1983-84 ANNUAL REPORT

USC SEA GRANT

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

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ANNUAL REPORT

UNIVERSITY OF SOUTHERN CALIFORNIA
SEA GRANT INSTITUTIONAL PROGRAM

Research, Advisory Services & Education
for
"THE URBAN OCEAN"

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

USCSG-SR-01-85

USC Sea Grant Program Management

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INTRODUCTION

Introduction

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

FY 83-84 was the 14th year of the University of Southern California's participation in the National Sea Grant College Program. At USC, Sea Grant researchers can draw on substantial facilities and a long tradition of excellence in marine research. The Sea Grant program is one of several programs within the university's Institute for Marine and Coastal Studies, founded in 1975.

Like other Sea Grant programs, USC is required by Congress to match federal funding with half again as much from non-federal sources. We are happy to acknowledge the receipt of $75,250 from the State of California's Resources Agency, more than $190,000 from other USC departments and more than $70,000 in services-in-kind from other sources. The support expressed by these institutions and companies makes our work possible and keeps it relevant.

Sea Grant projects run an extensive course of review before funding is awarded. A technical advisory panel makes recommendations to the program's management; academic peer reviewers from around the country comment on the professional quality of the work; a panel of state agency representatives comments on the worth of the projects to the state; and a team of scholars and administrators appointed by the federal government reviews the entire program. The members of the IMCS Technical Advisory Panel and the Resources Agency Sea Grant Advisory Panel are listed elsewhere in this report.

During 1983-84, the first USC student was awarded a Sea Grant Congressional Fellowship. Patience K. Whitten, a graduate student in the Master of Marine Affairs Program at USC, worked with the Merchant Marine and Fisheries Committee in the U.S. House of Representatives in Washington, D.C.

USC's Sea Grant Program during the year supported the following research projects, which are discussed in detail on subsequent pages:

<u>Living Marine Resources</u>

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

A Time Series of Satellite Thermal Imagery and Its Use in Evaluating Ocean Features and Variability on Small Spatial Scales (R/RD-19)

Economic Analysis for Management of the California Northern Anchovy Fishery: Multipurpose Fleets and Biological and Market Uncertainty (R/RD-20)

Environmental Quality

Problems of Paralytic Shellfish Poisoning (R/EQ-31)

Seaports and Marine Transportation

Fees for Services at Seaports: Approaches, Federal User Fees and Public Policy Issues (R/CM-26)

Coastal Planning

California Coastal Population: Transition and Development (R/CM-27)

Coastal Engineering

Corrosion Fatigue of Weldments in Offshore Structures (R/CE-8)

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

Projects that meet emergencies, ideas that are interesting but not yet fully developed, projects that must begin early or end late, and other discretionary situations can be covered by program development funds if they promise sufficient contribution to the Sea Grant Program. In 1983-84, program development funds went primarily to:

* Our second national workshop on seaport management, "Smaller Maritime Ports," cosponsored with the Port of Sacramento. Discussion topics were: changes in demand for smaller ports; strategic management; non-maritime options; financing; the relations between port managers and port commissioners; and the application of federal user fees. The summary of the workshop, including a research agenda, has been published.

* A contribution to The Third International Reef Conference sponsored by Occidental College and cosponsored with other Pacific Area Sea Grant Programs.

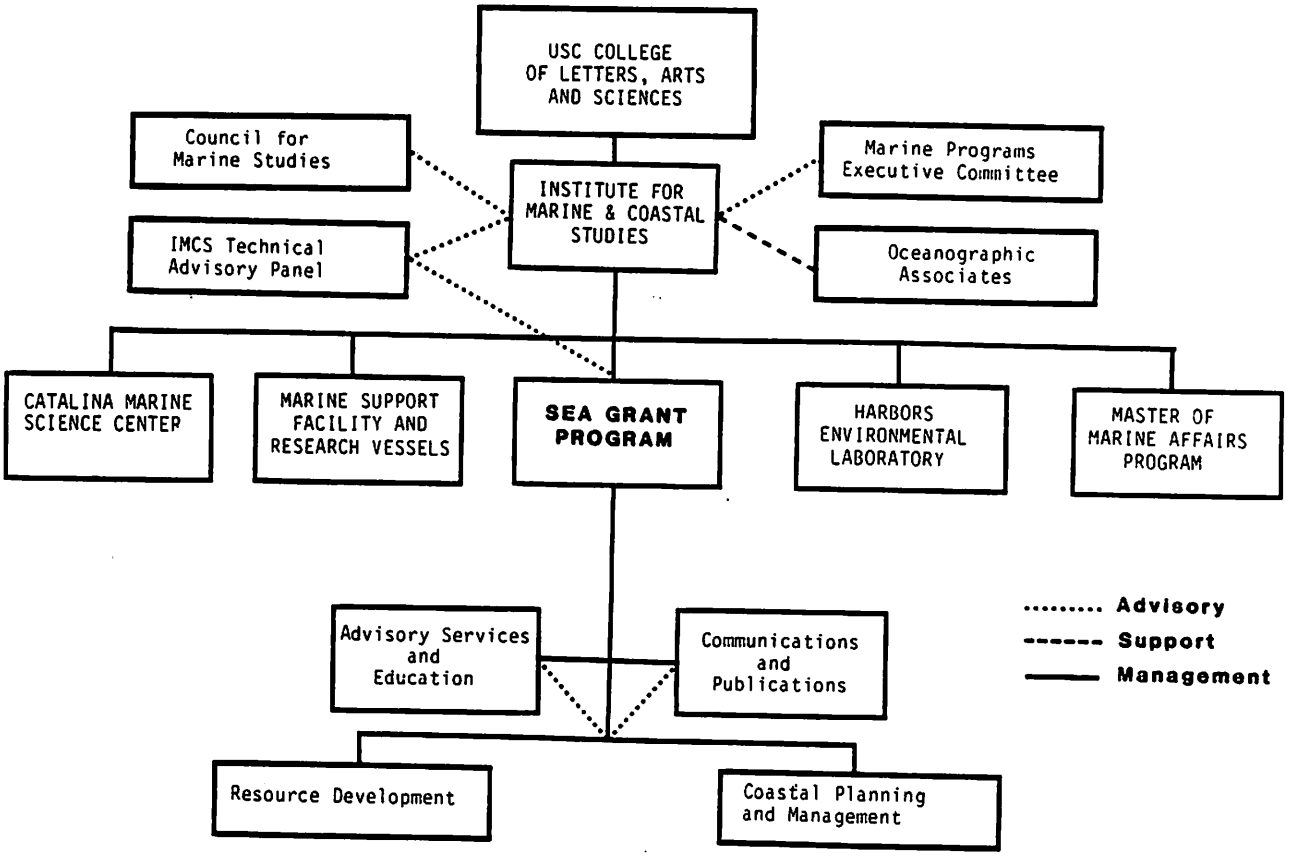
* Travel expenses for our first Sea Grant Congressional Fellow in Washington; and for a USC professor to meet with University of California researchers to plan work on the anti-cancer properties of marine natural products.

* Extra research expenses were awarded a Sea Grant graduate trainee who won a Sea Grant Association award, in lieu of the trip to accept the award, and for an extension of an 1982-83 project, R/CM-22, on the use of scientific information in making decisions about wetlands.

* A project on the distribution and cycling of free amino acids in the Los Angeles Harbor/Terminal Island Treatment Plant Outfall.

Robert L. Friedheim
Director
USC Sea Grant Program

ORGANIZATION OF USC SEA GRANT INSTITUTIONAL PROGRAM



BUDGET SUMMARY

1983-84 Budget Summary

		Sea Grant Funds	Grantee Share	State Share
MANAGEMENT, PROGRAM DEVELOPMENT, PUBLICATIONS				
M-1	Administration and Management	115,244	40,029	-0-
M-2	Program Development	38,371	11,475	5,116
M-3	Communications and Publications	56,104	3,060	8,204
	Subtotal	209,719	54,564	13,320
ADVISORY SERVICES AND EDUCATION				
AE-1	Advisory Services and Education	172,590	96,642	26,273
AE-2	Sea Grant Congressional Fellowship	28,000	-0-	-0-
E/M-1	Graduate Student Trainee Program	37,500	-0-	7,500
	Subtotal	238,090	96,642	33,773
LIVING MARINE RESOURCES				
R/RD-13	Factors Affecting the Survival of Nearshore Larval Fishes	66,699	32,085	9,342
R/RD-19	A Time Series of Satellite Thermal Imagery and Its Use in Evaluating Ocean Features and Variability on Small Spatial Scales	28,364	13,878	4,406
R/RD-20	Economic Analysis for Management of the California Northern Anchovy Fishery: Multipurpose Fleets and Biological Uncertainty	17,551	-0-	1,071
	Subtotal	112,614	45,963	14,819

Budget Summary, cont.

		Sea Grant Funds	Grantee Share	State Share
ENVIRONMENTAL QUALITY				
R/EQ-31	Problems of Paralytic Shellfish Poisoning	29,451	28,028	5,800
	Subtotal	29,451	28,028	5,800
SEAPORTS AND MARINE TRANSPORTATION				
R/CM-26	Fees for Services at Seaports: Pricing Approaches, Federal User Fees, and Public Policy Issues	27,560	15,784	2,096
	Subtotal	27,560	15,784	2,096
COASTAL PLANNING				
R/CM-27	California's Coastal Population: Transition and Development	12,664	10,369	2,382
	Subtotal	12,664	10,369	2,382
COASTAL ENGINEERING				
R/CE-8	Corrosion Fatigue of Weldments in Offshore Structures	15,902	12,893	3,060
	Subtotal	15,902	12,893	3,060
	TOTAL	646,000	264,243	75,250

ADVISORY SERVICES AND EDUCATION

Marine Advisory Services and Education (AE-1)

Stuart A. Ross, Ph.D., Director, Marine Advisory Services and Education, USC Sea Grant

Dorothy M. Bjur, Director, Marine Education, USC Sea Grant

James A. Fawcett, Ph.D., Coastal Resources Specialist, USC Sea Grant

Jacqueline B. Rojas, Assistant Director, Marine Education, USC Sea Grant

INTRODUCTION

An essential part of every Sea Grant program is to make information about the oceans, including recent research and policy developments, more readily available to the public and to specific groups that use or rely on the ocean. As Sea Grant is modelled after Land Grant, so advisory services in Sea Grant parallels the extension efforts in Land Grant.

Such advisory activities at USC were carried out by a staff of four professionals, located both on campus and at the USC Fish Harbor Laboratory in Los Angeles Harbor.

As in previous years, we carried out planning and programming in four areas of emphasis: coastal planning, marine transportation and seaport management, marine recreation, and marine education. Additionally, the staff gave presentations to civic groups and school classes, attended staff meetings of other marine groups, maintained two on-campus libraries, participated in regional Sea Grant activities with other Pacific area institutions, and answered individual requests for assistance from the general public.

RESULTS

Coastal Planning

In California, as in other states, coastal planning is a complex matter: state and local governments interact in regulating citizens according to guidelines provided by the federal government. Over the last several years, USC Sea Grant has served those who need more information about this process: first, by explaining the regulations to the average citizen, and more recently, by analyzing the political process itself primarily for the benefit of government officials, developers and environmentalists who are active in coastal zone management.

For the Marine Technology Society Conference, "Oceans '84," James Fawcett prepared an analysis of the budgets and priorities that have characterized the federal coastal zone management program. The paper is entitled "But a Faded Dream: Federal Coastal Zone Policy in the '80s." For the Real Estate Research Council, he wrote an article entitled "Planning the California Coast: Progress and Prospects." In addition, he assisted the director of the California Coastal Commission in briefing visiting Brazilian officials and in preparing a proposal for research on coastal management in three lesser-developed countries.

In addition, effort has gone into individual contacts with people confronted with specific problems. For example, James Fawcett assisted a real estate broker by determining whether a client's property was inside the coastal zone (it was) and, hence, subject to coastal regulations. By advising the broker on the specific administrative hurdles the client would face in converting the land from one use to another, we helped the client avoid several possible missteps, and the client saved an estimated $10,000 in contruction-loan carrying costs. In another instance, James Fawcett briefed a USC law professor on the progress and prospects of Outer Continental Shelf revenue sharing legislation after conversations with the congressman who sponsored the legislation. Approximately one-fourth of the coastal resources specialist's time has been spent on such individual contacts.

Marine Transportation and Seaport Management

Following the success of our first workshop on seaport management in 1983, we held a second workshop in April 1984, and we have a third planned for May 1985. The 1984 conference was held in Sacramento, in cosponsorship with the Port of Sacramento, and it focused on the special problems of smaller maritime ports. Approximately 50 specially invited academics and seaport managers attended, participating in six intensive sessions. The sessions covered the topics of manager-commissioner relations in smaller ports, changes in demand for port traffic, financing, nonmaritime uses of waterfront space, strategic management, and dredging and federal user fees. The proceedings of the conference has been published in the form of a research agenda for those who perform or fund research on seaport management. The document was jointly edited by Willard Price, Stuart Ross and Robert Friedheim. As noted in the introduction to the annual report, funds for this effort came primarily from the director's program development account.

The 1985 conference will be directed at the problems and opportunities associated with nonmaritime activites in ports and harbors. The conference will be in Baton Rouge, and will be cosponsored by the Louisiana Sea Grant College Program.

Stuart Ross also prepared an extensive set of slides of the Ports of Los Angeles and Long Beach and advised faculty and graduate students on possible research proposals.

Marine Recreation

Sea Grant continued its widely recognized efforts to convey accurate information to boaters and fishermen about marine weather. We continued to distribute thousands of copies of the popular booklet, "Weather To Go Boating," which describes common weather conditions in Southern California, how to cope with them and where to obtain accurate weather forecasts. We also continued the weekend marine weather broadcasts on KNX-AM radio that we have sponsored for more than 12 years. KNX provides the air time to Sea Grant at no charge; James Fawcett coordinates a team of student reporters who gather the weather information and read the reports for broadcast. Finally, we also have continued our cooperation with the National Weather Service (NWS) by providing a telephone answering machine to be used to supply callers with detailed marine weather information. In early 1984, we replaced the machines with more modern equipment, which now handles more than 50,000 calls per year. A survey of callers was conducted in late 1983 by asking the callers to write and send their comments and suggestions on the service. The results showed strong approval of the program, among both recreational and commercial boaters, and they also included suggestions on further improvements. Most of these changes have since been implemented by the NWS in its preparation of the taped message.

Beach-going is another popular recreational activity in Southern California; yet most persons have only a limited knowledge of what beaches and facilities are available to them. Although directories and guides have been produced in the past, they have proven to be too large, too expensive and/or too outdated to be of real use to many beachgoers. We have, therefore, designed a pocket guide to the beaches of Los Angeles County, one that will be quite portable and will display the needed information in easily recognizable symbols with a minimum of text. In 1983-84, we gathered the information on the beaches and their facilities, designed a mock-up of the brochure and initiated efforts to raise funds necessary for printing.

Marine Education

Through a combination of curriculum materials and special programs, the marine education effort conveys the importance of the oceans and knowledge about them to thousands of school children and adults, primarily — but not exclusively — in Southern California.

Six units of a curriculum guide for grades K-12 have been written, edited and distributed through teacher workshops, under the leadership of Dorothy Bjur. Two of the six were formally published during 1983-84 and have since also been indexed to the state's Science Framework Addendum, the formal promulgation of the topics that need to be covered in science education. In 1983-84, 10 workshops were held, reaching more than 200 teachers in Southern California. In an additional effort, two public school students were selected and sponsored for travel to Washington, D.C., to participate in the National Youth World of Water Conference held by the National Marine Education Association. Financial support for the students was provided by the Marina Foundation.

Adult education programs were also successful. Two courses were taught in USC's Master of Marine Affairs program by James Fawcett and Stuart Ross. Five workshops on Catalina Island were sponsored under the aegis of the Elderhostel program, a national program of activities and education for seniors. A newsletter on marine education was distributed to hundreds of teachers and other interested persons throughout the state; the newsletter was published jointly with the University of California Sea Grant College Program.

By virtue of being available to the public for help with marine problems, and by virtue of being in a national Sea Grant network, advisory services in not entirely able to limit itself to preplanned activities. For example, Stuart Ross helped an aquaculture entrepreneur rent lab space in the USC harbor lab building; James Fawcett distributed notices of geophysical exploration throughout the year to fishermen so their gear would not be fouled by oil company equipment; Dorothy Bjur served as a discussion section leader for Town Hall of Los Angeles. Such activities prove to be productive and needed to keep us in touch with the community and provide a useful service as well.

LIVING MARINE RESOURCES

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

Gary D. Brewer, Ph.D., Research Scientist, Institute for Marine and Coastal Studies, USC

Gary S. Kleppel, Ph.D., Adjunct Research Scientist, Institute for Marine and Coastal Studies, and Allan Hancock Fellow, USC

INTRODUCTION

A large number of fishes with recreational and commercial fishery importance occur and reproduce over shallow isobaths off Southern California. Basic information on distribution, abundance and the extent and nature of recruitment variability are prerequisites for effective management of these stocks. Yet, despite the widely held premise that recruitment success or failure is determined during the fishes' early stages of development, life history traits of most Southern California coastal fish stocks are poorly understood.

Our studies of the ecology of young fishes during the past three years have concerned the interaction of the small scale biological and physical environments on the survival of young fishes. Because it is generally believed that starvation or predation (or their combination) are the overwhelming factors that cause mortality in fishes, our research has emphasized: 1) the evaluation of the foods available to, and actually eaten by, larval fishes in nearshore waters; and 2) the identification of predators on the eggs and larval stages of fishes. To these ends, we adopted a sampling strategy to measure diel, vertical and horizontal variability of ichthyoplankton, their predators and their prey.

We were also interested in reproductive and behavioral strategies that might help insure the retention of the planktonic stages of coastal species over shallow isobaths. Many of the fishes, as adults, have a nearshore dependency (for example, shallow water, demersal-feeding species and those that spawn demersal eggs or larvae over shallow bottom depths). We believed that mechanisms must be present that help minimize transport of planktonic stages to less productive, offshore waters.

RESULTS

Highlights of our results and their implication include:

<u>Diel and vertical distribution of ichthyoplankton and their prey</u>

Plankton samples collected by bongo nets towed at discrete depths in Santa Monica Bay during different seasons showed that fish eggs and fish larvae were highly stratified during day and night sampling periods. Representative data show that fish eggs were abundant in near-surface waters (Figure 1) but after hatching, larvae became concentrated in near-bottom depths (Figure 2). Larger, older larvae were most numerous in near-bottom samples (Figure 3). These results are provocative because they suggest that conditions for survival and growth of fish larvae are best in a near-bottom, boundary layer over shallow isobaths.

Abundance and distribution of ichthyoplankton prey

Bivalve larvae and the larval stages of copepods were the most important food types in the digestive tracts of northern anchovy (Engraulis mordax) and white croaker (Genyonemus lineatus) larvae (Figure 4). The vertical distribution of potential microzooplankton prey for fish larvae (from plankton-pump samples) showed that microzooplankton abundance generally increased with depth (Figure 5). Hence, the preponderance of fish larvae near the bottom may be explained, in part, by the distribution of their foods.

However, there is an intriguing disparity between the large number of bivalves found in the stomachs of white croaker larvae and the abundance of bivalves in samples collected by plankton pump. Our current understanding of the ecology of larval fish feeding suggests that the bivalves occurred too infrequently in the water column to be a significant component in the diets of the fish. Overall, we found little or no evidence of starving, emaciated fish larvae in our nearshore samples. There are several possible explanations for this phenomenon, too detailed to be related here; important questions have been raised and further work needs to be undertaken.

Predators on fish eggs and larvae

We have identified a number of specific predators on fish eggs and larvae, including copepods, euphausiids, amphipods, decapod larvae and many species of fish. The incidence of attacks upon fish larvae by these predacious animals was sometimes as high as 23 percent of all fish larvae which occurred in some samples, suggesting that predation was, at times, a major factor in ichthyoplankton mortality. However, our data indicate that predation on ichthyoplankton was highly variable by season, site, time and depth. There was little or no correlation between the number of potential ichthyoplankton prey, the number of potential predators, and the incidence of predation. These data may indicate that predation of fish eggs and larvae is largely opportunistic; fish eggs and larvae are attacked if available, but other prey species may at times be more abundant, more easily captured, provide more food value and therefore preferred.

Our interpretation of the data leads us to conclude that attempts to quantify ichthyoplankton mortality from predation will require a very great effort with multi-gear sampling techniques, extensive field and laboratory work and multi-variable data analysis. The abundance,

distribution and feeding rates of all ichthyoplankton predators will require quantification, as well as all of the foods that are consumed in addition to the fish eggs and larvae. Such tasks are probably not economically feasible.

Future research needs

We believe that future research on factors affecting the survival of nearshore fishes should focus on effectively sampling the distribution and abundance of late larval and juvenile stages in addition to the eggs and young larvae.

A juvenile fish represents the product of successful feeding and predator avoidance of the larval stages, and it also represents a rare individual that has somehow survived while thousands of other eggs and larvae have died. We need to evaluate environmental factors that relate to surviving juvenile fishes instead of assessing how environmental factors relate to the distribution of the ephemeral spawning products of adults. If understanding recruitment variability is one's goal, there may be little justification for continuing, intensive and extensive study of embryo and young larval stages (sampled with standard plankton nets) exclusive of studying late larval and juvenile stages (which are not sampled with standard plankton nets). It may not be reasonable to expect insights into recruitment success by studying young fishes captured by plankton nets, when nearly all of those individuals would normally succumb to starvation or predation.

We might gain a better perspective of recruitment variability by assuming that nearshore spawning habitats and nearshore nursery habitats (i.e., where significant survival of spawning products occurs) do not necessarily co-occur. This past summer, we sampled fish eggs, larvae and juvenile distribution using a variety of sampling techniques. We found a significant offshore gradient of eggs and young larvae and a significant onshore gradient of (surviving) late larvae and juvenile stages. We hope to learn more about the causes and consequences of such trends in future Sea Grant years.

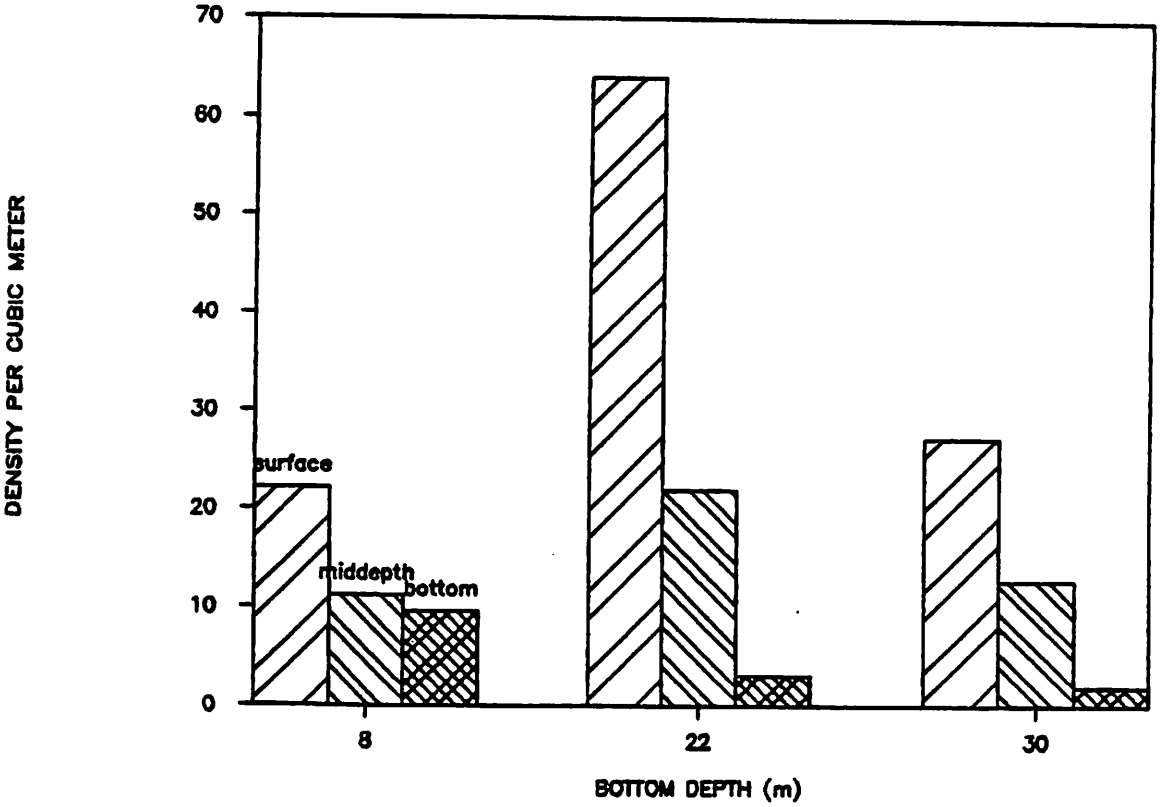


Figure 1. Average density of fish eggs in surface, middepth and bottom strata over bottom depths of 8, 22 and 30 meters. Representative data from a winter curise in Santa Monica Bay.

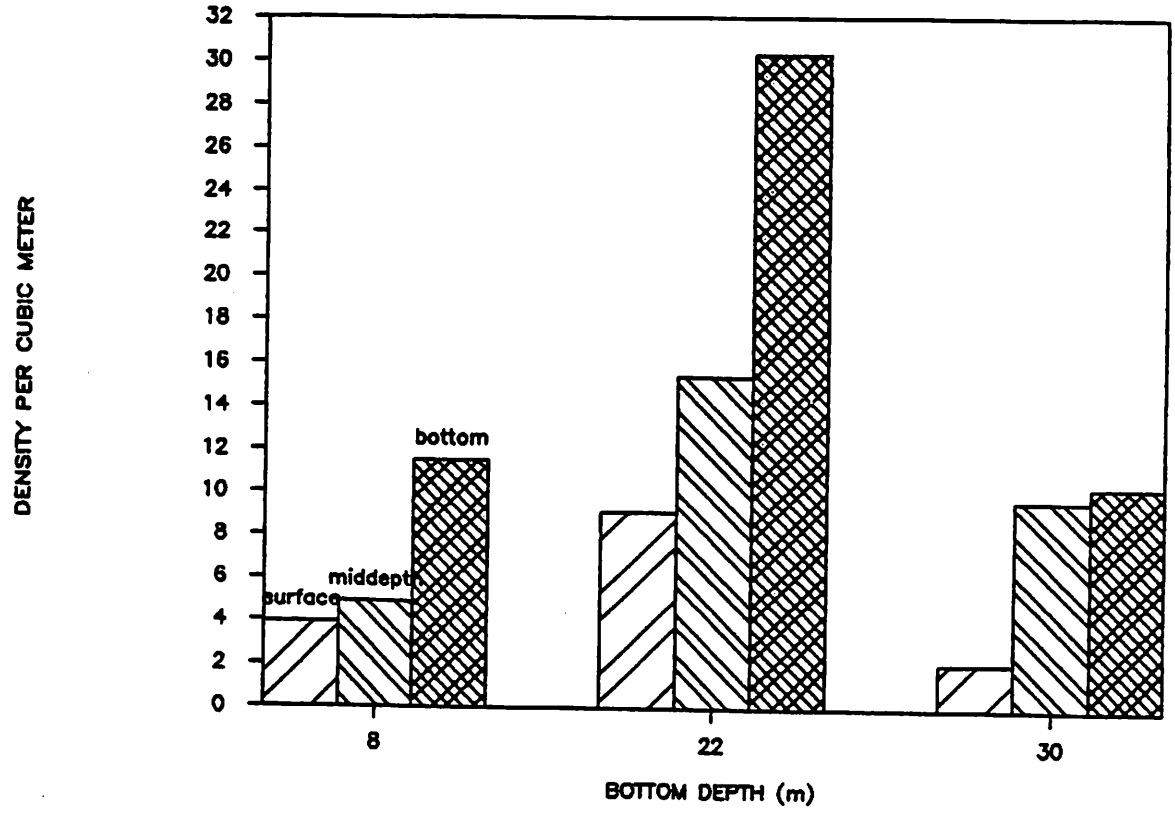


Figure 2. Average density of fish larvae in surface, middepth and bottom strata over bottom depths of 8, 22 and 30 meters. Representative data from a winter curise in Santa Monica Bay.

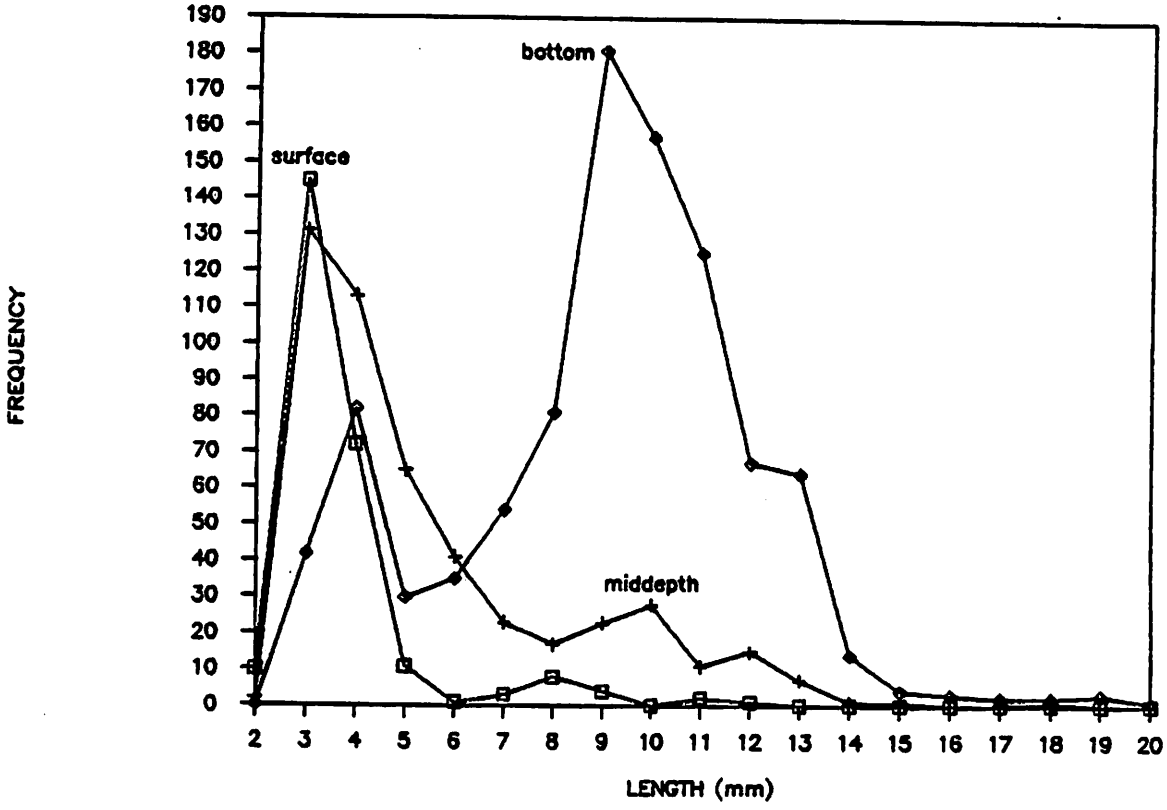


Figure 3. Size-frequencies of northern anchovy larvae in surface, middepth and bottom strata over bottom depths between 8 and 30 meters. Representative data from a winter curise in Santa Monica Bay.

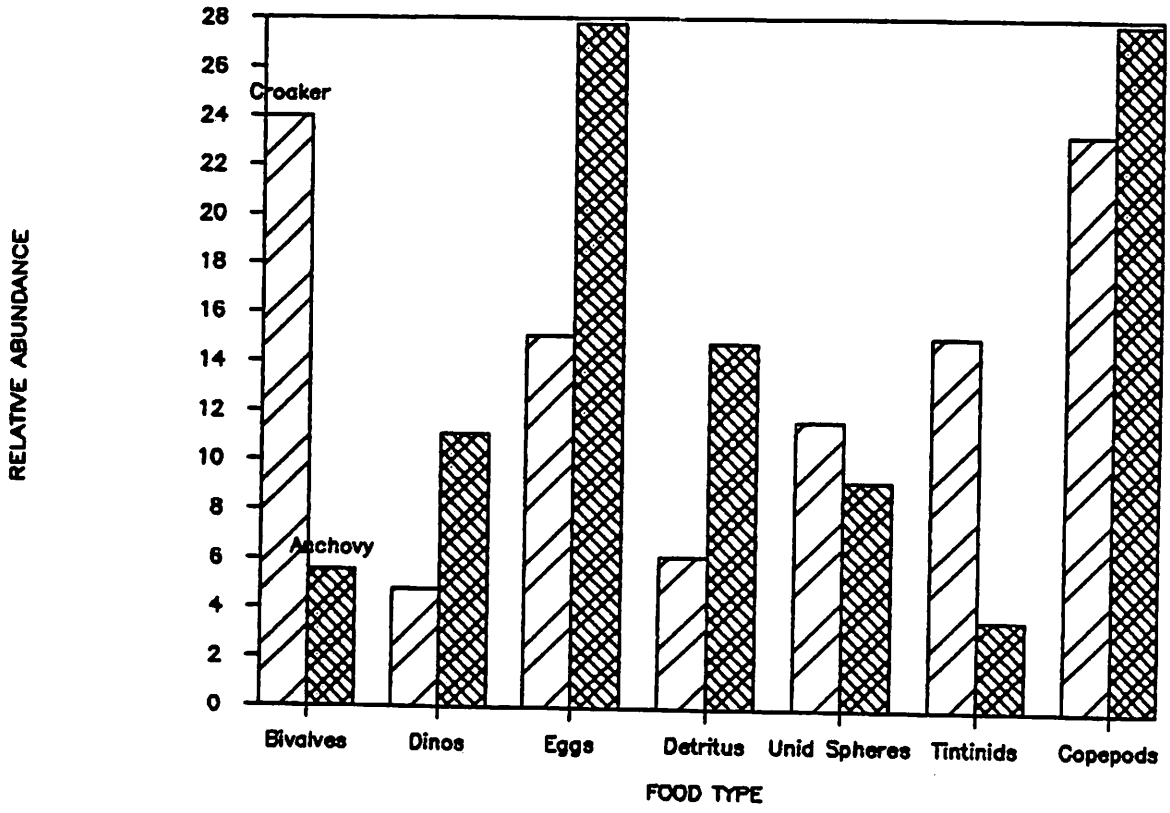


Figure 4. Relaltive abundance of bivalve veligers, dinoflagellates, invertebrate eggs, detritus, unidentified spheres, tintinids and copepods (nauplii and copepodites) found in the stomachs of white croaker and northern anchovy larvae.

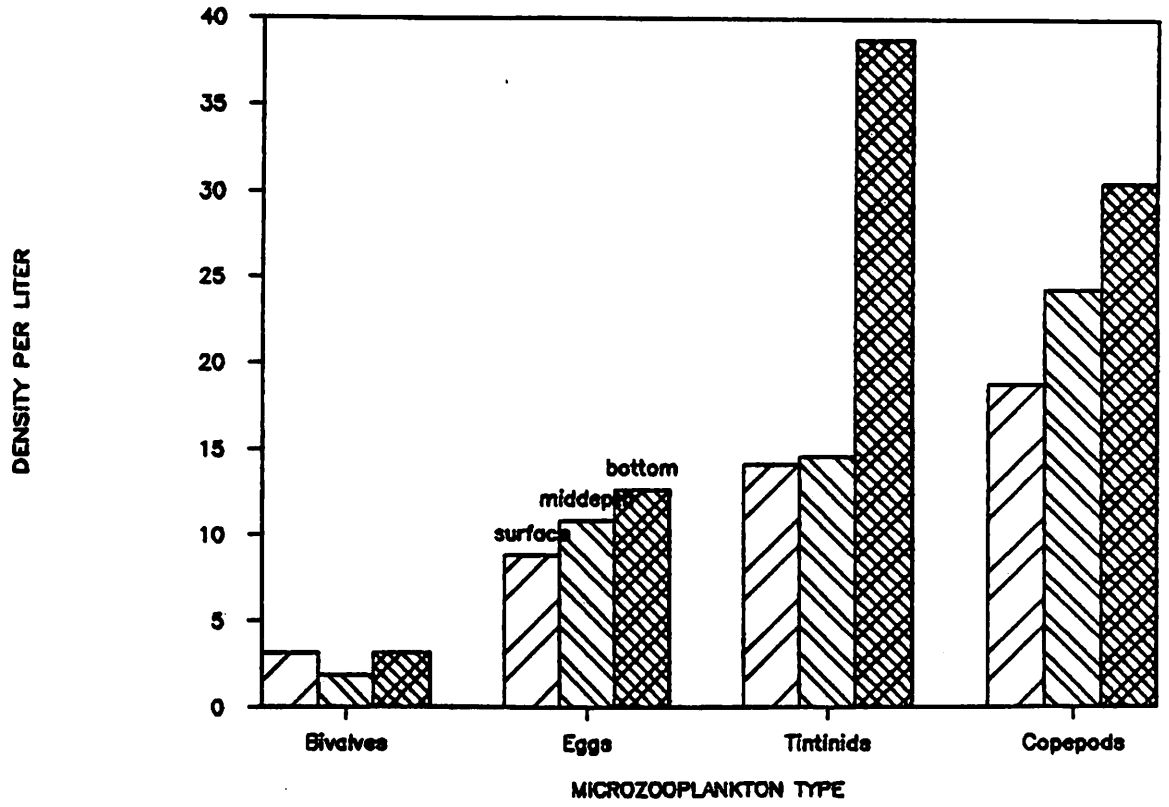


Figure 5. Average density of microzooplankton in surface, middepth and bottom strata over bottom depths between 8 and 30 meters. Representative data from a winter cruise in Santa Monica Bay.

A Time Series of Satellite Thermal Imagery and Its Use in Evaluating Ocean Features and Variability on Small Spatial Scales (R/RD-19)

Gary S. Kleppel, Ph.D., Allan Hancock Fellow and Adjunct Research Scientist, Institute for Marine and Coastal Studies, USC

INTRODUCTION

Large-scale, synoptic sea surface temperature (SST) data, collected from meterological satellites, are presently used worldwide for scientific, management and industrial purposes. Extensive use also is made of satellite imagery processed to encompass relatively small spatial scales during specific scientific or other operations that extend over short periods of time. However, few attempts have been made to systematically collect extended time series of satellite SST data for evaluation of the occurrence of small scale ocean features, and local coastal circulation patterns. Such information would be of value to numerous interests in the marine sciences, to resource managers (e.g., waste water discharge authorities), and to business interests confined to localized coastal areas (e.g., charter and small boat fishermen).

This project was an initial step toward achieving the long-term goal of understanding ocean variability in the Southern California Bight and of providing scientists and commercial interests with satellite SST data on spatial scales relevent to their needs.

RESULTS

NOAA satellite imagery is collected on most working days (Monday-Friday) by the staff of the Satellite Oceanography Facility, Scripps Institution of Oceanography. A time series of archived images extending from January 1981 through June 1982 was processed in this study. Each image was geometrically corrected for earth orientation in a region centered at 34°N Lat, 118°45'W Lon, and extending 282 km in each direction. Each image was then visually examined to determine the extent of cloud cover.

If at least a portion of the Southern California coastal zone was visible, the image was processed further to include reference point navigational correction (accurate to 1.1 km) and infrared brightness temperature calibration. Enlargements of four coastal areas (labelled A-D in Figure 1) were made by the algorithms PAN and MAGNIFY. Evaluations of the enlargements by potential users made it evident that PAN was a much preferred enlargement technique. Further, MAGNIFY produces a qualitative image, requires much more time to prepare than

PAN, and filters out potentially important small scale information. Use of the MAGNIFY option was dropped and supplemented with increased emphasis on various methods of processing imagery by PAN.

For various users, PAN 2 and PAN 4 (doubling and quadrupling of the image size) proved most valuable. Photographs (35 mm slide) were prepared for each full scale image and for each enlargement. The photographic catalog is presently available to all interested parties, and has been used by a number of scientists during the past year. In addition, the images that were suitable for processing have been saved on tape at the Scripps Satellite Facility, and are formatted for quantitative data analysis.

Of approximately 370 images examined, 162 (ca. 44%) contained enough information to warrant further processing. Qualitative evaluation of the data set has been ongoing and quantitative study of the archived imagery is underway.

The major warm and cool features present in the SST images are summarized in Figure 1. These include the well known upwelling feature at Point Conception that frequently enters the Santa Barbara Channel. Warm water is often seen landward of the cool plume in the channel. This warm water sometimes extends up to Point Conception. A nearshore cool plume, fed by upwellings in the region of Pt. Mugu, occurs in the lower Santa Barbara Channel and may cross or enter Santa Monica Bay. A cool plume generated by upwelling along the Palos Verdes Peninsula occurs regularly and appears to generally have a downcoast direction. The plume less frequently appears headed offshore or into Santa Monica Bay. Warm water "pools" are consistently observed in association with the leeward sides of the larger Channel Islands, and such a pool is especially obvious off Santa Catalina Island. Recurrent SST features are less frequently associated with land masses between Dana Point and San Diego, though numerous, short-lived, apparently shallow features (such as eddies on the order of 10-30 km diameter) are common. A region of warm water extending from San Diego to Santa Catalina Island occurs at irregular intervals, and an upwelling feature off Point Loma is relatively prevalent, but often cloud-obscured.

The majority of the descriptive effort has been focused on three regularly occurring features: 1) The lower Santa Barbara Channel cool plume; 2) The Palos Verdes cool plume; and 3) The Santa Catalina Island warm "pool." The features off Point Conception are presently being described by others (OPUS Project). The occurrences of the three features are summarized in Table 1. Of the total data set, the Santa Barbara Channel was unobscured by clouds 53 percent of the time. In the unobscured images, the cool plume was present in 64 percent. The apparent direction of the plume was down coast 55 percent of the time. The region off Palos Verdes was unobscured in 50 percent of the archived images. A cool, upwelling feature was evident in 74 percent of the clear images. The apparent direction of the upwelling plume was south southeast about 61 percent of the time. The region off Santa Catalina Island was visible in 47 percent of the images, and a pool of warm water was seen on the leeward side of the island in 63 percent of the images. This warm pool extends eastward from the tip of the island

in 67 percent of the images. At times when this warm pool and the Palos Verdes upwelling plume interface, in the middle of the San Pedro Basin, a sharp surface temperature gradient results.

Presentation of portions of the satellite time series have been made to several potential user groups, including Korean Ocean Research and Development Institute, UC Sea Grant Marine Advisors, Los Angeles City Hyperion Treatment Plant, Orange County Sanitation Districts, representatives from Los Angeles County Sanitation Districts, representatives from San Diego Sanitation Districts, Sea Otter Task Force-Petroleum Industry Consortium, representatives from Union Oil Corporation, representatives from Bechtel Corporation, USC Oceanographic Associates, and numerous local fishermen. Of these, the most promising interactions have been informal communications with local commercial fishermen. The meetings with fishermen have resulted in the development of a product for them that is now ready for testing.

Table 1. Descriptive summary of the occurrence of three persistent features observed in images of sea surface temperature of the Southern California Bight coastal region between January 1981 and June 1982.

Feature Location	Nature of Feature	Percentage of Occurrence		Predominent Apparent Direction (% of time)
		Region Clear[1]	Feature Present[2]	
lower Santa Barbara Channel	cool plume	53	64	downcoast (55%)
Palos Verdes Peninsula	cool plume	50	74	south southeast (61%)
Santa Catalina Island	warm "pool"	47	63	east (67%)

[1] Percentage of images in the data set in which a given region could be seen without clouds.

[2] Percentage of cloud free images that contained a given feature.

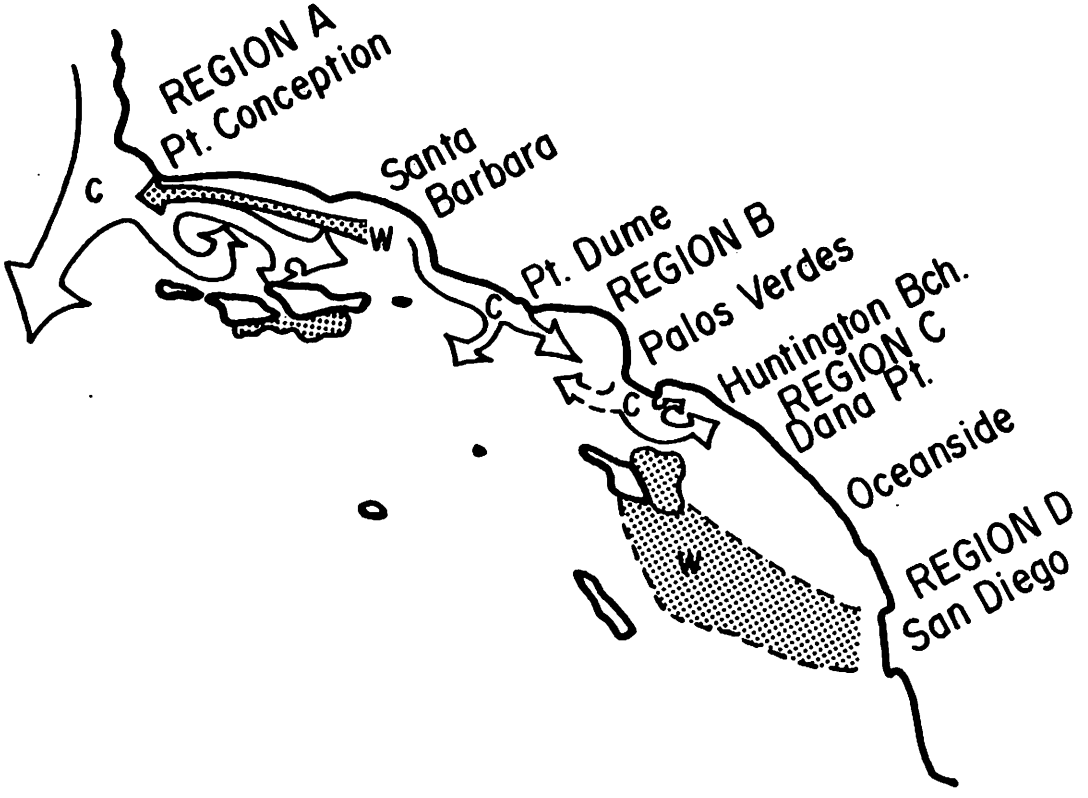


Figure 1. Descriptive summary of sea surface temperature features observed consistently in a timeseries of satellite images of the Southern California Bight between January 1981 and June 1982. Shaded areas, marked W, are regions of warm water. Unshaded areas, marked C, are regions of cool water. Arrows indicate the perceived directions of water movement. Solid boundary lines show most frequently occurring patterns. Dashed lines show secondary patterns.

Economic Analysis for Management of the California Northern Anchovy Fishery: Multipurpose Fleets and Biological and Market Uncertainty (R/RD-20)

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INTRODUCTION

This project has focused on two aspects of economic problems useful to modeling California's Northern Anchovy fishery: 1) market and biological uncertainty, and 2) multipurpose fleet behavior.

Market and Biological Uncertainty

Uncertain Growth

Renewable resources such as ocean fish are subject to significant environmental disturbances that result in random rates of growth. Harvesting of a resource in the presence of growth uncertainty raises two important economic issues:

First, how are biological and market dynamics affected when the resource is harvested under free entry competition? Stochastic growth may affect the biological survival of the resource.

Second, can a market allocation achieve dynamic optimality when property rights to the resource are clearly defined? Stochastic returns to resource conservation require rational expectations regarding future spot market allocations or a complete set of contingent futures markets.

Uncertain Harvesting

Due to the mobility of fish populations, lack of information about the location of fish is a significant source of uncertainty for the firm harvesting an ocean fishery. For this reason, fishing firms engage in search activity to locate areas with potential yield from which to harvest. The search effort decision of the firm is based upon the expected potential yield and the costs of search. The costs of search include the time spent searching, fuel and labor costs, and the costs of sonar, radar and other search equipment. The harvesting decision is based upon the size of the potential yield located by search and the costs of harvesting. The costs of harvesting include the time and equipment involved in bringing the fish on board and delivering the fish to the market.

In the free access fishery, individual firms may pursue myopic harvesting strategies if the returns to conservation are not

appropriable. The unregulated firm may not only harvest an excessive amount of fish but may devote an excessive amount of resources to search effort. Therefore, the regulator of a fishery with yield-effort randomness faces the difficult problem of controlling both the search and harvesting activities of the firm. The regulator's problem is complicated by the impossibility of observing the search effort directly, in particular, only policy instruments which depend upon harvest levels may be chosen. In addition, harvest restrictions must be established in each period before observing the potential yield obtained through search effort. Thus the regulator may try to control harvests which depend upon random potential yields while the degree of uncertainty regarding the yield is to an extent controlled by the fisherman.

In fishery models with a deterministic yield-effort relation, the fishing firm is able to obtain its desired harvest. The regulator is able to select an optimal harvest level in each period as a function of the current stock of fish. The landings tax and the vessel quota may both be employed to achieve the optimal harvest level. Because the tax and quota are price-quantity duals for the regulator's decision problem, they both require the same information and have the same incentive properties. It should be emphasized that this assertion only depends upon certainty within each period. The statement is still true with randomness across periods, such as in the case of the stochastic biological growth relation. The project studies fisheries regulation with yield-effect randomness. Given harvest uncertainty, the landings tax and vessel quota have different effects and applied alone each results in non-optimal search effort or harvest levels.

Multipurpose Fleet Behavior

The size of fishing fleets in a particular fishery is affected by the available group of species that can be harvested by multipurpose vessels. Two important constraints on harvesting are: 1) total fishing time which can be devoted to harvesting either species, and 2) individual time available for each species (as occurs when the species are harvested during different times of the year).

The multispecies fishery presents a number of important problems for future research:

First, models must be extended to a dynamic setting. The allocation of effort to independent species is reminiscent of the dynamic portfolio problem of capital theory because varying growth rates for the two species will yield differing returns to conservation.

Second, the market demands for the two species will, in general, be interdependent. A perfect foresight model will take into account the cross-elasticities of demand. In addition, the effects of imperfect competition on the multispecies fishery need to be examined. A monopolist harvesting the two species will take advantage of the market interdependence because the marginal revenue for each species will be affected by the supply of the other.

Third, restricting access to a multispecies fishery introduces strategic aspects to the multipurpose fleet problem. An imperfect competition framework may be needed to examine the multiple species fishing problem when constraints such as the time limits on fishing days are imposed.

Fourth, the assumption of biological independence of species needs to be relaxed. Harvested species may be predator and prey, directly competitive or related through more distant connections in the trophic web. May et al (1979) discuss the management of multispecies fisheries and the effects of maximum sustained yield policies for very complicated ecosystems, including, for example, harvesting at the top and bottom of a three-level trophic ladder of prey-predator/top-predator form. Time constraints and other technical constraints such as the yield-effort relation and limits on the degree to which species may be harvested, separately raise questions about the applicability of complex optimal harvesting for the multispecies fishery. What needs to be investigated is the optimal dynamic behavior of the multipurpose fleet harvesting interrelated species under time constraint. Given the large number of fisheries of this type, the implications for fishery regulation will be of significance.

RESULTS

1) The analysis of markets under uncertainty is contained in the paper "Uncertainty and Markets for Renewable Resources," written jointly with Leonard J. Misman. The paper appeared in the Journal of Economic Dynamics and Control 8, 1984.

The first part of the paper examines competitive free entry harvesting of a renewable resource that is the common property of firms. Free entry may result in departures from the social optimum as well as biological extinction of the resource. However, the presence of uncertainty introduces additional distortions in the free entry case. When there is free access to a renewable resource, firms pursue a myopic harvesting policy, ignoring future returns to conservation. Because of competitive harvesting of the same stock, firms are unable to appropriate future returns to conservation. This leads firms to select harvest levels that maximize static profits. Static profit maximization then leads to market prices for fish and harvesting cost levels which dissipate any rents which would accrue to ownership of the fishery. This was originally pointed out in the analyses of Gordon (1954) and Scott (1955). The presence of stock dependent harvesting costs introduces a technological externality because a firm's selection of a harvest level ignores the higher costs imposed upon other firms due to increased harvesting costs. When random disturbances affect the growth relation, firms basing their harvesting decisions on current stock levels ignore the risks of extinction posed by population variability. Furthermore, the variation in future rents caused by the stock fluctuations are not reflected in current harvesting decisions.

Free entry harvesting is studied here for the case of harvesting costs which do not depend upon the current stock as well as for the

case of stock dependent costs. It is shown that average behavior of the harvested stock may be very misleading because a stock which may survive "on average" may be extinct in a finite number of years with probability one. This is in contrast to studies which find that uncertainty in resource models has little effect on the "average" solution. The fluctuation of the resource stock is shown to imply that the free entry harvest level may be supported in some periods even if it is not sustainable indefinitely. This implies the need for flexible regulations that allow for different policies in good and bad years.

The optimal or centrally planned solution is analyzed next. This solution is shown to be achieved by a competitive allocation with endogenous prices. The decentralization may be achieved given rational expectations regarding the future spot price of fish or a complete set of contingent futures markets.

In this paper, the average dynamics of in situ prices or rents are shown to resemble dynamics in the deterministic case. However, the actual dynamics of rents and the resource stock are quite different. The long-run steady state of the system consists of one or more steady state sets and a probability distribution defined over each set. When the ergodic set of population escapement levels is unique, equilibrium rents may fluctuate within a positive interval, or they may be always zero if the entry output is both sustainable and optimal. It is shown that outside of the steady state interval of escapement levels the movement of rents may be determined with certainty and inferences may be made regarding the relation between market rates of return and the expected marginal growth of the resource. Given escapements within the steady state interval, only probabilistic statements may be made regarding the movement of future escapements and resource rents.

2) In the paper "Fishery Regulation with Harvest Uncertainty," joint with Leonard Misman (revised under this project), it is shown that uncertainty about the yield-effort relation implies that landings taxes do not have the desired effect. A landings tax may be employed in such a way that the firm devotes an optimal search effort. However, if the firm is "lucky" and discovers a large potential yield it will harvest too many fish, thus leading to excessive harvesting on average. This result goes a long way towards explaining why landings taxes have not been employed by fishery regulators.

Optimal vessel quotas may be used by regulators to prevent excessive harvesting. However, due to the riskiness of search effort, the vessel quota has the effect of encouraging excessive search effort by individual firms. The fisherman increases search effort to assure that the average harvest will be higher. The quota has the effect of lowering average harvest for any level of search effort by lowering the maximum harvest. The fisherman wishes to raise the minimum harvest by increasing his effort. These results suggest that in fisheries with vessel quotas, fishermen will respond with excessive search effort by increasing expenditures for sonar and other search equipment and for vessels with larger horsepower.

The special case in which harvesting costs do not depend upon the size of the yield located by search is considered. In this case an optimal maximum harvest level exists which depends upon the total current stock of fish but not upon the observed potential yield. The paper demonstrates that for this type of harvesting costs, landing taxes and vessel quotas applied together can be used to obtain socially optimal search effort and harvesting levels for the regulated firm. This result suggests that introducing landings taxes in fisheries already subject to vessel quota regulation will reduce search effort to the socially optimal level.

For many fisheries, harvesting costs in terms of time spent and equipment wear and tear depend upon the potential yield being harvested. In this case, the optimum harvest will depend upon the potential yield and this cannot be chosen by a regulator before a potential yield is observed. The paper demonstrates that a nonlinear landings tax with a quantity premium will result in optimal harvest levels as well as optimal search effort by the regulated firm. The tax schedule is decreasing in the size of the current stock of fish. In addition, the marginal landings tax is also decreasing in the current stock of fish because the marginal returns to conservation are lowered by a larger stock.

ENVIRONMENTAL QUALITY

Problems of Paralytic Shellfish Poisoning (R/EQ-31)

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INTRODUCTION

Paralytic Shellfish Poisoning (PSP) has become not only a national but an international problem because blooms of toxic dinoflagellates occur worldwide.

Molluscan shellfish are filter feeders and very opportunistic. The association of marine dinoflagellate blooms with "red tides" and mass mortalities of marine animals is well documented; however, not all marine species of dinoflagellates are implicated in the production of the paralytic shellfish toxin. Only certain species of the genus Protogonyaulax are toxin-producing (in western coastal United States, Protogonyaulax catenella, and on the East Coast, Protogonyaulax tamarensis). They will ingest dinoflagellates without respect to type and when feeding on the toxin-producing strains they will accumulate the poison. Incidents of paralytic shellfish poisoning in humans are the result of consumption of toxin-loaded shellfish.

Because of the hazard to human life, regular monitoring of the levels of paralytic shellfish toxin in harvested shellfish is mandated by the State Department of Health. To maximize safety, sample specimens have to be regularly submitted to state health authorities for bioassay. Sale of shellfish is banned when the threshold of 80 ug/100 grams of shellfish tissue is exceeded. Although the majority of shellfish harvesting is by commercial organizations that regularly supply samples for analysis, there exist long lengths of shoreline where native shellfish populations are harvested recreationally with no sample analysis undertaken.

The need for monitoring shellfish beds for PSP levels is undeniable in view of the seriousness of the toxic effects, for which no known antidote exists. The shellfish industry in the United States receives a severe economic blow each time a case of PSP is reported, and in fact the entire seafood industry is affected. Since it is improbable that any significant control can be anticipated for increases in PSP, it is important that the shellfish industry be protected by management procedures.

If clearance is to be retained for commercial harvesting and processing of shellfish, the only bioassay currently permissible by Food and Drug Administration regulations is the "Mouse Mean Death Time" Test. There are a number of disadvantages in using the mouse as the animal of choice for monitoring levels of PSP. First, at low levels of toxin, due to the "salt effect" (Schantz et al., 1957) the estimate of the actual toxin concentration in the shellfish tissue is significantly too small. Second, in the field it is too cumbersome to maintain a colony of mice (number of animals needed for the test). Third, because the testing laboratories are far removed from the harvesting areas, the results are delayed. Last but not least, the mouse assay is much too expensive.

In our laboratory at the University of Southern California, we have developed a new, sensitive, rapid and inexpensive test for PSP. Our animal of choice is the common housefly, Musca domestica, which counters all the disadvantages of the current use of the mouse.

RESULTS

The results to date are most encouraging. The reliability of the fly bioassay has been demonstrated by repeated assays and also by several individuals (Figures 1 through 5). Calibrations with the FDA-certified Saxitoxin (STX) standard have been carried out with variable injection volumes. The concentration of STX in 0.18 N HCl pH 3.3 when 1 ul and 1.5 ul volumes were used the ED 50 (50% effective dose) was shown to be 0.490 ug/ml and 0.281 ug/ml respectively.

The calibration experiments (Figure 3) were performed by one individual to test the reproducibility with variable sample number of flies. The data demonstrate the constancy of the method. When comparing the data of Figure 3 with that of Figure 4 (calibration experiments performed by another individual using 30 flies per each dilution), the results are superimposable and do not deviate. The two curves in Figure 4 were derived with different age groups of flies; the results suggest that the age of the flies does not affect the outcome of the test. This parameter of age was further tested with a single concentration of STX (0.707 ug/ml) and a dose volume of 1.5 ul. The following results were obtained:

— 1 to 5 days old flies 25/30, 83% affected

— 10 to 15 days old flies 26/30, 88% affected

— 45 days old flies 26/30, 88% affected

This confirms the findings shown in Figure 4.

As reported previously, our laboratory in 1982 participated in the North East Technical Services Unit (NETSU) toxic clam PSP split sample study used for quality assurance program. Again this year (1984), we were invited to participate in the quality assurance program. The results obtained are illustrated in Figures 1 and 2 and Table 1. Two

extractions of each, shellfish samples "A" and "B" provided by NETSU as homogenates, were prepared and analyzed by the fly bioassay method. The standard curve was obtained with the STX standard supplied by NETSU. The results of the fly bioassay method will be compared with results obtained in 19 laboratories nationally using the mouse bioassay method and one laboratory using the HPLC (High Pressure Liquid Chromotography) method. In the 1982 study, the toxin content of both samples estimated by the fly method was higher by more than a factor of two than the values estimated by the official mouse method (Table 2). This is as expected since Schantz et al (1959) showed that in this range the values obtained by the mouse method should be affected by about the same factor. Our studies have also emphasized the serious error of the Mouse Mean Death Time (MMDT) method at low levels of toxicity. The "salt effect" has been discussed by Schantz and by McFarren, but the error is not recognized by the majority of monitors. It can be as high as 2- to 3-fold at low levels, and we have shown that the fly assay is not subject to this error. In the 1984 study, the levels of toxin in the two samples were vastly different: sample "A" was highly toxic whereas sample "B" contained low levels of toxicity. We are awaiting the complete results from the NETSU laboratory.

Extracts of "non-toxic" shellfish tissues (as assayed by the mouse assay) were examined by the fly assay method. The clam extract affected 5 percent of the flies. This extract was further tested, by adding known concentrations of the FDA STX standard to a constant volume of the extract and dilution series prepared from each using 0.18 N HCl pH 3.3 as diluent. The results from these experiments suggest that a neurotoxic-like material (STX?) may be present in the "non-toxic" clam extract which affects the fly but is not detectable by the mouse method.

A similar study was carried out with the "non-toxic" mussel Mytilus edulis extract and the results are illustrated in Figure 5. The dose-response curve was obtained with known concentrations of STX standard added to the "non-toxic" mussel extract and compared with that of the STX standard diluted with 0.18 N HCl pH 3.3. Again the results demonstrate an elevated affect on the fly with a "non-toxic" mussel extract.

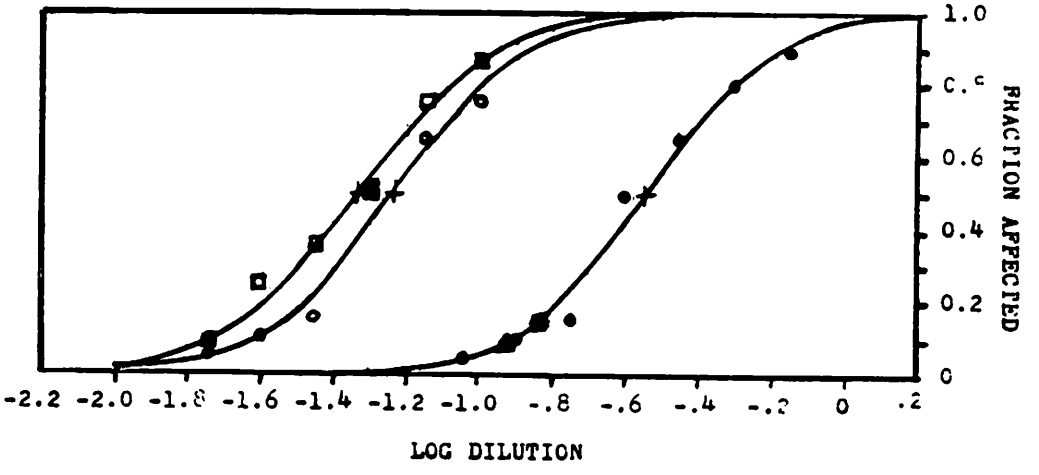
Studies with "non-toxic" extracts from a variety of shellfish species indigenous to the West as well as the East Coasts of U.S. and Canada are in progress at the present time. The results of these studies will be reported at a later time. These experiments with the "non-toxic" extracts will show that shellfish perhaps always retain some of the PSP.

The results of tests with larger species of flies are shown in Figure 6 and Table 3. These studies are not continuing at present. Although a larger species of flies may be desirable for injection purposes the unavailability of pupae commercially, in the case of the green bottle fly, Phoenecia cuprina, and the extremely long eclosion period of two weeks for the commercially available pupae of the blow fly, Sarcophaga bullata, precludes their use as the choice animal for the fly bioassay.

Mass cultures of the chain-forming dinoflagellate, Protogonyaulax catenella were initiated and studies were undertaken to measure the presence of PSP by the fly bioassay method in the extract prepared from them. The results obtained show the organism to be toxin producing with the range of toxin equivalents compared to STX standard of 7.88-11.70 picograms per cell. These studies are continuing with other strains of toxic dinoflagellates presently in our dinoflagellate culture collection.

In summary, we have demonstrated very clearly that the fly bioassay is a sensitive and reliable test for Saxitoxin. The results described above represent our efforts to move from the studies with the certified Saxitoxin standard to the extracts derived from various species of bivalve molluscs (mussels, clams, oysters, and scallops). This assay provides information of the total biotoxicity of the melange of the naturally occuring STX related analogues. The chemistry and relative toxicities of the various analogues is of scientific interest and is being pursued in our laboratory, but in the final analysis it is the determination of summated toxicity that is the pragmatic goal.

FIGURE 1. DOSE RESPONSE CURVES
"FLY BIOASSAY"
NETSU SAMPLES



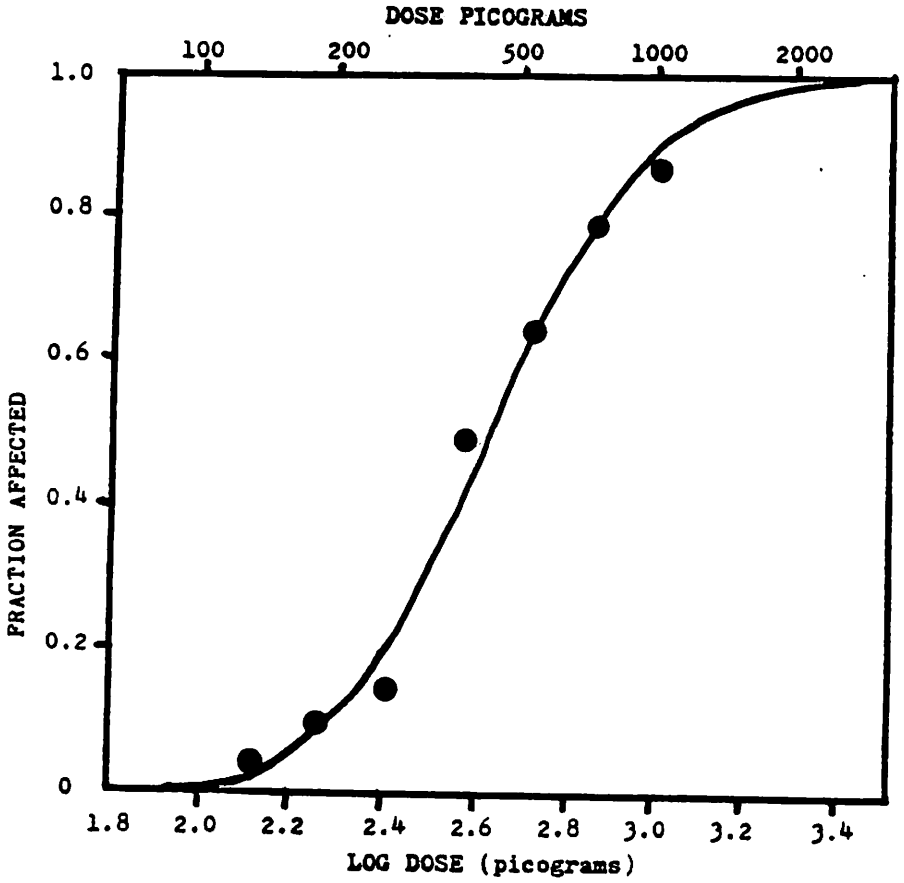
- ● NETSU Saxitoxin standard (1 µg/ml)
- □ A_1 toxic homogenate
- ○ A_2 toxic homogenate
- ▲ B_1 toxic homogenate
- ■ B_2 toxic homogenate

Injection volume - 1.5 µl/injection
Animal used - the house fly, Musca domestica
ED_{50} (50% effective dose) - 398 picograms, obtained with NETSU supplied Saxitoxin standard

FIGURE 2. SAXITOXIN STANDARD

MUSCA DOMESTICA

DOSE-RESPONSE CURVE



Injection volume used 1.5 µl/injection
Dose response curve obtained with NETSU supplied Saxitoxin standard (1 µg/ml).
ED_{50} (50% effective dose.calculated) 398 picograms

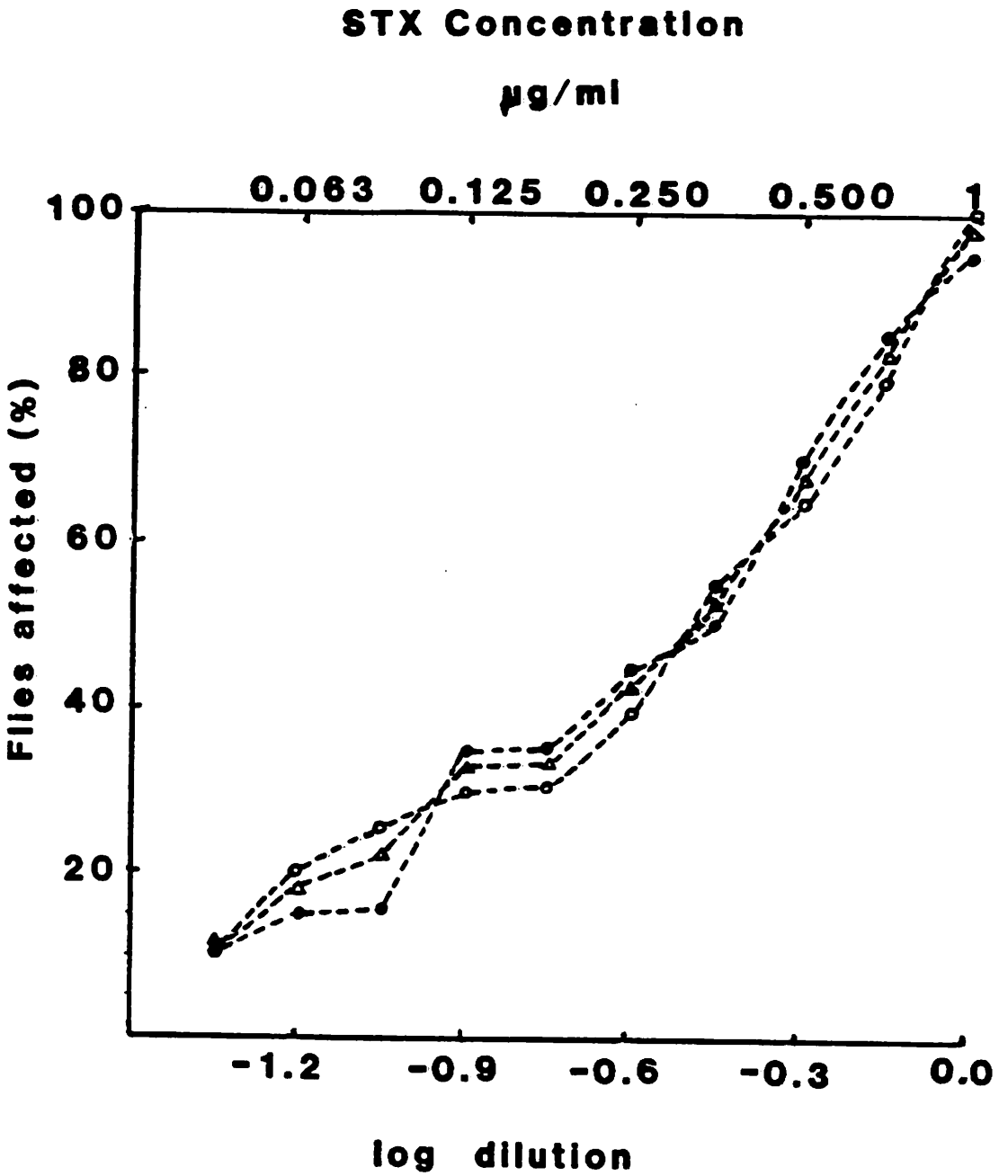


FIGURE 3. Dose-response curve FDA saxitoxin standard - Musca domestica
STX was diluted with 0.18N HCl pH 3.3. Twenty flies were used per each dilution. ED50 concentration 0.251 µg/ml
Dose volume - 1.5 µl ●----● O----O 20 flies
Δ----Δ 40 flies

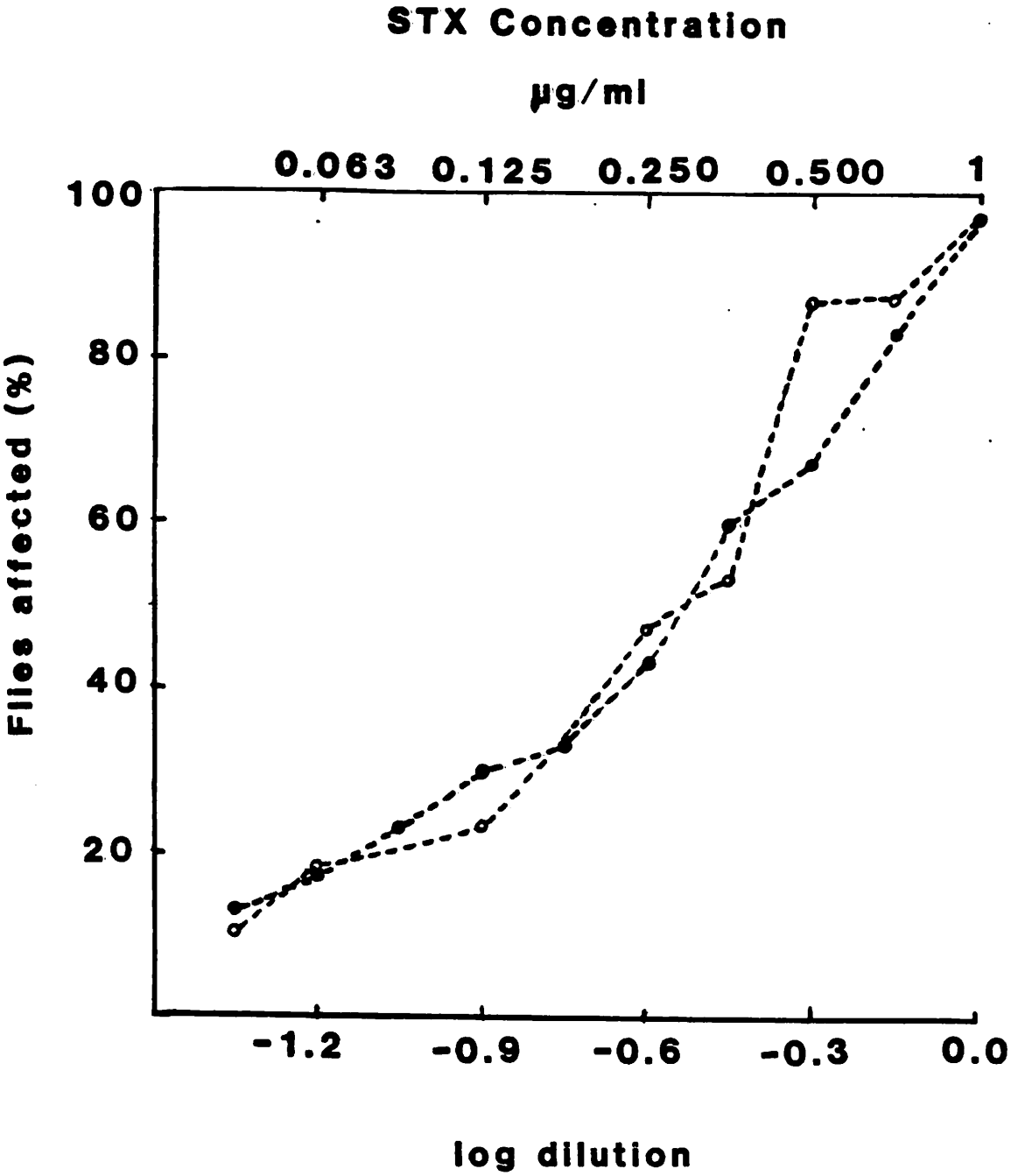


FIGURE 4. Dose-response curve FDA saxitoxin standard - Musca domestica

STX was diluted with 0.18N HCl pH 3.3. Thirty flies were used per each dilution. The age of the flies varied.
1-5 days old flies ●----● ED50 0.282 µg/ml
10 -15 days old flies ○----○ ED50 0.295 µg/ml
Dose volume 1.5 µl.

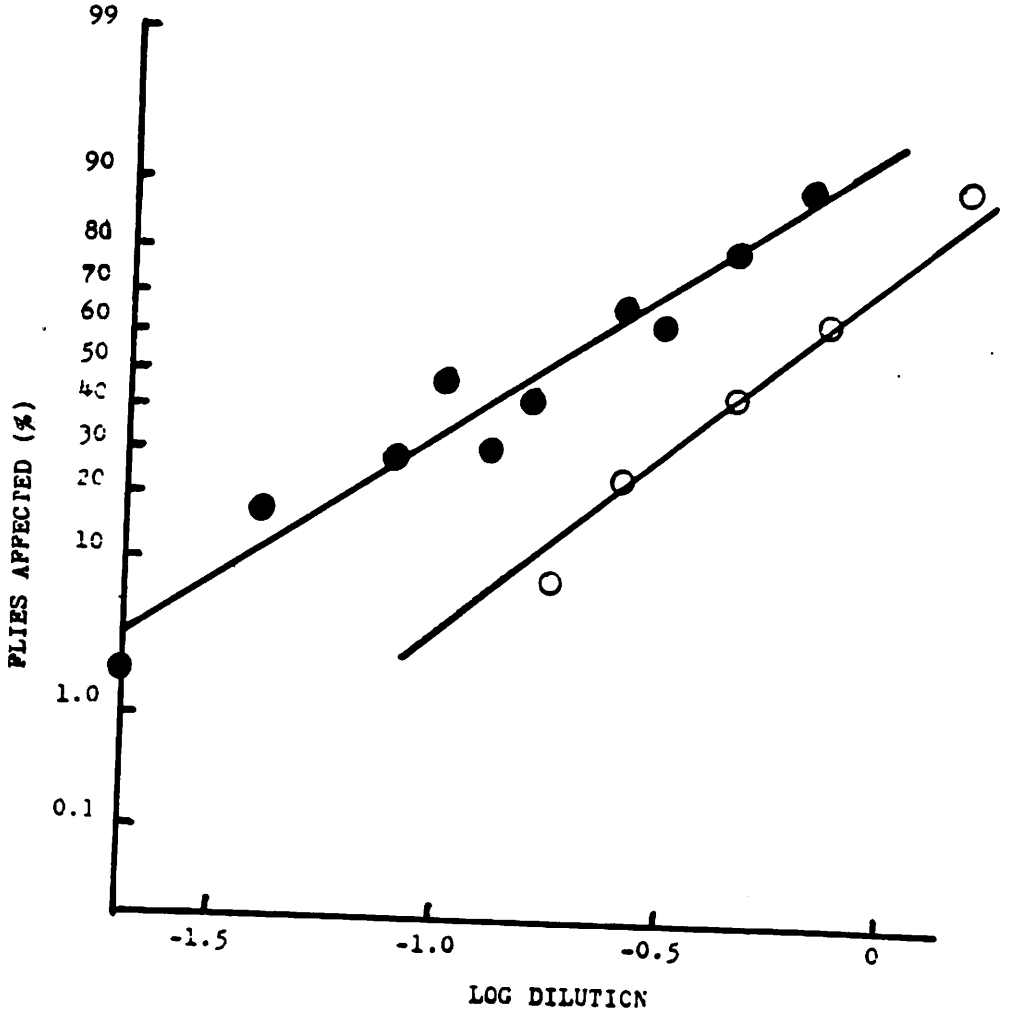


FIGURE 5. Comparison of Musca domestica response to PDA saxitoxin standard in Mytilus edulis extract and in 0.18N HCl pH 3.3

STX in 0.18N HCl pH 3.3 ○——○

STX in mussel (M. edulis) extract ●——●

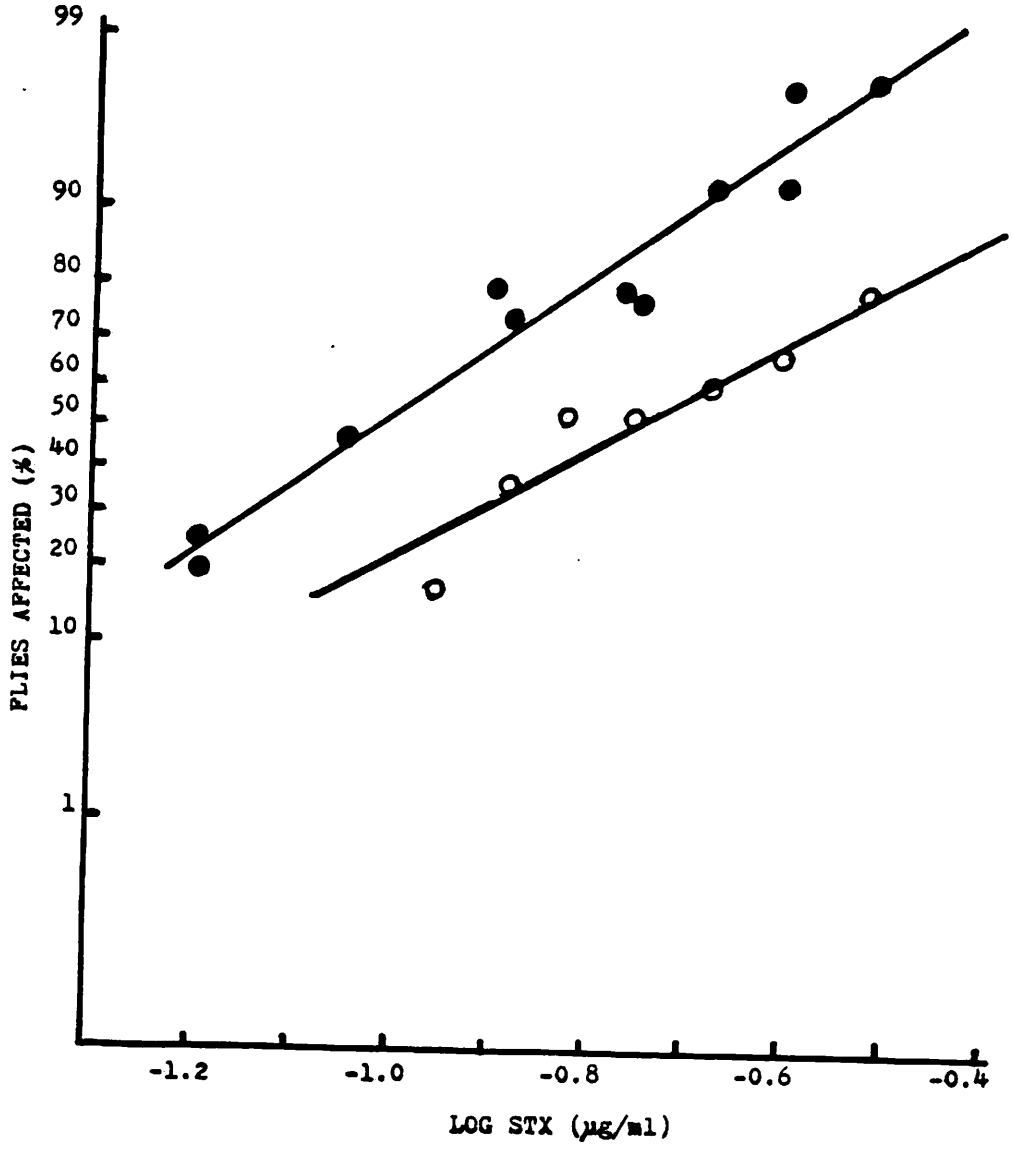


FIGURE 6. Dose-response curve FDA saxitoxin standard - Log Transform
Saxitoxin was diluted with 0.18N HCl pH 3.3

Phoenicia cuprina (green bottle fly) ●——● dose voume 4.0 µl
Sarcophaga bullata (blow fly) O——O dose volume 20 µl

TABLE 1. SHELLFISH EXTRACT ANALYSIS BY FLY ASSAY

NO. AFFECTED/NO. INJECTED

DILUTION	S	A_1	A_2	B_1	b_2
1(stock)		20/20	20/20	2/20	3/20
$\sqrt{2}$	18/20				
2	16/20				
$2\sqrt{2}$	13/20				
4	10/20				
$4\sqrt{2}$	3/20				
8	2/20				
$8\sqrt{2}$	1/20				
10		15/20	16/20		
$10\sqrt{2}$		13/20	15/20		
20		10/20	10/20		
$20\sqrt{2}$		3/20	7/20		
40		2/20	5/20		
$40\sqrt{2}$		1/20	1/20		
Median ED_{50}	.2852	.0580	.0467	------	------
Standard Deviation as % of Median upper	+8.69	+9.88	+9.81		
Standard Deviation as % of Median lower	-8.00	-9.00	-8.94		
Median toxin content ug/100g meat		983	1220	23	30
Standard Deviation of the estimate		+13.41%	+13.34%	±25%	±25%
		-11.81%	-11.77%		

S - NETSU Saxitoxin standard
A - toxic homogenate sample
B - toxic homogenate sample

TABLE 2. SPLIT SAMPLE PSP BIOASSAY

AVERAGES FROM PARTICIPATING LABORATORIES

LABORATORIES	N(sample A)	Sample concentration µg/100 gr tissue A1	A2	B1	B2	N(sample B)
NETSU*	5	132	136	87	81	4
Participating laboratories "mouse bioassay"	19	138 ±33	139 ±28	58 ±13	58 ±12	19
USC "fly bioassay"	1	284	280	115	139	1

NETSU* - Northeast Technical Services Unit Laboratory originating the Split Sample PSP Bioassay study (1982).

**The averages of the 19 participating laboratories performing the mouse test was derived from a range of values as follows:

SAMPLES	RANGE
A1	89-196
A2	84-186
B1	40-87
B2	42-78

TABLE 3. SPECIES OF FLIES - COMPARISONS

SPECIES	WEIGHT-mg	VOLUME INJECTED µl	ED50 µg/ml
M. domestica	10	1.5	0.285
P. cuprina	35	4.0	0.090
S. bullata	60	20.0	0.170

Musca domestica - house fly

Phoenicia cuprina - green bottle fly

Sarcophaga bullata - blow fly

Total toxin per fly can be calculated by multiplying the volume injected times the ED50 in µg/ml.

SEAPORTS AND MARINE TRANSPORTATION

Fees for Services at Seaports: Approaches, Federal User Fees and Public Policy Issues (R/CM-26)

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INTRODUCTION

Over the last several years, Dr. Willard Price has been engaged in Sea Grant-funded teaching and research in the field of seaport policy and management. A basic concept underlying his research is a view of seaports as public enterprises, owned by governments but seeking to operate with some degree of independence in their governance, management and financial decisions. One of the most impórtant aspects of such autonomy is the ability of seaport enterprises to raise revenues through fees for services, allowing financial independence without the necessity of subsidy from other government nits.

This financial independence involves decisions about separate accounting systems (enterprise funds), pricing services, acquiring debt if needed, and allocating any surplus revenues to future activities and development. The critical decision in this cycle is the setting of prices, which should be recognized as a political choice of the governing commissions of these seaports. We argue that there has not been sufficient discussion of policy issues in the literature or understanding by the public of pricing policy options.

To study seaport pricing behavior, a project was designed to include investigators with backgrounds in finance (Dr. Donald Bryan) and accounting (Dr. Peter Kenyon). The focus of the study is the methods used by seaports to determine prices, and not the specific rate structure of each port. There was no intent to compare rates or to evaluate the appropriateness of these rates. Rather the concern was how prices are determined and the alternative policy options available to public enterprises in setting fees.

One initial assumption was that there is not an ideal or correct pricing method expected of port managers. In addition, prices will likely be affected by a set of external factors beyond the direct and indirect cost of developing facilities and delivering services, including:

1) Market place of competing ports.
2) Political influence of government leadership.
3) Seaport associations acting like cartels.
4) Federal (or state) regulatory bodies, including the Federal Maritime Commission.
5) Legislative proposals to recover federal dredging costs by user fees.

Therefore, a study of pricing needs to look beyond cost to understand the determination of fees in seaports.

RESULTS

To address these questions, 14 California and Oregon ports were surveyed regarding their pricing behavior and to compare empirical results against a broad theoretical framework of possible factors and methods. The 14 ports were:

Astoria, OR
Coos Bay, OR
Humboldt, CA
Long Beach, CA
Los Angeles, CA
Oakland, CA
Port Hueneme, CA
Portland, OR
Redwood City, CA
Richmond, CA
Sacramento, CA
San Diego, CA
San Francisco, CA
Stockton, CA

Interview data from these ports were gathered by a survey that covered the topics listed below. For most ports, two to three key managers were interviewed, including the finance director, marine terminal manager, rate/tariff manager or other relevant individuals. The responses of these managers were synthesized into a set of data from each port for each of the 20 topics. The responses include both quantitative and qualitative data. Research results will provide port comparisons, when possible, and will identify and develop the more significant port policy issues that were surfaced by the study.

General tax subsidy
Operating/landlord ports
Tariff structure method
Non-tariff services
Lease agreement method
Non-priced services
Cost centers
Cost allocation
Rate of return
Surplus revenue
Cargo uncertainty
Prices and demand
Competition and demand
Negotiated pricing
Cost recovery
Politics and pricing
Commissioners & pricing
Port association influence
FMC-review and cartels
Federal user fees impact

Pending the completion of the final report, several initial and informal results are mentioned here.

1) Contrary to what certain literature has suggested, cost was not the primary emphasis in setting prices. In fact, elaborate cost accounting systems were absent in most ports.

2) Quite often prices were influenced heavily by the rates of competing ports, particularly where shippers have an option of shifting cargoes to other ports without significantly affecting their overall transportation costs.

3) Further influence on prices comes from the negotiation which occurs between users and the port. Ports value the terminal agreements they have with shippers and try not to set prices without considering the users' willingness to pay.

4) Even though port managers consider the industry quite competitive, they do prefer to retain the right to meet with other ports to discuss services and prices. This cartel-type behavior has received an exemption from the federal government antitrust laws. Nonetheless, the meeting of such port associations does not result in rigid price-setting. Port managers value the exchange of information most highly, but without the strict control over members' individual actions.

5) Contrary to initial expectations, local politicians' influence in price determination was minimal. Political leaders appear to understand and respect the several factors which port managers must balance as they set their prices. Political influence is felt more strongly in the allocation of surplus revenue than in rate structures.

6) Rates of return (or profitability) of ports were not studied in detail by this project. But it is clear that there is a wide variance in the success of ports, likely caused more by their ability to sustain and build cargo movements at their particular geographic location than by the prices set.

7) Given the competitiveness of the port industry and the effect of trade fluctuations, it requires a knowledgeable and alert management to insure revenues exceed costs. One conclusion is that given the complexity of their task, port managers are either fortunate or quite competent, or both, because most ports are surviving in what certainly has been a difficult period in international trade.

8) At the same time, without a stronger international economy, some ports may be experiencing financial stress and may not be able to sustain their maritime business, no matter what prices they set.

9) The proposed legislation to establish federal user fees to recover the cost of dredging was not passed by the last Congress. As a result, there has been very little effect on port prices due to such user fees during this survey. Once again, user fee bills have been introduced in the new Congress and will certainly be contested quite seriously given the large federal deficits. The renewed debate over the specific form of user fees will likely aggravate the distinction between the more successful and less successful ports.

COASTAL PLANNING

California Coastal Population: Transition and Development (R/CM-27)

Maurice D. Van Arsdol Jr., Ph.D., Professor of Sociology and Director, Population Research Laboratory, USC

INTRODUCTION

Decisions regarding the management of coastal areas require information on changes in human population in coastal communities, as well as impacts of technology on environmental quality. People and their modes of organization are often responsible for coastal zone environmental problems.

California's population in 1970 was 20 million persons. Since then, it has increased to more than 24 million. More than 19 million, or 79 percent of all Californians, live along a thin strip of coastal and inland waterway counties. More than two-thirds of California's population increase in the 1970s was in these areas.

On-shore building, loss of vegetation and watershed, increased use of coastal areas, and pollution of shallows have accompanied human population increases on the California coast. Data from the 1980 Census of Population and Housing were used to update a previous Sea Grant report on population and urban growth in California through 1970. The resulting document will be distributed to policymakers who are faced with managing population distribution and growth and their social and environmental effects on California's coast.

RESULTS

Although the final report is now being drafted, some results are summarized in the following paragraphs.

1) Population redistribution between metropolitan/nonmetropolitan and rural/urban portions of the coastal zone and rest of the state.

The coastal zone study included those areas under the control of the California Coastal Commission, coastal communities, and the inland areas of the coastal counties. About 90 percent of California's coastal population lives in metropolitan areas. The nonmetropolitan coastal counties (Del Norte, Humbolt, Mendocino) are also experiencing rapid growth. Generally, the greater the absolute growth and size of population in coastal areas, the more serious the environmental problems. The population carrying capacity of some portions of the

coast has apparently been reached, and population is ebbing into nonmetropolitan and noncoastal counties.

2) Stages of urban growth in the coastal zone.

The housing stock in coastal areas is aging with increasing social-economic mix in coastal populations. One important consequence of this increasing mix is more diversified demands on the environment.

3) Employment and industry in the coastal zone.

Employment and industrial development have become more decentralized and more diverse along the coast. Meanwhile differences between areas have decreased, with mixes of industries becoming more similar and local coastal areas less unique. Employment changes have generated much population redistribution.

4) Population trends related to changes in wetland and marine resources.

Urban residential and industrial growth in the coastal zone have reduced wetland areas considerably in the past decade. Housing and land use trends are described. The report concludes with some preliminary findings regarding problems in coastal populations and land use management and the variety of policies used in attempts to deal with these problems. The project team is conducting a more in-depth study of coastal area population policies in a 1984-85 Sea Grant project.

5) Importance of findings.

Conversion of natural land and agricultural land to urban uses is proceeding at a rapid rate along California's coast, and it appears likely that unless stronger policy tools are used than have been used in the past, the only coastal land that will be secure from development is that in public ownership that is retained and managed as open space, plus that owned by organizations or individuals committed to retaining it as open space. Because only a small fraction of the coastal counties' land is publicly owned, projections of population growth and land use, based solely upon past trends, suggest a densely settled urban strip from Marin County south to the Mexican border by the mid-21st century.

Stakeholders must consider whether this settlement pattern is desirable for our coast, and what policy tools may be used to achieve desired population patterns. The report, in the form of a technical monograph, will be made available to as many groups as possible, to help them monitor population trends and their implication for the coast.

COASTAL ENGINEERING

Corrosion Fatigue of Weldments in Offshore Structures (R/CE-8)

Judith A. Todd, Ph.D., Assistant Professor, Department of Materials Science, USC

INTRODUCTION

Low- and medium-strength structural steels, when subjected to cyclic stresses in the marine environment, exhibit more rapid nucleation and propagation of corrosion fatigue cracks than comparable steels tested in air. The critical areas in fatigue performance of marine structures (offshore platforms, deep sea pipe, ship plate, submarine hulls) are welded joints, which may be submerged fully in sea water and which must be protected by cathodic polarization. Although sea conditions are relatively quiescent along the California coast and in the Gulf of Mexico (compared to the North Sea), corrosion fatigue problems have still been reported. Such failures typically occur in the welded nodes of offshore structures, and corrosion fatigue crack growth may be sufficiently severe to result in detachment of the structural braces.

Relatively few studies exist on corrosion fatigue of weldments in the marine environment, particularly for the low frequencies (0.1-0.2Hz) associated with offshore structures. The mechanisms of corrosion fatigue crack nucleation and the roles of metal dissolution at the crack tip, corrosion debris, cathodic hydrogen and weld residual stresses are not well defined for natural sea water environments. There is a critical need for long-term corrosion fatigue crack propagation studies in the slow-growth regime (10^{-6} - 10^{-5}mm/cycle), which marks the transition from threshold behavior below which flaws are non-propagating, to the midgrowth (10^{-5}-10^{-3}mm/cycle) where the effects of mean stress, microstructure and environment are not longer dominant. A fundamental study relating fatigue design parameters to corrosion fatigue mechanisms and crack propagation rates is being undertaken in this research.

RESULTS

During the first year of the corrosion fatigue program, significant progress has been made. The National Association of Corrosion Engineers, recognizing the importance of this research, awarded the USC program with one of their two National Seed Grant Awards for 1983-1984, which included funds for scholarship and small equipment, plus a library of NACE publications.

In addition to the NACE award, the USC program received considerable industrial support: 1) Armco Inc. Southwestern Steel

Division provided the program with 10 plates each of 32 mm and 16 mm ASTM A710 Ni-Cop (IN 787) steel, a high-strength, low-alloy steel with copper additions for improved corrosion resistance. (Compositions of these steels, heat treatments and mechanical property data, from tests conducted at USC, are given in Tables I and II); 2) Northrop Corporation allowed the Sea Grant trainee, Shishir Shah, to gain valuable experience as an observer in their fracture mechanics laboratory while USC equipment was being modified; 3) Dr. Czyryca at the David Taylor Naval Ship R & D Center provided advance reports in Ni-Cop steel for the USC program; 4) Rockwell International Corporation donated a surplus control console for the CGS Model 110-12A servohydraulic fatigue equipment.

Corrosion fatigue testing facilities were fully established although a number of delays were incurred due to problems with the CGS servohydraulic fatigue machine. The pump and motor had to be rebuilt and, when the control unit completely failed, a six-month delay was experienced while the Rockwell equipment was approved for transfer to USC. New grips for the fracture mechanics test specimens were machined and heat treated at USC. It was decided to adopt a clamp-on cell for the first tests using 3.5% NaCl environment. The equipment is now fully functional the potential drop system has been calibrated and our test program is now in progress.

The first series of welds were fabricated in the 16 mm plate by Dr. George Reynolds of MSNW Inc. The welding parameters and weldment properties for these submerged arc welds on AST, A710 (Ni-Cop) plate are described below.

Welding Procedures

Six submerged arc welds were prepared, two without and four with metal powder additions. Table III shows the compositions of the Linde 95 electrode and L95 metal powder blend used to prepare the experimental welds. A GMAW (gas metal arc weld) root pass was used for each plate. This was followed by four submerged arc passes from one side. Each plate was inverted, the root pass was completely removed by grinding and a single submerged arc pass was deposited on the reverse side to complete the weld. Table IV shows the welding parameters used for each of the six plates prepared. Two additional submerged arc welds, with metal powder additions, were prepared using Linde 44 electrode and L44 metal powder blend (Table V). These welds are identified as #8 and #9 in Table IV.

Weld evaluations

Each plate was radiographed per ASME Section VIII. All welds were found to be acceptable, except for the normal stop/start regions, which extend approximately 1.0 inch from the edges of the plate. Tensile tests were performed on subsize, all weld metal specimens cut from one end of each test plate. All results were acceptable as shown in Table VI.

The modified goal of establishing a sound experimental test technique for measuring threshold stress intensity ranges has now been achieved. We are beginning our corrosion fatigue crack propagation measurements for samples of base plate and weld metal tested in air.

Table I
Compositions of Armco Ni-Cop Steel

	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Cb
Armco Class3 5/8" plate	0.04	0.58	0.01	0.004	0.28	0.85	0.76	0.21	1.18	0.042
Armco Class 2 1 1/4" (32mm) plate	0.04	0.44	0.01	0.012	0.26	0.74	0.90	0.19	1.18	0.034

Heat Treatment
Armco Class 3 (5/8" plate) - Austenitized at 1650°F (899°C) water quenched, precipitation hardened at 1100°F (598°C) and furnace cooled.

Armco Class 2 (1 1/4" plate) - Normalized at 1650°F (899°C) for 30 minutes, air cooled, precipitation hardened at 1100°F and air cooled.

Table II
Mechanical Properties

	σ_y ksi	σ_y MPa	σ_{UTS} ksi	σ_{UTS} MPa	% elong	% RA	50 ft-lb temperature °F	50 ft-lb temperature °C
Class 3 Armco 5/8" plate	93	639	102	702	38	--	-80	-62
Class 3 5/8" plate USC	89	619	101	697	35	77	--	--
Class 2 1 1/4" plate ARMCO	76	525	92	631	27	--	-50	46
Class 2 1 1/4" plate USC	69.3	479	85.6	591	37	78	--	--

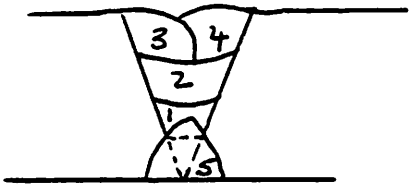
Table III
Nominal Composition (Wt.%) of Electrode and Powder Used

ELEMENT	LINDE 95 ELECTRODE	L95 POWDER
C	0.06	0.04
Mn	1.65	1.65
Si	0.35	0.35
Mo	0.40	0.49
Ni	1.50	1.80
Cr	0.25	0.25
Fe	Bal.	Bal.

Table IV
Welding Parameters

Parameters Common to All Plates

Base Plate	ASTM A710
Plate Length (in.)	24.0
Joint Configuration	Single Bevel, 60° Included Angle, 0 Root Opening
Preheat (°F)	None
Interpass Temperature (°F)	250
Root Pass:	
Electrode	E70T1, .045 in. diameter
Voltage (V, DCRP)	21
Amperage (A)	140
Number Sub-Arc Passes (See Sketch)	5



Electrode Type	Linde 95, 0.093 in. diameter
Powder Type	L95
Flux Type	Linde 709-5
Electrode Extension (in.)	1.25

Variable Parameters

I.D. No.	Voltage (V,DCRP)	Amperage (A)	Powder/Wire Weight Ratio	Travel Speed (ipm)	Heat Input (J/in.)
2	33	300	0*	8.0	75
3	33	300	0	8.0	75
4	35	300	.31	10.5	60
5	35	300	.31	10.5	60
6	35	300	.75	13.125	48
7	35	300	.75	13.125	48
8	35	300	.31	10.5	60
9	35	300	.31	10.5	60

*12.0 lbs/hr. electrode wire deposition rate

Table VI
Tensile Properties

I.D. No.	YS(Ksi)	UTS(Ksi)	% Elong.	%R.A.
2	73.2	91.6	28	63
3	80.8	95.9	27	65
4	81.1	96.5	25	64
5	81.8	98.2	25	60
6	79.1	101.0	22	60
7	84.0	98.4	23	64
8	75.2	100.0	20.5	55
9	84.0	98.9	22	59

APPENDIX

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