CALIFORNIA SEA GRANT AND THE EMERGING PACIFIC AGE

A SUMMARY REPORT OF THE CALIFORNIA SEA GRANT COLLEGE PROGRAM 1984-85

CALIFORNIA SEA GRANT

The California Sea Grant College Program is a statewide multiuniversity program of marine research, education, and advisory services, administered by the University of California Institute of Marine Resources. Sea Grant-sponsored research contributes to the growing body of knowledge about our coastal and ocean resources and, consequently, to the solution of many marine-related problems facing our nation. Through its Marine Advisory Program, Sea Grant transfers information and technology developed in research efforts to a wide community of interested parties and actual users of marine information in California and throughout the nation. Sea Grant also supports a broad range of educational programs for university students, public school teachers and students, and the general public so that our coastal and ocean resources can be understood and used judiciously by this and future generations.

ROSEMARY AMIDEI,
COMMUNICATIONS COORDINATOR

Published by the California Sea Grant College Program, University of California, La Jolla, California, 1986. Additional single copies are available free of charge from: California Sea Grant College Program, University of California, A-032, La Jolla, California 92093.

This work was sponsored in part by NOAA, National Sea Grant College Program, Department of Commerce, under grant no. NA80AA-D-00120, Project #A/P-1 and by the California State Resources Agency. The U.S. Government is authorized to produce and distribute reprints for governmental purposes.

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COLLEGE PROGRAM
UNIVERSITY OF CALIFORNIA
LA JOLLA, CALIFORNIA 92093
PUBLICATION NO. R-CSGCP-018

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INTRODUCTION

James J. Sullivan
Program Manager

The mission of California Sea Grant, and that of the other Sea Grant programs as well, is to promote the understanding and wise development of our nation's coastal and ocean resources. But no nation in today's world exists in isolation, and thus Sea Grant also maintains ties to the global community of scientists who are seeking to better understand and utilize the riches of the world's great seas and oceans. Indeed, the 29 programs that constitute the core of the National Sea Grant College Program are presently involved in cooperative work with scientists on five continents.

California Sea Grant, by virtue of the state's geography, history, and economy, has especially strong ties with the nations and states of the Pacific and a particular interest in the issues important to the region. Consequently, we are excited by the emerging sense of community apparent within the Pacific Basin—a region that has become one of the most dynamic growth areas of the world. We believe strongly that much of the vitality of California Sea Grant is derived from our international associations, from the flow of information and intellectual energy between colleagues of similar interests in and around the Pacific.

For this reason, we have chosen to focus this 1984-85 summary report on our program's activities as they relate to the Pacific region. A few examples deserve special mention:

- *Marine Biotechnology*: Last summer, we were invited to testify before the House Subcommittee on Oceanography (Committee on Merchant Marine and Fisheries) regarding the international strategic implications of commercial applications of marine biotechnology. The United States presently leads in biotechnology research and development. But our nation's competitive strength will be tested when large-scale production

begins, with challenges coming from companies in Europe, Canada, and especially Japan, which considers biotechnology the last technological revolution of this century. In our testimony we emphasized our nation's present opportunity to develop new goods and services—and thus improve our balance of trade—through genetic enhancement of fisheries and aquaculture ventures and through development of new marine products such as pharmaceuticals.

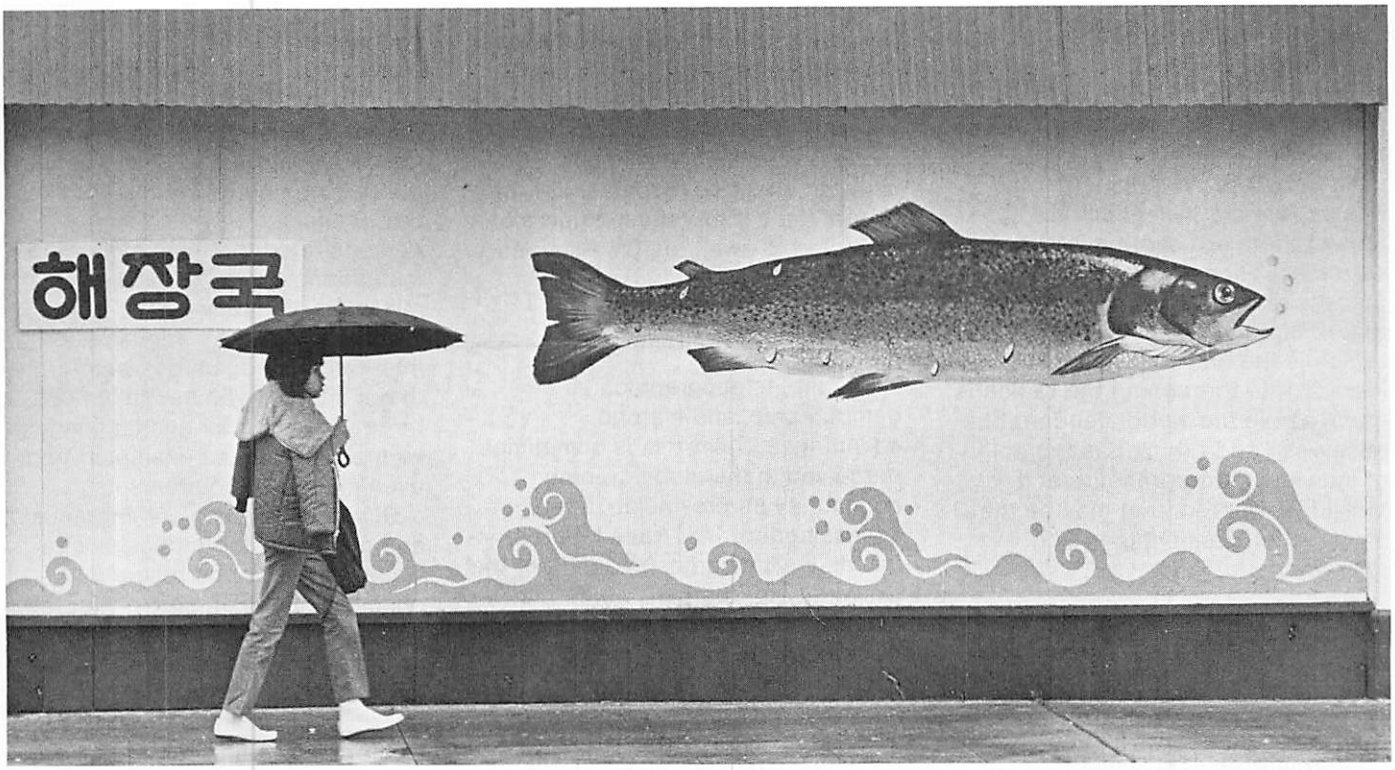
- *Pacific Science Development*: California Sea Grant has been involved in preliminary discussions aimed at the establishment of a new organization, the Pacific Research Foundation. The Foundation would establish an advanced Pacific study center to foster and conduct research, development, and training in the Pacific region. Its associated consortium, the Pacific Research Alliance, would initially include the University of Hawaii, the University of California, the University of Tokyo, and the Academia Sinica of the People's Republic of China. The consortium would coordinate pan-Pacific academic and industrial work in basic science and technology.
- *Science Teacher Training*: California Sea Grant has worked cooperatively with the University of Hawaii for the past several years to sponsor training workshops for science teachers from the U.S. trust territories in the Pacific. Our aim has been to equip teachers in this region with the skills, knowledge, and confidence to teach about the spectacular resource represented by the oceans.
- *Marine Resources Development*: This past fall we were invited to address a workshop at the Universidad de Concepción in Chile on ways of better developing Chile's marine resources. Workshop participants were eager to learn about Sea Grant as an organizational model for promoting fundamental yet application-oriented research across a variety of academic institutions.
- *Cross-Cultural Contact*: Because scientists from the Pacific share many research interests, California Sea Grant supports opportunities for cross-cultural contacts. For example, with our sponsorship, a fisheries ecologist from the University of Tokyo is presently working in this country with a Sea Grant project leader, analyzing recruitment in several fisheries.
- *Regional Sea Grant Activities*: Five Sea Grant college programs in the Pacific states—Alaska, California, Hawaii, Oregon, and Washington—have cooperatively supported major regional activities in education, research, and advisory services for nearly 15 years. The formalized network organized by these programs, known as the Pacific Sea Grant College Program (PSGCP), sponsors conferences, workshops, training sessions, and some joint research projects. In June 1984, for instance, California Sea Grant in cooperation with the other PSGCP states sponsored an international workshop on the taxonomy of commercially important seaweeds in the Pacific and Caribbean. Participants included scientists from Taiwan, China, Japan, Chile, Guam, New Caledonia, and the United States. As a result of the meeting, California Sea Grant published a taxonomic guide to commercially important species of seaweed. And, at the suggestion of China's Academia Sinica, we plan to co-sponsor with that organization a second taxonomic workshop.

As these examples demonstrate, California Sea Grant is extensively involved with its Pacific neighbors. In the pages that follow we will highlight other activities of the program that contribute to information development and exchange, to resource protection and utilization, and to cultural understanding throughout the Pacific.

"...by virtue of its geography, its economy, its history, its character and its wealth, California is fitted to play a pivotal role in what will surely be one of the greatest centers of trade, commerce, and cultural exchange the world has ever known."

David P. Gardner
President, University of California

CALIFORNIA AND THE AGE OF THE PACIFIC



—Los Angeles Times photo

A girl walks past a mural adorning a restaurant in Los Angeles' Koreatown. California's rich multicultural heritage is one of its most important assets.

California lies at the gateway to one of the most dynamic regions of the globe—the Pacific. The 28 nations[1] that border the shores of the Pacific, together with the oceanic islands, are home to about half of the world's population. Their economies account for more than 40% of the gross world product, a figure expected to approach 50% in the next decade.

An Awakening Giant

In a 1985 report published by California's Department of Commerce, entitled *Facts on the Pacific Rim*, the Pacific Basin community is described as a $3 trillion market that is growing at the rate of $3 billion a week. The region has been described as an "awakening giant."

It was in 1978 that the United States for the first time shipped more goods across the Pacific than across the Atlantic. By 1984, only seven years later, Pacific trade exceeded Atlantic trade by $26 billion, and an astonishing 25% of all world trade was being conducted between the industrial superpowers of Japan and the United States.

The nations that surround the Pacific Basin are enormously diverse in the size of their economies and the stages of their economic development. Despite these differences, or perhaps in part because of them, the nations of the Pacific are becoming increasingly integrated. Sixty percent of all trade by countries in the region, including the United States and Japan, is with others in the region. Economic analysts at the Security Pacific National Bank speak of a "Pacific

[1]The Soviet Union is typically omitted from the list of Pacific Rim nations because of the paucity of data available and because it is considered European in orientation. Nevertheless, Siberia—Russia's Pacific Rim area—is rich in resources and home to the Soviet's Pacific Fleet.

matrix...a natural and complementary mix of natural resources, skilled and unskilled labor, agricultural capabilities, and research/education/training facilities."

And many of the peoples of the Pacific Rim are well educated, though there are enormous national extremes. Richard Fairbanks, U.S. ambassador-at-large, has argued that in fact the major resource of the region is the human resource. "The literacy rate throughout the region is much above the world standard," he observes, "and I think it is the ability of individual entrepreneurs and individual workers that may be the single most identifying characteristic."

California's "Pivotal Role"

California's role in the Pacific Rim is central to our national presence in the region. University of California President David P. Gardner has observed that "by virtue of its geography, its economy, its history, its character and its wealth, California is fitted to play a pivotal role in what will surely be one of the greatest centers of trade, commerce, and cultural exchange the world has ever known."

Though California's population of some 26 million represents just 1% of that of the entire region, the state accounts for 7% of the region's gross product. California has the third largest economy in the Pacific Basin, smaller only than those of Japan and China. In fact, California is Japan's second largest trading partner after the United States as a whole.

The dynamism of the Pacific region presents California with enormous opportunities. In 1984, the state did more than $67 billion worth of business with Pacific Rim countries (see the table). And more than half of all American trade with the Pacific passed through California ports.

Governor George Deukmejian is determined to see California lead this new international marketplace. One strong plus that Deukmejian sees for the state is its demographic makeup—California's population today is 7% Asian and Pacific Islander and 19% Hispanic. By the turn of the century these figures are expected to swell to 10% Asian and 28% Hispanic.

Realizing the Promise

Despite its geographic, demographic, and historic advantages, California is sometimes perceived in the global trading community as provincial. In his assessment of U.S. trade failures, James H. Zumberge, president of the University of Southern California, acknowledges the importance of trade barriers, the strong U.S. dollar, and other factors, but he also points out that California has failed to use the vast array of knowledge available within the state. "In the world of commerce," he observes, "we have created a self-centered trade culture and ignored information about other cultures."

Education in California can be used to illustrate this point. A study of colleges and universities in the San Francisco Bay area demonstrated that only half of the institutions surveyed have any minimum requirements for their students in foreign languages or international education—and further that a student who has taken two or three years of a foreign language in high school can be exempted from even minimum requirements.

But for those who are interested and motivated there does exist a wealth of study and research opportunities. For example, at the various campuses of the University of California (UC) there are three large campus Institutes for Area or International Studies; five campus Centers for Asian Area Research; two campus Centers for Slavic and

California Exports and Imports to and from Pacific Rim Countries: 1984

California Imports from		California Exports to	
Japan	20,374,830,300	Japan	$ 7,690,985,544
Taiwan	5,211,252,978	South Korea	2,820,304,574
South Korea	3,564,135,350	Australia	2,797,024,744
Hong Kong	2,277,240,431	Singapore	1,835,865,286
Mexico	1,496,462,760	Taiwan	1,749,942,551
Singapore	1,492,966,680	Hong Kong	1,563,308,927
Maylaysia	1,480,994,649	Mexico	1,554,280,205
Indonesia	1,453,229,387	Maylaysia	1,358,504,169
Philippines	1,119,366,152	Philippines	1,056,755,584
China	781,143,440	Canada	757,734,093
Canada	727,358,813	Thailand	503,976,083
Australia	546,035,633	China	452,822,486
Thailand	528,337,064	Indonesia	392,786,301
New Zealand	167,330,897	New Zealand	387,733,926
Colombia	119,012,059	Panama	84,623,439
Equador	106,328,877	Chile	48,763,088
Peru	82,476,425	Papua New Guinea	44,652,718
Chile	58,026,798	El Salvador	29,904,768
El Salvador	51,723,563	Peru	28,941,996
Costa Rica	49,725,213	Colombia	14,915,649
Panama	37,275,230	Nicaragua	14,291,171
Guatemala	29,107,078	Vietnam	12,827,628
Nicaragua	25,541,689	Equador	11,615,096
Papua New Guinea	23,081,095	Costa Rica	9,036,156
Honduras	2,646,456	Guatemala	4,331,300
Brunei	909,001	Honduras	556,604
Vietnam	0	Brunei	22,424
PACIFIC RIM	$41,806,538,018	PACIFIC RIM	$25,226,506,510
TOTAL CALIF. IMPORTS	$49,300,000,000	TOTAL CALIF. EXPORTS	$32,200,000,000
Pacific Rim % of Total	84.8%	Pacific Rim % of Total	78.3%

Adapted from *Facts on the Pacific Rim*, California Department of Commerce; data from Security Pacific Bank, International Trade Data Bank.

—Bettmann Archive, Inc.

Commodore Matthew Perry concluded the first treaty between the United States and a reluctant, isolationist Japan in 1854. Presents given by Perry included a model railway, telescopes, and guns—items intended to impress the Japanese with the scientific and technological achievements of the West.

East European Research; and a universitywide consortium for Mexican and border studies (UC MEXUS). Throughout the system, approximately 65 degrees on Pacific languages, literatures, and cultural and area studies are offered, enrolling about 1200 majors—800 undergraduates and 400 graduates. In addition, many more students are exposed to courses about the Pacific region while majoring in other disciplines.

Nevertheless, the belief persists that insufficient numbers of students are taking advantage of the programs offered at the University of California and elsewhere, given the importance of the Pacific community to our future. A 1984 study showed that as against 3700 students from the Pacific Rim studying at the University of California, only 123 UC students were studying abroad in Pacific study centers administered by the University's Education Abroad Program.

In response to the need to "internationalize the education experience," a significant expansion of the Education Abroad Program is planned over the next three years, with hopes of increasing the numbers of students studying in Pacific countries from 123 to more than 450 students. Study experiences already exist in China, Japan, Australia, Peru, and Mexico. By 1988-89, the University hopes to have additional centers in China and Japan and to create new study opportunities in Korea, Southeast Asia (including Indonesia, Malaysia, Singapore, and Thailand), New Zealand, Costa Rica, and Canada.

Also established as new Pacific Rim initiatives are a universitywide research program and a Graduate School of International Relations and Pacific Studies. This new professional school on the University of California, San Diego campus will be the first school of international relations within the UC system and the first in the country to focus primarily on the Pacific region. In addition to supporting research, the new school will train students for professional careers in businesses and industries that operate in the Pacific region, as well as for careers in diplomacy, policy analysis, and communications.

One Prospering Economy

The dynamic growth of the Pacific Rim nations has resulted in strongly competitive relations. For example, the massive trade deficits that the United States is experiencing have resulted in fervent calls for protectionist trade policies. And yet, Zumberge has pointed out that in the context of international trade, competitive relations do not necessarily imply adversarial relations—our global economy will be healthy only to the extent that its participants are prospering.

The potential of the Pacific region will be met when the Eastern and Western cultures that compose it recognize the best of each other's traits. Even now the region is characterized by a remarkable willingness of its member societies to learn from one another; and it is this openness, this internationalism, that will allow the community of the Pacific to develop to its fullest potential.

Sea Grant's Role

California Sea Grant is part of a national investment in research and education that ultimately will benefit our nation's competitive position in the world marketplace. Beyond that, by promoting wiser management and use of marine resources, we are contributing to the prosperity of all the world's peoples.

Through our joint scientific ventures with colleagues from other nations, through our far-reaching research programs into questions of national and international interest, we seek the benefits of cooperative efforts: sharing our special expertise with the world community of scientists and receiving that community's expertise. Such international give and take has always been a hallmark of productive science.

SEARCHING FOR STABILITY

In coastal regions throughout the world, people increase the amount of land available for port facilities, industrial plants, and residential and recreational developments by using dredged sand to construct landfills. In San Diego, hotels, restaurants, and marinas stand on Shelter and Harbor islands, two typical examples of the many coastal fills in the world.

Underwater fills are usually constructed by dumping dredged sand in water without compacting it. Once the fill rises above water level, vibrating rollers can be used on the surface to compact the sand. Underwater parts of the fill are not compacted in this manner but require special techniques, all of them expensive. These include driving piles, vibroflotation, and dynamic compaction, which consists of dropping very large weights on the ground. Because these techniques are used *after* construction of the fill, and because they do not lend themselves to quality control, a large number of existing man-made coastal fills are unstable. Many of them in seismically active areas—and this includes the whole "ring of fire" that girdles the Pacific—are in danger of liquefaction, a phenomenon marked by instantaneous loss of soil strength caused by ground shaking during an earthquake. The landslide at Anchorage Harbor in Alaska in 1964 was one among many disastrous ground failures caused by liquefaction.

A research project by Iraj Noorany, professor of civil engineering at San Diego State University, has been looking at the possibility of improving the strength—that is, the resistance to liquefaction—of saturated sand by adding synthetic fibers to the sand at the time the fill is constructed.

Using fibers to increase soil strength is an ancient practice; straw, for example, has been added to clay bricks for centuries. Use of synthetic fibers or fabrics in soils is recent, however. The earliest experiments with synthetic fabrics began in the late 1960s, and their use expanded rapidly after an international conference in Paris in 1977. Today synthetic fabrics such as rayon, nylon, and polyester are used widely in geotechnical construction, where they are known as "geofabrics." Like carpets, they are available in large rolls and are used, among other things, to control soil erosion and to reduce lateral pressure against retaining walls.

In contrast, Noorany sought to examine the mechanics of loose sand reinforced with fibers or pieces of fabric and deposited under water.

Results of a feasibility study he performed showed that inclusion of certain types of fabrics or fibers did improve the resistance of the sand to liquefaction when it was subjected to dynamic forces such as those occurring during earthquakes. The tests indicated further that for the reinforced sand to withstand liquefaction it had first to be compacted: simply depositing a mixture of sand and geofibers under water did not produce satisfactory results.

In the Sea Grant-funded study completed last year, Noorany and his trainee focused specifically on the effect of thin, randomly distributed synthetic fibers on sand's resistance to liquefaction. Cylindrical specimens of fiber-reinforced sand (prepared by a moist tamping technique at a relative density of 50%) were subjected to pulsating loads. Results were analyzed by comparing the number of cycles of stress required to cause initial liquefaction of the unreinforced and reinforced sand. In addition, patterns of deformation were photographed and studied to evaluate the effect of geofibers on the deformation characteristics of the sand. The tests showed that using small amounts of randomly distributed fibers (about 0.1% to 0.2% by weight of sand) did improve sand strength. What is needed now, according to Noorany, is a practical method for placing fiber in sand during the actual fill process.

(I. Noorany, "Liquefaction Susceptibility of Fiber-Reinforced Coastal and Offshore Fills," R/CZ-72.)

Related Sea Grant Projects (Coastal Resources)

Raymond C. Smith (UCSB), "Phytoplankton Dynamics in Eutrophic Coastal Waters," R/CZ-64A.

The fundamental ecological process in the oceans is the conversion of solar radiation into biochemical energy by free-floating plants called phytoplankton. A major objective of this research was the collection, organization, and utilization of combined ship, satellite, and other data for the purpose of better understanding the dynamics of phytoplankton, and the relationship of phytoplankton distributions to the abundance and distribution of other marine organisms in the Southern California Bight region. These data are being used to model plankton dynamics in this eutrophic region as a basis for increased understanding of production at higher trophic levels. In addition, sea-surface temperature and chlorophyll concentration have been used as "habitat descriptors" for more accurately assessing the abundance and distribution of marine mammals.

Robert N. Colwell (UCB) and Allen W. Knight (UCD), "Development of a Remote Sensing-Aided Procedure

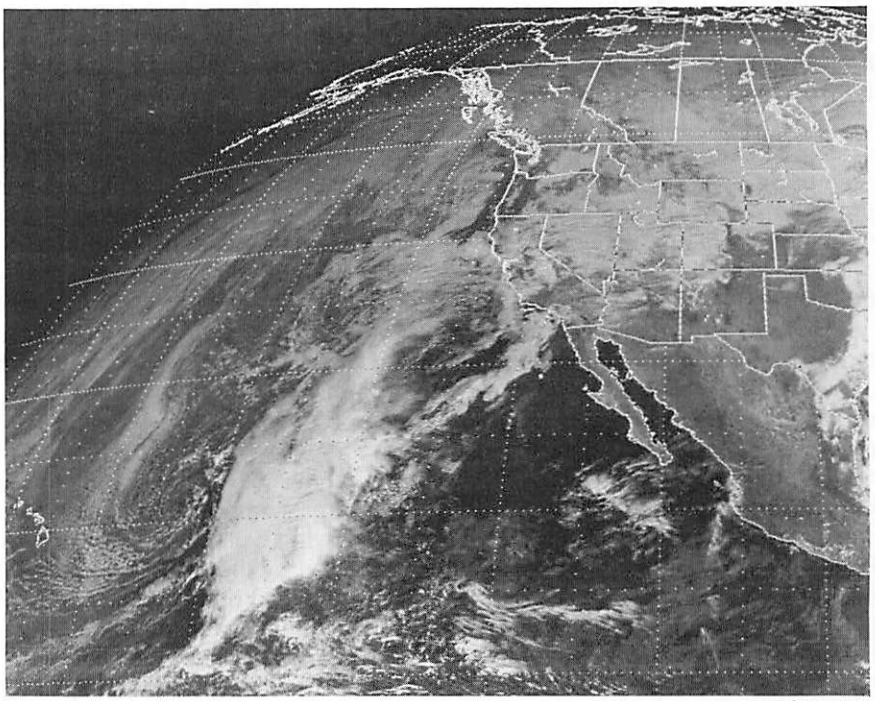
for Water Quality Monitoring," R/CZ-68.

Knowledge of marine water quality is essential for wise management of marine resources. An inexpensive and convenient method of obtaining information on water quality is needed to establish and meet water quality standards, plan and evaluate water management activities, enforce environmental regulations, and improve our understanding of aquatic ecosystems. Researchers are using satellite and water sampling data on salinity, suspended solids, turbidity, and chlorophyll concentrations to develop a procedure for mapping water quality of the San Francisco Bay and Sacramento Delta.

Joy B. Zedler (SDSU), "Modified Watershed Hydrology: Effects on Estuarine Ecosystems," R/CZ-73.

Human manipulation of stream flow into estuaries has a great impact on coastal ecosystems. The goal of this project is to establish guidelines for the management of estuarine hydrology and salinity by determining how estuarine ecosystems respond to increased streamflow (caused by releasing treated sewage effluent). The findings are being incorporated into a book, *The Ecology of Tijuana Estuary, California: An Estuarine Profile.*

Cooperative work with researchers in Mexico on the Tijuana Estuary has begun, and stream-flow ideas developed in this work have been proposed for testing in southwestern Australia.



—NOAA photo

Satellite view off west coast. Some scientists think a new El Niño may be building.

Predicting Floods

Unusually high sea levels and large waves along the west coast of North America are related to large-scale meteorological and oceanographic events, sometimes affecting the entire Pacific Ocean. For example, during the devastating El Niño winter of 1982-83, during which over $100 million damage occurred in California alone, a combination of oceanographic and meteorological factors caused sea levels to exceed predicted high tides by an average of 15 cm at San Diego and up to 60 cm at San Francisco.

Reinhard Flick of the California Department of Boating and Waterways and UCSD's Scripps Institution of Oceanography, with funding from California Sea Grant, has been studying the extent to which these sea-level extremes can be related to wind velocity, atmospheric pressure, and ocean temperature. His preliminary results indicate that about 50% of sea-level fluctuations *beyond* predicted tides can be statistically related to local air pressure and wind speed variations on time scales ranging from two days to a month.

The study is already helping coastal engineers from the California Department of Boating and Waterways and the City of San Diego to better evaluate risks from coastal flooding and is a first step toward allowing planners to estimate a few days in advance when sea level will exceed predicted tides during severe storm conditions.

Future joint research may occur with scientists in Venice, Italy, where storm surge flooding is a serious problem.

(Reinhard E. Flick, "Coastal Engineering Implications of Trends and Fluctuations in California Coastal Sea Level," R/CZ-69.)

CRYOGENIC STORAGE OF SHRIMP GAMETES

U.S. per capita shrimp consumption jumped 56% over the last decade, making wholesalers and retailers in the seafood industry happy indeed. But prices and supplies are still unpredictable, creating headaches for large restaurant chains that use seafood promotions heavily and must be able to back promotions up with high-quality products in dependable quantities.

The demand for shrimp is so great that it is no longer practical to think about netting more of the small crustaceans from the sea. The growth in supplies in recent years has resulted not from increased catches but from aquaculture ventures in Panama, Taiwan, the Philippines, Ecuador, and elsewhere, some of which are owned by U.S. interests. Though the United States has its own shrimp farming industry, it is still very young and not yet profitable.

The major problems of shrimp culture appear now to have been solved. One stumbling block that remains is providing a constant year-round supply of shrimp gametes (eggs and sperm).

Zoologist John H. Crowe and his associates at the University of California, Davis, believe that low-temperature (or "cryogenic") storage might be one way of assuring hatchery managers of high-quality shrimp gametes throughout the year, not just seasonally when the animals spawn.

With funding from Sea Grant, his team looked first at the relative effectiveness of several potential cryoprotectants—compounds that protect cells from the damaging effects of freezing—and then looked in detail at the mechanisms by which the most effective cryoprotectants work.

Crowe and his associates knew that the cell damage caused by freezing also occurs with dehydration. Recognizing this similarity, the scientists focused their attention on the soil-dwelling nematode, a small drought-resistant worm, and found that during dehydration the organisms synthesize large quantities of a sugar called trehalose. Might this sugar protect cells against freezing?

The team screened a number of potential cryoprotectants, including trehalose, on muscle cells of lobsters (these cells contain a membrane that can be isolated in large quantities). With this model membrane preparation, they have shown that trehalose is much more effective than are traditional cryoprotectants in preserving membrane structure during freezing and thawing. They next attempted to determine how trehalose works.

In living cells, the key structure affected by the stress of freezing is the cell membrane. Thousands of individual threads, made of fatty substances called phospholipids, are packed closely together to form this casing. Wedged between the phospholipids are protein molecules that form tunnels through which essential minerals enter and leave the cell.

When temperatures drop to freezing, order within the membrane deteriorates. The proteins are displaced from their normal positions. Membranes from one cell fuse together with those from other cells, losing their separate identities. The membrane's organization is lost, and the cell may begin to die.

The Sea Grant group believes that the trehalose sugar attaches to the end of the phospholipid molecules, fastening one thread tightly to another. The interwoven proteins are thus guarded securely, unable to slip from their position. The structure is solidly fixed, which prevents the phospholipids from undergoing the usual phase transition during freezing from the normal fluid state to the more rigid gel state. Because this phase transition is avoided, the cell is later able to recover when it is thawed. Crowe and his associates have found that trehalose depresses the phase transition temperature of membrane phospholipids by as much as 30°C.

In addition to trehalose, an amino acid called proline has been found to protect lobster membranes during freezing. In the next research phase, these protectants are being tested on whole cells. Crowe's group is collaborating with colleagues at the Bodega Marine Laboratory to test the cryoprotectants on shrimp eggs, sperm, and embryos.

Closely related studies have presented the possibility of a very different application of their work. Crowe's group has shown that small spheres (called vesicles) prepared from phospholipids can be preserved by freezing in the presence of trehalose or proline, and by freeze drying in the presence of trehalose. This finding is of enormous potential importance to the pharmaceutical industry, where phospholipid vesicles are used to deliver water-soluble drugs to specific sites in the body.

(John H. Crowe, "Cryopreservation of Crustacean Gametes," R/A-62.)

BIOTECHNOLOGY IN THE SERVICE OF AQUACULTURE

Abalones are a delicacy to the gourmet palate. Unfortunately, these molluscs grow slowly and at variable rates, making cultivation difficult.

Daniel E. Morse, a professor of molecular genetics and biochemistry at the University of California, Santa Barbara, and his associates have been using the techniques of biotechnology and genetic engineering to address these problems. With support from California Sea Grant, they have been finding ways to ensure that the mollusc matures to a healthy size. For example, by supplementing its diet with growth hormone and the hormone insulin, they have observed that the abalone grows at an accelerated rate.

The recent work of the research group has focused on insulin in particular. The abalone stores the bulk of its insulin in its digestive tract rather than the pancreas as humans do. Morse and his associates speculate that the insulin is helping the nutrients cross the intestinal wall. This would aid in explaining the increased growth rate of hormone-fed abalone.

Measuring the activity of enzymes supplies information about growth-related events that cannot be examined directly. Certain enzymes affect the breakdown of food; some help with absorption; while others build new tissue. Thus, by monitoring enzyme activity, scientists can begin to understand where and how extensively the hormones are operating.

Specialized proteins found in the abalone shell have a simple structure and increase rapidly in size. Tracking the growth of these proteins provides another way to study the hormone's effects.

Because the insulin molecule is similar across species, the Sea Grant group has used readily available mammalian insulin in its experiments. Success in this area has been valuable for other researchers. For example, the Japanese have used salmon growth hormone to improve their own abalone cultivation.

Mammalian insulin has been useful in preliminary experiments. Morse's group has demonstrated its value in growth regulation. But now comes the fine tuning. Using DNA technology, the group has been deciphering the structure of the abalone-specific insulin. Once they know the DNA sequence of the genes that regulate insulin production, they can manufacture the hormone at low cost and in sufficient quantities.

Studying the hormone at the gene level is providing exciting new information. Not only can the researchers determine how much insulin the mollusc normally makes, but they can also identify the factors that increase or decrease insulin production. When they understand the natural manufacturing process, they can begin to manipulate it for their own needs.

Morse has discussed applications of his work at the invitation of several U.S. biotechnology and aquaculture firms. He has collaborated with scientists from the Oyster Research Institute in Japan, the Institute of Oceanology in the People's Republic of China, and the Central Marine Fisheries Research Institute in India. He has also shared his research at the Sea Grant-sponsored International Symposium on Recent Advances in Cultivation of Pacific Molluscs and co-edited the symposium proceedings. He has given lectures and demonstrations of his team's research findings at universities and fisheries in Japan, the People's Republic of China, Thailand, India, New Zealand, Fiji, and the Cook Islands, and he has consulted with researchers in the Philippines, Chile, Mexico, and Australia.

Morse has now concluded the Sea Grant-supported phase of his studies and has succeeded in obtaining support from private industry to continue his work. Expanding on his ideas, researchers worldwide hope to reveal how hormones affect all levels of growth and development in molluscs.

(Daniel E. Morse, "Genetic Engineering: Modern Technology Applied to Improvements in Molluscan Aquaculture," R/A-51.)

Related Sea Grant Projects (Aquaculture)

Grover C. Stephens (UCI), "Culture of Marine Bivalves: Utilization of Dissolved Amino Acids," R/A-60.

Researchers in this project are attempting to explain the regulation of amino acid uptake, which permits molluscs to control their intake of food from the environment. An understanding of this mechanism may lead to increased productivity and quality of cultured molluscs. An important accomplishment in their work thus far has been to show that amino acids actually do enter into marine molluscs from natural sources in seawater and are distributed to internal tissues.

Laura Kingsford (CSULB) and Douglas W. Hill (UU), "*In Vitro* Cultivation of Marine Crustacean and Molluscan Cells," R/A-56.

Presently no known methods for isolating and identifying the agents of viral disease in marine molluscs and crustaceans exist, and thus it is difficult to diagnose their diseases. This is particularly critical in the aquaculture industry. Researchers are working on establishing the best conditions for laboratory growth and maintenance of cells from clams and shrimp since the ability to culture these cells would allow isolation and identification of viruses.

William N. Shaw, "Natural Setting of Purple-Hinge Rock Scallop, *Hinnites multirugosus*, in Northern California, R/NP-1-13K.

The major goal of this project is to provide potential scallop culturists in northern California with guidelines for the placement and removal of spat collectors in order to maximize the collection and survival of juvenile purple-hinge rock scallops.

Prudence Talbot (UCR), "Control of Reproduction in Crustaceans," R/A-59.

In their biochemical work on fertilization in crustaceans, researchers are attempting to aid the aquaculture of these commercially important marine invertebrates through control of their reproduction. Work is being done on artificial insemination of females with banked sperm, study of egg coats, and examination of sperm formation.

Joint work has been conducted with a researcher from the University of Paris on egg-coat formation and egg attachment, and technical information on the collection of sperm from crayfish has been shared with a colleague in Australia.

Ernest S. Chang, Wallis H. Clark, Jr., Douglas E. Conklin (UCD, BML), "Reproduction and Growth in Crustacean Aquaculture," R/A-61.

Control over reproduction and growth of crustaceans is necessary for the aquaculture of this important food source. Researchers have begun to elucidate the basic processes of reproduction through work on isolation of the molt-inhibiting hormone in lobster, demonstration of gamete binding and activation in shrimp, and determination of the role of Vitamin C in crustacean development.

Research on isolating molt-inhibiting hormone from the lobster is being done in collaboration with colleagues at Stanford and the University of Hawaii. Work on artificial insemination techniques has been aided by a visiting researcher from India.

Jared M. Diamond (UCLA), "Nutrient Uptake by Fish Intestine," R/A-57.

The goal of this project is to obtain information about nutrient absorption in fish intestine. Such information is essential for the rational design of fish diets—a major expense for commercial fish producers. Through study of nine fish species, the rates of absorption of sugars versus amino acids were compared. Testing was done on trout and carp to determine whether an individual animal can adapt to a change of diet during its lifetime. Also, studies were begun on how age and reproductive status affect absorption rates.

Cooperative studies on fish intestines have been conducted with researchers in Spain and Scotland, and future work is being considered with researchers in Italy and Israel. In addition, visitors from the Southeast Asian Fisheries Development Center in the Philippines were instructed in the laboratory's techniques.

Ronald P. Hedrick (UCD), "Evaluation of Protective Antigens of *Aeromonas salmonicida*," R/A-58.

Researchers in this project have examined antigens of the bacteria *Aeromonas salmonicida* for their potential for vaccinating salmon and trout to prevent furunculosis, an untreatable disease that kills large numbers of cultured salmon. To evaluate these antigens, four bacterial strains were tested for their virulence, and each was used to immunize trout to produce antiserum. There are three major antigens under study; each will be tested for potency and effectiveness in protecting immunized fish against the disease.

Information and results have been shared with colleagues from Oregon, British Columbia, and Washington.

Aharon Gibor (UCB), "Domestication and Genetic Improvements of *Sargassum* Species," R/NP-1-14A.

Species of seaweed such as *Sargassum muticum* that are abundant along the California coast have the potential for being harvested and fermented to produce methane. Work done in this study will make it possible to select the fastest growing plants, which can yield the highest fermentable biomass, and to develop strains having optimal growth under certain temperature and light conditions. Researchers have isolated and regenerated plant protoplasts from *S. muticum*, which will make biomass cultivation of this alga possible. Their techniques of protoplast isolation and improved tissue culturing can also be applied to other economically important seaweeds.

The project leader recently spent six months in Japan, sharing information and techniques with his colleagues there. His laboratory has also had a postdoctoral researcher from Japan and has hosted many Japanese visitors.

TROUBLES IN THE TUNA INDUSTRY

We Americans love our tuna salad sandwiches. In 1983, we purchased more than a third of the world's tuna harvest and nearly 60% of the canned tuna. Canned tuna is in fact the only seafood staple in the average American's diet, and U.S. consumption has been on the rise over the past 25 years.

Why then is our tuna industry in such serious trouble? In early 1985, 26% of the U.S. purse-seine fleet, 10% of the U.S. bait boat fleet, and 25% of the U.S. albacore troller fleet lay idle because they could not operate profitably or find a market for their catch. Further, only one small tuna cannery is still operating in the United States. The major U.S. tuna processing companies (Star-Kist, Van Camp, and Bumble Bee), which account for 70% of the U.S. canned tuna supply, now rely on production from offshore facilities in American Samoa and Puerto Rico and canned tuna imports from Asia to meet market requirements.

A report prepared for California Sea Grant, *The Economic Impact of Recent Changes in the U.S. Tuna Industry* by Dennis King and Harry Bateman (E.R.G. Pacific Inc.), analyzes the dramatic impacts of recent changes in the tuna industry on the U.S. economy.

King and Bateman point out that for the United States, as for other nations, high-seas tuna offer special opportunities because the fish grow quickly to market size and are harvested in the open sea.

Tuna exist in the tropical and temperate waters of the Atlantic, Pacific, and Indian oceans and tend to be most abundant in a band extending 20° on either side of the equator. Highly migratory, they travel up to 10,000 miles a year at speeds of up to 40 miles a day. There are a few locally based tuna fisheries, but most tuna fishing is conducted by distant-water fleets that follow tuna across the high seas.

As more is learned about the migratory nature of tuna, it becomes easier to understand the fiercely competitive nature of the international fishery. Albacore taken in the traditional winter fishery off Japan, for instance, now appear to be the same group of fish taken during the following spring near Hawaii and as part of the catch during the following summer and fall off the U.S. West Coast. Vessels in different national fleets, in other words, compete for the same resources even though they may be fishing thousands of miles apart.

Though U.S. tuna fishermen are basically involved in hunting—one of the most primitive of human activities—tuna fishermen may use the most modern technologies, sometimes including helicopters and satellite data. Purse seiners travel around the world on fishing trips that last up to four months aboard vessels that may cost as much as $10 million. They compete first of all on the high seas with fleets from more than 20 other nations—many nationalized or heavily subsidized. Later, they must compete again to sell their catch in a highly competitive international market.

—Los Angeles Times photo

San Pedro, once the nation's leading port both in value and poundage of fish landed, fears ruin as a result of overseas competition and skyrocketing insurance rates. The area has seen a dozen canneries close and a dramatic decline in the number of fishing boats berthed at the port. Here, the remaining vessels, which still hunt tuna, bonito, squid, and mackerel, turn out for the annual blessing of the fleet.

King and Bateman found dramatic changes in the structure of the U.S. tuna industry over the past 10 years. Through the mid-1970s the harvesting and processing segments of the U.S. tuna industry had been well integrated. Foreign-caught tuna was more expensive and was imported primarily to cover domestic shortages.

During the 1970s, however, the international tuna fleet grew enormously, many nations turning to high-volume "U.S. style" tuna purse-seine fishing. As a result, the supply of foreign-caught tuna increased significantly and prices dropped dramatically. Domestic tuna processing companies began to increase purchases of low-cost tuna in the international market and accelerated the movement of their own operations offshore to American Samoa and Puerto Rico.

American tuna fishermen, who had until this time relied on U.S. processors for financial, managerial, and marketing support in addition to a secure market, found themselves competing for their own domestic market against well-organized, government-supported, low-cost foreign tuna producers. To make matters worse, fuel prices and interest rates increased dramatically in the American economy, causing domestic fishing costs to skyrocket at a time when foreign competition and the strong dollar were driving tuna prices down. The upshot was that between 1980 and 1984, the U.S. fleet (seiners, bait boats, and trollers) declined by over 100

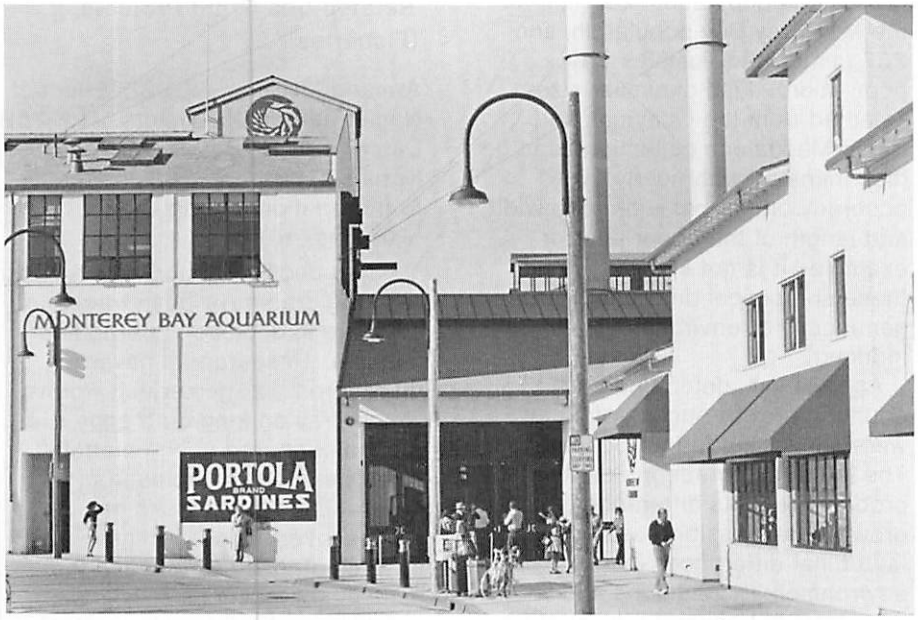
vessels, and most large vessels began to deliver their catch to offshore ports. Particularly hard hit were the smaller vessels that had been designed specifically to serve a West Coast tuna processing industry.

The relocation of U.S. tuna canneries has had obvious direct economic impacts, plus indirect and induced economic impacts as well. In 1980, 50% of the U.S. canned tuna (representing a total of around 30 million cases, worth about $1.5 billion) was supplied by U.S.-based processors, as compared to 15% in 1984 and only 2% in 1985. Since each case of canned tuna processed in the United States requires not only fish purchases of $10 to $12, but also another $6 to $9 in materials such as cans, cartons, labels, and port services, the effects of relocation move quickly throughout the economy. Lost too are jobs, income tax revenues, and landing fees.

Additional losses stem from the fact that, to remain competitive, U.S. vessels must refuel, reprovision, and perform repair and maintenance where they offload fish. When they deliver their harvest to foreign ports, these U.S. vessels take with them the market for shoreside support services, resulting in significant losses to other U.S. maritime businesses.

Using generally accepted economic multipliers to estimate impacts from changes in the tuna processing industry between 1980 and 1984, King and Bateman estimate the number of lost job opportunities for U.S. workers at nearly 4,000 jobs; the loss of income to U.S. households at nearly $82 million; the loss of revenues to U.S.-based industries at $395 million; and the loss of federal and state tax receipts at some $18 million. If changes in the fishing industry and related industries are added in, the losses swell to 12,500 lost jobs; nearly $300 million in lost household income; over $1.3 billion in lost sales by industry; and over $66 million in lost tax receipts. (D. M. King and H. A. Bateman, "The Economic Impact of Recent Changes in the U.S. Tuna Industry," R/NP-1-14G.)

SARDINE COMEBACK IN THE MAKING?



—© *Monterey Bay Aquarium*

The Hovden Cannery, located on the site where the Monterey Bay Aquarium now stands, packed Portola Brand Sardines among other products. In 1972, Hovden became the last cannery on the old row to close. Aquarium construction began in 1981.

The collapse of the Pacific sardine fishery in the years following World War II devastated a major fishing and processing industry, changing forever the character of coastal areas such as Monterey's famous Cannery Row. At its peak in the 30s and early 40s, the fishery had supplied fully one-fourth of the entire tonnage of fish landed in the United States, reaching a record yield of nearly 800,000 tons during the 1936-37 season. During this abundant period, it was believed that some schools contained over 10 million fish.

After the war, however, the Pacific fishery began a spectacular decline—most likely as a result of overfishing—dropping to a low of 14,800 tons in 1952-53 before recovering slightly. It is thought that this precipitous drop in the catch resulted from a decline in reproduction among two, or possibly more, genetically distinct subpopulations that failed successively from north to south, first in the Pacific Northwest, then in Northern California, and later in Southern California and Baja California.

In an attempt to understand the causes of the decline in the sardine catch, a joint research project was initiated. Fishery biologists and oceanographers from the California Department of Fish and Game, National Marine Fisheries Service, and UCSD's Scripps Institution of Oceanography, organized under the umbrella of the California Cooperative Oceanic Fisheries Investigations (CalCOFI), began the most intensive study ever undertaken of any marine fish found in U.S. coastal waters.

In 1967, as a result of the CalCOFI investigation, a moratorium on sardine fishing in California was finally enacted, and in 1974 state legislators voted to prohibit sardine fishing. But the law also provided for a 1,000-ton annual fishery in California whenever the state's Department of Fish and Game determined that the population of adult sardines had reached 20,000 tons.

On January 1 of this year, after five years of encouraging signs that a population resurgence might be in the making, Fish and Game opened a 1,000-ton commercial sardine fishery. Has the fishery actually begun a comeback?

With support from California Sea Grant, Dennis Hedgecock of Bodega Marine Laboratory and the University of California, Davis, has been looking at biochemical and anatomical differences in sardine and anchovy populations in order to gain information about their genetic structures. Hedgecock hoped to determine, among other things, whether genetically distinct populations of sardines do in fact exist, and, if so, which group is recovering.

Information about fish population structure is extremely important to fisheries managers around the Pacific Basin, especially in light of the collapse not only of the Pacific

sardine fishery, but also of the Japanese sardine and the Peruvian anchoveta fisheries. Cooperating with Hedgecock in his study were the Southwest Fisheries Center and Pacific Environmental Group Laboratories of the National Marine Fisheries Service; the Universidad Autonoma de Baja California Sur, La Paz; the Centro Interdisciplinario de Ciencias Marinas, La Paz; and the Departamenta de Pesca in Guaymas, Mexico.

Hedgecock and his Sea Grant trainee analyzed extracts of homogenized eye, liver, heart, and skeletal muscle tissues from sardines for 23 different enzymes and proteins thought to be the products of 32 separate genes. The fish came from populations from the vicinity of Guaymas in the Gulf of Mexico; Baja California Sur; and from Monterey and Tomales bays in California.

To Hedgecock's surprise, the biochemical analysis showed the sardines to be quite homogeneous within populations, and the four populations proved to be virtually identical genetically. That is, there is no biochemical evidence that subpopulations presently exist. Further, because of the similarity of samples from the Pacific Ocean and the Gulf of California, it does not appear likely that the collapse of the Pacific fishery was the cause of a widespread reduction in genetic variation. Without samples from historical populations, however, Hedgecock cannot determine whether his techniques would have detected genetically distinct subpopulations prior to the decline.

Hedgecock's analysis of 13 anatomical features at first revealed no variation in shape among the four sardine populations. However, it was later found that significant differences in size were obscuring slight but significant differences in shape (average standard length recorded for different locations were 150 mm for the Guaymas population, 165 mm for the Bahia Magdalena population, 202 mm for the Monterey Bay population, and 237 mm for the Tomales Bay population). Fish of similar sizes selected from the Guaymas and Bahia Magdalena collections can be discriminated with nearly 100% accuracy on the basis of head width and length of the upper jaw, for example. It is not known whether these anatomical differences are genetically or environmentally induced.

Ages of fish, determined by counting growth rings in otoliths, were similar in the four populations. The latitudinal grade in fish length probably reflects differences in growth rate, possibly resulting from latitudinal differences in environmental conditions and suggests that geographic variation in growth rate today is at least as great as that reported for historical sardine populations.
(D. Hedgecock, "Genetic Analysis of Anchovy and Sardine Populations in the California Current System, R/F-98.)

Related Sea Grant Projects (Fisheries)

Armand M. Kuris (UCSB), "Effect of Nemertean Egg Predators," R/F-75B.
Daniel E. Wickham and Armand M. Kuris (UCSB), "Brood Mortality and Egg Predation in King Crab Fisheries," R/F-AL.

Rapid decline in stocks of Alaskan red king crab have been traced to severe egg depletion in brooding females. Researchers have discovered that nemertean worms, which prey on king crab eggs, are the major source of egg mortality. Analysis of egg samples from several important stocks has led to the discovery of several new species of these worms and the mapping of locations of epidemic conditions. Analysis of samples taken through three brooding seasons has revealed how worm density and egg mortality change through the course of the brooding season. In a related cooperative project with Alaska Sea Grant (R/F-AL), California Sea Grant is supporting a graduate student's work on brood mortality and egg predation in the fishery.

Reuben Lasker (SIO, SWFC), "The Effects of Climate and Weather on Albacore Migration and Distribution in the Northeastern Pacific," R/F-86.

The objective of this project has been to determine the influence of climatic and weather fluctuations on the migration and distribution of albacore tuna along the North American coast. The researchers have used satellite data to monitor surface thermal and chlorophyll patterns; estimates of surface wind stress to monitor variability in wind forcing; and catch data from the North American fishery to study seasonal albacore migration. They have found a strong correlation between the persistence of surface thermal fronts and areas of high albacore aggregations. Image-processing techniques developed in this project hold the potential for

quickly identifying regions of high albacore concentrations and forecasting the destruction of such regions.

Graham A. E. Gall (UCD), "Contributions of Coho and Chinook Spawning Populations to Mixed Fisheries: A Management Study," R/F-87.

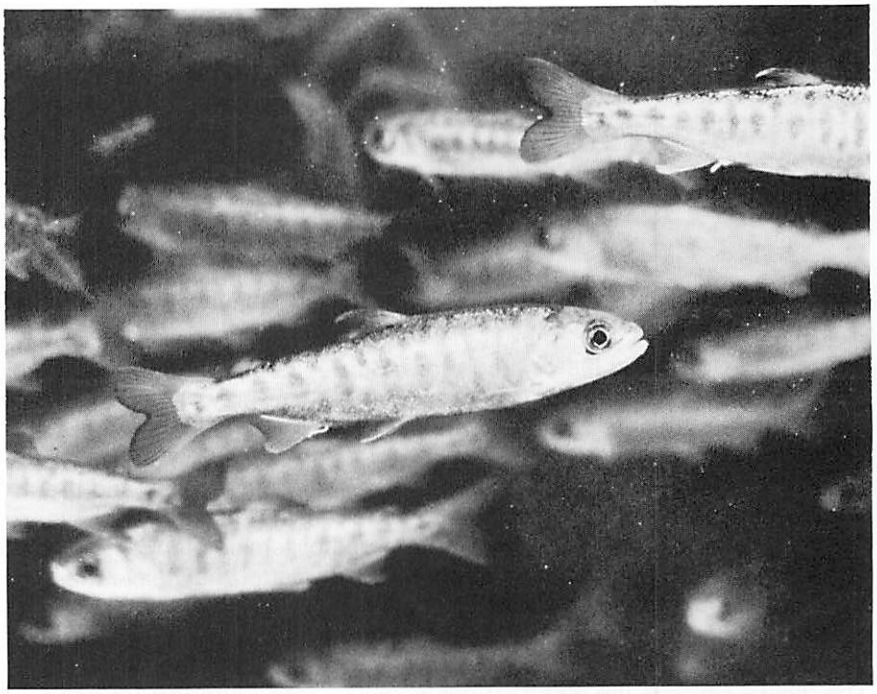
To allow more effective management of the salmon fishery, researchers are studying the population structure and genetic differentiation of chinook and coho salmon. This work is being used to estimate the contribution of various stocks to the fishery and to identify genetically interesting stocks. Locations of seasonal runs have been found, and extensive population sampling done. Electrophoretic analyses and life history data are being used to elucidate genetic differences and other biological parameters of the populations.

Close collaboration is maintained with colleagues in California, Oregon, Washington, and British Columbia.

Serge I. Doroshov, Joseph J. Cech (UCD), "Establishment of Parameters Critical to Sturgeon Management in the Pacific Northwest," R/F-90.

Researchers in a multidisciplinary project are studying the biology of white sturgeon to develop better management policies based on proper fishery regulation and environmental protection. Adult sturgeon from San Francisco Bay have been extensively sampled and analyzed, leading to the examination of food attractants, the improvement of induced spawning techniques, the documentation of salinity tolerance, the establishment of some nutritional requirements, and the identification of disease agents.

A significant information exchange is conducted with Fisheries Canada and the University of Washington. Project results have influenced a



Because salmon support one of the most valuable fisheries in the northern hemisphere, this project has attracted collaborators from around the world.

Salmon Attract International Interest

The remarkable physiological transformation of salmon from freshwater fish to saltwater fish, a process called smoltification, appears to be influenced by the thyroid hormone and to be primed by environmental conditions, including the phase of the moon.

Howard A. Bern and Charles S. Nicoll of the University of California, Berkeley, have been studying hormonal control of salmon growth and development for several years now with support from California Sea Grant, in company with their associates Richard S. Nishioka and Graham Young. Because salmon are one of the most valuable fisheries in the northern hemisphere, this project has attracted collaborators from around the world. These include M. Iwata of Otsuchi Marine Research Center, Tokyo University, who spent two years in the Berkeley laboratory conducting studies of salmonid seawater preference and osmotic pressure; T. Hirano and J. Bolton of the Ocean Research Institute, Tokyo University, who developed a test for salmon growth hormone and who measure levels of growth hormones for the Berkeley laboratory; K. Yamauchi of Hokkaido University, who spent a year at the Berkeley laboratory studying, among other things, salmonid seawater preference; and P. Prunet of INRA, Rennes, France, who developed a technique for measuring salmon prolactin and assays blood samples for the project.

(H. A. Bern, C. S. Nicoll, "Endocrine Control of Salmonid Development and Seawater Adaptation," R/F-101.)

Tracking Elephant Seals

Project leader Daniel Costa attaches a time-depth recorder to a female elephant seal.

Daniel P. Costa and his collaborators, Burney LeBoeuf and Anthony Huntley, of the University of California, Santa Cruz, may have provided the solution to the case of the disappearing elephant seals through their work for California Sea Grant.

As part of this study of the impact of the California sea lion and the northern elephant seal on commercial fisheries, the researchers have been trying to determine the feeding patterns of female elephant seals, which forage at sea for as long as three months after they leave the beaches at the end of the breeding season.

Since 1983 they have been experimenting with the use of recoverable depth recorders, which are glued to the animals to track their behavior. The device records the elephant seals' diving activity on film for up to two weeks.

In 1984-85, they successfully attached the devices to three females, preferred over males for these studies because they tend to return within 60 to 80 days to their established breeding grounds to molt. When the animals later returned to the beach, the researchers recovered the film and found that, among other things, the three animals routinely dove to 330 to 375 m, reaching maximum depths of 820 to 850 m—the deepest range recorded for any pinniped.

In addition, the film indicated that diving was continuous for at least the first 11 to 16 days after the animals left the beach (after that the film ran out). Animals made between 2.2 and 3.2 dives per hour, staying under water an average of 22 minutes (the longest dive recorded was 42 minutes). Since the elephant seals only spent about 3 minutes at the surface between dives, this meant that over the period during which their behavior was recorded, they were under water 89% of the time!

Costa's results solved quite a mystery for researchers from the Department of the Interior. Their aerial surveys, conducted after the animals had left the beaches, showed fewer animals at sea as compared with those originally counted on the beaches. The discrepancy had led to speculation that elephant seals leave California waters immediately after the breeding season. But this work suggests that aerial surveys may pick up only one of every ten animals—those that happen to have surfaced.

This study has important implications for managers interested in the seasonal abundance and movement patterns of this species. It has proved of interest to researchers from countries around the world, including Canada, Australia, New Zealand, and Chile, who are interested in the interactions between marine mammals and fisheries.

(Daniel P. Costa, "Assessment of the Impact of the California Sea Lion and Elephant Seal on Commercial Fisheries," R/F-92.)

new international export trade in sturgeon larvae.

Ronald P. Hedrick (UCD), "Kidney Diseases of Pacific Salmon," R/F-100.

Proliferative kidney disease (PKD) and bacterial kidney disease (BKD) have both caused devastating losses in fresh- and saltwater Pacific salmon. To prevent the spread of these diseases, researchers are working on determining the nature, source, and seasonality of the parasite that causes PKD and on examining the effect of BKD on saltwater adaption. The PKD parasite has been identified and its stages in the salmon host described.

A workshop on PKD attracted workers from the Pacific Northwest and Canada; cooperative studies with the Ministry of Agriculture, Fisheries and Food (United Kingdom) are in progress.

David G. Hankin (HSU), "Chinook Salmon Spawning Behavior," R/F-103.

Fishery biologists are concerned that present fishery-induced shifts toward smaller sizes and younger ages in chinook salmon spawning populations may result in long-term genetic shifts in maturation schedules of these salmon. This concern is being addressed in this project through observations of the relationship between size and mating success. Thus far it has been shown that dominance among males is achieved principally through size and that dominant males are nearly always first to spawn with females.

George N. Somero (SIO), "Biochemical Indices of Activity in the Northern Anchovy," *Engraulis mordax*," R/F-102.

In a continuing study, researchers have begun to develop a series of biochemical measurements for estimating the physiological state of

the northern anchovy, which ranges from Baja California to British Columbia. This information will eventually be used to develop field energy budgets for pelagic marine fishes. Thus far, researchers have perfected their analytical procedures and have begun a study of how biochemical properties vary with size of fish. Work has also been done on the laboratory conditioning of anchovies and the effects of different conditions of diet and exercise on biochemical properties of muscle.

Dennis Hedgecock (UCD, BML), "Relationships Among Ploidy, Success of Eyed-Larval Settlement, and Early Growth in the Pacific Oyster," R/NP-14B.

To improve the utilization of Pacific oyster seed imported by California's oyster growers, biologists in this project have studied seasonal variation in the reproductive conditioning of local oysters and investigated ways to condition and spawn these oysters throughout the year for controlled hatchery reproduction. Experiments in the laboratory have shown larval survival to be dependent on water quality, size and shape of larval culture vessels, and nutrition, among other factors. It was found that substances used to artificially induce metamorphosis are useful for controlling production of oysters.

The results have potential application throughout the Pacific Basin, since the Pacific oyster is now cultivated in Mexico, several Pacific Islands, Australia and New Zealand, the Philippines, and Japan

Judith W. Zyskind (SDSU), "Enzymatic Degradation of Material from Shellfish Processing," R/F-93.

Chitin is an insoluble organic component of all shellfish and is very common in the marine environment. Researchers in this project are working to develop methods for producing enzymes to break down chitin into commercially valuable products. Using genetic engineering techniques, they have cloned the genes of a marine bacterium that produces the enzymes that degrade chitin. They have developed a simple one-step purification procedure for the isolation of one of these enzymes.

David M. Ogrydziak (UCD), "Genetic Improvement of a Chitinase-Producing Microorganism," R/F-96.

Researchers are investigating ways in which chitin waste from shellfish can be disposed of economically and/or converted into usable products. An enzyme called chitinase, which breaks down chitin, is produced from the bacterial strain *Serratia marcescens*. Attempts are being made in this project to clone the gene in this bacterium responsible for production of chitinase.

Constantin Genigeorgis (UCD), "Quantitative Evaluation of *Clostridium botulinum* Growth Risk in Seafood at Low Temperatures Under Modified Atmospheres," R/F-99.

Modified atmospheres (MA) are new technologies (involving vacuum, air, or CO_2 environments) that delay spoilage of fish and other perishable foods. The potential of botulism during MA storage remains the one limitation to expansion of its use. Researchers studied the rate of spoilage of fish inoculated with *Clostridium botulinum* and stored under a variety of predetermined MA conditions. They have demonstrated the feasibility of predicting the probability of *C. botulinum* growth and toxin production in seafood stored at various temperatures under MA.

Louis W. Botsford (UCD, BML), "Comparative Study of Dungeness Crab Fisheries," R/MA-20.

Researchers have focused on a potential environmental mechanism (wind-driven larval transport) that may be responsible for cycles in dungeness crab populations along the Pacific Coast. Through sampling of the planktonic larval phase, they have begun to determine how oceanic conditions influence year-class size. This has led to the development of a coastwide model of the interaction of oceanographic conditions with population dynamics.

ON MAKING QUALITY KING

The Japanese, who consume over 70 pounds of fish per person each year—compared to 13.6 pounds for U.S. citizens—are known to be discriminating buyers. They expect a fish to be unbruised, its scales shiny, its gills bright red, and its eyes bright. In the giant seafood markets of Japan, one does not even smell fish!

In Japan quality is king; that nation's knowledgeable seafood consumers expect fish to be absolutely fresh in taste and in appearance. As a result of consumer demand, the Japanese seafood industry is dedicated to high quality at every step. Whereas a U.S. fisherman might place a newly caught fish on ice, for example, Japanese fishermen fill it with ice.

California Sea Grant's Marine Advisory Program has been working with U.S. harvesters, wholesalers, and retailers to educate them about the importance of quality-control, both as a basis for increasing domestic consumption and for creating export products acceptable to overseas markets.

In addition, Sea Grant-funded scientists are studying better ways to keep fish fresh. Davis S. Reid of the Department of Food Science and Technology at the University of California, Davis, and his Sea Grant trainee, Nai-Fen Doong, are, for example, evaluating the effects of rate of freezing, and temperature and length of storage, on deterioration of fish tissue. The project originally evolved as a collaborative effort with a Norwegian research team, the leader of which spent some time in Reid's lab.

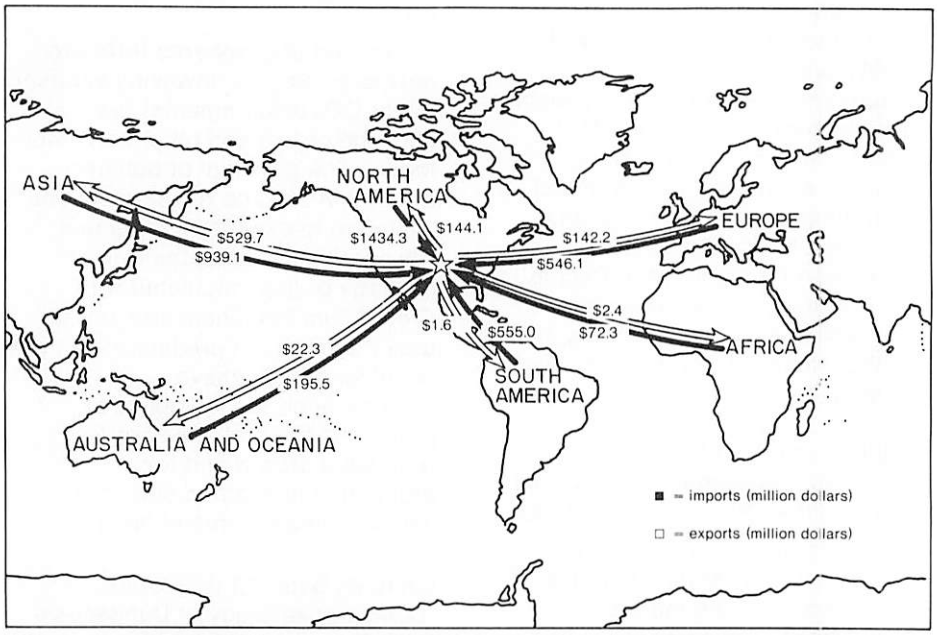
Reid's study involves analyzing the structure and biochemistry of fresh rockfish and then freezing the fish either quickly (in less than 1½ hours) or slowly (in more than 24 hours). Frozen fish are stored at one of three temperatures: −5° C, −12° C, or −20° C. To facilitate study of the microscopic changes in the structure of the frozen fish over time, a specialized fixation method known as isothermal freeze fixation was developed at the Davis lab. Without disturbing the ice present in the tissue, the method allows the tissue to be observed either by an optical or scanning electron microscope.

In addition, Reid and Nai-Fen Doong are following particular biochemical indicators of deterioration. These include degree of water loss, changes in protein structure and solubility, changes in enzyme activity, and lipid degradation. Ultimately the researchers hope to correlate differences in freezing regime and storage conditions with specific changes in structure and biochemistry.

Reid and his trainee, a graduate student from Taiwan pursuing her Ph.D at Davis, plan to use the experimental data to prepare a computer model which can predict how the temperature will change at different positions within a fish under other freezing conditions.

(D. S. Reid, "Freezing-Induced Changes in Fish Tissue," R/F-95.)

Nai-Fen Doong was one of the graduate trainees who worked with Sea Grant project leaders at 12 California colleges and universities during 1984-85.



U.S. exports of edible fishery products in 1984 totaled $842.3 million, while imports hit $3,742.3 million. Better storage and processing techniques could help the United States improve its trade balance. (Data source: *Fisheries of the United States*, 1984. National Marine Fisheries Service/NOAA.)

OIL FROM ARCTIC WATERS

Offshore oil exploration and production have moved successfully over the past three decades from the shallow waters of coastal regions into the more hostile deep ocean areas of the Gulf of Mexico, the North Sea, and the northwest coast of Australia.

More recently, the Arctic Ocean has become the frontier for exploration activity. Prospects of finding large or even giant reserves of gas and oil in the Beaufort Sea have stimulated large exploration projects, leading in some instances to the discovery of viable oil and gas reservoirs.

Future lease sales in the Alaskan sector of offshore continental shelf areas will open for exploration zones in water depths from 60 to 300 feet and even greater. These areas lie in the dynamic Stamukhi shear zone of the polar ice pack, where ice poses a year-round threat to production structures. In summer, ice floes can achieve velocities of 3 feet per second. Even when moving more slowly, these floes can produce extremely large impact forces due to their huge masses—floes of up to 10 million tons have been sighted. In winter, ice floes with dense embedded ridges that have built up over many years will subject structures to enormous pressures.

Compounding design difficulties is the fact that oil production structures destined for Alaskan waters will typically be constructed in warm-water ports and then towed across the Pacific Ocean to the site—during this period, the structure will have to act as a floating vessel, a kind of ship.

A Sea Grant-funded project by Ben C. Gerwick, Jr., of the University of California, Berkeley, and his trainee Sanjay Sakuja has produced a preliminary assessment of the design aspects, constructibility, and durability required of offshore oil production platforms in this area of the Arctic. The report addresses a variety of subjects, including ice-force analysis, foundation and structural design, marine considerations, risk and reliability evaluation, and constructibility. The study, intended to provide designers and regulatory agencies with a means for designing and evaluating oil production structures for the Alaskan Beaufort Sea, has already sparked the interest of Japanese, Canadian, and Norwegian groups—all of which are in the process of designing and constructing offshore structures to meet the rigors of the Arctic.

(Ben C. Gerwick, Jr. (UCB), "Development of a Methodology for the Design of an Offshore Oil Production Platform on the Alaskan Arctic Ocean Continental Shelf," R/OT-11).

Related Sea Grant Projects (Ocean Technology)

Bruce P. Luyendyk (UCSB), "The Geology and Structure of the Southern Hosgri Fault Zone Offshore California: A 3-D View Using Computer Color Graphics," R/OT-10.

The seismically active Hosgri fault zone cuts across an area near Point Arguello that is being developed for offshore oil. Because of the resulting need for hazard assessment, it is important to understand the structural nature of the fault zone. Geologists in this project are using three-dimensional color graphics techniques to obtain a better view of the geologic structure. Detailed data have been collected and stored in a computer. Using this data base and software that the researchers have developed, the location and form of sub-bottom folds and faults can be examined. Thus far, both the southern and northern terminations of the fault zone have been found, and some of the complexities of its relationship with the Transverse Ranges are being unravelled.

Jean-Louis Armand (UCSB), "Capsizing of Semi-Submersible Platforms," R/OT-12.

Semi-submersible platforms used in offshore oil and gas exploration can become unstable under extreme conditions, such as when damaged during a severe storm. Using mathematical methods, researchers have derived a new analytical formula to express the effects of waves, currents, wind, and hydrodynamic impact on a semi-submersible rig. This formula will provide a better understanding of how a platform will respond to such forces and help in the derivation of equations describing a platform's motion.

Rodney J. Sobey (UCB), "Wave Groups in Surface Gravity Waves," R/NP-1-14D.

Models that describe real oceanic conditions are used extensively by coastal and ocean engineers and naval architects to evaluate design alternatives and to predict the evolution of coastal processes. There is a need to adequately represent wave groupings, which are runs of consecutive high waves in surface gravity waves. Engineers in this project are working to establish the nature and extent of wave groupings and to develop a comprehensive range of suitable analysis techniques. They have developed wave record analysis algorithms to allow the identification of wave groups in both the frequency and time domains. The major part of their extensive wave data base has come from Australia.

THE RENAISSANCE OF AMERICAN PACIFIC OCEAN SCIENCE

"High seas research on a scale far beyond anything that the United States has undertaken or thought about in the past...." This was the vision in 1946 that motivated Wilbert Chapman, a young marine biologist at the California Academy of Sciences, and two colleagues, Oscar Sette and Milner Schaefer of the U.S. Fish and Wildlife Service (USFWS). Their efforts to achieve that vision would help to put American science on the map in Pacific high-seas research.

The complex political process that created the postwar U.S. Pacific oceanographic program is being analyzed by Professor of Law Harry N. Scheiber and his Sea Grant trainees at the University of California, Berkeley. In their work, Scheiber and his associates have examined the development of the West Coast fisheries from 1945 to the present in relation to science, government, political process, and international relations and law.

Although the United States had just fought a protracted naval war in the Pacific, most of that ocean's deep-water regions were still a largely unknown frontier to American science in 1945-46. Not since the last *Albatross* voyages 30 years earlier had there been a major U.S. Pacific high-seas oceanographic expedition concerned primarily with marine biology. There had indeed been some distinguished West Coast research in the 1920s and 1930s on marine fisheries, but it had been confined almost exclusively to nearshore waters. In 1940, there were only two small vessels that could conduct deep-water research of any kind on the entire Pacific coast.

Chapman, Sette, and Schaefer were determined to change all that. Their goal was a new large-scale study of the Central and South Pacific regions aimed at identifying and opening up for American fishing fleets the untapped tuna resources of that vast region. The project they envisioned was to be a major scientific enterprise, with three large ships outfitted with state-of-the-art scientific instrumentation and gear, to be based in Hawaii and run by the USFWS in collaboration with Pacific coast and Hawaiian academic and governmental institutions.

In a few days of concentrated work, Chapman, Sette, and Schaefer produced a draft of a statute that they hoped could win the support of American fishing industry interests, the scientific establishment and state marine agencies, and a significant block of votes in Congress. In subsequent lobbying efforts, Chapman repeatedly declared that the Pacific Ocean was "the Great Plains of the twentieth century."

Key senators and representatives from the West Coast, but particularly Hawaii's Delegate Joseph Farrington, pushed the legislation through Congress in 1947. The new measure, passed essentially as the three scientists had written it, launched the Pacific Ocean Fishery Investigations (POFI), financed initially at more than $1 million—more than the federal government had spent on Pacific high-seas fisheries research in the previous two decades. Within about six years, Chapman's, Sette's, and Schaefer's efforts had established the foundations of a major scientific enterprise for the United States and also a scientific basis for the modern Pacific fisheries economy. They had also helped advance the methods of oceanography and marine biology.

The POFI project resulted in a quantum jump in America's scientific presence in the Pacific. And, as Scheiber's research shows, the POFI investigations were soon linked systematically into two other major new projects on Pacific fisheries. One, the California sardine study, was the first major West Coast undertaking in coordinated research in deep-water fishery studies. Sponsored largely through a special landings tax in California, this study involved mainly the cooperative efforts of the USFWS, Scripps Institution of Oceanography (SIO), the California state marine laboratory scientists, and the California Academy of Sciences. Like POFI, the sardine study vastly increased the equipment, personnel, and scientific work dedicated to Pacific waters.[1]

The second project, the Inter-American Tropical Tuna Commission investigations of Eastern Pacific tuna, was launched in 1951 under the joint auspices of the United States, Costa Rica, Mexico, and (later) other Latin American nations. Appropriately enough, Milner Schaefer, who had been assigned to POFI as biological studies director, was given charge of the Tuna Commission. Oscar Sette meanwhile masterminded the spectacularly successful scientific studies conducted by POFI in the 1950s—studies that did much to open up the expanded U.S. tuna fishery of that era.

Wilbert Chapman, third of the scientific trio that had planned POFI, was also at the center of subsequent developments. Together with Roger Revelle and Carl Hubbs, SIO, and Montgomery Phister of the Van Camp Sea Food Company, he became the prime mover in organizing the California sardine study. Appointed in 1948 as the U.S. State Department's first top-level fisheries officer, Chapman negotiated the two international agreements that initiated Tuna Commission studies.

One irony of history is that POFI, and to some extent the Tropical

[1]Scheiber and Arthur McEvoy, associate investigator under California Sea Grant project R/MA-13, published a study in *The Journal of Economic History* (1984) analyzing the interplay of science, industry interests, and political leadership in the sardine investigation.

Tuna Commission projects, initially aimed at heading off potential Japanese competition. Meanwhile, on the other side of the Pacific, the Allied occupation authorities under General Douglas MacArthur were giving high priority to rebuilding the capacity of the Japanese fishing fleet. Within a few years, Japanese tuna vessels were plying waters that had been discovered to be rich with tuna by the new American scientific projects, and Japan's own leaders in ocean sciences were establishing productive new cooperative relationships for joint studies of Pacific resources with the United States and other Pacific nations. Thus Japan quickly regained its position as the world's leading power in marine fisheries, but in an entirely new relationship to American science and industry—a fascinating development that Scheiber and his students are investigating in continuing studies.

(H. Scheiber, "The California Fisheries and Ocean Policy: State and Federal Dimensions, 1945-85," R/MA-25.)

Related Sea Grant Projects (Marine Affairs)

Ronda K. Hageman (SDSU), "Benefit/Cost Valuations in a Multispecies Ecosystem: Implications for Management of the Southern Sea Otter," R/MA-24.

Researchers will provide data on the costs and benefits associated with protection of the southern sea otter. This will aid management authorities in protecting the otter populations while managing interrelated and competing marine resources. Researchers have thus far been able to estimate economic losses in the abalone fishery and in the recreational clamming industry, and to refine and apply a valuation methodology for determining the "existence value" of a threatened species.

Carroll W. Pursell (UCSB), "Containerization in the California Maritime Transportation Industry: 1958-1980," R/MA-23.

Containerization has been a major factor in the development of key California ports for more than 25 years and has affected the policies of every element of the maritime transportation industry. Yet no study has been made of the growth and adoption of this technology, nor has an analysis been made of the technical, social, or economic changes it has caused. It is hoped that this analysis will provide members of the California maritime industry, governmental agencies, the academic community, and the public with an improved policy-making capability.

Biliana Cicin-Sain (UCSB), "New Challenges Ahead in Managing Santa Barbara Channel Resources," R/NP-1-14F.

Offshore oil activity is projected to increase dramatically in the Santa Barbara Channel. To aid government agencies in analyzing proposals and regulating this rapid development, researchers have reviewed the specific impacts on other users of the marine environment, and the cumulative regional impact as well. The major issues and management dilemmas involved in the current oil build-up have been characterized, and the conflict between the offshore oil and fishing industries analyzed.

George T. Hemingway (UCSD, SIO), "Scientific Liaison, Joint Research, Planning, and Information Exchange Among Alta California, Baja California, and Gulf of California Marine Scientists," A/S-1.

The major goal of this project has been to provide liaison between U.S. and Mexican scientists for the purpose of introducing workers with mutual scientific interests and facilitating research planning, information exchange, and bibliographic support. All of the goals have been met through many cruises carried out on both U.S. and Mexican vessels, with scientists from both countries participating, and through extensive exchange of books, journals, and reprints.

DRUGS FROM THE SEA

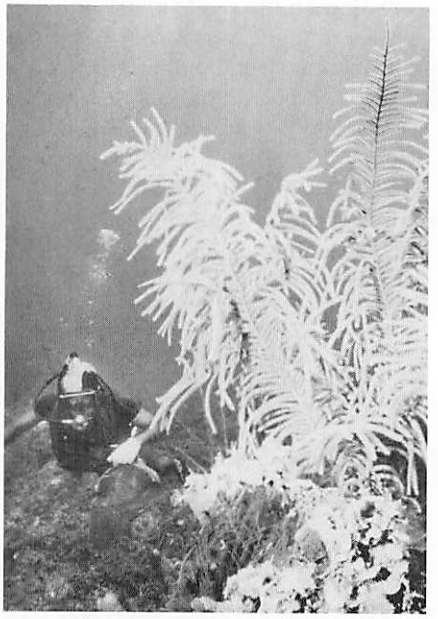
Plants and animals from the world's seas and oceans have been almost totally ignored as possible sources of medicinal drugs and insecticides. Thus, the estimated half million different marine species remain a vast and virtually untapped resource of new and useful natural products.

Since 1977, California Sea Grant has been supporting the work of an interdisciplinary team of University of California researchers and their graduate-student trainees, who are exploring the potential of marine invertebrates and algae to supply drugs. Team members—John Faulkner and William Fenical of UCSD's Scripps Institution of Oceanography; Robert Jacobs of the University of California, Santa Barbara; and Phillip Crews of the University of California, Santa Cruz—are examining organisms such as sponges, soft corals, nudibranchs, and algae for compounds with promising drug action.

Each year, members of the team collect and identify specimens in Mexico, the Caribbean, and in the South and Western Pacific. Extracts from these organisms are immediately prepared and concentrated so that their biological activity can be measured. In particular, researchers test for compounds that are anti-inflammatory, retard cell division, or affect the skeletal system.

Since the beginning of this project, over 800 compounds have been tested. Of these, 17 have been selected as novel and pharmacologically potent enough to be of possible interest to the pharmaceutical industry.

In order to facilitate the patenting of these drug candidates, the researchers have established a "Marine Materia Medica" program within the UC Santa Barbara Foundation. They also work closely with industry at several steps. While the reseachers provide industry with new drug leads, their industrial collaborators provide advanced biotesting, patent counseling, and matching funds for continued investigations.



Researchers have extracted an anti-inflammatory drug from a species similar to this Caribbean sea whip.

Among the compounds with the most promise are potent anti-inflammatory drug agents derived from a sponge and from soft coral; a compound extracted from a brown seaweed that inhibits cell division; a new drug agent from a sponge which facilitates neuromuscular transmission and can reverse drug-induced paralysis; and a fungicide derived from a sponge.

Team members have had cooperative relations with researchers in Chile, India, and Fiji, and will participate in a major workshop on marine biomedicinals in Japan this summer.
(Marine Chemistry and Pharmacology Program, Phase II: R. Jacobs, "Pharmacological Screening and Evaluation," R/MP-31; W. Fenical, "Chemical Studies of Tropical Marine Algae and Coelenterates, R/MP-32; D. John Faulkner, "Metabolites from Marine Invertebrates, R/MP-30; P. Crews, "Natural Products from Toxic Marine Organisms," R/MP-33.)

Related Sea Grant Project (New Marine Products)

Leonard J. Deftos (UCSD), "Natural Marine Products That Regulate Mineral and Bone Metabolism," R/MP-28.

The overall objective of this project is to study the application of natural biological products isolated from fish as a treatment to regulate bone formation and resorption in people suffering from bone diseases. In their metabolic work on bass and sharks, researchers have discovered several major biological principles that will allow the development of therapeutic and diagnostic agents useful to the pharmaceutical industry. Specifically they have found that bass can dissolve implanted bone particles and that a substance called calcitonin raises blood calcium in sharks.

HELPING A REFUGEE COMMUNITY ADAPT

Many of the nearly half million Vietnamese who entered the United States in the past decade elected to call California home. For most, the decision hinged on the presence of family, friends, or jobs. But a few were drawn by the possibility of returning to their traditional livelihood, fishing.

Like any immigrant group, the Vietnamese have had some difficulties adjusting to their new culture. To ease their integration into California's commercial fisheries, Sea Grant's marine advisors and specialists have been working with this community for the past several years. Their work has been based in part on understandings provided by social scientist Michael Orbach. In 1980 Orbach, with Sea Grant support, had investigated the adaptation of Indochinese refugees to the Monterey Bay fishing industry.

The first Vietnamese refugees to enter California fisheries were crew members on squid and anchovy boats around Monterey Bay. By 1978, however, the refugees were purchasing fishing vessels. Today they own approximately 80 fishing boats, or roughly 1% of California's commercial fishing fleet.

Prohibited by federal law from owning vessels over five net tons (about 35 feet), the newcomers acquired small vessels, generally designed for use in inshore waters. Often these were recreational vessels that had to be modified by enlarging cabins, increasing railing heights, and adding commercial fishing gear.

Vessel size was one of the factors that led the Vietnamese to choose set gillnets as their primary fishing gear—a choice that turned out to be controversial. Set gillnets, used throughout the world but not widely accepted in California, run along the ocean bottom like a fence, entangling fish that run into them. Nontargeted fish, birds, and mammals can also become entangled in the nets. In addition, conflicts arise when other types of fishing gear are used in the same area.

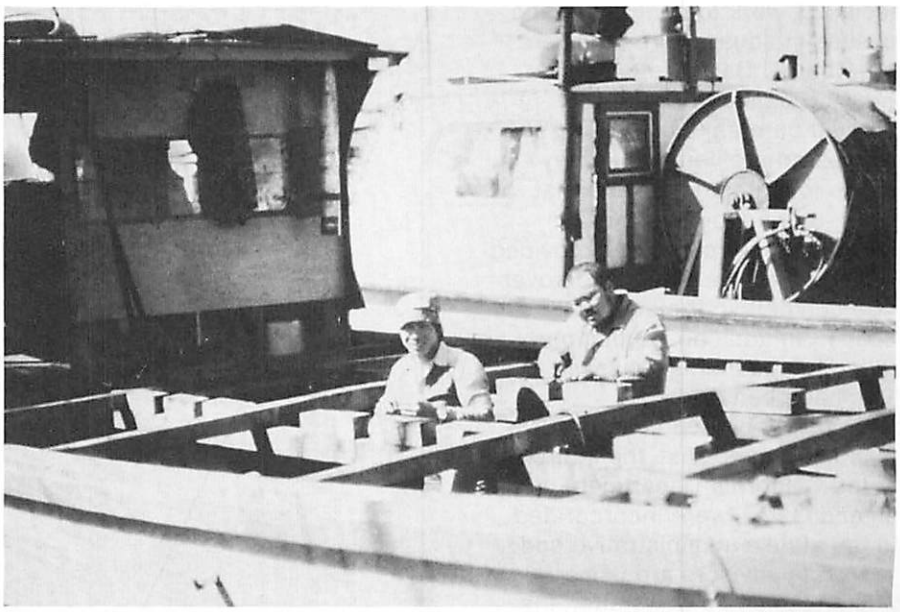
Initially the new gillnetters focused on white croaker, called kingfish locally, a species ignored by domestic fishermen but readily saleable to U.S. Asian markets. Thus, like other newcomers before them, the Vietnamese developed and expanded markets for what had been an underutilized species.

Later, some refugees began targeting California halibut, a species much-prized by domestic fishermen. Competition grew when, as a result of legislation that restricted nearshore gillnetting, a large portion of the gillnet fleet shifted to deepwater rockfish. This move to waters farther offshore necessitated longer fishing trips and created serious safety problems for the refugees, whose boats, as mentioned, are small vessels designed for use closer to shore.

The refugees' poor English skills have also contributed to their safety problems. In emergency situations, their inability to communicate with the Coast Guard has resulted in the loss of lives and vessels. In response, Sea Grant's Marine Advisory Program has cooperated with the California Department of Boating and Waterways, the Coast Guard, and various fishing associations to sponsor workshops on the use of radio and safety equipment. A videotape on safety practices is also planned.

Language problems have made it difficult for the refugees to learn complex fishing and boating laws, and local fishing customs. Here Sea Grant's Marine Advisory Program helped bridge the language barrier by developing, in conjunction with the California Department of Fish and Game, a Vietnamese edition of the *Summary of Commercial Fishing Laws*. Sea Grant advisors also conducted joint workshops in order to explain the laws to the fishermen with the California Department of Fish and Game, the U.S. Coast Guard, and a number of fishing organizations.

A recent assessment by the advisory program identified safety and use of marine electronics as two top-priority areas for continued work. In addition, marine advisors are attempting to interest the Vietnamese in the use of gear other than gillnets.



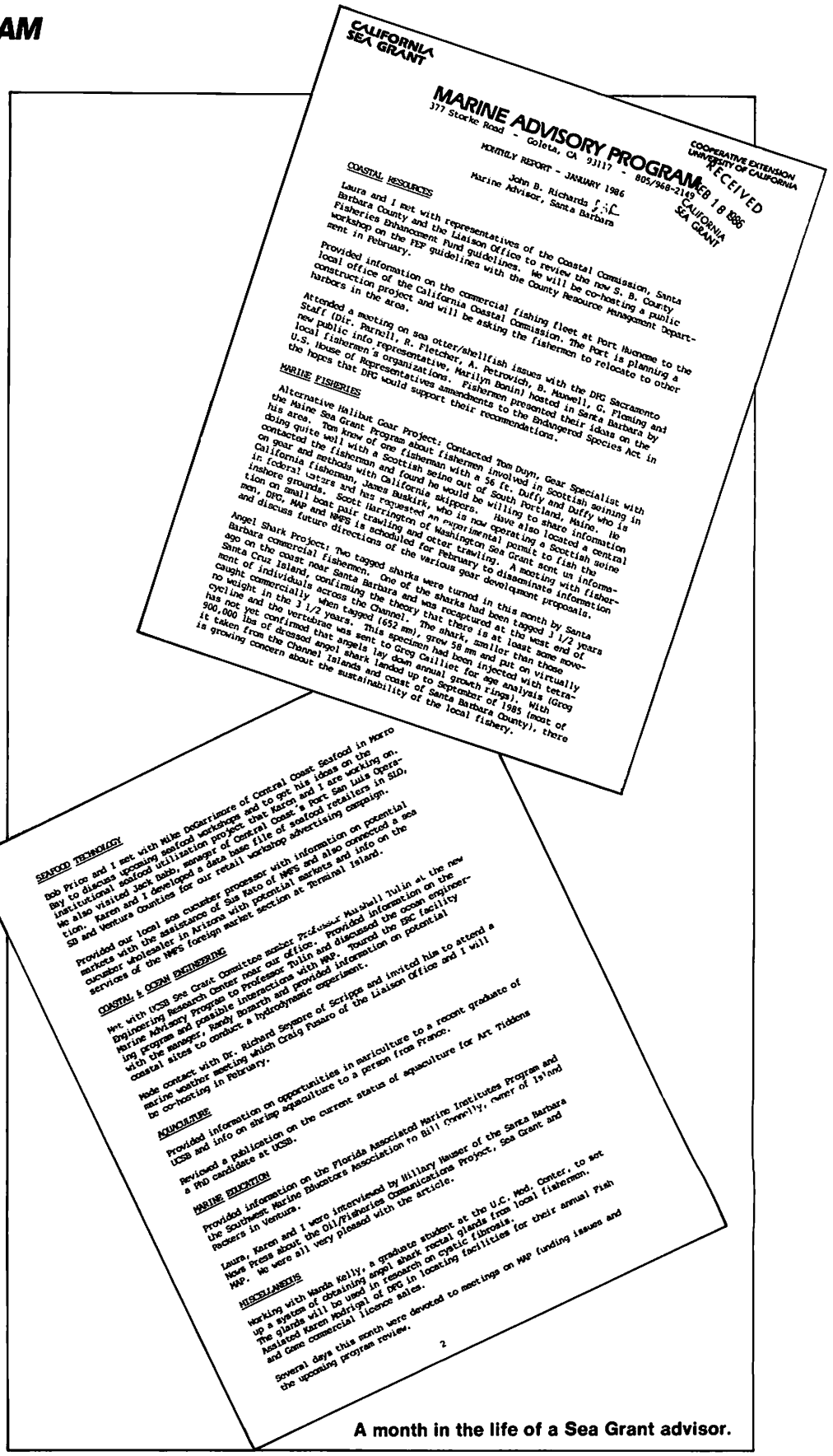
Sea Grant's marine advisors are working with refugee fishermen on safety equipment and practices and use of marine electronics.

MARINE ADVISORY PROGRAM

Part of Sea Grant's mission is to transfer research results into the hands of people who face practical problems. This "linking" function is one of the most important roles played by Sea Grant's Marine Advisory Program (MAP).

The Marine Advisory Program, coordinated by Robert J. Price, Food Science and Technology Extension, University of California, Davis, includes specialists in marine fisheries, seafood technology, and aquaculture in addition to seven marine advisors stationed along the coast. Here is just a small sample of their recent activities.

- One MAP project seeks to increase public knowledge about paralytic shellfish poisoning (PSP) and to establish an effective early-warning monitoring program. In 1984, a PSP outbreak on the central coast was detected using a test-monitoring station established through the efforts of Sea Grant, the California Department of Health Services, and the commercial oyster industry. On the basis of test results, an early sports-harvesting closure was initiated and no PSP incidents occurred.
- Sea Grant's advisors and specialists work to control aquatic diseases in aquaculture facilities. When the UC Davis Aquaculture Disease Diagnostic Laboratory identified outbreaks of whirling disease and proliferative kidney disease in state and commercial salmon-rearing facilities, Sea Grant's advisory personnel provided information on the diseases to over 2,400 contacts in the aquaculture industry. In addition, regulations relating to aquaculture disease, which had been drafted cooperatively by Sea Grant's aquaculture specialist, the industry, and the California Department of Fish and Game, were incorporated into the state's administrative code.
- Marine advisors are using conferences and a newsletter, the *Oil and Gas Project Newsletter for Fishermen and Offshore Operators*,



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MONTHLY REPORT - JANUARY 1986

John B. Richards
Marine Advisor, Santa Barbara

COASTAL RESOURCES

Laura and I met with representatives of the Coastal Commission, Santa Barbara County and the Liaison Office to review the new S. B. County Fisheries Enhancement Fund guidelines. We will be co-hosting a public workshop on the FEF guidelines with the County Resource Management Department in February.

Provided information on the commercial fishing fleet at Port Hueneme to the local office of the California Coastal Commission. The Port is planning a construction project and will be asking the fishermen to relocate to other harbors in the area.

Attended a meeting on sea otter/shellfish issues with the DFG Sacramento Staff (Dir. Parnell, R. Fletcher, A. Petrovich, B. Maxwell, G. Fleming and new public info representative, Marilyn Bonin) hosted in Santa Barbara by local fishermen's organizations. Fishermen presented their ideas on the U.S. House of Representatives amendments to the Endangered Species Act in the hopes that DFG would support their recommendations.

MARINE FISHERIES

Alternative Halibut Gear Project: Contacted Tom Duyn, Gear Specialist with the Maine Sea Grant Program about fishermen involved in Scottish seining in his area. Tom knew of one fisherman with a 56 ft. Duffy and Duffy who is doing quite well with a Scottish seine out of South Portland, Maine. He contacted the fisherman and found he would be willing to share information on gear and methods with California skippers. He also operating a Scottish seine in federal waters and has requested an experimental permit to fish the inshore grounds. Scott Harrington of Washington Sea Grant sent us information on small boat pair trawling and James Buskirk, who is now located in California fishermen, has recapitulated otter trawling. A meeting with fishermen, DFG, MAP and NMFS is scheduled for February to disseminate information and discuss future directions of the various gear development proposals.

Angel Shark Project: Two tagged sharks were turned in this month by Santa Barbara commercial fishermen. One of the sharks had been tagged 1 1/2 years ago on the coast near Santa Barbara and was recaptured at the west end of Santa Cruz Island, confirming the theory that there is at least some movement of individuals across the Channel. The shark, a 58 mm and part on virtually has not yet when tagged (652 mm), grow no smaller than those no weight in the 1 1/2 years. This specimen had been injected with tetra-cycline and the vertebrae was sent to Greg Cailliet for age analysis (Grog caught commercially when tagged (652 mm), grow no smaller than those 900,000 lbs of confirmed that angels lay down annual growth rings). With it taken from the Channel Islands and coast of Santa Barbara County), there is growing concern about the sustainability of the local fishery.

SEAFOOD TECHNOLOGY

Bob Price and I met with Mike DeGarmoe of Central Coast Seafood in Morro Bay to discuss upcoming seafood workshops and to get his ideas on the institutional seafood utilization project that Karen and I are working on. We also visited Jack Dalb, manager of Central Coast's Port San Luis Operation. Karen and I developed a data base file of seafood retailers in SLO, SB and Ventura Counties for our retail workshop advertising campaign.

Provided our local sea cucumber processor with information on potential markets with the assistance of Sue Kato of NMFS and also connected a sea cucumber wholesaler in Arizona with potential markets and info on the services of the NMFS foreign market section at Terminal Island.

COASTAL & OCEAN ENGINEERING

Met with UCSB Sea Grant Committee member Professor Marshall Tulin at the new Engineering Research Center near our office. Provided information on the Marine Advisory Program to Professor Tulin and discussed the ocean engineering program and possible interactions with MAP. Toured the ERC facility with the manager, Randy Bozarth and provided information on potential coastal sites to conduct a hydrodynamic experiment.

Made contact with Dr. Richard Seymore of Scripps and invited him to attend a marine weather meeting which Craig Fusaro of the Liaison Office and I will be co-hosting in February.

AQUACULTURE

Provided information on opportunities in mariculture to a recent graduate of UCSB and info on shrimp aquaculture to a person from France.

Reviewed a publication on the current status of aquaculture for Art Tiddens a PhD candidate at UCSB.

MARINE EDUCATION

Provided information on the Florida Associated Marine Institutes Program and the Southwest Marine Educators Association to Bill Connelly, owner of Island Packers in Ventura.

Laura, Karen and I were interviewed by Hillary Hauser of the Santa Barbara News Press about the Oil/Fisheries Communications Project, Sea Grant and MAP. We were all very pleased with the article.

MISCELLANEOUS

Working with Wanda Kelly, a graduate student at the U.C. Med. Center, to set up a system of obtaining angel shark rectal glands from local fishermen. The glands will be used in research on cystic fibrosis. Assisted Karen Abdrigal of DFG in locating facilities for their annual Fish and Game commercial license sales.

Several days this month were devoted to meetings on MAP funding issues and the upcoming program review.

2

A month in the life of a Sea Grant advisor.

to improve communications and to resolve conflicts between the oil and fishing industries. Sea Grant advisory personnel were instrumental, for example, in establishing agreements on vessel traffic lanes to help oil-support vessels avoid nearshore fishing areas.

- Water allocation, another of the state's critical issues, is on the MAP agenda. One MAP concern is that the salmon and trout fisheries of the northern and central coastal areas are vulnerable to fluctuating water supplies in rivers and streams. Water policy recommendations are being used in water planning by counties along northern California's coast.
- Dozens of fishing vessels were lost at sea in the past year, a period during which insurance costs increased tremendously. To increase awareness of safety on the ocean, Sea Grant's advisors are using workshops and videotape to inform fishermen of safety equipment and practices. The U.S. Coast Guard, the State Coastal Conservancy, and industry groups are cooperating with Sea Grant in this needed program.
- Sea Grant's Marine Advisory Program and the California Department of Fish and Game co-sponsored a third statewide "Salmon and Steelhead Restoration Conference" and published the proceedings.
- Marine advisors have studied the modernization of California's fisheries. One innovative MAP project, completed in the last year, sought to determine the factors that cause commercial fishermen to adopt or reject technical innovations. Analysis of data from interviews and questionnaires provided insights into industry problems, communications networks, and fishermen's reasons for adopting or rejecting new technology and behaviors.
- MAP's Marine Transportation and Port Development program is surveying marina managers and harbor masters to learn their specific education and research needs. The program is also obtaining information from waterfront managers, attorneys, and insurance industry representatives on problems of waterfront liability and the need for research on risk management and model legislation.
- In 1984, Sea Grant's Marine Advisory Program revised and published a *Seafood Retailing Manual.* The manual contains information relevant to California's large and diverse seafood industry, which has over 1,300 licensed seafood processors, wholesalers, brokers, and importers, and 139 seafood processing and wholesale plants employing over 9,800 seasonal workers.

Another project seeks to improve seafood quality by increasing industry adoption of improved practices and industry participation in Cooperative Extension short courses on sanitation, microbiology, and quality control.

- The closing of all but one of California's tuna canneries has depressed markets for West Coast albacore. And lack of knowledge inhibits some institutional and retail buyers from making full use of those products that are available. One MAP project is helping seafood processors to develop alternative albacore products, including frozen albacore steaks and fish sticks, and fresh albacore steaks.

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TRAINING FUTURE GENERATIONS OF TALENT

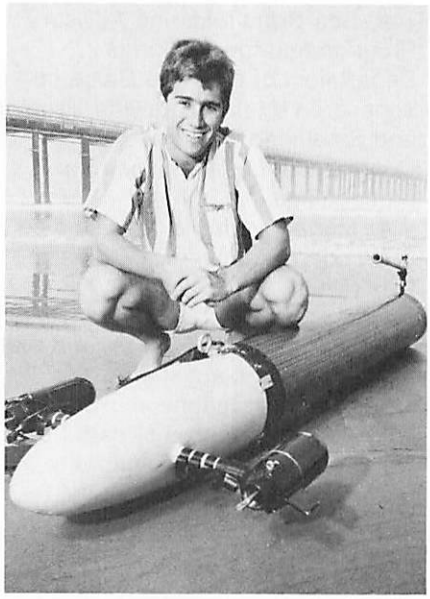
Sea Grant's commitment to education in marine science and technology is evident in the projects it supports for students at all levels, as well as for teachers and the general public.

The Graduate Trainee Program

Almost all of the research projects supported by California Sea Grant include at least one graduate trainee. During their training, these students conduct valuable and often independent marine-related research alongside university scientists and engineers. In 1984-85, 72 trainees worked with Sea Grant project leaders at 12 California universities and colleges. Most of these students worked on or completed graduate degrees during their traineeships. The new talent assured by such programs will be responsible for maintaining American scientific and technological leadership in coming years.

National Intern Program

Each year California Sea Grant nominates outstanding graduate students for an extraordinary internship opportunity in the nation's capital. Sponsored by the National Sea Grant College Program, the one-year paid internship matches graduate students who have an interest both in the marine sciences and in ocean policy with "hosts" in Washington, D.C. Justin Lancaster from UCSD's Scripps Institution of Oceanography, selected for a 1985 internship, served on the staff of the Senate Committee on Environment and Public Works, where he was instrumental in drafting legislation on acid rain and provided background for legislation on ocean dumping.



—SIO photo

Michael Topolovac, 1985 Isaacs scholarship winner, with his "hot sub."

Isaacs Scholarship

The fourth John D. Isaacs Memorial Sea Grant Scholarship was awarded in 1985 to Michael Topolovac, Torrey Pines High School in Del Mar, for his investigations into reducing drag on an unmanned submersible he designed and constructed. The scholarship, awarded at the state science fair, recognizes excellence in research by a California high school senior and encourages students to continue their education in marine science or technology. Michael is presently a freshman at Stanford University.

Ocean Education for the Public

Sea Grant also supports outreach programs that educate teachers, students, and the general public about the marine environment. Through its *Ocean Education for the Public* program, Sea Grant has supported educational activities at five university-based marine institutions in the state.

The ocean education program at the Institute for Marine Studies, *University of California, Santa Cruz*, restructured its program in 1984-85 to focus more directly on the needs of teachers. One major activity was sponsorship of a Marine Science and Ecology Institute for teachers, a week-long training symposium with four follow-up sessions. In addition, program participants developed a comprehensive K-12 resource kit for teachers. The program continues to give special presentations to community groups.

With Sea Grant support, the Marine Science Institute at the *University of California, Santa Barbara*, hosts scheduled educational events at the campus marine laboratory at the end of each academic quarter. Students, teachers, and others from the community are taken through the laboratory by undergraduate marine science students. Numerous educational displays, including "touch tanks" and collections of marine plants and animals, are prepared especially for these events. Last year over 5,000 individuals took advantage of this opportunity, including groups from 70 elementary and secondary schools and youth activity groups from such organizations as the YMCA and the Braille Institute.

The education project at *Moss Landing Marine Laboratories* involved over 15,000 people in a variety of marine education activities. Project leaders have responded to ever-increasing public demand by expanding their community-outreach program. Approximately 8,000 students from all grade levels heard slide talks on marine research activities and on higher education and career opportunities in marine science.

The main objective of the public education program at Telonicher Marine Laboratory, *Humboldt State University*, has been to increase public awareness and knowledge of the marine environment through slide shows, laboratory tours,

COMMUNICATIONS AND PUBLICATIONS

"hands-on" experience with marine animals, and self-guided tours. During the summer of 1985, over 4,000 tourists, residents, and members of special interest groups attended a total of 128 sponsored events. During the academic year, over 1200 students and teachers received special presentations on marine science and advances in research.

The major objectives of Sea Grant's Ocean Education for the Public program at *Scripps Aquarium-Museum*, Scripps Institution of Oceanography, have been to increase public understanding of the ocean and to educate teachers and students about ocean-related topics.

More than 40,000 school students took part last year in the education program offered by the aquarium, and a 3-month training course was provided for the 40 volunteer guides who work with these students. Teacher training is always one of the aquarium's primary goals, so it once again offered two intensive 14-hour courses to teachers, "Tidepool Inhabitants" and "Fishes, Shore Birds, and Marine Mammals." Gifted and Talented Education, a California state-mandated program for gifted students, and Science Magnets, a San Diego program, again requested that docents from the aquarium-museum teach one-week ocean units in their schools.

Finally, comprehensive planning took place for a major shift in the education program sponsored by California Sea Grant. The new program will focus much more strongly on teacher motivation and training, and will feature a special workshop or symposium for teachers each year. It will also seek to foster closer ties with other educators around the Pacific region.

The communications office of the California Sea Grant College Program responds to requests for information from marine-related industries, government agencies, special interest groups, educational institutions, nonprofit organizations, and the general public. It also produces a number of publications in the Sea Grant educational, reference, and technical report series.

In FY 1984-85, the following publications were produced by the program (listed in order by Sea Grant number):

Sea Grant Technical Series

Anderson, Kelly, Editor. 1985. *Advances in Aquaculture and Fisheries Research*: Report of a California Sea Grant Symposium, May 18-20, 1983. T-CSGCP-010. (56 pages.)

Abbott, Isabella A. and James N. Norris, Editors. 1985. *Taxonomy of Economic Seaweeds, with Reference to Some Pacific and Caribbean Species.* Results of an international workshop sponsored by the California Sea Grant College Program in cooperation with the Pacific Sea Grant College Programs of Alaska, Hawaii, Oregon, and Washington and hosted by the University of Guam, U.S.A., June 15–20, 1984. T-CSGCP-011. (184 pages, 43 plates.)

Educational Series

Zedler, Joy B. 1985 *Vegetación de la Marisma: Ejemplos del Estuario del Río Tijuana.* E-CSGCP-004. (40 pages, 31 figures.)

Sea Grant Reference Series

California Sea Grant College Program. 1985. *Directory of Academic Marine Programs, A Guide to Programs in the Marine Sciences at California Colleges and Universities.* R-CSGCP-014. (148 pages, 14 figures, 2 tables.)

Amidei, Rosemary. 1985. *California and the Pacific: Exploring the Exclusive Economic Zone, A Summary Report of the California Sea Grant College Program, 1982-1984.* R-CSGCP-016. (40 pages, 15 figures.)

California Sea Grant College Program. 1985. *California Sea Grant 1985-86 Program Directory.* R-CSGCP-017. (28 pages, 7 figures.)

Other

King, Dennis M. and Harry A. Bateman. 1985. *The Impact of Recent Changes in the Tuna Industry.* Working Paper No. P-T-47. (30 pages.)

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1984-1985

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Activity Budget, 1984-1985

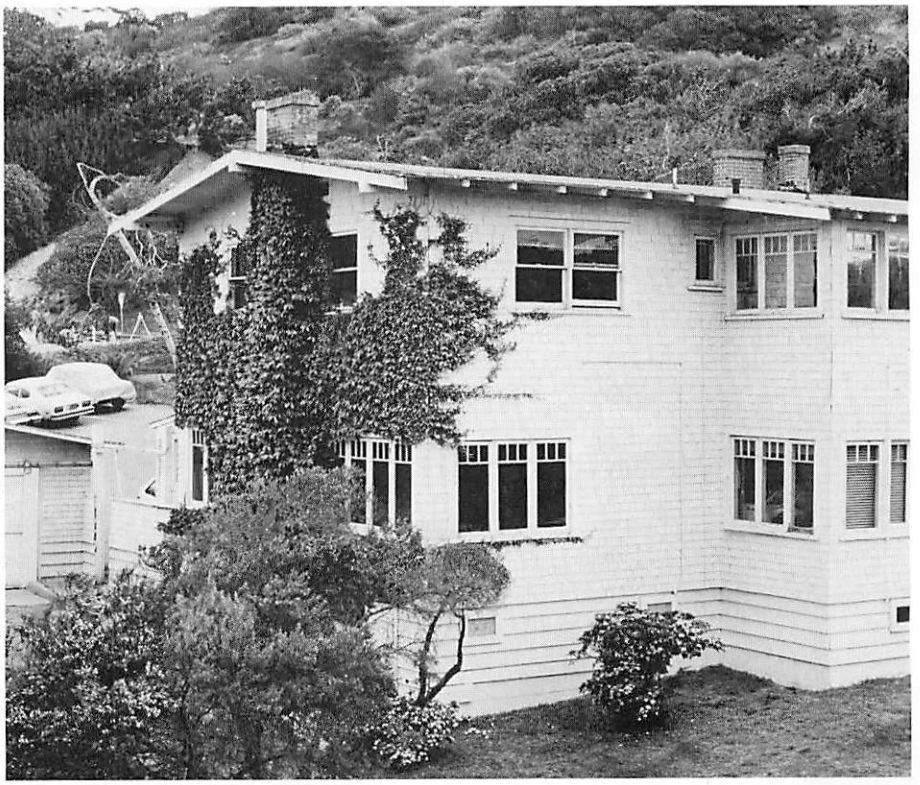
	NOAA Grant Funds	Matching Funds
Marine Resources Development		
Aquaculture	$ 410,066	$ 436,877
Living Resources, other than Aquaculture	323,568	258,028
Marine Biomedicinals and Extracts	276,001	201,727
Socioeconomic and Legal Studies		
Marine Economics	15,825	17,471
Sociopolitical Studies	23,796	24,321
Marine Technology Research and Development		
Ocean Engineering	111,879	97,737
Resources Recovery and Utilization	87,279	84,308
Marine Environmental Research		
Ecosystems Research	18,810	32,449
Environmental Models	96,783	70,099
Marine Education and Training		
Other Education	454,700	51,600
Advisory Services		
Extension Programs	792,217	372,212
Other Advisory Services	244,436	151,001
Program Management and Development		
Program Administration	410,933	243,339
Program Development	200,000	6,900
Total	$ 3,466,293	$ 2,048,069

Matching Funds Sources 1984-85

State of California:	
California Resources Agency	$ 392,500
Allergan Corporation	46,475
Aquaculture Enterprises	23,860
Aquarium-Museum Docents	41,017
Bristol-Meyers	14,300
Ciba Geigy, Hybritech	16,380
Counties of Del Norte, San Diego, Santa Barbara, Santa Cruz, and Sonoma,	35,076
Donations	33,338
Syntex Corporation	3,000
California State University, Long Beach	11,525
California State University, Stanislaus	4,406
Humboldt State University	7,687
San Diego State University	77,567
San Jose State University	4,416
University of California	827,525
Central University of Venezuela	23,600
Total	$1,562,672

Participating Institutions, 1984-85

BML	Bodega Marine Laboratory Bodega Bay, California
CSULB	California State University Long Beach, California
HSU	Humboldt State University Arcata, California
IMS	Institute of Marine Sciences University of California Santa Cruz, California
MLML	Moss Landing Marine Laboratories Moss Landing, California
MSI	Marine Science Institute University of California Santa Barbara, California
SDSU	San Diego State University San Diego, California
SIO	Scripps Institution of Oceanography University of California, San Diego La Jolla, California
SJSU	San Jose State University San Jose, California
SWFC	Southwest Fisheries Center La Jolla, California
UCB	University of California Berkeley, California
UCD	University of California Davis, California
UCI	University of California Irvine, California
UCIMR	University of California Institute of Marine Resources La Jolla, California
UCLA	University of California Los Angeles, California
UCR	University of California Riverside, California
UCSB	University of California Santa Barbara, California
UCSC	University of California Santa Cruz, California
UCSD	University of California, San Diego La Jolla, California
UU	University of Utah Salt Lake City, Utah



The headquarters of California Sea Grant, a statewide, multiuniversity program, is located at UCSD's Scripps Institution of Oceanography in La Jolla.

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