program development funds, the investigators were also able to get a head start on a research project that later received funding for the 1982-83 year. The project concerns the development of an assay for the presence of the PSP toxins that is much less expensive and much simpler than the assay currently in use.

Gut Contents Analysis in Copepods by Use of High Pressure Liquid Chromotography (M/2/12.2).

Dr. Gary Kleppel, Allan Hancock Fellow, Allan Hancock Foundation; Adjunct Research Scientist, Institute for Marine and Coastal Studies, University of Southern California.

Successful fisheries management requires a thorough understanding of resource energetics. Two factors that must be recognized in this respect are that: 1) biological energy flow through marine ecosystems commences with the phytoplankton and 2) the conversion of phytoplankton to animal biomass is performed largely by crustaceous zooplankton, notably the copepods. The realization that larval and adult copepods are among the chief foods of both the juveniles and adults of many commercially and recreationally exploited fishes makes information on copepod feeding directly applicable to fisheries management.

Difficulties in making measurements on small planktonic animals collected at sea have obscured the desired goal of understanding the rules governing feeding in natural zooplankton assemblages, and have forced most scientists to confine their efforts to laboratory research. Although much of this work has been of high

quality, the extent to which the artificiality of the laboratory environment has biased our conception of feeding and food selection is substantial, in the opinion of many.

In recent years, we have come to recognize the need for experimental techniques applicable to natural populations collected at sea. With this goal in mind, this project has been investigating the feasibility of extracting and identifying phytoplankton pigments from copepod guts to infer the types of phytoplankton being eaten. The rationale for this approach is that many types of phytoplankton can be distinguished taxonomically by the kinds of xanthophyll and chlorphyll pigments they contain. Comparisons of the relative amounts of these pigments in the copepod gut with those in phytoplankton in the water can be used to indicate the selection or rejection of various categories of phytoplankton as food.

The sensitivity and versatility of High Pressure Liquid Chromotography (HPLC) makes it an obvious possible choice for this task. The investigator reviewed the literature on HPLC, used some of the HPLC equipment already available in our Fish Harbor laboratory, and used Program Development funds to round out the equipment and supplies necessary for the work. The technique involves a two-solvent, continuous, reserve-phase elution of the pigments.

In this study, HPLC was used to isolate three phytoplankton xanthophylls from the gut contents of three copepod species offshore San Onofre, California, in June 1982. Phytoplankton xanthophylls function as photosynthetic accessory pigments via Pigment System II. The various xanthophylls are fairly class-specific. Fucoxanthin (found in diatoms, chrysophyceae, haptophyceae and a few peridinales) peridinin (a dinoflagellate pigment) and neoxanthin (a green algal pigment) were isolated by reverse phase LC from cultured phytoplankton, water samples and copepod gut contents.

These preliminary results suggest that as feeding intensity increases, the copepods may be narrowing their food spectrum to include only the more nutritious phytoplankton. A paper detailing the results has been submitted to Marine Biology.

Communications and Publications (M-3)

Karen S. Charest, Communications Specialist, Sea Grant Program, University of Southern California.

INTRODUCTION

The communications and publications function provides an array of services necessary to ensure the timely production and distribution of information resulting from the research, and advisory and education projects supported by the University of Southern California Sea Grant Program. These services include writing, editing, design, production and distribution of printed materials; obtaining art, photographic and media support; assisting with seminars, workshops and exhibits; and preparing reports and proposals.

The communications and publications function of the USC Sea Grant Program became part of Marine Advisory Services in 1970 and was designated a separate project during 1981-82. This change more accurately reflects the activities of the project and is in keeping with the procedures followed by the majority of the Sea Grant programs throughout the nation.

RESULTS

Beginning in FY 81-82, the Communications and Publications Office was staffed with a half-time communications specialist. Because of this change from a full-time communications specialist -- necessitated by budget cuts -- activities have focused on print rather than electronic media. In this era of fiscal austerity, it remains mandatory that communication efforts make the most efficient use of time and money.

Cost-saving techniques have included keeping a closer scrutiny on proposed publications, smaller print runs, the use of the IMCS word processor to cut typesetting costs, increased photocopying reproduction rather than costly printing, and in-house preparation of charts, graphs, posters and camera-ready copy where practical.

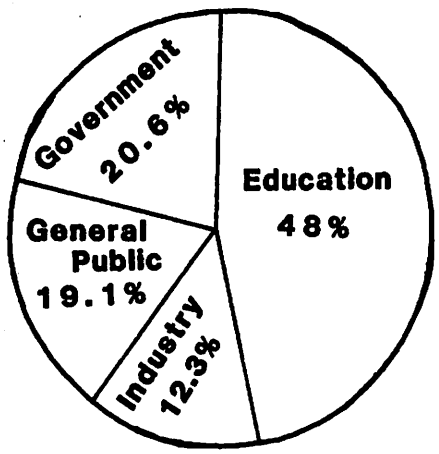
In addition, we have standardized editorial and production considerations common to all technical reports, journal article reprints and theses/ dissertations. The use of pre-printed covers for these publications provides an easy and cost-effective production system and a modern identity for USC Sea Grant publications.

Forms and checklists have also been developed to secure peer reviews of possible publications, which aids the authors in integrating this input into a product that is complete, accurate, clear and usable.

During the period of peer reviews, we develop a concurrent strategy for distribution and marketing the publication, working with the authors, administrators and others. By the time production begins, analyses of audience needs, efficient manufacturing techniques and distribution avenues lead to an action plan.

We believe these policies and review procedures have strengthened the overall communications and publications program, which consists of five major series of materials: Reprints, Technical Reports, Advisory and Educational Materials, Master's Theses and Ph.D. Dissertations, and program management support documents.

During 1981-82, the office distributed more than 1,300 publications. The following pie-chart diagram reflects the categories of users who requested these publications.



Reprints

Project investigators are encouraged to submit their research results to refereed journals in their fields of studies. This provides a focused outlet for the research results, greater exposure for the USC Sea Grant name, and reduces the cost of publication production for the program.

Our active reprint series emphasizes USC Sea Grant research in the areas of socio-economic programs, living marine resources, nonliving marine resources, coastal engineering, and advisory and educational services. Reprints from previous years continue to be popular, and we have had enthusiastic response to the new covers that grace reprints from late 1982 onward. During 1981-1982, 17 reprints were completed.

Technical Reports

Despite the policy that publication of research results in a refereed journal is encouraged, there are still certain manuscripts which, because of length or other factors, are best disseminated as reports produced in-house. These monographs, or Technical Reports, are produced when the research work is highly interdisciplinary and/or only preliminary results are available. As with a journal article, the technical report must be of professional quality and must undergo peer review prior to publication. We produce these reports in limited quantities because of their subject matter and distribute them to technical or scientific audiences. Four technical reports were produced in FY 81-82.

Theses and Dissertations

The USC Sea Grant Communications and Publications Office also produces a Theses and Dissertations Series for the master's and doctoral candidates who have served as trainees in the marine education program. In this area, 14 documents were added to the series during the year.

These trainees work with project investigators on Sea Grant-funded research, which is usually the focus of the thesis or dissertation. Such publications, also produced in limited quantities, prominently feature the Sea Grant name on the document's pre-printed cover.

Advisory and Educational Materials

In some instances, the findings from a research project can best be communicated in a less-academic format. This format is usually appropriate for disseminating information and knowledge to the general public -- the task assigned the Advisory Services and Marine Education components of the Sea Grant program.

In this case, the Communications and Publications Office aids in producing attractive and easily comprehended printed materials, including monographs, books, brochures and flyers.

Much work has been accomplished during the past year in producing Marine Education documents, including journal reprints, trainee annual report, program evaluations, and seminar and conference materials. All publication efforts of the Marine Education project now utilize the expertise of the communications specialist. During 1981-82, two advisory services and two marine education documents were produced.

Publications Announcements

The specialist designed a publication announcement form to distribute information on our publications at minimum cost. This tri-fold, self-mailer provides all necessary information on a publication -- including title, author, number of pages, cost, and an abstract of contents when needed. Targeted audiences generated by a computerized mailing list receive these announcements.

The computerized mailing list aids in distribution of information and publications. It combines audience lists used by all elements of the marine and Sea Grant programs, and can identify each entry by an audience code. Keeping these mailing lists up to date is a continuing process and a vital one for the communications and publications function.

Distribution

The National Sea Grant Offices receives copies of all publications, as do the National Technical Information Service (NTIS), Sea Grant Depository and Sea Grant Today. After initial mandatory distribution (in accordance with the guidelines formulated by the Council of Sea Grant Directors), we distribute publications in response to requests made directly to the USC Sea Grant program office.

Copies are available for a minimum fee to cover postage and handling and, in some cases, production costs. Publication announcement flyers advertise the availability of these publications. Reports and articles that are out of stock in the Publications and Communications Office are available through NTIS or the Sea Grant Depository.

External/Internal Communications

In addition to producing the above mentioned publications, the communications specialist is responsible for communicating Sea Grant activities to both external and internal audiences.

Liaison with the USC News Service and the USC Public Information Council increases the opportunity for news coverage. In addition, membership in the International Association of Business Communicators (IABC), an organization renowned for its offerings of seminars and workshops on the latest communication trends and techniques, keeps us "current."

During 1981-82, these efforts resulted in submission and publication of two articles in Sea Grant Today on current USC Sea Grant research; publication of an expanded article and pictures on USC Sea Grant in an annual special tabloid of the San Pedro (California) News-Pilot; distribution of press releases to more than 200 media in Southern California; and advertisement of the availability of Sea Grant funding for projects on 30 university and college campuses in the Southern California area.

In the internal communications arena, great efforts to improve communications with investigators have established an early understanding of mutual expectations and reponsibilities. These efforts have resulted in researchers seeking the advice of the communications specialist when preparing proposals, journal reports and other printed materials.

Through work with the editor of the Institute of Marine and Coastal Studies, the Sea Grant program receives very good coverage in an Institute newsletter distributed on campus and to businesses and industries in the Southern California area.

Marine Advisory Services and Education

Advisory Services and Education (AE-1)

Stuart A. Ross, Director, Marine Advisory Services, Sea Grant Program, University of Southern California.

Dorothy M. Bjur, Director, Marine Education, Sea Grant Program, University of Southern California.

James A. Fawcett, Coastal Planning Specialist, Sea Grant Program, University of Southern California.

Jacqueline B. Rojas, Assistant Director, Marine Education, Sea Grant Program, University of Southern California.

INTRODUCTION

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 upon the ocean. Californians depend upon their coastal environment for recreation, for food, for transportation, and many other functions. In order to manage this delicate environment and at the same time preserve its resources for future generations, its citizens must be able to make wise decisions regarding its management. This is made possible through processes of education -- about the ocean in general and about specific uses of it.

These activities at USC Sea Grant are carried out by a staff of four professionals (3.17 FTE), located on campus and in the harbor area. As will be seen, we have used a variety of modes of communication: formal curriculum materials, workshops, personal assistance in problem solving, mass media broadcasts, publications and more. Their efforts have been directed primarily at five subjects: general marine education, marine recreation, coastal zone management, commercial fishing and marine transportation.

Marine Education

Since its conception in late 1975, the goal of the USC Sea Grant Marine Education Program has been to promote the understanding of marine and coastal issues among citizens of all ages -- to foster a "marine aware" society, not only for the good of present generations, but for future ones as well.

To obtain this goal, a series of multidisciplinary marine education curriculum materials were developed,

programs for a wide range of special students (including handicapped, minority groups, etc.,) were created, and training on the use of these materials and programs offered to teachers.

During 1981-82, considerable progress was made in finalizing the evaluation, editing and publication of written materials, assisting in the dissemination and implementation of marine education programs in California (through workshops, teacher training and a university course) and promoting a network for the continuation of these programs.

More workshops were conducted and programs started than had been projected, although not as many bilingual programs were developed as anticipated. The following text will describe more in detail the progress made to date in reaching the goals and objectives of the USC Marine Education Program.

Publications

1) Multidisciplinary Teacher Guide, Grades K-6. "Wet and Wild," the 400-page supplementary marine education curriculum guide, written in English and translated into Spanish, includes six units, each with an introduction, lesson plans, supplementary materials and a bibliography. Its publication is presently contracted to the National Evaluation, Dissemination and Assessment Center for Bilingual Education at California State University, Los Angeles. The first unit, THE PHYSICAL OCEAN, should be ready for dissemination in the spring of 1983.

2) Marine Studies Idea Book, Grades K-6 was translated into Spanish, and now both the English and Spanish editions are being printed and disseminated.

3) The Marine Studies Idea Book, Grades 7-12 has been evaluated by 16 teachers from the Los Angeles County Schools and is being edited for final printing by the spring of 1983.

4) The Teacher Training Handbook, first discussed at the 1980 National Marine Education Association (NMEA) Conference in Salem, Mass., was again the focus of a workshop at the 1981 NMEA Conference in Galveston, Texas. The outline for the handbook was presented for participants' inputs, and several provided written suggestions and content materials. The first chapter has been written and the other five chapters outlined and assigned for writing.

5) Four issues of the statewide Marine Education Newsletter, jointly published by the University of

California Sea Grant and USC Sea Grant programs, has been distributed to educators throughout California. This project will eventually be taken over by the Southwest Marine Education Association.

6) A four-page Annotated Inventory and Order Form, describing all of the USC Sea Grant Marine Education materials and training programs, was developed, printed and is being disseminated. Approximately 650 copies have been distributed at conferences and science meetings and through the school districts.

Program Implementation

1) The USC Sea Grant Marine Education materials were introduced into 14 new schools during 1981-82 as a result of calls, visits and letters about our program.

2) Approximately 375 local teachers were trained in the use of the marine education materials through 19 workshops conducted by this program.

3) Approximately 6,500 students have been reached through staff participation at science fairs, career symposia and summer youth programs. By working with the Marina Foundation, a prize for ocean-related science projects was established at the Los Angeles County Science Fair for 1983.

4) Workshops were conducted for two Future Studies Programs: one at an elementary school in San Bernardino County and the other at Culver City High School.

5) Marine Education was introduced at two Science Magnet schools. (Magnet schools focus on a particular discipline, attracting students from the entire city of Los Angeles in an effort to racially integrate the school population.) The USC 32nd Street Magnet School has been using our program in grades K-5 for several years. The school has now asked our assistance in extending the program to grades 6-9 as well. Materials and training were provided for the San Pedro High School for a new marine science magnet program to be initiated for the 10th grade. This program will be expanded to include grades 11-12 over a three-year period.

6) Five bilingual workshops were conducted. The development of more bilingual programs has been delayed as the bilingual publication of the multidisciplinary guide is in process.

7) A three-unit graduate course, "Methods and Materials for Marine Science Education, Grades K-12," was developed by this program, and conducted in

cooperation with the USC School of Education. It was taught during the summer of 1982 by the assistant director of Marine Education.

Handicapped Program

Three Marine Education Programs for the Visually Impaired Student were conducted and recorded on film in 1980. In 1981, the film was edited and a 10-minute color and sound documentary was completed. Complimentary copies have been distributed to cooperating schools and institutes, as well as to state and federal departments of education.

Special learning tools developed for the visually impaired program (a children's books in braille and large letter, a compartmentalized box for dried marine specimens, and cassette tapes) have since been used in the classrooms, in educational institutions for handicapped youngsters, special presentations, etc., thus benefitting an additional 2,500 handicapped youngsters.

Advisory Group

During the year, a distinguished group of ten professionals from USC and the Los Angeles County and City school systems was selected to assist the staff in setting priorities for the program in the future. This action was in keeping with the National Sea Grant focus on marine related careers and vocational education. Among those on the advisory group are: Dr. David Tiedeman, director of the National Institute for the Advancement of Carer Education; Anna Miller-Tiedeman, research associate for the institute; Dr. Vernon Broussard, appointed by President Reagan to the National Advisory Council on Vocational Education and formerly manager of Secondary Planning and Program Development for the California State Department of Education and the Development of the California RISE Committee (Reform of Intermediate and Secondary Education.)

Evaluations

Five evaluations on marine education programs and materials were conducted during the past few years. This past year the data collected in these evaluations was compiled, analyzed and published.

The projects evaluated included: the Multidisciplinary Marine Education Teacher Guide, the Sea Grant Adult Education Program, a Marine Studies Program for the Visually Impaired Student, the year-long Bilingual Marine Education Program in the Lennox School District and the Catalina Workshop for Inner City High School Students.

General Public

The Advisory Services and Education staff also were invited to speak or be interviewed in a variety of public forums about Sea Grant, about the ocean in general, or about their own subject specialities. Stuart Ross gave presentations on marine energy sources to local civic groups, to a campus conference on ocean energy sources in April 1982, and on television station KCOP. Jacqueline Rojas appeared on radio station KZLA to talk about marine education. Dorothy Bjur organized a series of presentations on ocean topics for Town Hall of California.

Coastal Zone Management

California has one of the nation's most comprehensive state programs for governing its coastal zone. The state has long had regulatory authority over coastal development and is now assisting local governments in resuming that role after completing locally prepared coastal plans. An important problem for citizen and bureaucrat alike has been to understand such a complex procedure well enough to use it effectively. Beyond that, participants need to understand the short and long term effects of this new set of political processes. James Fawcett has led USC's effort to explain these processes.

One of the most effective means of promoting that understanding among citizens and researchers alike has been to write clear analyses of the processes. Toward that end, two papers were prepared that explain and analyze the California situation for academic and bureaucratic audiences here and around the nation. These dealt with the experience of local governments in developing coastal plans in urban and urban fringe areas, and with the conflicts between state and local levels of government. Both were written by James Fawcett in joint authorship with Professor Lowdon Wingo of the School of Urban and Regional Planning; both papers result from a 1980-81 Sea Grant project conducted by the two authors. One of the papers was presented at a UNESCO Conference in Tampa, and the other at a conference near Monterey sponsored by the California Coastal Commission. The latter paper is especially important to the commission, which is currently redirecting its efforts toward managing nearshore ocean resources in addition to the land resources of the shoreline, its past area of concern. The paper identifies those issues that produce the most contention (and hence delay) between local governments and the state in the coastal planning process. If the state could have been aware of the nature of those

issues early in the planning process, the researchers suggest, skillful management might have expedited implementation of the program. With respect to water and marine resource issues, their work will help by providing that advance information.

The State Coastal Conservancy, an agency developed to accept or purchase land for sensitive habitats and buffers to those habitats as well as coastal accessways, has long pursued its role in the shadow of the Coastal Commission. Too few city governments and members of the public know about this important public agency. To improve information about the agency, Peri Muretta, former Sea Grant trainee and graduate student in the School of Urban Planning, was commissioned to write a monograph on the Conservancy as a companion piece to that published in 1979 on the Coastal Commission's regulatory process. With the advice and consultation of Fawcett and Ross, the monograph was completed and adds substantially to our ability to educate the public about the operation of state coastal management agencies.

The Marine Advisory Program has also provided briefings on the structure, function, operation and policies of California's coastal agencies. Fawcett, the coastal planning specialist, lectured to two classes each academic quarter in the Department of Real Estate at California State Polytechnic University on the issue of why the Coastal Commission exists, what it does, and how its decisions affect real estate markets. This is the third year that he has given this series of lectures. Fawcett also met with three West Coast executives of Exxon at their request to brief them for a few hours on the general trend of coastal planning in Southern California.

Fawcett also spends a small fraction of his time assisting individuals and organizations who have questions about the coastal development permit process. These are primarily individual home owners and group property owners who may have never used the system previously. A typical case involved a woman seeking to get approval for a lot merger and subsequent relocation of an existing house onto her lot. As a result of Fawcett's help, the merger and coastal development permit were rapidly obtained by the woman, resulting in savings to her from avoided delays.

Marine Recreation

Recreational use of the marine environment is a major industry in Southern California and it affects

many southland residents and tourists during the year. Sunbathers, tidepool explorers, surfers, fishermen and boaters all utilize coastal waters, and we have provided information helpful to all of these groups.

The most commonly desired information has been weather information for the coastline and nearshore boating areas. Since 1972, we have provided marine weather information by broadcasting 26 one-minute reports each weekend to over 120 million listeners of over the CBS network-owned and operated radio station in Los Angeles, KNX-AM. Five reporters and one alternate, including and coordinated by Jim Fawcett, prepare and broadcast these reports -- over 1,300 each year. The service completed its 10th year of operation in 1982.

A mail survey of information needs among recreational boaters, conducted in the summer of 1982, with the assistance of the Los Angeles County Department of Beaches and Harbors, revealed that the KNX reports were listened to by these boaters far more than any other AM station. The survey also revealed the subjects on which boaters (over 800 respondents) felt the greatest need for information -- engine repair, electrical systems, fiberglass repair, boat handling in bad weather, and corrosion problems. Efforts will be made during 1982-1983 to prepare booklets or workshops on these matters.

A series of nine seminars for the advanced diver were sponsored in conjunction with the Los Angeles County Department of Parks and Recreation. Presentations provided by professionals from USC, IMCS and industry, included information on Diving First Aid and Emergency Procedures, Practical Oceanography, Coastal Monitoring, Seafood Preparation, Navigation, Underwater Communication, etc. Approximately 100 divers and interested public attended each of the seminars.

We have also published and distributed thousands of copies of a booklet on marine weather, entitled Weather to Go Boating. The booklet, which includes cartoons prepared by the staff of Hanna-Barbera, covers such subjects as sources of weather information, signs of bad weather, boat handling in bad weather, and the use of visual and radio distress signals. First prepared in 1976 by our recreational advisory staff, the booklet, by 1980, had been reprinted three times to accommodate the demand. The Sea Grant communications specialist coordinated a complete revision of the text and the information in the book in late 1981, and the (fourth) printing was paid for by ABC-TV, whose weatherman has been instrumental in advertising the booklet.

Fishing

Los Angeles Harbor has, for a number of years, been one of the largest commercial fishing ports in the United States. The indigenous fleet of 250 boats work a variety of fisheries with various gear. USC has a laboratory in Fish Harbor, one of the two concentrations of the local fishing industry. We have provided assistance to fishermen with their "landside" problems. For example, we have worked with the California State Lands Commission in notifying commercial fishermen of geophysical research vessel operations in the Santa Barbara Channel, to prevent loss of gear. Organizations planning marine geophysical research are required to notify Marine Advisory Services and we, in turn, notify the fishermen. It is expected that this procedure will greatly reduce the number of fishing nets and other gear which might have been damaged or destroyed without this procedure. If damage to only ten nets per year is prevented, the savings to fishermen could easily amount to more than $100,000.

In addition to our cooperation with the State Lands Commission, we have encouraged urchin fishermen to explore the notion of switching from urchin to the sea cucumber in slack times. Only one sea cucumber buyer has been found in California, but the industry is growing and USC Sea Grant has done pioneer research on the distribution and availability of the species. The efforts of Jim Fawcett, in cooperation with the University of California marine advisory agent in Santa Barbara, John Richards, were sufficient to find an economically viable alternate species for an otherwise idle fishing boat with a crew of three.

Fawcett was also instrumental in arranging for a reporter from Fishermen's News, a West Coast commercial fishing newspaper, to visit USC's Catalina Marine Science Center to write a story on the research being done there that would be of interest to commercial fishermen. The story, which appeared September 1981, covered the research and the safety equipment, such as the decompression chamber, which is always available to handle diving accidents in Southern California waters. The reporter was delighted at the opportunity for the story and the fishing community was well-served by accurate and up-to-the minute information on research in progress.

Marine Transportation

During 1981-82, preparations were begun for a larger education and advisory effort in the field of marine transportation and seaport management. USC's

research base in this area has been established for several years, and USC agreed to coordinate a research symposium on seaport management for the Sea Grant network in the Spring of 1983.

The bibliography on seaport management published in 1979 by USC Sea Grant was revised and will be distributed in early 1983. Peri Muretta, research assistant for Professor Willard Price's work, led the bibliographic effort, with computer literature search assistance from Stuart Ross.

Working with professors in public administration, Dorothy Bjur is planning research and educational efforts on trends and changes in seaport management, especially personnel management; and on the assessment of earthquake hazards in ports.

Systems Analysis and Operations Research: Applications to Seaports (E/CD-2)

Dr. Willard T. Price, Associate Professor, School of Business and Public Administration, University of the Pacific, and Adjunct Research Associate, Institute for Marine and Coastal Studies, University of Southern California.

INTRODUCTION

Major seaports face complex financial and logistical decisions. They must determine the costs and benefits of major construction projects, the financial impact of their fee structures, the degree of utilization of their facilities, the projected waiting times and unloading times for different kinds of ships, etc.

The field of management science -- incorporating such topics as systems analysis and operations research -- can offer answers to such problems. This project was conceived to define more precisely the usefulness of such techniques for ports and to construct a curriculum for training managers in these techniques.

The project included the following tasks: complete a literature search; prepare a concept of seaports as systems; interview selected seaport managers on existing and potential applications; prepare a syllabus; offer a critical view of the role of systems analysis and operations research in seaports; and evaluate the potential for curriculum offerings.

RESULTS

As a result of the literature search and the interviews with seaport managers at the ports of Seattle, San Francisco, Ashland, Long Beach and Los Angeles, a concept of seaport systems has been developed that provides a framework for the application of systems analysis and operations research techniques.

This framework begins with approaches to modeling seaports as systems. Modeling seaports suggests the following perspectives:

1) Simple input-output models with cost-effectiveness and/or benefit cost analysis.

2) More complex production models that include several input and intervening variables in regression equations to predict output.

3) More detailed simulation models that abstract part or all of the seaport system. These models are

normally analyzed by computer programs, which simulate alternative configurations of physical systems and alternative users and demand..

4) Specific models for parts of the seaport system such as a queuing analysis of a pier, an inventory approach to a terminal, or a PERT analysis of a capital project.

Given this conceptual view of seaport systems, the established methodologies in the literature and discussions with seaport managers, an initial syllabus has been prepared. A skeleton of that syllabus is shown in Figure 1.

Figure 1

SYLLABUS

Course Title: Seaport Systems Management: Applying Systems Analysis and Operations Research Methods

Objectives: Introduce students to the concepts and methods for modeling seaports as systems and to several systems analysis and operations research techniques with application to seaports. Students are not expected to have any specific academic preparation, but would benefit from a basic skill in algebra and statistics.

Topics

1) Introduction to the Systems Approach

2) Seaport Management Tasks and Information Systems

3) Modeling Seaport Systems

4) Economic Analysis
   a) Benefit-Cost
   b) Cost Effectiveness
   c) Multiple Attribute

5) Planning Techniques
   a) Forecasting and Regression Analysis
   b) Decision Theory - Uncertainity and Risk
   c) Project Planning - PERT/CPM

6) Allocation Models
   a) Linear Programming
   b) Transportation Model
   c) Assignment Model

7) Waiting Line Theory
   a) Basic Queuing Models
   b) Simulation Approach

8) Inventory Theory
   a) Basic Inventory Model
   b) Other Inventory Models

9) Replacement Theory

Selected Readings:
1) Churchman, The Systems Approach, 1968.
2) Turban and Meredith, Fundamentals of Management Science, 1981.
3) Turban and Loomba, Cases and Readings in Management Science, 1982.

Discussions with West Coast seaport managers also have yielded valuable insight on the viability of a seaport systems course. There is currently a limited use of these systems techniques by practitioners on the West Coast. The potential and current application of various techniques based on the survey of the selected ports is summarized below:

Systems Techniques	Application Potential	Currently Used
Benefit-Cost Analysis		x
Cost Effectiveness Analysis		x
Multiple Attribute Analysis	x	
Simulation Models		x
Decision Theory	x	
PERT/CPM or Network Analysis		x
Forecasting and Regression Analysis		x
Linear Programming (Including Transportation and Assignment Models)	x	
Queuing or Waiting Line Theory		x
Inventory Models	x	
Replacement Theory	x	

There are several reasons offered by port practitioners why these techniques are not more widely used.

1) Some port practitioners lack the knowledge of systems techniques. This is likely because many practitioners come from the maritime industry or from educational fields that do not emphasize systems techniques. At the Port of Oakland, for example, they are just beginning to computerize their financial systems.

2) Some ports perceive little or no need for these techniques. Often when an organization is in high growth period, as some ports are, they can afford to make decisions without the benefit of analytical models. There may be little organizational pressure to optimize performance when financial slack is available. The Port of Seattle, among other, contends that investment decisions are made on speculation rather than a cost/benefit ratio. Decision-making is often political, not economic, and although a systems course may be informative, the newly-acquired techniques would probably not be used.

Most ports acknowledge the benefits of a systems knowledge but say that the techniques are applied so infrequently that it is more cost-effective to rely upon outside consultants rather than to develop staff expertise. An ongoing in-house capability would not be fully utilized. Given the development of micro-computers and many software packages, there is now less need for a fully trained systems analyst. As a result, some professionals will need training to be able to deal with consultants and the available systems programs. Therefore, some education preparation is desirable for many existing and future seaport managers.

The insights gained through discussions with port practitioners may even mean that a separate systems course is not warranted, although the market is not yet tested. If these techniques are incorporated in the existing curriculum in seaport management at USC, it may be desirable to provide an overview in the introductory course or to discuss systems analysis and operations research more fully in the "Port Performance and Financial Management" course.

We do propose a test of this content in a separate offering, suggesting that in the future it will be more attractive than general management planning, environmental or coastal zone topics.

In sum, this research is determining relevant content for academic application subject of the systems analysis and operations research as well as testing the nature of university offerings that could provide educational outputs for professional seaport managers. Although we used both the literature and practitioners in developing this syllabus, future research can best determine the validity of systems techniques for seaport managers and the usefulness of the university to transfer this knowledge.

Graduate Student Trainee Program (E/M-1)

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

The Graduate Student Trainee Program at USC has provided an opportunity for graduate students to work on degree-related research in real-world situations. Concurrently, their research assists Sea Grant principal investigators to fulfill the goals and objectives of their Sea Grant projects.

This continuing program within the USC Sea Grant Program selects its candidates from many disciplines. Students interested in becoming a Sea Grant trainee must submit an application accompanied by at least three letters of recommendation, a statement of intent, and copies of both their transcripts and graduate record exam (GRE) scores.

During 1981-82, the USC Sea Grant Graduate Student Selection Committee chose six students to participate in the trainee program. Of these six, one completed his Ph.D. program and is employed in a marine-related organization. Three more are completing their Ph.D. programs and will continue in the USC Sea Grant Graduate Student Trainee Program. Two of the students completed their master's degrees, with one deciding to pursue a Ph.D. at USC. The students selected for 1981-82 projects include:

Hartman, Blayne, Ph.D. candidate, Department of Geology, "Gas Exchange Rates at the Air-Water Interface in Coastal Waters," R/EQ-26.

Iradjpanah, Kamram, Ph.D. candidate, Department of Civil Engineering, "Wave Uplift Pressure on Horizontal Platforms," R/CE-7.

Muretta, Peri, Masters candidate, Department of Urban and Regional Planning, "Systems Analysis and Operations Research: Applications to Seaports," E/CD-2.

Muscat, Ann, Ph.D. candidate, Department of Biology, "Aspects of the Biology of the Sea Cucumber Parastichopus parvimensis: A Developing Commercial Fishery," R/RD-14.

Sobhani, Seyed Mehdi, Ph.D. candidate, Department of Civil Engineering, "Waves and Currents in Coastal Regions of Sharply Changing Water Depth," R/CE-6.

Stepien, Carol A. Masters candidate, Department of Biology, "Factors Affecting the Survival of Nearshore Larval Fishes," R/RD-13.

During the academic year, monthly meetings are held for the trainees, principal investigators and Sea Grant administration. These meetings provide a forum for oral presentations by the trainees on their own progress and up-to-date information on the status of the project itself.

Through this trainee program, students have the optimum environment for broadening their intellectual scope, as well as the opportunity for preparing themselves as specialists who can deal effectively with a broad range of social, economic and scientific problems. They work closely with their assigned principal investigators on research, and have the opportunity to interact with other Sea Grant staff members and professionals to become familiar with the needs of the ultimate recipient of research -- the public. Sea Grant's applicability to the citizen user is certainly enhanced through the endeavors of the trainees.

Living Marine Resources

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

Dr. Richard C. Dugdale, Professor, Biological Sciences, University of Southern California.

Dr. Dale A. Kiefer, Associate Professor, Biological Sciences, University of Southern California.

Jane MacIsaac Dugdale, Hancock Fellow, University of Southern California.

INTRODUCTION

Marine sewage outfall design conventionally is directed toward the achievement of a "buried" effluent field. The approach used to achieve the "buried" field is to discharge the effluent at some depth below a thermocline or pycnocline, the steep density gradient acting as a barrier to prevent the effluent from reaching the surface. There are, however, serious problems associated with the deep diffuser approach.

In temperate regions, the density stratification disappears in winter, allowing the effluent to reach the surface. In addition, subsurface currents are generally less energetic than surface currents, decreasing the rate of turbulent diffusion; subsurface discharges are difficult to monitor; and, on an upwelling coast such as that of California, an undercurrent may transport discharged materials into the surface at an upwelling center (as at the White's Point outfall at Palos Verdes).

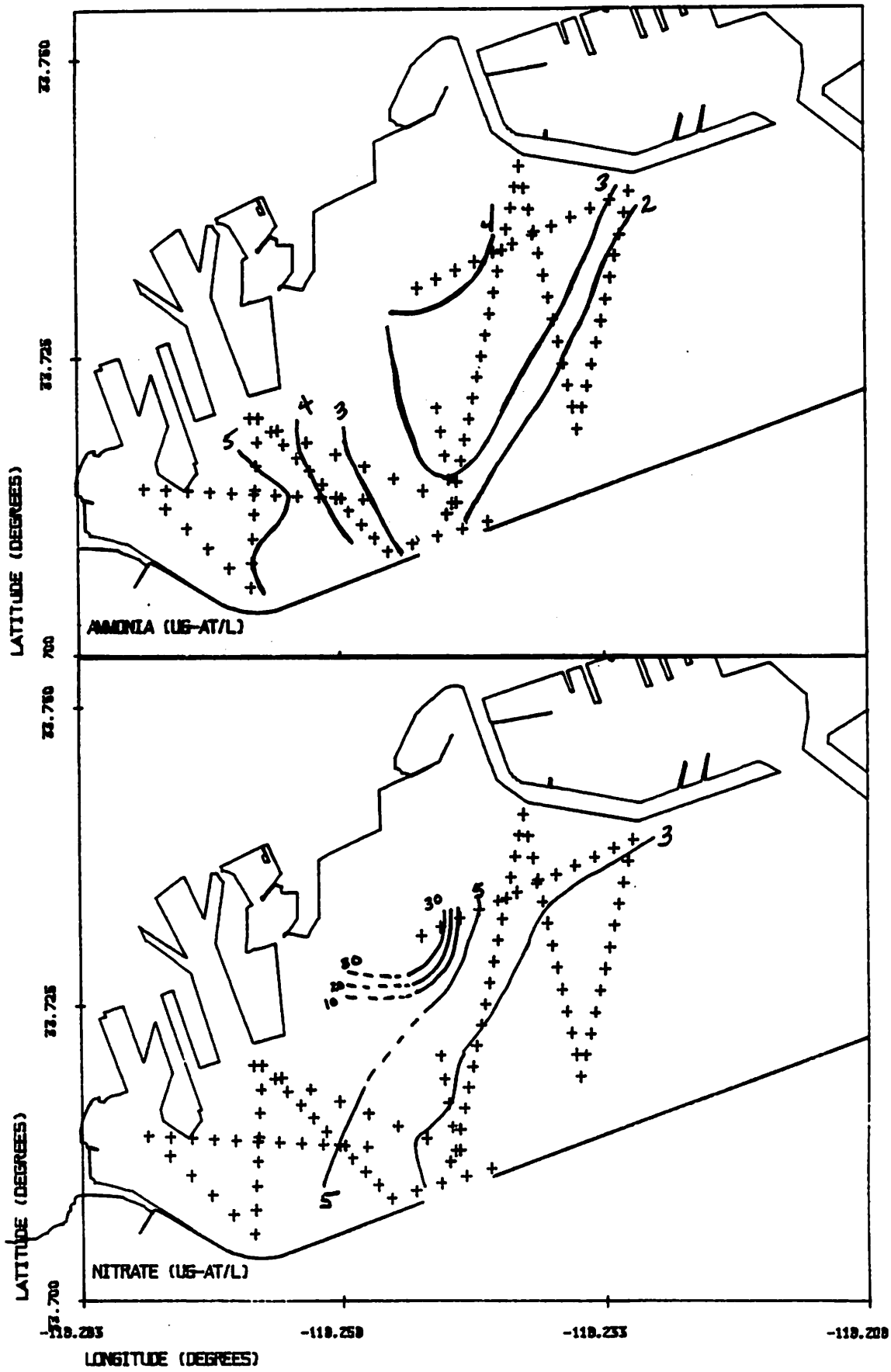
Surface discharge -- with the advantages of high diffusion rates, ease of monitoring and processing of nutrients by phytoplankton -- may provide a viable and economically desirable alternative to deep diffuser discharge under some circumstances. The Terminal Island Treatment Plant (TITP) outfall discharges secondary-treated effluent that produces a surface boil at all times of the year as a result of the shallow depth of the diffuser. The TITP outfall provides a unique opportunity to examine the surface discharge option wherein phytoplankton are deliberately included as an element of the disposal system, primarily as nutrient sinks. Consequently, the overall goal of this project is to determine whether secondary-treated surfacing outfalls provide an attractive alternative to at-depth outfalls. The immediate objective of the project is to determine whether the TITP outfall significantly influences the nutrient characteristics of Los Angeles Harbor in any deleterious way, i.e., whether the receiving capacity of the harbor is exceeded and, if so, when and why?

RESULTS

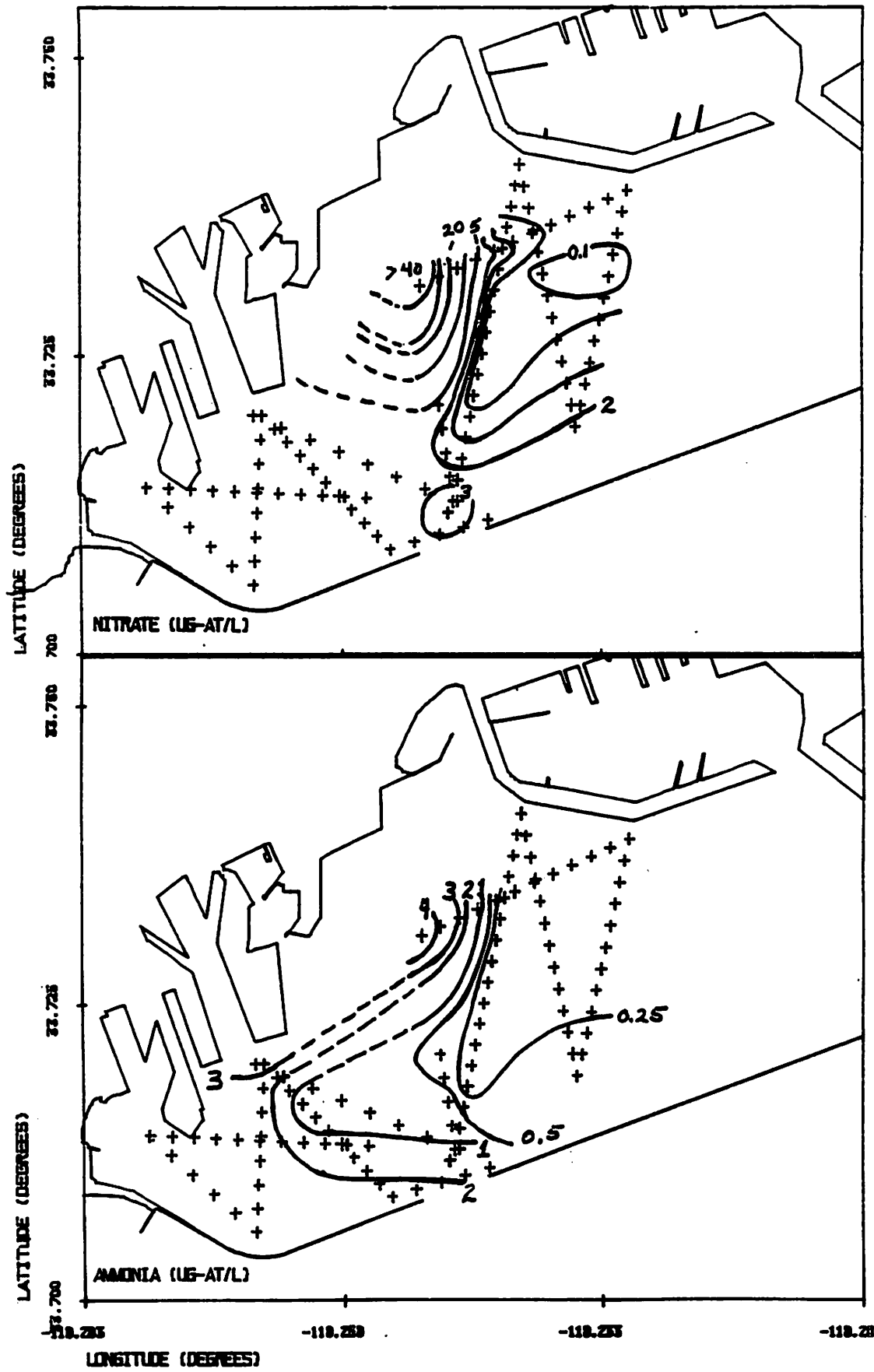
Mapping, hydrography and nitrogen kinetic experiments have demonstrated the effects of varying seasonal conditions within the Los Angeles Harbor. Horizontal maps of near-surface concentrations of nutrients have shown changes in nutrient concentrations during different seasons. During a February 1982 cruise, nitrate and ammonia concentrations were relatively high throughout the harbor. Nitrate ranged from a minimum concentration of 2.3 ug-at/l in the eastern section of the harbor to more than 6 ug-at/l in the west (Figure 1). The maximum, more than 30 ug-at/l, was at the outfall with strong gradients immediately around the outfall. Ammonia showed a similar distribution ranging from less than 1.5 ug-at/l in the east to more than 5 ug-at/l in the west with the maximum also at the outfall (Figure 2).

At the end of the summer, in September 1982, distributions of nitrate (Figure 3) and ammonia (Figure 4) were similar to distributions in the winter observations. However, both the range and the absolute magnitudes of the nitrate and ammonia concentrations were lower than in winter. At the eastern end, nitrate concentrations were as low as 0.1 ug-at/l, and the ammonia concentration was 0.2 ug-at/l. Both nutrients increased to more than 2.5 ug-at/l at the west end of the harbor.

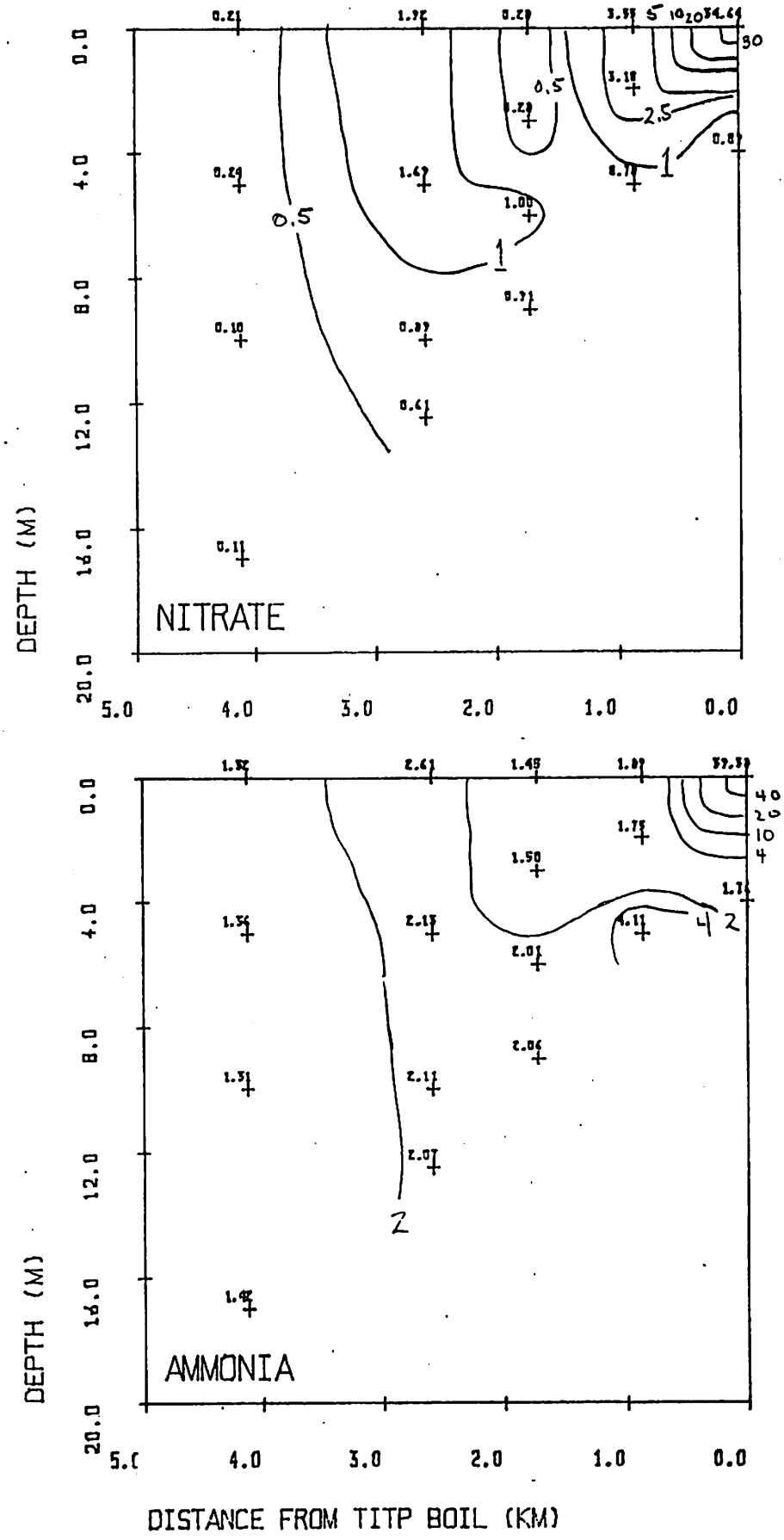
During the late summer, a series of hydrographic stations located between the outfall and the harbor entrance showed vertical structure. Within the harbor, strong temperature gradients ($T=2^{o}C$ over about 6 m) were present indicating strong stratification within the harbor. Within 1 km of the boil, the highest nutrient concentrations (Figure 5 and 6) were at the surface. The presence of high nutrient concentrations near the surface with the associated strong stratification provide the opportunity for phytoplankton to shift-up to optimal rates of photosynthesis and nutrient uptake. This may account for the lower nutrient concentrations in the September observations. The combination of lower light during winter, and hence lower rates of solar heating, and more wind-induced mixing may result in suboptimal rates of phytoplankton photosynthesis and nitrogen uptake. Experiments to determine the kinetics of nutrient uptake of harbor phytoplankton have been made on water taken from both near to and far from the outfall and at all seasons of the year. The results of these ^{15}N experiments are being analyzed and it is already apparent that lower maximum uptake rates occur in winter than in summer.



Figures 1 and 2: Maps of the concentrations of ammonia and nitrate sampled from a depth of about 2 m.



Figures 3 and 4: Maps of the concentrations of nitrate and ammonia.



Figures 5 and 6: Maps of the concentrations of nitrate and ammonia from a hydrographic section.

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. Gordon T. Taylor, Research Assistant, Biological Sciences, University of Southern California.

INTRODUCTION

The potentially toxic substances in the environment include both naturally occurring toxic inorganic elements (such as heavy metals) and hazardous organic compounds synthesized industrially or related to petrochemicals (such as insecticides and combustion products).

In the marine environment, the uptake of these elements by bacterioplankton and phytoplankton at the first levels of the marine food web may be of considerable significance. The initial accumulation of these potentially hazardous materials by bacterioplankton, phytoplankton and organic detritus could provide the first step, or the "momentum," for the entry and transfer of these toxic substances along marine food webs leading to fish, mammals and humans.

In an earlier Sea Grant study, we established that the bacterial fraction of the microplankton were very important to the uptake of selected organic compounds. In this study, we have focused on potentially toxic trace metals, often called heavy metals. In particular, we have chosen to examine the manner in which trace metals cadmium (Cd) and cobalt (Co) enter into the microbial component of marine food webs.

These two trace metals are among the 92 elements that occur naturally in seawater. In the environment, trace metals may be important as limiting nutrients for primary productivity or as toxicants to all levels of oceanic food webs. Both effects are clearly concentration-dependent phenomena; in the coastal zone, we are primarily concerned with the high concentrations of trace metals resulting from the activities of man. Cd and Co have both been shown to be present in coastal waters in relatively high concentrations. Cd is a toxicant even at low concentrations; Co plays a well-known role in cellular metabolism as the coordinate element in vitamin B_{12}. It is unknown whether Co in high concentrations acts as a toxicant.

In order to assess the role that the microplankton play in removing Cd and Co from seawater and transferring them to higher trophic levels in marine systems, we

measure rates of association of the radionuclides ^{109}Cd and ^{57}Co with microbial particles by collecting subsurface samples (1 meter depth) from two stations in Los Angeles Harbor and one adjacent coastal station (Figure 1). Sampling in the harbor was conducted along a nutrient gradient (ammonia) produced by the Terminal Island Treatment Plant (TITP), described in full by the Sea Grant project R/EQ-24, conducted by Drs. Dugdale and Kiefer.

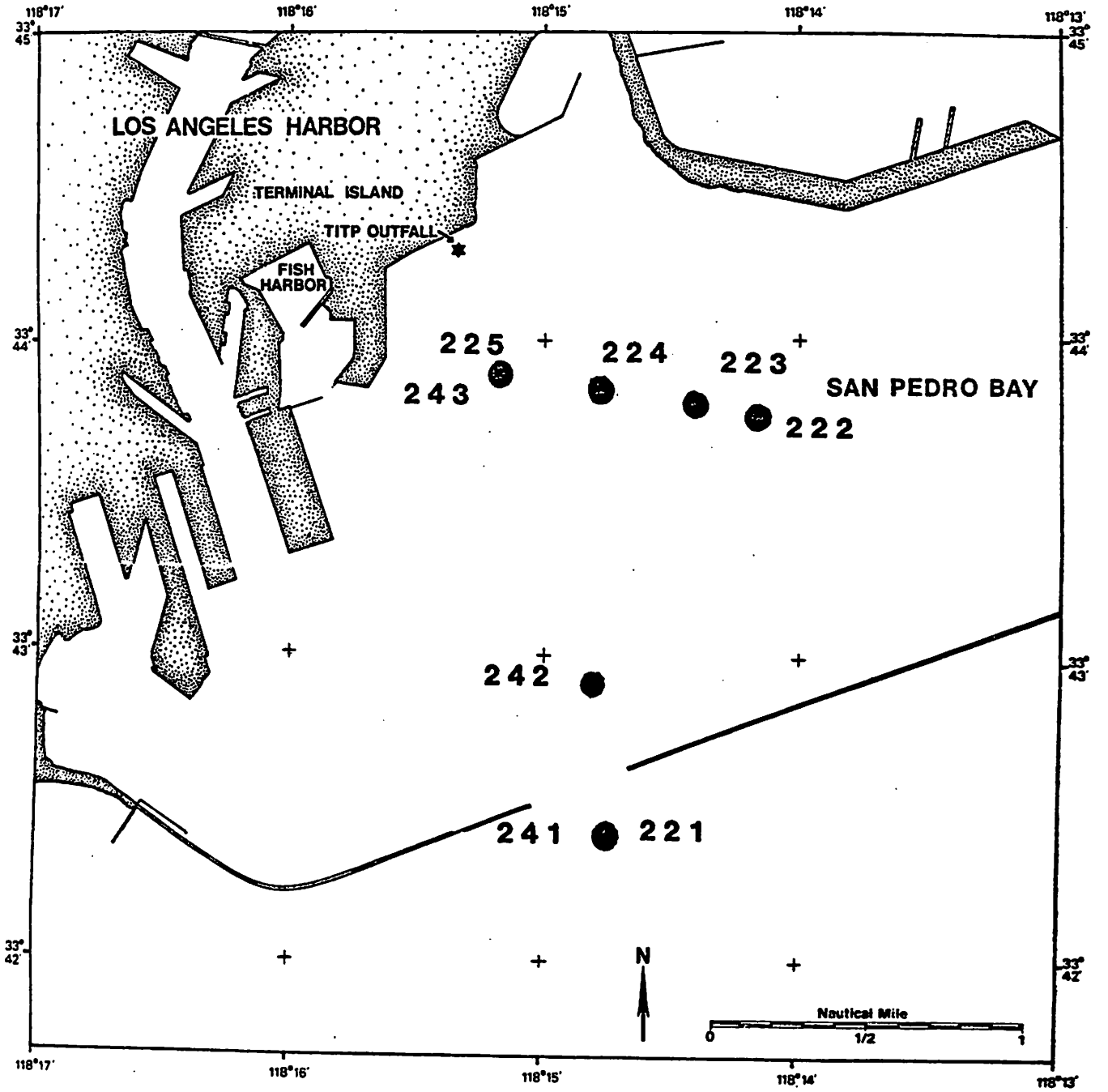


Figure 1: Location of sampling stations in Los Angeles Harbor.

The questions that we have addressed in our study over the past year are as follows:

1) At what rates are Cd and Co ions removed from seawater by microbial particles?

2) What are the relative roles of bacterioplankton, phytoplankton and organic detritus in removing Cd and Co ions from seawater?

3) Are there discernible differences in the association of Cd and Co relative to the microplankton?

4) Are there any correlations between metal association rates and the chemical and biological characteristics of the seawater?

5) Do Cd and Co association rates vary spatially and temporally?

With these questions in mind, we have been examining the rates at which inorganic metal pollutants enter marine food webs via the microbial component. With the information gained, we hope to be better equipped to assess the effects of trace metal pollution on the coastal environment and to be able to determine the paths by which two selected trace metals enter marine food webs.

RESULTS

Studies were conducted on samples collected from three stations: coastal water (outside the Los Angeles Harbor breakwater), the edge of the TITP outfall plume, and near the TITP outfall. These stations were sampled on Oct. 22, 1981, and Feb. 24, April 21 and July 14, 1982. Low levels of the radionuclides ($^{57}CoCl_2$ and $^{109}CdCl_2$) were introduced to replicate samples, with live and poisoned controls. The rates of removal of the soluble metals were studied for the living and dead components of two size ranges of organism: 0.2 to 1.0 um (the bacterially enriched fraction, or BEF) and 1.0 to 203 um (the phytoplankton-enriched fraction, or PEF). The rates of removal were determined by filtration and radioassay techniques.

Data from these cruises reveal that ^{57}Co becomes associated with microbial particles (203 um) at a relatively slow rate. The dissolved residence times (DRT) in the samples averaged 137 days. Differences in DRTs were observed seasonally and spatially. We observed the lowest DRTs (i.e., the most rapid association rate) in the Oct. 22 and July 14 samples. With the exception of the Oct. 22 sample, the lowest DRTs were at the stations near the TITP outfall. Of

the total associated ^{57}Co, the average distribution among the particles was as follows: 41% was associated with the live PEF, 8% with the live, BEF 1% with the dead bacteria, and the remainder with the dead phytoplankton. These data suggest that most of the ^{57}Co is associated with the particles larger than 1.0 um and active biological uptake and abiotic adsorption seem to play equal roles in this association. Only a small portion of the label was associated with the BEF, which comprised 30%-40% of the adenosine triphosphate (ATP) biomass, and almost all of that association was due to active biological uptake.

These studies have shown that Cd association rates with microbial particles are slower than Co association rates, with DRTs averaging 322 days. Total Cd association rates followed the same spatial and temporal trends as Co. Only three of the samples demonstrated active biological uptake in the BEF and five samples demonstrated abiotic adsorption. Most samples showed no Cd association in the BEF. As with Co, most of the Cd association was with the PEF, and active biological uptake and abiotic adsorption appeared to play equal roles with daily association rates of 39% and 46%, respectively.

Other experiments were conducted simultaneously to determine the effects of concentration on association rates. Replicate samples from two stations were concentrated to 5 ml over 1.0um Nucleopore membranes and resuspended in defined nutrient medium. This medium was a modified inorganic seawater mix that was rendered free of trace metals. Trace metals were then added in known amounts so that the medium was well-defined. Co and Cd were added to comprise final concentrations that were 0.04%-0.2% and 2.0%-9.2%, respectively, of ambient Co and Cd concentrations. Samples suspended in this medium were then treated the same as the samples described above.

These experiments permitted the measurement of potential rates of uptake and adsorption for the PEF and examination of concentration effects. For the Feb. 24 sample, the only data set completely analyzed to date, we found a marked concentration effect on total association rate. The samples in natural seawater, which had much higher Co and Cd concentrations, also had higher absolute rates than the samples suspended in the defined medium. In the defined medium, in which Co and Cd concentrations were comparable, there was no consistent difference in absolute association rates. In the natural seawater, in which Co concentrations were 29-48 times greater than Cd concentrations, Co association rates were 56-265 times greater than Cd association rates.

In addition to the radioassay data, we have been compiling other biological and chemical data for each station. With the assistance of Dr. J. SooHoo and R. Iturriaga, we have been measuring selected parameters of planktonic standing stocks, such as chlorophyll concentrations, bacterial number and ATP biomass. For the last two sampling dates, we have also measured total particulate carbon as a measure of organic detritus and biomass. We are also awaiting the results from atomic absorption analysis of the samples for total Co and Cd concentration. We do have Cd and Co data for the Feb. 24 sampling date, which indicate that Co is present at our stations in concentrations 1-2 orders magnitude greater than Cd.

The analysis comparing DRTs with various biological parameters is not complete, but it appears so far that there is a negative correlation between biomass indicators, such as chlorophyll-a and ATP, and total association rates. It may be that total association rates are most dependent upon levels of detritus and metal ion concentrations. These questions will be more easily addressed once all the data have been compiled.

The work completed in the past year has revealed that Co and Cd interact with the microplankton in different ways. We have shown that both metals are removed from seawater at rather slow rates by microplankton, in comparison with the total metal ion pool. From our data, it is apparent that the bacterial component of the microplankton plays a minor role in the removal of Co and Cd from seawater. This finding is contrary to our earlier observation that the BEF was very important for the uptake of some organic compounds. Live and dead particles in the PEF are the major scavengers of Co and Cd ions. The ion concentrating effect that these organisms and particles have may represent a hazard to organisms that consume them. In turn, as ambient concentrations of these metals increase, so too does the concentrating effect of the PEF, which may impact organisms higher up the food web, including man.

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

Dr. Gary D. Brewer, Research Scientist, Institute for Marine and Coastal Studies, University of Southern California.

Dr. Gary S. Kleppel, Research Scientist, Institute for Marine and Coastal Studies, University of Southern California.

INTRODUCTION

Fish populations often undergo dramatic fluctuations in size from year to year, and the accurate prediction of such changes is, perhaps, the major goal of fishery research. It is clear that the number of young recruits that enter a fishery is often not proportional to the biomass that spawned them. Environmental factors that influence the embryo, larval and post-larval stages ultimately control recruitment success or failure; apparently, starvation and predation are key factors in the mortality of the early developmental stages. Despite this widespread premise, predatory-prey interactions of fish eggs and larvae are poorly understood. Southern California has an abundance and diversity of commercial, sport and ecologically important fishes, but studies of the feeding ecology of most taxa have not been undertaken; information on the impact of predators is virtually nonexistent for these valuable taxa in Southern California nearshore waters. Understanding the sources of mortality during the early life history stages is vital to forecasting stock size and managing fisheries effectively.

The overall goal of the project is to explain the physical and biological factors that contribute to the survival or mortality of the early life history stages of fishes in nearshore waters off Southern California. We believe that this goal can be achieved, in part, by sampling a representative shallow water marine community off Southern California intensively and repetitively during 4-6 day periods in the winter, spring and summer and thereby:

1) Identify the ichthyoplankton and determine its vertical distribution on a diel cycle.

2) Assess the species occurrence, vertical distribution and abundance of the phytoplankton and micro- and macrozooplankton on a diel cycle.

3) Examine the feeding habits of selected fish larvae in relation to vertical distribution of actual

and potential food organisms (phytoplankton and microzooplankton).

4) Determine the feeding habits of potential predatory species of macrozooplankton for the occurrence, identification and abundance of icthyoplankton prey.

5) Capture adult fishes from different depth strata and examine their gut contents for the presence and identity of fish eggs and larvae.

6) Collect benthic epifauna and microflora and determine if these organisms contribute to the foods or predation of ichthyoplankton.

RESULTS

Our studies of nearshore ichthyoplankton ecology during the 1981-82 Sea Grant year included winter (January) and summer (August-September) cruises in Santa Monica Bay (Figure 1). Ichthyoplankton, macrozooplankton, (>0.333 mm), microzooplankton,(0.032-0.333 mm), and phytoplankton were sampled at 3-5

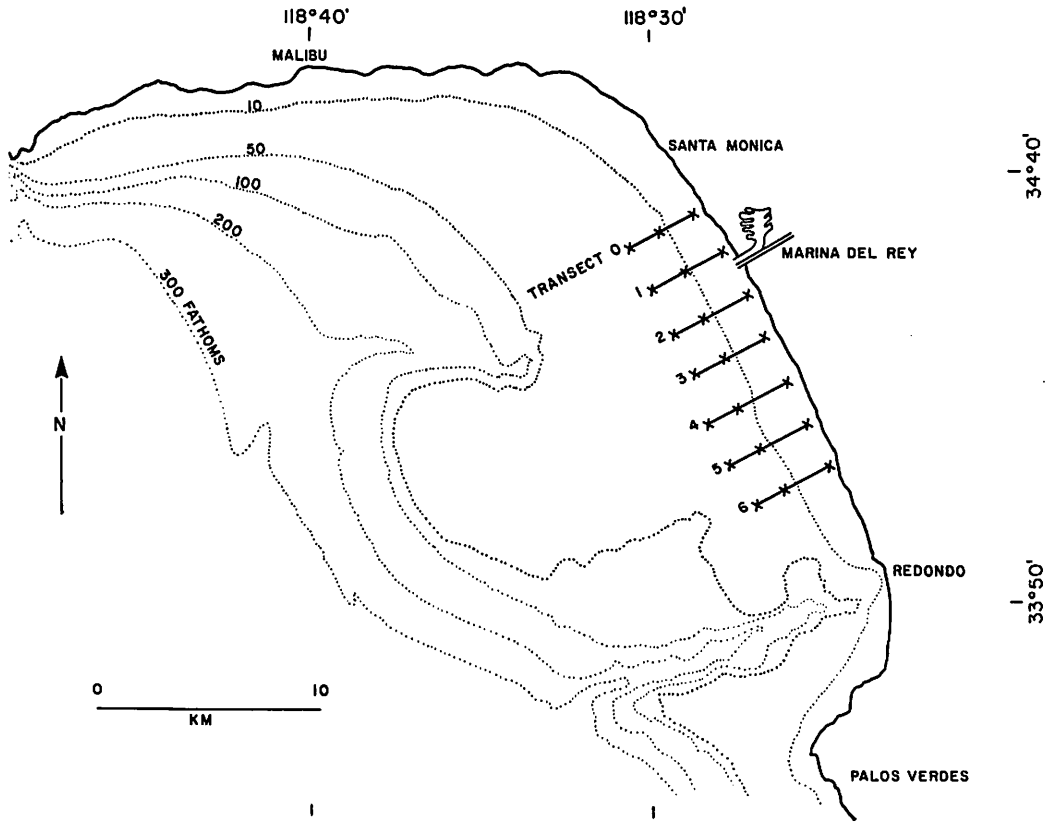


Figure 1: Transect locations in Santa Monica Bay. Three stations along each transect were over the 8, 22 and 30 m isobaths.

discrete depths with opening/closing Bongo nets and pumps along a series of transects over isobaths between 8 and 40 m. Salinity, temperature and depth (STD) casts and vertical profiles of chlorophyll fluorescence were taken throughout the 48 km^2 study area. Otter trawls and gill nets were deployed to capture juvenile and adult fishes.

The ichthyoplankton fauna was dominated by white croaker (Genyonemus lineatus) and northern anchovy (Engraulis mordax) during the winter cruise. Water temperatures (13.8± 0.4°C) were relatively homogeneous vertically and horizontally, while chlorophyll fluorescence showed horizontal structure. Queenfish (Seriphus politus), northern anchovy and Pacific mackerel (Scomber japonicus) were relatively abundant during the summer cruise when surface to bottom temperatures over the 30 m isobath varied 8.2°C (13.4-21.6°C).

Preliminary results of the winter cruise indicate that significantly more northern anchovy larvae were captured in nighttime relative to daytime Bongo tows; differences were not significant for white croaker larvae. There was no significant difference in abundance of northern anchovy larvae between near surface, middepths and nearbottom Bongo tows, but the average size of the larvae increased significantly between the three depth strata, respectively. The abundance of white croaker larvae was significantly stratified by depth; highest densities of the larvae were found in the near-bottom samples.

The incidence of feeding (presence of food particles in the gut) was as high as 100% for white croaker larvae. Bivalve veligers and tintinids were important foods for white croaker larvae. The digestive tracts of most northern anchovy larvae were devoid of particles, but dinoflagellates, copepod eggs-nauplii and tintinids were found. The phytoplankton (diatoms, dinoflagellates, microflagellates) were diverse (87 diatom species and 32 dinoflagellate species), but organisms considered food items (dinoflagellates and possibly microflagellates) were generally low in abundance. Microzooplankton were also of lower abundance than expected, but extensive vertical variability was evident in the data. The distribution of larvae appeared to parallel the distribution of certain potential foods.

Apparent zooplankton predators on the fish larvae during the winter included the copepods Corycaeus anglicus, Labidocera trispinosa, the furicula stage of Euphausia pacifica, and the chaetognath Sagitta euneritca. The incidence of apparent predation by the

three taxa ranged from 0%-6% of white croaker and northern anchovy larvae. Over 150 individuals of juvenile and adult fishes representing 30 taxa were examined for gut contents. Only four species were found with fish eggs and/or larvae in their guts; seven individuals contained a total of only 28 fish eggs and 1 fish larva.

Perhaps one of the most important aspects of larval fish predator-prey relationships is the phenomenon of small scale patchiness. The distribution of planktonic organisms is neither uniform nor random -- instead, planktonic organisms are almost always aggregated or patchy. Small scale patchiness was evident during the summer cruise when a series of samples were collected at 10-minute intervals at a single depth (20 m) while the ship was anchored. The data (Figure 2) suggests the presence of strong physical gradients as seen in the temperature and salinity plots. The order of magnitude changes in the abundance of the microzooplankton along the temperature and salinity gradients indicate substantial small scale variability. Such variability may have profound impacts on feeding by larval fish. The passive or active encounter of food gradients by the young larvae might ensure successful feeding. At present, we are studying how these gradients influence the distribution of the macrozooplankton predators on the fish larvae.

An understanding of the intensity and scale of food particle (and predator) gradients is critical to our overall goals; attention will be focused on adequately sampling small temporal and spatial scales during the next year.

Results are preliminary, and plankton sorting, data analysis and interpretation are ongoing. Although many questions are unanswered, we are convinced that this Sea Grant study will make a significant contribution to nearshore plankton ecology and fishery biology by evaluating the role of foods, feeding and predation in the early life history of important fishery stocks.

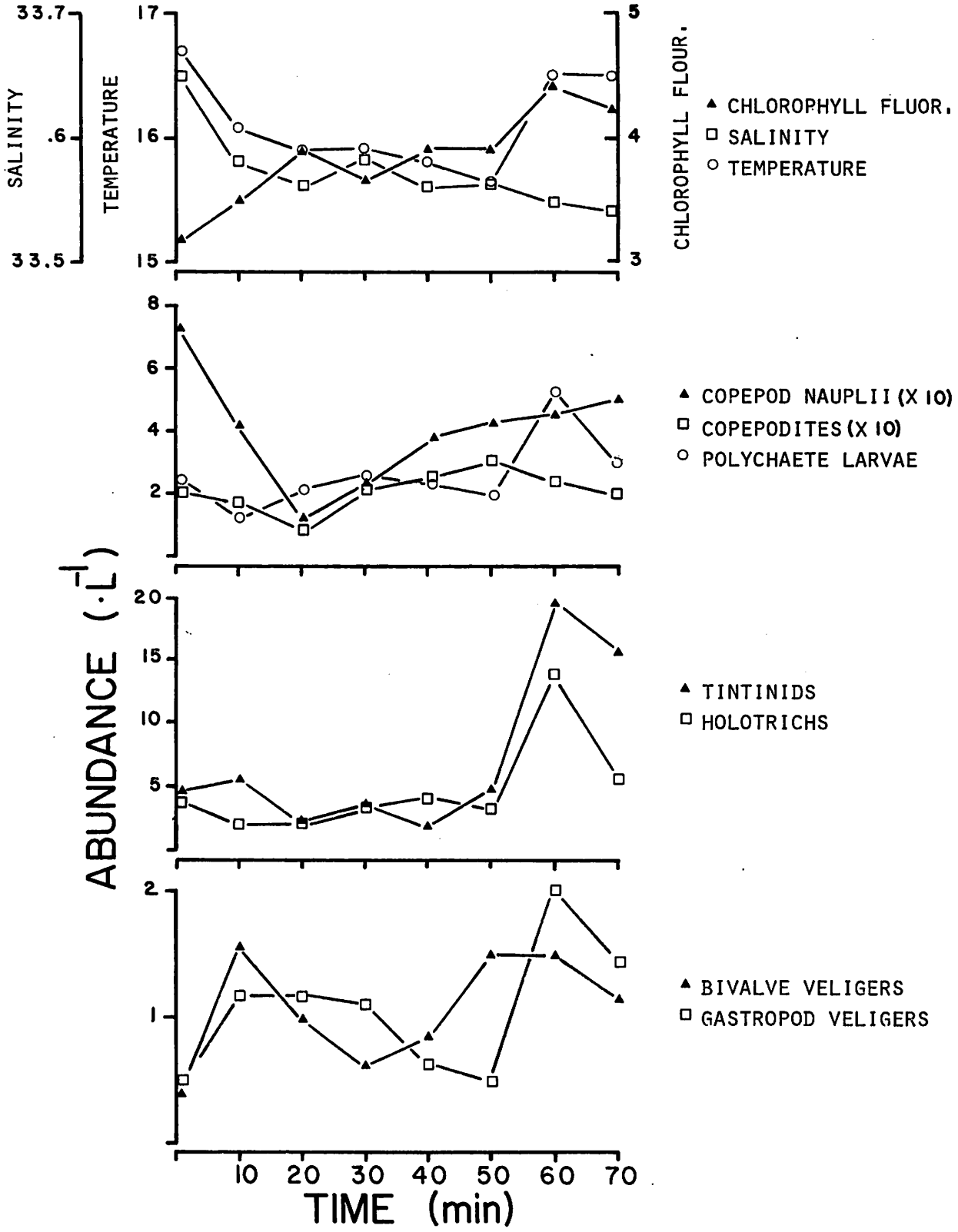


Figure 2: Variability of temperature, salinity and chlorophyll fluorescence and microzooplankton taxa at 10 minute intervals at one location. Data from the summer cruise; sample depth was 20 m.

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

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Ann Muscat, Resident Biologist, Catlina Marine Science Center, University of Southern California.

INTRODUCTION

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 insufficient 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 a economically important species. Our discussions with commercial fishermen, sea cucumber buyers, and California Department of Fish and Game representatives indicate a great deal of interest on their part in any information we may provide, and they have given cooperation in our work.

The overall goal of this project is to gather data on the natural history, behavior and population interactions of Parastichopus parvimensis as they pertain to the successful utilization and management of the resource.

Our particular objectives for the 12 month period from October 1981 to October 1982 were to determine:

1) Fluctuations of distribution and abundance patterns in space and time.

2) Preferred habitats of adult and juvenile cucumbers.

3) Type and extent of predation pressure exerted on cucumber populations.

4) Impact of the "echinoderm disease" on cucumber populations.

5) Activity patterns and emigration and immigration rates between areas.

6) Annual reproductive cycle.

7) Annual patterns of intestinal growth.

8) Growth rates and age structures of selected populations.

9) Recruitment patterns.

10) Impact of cucumber populations on benthic infaunal populations.

In addition, we sought to significantly increase communication and contact with commercial cucumber fishermen and buyers.

RESULTS

The first year's data indicate significant fluctuations in the abundance of adults and juveniles in space and time: cucumbers are ten times more abundant on rocky substrates than sand bottoms. There are also more individuals on the rocks inside a kelp bed than outside, and when given a choice between hard and soft substrates, individuals spend significantly longer times on the rocks. There are dramatic seasonal fluctuations in population densities, with nearly complete disappearance of the cucumbers from shallow waters (less than 40 feet) during August through November. This is due to a downslope migration from warmer to colder waters, seen on both hard and soft substrates. In December and January, the cucumbers then move back upslope into the shallower areas as the summer-fall thermocline disappears and the winter water mixing occurs.

The preferred habitats of adult and juvenile cucumbers are different. Juveniles are almost exclusively in kelp holdfasts and under rocks, while adults are found on more open sandy and rocky substrates. In addition, adult populations have size-specific distributions, with the largest individuals found on soft-bottoms and an intermediate size class on the surface of rocks. There is very little mixing between size classes.

We believe the difference in distribution patterns between adult and juvenile cucumbers is due to differen-

tial predation pressures, and we have actually demonstrated that fish will eat the smaller individuals but not adults. Experiments are continuing to examine more closely this relationship between size and escape from predation. The only other source of mortality we have observed in adult populations is the "echinoderm disease," a bacterial infection that affects cucumbers during the late summer and fall months.

There are different movement patterns on soft and hard substrates, with cucumbers on the sand moving significantly more than those on the rocks. The recapture rate is 100 times greater on the rocks than the sand, and "substrate preference" trials show a greater length of residence time on rock surfaces than sand bottoms. Individual cucumbers on the sand have been monitored during daylight hours and they have averaged 50 cm per hour of movement.

There is a definite reproductive cycle, with spawning occurring in May and June. There is complete loss of the gonadal structures from this time until December and January, when gonadal material begins to rebuild. There is also an annual pattern of intestinal growth and development, with loss of all internal viscera (disgestive tract and respiratory trees) during September and October. The cucumbers then regenerate these lost parts in the next one or two months, and attain a maximum overall body weight during the winter, presumably when they are again capable of feeding and are producing gonadal material. Comparative data have been collected to examine these phenomena in terms of depth (shallow and deep populations) and habitat (soft and hard bottoms).

It is difficult to measure growth in sea cucumbers because they are soft-bodied and can contract and expand at will. An experimental tagging method using tetracycline is being tried. Tetracycline is taken up as plate material is laid down in the calcareous ring. When the ring is examined under ultraviolet light, growth lines will flouresce yellow. If we can demonstrate uptake, we will begin a large scale tagging of cucumber populations, to determine growth rates and age structures. We have also been collecting length and weight frequency data, which we hope will give us information on growth rates and age structures.

Information on recruitment is being collected bimonthly by sampling juvenile habitats, both in kelp holdfasts and under rocks. Very small individuals (1-2 cm) are found only in kelp holdfasts, while those in the 5-8 cm range are found only under rocks.

Air-Sea Exchange Rates of Dissolved Gases in Coastal and Estuarine Waters (R/EQ-26)

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INTRODUCTION

There are a number of gases that are of critical importance to the biota of all ecosystems, including oxygen, nitrogen, nitrous oxide and carbon dioxide. Exchange of these gases across the air-sea interface is of fundamental importance in controlling their distribution. Presumably, gas exchange rates depend on the degree of turbulence in the upper portion of the water column. Several models have been developed to predict gas exchange rates, based on environmental variables which generate water column turbulence, such as wind speed and current shear. However, there is very little reliable field data that can be used to verify the accuracy of these models in coastal and estuarine systems, and thus there are no clear criteria for selecting what model is appropriate. In order to develop criteria for model selection, the relationship between the intensities and length scales of turbulence and the flux of dissolved gases across the air-sea interface must be examined.

Water quality management decisions related to biological oxygen demand (BOD) and nutrient loading must be based upon predictions of assimilation capacity. The prediction of assimilation capacity, in turn, depends critically upon accurate values of gas exchange rates. At present, these rates are known only within an order of magnitude. Results developed in this project will be of value to ongoing research programs funded by Sea Grant in Los Angeles Harbor and in San Francisco Bay. In addition, the relationship between gas exchange rate and turbulence is a fundamental problem in a variety of fields, including aquatic systems ecology, global geochemistry, atmospheric science and chemical engineering.

RESULTS

During the past two years we have studied gas exchange rates in the field to determine the response of an estuarine system to variations in wind speed and

current velocity. We have also constructed a state-of-the-art turbulence tank to study gas exchange rates under controlled conditions in the laboratory, where we hope be able to expand our understanding of the theoretical underpinnings of the gas exchange process.

Field Results. For field work in San Francisco Bay, we have used radon-222, a naturally occuring radioactive gas, as a tracer for gas exchange. The technique involves construction of a mass balance for radon in the system. We have determined the rate at which radon is added to the water column from the sediments, and we can measure the rate at which radon is lost from the system by radioactive decay in the water column. The remaining term required by the mass balance is the loss of radon to the atmosphere.

Radon mass balances have been constructed during periods of varying wind speeds and current speeds in order to explore the relationship between gas exchange and the environmental inputs of turbulence. Figure 1 illustrates the variability of the rate of gas exchange with current velocity. It can be seen from this figure that gas exchange has little or no relationship to current speed. On the other hand, Figure 1 illustrates clearly that the rate of gas exchange increases dramatically with increasing wind speed. These results correspond very nicely with the relationship between gas exchange rates and wind speed which were developed using rates of gas exchange determined for lakes and the ocean. It does not fit well at all with the various theoretical models (Figure 2), indicating that the level of theory at present is not satisfactory.

One implication of these results is that in coastal and estuarine systems, where current speeds are only 1-2 knots, wind speed may be of far more importance than current shear in generating the turbulence which is responsible for gas exchange at the air-sea interface. Most environmental engineering models utilized to date assume the contrary. Note that the relationship between the gas exchange and wind speed fits data points quite closely (Figure 2), and with this relationship we can predict the rate of gas exchange to within 20% in San Francisco Bay.

Laboratory Experiments. A technique has been developed to simultaneously measure fluid turbulence and the exchange rate of gases across the air-water interface of a tank under controlled laboratory conditions. Turbulence is generated with a vertically oscillating grid whose stroke length, frequency and distance from the interface may be varied. Instantaneous fluid velocity vectors are determined using a

streak photography method. Tracks of neutrally buoyant particles are recorded photographically, digitized, and the displacement is determined. Exposure times are controlled by a light chopping wheel and measured with a photo-diode and time system. Ensemble average turbulent velocities and turbulent integral length scales are then computed as functions of distance from the grid. The gas transfer rates of five gases (O_2, N_2, CH_4, CO_2, and Rn) are measured concurrently with these turbulence measurements.

Experiments have been conducted utilizing three different locations of the grid and two oscillation frequencies. The turbulent kinetic energy (proportional to the square of velocity) decreased nearly exponentially with distance from the grid (Figure 3) while the turbulent integral length scale increased linearly with distance from the grid (Figure 4). These relationships can be extrapolated to determine turbulent velocities and length scales at the air-sea interface.

Mass transfer coefficients determined simultaneously for various gases appear to be proportional to the square root of the molecular diffusivities and to the square root of the ratio of the turbulent velocity to the turbulent integral length scale. Results are plotted in Figure 5, and are in accordance with the surface renewal concept of gas exchange. They represent one of the first attempts to quantitatively define the turbulence field in relation to the gas exchange process and serve to constrain the physics described by theoretical models.

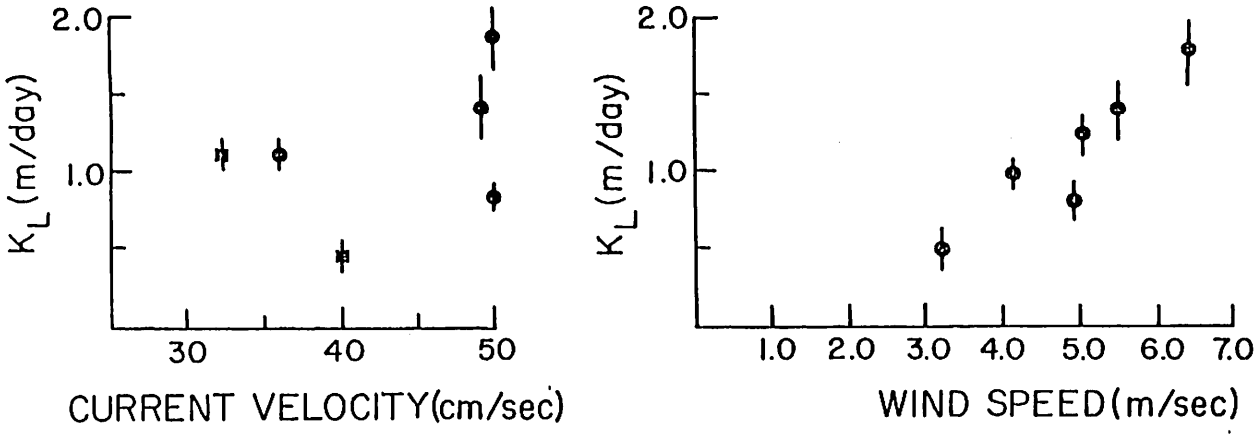


Figure 1: Gas Exchange Rates vs. Environmental Variables. K_L = mass transfer coefficient which characterizes gas exchange rate of radon.

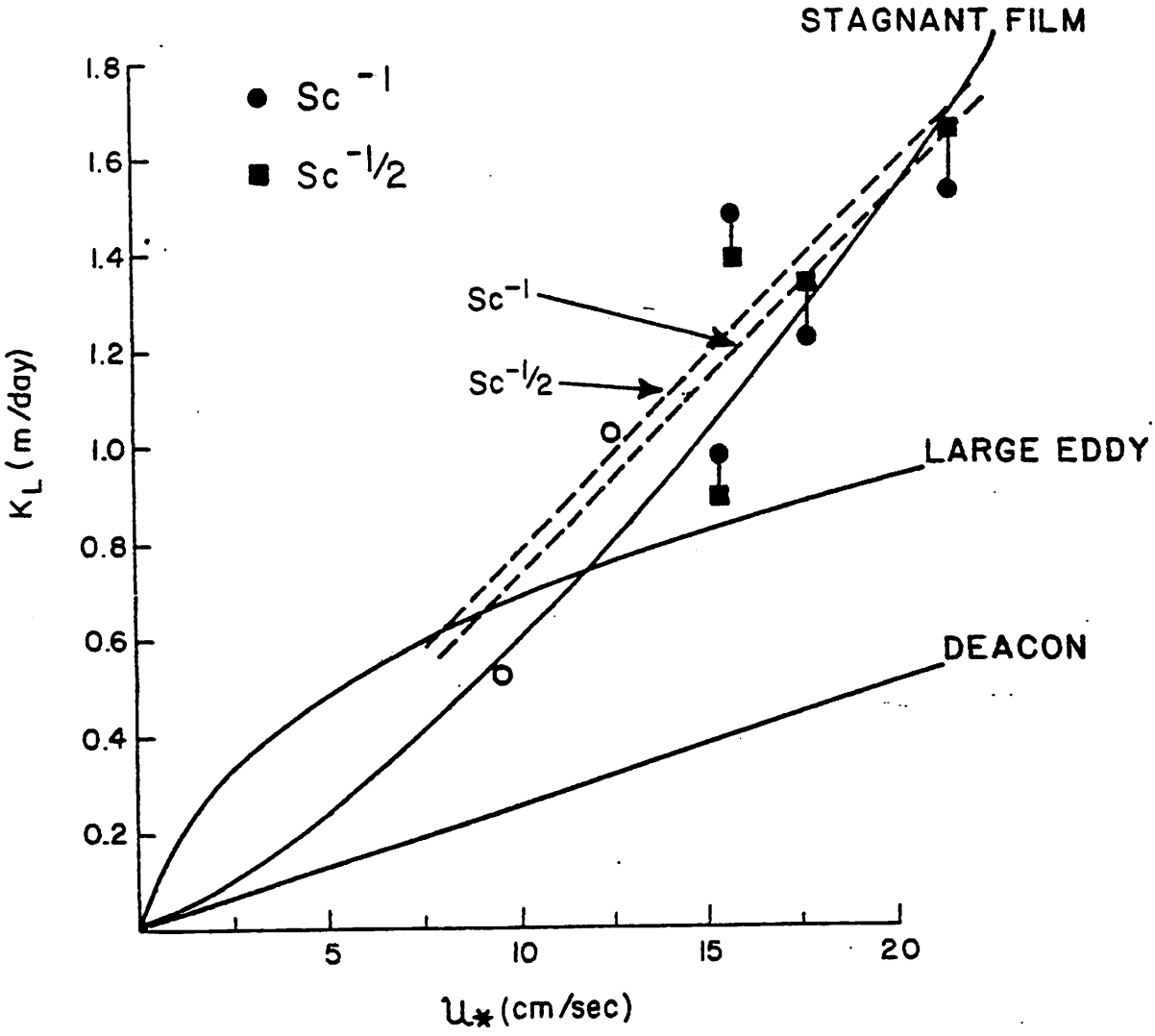


Figure 2: Gas Exchange Rates vs. Friction Velocity. U_* = wind friction velocity. Data points corrected to 15°C, assuming K_L depends on D^n (D = diffusivity; n = 1.0 or 0.5). Other theoretic models plotted: Deacon (1977); Large Eddy = Brtko and Kabel (1978); and Stagnant Film = Broecker, et al (1980). Dashed lines = linear regressions to the data points (Sc^n = Schmidt number, which is proportional to $1/D^n$).

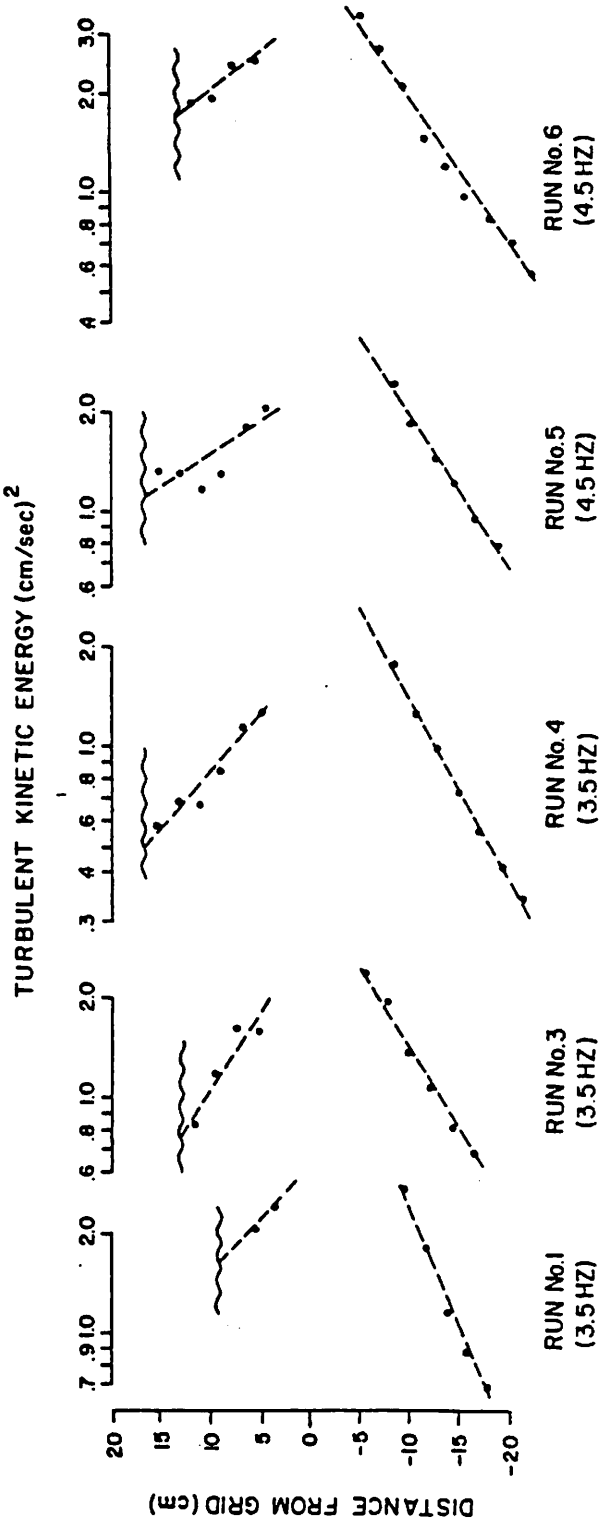
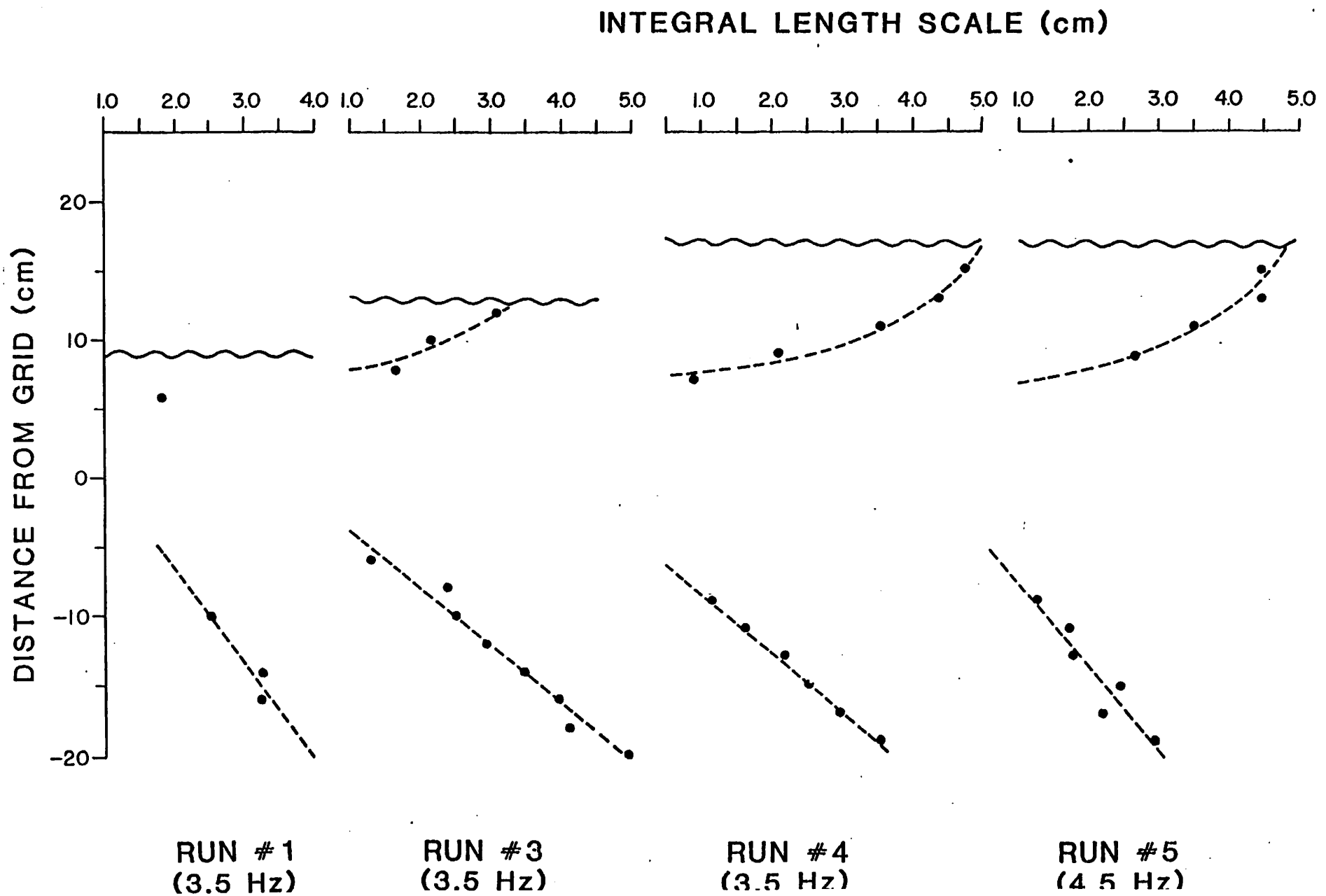


Figure 3: Turbulent Kinetic Energy vs. Distance from Mean Grid Position for Laboratory Experiments. Wavy lines = water surface.

Figure 4: Integral Length Scale of Turbulent Motions vs. Distance from Mean Grid Position for Laboratory Experiments



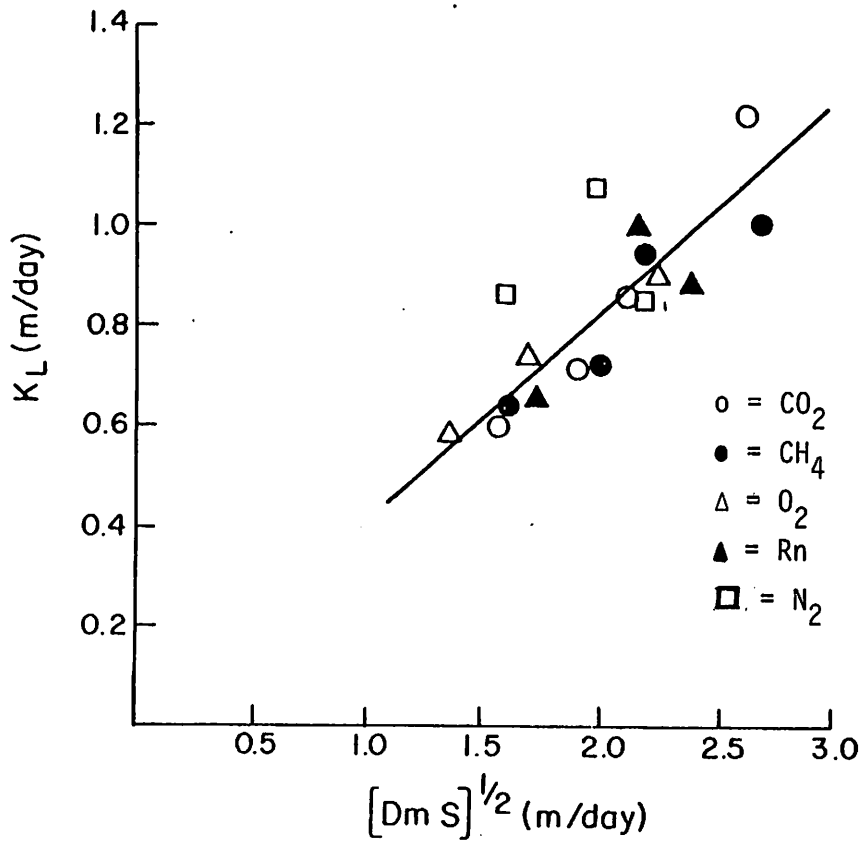


Figure 5: Measured Mass Transfer Coefficient for Various Gases vs. Predicted Coefficients. Surface renewal models for gas exchange predict that $K_L = (DmS)^{\frac{1}{2}}$ where Dm is molecular diffusivity and S is $q^{\frac{1}{2}}/L$ (q = turbulent energy; L = integral length scale).

Coastal Engineering

Waves and Currents in Coastal Regions of Sharply Changing Water Depth (R/CE-6)

Dr. J.J. Lee, Professor, Civil Engineering, University of Southern California.

Dr. L.C. Wellford Jr., Associate Professor, Civil Engineering, Unversity of Southern California.

INTRODUCTION

To design harbors and other coastal facilities, it is necessary to be able to predict the behavior of waves and currents propagating in the coastal region. Coastal wave and current propagation is the most complicated phase of the general propagation process because the irregular topography of the coastal region is further complicated by the construction of coastal structures in the nearshore region. When the water depth varies slowly, techniques exist for defining the wave propagation process. However, in many instances, the water depth varies rapidly and sometimes discontinuously. The problem of predicting the behavior of propagating waves and currents in regions with rapidly varying depths is difficult and is the subject of this research project.

During the last two years the overall goals set at the initiation of the project have largely been achieved. These are:

1) To study through analytical and numerical means the response of the harbor basins and coastal regions to incident waves and currents. The flow region considered would involve sharply discontinuous water depth. The direction of the propagation of waves and currents would not be restricted to one preferred direction. Both periodic and random waves will be considered.

2) To discover the mechanism of energy trapping associated with regions of rapidly varying depth and horizontal plane form.

3) To conduct experiments for verification and modification of the analytical and numerical techniques developed.

4) To explore the use of the developed techniques in application to problems of the design of harbor modifications. For example, to assess the impact of channel dredging, in a harbor region, on the wave and current environment in the harbor.

Major effort has been devoted to developing analytical and numerical techniques to allow matching the most efficient solution techniques in various subregions. Therefore, matching techniques at the sharp discontinuity in the water depth combine the eigen-function expansion, boundary integral equation method and finite elements technique, as well as various integral transform methods.

In this brief summary, some applications of the analytical and numerical methods developed through this research project will be illustrated.

RESULTS

In the first example, wave propagation across an arbitrarily shaped submarine channel was studied (Figure 1). As pictured in the insert of Figure 1, waves propagate from left to right across a trapezoidal shape submarine channel. (This is a common shape for dredged navigation channels.) In order to find a solution for this problem, an imaginary boundary between points A and B was constructed. Thus, an exact eigen-function expansion solution for the constant water depth region along AB is matched to the solution obtained by boundary integral equation method for the trapezoidal shaped channel region to find the unknown vertical velocity along the boundary AB. The results show that--from long wave limit to short wave limit--there are an infinite number of wave periods at which the wave will propagate without modification. However, at some wave periods, transmitted wave energy will be less than the incident wave energy. (In Figure 1, this is noticeable for $h/\lambda = 0.05$ and 0.13.) From this phenomenon it is quite possible that for an incident wave condition, a submarine channel shape can be designed to achieve a substantial reduction in wave energy for the shoreward region of the submarine channel.

The second example deals with the response to an incident wave in a harbor that contains a submarine island. This submarine island would produce a sharp discontinuity in water depth. (It should be noted that an island extending above the water surface would be a much simpler problem to solve because the water depth would be constant.) Results using the methods developed in this research project are shown in Figures 2 and 3.

Figure 2 shows the response curve at two locations within the harbor compared with the case of no island. The abscissa represents the dimensionless wave number kl (where k is the wave number defined as $2\pi / k$, and 1 is the harbor length); the ordinate represents the wave amplitude at location A or B divided by the

incident wave amplitude. It is seen from Figure 2 at kl = 1.2 that the effect of the island is to increase the wave amplitude inside the harbor region. However, for the mode of oscillation at kl = 4.0, the reverse is true for some locations. This clearly shows the need for an analytical method, such as the one developed here, to handle the engineering analysis if modification of a harbor is planned.

Figure 3 shows the results of the analytical model which incorporated dissipation mechanisms as compared with the case of an inviscid solution. The results show that the dissipation mechanism shifts the resonant frequencies to a moderate degree. At some resonant frequencies, the amplification factor actually increases (e.g., the mode at kl = 1.2). However, at some other frequencies, substantial reduction in wave amplitude can be found (e.g., the modes at kl = 3.2 and 4.8).

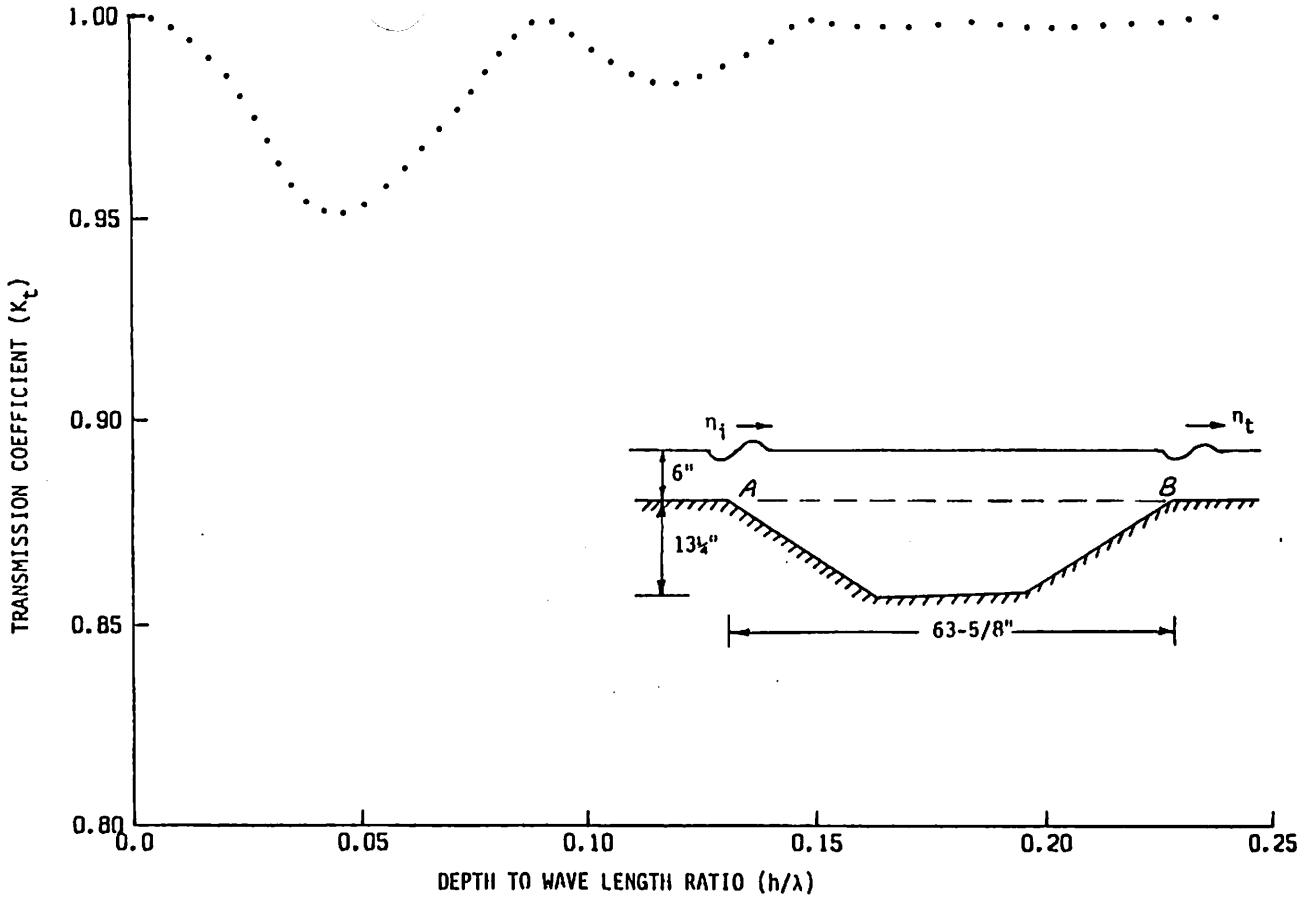


Figure 1: Transmission coefficient as a function of relative wave length.

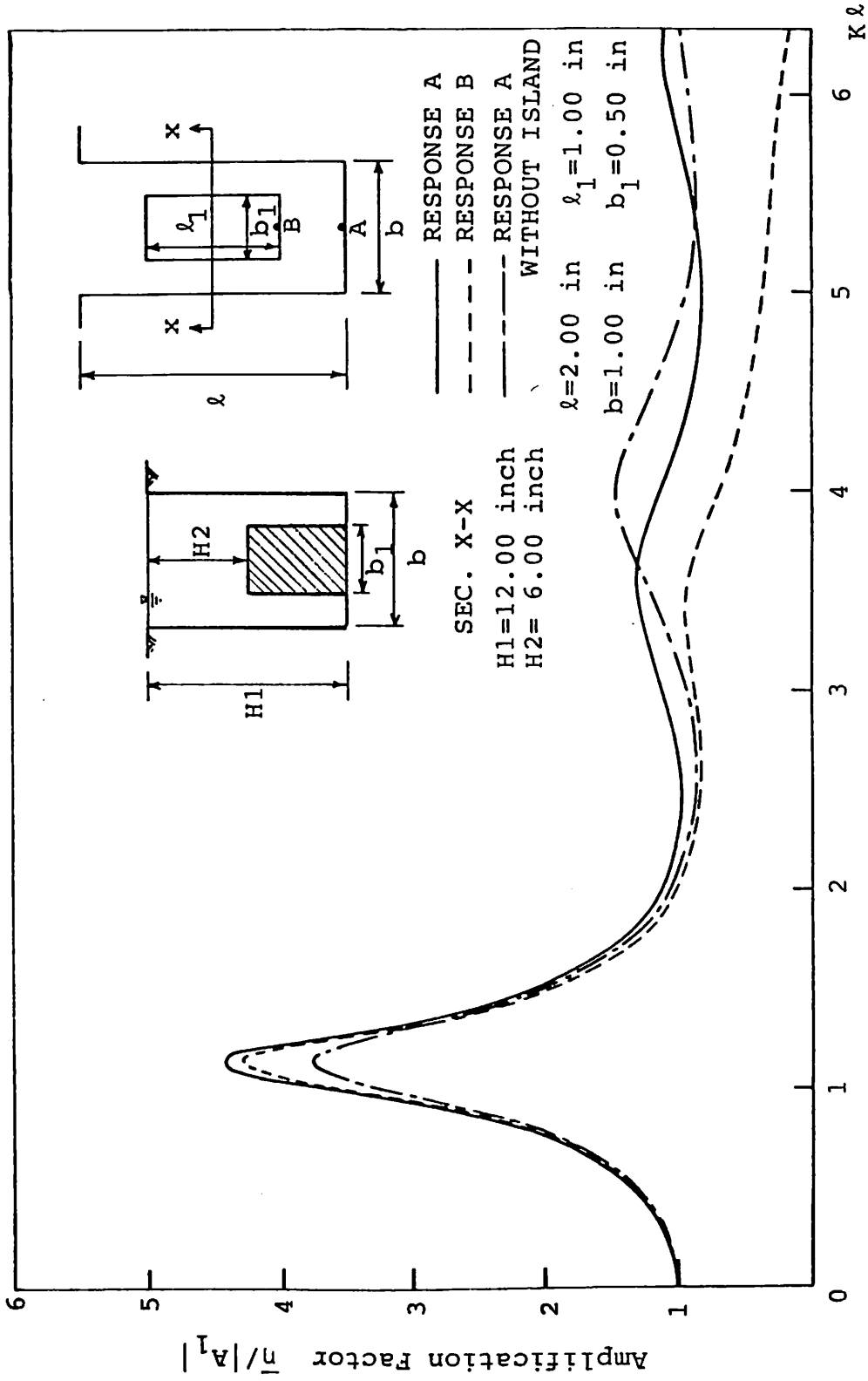


Figure 2: Response curves for the fully open rectangular harbor with a piecewise change in depth; with and without center island; and for a point at the island.

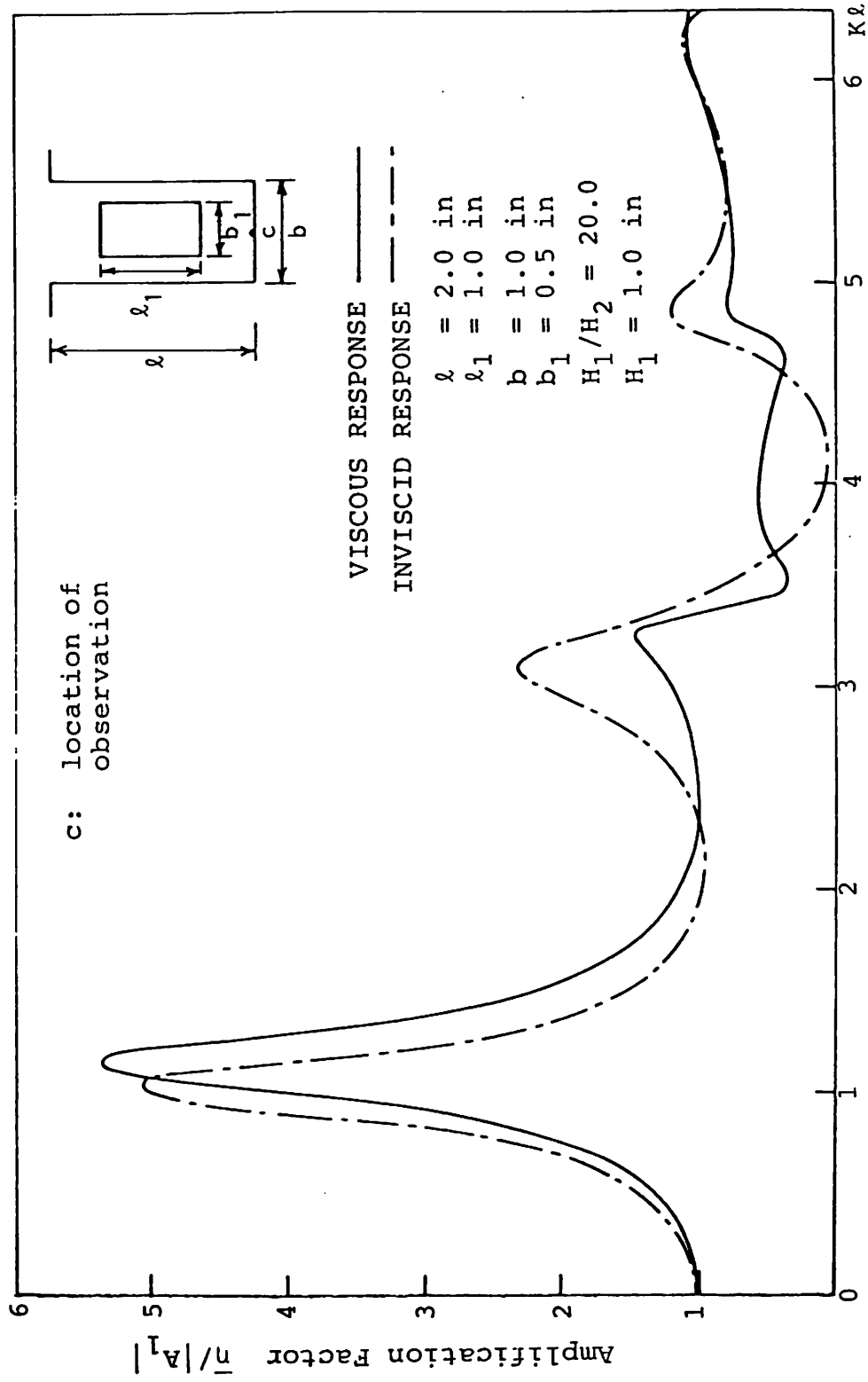


Figure 3: Response curves for the fully open rectangular harbor with a piecewise change in depth (inviscid and viscous effects).

Wave Uplift Pressure on Piers and Platforms (R/CE-7)

Dr. J.J. Lee, Professor, Civil Engineering, University of Southern California.

Dr. L.C. Wellford Jr., Associate Professor, Civil Engineering, University of Southern California.

INTRODUCTION

The problem of the interaction of waves and certain ocean structures is analyzed in this research project. The ocean structures considered are the nearshore pier and the offshore platform, constructed in such a way that they are reasonably close to the water surface. When waves impact these structures, they are greatly altered kinematically. Often the waves pass under the structures while remaining in contact with the structural underside. Large uplift pressures result on the structures. Currently there are no techniques available for determining the effects of these uplift pressures on ocean structures. Thus, it is very hard to design this type of structure for use in the ocean environment.

The objective of this work is to develop a reliable model to define the uplift pressure which occurs when large incident waves impact fixed and rigid ocean platforms. To define the uplift pressure as a function of time and location, the water particle velocities in the fluid domain near the platform must be computed. The accurate prediction of wave forces on a structure can be made only after the water particle velocities to which the structure may be exposed are estimated. The first step in this process is to adopt a wave theory that predicts an incident wave profile similar to that in the observed or assumed wave environment. The results of that wave theory are used to compute the kinematic properties of the incident design wave. A solitary type of wave is chosen as the incident wave for this analysis because it represents a finite-amplitude ocean wave propagating through shallow water. A solitary wave has a symmetric profile, and it propagates without change of form. There have been a large number of theoretical studies on the properties of solitary wave which provide a good comparative base. The profile, celerity and other characteristic of the solitary wave have been theoretically analyzed by Boussinesq.

RESULTS

It is assumed that the fluid is inviscid, incompressible and irrotational with a free surface. The fluid motion can be described by a boundary-value

problem composed of a laplace equation with a mixed boundary condition on the free surface. A homogeneous neuman condition holds at the bottom of the ocean. Isoparametric mappings and finite element techniques are used in appropriate numerical models. The continuum is divided into many small elements of convenient shape. Certain points within the elements are chosen as nodes. The variable in the differential equation is written as a combination of appropriately selected interpolation functions and the value of the variable or its derivatives as the nodes.

Using weighted residual methods (Galerkin Methods), the governing differential equations are transformed into finite element equations and then all elements are collected together to form a global system of algebraic equations. The equations are formulated accounting for the change in domain associated with large amplitude waves. The technique can be best described as a finite volumes procedure. An iterative method is used to obtain the solution to the system of non-linear equations resulting from the finite element discretization. A multi-grid iterative method is employed in this work. The physical problem, including the large amplitude solitary wave and the platform, is pictured in Figure 1.

Computer programs have been developed to implement the numerical algorithm needed to solve for the velocity potential function and the water particle velocities, as well as the pressure beneath the platform. The results obtained to date have been very encouraging as they compare very favorably with the experimental data.

Another aspect of the research effort concerns providing reliable experimental data. The experiments, completed at Caltech's Keck Laboratory facilities, utilize a wave tank with glass sidewalls and a stainless steel flat bottom. The wave tank can be tilted to a maximum slope of one vertical to fifty horizontal. A wave machine, which is connected to and tilts with the

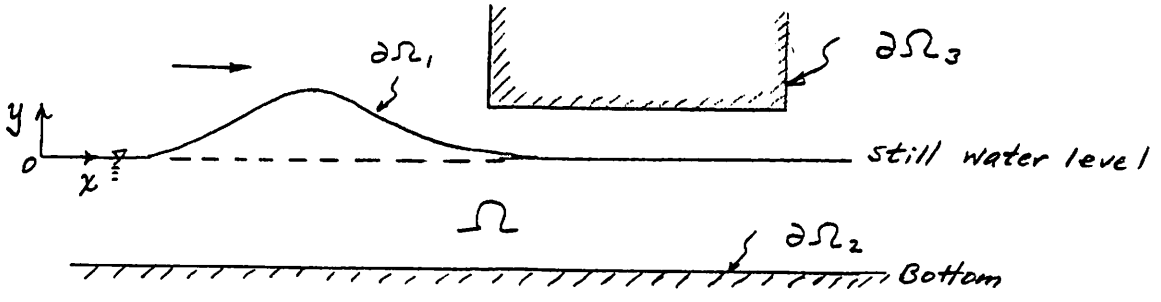


Figure 1: Sketch showing incident wave approaching a platform.

tank, is a piston-type generator driven by an electro-hydraulic system, which consists of a hydraulic power supply accumulators, servo-valves and an electro-servo system. The ability to generate a repeatable incident wave profile is essential for the present study, and this has been successfully achieved.

Water particle velocities of the flow field beneath the platform are measured using a three beam, two dimensional laser-doppler velocimeter (LDV) employing the reference beam technique. A laser beam from a 5 mw helium-neon laser was divided into two reference beams and a scattering beam. The two reference beams (each very much dimmer than the scattering beam) and the scattering beam were focused by an optical system to a location near the center of the wave tank and each reference beam was directed into a photo-detector. A carriage supporting the laser optics permits moving the LDV vertically and easily positioning the unit along the wave tank. All experimental data are recorded in a self-contained, micro-computer system.

Figure 2 shows the theoretical results of the wave profiles before and after the wave strikes the platform. The initial wave profile is a solitary wave with a maximum wave amplitude ratio of 0.15 (wave amplitude/water depth). The platform clearance divided by the water depth is set at .10. When the incident wave strikes the platform, a portion of the wave is reflected while the other portion is propagating through the opening between the platform and the still water level. This will produce a complicated wave profile, as shown in Figure 2.

Figure 3 shows a comparison of the experimentally measured pressure beneath the platform and the theoretical value computed by the theory developed in this project. It was found that the agreement is surprisingly good considering the complex nature of the problem and the theoretical modeling technique. There appears to be some phase shift between the theoretical curve and the experimental data. We are continuing to investigate the reason for such a divergence. As the reason is ascertained, improvement on the theoretical model will be implemented. Comparisons of the data on the water particle velocities with the theoretical results are also being made.

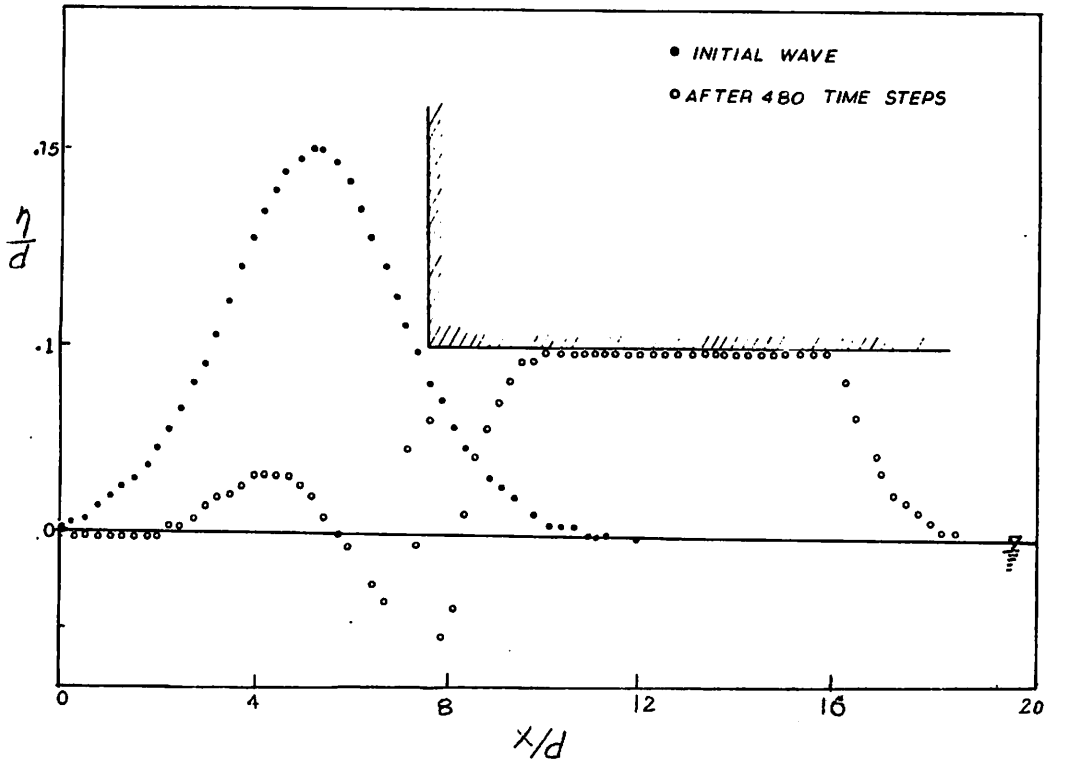


Figure 2: Theoretically computed wave profiles before and after the wave strikes the platform, which is located above the still-water level.

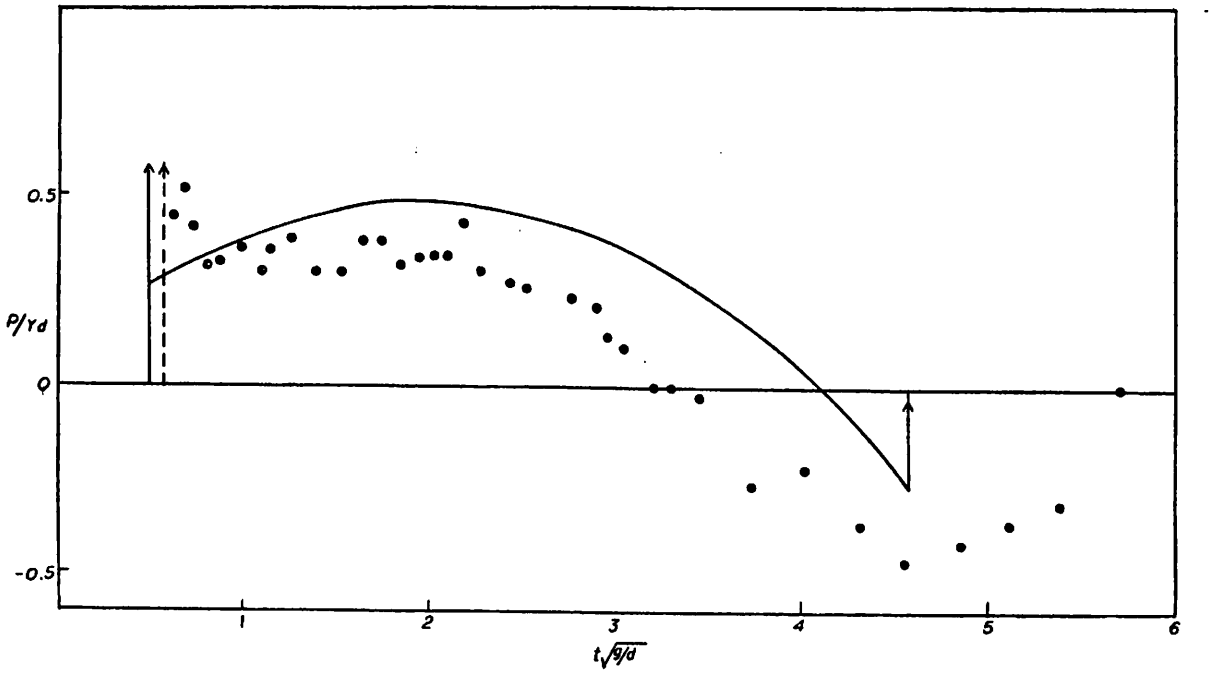


Figure 3: Comparison of the theoretically computed pressure (solid line) and the experimental data (circles).

Appendixes

UNIVERSITY OF SOUTHERN CALIFORNIA'S
INSTITUTE FOR MARINE AND COASTAL STUDIES
TECHNICAL ADVISORY PANEL

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Colonel Ted Gillenwaters (USAF Ret.)
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Michael Glazer (Esq.)
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Robert Hittleman, President
Hydro Products

Robert Kleist
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Port of Los Angeles

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RESEARCH-RELATED PUBLICATIONS
1981-82

Marine Advisory Services

The California State Coastal Conservancy: A Guide for Planners.

Muretta, Peri A. A booklet summarizing the activities of the California State Coastal Conservancy, an agency which strives to restore and enhance the coastline through planning and acquisition of important sites. 30 pp. 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. Evaluations are given on five marine awareness programs, including information on development, organization and implementation. Also indicated are the degree of acceptance and success each program experienced. 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). Serves as an inspiration for other groups to conduct similar programs. 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, accompanied by a written narrative which can be adapted by teachers to the appropriate grade level. USCSG-ME-04-82.

Mini-Information Booklets (Bilingual).

a. Tidepool Animals/Los animals 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, in both English and Spanish, about marine animals, their characteristics and behavior. 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.

Port Planning and Risk Management.
USCSG-ME-03-81. SPM-PL-5.

Service Delivery at the Port of Seattle.
USGSG-ME-02-81. SPM-MG-1.

Intermodel Transportation and Seaports.
USCSG-ME-01-81. SPM-PL-4.

Environmental Mediation: An Alternative to Litigation.
USCSG-ME-08-80. SPM-PL-3.

Is There a Federal Port Policy?
USCSG-ME-07-80. SPM-GV-3.

Port Hueneme: A Small California Port Grapple With Its Future.
USCSG-ME-06-80. SPM-GV-2.

Public Access: An Issue for Seaport Planning: An Introduction with Selected Readings.
USCSG-ME-05-80. SPM-PA-3.

Seaport Dredging and Environmental Mitigation: The Case of Coos Bay/North Bend, Oregon.
USCSG-ME-04-80.

Marina Management: A Research Study on the Development and Management of Marinas in California.
USCSG-ME-03-80. SPM-PA-2.

The Cabrillo Project: A Case of Seaport Planning for Public Access.
USCSG-ME-02-80. SPM-PA-1.

The Influence of Coastal Legislation on Port Development with Application to the State of California.
USCSG-ME-01-80. SPM-PL-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.

Lee, Jiin-Jen, 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.

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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.

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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.

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Hudgins, Shirley J. Reprinted from Sea Grant Today 11(3):114-16, 1981. USCSG-R-11-81.

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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 fo Petro-Graphic Model Analysis. pp. 1-48.

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Socio-Economic Systems

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