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**California  
Sea Grant  
College Program  
Annual Summary  
1980-81**

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SEA GRANT  
CALIFORNIA

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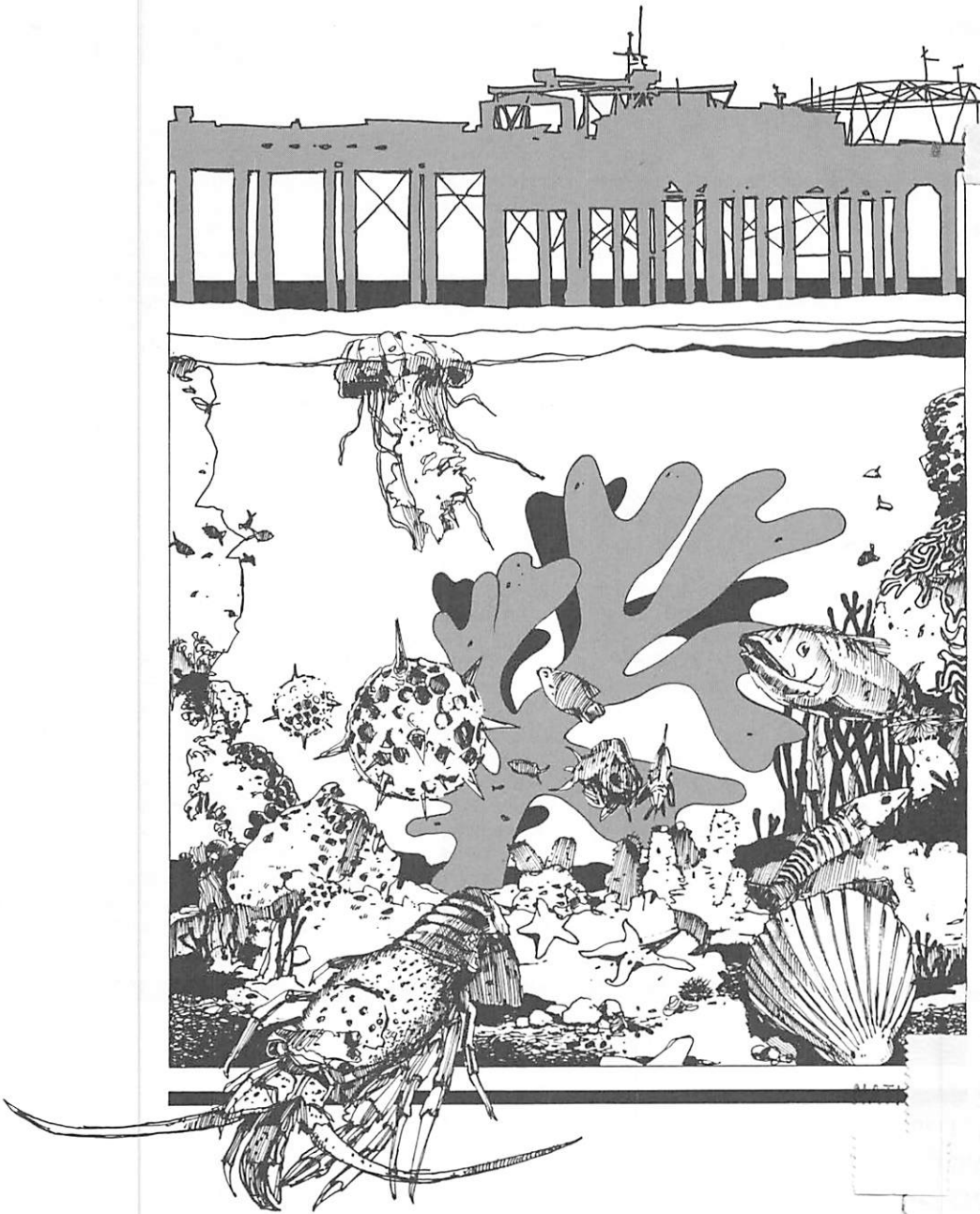
We hope you find it useful and welcome any  
comments or suggestions.

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Program Manager

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# Annual Summary 1980-81

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Writer and Editor:  
Kelly E. Anderson

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# The Program Manager's Perspective

This year's summary—in its newsmagazine format—addresses our need to more effectively communicate the activities and results of the California Sea Grant College Program. It is purposefully unlike other summaries we've produced in the 10 years since California was awarded a Sea Grant College, reflecting the changes that have taken place in the last year in California, in the West, and in the United States.

The California Sea Grant College Program has traditionally been the "silent supporter" of valuable marine research projects, educational programs, and marine advisory activities conducted throughout the state. With a new administration and a strong national commitment to get the economy back in shape, Sea Grant has realized the need to "go public" with the results and benefits of the projects it supports in order to stimulate innovative and imaginative solutions among researchers, educators, industries, and government agencies involved in the diverse marine realm.

Sea Grant is in a strong position to aid the nation's economy, since it was designed with the nation's economy in mind. Sea Grant was created in the mid-60s to promote the wise use and development of our ocean resources by supporting research, education, and advisory services. The program was patterned after the highly successful Land Grant College Program, established in 1865, which has been instrumental in helping the U.S. become the world's leading agricultural nation. Following Land Grant's lead, Sea Grant links university research with industry and user groups who put research results into practice, allowing the nation to develop its marine economy as it has developed its agricultural economy.

And since its inception, Sea Grant—in California and the 26 other states that have programs—has been contributing to the nation's economy. It has developed new and innovative scientific

and engineering techniques that increase the contribution of marine resources to the economic and social well-being of the nation. It has analyzed the allocation and distribution of marine resources and marine products to aid public policy-making. It has provided scientific and technical training necessary for productive use and management of marine resources. And it has communicated the results of university research efforts to all segments of the marine community, to the public, and to governmental offices.

What does this mean to you and me? It means increases in the supply of marketable protein from marine sources for human and animal consumption. It means improved efficiency of public capital expenditures on ports, harbors, and beaches. It means an improved understanding of defense against the destructive forces in the marine environment. And it means improved existing and new technology to increase the contribution of marine resources to the production, transportation, and distribution of energy supplies at minimal social cost.

As budget cuts reflect the nation's changing priorities, it is exciting to see that the principles upon which Sea Grant was formed remain relevant and even necessary to aid the nation's economy.

Peter Orahovats, vice president and scientific director of Bristol-Myers Products, is a strong Sea Grant supporter. Before a subcommittee of the U.S. House Committee on Merchant Marine and Fisheries last year, Orahovats testified to the significance and national importance of Sea Grant-sponsored biomedical research, much of which is currently supported by the California Sea Grant College Program. He cited Sea Grant's "very innovative and highly productive marine biomedical research support at several universities" and "the obvious benefits to our pharmaceutical industries and the inherent virtues in the

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J. D. Frautschy, G. G. Shor, Jr., the late J. D. Isaacs, W. A. Nierenberg, and J. J. Sullivan admire plaque designating the University of California a Sea Grant College in 1973 for its "sustained excellence in research, education, and public service dedicated to the wise use of America's marine resources."

development of our national marine resources" as reasons for continuing federal support of the Sea Grant program.

Last year strong words also came from University of California President David Saxon, who testified in support of science education and research before the U.S. House Committee on Science and Technology. "Maintaining our ability to educate the next generation of scientists and giving appropriate attention to encouraging the work of the current generation of scientists are both important."

President Saxon's words deserve special consideration during

this time of fiscal restraint and low productivity. According to figures published in *Science 81*, more than half of America's high school students graduate with no more science and math than the minimum required biology and algebra courses. Less than a third take chemistry, and less than a sixth take trigonometry.

The numbers are even more startling when compared with other technologically advanced countries. There are 50 Soviet high school students taking calculus for every 1 student doing so in the United States. Japanese high school graduates receive twice as many hours of instruction in science and math as do American students. In proportion to its population, Japan produces five times as many engineers as does the United States.

Providing scientific and technical training to students who will become the next generation of scientists responsible for developing the nation's ocean resources is just one of the areas Sea Grant supports. Sea Grant funds important research and activities in many aspects of the marine sphere: coastal resources, aquaculture, fisheries, ocean technology, and marine affairs, and it provides marine advisory assistance to fishermen, industry, and government agencies that are using, developing, and protecting California's valuable marine resources.

With this summary, we want the people of California to be aware of the contribution Sea Grant is making to their lives. We want state and federal agencies to realize the level of coordination and cooperation that exists between Sea Grant and the groups charged with developing and managing the nation's coastal resources. We want university officials, researchers, and specialists to know about the research Sea Grant supports at their institutions. And we want governmental officials to be informed about Sea Grant activities that contribute to wise ocean development for the state and the nation.

I welcome your comments and suggestions.

James J. Sullivan  
Program Manager

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*The California Sea Grant College Program is a statewide, multiuniversity program of marine research, advisory services, and education, administered by the University of California Institute of Marine Resources. Through the research it sponsors, Sea Grant contributes to the growing body of knowledge about our coastal and oceanic resources and aids the solution of contemporary problems in the marine sphere. Through its Marine Advisory Program, Sea Grant transfers information and technology developed in its research efforts to a wide community of users in California, the Pacific region, and the nation. Sea Grant also supports a range of educational programs for students, teachers, and the general public to promote the wise use of our coastal and oceanic resources by this and future generations.*



# The Sea Grant College Program

*The Land Grant idea is expanded to develop ocean resources*

*Marine resources in the United States potentially represent a major segment of our economy. In 1966 Congress created the National Sea Grant College Program, a three-part program of research, education, and advisory activities modeled after the successful Land Grant College Program which was instrumental in helping the U.S. become the world's leading agricultural nation.*

*Sea Grant's purpose is to accelerate the sound development of marine resources by supporting application-oriented marine research projects at the nation's leading universities. Equally important is Sea Grant's role in sponsoring educational activities to communicate the results of that research to government agencies, industry, scientists, fishermen, and consumers—people who can translate research results into social and economic benefits for the nation, for coastal regions, and for states that currently have Sea Grant programs.*

## California Program Is the Largest

California's Sea Grant College Program is the largest of 29 Sea Grant programs currently underway in more than half of the nation's states and Puerto Rico. Since 1968 California's program has supported a unique combination of marine research, education, and advisory activities at more than 25 California universities and colleges to address marine problems of national, regional, and local importance.

## Benefiting the Nation and the West

**Nationally, the California Sea Grant program has**

- increased the marketable supply of protein from the ocean for human and animal consumption
- provided scientific and technical training to nearly 400 graduate students since 1972, most of whom are now sharing their acquired skills and knowledge in

government, industry, and university positions throughout the United States

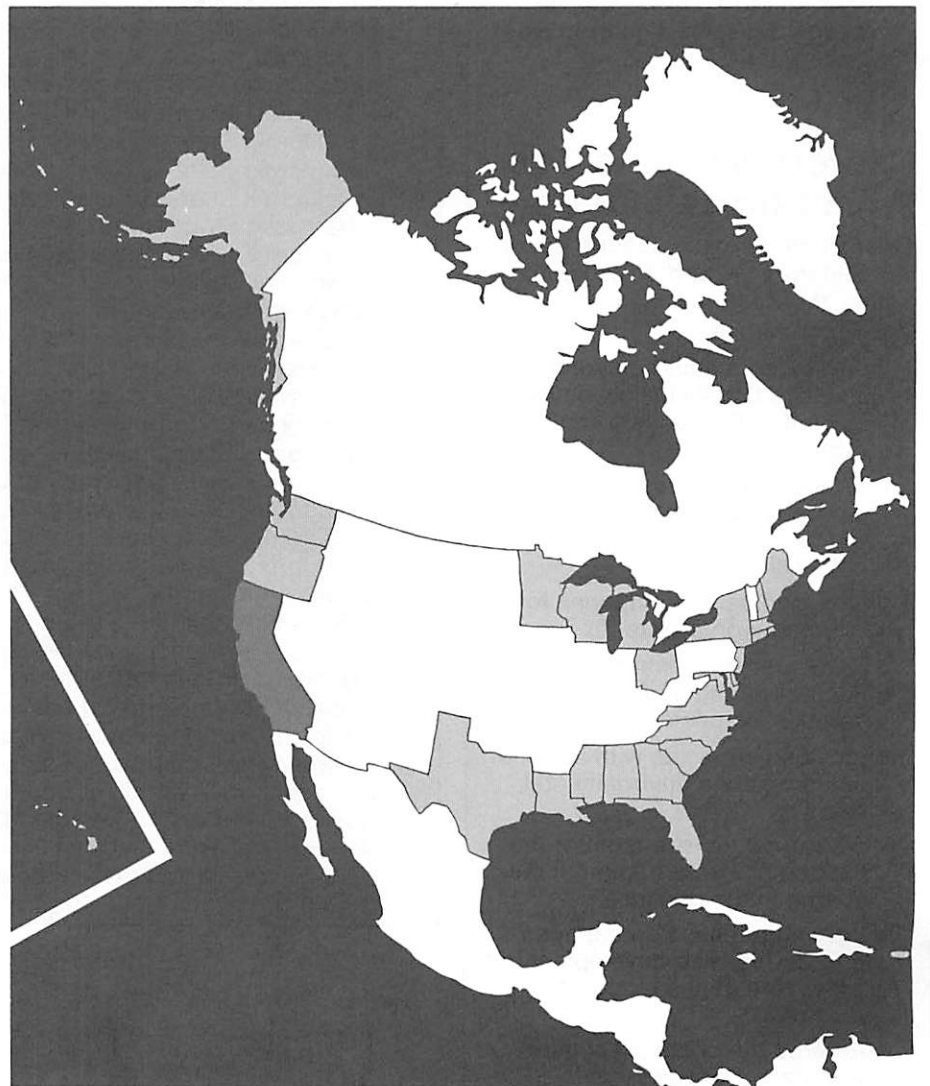
- increased the marketable supply of marine resources for industrial use
- developed new ways to increase the contribution of marine resources to the production, transportation, and distribution of energy supplies at minimal social cost.

### On a regional level

The California Sea Grant College Program, in cooperation with Sea Grant college programs in **Alaska, Washington, Oregon, and Hawaii,**

is working to develop, use, and conserve the vast resources of the Pacific Ocean—a largely undeveloped wilderness that occupies nearly one-half of the globe.

For more than a decade the Sea Grant college programs in these states have provided advisory education and services to Pacific fishermen and mariners through the Pacific Area Sea Grant Advisory Program (PASGAP). This successful effort has led the five Pacific Sea Grant colleges—University of Alaska, University of Washington, Oregon State University, University of California, and University of Hawaii—to form a closely coordinated research collegium called the





### Pacific Sea Grant College Program (PSGCP).

Realizing the benefits from a coordinated Sea Grant research base in the West, the collegium is promoting the wise use, development, and management of the Pacific's resources through research to

- increase food yield from the sea
- develop new marine related industries
- improve marine management techniques and policies
- improve harvest methods and conservation practices
- identify and develop pharmaceuticals and other new marine products from the sea
- improve the handling, processing, and marketing of Pacific seafoods
- develop marine aquaculture in the Pacific, particularly of salmon and commercially valuable shellfish
- develop ocean technology to allow more efficient marine operations and to confront special marine transportation problems in the Pacific.

### California Profits Too From Efforts of a Few

Through its research, marine education and training, and advisory activities, the California Sea Grant College Program has

- developed a squid-cleaning machine that will allow development of California's squid fishery
- established methods to decrease water consumption and wastewater discharge in shrimp processing
- designed safe foundations for structures on coastal fill
- developed new fisheries for Pacific whiting and other underutilized species
- provided agencies with information on marine environmental quality
- developed tools to monitor the buildup of waste treatment discharge in the ocean
- advised permit-granting agencies on the wise development of areas threatened by coastal erosion
- lowered the costs associated with harbor development

- provided schools with marine education materials
- developed new pharmaceutical chemicals from marine organisms
- reduced fuel costs and consumption by fishermen
- expanded the use of seafood products
- reduced seafood transportation costs
- controlled diseases that restrict development of California's aquaculture industry
- created new seafood products for export

- discovered ways to use power plant thermal effluent to enhance the aquaculture industry.

In 1980-81 Sea Grant invested in California more than \$3 million of federal funds and \$2.5 million of state matching and other nonfederal funds. The benefits accrued to the nation, the region, and the state resulted from the efforts of about 500 individuals involved in the research, education, and advisory services provided by the California Sea Grant College Program.

### California's Sea Grant Institutions Since 1977

California Academy of Sciences  
California Institute of Technology  
California State University, Long Beach  
California State University, Northridge  
Claremont College  
Humboldt State University  
Loyola Marymount University  
Moss Landing Marine Laboratories, a consortium of  
California State University, Fresno  
California State University, Hayward  
California State University, Sacramento  
California State University, San Francisco  
San Jose State University  
California State University, Stanislaus  
Occidental College  
San Diego State University  
San Francisco State University  
San Jose State University  
Southern California Ocean Studies Consortium  
California State University at Dominguez Hills  
California State University at Fullerton  
California State University at Long Beach  
California State University at Los Angeles  
California State University at Northridge  
California State University at Pomona  
Stanford University  
University of California at Berkeley  
University of California at Davis  
University of California at Irvine  
University of California at Los Angeles  
University of California at Riverside  
University of California at San Diego  
University of California at Santa Barbara  
University of California at Santa Cruz  
University of San Diego  
University of Southern California

# Marine Education and Training

*Sea Grant confronts widening gaps in science education*

*At a time when funding support for education in general is declining, Sea Grant has continued to support marine education and training for students from primary school through graduate school, as well as for the general public.*

*Sea Grant is committed to training people with the essential scientific and technological education needed to allow our nation to grow scientifically and economically. Through Sea Grant's trainee program, graduate students work alongside highly respected university research scientists and engineers in nearly all of the application-oriented research projects supported by California Sea Grant. In 1980-81, 73 Sea Grant trainees conducted practical marine research with project leaders at 12 California universities. Trainees usually complete an M.S. or Ph.D. based on their Sea Grant research and secure jobs in private industry or academia soon after their traineeships end.*

## Graduates Bring Valuable Skills Into Workforce

During their Sea Grant traineeships, graduate students solve marine-related problems and learn innovative research techniques that will be used in their professional careers.

Scott Selover, a 1978-1981 trainee in Sea Grant's Marine Chemistry and Pharmacology Program, received his Ph.D. in chemistry from **UC Santa Cruz** and is now a staff research chemist at **SRI International** in **Menlo Park, California**—a position he attributes to his 3-year trainee experience.

As a Sea Grant trainee Selover investigated the chemistry of a common gorgonian coral, *Briarium asbestinum*, and successfully identified a variety of diterpene metabolites—just a few of the new, potentially bioactive, natural marine products that have been discovered in the pharmacology research program. Selover accompanied project investigators on overseas collecting expeditions to **Honduras** and the



L. D. Ford/SIO

**Tonga Islands**, gaining valuable field experience that he says greatly expanded his knowledge of coral reef inhabitants. "The interactions I observed there provided valuable insight into the possible reasons secondary natural products are found in certain organisms."

Through his doctoral research, Selover was exposed to many aspects of analytical organic chemistry and was thus well prepared for a research position in private industry. "The techniques I learned gave me state-of-the-art experience in analytical organic chemistry," he writes. "Thus, I was an attractive candidate to the chemical industry, and this was a major factor in securing my present professional position."

The career preparation experience Selover received during his traineeship is not unique. Martha Bean, one of last year's Sea Grant trainees, developed a model land-use planning system for wetland watershed development with researchers at **UC Berkeley** while completing her M.L.A. in environmental planning (landscape architecture). In developing the model system, Bean says she gained extensive experience in quantitative impact assessment, aerial photography interpretation, applied hydrology and hydrologic assessment, and computer applications of environ-

mental data and mapping measurement techniques—experience which she says allowed her "to step into an upper-level planning position in times of job scarcity." Bean now works as a county environmental planner and water management specialist in **Washington**.

## High School Researcher Receives Award

Sea Grant awarded its first John D. Isaacs Scholarship last year to Amy Kimball, a senior at **Point Loma High School** in **San Diego**, for her study of environmental impacts on tidepool limpets. The California program offers the \$10,000 award, allocated over a 4-year period, to recognize research excellence by California high school seniors, and to



*The late Professor John Isaacs discusses marine affairs with California Governor Edmund G. Brown, Jr.*

encourage further pursuit of marine science education at the state's colleges and universities.

Ms. Kimball's study was selected from other unique marine-related projects that had advanced to the **California State Science Fair**. Currently a freshman biology major at **UC Santa Cruz**, Ms. Kimball is





P. Kampmann/SIO

## Update: 14 Years Later, Diver Training Funded by Industry

SANTA BARBARA—Hundreds of years ago, people imagined that in order to work underwater they would have to wear wooden barrels resembling upside-down trash cans and leather helmets with spikes to ward off sea monsters.

Though these early ideas seem amusing to us today, they pointed the way to an engineered approach to deep-sea diving that today helps make offshore mariculture, oil, and mining operations safe and practical.

The fact that modern divers now work safely at depths of more than 1000 feet indicates just how far that technology has advanced. One example is the dramatic improvement in diving skills training that has occurred in the last 15 years—due in part to the strong desire of community colleges to provide diver training programs for students interested in marine-related careers.

In 1968 Sea Grant funded a proposal by **Santa Barbara City College (SBCC)** to develop a 2-year Marine Diving Technician Program. It was the first of a series of grants Sea Grant provided to develop Santa Barbara's diving program and similar marine training programs at other California colleges.

Today, "Marine Tech" at SBCC is still going strong. The curriculum covers all aspects of modern diving technology, including new magnetic particle and ultrasonic inspection techniques, plus such practical skills as welding and boat handling. "The goal of the program is to train people to enter the job market," says program director Bob Christensen. Because a large part of that job market is provided by oil companies interested in offshore oil and mineral development, partial funding for the Santa Barbara program is now provided by a yearly grant from **Exxon Company, U.S.A.**

(Adapted from "DaVinci, Diving, and Drilling," *Exxon USA*, Second Quarter, 1981.)

planning to expand her behavioral research to include histological studies of the molluscan life cycle.

The award is given in honor of John D. Isaacs, professor of oceanography and director of the University of California's Institute of Marine Resources. Author, inventor, scientist, and educator, Professor Isaacs inspired others with his energy, enthusiasm, and unfettered imagination. His research interests ranged from deep ocean ecology to climate studies, from ocean energy

development to space exploration. He will always be remembered for his unique ability to ask the right questions, as well as his use of parables and stories to make complex topics easier to understand.

Each year nearly 200 students from the state's junior and senior high schools advance from county science fairs to participate in the California State Science Fair. Projects are divided into 11 categories, including botany, microbiology, biochemistry, and engineering.

## Marine Education for Californians

An additional facet of Sea Grant's commitment to education and training is its support of outreach programs that bring important marine research information and education materials to the general public. Sea Grant's Ocean Education for the Public Program provides public advisory services through university-based marine institutions and is described in the marine advisory services section.

## Budget Cuts Threaten Future For Young Scientists

In testimony before the U.S. House Committee on Science and Technology, University of California President David Saxon voiced concern over the nation's ability to turn out the next generation of scientists given the present administration's attitudes on science and technology.

"The most important incentive for young people to pursue the rigors of a scientific education is the vigor and excitement of the scientific enterprise in university departments and laboratories," he said. "The current doubts cast upon the future of science, on top of a decade of ups and downs in federal funding, have to some extent undermined the morale of the enterprise and its attractiveness."

Saxon noted the federal commitment to support science as expressed by George Keyworth, director of the Office of Science and Technology Policy; however, Saxon was skeptical whether "the administration will succeed in sustaining science as a vital national effort or whether, by the unintended side effects of policies directed toward reducing the relative size of the federal government, some serious, costly, and even permanent damage to science will result.

"This situation is to me the most alarming effect of the confusion resulting from the present administration's attitudes and performance. The environment of uncertainty is surely doing short-term damage. It may very well have severe long-term consequences also."

Saxon told the committee there were "mixed signs and portents" in the administration's policies affect-

ing science and technology, policies that make demands on science and technology without making available the resources needed to meet those demands.

"In short," he said, "it does not make sense to reduce the current support of scientific research, the results of which will be needed in the future. It does not make sense to reduce support that enables students to attend college, and particularly to continue their studies as graduate students.

"It does not make sense to diminish resources available for improvement of scientific education throughout the school system. It does not make sense to impose, by selective budget cutting, decisions about what parts of the scientific endeavor should be supported without any consultation or policy discussion. It does not make sense to force on the states responsibility for expectations that they are unable to meet."

To keep pace with the demands of an increasingly technological world, Saxon stressed the need for a national science policy that supports basic and applied research and development, balances supporters and performers, and assures excellence and pertinence of scientific work.

"I am encouraged by the administration's avowed policy of support for scientific research, but I am concerned that in the process of cutting support for students and for research serious damage may be done to our scientific capacity. Maintaining our ability to educate the next generation of scientists and giving appropriate attention to encouraging the work of the current generation of scientists are both important."

(Adapted from *UC Bulletin*, March 1, 1982.)



P. Kampmann/S/O

Sea Grant's Projects in Marine Education	FY79	FY80	FY81
Sea Grant Trainees (E/G-2, Sullivan)	O	O	O
Marine Education: Undergraduate Independent Research (E/UG-1, Doyle)	C	—	—
Development of a Prototype Course in Marine Policy (R/NP-1-8D, Sorensen)	N/C	—	—
A History of the Santa Barbara Channel (E/UG-2, Talbott)	—	N/C	—
Ocean Engineering and the Future: Long-Range Planning: A Graduate Seminar (E/G-8, Webster/Tulin)	—	N/C	—

C = Completed; N = New; O = Ongoing



# Marine Advisory Services

*A three-part program disseminates important research results*

Sea Grant's marine advisory services bring university-level resources, techniques, and knowledge about the wise development of our oceans to the people in the Pacific rim—many of whom not only enjoy the ocean as a source of recreation and pleasure but must earn their living from the sea. These activities, frequently in cooperation with the National Oceanic and Atmospheric Administration (NOAA) and other federal and state agencies, allow a vehicle of communication between ocean users and the national scientific community.

The focal point of Sea Grant's statewide advisory services is the Marine Advisory Program (MAP), headquartered at UC Davis. Two other programs provide important advisory services to California: the Sea Grant Communications Office, based at UC San Diego in La Jolla, and the Ocean Education for the Public Program, which currently supports marine institution programs at five California universities.

## Communications and Public Advisory Services

### *Printing results brings results*

Through the research it supports, Sea Grant generates a wealth of new information concerning the nation's ocean and coastal resources. Because this information affects decision making regarding the use, management, and development of our resources, Sea Grant disseminates its research results to many audiences: fishermen, industries, and nonprofit organizations; elected officials, government agencies, and the scientific community; schools, the general public, and members of Sea Grant's statewide and national programs.

To spread this knowledge effectively, the communications office performs a variety of services, including the following:

- writing and publishing Sea Grant project results in publica-



L. D. Ford/SIO

tions aimed at technical and lay audiences

- providing the public with information about Sea Grant's projects, services, products, and activities
- distributing the books, reprints, technical reports, and activity announcements produced or sponsored by Sea Grant
- advising project leaders, administrators, and advisory personnel about effective techniques for communicating with user groups, the scientific community, and the general public.

The Sea Grant Communications Office receives thousands of information requests each year from industries, government agencies, special interest groups, legislators and congressmen, schools, nonprofit organizations, and the general public.

In 1980-81 California Sea Grant received more than 14,000 information requests—a 52 percent increase over the previous year—and distributed more than 21,000 leaflets, journal articles, technical reports, and books.

## Ocean Education for the Public

*Five marine labs "go public" with ocean's secrets*

Sea Grant's Ocean Education for the Public Program supports the educational and interpretive activities at university-based marine facilities located along California's 1100-mile coastline. The five laboratories and museums currently involved in the program provide



displays, tours, workshops, and field trips to residents and tourists who want to learn more about California's rich coastal marine life.

**ARCATA**—The Fred Telonicher Marine Laboratory at **Humboldt State University** provides the public with interpretive materials and activities related to marine environments in the Trinity Bay area and northern California. During 1980-81 the laboratory staff prepared photographs and photomicrographs of marine organisms in their natural environment for the lab's thematic displays, outreach presentations, and for use in the interpretive program at **Redwood National Park**.

Staff at the lab visited **Steinhart Aquarium** in **San Francisco** to get ideas for constructing an intertidal tank that will simulate marine habitats. They also prepared a new, automated audiovisual presentation identifying local seashore life which proved quite valuable to summer weekend visitors. More than 1000 people visited the lab during its 2-day open house, and the lab continued to offer outreach presentations to clubs, service organizations, and elementary and secondary schools throughout the year.



**SANTA CRUZ**—The Center for Coastal Marine Studies (CCMS) at **UC Santa Cruz** supplements its traditional interpretive program with unique activities that provide academic training to student interns working at **Natural Bridges State Park, Long Marine Laboratory, Elkhorn Slough, and Año Nuevo Park**.

Last year CCMS offered a first-of-its-kind seminar series in which

UC faculty presented and discussed their current research and field techniques with the student interns. Two new slide shows on the elephant seals at Año Nuevo and the addition of a second intern training handbook helped the center's growing interpretive and public information programs attract more than 11,000 people last year.



**MOSS LANDING**—**Moss Landing Marine Laboratories (MLML)**, a research-teaching facility operated by a consortium of six California state universities, has extended its Visitors Days program after an overwhelming response from area schools. More than 1300 preschool- through high school-level students visited MLML during the week-long science program designed to show local school children the marine life of Monterey Bay.

More than 6000 people attended MLML's sixth annual open house this year. The 2-day event provided visitors with information about Monterey's valuable marine resources and the research under way at MLML in an outdoor fair atmosphere of displays, cooking demonstrations, puppet shows, and sand dune tours.

For the third year in a row MLML offered marine science minicourses to students at a local continuation school and a 2-week marine science summer workshop for highly motivated children in grades 5 through 8. Additional MLML-sponsored activities include a student intern program, weekly ad hoc tours, and scheduled outreach presentations.

**SANTA BARBARA**—Each quarter the Marine Science Institute at **UC Santa Barbara** offers a marine science public education program for visitors and residents interested in learning more about the marine resources of southern California. Special diving collections provide

samples of organisms that live in the Santa Barbara Channel area, tanks and aquaria display local plants and animals, and microscope stations, "touch" tanks, and field research displays provide the public with a closer look at ocean life.

More than 3700 scheduled visitors toured the UCSB marine laboratory, viewing the displays and sample research projects and discussing the lab's research activities. Last year the laboratory extended its hours into the evening, which allowed students to bring their parents and families to the center to learn more about California's marine resources.

**LA JOLLA**—The Thomas Wayland Vaughan Aquarium-Museum at **Scripps Institution of Oceanography** at **UC San Diego** is open year-round to residents and visitors interested in learning about California's marine life. The Aquarium-Museum had more than 350,000 visitors last year; more than 34,000 preschool- through college-level students took part in its organized education programs. Last year's programs included 20 summer workshop courses for high school students and 17 1-week courses in area schools as part of the state-mandated Gifted and Talented Education Program.

Docents in the Aquarium-Museum's outreach program made presentations to more than 2,000 school students unable to visit the aquarium last year, and monthly lectures and field trips were held for students participating in the Junior Oceanographer Corps.



C. Foote



## Marine Advisory Program

*Marine specialists bring university research to ocean's users*

Throughout the year, California's Sea Grant regional marine advisors and MAP subject area specialists work closely with more than **60 cooperating organizations** in the state, providing information and support to thousands of commercial and recreational fishermen, seafood processors, coastal planners, consumers, aquaculturists, and residents who use the ocean for profit or recreation.

Since the program's inception, MAP advisors and staff have actively encouraged the adoption and implementation of new marine technologies by providing valuable information and support in such areas as seafood processing, ocean transportation, port development, retail handling, fishing methods, organization of fishermen's associations and cooperatives, aquaculture development, coastal planning, marine recreation, and public education. A brief overview of the Marine Advisory Program's 1980-81 activities follows.

### Fishermen Take Classes for A+ Catches

Each year, MAP advisors and specialists offer a series of workshops, minicourses, and training sessions to share technical information with fishermen and other user groups. In 1980-81 nearly 1000 commercial fishermen attended workshops to learn how lure speed, currents, and water temperature affect salmon catches. In other workshops they learned about Pacific whiting utilization, abalone fishery enhancement, fisheries management, trawling and other gear development, salmon stream enhancement, antitrust laws, fisheries economics, and federal assistance programs.

Several fishermen's groups learned how to form cooperatives; how to develop alternative fisheries such as shark, octopus, scallops, sea cucumbers, sablefish, Pacific whiting, rockfish, squid, and rock crab; and how to use remote sensing data. Because of these workshops, California fishermen are now fishing more efficiently using salmon lure speed information, and they are generating off-season income pur-



*Fishing captains Bob Strong and Bill Epple exchange valuable fishing information with California Sea Grant marine fisheries specialist Chris Dewees and marine advisor Bruce Wyatt.*

suing supplemental fisheries.

Estimates have shown that west coast salmon and albacore fishermen could save \$500,000 yearly in fuel consumption by using remote sensing data to determine the location of fishing grounds. MAP staff, in cooperation with **NMFS, NESS, JPL, NASA/Ames, and Scripps Institution of Oceanography**, are holding workshops to provide fishermen with satellite remote sensing temperature charts and information on their effective use, which could result in substantial fuel savings for the west coast fishing industry.

### Blue Shark Steak and Shoes

A need to better utilize California's abundant blue shark fishery prompted the Marine Advisory Program to conduct a feasibility study of an on-board mechanical skinning machine. The machine as conceived would remove the shark skin and keep the shark flesh intact for sale to fish wholesalers. The shark skin could be treated and sold overseas as a form of leather. The study showed that while the technology is available to design a marketable skinning machine, the device would not be economically viable until a larger market for the blue shark is developed.

A related cooperative study between MAP advisors and the **West Coast Fisheries Develop-**

**ment Foundation** resulted in further development of southern California's blue shark fishery and increased sales of blue shark in the area. Marine advisory staff will continue to work with the fishing industry in California and other Pacific coast states to further develop shark fisheries.

### California Salmon and Whiting Fisheries Expand

In northern California, a project to develop Pacific whiting markets has led to the expansion of the Pacific whiting fishery in that region. Marine advisory technical assistance in a **San Francisco Bay** salmon enhancement project resulted in increased sport and commercial catches during the 1980 and 1981 seasons. More than a thousand king salmon released in a 1977 salmon enhancement project, in cooperation with the **Tyee Foundation** (a San Francisco sportsmen's group) and **National Marine Fisheries Service**, were harvested with a market value of over \$50,000.

### Oil Industry Reps and Fishermen Meet

Last year marine advisors continued to facilitate group meetings and individual contacts between commercial fishermen, oil industry representatives, and resource management agencies including the **Department of Fish and Game**, the

**Bureau of Land Management, the Pacific OCS Office, the Coastal Commission, the State Lands Commission, and the Minerals Management Service.**

Communications between these groups has continued to improve, and much progress has been made in resolving conflicts between fishermen and industry regarding seismic survey vessels, bottom obstructions, and underwater pipe lines.

### **From Fish Refuse to Plant Food and Other Research Ideas**

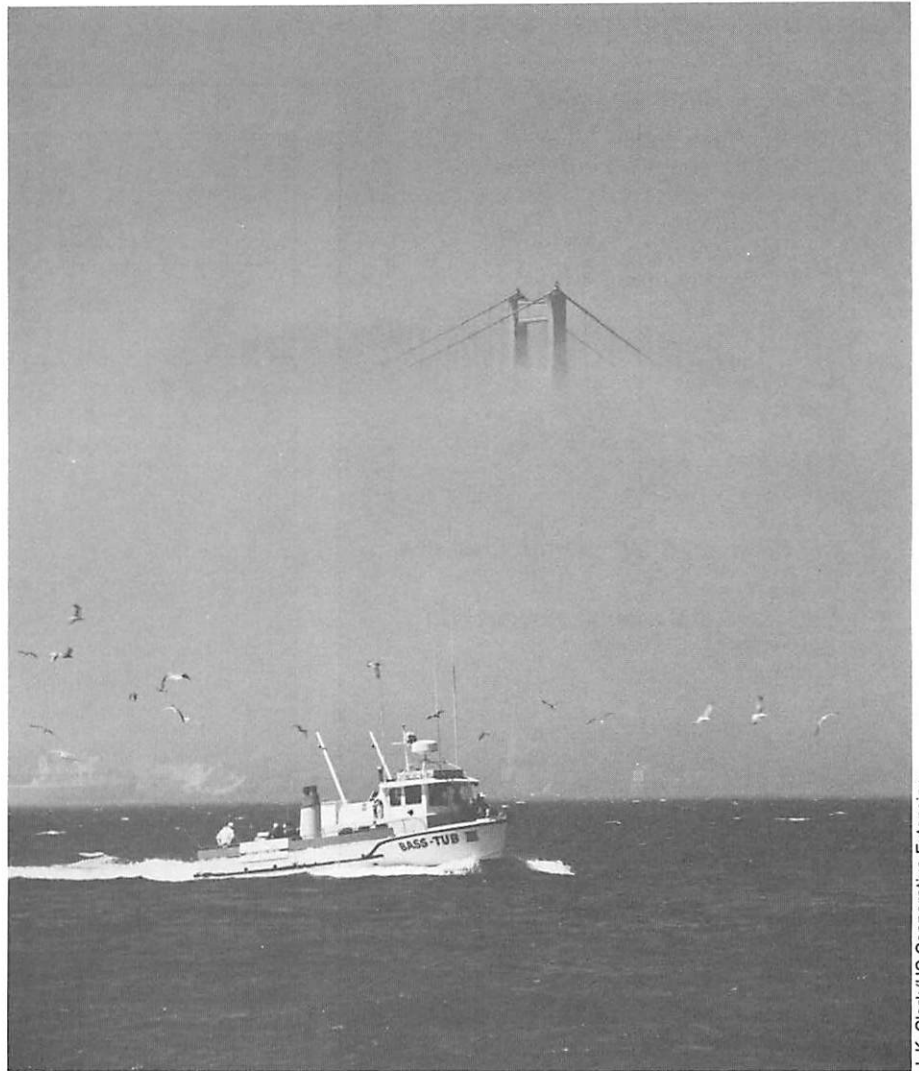
A MAP demonstration project offered several years ago has resulted in the development of a new industry in northern California. In **Fort Bragg** a seafood processor who learned how to convert fish waste into houseplant food at a MAP workshop has successfully used that information to produce a plant food that is now being sold nationwide in a major supermarket chain.

California seafood processors attended similar MAP demonstration projects last year to learn about current developments in seafood research. Companies used sanitation and quality control information to develop in-house training programs, or they simply adapted the processing waste utilization procedures suggested by the Marine Advisory Program. Others used information on modified atmosphere packaging and storage using carbon dioxide to study the feasibility of incorporating this new technology in their operations.

Last year processors requested and used research data on water conservation, processing techniques, shark jerky production, and seafood marketing. County planning departments and coastal commissions requested information on aquaculture, harbor planning, and sports and commercial fisheries for developing local coastal plans.

### **Port Authorities Do Their Job With Sea Grant's Help**

In cooperation with the **Port of Oakland**, the Marine Advisory Program conducted a survey of wood piling performance and presented a research forum on ports and transportation. The forum supplied impor-



J. K. Clark/UC Cooperative Extension

tant information on dock piling specifications and maintenance programs to port and harbor districts concerned with minimizing dock deterioration. Several port and harbor authorities have requested additional information on seafood

handling and processing needs; and the **California Coastal Commission** and county, city, and local coastal programs have requested information on harbor expansion planning, projected vessel berthing needs, and commercial marine fisheries.

<b>Sea Grant's Marine Advisory Projects</b>	<b>FY79</b>	<b>FY80</b>	<b>FY81</b>
Ocean Education for the Public (A/PE-1, Wilkie et al.)	O	O	O
Marine Advisory Program (A/EA-1, Cummings)	O	O	O
Publications and Public Advisory Services (A/P-1, Frautschy)	O	R	—
Communications, Publications, and Public Advisory Services (A/P-1, Sullivan)	—	R	O
The Golden Gate Marine Center (R/NP-1-9D, Caya)	—	N/C	—
Mobile Marine Science Outreach Program (R/NP-1-9J, Bauer)	—	N	C
Studies of Light and Life in Natural Waters (R/NP-1-10C, Tyler)	—	—	N
Workshop on Coastal Wetland Restoration and Enhancement (R/NP-1-10H, Josselyn)	—	—	N

C = Completed; N = New; O = Ongoing; R = Restructured



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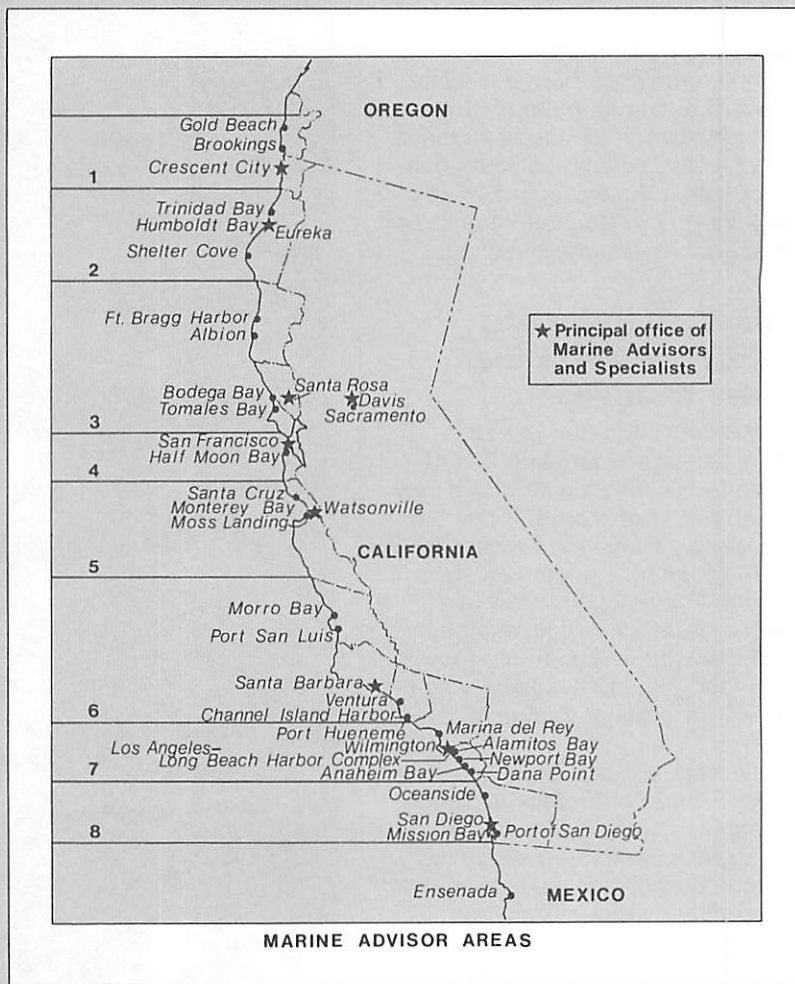
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# Coastal Resources

*Research helps restore and develop California's valuable coastal areas*

*The shallow-water marshes and tideflats of California's coastal lagoons, estuaries, and sloughs are valued by wildlife enthusiasts, biologists, conservationists, and developers interested in restoring, developing, and managing the state's coastal resources.*

*Because of the unique nature of these resources and the conflicting demands for their use, federal, state, and local agencies responsible for managing California's coastal zone have looked to Sea Grant for valuable research information in order to make wise management decisions.*

*Much of the research Sea Grant has supported in this area has shown that California's coastal resources problems are regional in nature; policy developed for east coast resources is not appropriate.*

*In 1980-81 Sea Grant remained committed to solving the region's critical coastal problems, particularly those which university research appears uniquely suited to answering.*

## **New Tool Catches Particles "In the Act"**

PASADENA—More than 300,000 tons of particulate matter from rain runoff and treated sewage are dumped into southern California's coastal waters every year, creating a particle "stew" that includes chlorinated hydrocarbons and toxic metals such as chromium, lead, and arsenic.

Researchers assumed that these particles were carried out to sea, where their diffused concentrations would be harmless. But some researchers weren't convinced, claiming that the particles might be settling into nearshore sediments where concentrations could reach potentially hazardous levels.

Dr. E. John List, professor of environmental engineering science at the **California Institute of Technology** (Caltech), has designed and built a device to determine the fate of these potentially harmful chemicals. With Sea Grant's support, List has built a 6-foot-long submarine

equipped with lasers to observe the particles in the act of whatever it is they do down there.

The little submarine, technically called a "laser-based velocimeter," is part of a larger Sea Grant project investigating the chemistry and physics of particulates in seawater. List and his cohorts have developed mathematical models that describe physical processes in the ocean that determine where the particles end up. The submarine, with its lasers and sophisticated electronics, is designed to gather field data to complement computer simulations of the mathematical models.

Whether a particle remains suspended is determined by two main processes: ocean turbulence and particle coagulation rate. Ocean turbulence affects the speed and direction of the suspended particle. As turbulence increases, the particles are pushed around more violently and bump into each other, sticking together to form clumps that eventually fall to the ocean bottom as sediment. The rate at which these particles stick together is called the coagulation rate.

Turbulence is the major factor that determines the coagulation of particles between 1 and 100 micrometers—the size of treated wastewater particles—but other factors are also involved, such as the differences in temperature as particles descend through the ocean's thermal layers.

List's submarine houses a laser-Doppler velocimeter, an instrument that tells the Sea Grant scientists how fast the suspended particles are moving. Towed behind a boat, the submarine "porpoises" up and down through thermal layers as far as 100 meters below the surface.

Particles passing through the velocimeter's path create a series of flashes, which are received by an onboard data system on Caltech's 32-foot research vessel *Osprey*. The flashes, when measured, tell the researchers how fast the particles are moving. By combining this information with the mathematical models developed in supporting Sea Grant research, the investigators

hope to determine the fate of potentially hazardous chemicals that enter the waters each year off southern California's coast.

The researchers are conducting most of the fieldwork out of the **Kerchoff Marine Biological Laboratory at Corona del Mar**. Additional funds for this research are provided by the **Office of Marine Pollution Assessment**, which, like Sea Grant, is part of the National Oceanic and Atmospheric Administration; by the **National Science Foundation**; and by part of a **Mellon Foundation** grant to Caltech. (R/CZ-48)

(Adapted from "Ocean Motion," *Engineering and Science*, January 1982.)

## **Gov't and University Help Restore Wetlands**

SAN DIEGO—Ecological guidelines for restoring and creating wetland communities are being developed and disseminated by Dr. Joy Zedler and staff at **San Diego State University** (SDSU) in a unique cooperative project between Sea Grant and federal, state, and local agencies.

In response to requests from the **U.S. Navy**, the **U.S. Fish and Wild-**



K. Witt/Sea Grant



**life Service, the California Department of Parks and Recreation, the City of San Diego, and the Port of San Diego,** the researchers have provided information and advice on wetlands management guidelines and specific management and mitigation plans. They have served on wetlands management advisory panels, consulted during wetlands project planning, and provided guidance to agencies responsible for managing California's coastal wetlands.

This Sea Grant project is an outgrowth of previous ecosystems research in the **Tijuana Estuary and San Diego Bay.** Several organizations have already put to use the results of California Sea Grant research on coastal wetland restoration. The U.S. Navy, which owns much of southern California's Tijuana estuary and must protect its wildlife, worked with Sea Grant researchers to increase cordgrass distribution in the estuary, providing a better habitat for the endangered clapper rail and other species that live there. (R/CZ-51)

### **Sludge Island Becomes Home for Wildlife**

SAN DIEGO—Creating a wildlife habitat out of an 80-acre dredge waste island is a problem the **Unified Port District of San Diego** hopes to solve using results of Dr. Zedler's Sea Grant research at SDSU. The island was created in south San Diego Bay when a nearby boat basin was dredged. Test-plantings of marsh vegetation on the island's dike will provide information for use by the port district once the island is ready for planting, possibly as soon as this fall. (R/CZ-51)

### **Wetlands Present Management Problems**

SANTA BARBARA—At the Navy installation at Pt. Mugu, complementary Sea Grant wetlands research is being conducted by Drs. Christopher Onuf and Robert Holmes from **UC Santa Barbara** and Dr. Charles Peterson from the **University of North Carolina.** The researchers applied the research results of previous work on the biological history of coastal wetland ecosystem function to three practical wetlands management problems. They documented the immediate effects of siltation caused by heavy rains in

1978 and monitored the wetland's recovery rate. They tested the effects of increased tidal flushing—a procedure proposed for improving coastal wetland productivity—on lagoon use by water fowl.

The researchers are presently defining the important food web relationships that would be affected by planned coastal wetland alterations such as dredging and filling for navigation, flood control, and habitat improvement. (R/CZ-52)

### **Salt Marsh Comes Back...Slowly**

ARCATA—To evaluate the effectiveness of an estuarine mitigation project, Drs. Roger Barnhart and Milton Boyd at **Humboldt State University** assessed and monitored the fisheries resources of a salt marsh restored through tidal flushing in Humboldt County. They compared the area's fish abundance, diversity, and degree of usage with a nearby undisturbed salt marsh, and they developed an innovative sampling program to monitor the salt marsh habitat—a habitat which has historically posed problems to researchers conducting government-mandated field studies.

The researchers' data suggest that it can take at least several years for a fully developed salt marsh to be completely restored. Information from this study will allow local, state, and federal agencies to assess the degree of restoration possible in wetland restoration projects. The **U.S. Fish and Wildlife Service** and five California state and local agencies sought technical advice from the researchers and used their preliminary data to design mitigation projects required by permitting agencies. (R/CZ-56)

### **So. California Profile Sets Standard for National Wetlands Series**

SAN DIEGO—At the request of the **U.S. Fish and Wildlife Service,** Sea Grant researcher and wetlands specialist Dr. Joy Zedler of **San Diego State University** has written a 110-page community profile of southern California salt marshes. *The Ecology of Southern California Coastal Salt Marshes: A Community Profile* describes the history, functions, and resources of the salt marsh ecosystem, and it presents common problems and possible so-

lutions—developed in Sea Grant research—to aid government agencies responsible for managing southern California's marsh areas.

Dr. Zedler's publication will serve as the model for a series of community profiles Fish and Wildlife is producing for distribution to major federal, state, and local agencies in coastal areas throughout the United States, as well as to universities, libraries, and interested individuals. The California Sea Grant communications office is working with Fish and Wildlife to coordinate the profile's distribution in California. (R/CZ-51)



J. Zedler/Sea Grant

### **Phosphorus Deposits Located Off California's Shores**

MOSS LANDING—The distribution and resource potential of phosphorites off central California's shores have been determined by **San Jose State University** researcher Dr. Michael Mullins at Moss Landing Marine Laboratories. The extensive phosphorous-rich deposits, which could provide a valuable source of the mineral for use in fertilizers, were located and mapped offshore **Pt. Sur** and **Cape San Martin,** and minor deposits were found off **Pescadero Point.**

Sea Grant is extending this 3-year project to allow researchers to supplement raw chemical data with bottom photographs to estimate the volume and concentration of the phosphorite deposits. The results of this Sea Grant project will help federal and local government agencies that lease offshore mineral rights and chemical companies that want to mine this resource. (R/CZ-54)

### **Watershed Development Model Has Wide Potential**

BERKELEY/MOSS LANDING—Urbanization, agricultural development, and forestry practices often affect the upstream watersheds that



feed coastal wetlands. Dr. Thomas Dickert at **UC Berkeley** and researchers at **Moss Landing Marine Laboratories** recognized this problem and designed a model planning system for coastal wetland watershed development around **Elkhorn Slough**. Their model system is now the major basis for Monterey County's land use program.

Land use planners are reviewing the system for possible adaptation and application in other areas, including the **Columbia River Estuary** on the Washington-Oregon border, **Yaquina Bay** in Oregon, **Gray's Harbor** in Washington, and **Chesapeake Bay** on the east coast. (R/CZ-57)

### **Kelp Bed Currents Stir Up Abalone, Energy Interests**

**SAN DIEGO**—The relationships between large kelp beds and the water currents and mixing rates within them are being studied by Drs. George Jackson and Clinton Winant at **UC San Diego**.

Current flow, mixing, and offshore exchange play important roles in the distribution of nutrients and larvae in kelp beds. Preliminary results from this project indicate that kelp

#### **Sea Grant's Coastal Resources Projects**

	<b>FY79</b>	<b>FY80</b>	<b>FY81</b>
Coastal Wetlands Management: Biological Criteria (R/CZ-33A, Holmes et al)	C	—	—
Coastal Wetlands Management: Effects of Disturbance on Estuarine Function (R/CZ-33C, Zedler/Mauriello)	C	—	—
Thermal Variability in Coastal Waters in the Southern California Bight (R/CZ-31, Winant)	C	—	—
Geological and Historical Analysis of Coastal Zone Environmental Hazards and Liability for Losses Caused by Them (R/CZ-43, Shepard/Hildreth)	C	—	—
Kelp Forest Ecology of Central California (R/A-16C, Pearse)	C	—	—
Wetlands Management in Coastal Zone Planning: A Prototype Framework for Relating Natural Science and Land-Use Planning (R/CZ-45, Dickert/Nybakken)	N	C	—
An Experimental Program to Develop Methods for Kelp Bed Expansion and Enhancement (R/CZ-46, Neushul/Coon)	N	C	—
A Study of the Entrance Problems at Humboldt Bay (R/CZ-47, Isaacs/Kerstetter)	N	C	—
Coastal Governance in California, with Special Reference to State-Local Collaborative Planning (R/CZ-49, Lee/Scott)	N/C	—	—
Feasibility Study of <i>in situ</i> CPR Using SCUBA-ERR (Emergency Regulator Resuscitation) and Closed-Chest Cardiac Massage (R/NP-1-8A, West)	N/C	—	—

(continued on next page)



beds influence their physical environment in much the same way terrestrial forests do. The researchers' description of water currents and mixing rates in and around the beds will aid development of effective kelp fertilization methods and help explain abalone and sea urchin recruitment in the beds.

Sea Grant investigators at **California Institute of Technology** and **UC Santa Barbara** are interested in using the results of this project in their research, which has received support from the **Department of Energy** and the **American Gas Institute**, to determine the feasibility of farming kelp as a potential energy source. Knowledge of the role currents play in the dispersion of nutrients, fertilizers, and larvae will help determine kelp farming's potential, and it will aid other kelp fertilization projects as well as enhancement programs for lobster, crab, and abalone. (R/CZ-59, R/CZ-46)

### Will Landfill Hold During Quake Shake?

**SAN DIEGO**—The stability of landfill areas during an earthquake is being studied by Sea Grant researcher Dr. Iraj Noorany in the Civil Engineering Department at **San Diego State University**. Dr. Noorany is conducting a critical study of the soil conditions and liquefaction potential of **Harbor Island**, a 70-acre landfill built in San Diego Bay in 1961.

The construction history of the island and the regional seismology of the area are being considered to determine the potential liquifying effect of earthquakes most likely to affect the island.

Dr. Noorany's findings will be used to recommend possible mitigative measures to the **Unified Port District of San Diego**.

The study of Harbor Island could serve as a model for studying the stability of similar coastal fills elsewhere. (R/CZ-61)

<b>Sea Grant's Coastal Resources Projects (continued)</b>	<b>FY79</b>	<b>FY80</b>	<b>FY81</b>
Dioxins—Historical Record of Fluxes in Lake Michigan Sediments (R/NP-1-8C, Goldberg)	N/C	—	—
Coastal Wetlands Management: Review of and Recommendations about Local Plans (R/NP-1-8E, Onuf)	N/C	—	—
Methods of Increasing Diver Effectiveness Through CO <sub>2</sub> Absorbers and Decompression Computers (R/NP-1-8F, Mote)	N/C	—	—
Wetlands Restoration Option Study—Ballona Wetlands (R/NP-1-8G, Clark)	N/C	—	—
Recreation Transportation Analysis for Coastal Planners: A Technical Report on the Methods Used in California (R/NP-1-8H, Kanafani)	N/C	—	—
Feasibility Study to Assess the Development of an Applied Marine Research Directory (R/NP-1-8K, Sorensen)	N/C	—	—
Acoustic Tomography (R/CZ-P-1, Munk et al.)	N/C	—	—
Coastal Wetlands Management: Restoration and Establishment (R/CZ-51, Zedler)	—	N	C
Coastal Wetlands Management: Application of Biological Criteria (R/CZ-52, Onuf et al.)	—	N	C
Investigation of Coastal Bluff Retreat for the Trinidad Headland Area of Northern California (R/CZ-53, Carver)	—	N/C	—
Analysis of Coastal Ocean Mixing Models (R/CZ-48, List/Morgan)	—	N	C
Phosphorites Along the Central California Continental Margin (R/CZ-54, Mullins)	—	N	C
Evaluation of the Mad River Estuary (R/NP-1-9C, Crandell)	—	N/C	—
The Role of Nutrients in Supporting Phytoplankton Productivity in Humboldt Bay (R/NP-1-9E, Pequegnat)	—	N/C	—
Sea Cliff Erosion and Beach Accretion Along San Onofre State Park and Camp Pendleton, San Diego County, California (R/NP-1-9G, Shepard)	—	N/C	—
Aerial Survey of Humboldt Bay, California (R/NP-1-9I, Stork/Costa)	—	N/C	—
Salt Marsh Restoration: An Ecological Evaluation of an Estuarine Mitigation Project (R/CZ-56, Barnhart/Boyd)	—	—	N
Sea Urchin Diseases (R/CZ-58, Hinegardner)	—	—	N
Liquefaction Potential of Coastal Fills (R/CZ-61, Noorany)	—	—	N
Coastal Zone Geology and Related Sea Cliff and Bluff Erosion: Oceanside South to Batiquitos Lagoon, Carlsbad, Oceanside Littoral Cell, San Diego County, California (R/NP-1-10E, Shepard)	—	—	N
Investigation of Coastline Retreat, Humboldt County, Northern California (R/NP-1-10F, Rust)	—	—	N
Longard Tube Survey and Documentation, Del Mar, California (R/NP-1-10G, Flick)	—	—	N
Planning Methods for California's Coastal Wetland Watersheds (R/CZ-57, Dickert)	—	—	N
Water Currents and Mixing Rates in Kelp Beds (R/CZ-59, Jackson/Winant)	—	—	N

C = Completed; N = New

# Aquaculture Research and Development

*Ocean farming could provide steady protein source for nation's landlubbers*

*Aquaculture—the controlled cultivation and harvest of aquatic plants and animals—has not yet realized its full economic potential in the United States. With the help of major research advances, however, aquaculture offers the possibility of meeting the nation's increasing demand for useable protein from the sea and reducing the nation's imports of fishery products.*

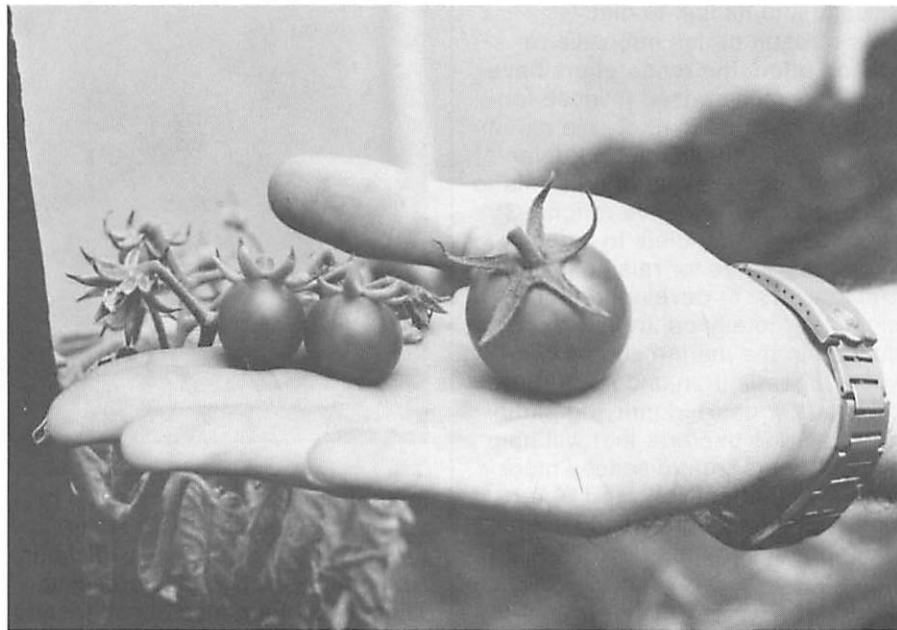
*Aquaculture is a major component of California's Sea Grant research. In 1980-81, aquaculture research addressed problems in traditional agriculture as well as problems that hinder aquaculture development of many commercially-valuable marine species native to California's waters.*

## Tomatoes Thrive in Sand and Saltwater

DAVIS—Salt-tolerant barley, wheat, and tomato crops have been developed in a 6-year effort by Sea Grant researcher Dr. Emanuel Epstein and staff at **UC Davis**. Dr. Epstein focused on developing crops that could be grown in sandy soil using seawater or brackish water but his work also has important applications in regions where conventional crop production is hindered by soil salinity problems.

The researchers have determined that certain strains of barley, wheat, and tomatoes possess a high degree of salt tolerance. For example, the progeny of an initial cross between a domestic tomato and a wild, salt tolerant one grew successfully in salinities of up to 70 percent seawater. Furthermore, the researchers' production of barley under saltwater conditions equaled the best yields currently obtained in coastal India in conventional agriculture operations.

Selected germplasm from this project is now being supplied to tomato breeders for commercial development of salt-tolerant varieties. Several public and private institutes are modifying the researchers' basic scheme of selecting and breeding salt-tolerant crops for application in



*These tomatoes were grown from offspring of a cross between a commercial salt-sensitive tomato and a wild salt-tolerant one. Tomatoes on left received 70% seawater, one on right received fresh water.*

arid and semi-arid regions where agriculture is beset by soil salinity problems. Scientists from **India, Pakistan, Israel, Egypt, Mexico, and Australia** have expressed interest in the results of this project. (R/A-42)

## New Plants Grown From Parent Cells

SANTA BARBARA—Modern propagation techniques may be used to develop new varieties of marine plants that will have nutritional, medicinal, and chemical applications, according to research results obtained in a Sea Grant project underway at **UC Santa Barbara**. Drs. Aharon Gibor and Michael Neushul are developing techniques for vegetative propagation and selection of commercially important benthic marine algae.

Vegetative propagation allows researchers to bypass certain life stages in plants, thereby increasing the number of plants that can be grown. Previously, the researchers overcame a major obstacle to cul-

tivating isolated tissues and cells from marine algae by developing a procedure to rid the cultures of bacteria and fungi. With contaminant-free tissues from *Porphyra tenera*, a red alga of significant commercial value in Japan, the researchers successfully grew small fragments of tissue using modern propagation techniques, and they isolated live cells, which in turn will be induced to grow into new plantlets. (R/A-37)

## Lobster and Shrimp Successfully Raised

DAVIS—The development of a diversified and economically viable crustacean aquaculture industry in California is the goal of **UC Davis** researchers at **Bodega Bay Marine Laboratory**. Drs. Wallis Clark and Douglas Conklin are conducting interdisciplinary Sea Grant projects dealing with crustacean aquaculture, particularly that of shrimp, lobster, and brine shrimp. Their research attacks the problem in six related areas: broodstock development, endocrinology, larval biolo-



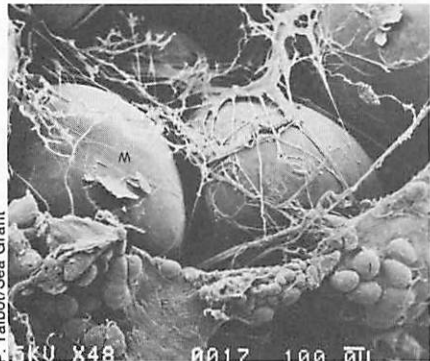
gy, nutrition, engineering, and pathology.

In 1980-81 the researchers controlled reproductive cycles, studied growth physiology, defined nutritional requirements to develop artificial food, developed technology and broodstocks for genetics research, and improved their knowledge of disease and its link to diet.

As a result of this intensive research effort, the researchers have 1) successfully raised juvenile lobsters to 1-pound market size on an exclusively artificial diet, 2) determined optimum levels of nutrients to formulate cost-effective rations, 3) supplied artificial diets to industry and researchers for raising prawns and lobsters, 4) developed techniques for totally controlled reproduction in the marine shrimp *Sicyonia ingentis* (Penaeidae), 5) developed a flow chart identifying pathogenic marine bacteria that will help mariculturists treat diseases more rapidly and effectively, and 6) provided disease diagnosis to several California fish hatcheries. (R/A-28)

## Fertilization Under Control, Sperm Banks Will Follow

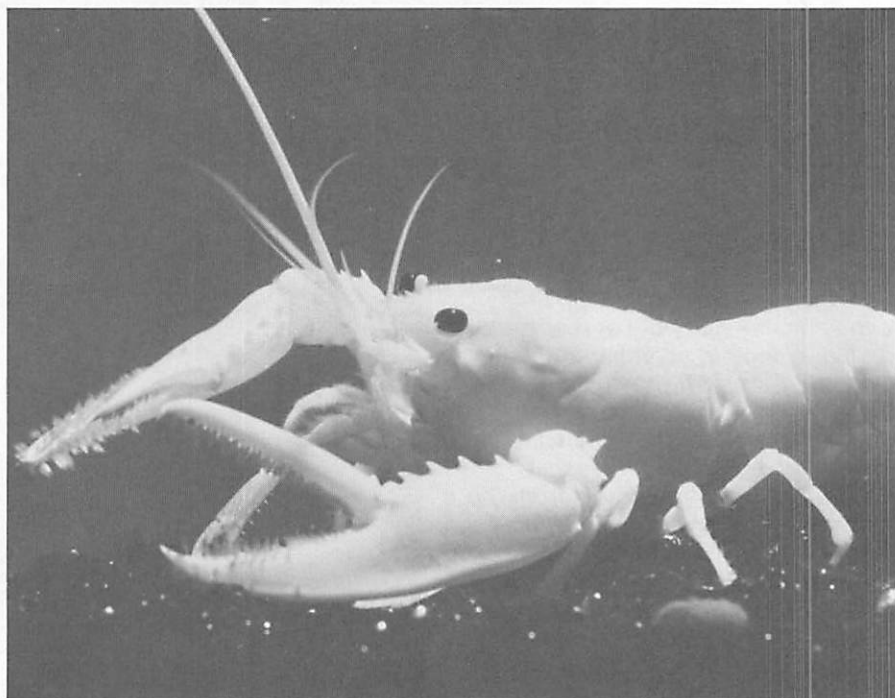
RIVERSIDE—Lobsters won't have a choice in the matter if researchers at UC Riverside have their way. Project leader Dr. Prudence Talbot is exploring the basic mechanisms involved in lobster fertilization. Dr. Talbot and her staff have developed a technique for collecting viable sperm from live male lobsters that



Electron micrograph of lobster ovary. Muscle threads along follicles (I, M) may play role in ovulation.

should be directly applicable to aquaculture technology for lobsters and other crustaceans.

The technique, which electrically induces extrusion of lobster sper-



matophores, provides a source of sperm, in its natural packet, for further experimentation, artificial insemination, and genetic crossing. The researchers also began testing a technique they developed for long-term storage of sperm, which will lay the groundwork for future development of sperm banks for lobsters. (R/A-29)

## Vaccine Protects Shrimp From Disease

SAN DIEGO—Successful mass-culturing of shrimp is occurring at the pilot-farm stage in Hawaii, Texas, Mexico, and Central and South America, but problems of reproduction, nutrition, and disease pose major obstacles to successful commercial shrimp production. Researchers from San Diego State University are working with colleagues at the University of Arizona to develop an easily administered vaccine for *Fusarium* disease—the most serious to affect shrimp.

Building on their previous year's development of microassay and respirometric techniques, Dr. James Steenbergen and Dr. Donald Lightner have demonstrated that injections of heat-killed vaccines will immunize shrimp against *Fusarium* disease. Although the vaccination process is labor-intensive, vaccine use has considerable potential in protecting brood stocks for further aquaculture propagation. In the

next phase of this project, the researchers will test methods for administering the vaccine through osmotic absorption. (R/A-38)

## Hybrid Abalones Help "Ab" Aquaculture

LA JOLLA—In previous Sea Grant research, investigators at the Scripps Institution of Oceanography at UC San Diego developed significant interspecific hybridization in California abalone. Armed with a better understanding of abalone fertilization processes, project leader Dr. Victor Vacquier has now produced hybrid abalones by carefully controlling final sperm concentration and by adding sperm quickly to newly spawned eggs. The survival and growth rates of the hybrid juveniles are encouraging for eventual production of a superior breeding stock. The ability to produce heterotic hybrids in a controlled manner should be widely applicable to commercial abalone aquaculture. (R/A-39)

## Abalone, Shellfish Production Improved

SANTA BARBARA—New techniques for improved production of commercially valuable shellfish have been developed by Sea Grant researchers at the Marine Science Institute at UC Santa Barbara. With the

cooperation of commercial shellfish producers, Dr. Daniel Morse and his associates have developed techniques that inexpensively and reliably control reproduction (accelerated gametogenesis, controlled spawning), larval development, settlement, metamorphosis, and survival, and will aid production of more commercially-valuable species of abalone hybrids and other shellfish, including some previously considered too difficult to produce.

One biomedical technique developed for inducing larval settlement and metamorphosis is less expensive and more useful than current methods and may prove applicable to other species of valuable shellfish. The researchers have also identified principal factors responsible for the slow growth rate of cultivated abalones and subsequently identified two natural hormones that safely accelerate abalone growth rate. (R/A-43)

### Special Diet Helps Rock Scallops Grow

SAN DIEGO—Survival and healthy growth—not weight control—are the reasons rock scallops at **Scripps Institution of Oceanography (SIO)** are dieting today. Using a specially-designed laboratory at SIO, Drs. Charles Phleger and David Leighton at **San Diego State University** are refining and developing aquaculture technology for the purple-hinge rock scallop. At this point in their project, the researchers have shown that adult brood stock remain healthy and continue to grow on a single diet of *Tetraselmis suecica*.

The researchers have also shown that 1) temperature and photoperiod control allow maturation of the scallop brood stock during late summer and fall months, 2) larvae produced by artificially conditioned brood stock are normal, 3) a mixture of food algae provides a superior diet for the juvenile rock scallops, and 4) the nutritional value of food algae varies with the algae's culture growth stage. Results of this ongoing project should stimulate the commercial development of rock scallop aquaculture. (R/A-44)

Sea Grant's Aquaculture Projects	FY79	FY80	FY81
Use of Thermal Effluent in the Culture of Crustacea and Fishes (R/A-21, Van Olst/Ford)	C	—	—
Genetic Program for Improvement of Carrageenan Production in <i>Gigartina</i> (R/A-17B, West)	C	—	—
Toward Seawater-Based Crop Production (R/A-22, Epstein)	C	—	—
Development of the Science and Technology of Crustacean Aquaculture (R/A-28, Clark/Hand)	N	O	C
Control of Reproduction in the Decapod Crustaceans (R/A-29, Talbot)	N	O	C
Studies to Refine Hatchery and Ocean Rearing Methods for the Purple-Hinge Rock Scallop (R/A-31, Phleger/Leighton)	N	C	—
Biochemical and Genetic Control of Critical Physiological Processes in Molluscan Life-Cycles: Basic Mechanisms, Water-Quality Requirements, and Sensitivities to Pollutants (R/A-32, Morse)	N	C	—
Aquaculture of Red Algae (R/A-34, Abbott)	N	C	—
Culture of Marine Bivalves: Effects of the Uptake of Amino Acids (R/A-33, Stephens)	N	O	C
An Exploratory Study of the Vegetative Propagation of Benthic Marine Algae (R/A-37, Gibor/Neushul)	N	O	C
Investigations of Population Genetic Structure in Abalones (R/NP-1-8B, Hedgecock/Morse)	N/C	—	—
Procurement of Wildstock Sturgeon (R/NP-1-8J, Clark/Doroshov)	N/C	—	—
Protective Measures Against <i>Fusarium</i> Disease in Shrimp (R/A-38, Steenbergen/Lightner)	—	N	C
Assessment of Sperm-Egg Interactions During Fertilization and Hybrid Formation of California Abalones (R/A-39, Vacquier)	—	N	C
Food and Fiber from Seawater, Sand, and Solar Energy (R/A-42, Epstein)	—	N	C
Regulation of the Production of Dormant Cysts by the Brine Shrimp, <i>Artemia salina</i> , and Factors Influencing the Viability of Such Cysts (R/A-41, Crowe)	—	N	C
Pathology and Bacteriology of a Disease of Crustaceans Caused by a Marine Bacterium (R/NP-1-9H, Baumann/Bowser)	—	N/C	—
Ova Development Success as a Function of Temperature and Delay in Fertilization Post Spawning (R/NP-1-9L, DeMartini)	—	N/C	—
Improved Procedures for Salmon Management in California: Bioeconomic Approaches (R/MA-3, Wilen/Botsford)	—	—	N
Seasonal Growth Responses of Vegetative Axes and Spores of an Agar-Producing Marine Alga (R/NP-1-10B, Stewart)	—	—	N
Biochemical Engineering for Improved Production of Commercially Valuable Marine Shellfish (R/A-43, Morse)	—	—	N
Artificial Control of Gametogenesis, Spawning, and Larval Production in the Purple-Hinge Rock Scallop (R/A-44, Phleger/Leighton)	—	—	N

C = Completed; N = New; O = Ongoing



# Fisheries Research and Development

*Sea Grant helps the nation get more protein from the sea*

*Sea Grant fisheries research focuses on four approaches to provide increased supplies of marine protein for human consumption: 1) enhancing traditional fisheries such as salmon and abalone, 2) developing the fisheries of underutilized species through biological, technological, and public policy studies, 3) developing wise utilization and management approaches for all fisheries, and 4) increasing the use of current catch through product development.*

## Developing Fisheries Supply More Food for Nation

### Abalone

LA JOLLA—Enhancing California's abalone population is the aim of Sea Grant's fisheries specialist, Dr. Mia Tegner of **Scripps Institution of Oceanography at UC San Diego**. Dr. Tegner is testing four abalone enhancement approaches: seeding, broodstock transplantation, habitat modification, and closure.

Dr. Tegner is studying the effects of habitat, looking at size-specific survivorship, and monitoring changes in abalone populations resulting from previous seeding experiments and the closure at **Palos Verdes**. Last year she completed experimental plants of red and green abalone seed at **Palos Verdes Peninsula** and **Santa Cruz** and **San Miguel Islands**. Last year she also conducted a drift-bottle experiment to study green abalone larval dispersal and continued life table studies on **Santa Rosa Island**.

Given abalones' slow growth rate and the 2- to 4-year experimental lag time, it is too early to determine which experimental approach is most feasible. However, preliminary results are encouraging and the data are already being used by management agencies and private industry. The **Department of Fish and Game** and the **California Legislature** used the UC researcher's

data to extend fishing closure from Palos Verdes Point to Dana Point for a second 5-year period.

**Southern California Edison**—with the Department of Fish and Game—is using Dr. Tegner's abalone habitat data to design eight experimental artificial reefs near **San Onofre**. To the researchers' knowledge, these are the first artificial reefs in the U.S. designed to enhance invertebrate and fish populations. The Department of Fish and Game is currently seeking funding to implement the successful seeding techniques on a larger scale. (R/F-47)

SANTA BARBARA—Each of the proposed enhancement methods studied by Dr. Tegner at **UC San Diego** is being analyzed in a related project at **UC Santa Barbara**. An economic model of the California abalone fishery developed by Dr. Robert Deacon will provide cost-benefit estimates of the proposed abalone enhancement methods.

Dr. Deacon has tested the model with historical data on commercial catch, effort, prices, and cost components of the pink abalone fishery, and his results strongly indicate that the declining catches observed in the fishery since 1950 are not primarily due to overfishing. Rather, the model indicates the trend is due to 1) introduction of a commercial fishery into a previously unexploited population, 2) the increased harvesting size limit imposed on the fishery in 1970, and 3) the introduction of a limited entry program in 1977. (R/F-53)

### Shark

MOSS LANDING—The popularity of using elasmobranchs—primarily sharks—as food is increasing, yet very little is known of the species' life history. At Moss Landing Marine Laboratories, Dr. Gregor Cailliet and his associates from **San Jose State University** are testing several techniques for determining the age of elasmobranchs. The researchers have identified several aging techniques to count rings in elasmobranch vertebrae, as no one tech-

nique works with all species. Using those techniques they determined the ages of more than 1,100 specimens from 23 species of sharks, skates, and rays. The next step in this project will be to verify the annual periodicity of the vertebrae rings.

Dr. Cailliet has produced reliable growth curves for five elasmobranch species common in central California (bat ray, leopard shark, gray and brown smoothhounds, and blue shark) and preliminary curves for three others (thresher shark, bonito shark, angel shark). The researchers have also verified that elasmobranchs grow slowly, mature late in life, and produce a small number of offspring. Their data emphasizes the importance of wise management to ensure survival of this fishery. (R/F-57)

### Herring

SANTA CRUZ—Presently, **Fish and Game** officials cannot determine if fish that spawn in the northern California bays are from separate stocks or represent one population of fish; hence, they must set separate quotas for each bay to insure the integrity of the fishery. Mike Moser at the Center for Coastal Marine Studies at **UC Santa Cruz** has collected 550 Pacific herring from **Monterey, San Francisco, Tomales, and Humboldt** bays and off **Crescent City's** shoreline in a study to determine whether parasites can be used as biological tags to separate California stocks of Pacific herring.

In his preliminary analysis of fish muscle tissue, Moser found differences in infection rates and the number of parasites per infected host between areas. This finding could suggest that the fish are from different stocks which would strengthen the rationale for continuing separate quota systems. (R/F-65)

### ...Eggs-on-Seaweed

PACIFIC GROVE—At **Stanford University's Hopkins Marine Station**, Drs. Isabella Abbott and Judy Han-

sen are exploring ways of integrating two marine fisheries: the existing winter "herring eggs-on-seaweed" fishery that is harvested for consumption in **Japan**, and the potential mariculture of *Gracilaria*, a seaweed that produces agar which is a substance of great commercial value to the biomedical community. Both fisheries require a stable and predictable seaweed source, and if the *Gracilaria* crop can be cultivated within the herring spawning grounds, the two can be harvested for their separate uses.

The researchers' three-fold approach of field, controlled culture, and laboratory studies enabled them to determine growth rates for natural *Gracilaria* crops in **Elkhorn Slough**, and they successfully cultivated a crop using monoline techniques. The crop was transplanted to **San Francisco Bay** for the herring spawning season, where it was spawned on twice at commercially harvestable levels.

The commercial value of bacteriological grade agar is approximately \$52. per kilogram (about 2.2 pounds). The commercial value of cured herring eggs-on-seaweed currently ranges in Japan from \$6000 to \$20,000 per wet ton. The demand for this delicacy can fluctuate dramatically from year to year. Development of this industry could have a substantial impact on California's export economy. (R/F-65)

## Crab

DAVIS—Biological factors that contribute to cyclic fluctuations in northern California's crab fishery are being studied by researchers at the Bodega Marine Laboratory and **UC Davis**. Drs. Botsford, Hand, and Johnston narrowed potential causes of cyclic crab population fluctuations to environmental factors and density-dependent recruitment stemming from either cannibalism, the egg-predator worm, or an as yet unidentified mechanism. In related work, the researchers described the fishery's important economic aspects and worked toward evaluating management policy recognizing both biological and economic factors. (R/F-52)

## ...and Lobster

SANTA BARBARA—At **UC Santa Barbara**, Dr. James Case and his associates are analyzing bait and trap functions to improve efficiency

of commercial shellfishing operations, particularly those of crab and lobster. They conducted field and laboratory experiments to determine the most effective composition, solubilization rate, and concentration of bait, and the role of certain behavioral and environmental variables, principally light and water movement, in lobster foraging behavior.

A large behavior tank allows the researchers to observe directly the lobster's orientation behavior in the presence of baits and traps. Preliminary results from this project demonstrate that some baits are being inefficiently used by commercial fishermen and seafood industries.

For example, most shellfish fishermen prefer to use abalone bait—a potent, expensive bait that is in short supply. The UC Santa Barbara researchers have shown that fishermen can cut in half the amount of abalone bait they presently use and maintain the same catch yields. They have also shown that mackerel bait, a less expensive and less potent bait, increases in effectiveness when it is ground. The potential cost savings of these two findings should have a substantial impact on the economy of shellfish fishing. (R/F-67)

## More Crab

ARCATA—To determine the vital statistics of northern California's female dungeness crab (*Cancer magister*) stock, Dr. David Hankin at **Humboldt State University** marked and released 5,000 adult females in an ocean mark-recovery program to generate molt increment data. Dr. Hankin is investigating the hypothesis that variations in the abundance of female crabs, which are not currently fished, may be involved in the cyclic nature of crab landings. Cooperating fishermen have begun to return the released crabs, which researchers will study for changes in size.

In a related aspect of the project, a 2-day workshop was held on dungeness crab dynamics and fishery management on the Pacific coast. The workshop brought together scientists involved in dungeness crab studies in **California, Oregon, Washington, and British Columbia**. Preliminary research results from this Sea Grant project were shared with researchers in attendance, and subsequent information and data has been disseminated through the

dungeness crab research network that has resulted from the workshop. (R/F-72)

## Salmon

BERKELEY—Timing the release of hatchery-reared coho salmon into seawater is a difficult problem for California salmon hatcheries. At **UC Berkeley**, Dr. Howard Bern and his associates are studying ways to minimize losses caused by abnormal smoltification or stunting that occurs when hatchery-reared salmon are released prematurely into seawater. The researchers looked for a developmental indicator to make sure the salmon enter the seawater at an appropriate stage, and they discovered a link between a surge in salmon thyroid hormone levels—a probable indicator of when smolting will occur—and the new moon after the vernal equinox.

Collaborative programs with the **California Department of Fish and Game** led to timed releases of tagged coho salmon in 1980-81 from the **Trinity and Iron Gate** hatcheries; the release dates were based on the lunar hypothesis of the smoltification-associated thyroid hormone peak. Additional smolt trapping studies were begun at the **Mad River** hatchery to develop a method of segregating fish ready for migration from the remaining population.

In a secondary aspect of their project, the researchers helped organize and participated in the Sea Grant-sponsored First International Salmon Smoltification Symposium in **La Jolla**, which was attended by researchers from the **United States, Canada, Japan, and Europe**. (R/F-45)



R. J. Hallock/DFG



## New Products Cut Costs, Get Fish to Market

### Modified Atmospheres Keep Fish Fresh Longer

DAVIS—The shelf life of fresh fish has been doubled by researchers at UC Davis who are testing the use of modified atmospheres (MA) in storing various fish products, including round fish, fish fillets, and minced fish.

In his study, Dr. W. Duane Brown has shown that high carbon dioxide levels (80%) in modified atmospheres prevent fish spoilage, extend shelf life from 5-7 days to 14 days, and lessen skin color fading on Pacific red snapper. The results of this project could substantially influence the handling, distribution, and cost of a variety of seafood products. Three major seafood industries are providing technical support and fish products for this study; one firm has already used the results of this study for commercial shipping of seafood products. (R/F-68)

Also at UC Davis Drs. Ericka Barrett and David Ogrydziak conducted related studies on the microbiology of rock cod stored in air and modi-



fied atmospheres. They determined optimum conditions for microbial analysis of MA-stored fish and identified bacteria present in MA-stored rock cod after 3 weeks at 4° C. They isolated and identified the predominant microorganisms present before and after 21-day MA storage and determined that bacterial load increases during MA storage as it does during air storage. However, unlike air storage, the increase was largely in the number of lactobacillus. (R/F-69)

## Recycling Cuts Shrimp Waste and Water Use

DAVIS—The use of water recycling in shrimp processing is being tested by Drs. Paul Carroad and Robert Price at UC Davis to reduce water consumption and waste processing treatment costs in the shrimp processing industry. Mechanical shrimp processing requires large volumes of water and produces high flows of effluent. Researchers surveyed the Pacific shrimp processors in California to determine design changes that would reduce water use and pollution output.

The researchers selected a large Sacramento-based shrimp processing plant for detailed processing studies. Their preliminary results show that water consumption for the mechanical shrimp peelers

used by California Pacific shrimp processors can be reduced from 70 gallons per minute—recommended by the equipment manufacturers—to 40 gallons per minute without affecting efficiency, yield, or shrimp quality.

Shrimp peeling requires 20 to 40 gallons of water per pound of finished product, or more than 90 million gallons of water annually. The modifications proposed in this study could save 39 million gallons of water annually—a 43 percent savings—and could reduce the amount of wastewater generated by the same amount. Based on these results, the shrimp processing plant used in the study has adopted a lower gallons-per-minute water load in its mechanical shrimp peelers and is experiencing significant savings in water use costs. (R/F-71)

Sea Grant's Fisheries Projects	FY79	FY80	FY81
The Effects of Food Availability on the Growth and Survival of California Jack Mackerel Larvae (R/F-44, Mullin/Lasker)	O	C	—
Development of Multispecies Management for Kelp Bed Resources with an Emphasis on Sea Urchins (R/F-36, Tegner)	O	O	C
Improved Marine Food Products and Marine Food Technology (R/F-32, Brown)	O	C	—
Amine Toxicity of Fish Products (R/F-43, Bjeldanes)	C	—	—
Design and Development of a Squid Processing Machine (R/NP-1J, R/F-33, Singh)	O	C	—
Bioconversion of Chitin Wastes (R/F-34, Carroad)	O	C	—
Endocrinology of Normal and Abnormal Salmon Smoltification and Adaptation to Seawater (R/F-45, Bern)	N	O	C
Artificial Imprinting of Chinook Salmon in a Multispecies Hatchery (R/F-46, Hassler)	N	C	—
Experimental Abalone Enhancement Program (R/F-47A, Tegner)	N	O	C
Experimental Abalone Enhancement Program (R/F-47B, Connell)	N	C	—
Sensory and Behavioral Effects of Pollutants on the Crab and Lobster Fishery (R/F-48, Case)	N	C	—
Genetic Improvement of a Chitinase-Producing Microorganism (R/F-50, Ogrydziak)	N	C	—
Coordination of Federal, Regional, and State Policies for Managing Marine Fisheries (R/F-51, Moore/Wyner/Cicin-Sain)	N	C	—
Economics of Fisheries and Aquaculture Development (R/F-52, Johnston/Hand)	N	O	C
An Economic Analysis of the California Abalone Fishery and the Experimental Enhancement Program (R/F-53, Deacon)	N	O	C

(continued on next page)

Sea Grant's Fisheries Projects (continued)	FY79	FY80	FY81
Economics of Swordfish Vessel Participation and Catch (R/F-54, Holt)	N/C	—	—
Assessment of Aging Techniques and Their Application to Elasmobranch Fisheries (R/F-57, Cailliet)	—	N	C
Multiple Species Utilization of the Herring Eggs-on-Seaweed Fishery (R/F-58, Abbott)	—	N	C
Storage Stability of the Purple-Hinge Rock Scallop, <i>Hinnites multirugosus</i> (R/F-59, Josephson)	—	N/C	—
Demographic Analysis of Porpoise Populations Subject to Time-Varying Tuna-Net Mortality (R/F-56, Goodman)	—	N	C
Economics of Multipurpose Fishing Vessels: Assessment and Policy (R/F-61, Holt)	—	N	C
An Economic Analysis of the Gains from Joint Management of Fishery Stocks (R/NP-1-9A, Johnston/Howitt)	—	N/C	—
Feasibility of Mechanical Skinning of Blue Shark (R/NP-1-9B, Singh/Katz)	—	N/C	—
Multispecies Aspects of CalCOFI 1955-59 Ichthyoplankton Data: A Source of Information for Variations in California Current Fisheries Resources (R/NP-1-9F, Loeb)	—	N	C
Chitin Waste Utilization (R/F-70, Carroad/Ogrydziak)	—	—	N
An Isotopic Aragonite-Water Temperature Scale Determined From Selected Shell-Bearing Marine Organisms (R/NP-1-10D, Shull)	—	—	N
A New Method for Estimating the Energy Available to Fisheries (R/F-62, Mullin/Goodman)	—	—	N
Functional Structure of Fish Assemblages of the Southern California Sublittoral Soft-Bottom Habitat (R/F-63, Rosenblatt)	—	—	N
Anchovy Management and Stock Assessment: Seabird Reproduction as an Indicator (R/F-64, Hunt)	—	—	N
Parasites as Biological Tags for Pacific Herring Stock Identification (R/F-65, Moser)	—	—	N
Vital Statistics of the Female Stock of Dungeness Crab ( <i>Cancer magister</i> ) in Northern California (R/F-72, Hankin)	—	—	N
Improving Efficiency of Commercial Shell-fishing by Analysis of Bait and Trap Functions (R/F-67, Case)	—	—	N
Seafood Science and Technology: Modified Atmosphere Storage (R/F-68, Brown)	—	—	N
Seafood Science and Technology: Microbiology of Fish (R/F-69, Barrett/Ogrydziak)	—	—	N
Water Conservation and Pollution Abatement in Seafood Processing Through Water Recycling (R/F-71, Carroad/Price)	—	—	N

C = Completed; N = New; O = Ongoing

### Shrimp Waste Converted Into Useable Protein

DAVIS—Turning useless waste into a marketable product is the goal of researchers at UC Davis. Using data from two earlier projects on bioconversion of chitin wastes and genetic improvement of a chitinase-producing microorganism, Drs. Paul Carroad and David Ogrydziak tested the feasibility of a shrimp waste treatment process for converting chitinous shell material to a useful product (a single-cell protein).

The researchers incorporated new data on waste pretreatment and completed the preliminary design and economic analysis of the waste treatment process. They then developed a strain of chitinase-overproducing microorganism and investigated the possibility of using recombinant DNA techniques to substantially increase chitinase production. The results offer new information on chitin pretreatment, and the process they designed could offer shellfish processors a waste treatment alternative to dumping. However, recent economic analysis shows that the process is not quite at the break-even point, and the process has not been tested on a large scale. (R/F-70)



# New Marine Products

Research and development bring useful drugs from the sea

Since the discovery of morphine in the early 1800s, the pharmaceutical industry has relied on potent substances derived from natural sources for new drugs to combat infection and disease. Several approaches have been taken toward developing new medicines, including the development of synthetic organic compounds and the continued investigation of land-based natural sources. Only recently has this investigation extended to the marine sphere.

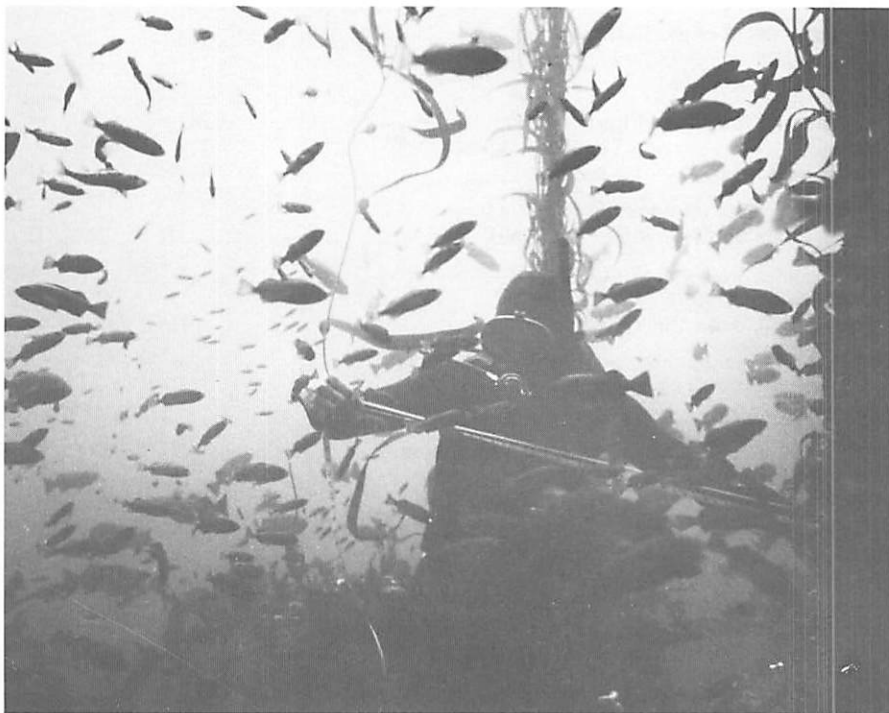
## Research Requires UC, Industry Collaboration

Five years ago, Sea Grant brought together researchers from **UC San Diego, Santa Barbara, and Santa Cruz** in an uncommon collaborative effort with several pharmaceutical industries to explore marine sources of new and useful chemicals. The Marine Chemistry and Pharmacology Program grew out of this initial collaboration, and today Sea Grant researchers are defining the biological properties and therapeutic value of chemicals derived from soft corals, algae, sponges, and nudibranchs collected from the California coast, the Gulf of California, and tropical regions including Honduras, the Tonga Islands, and Palau.

During 1980-81, researchers at UC Santa Cruz and **Scripps Institution of Oceanography** at UC San Diego continued to isolate and purify potential drug candidates for researchers at UC Santa Barbara, who identify and document the compounds' pharmacological properties.

## Potential Drugs From Sea Identified

A major new neuromuscular toxin, lophotoxin (LTX), has been isolated and defined by Drs. William Fenical and D. John Faulkner from the **Scripps Institution of Oceanography**. Lophotoxin occurs in sizeable quantities in 6 species of gorgonian coral (of the genus *Lophogorgia*)



from the Pacific Coast. Like common pain killers, lophotoxin inhibits neuromuscular transmission, but with a potency 10 times that of curare, a known muscle relaxant.

This is the first time a compound without nitrogen has been found which exhibits such neurotoxic properties. As a result, an entirely new class of compounds can now be explored for their potential analgesic properties. Besides its potential use as a pain killer, lophotoxin, by virtue of its novel functional groups, represents a new tool for application in research involving neurological disease. (R/MP-22, R/MP-23)

The **UC San Diego** researchers also made substantial collections of a Palau sponge and prepared a sponge derivative that appears to be an effective topical anti-inflammatory agent. Dr. Phillip Crews at **UC Santa Cruz** explored the chemistry of soft-bodied invertebrates from coral reefs and isolated several pharmacologically active constituents. (R/MP-24)

A potent cytotoxin, stypoldione, isolated by the Sea Grant research team, was evaluated by the **National**

**Cancer Institute** and was found to possess potentially useful activity. The researchers also isolated an unusual cell division inhibitor from the Caribbean purple sea whip, which may be useful in studying basic cell division.

At **UC Santa Barbara**, Dr. Robert Jacobs analyzed 83 new compounds last year and continued to analyze several biologically interesting compounds identified previously: a neuromuscular toxin, an anti-inflammatory and analgesic agent, and six compounds that inhibit cell division. (R/MP-21)

Several industries including **Syntex Laboratories, Inc.** in California, and **Lilly Laboratories** in Indianapolis, Indiana are collaborating with the researchers to translate the results of this research into new products. Once initial discoveries are made, substances are transferred to the proper collaborating industry for more costly testing and possible development. The National Cancer Institute in Washington is providing particularly important support for the biotesting of potential anticancer drugs.

## Bristol-Myers VP Urges Congress To Support Sea Grant

*In testimony before the House of Representatives Subcommittee on Oceanography last year, Peter Orahovats, vice-president and scientific director of Bristol-Myers Products, applauded the innovative marine biomedical research supported by Sea Grant at several major universities. In his testimony Orahovats summarized Sea Grant's achievements in this important research area, in particular those of California's Marine Chemistry and Pharmacology Program. A shortened version of his testimony is presented below.*

For several years the Sea Grant Program has provided support for the exploration and development of marine biomedical resources. Being part of the Department of Commerce, this program has emphasized the development of nonutilized marine resources through the close collaboration of university researchers with industrial scientists. While several areas of medical importance have been investigated in this program, a major emphasis has been placed upon the investigation of marine plants and animals for the isolation of new medicinal agents useful in the treatment of human disease. As ailments such as cancer, cardiovascular disease, and resistant bacterial and viral infections increase in importance, the necessity to explore new sources for safe and effective drugs cannot be overemphasized.

The Sea Grant Program has evolved as a unique blending of academic and industrial collaboration not equaled in other U.S. granting institutions. Biomedical Sea Grants currently exist at universities in **California, Rhode Island, Oklahoma, Washington, Delaware, Maine, New Hampshire, and South Carolina**, as well as at **Texas A & M University** and the **Massachusetts Institute of Technology**. Each of these projects is based upon interaction with an industrial counterpart involving such companies as **Merck, Sharpe, and Dohme Laboratories; E. I. Dupont Company; Syntex Research; G. D. Searle Company; and Eli Lilly Laboratories**.

I am most acquainted with the **University of California** project at



W. Fencal/Sea Grant

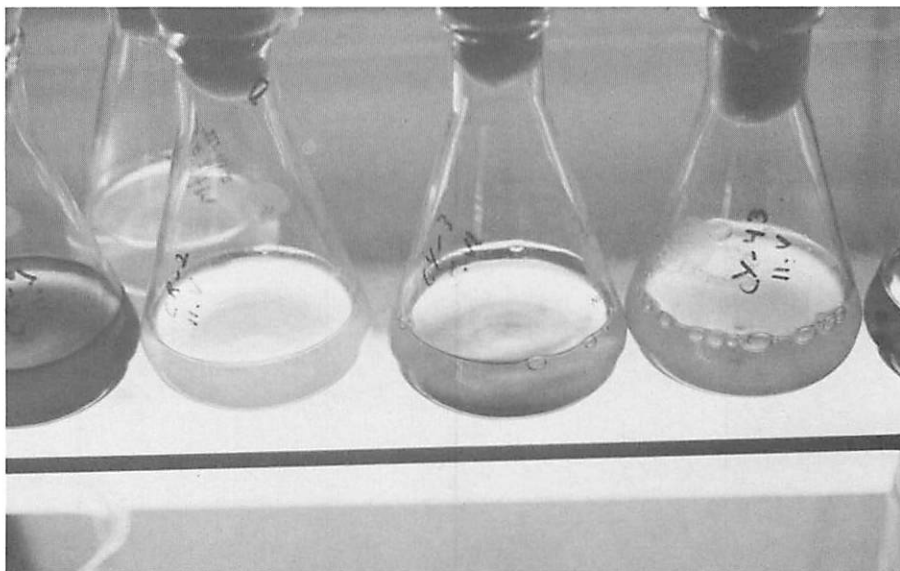
the **Santa Barbara** campus. An unusually large number of new drug candidates has been isolated by the California group, and their productivity perhaps illustrates the biomedical potential of marine organisms. Among their discoveries is a novel new analgesic/anti-inflammatory substance which is more potent than Indomethacin, and which could be highly useful in treating arthritis. An exceptionally active and selective antiviral drug was also isolated by the California group, which shows potent activity against Herpes Simplex infections. This compound could be the first step toward a successful cure of this now incurable and dreaded disease.

A new toxin is also under current investigation in California as a neu-

rophysiological probe in studying neurotransmission. This compound blocks nerve transmission by a new mechanism which is, as yet, unknown. In the California program, 14 new compounds have been isolated which show impressive levels of cancer cell growth inhibition. These new compounds are being studied at several UC campuses for their efficacy in the treatment of solid tumors and in the control of leukemia. The California group is interacting with the **National Cancer Institute** to assess the application of these compounds in anti-cancer chemotherapy.

Nationwide, I have been informed of significant findings in several Sea Grant projects. Researchers at the **University of Oklahoma**, for example, have reported the isolation of a new marine polyether which inhibits cancer cell growth and which also may be useful as an antibiotic agent. The Oklahoma program has also been responsible for the isolation of 15 cancer cell inhibitors as well as a potent substance which prolongs the effects of existing pharmaceuticals.

A group of researchers at the **University of Rhode Island** have been instrumental in providing a sound understanding of numerous marine toxins, and in exploring marine-derived polymers also for anticancer drug development. Likewise, scientists at the **University of Washington** have discovered that chitosan, a derivative from shellfish waste, may be useful as a commercial fungicide. These findings represent only a few of the more notable discoveries made through Sea Grant funding, and they clearly attest to the future



W. Fencal/Sea Grant



potential of the marine environment in biomedical research.

Support through Sea Grant for the educational aspects of this program should also be emphasized. Students with experience in collaborative Sea Grant-industry projects are ideally suited for employment in the pharmaceutical industry, and numerous former graduates now hold important industrial research positions as a result of the program.

It is for these reasons that I strongly support the Sea Grant Program and feel so committed to its continuation. The merits and current benefits are considerable, and the potential for significant commercial development, as supported by the close collaboration with industry, is clearly very great. Considering the quality of this program and the modest investment involved, I strongly urge your positive review.

Peter Orahovats  
 Vice-President and  
 Scientific Director  
 Bristol-Myers Products  
 March 30, 1981

Sea Grant's Projects in New Marine Products	FY79	FY80	FY81
Marine Plants as a Source of Insect Growth Inhibitors (R/MP-14, Crews)	O	C	—
Pharmacological Evaluation Program (R/MP-15, Jacobs)	O	C	—
Marine Natural Products for Pharmacological Evaluation (R/MP-16, Faulkner)	O	C	—
New Agricultural Chemicals from Marine Organisms (R/MP-18, Fenical)	O	C	—
Neuronal Blocking Substances from California Gobiidae (R/MP-19, Fuhrman)	N/C	—	—
Antiviral Compounds from Algae (R/MP-20, Vedros)	N	C	—
Marine Chemistry and Pharmacology Program: Pharmacological Screening and Evaluation (R/MP-21, Jacobs)	—	—	N
Marine Chemistry and Pharmacology Program: Chemical Studies of Tropical Marine Algae and Coelenterates (R/MP-22, Fenical)	—	—	N
Marine Chemistry and Pharmacology Program: Chemistry of Sponges and Opisthobranch Molluscs (R/MP-23, Faulkner)	—	—	N
Marine Chemistry and Pharmacology Program: Natural Products from Toxic Marine Organisms (R/MP-24, Crews)	—	—	N

C = Completed; N = New; O = Ongoing

# Ocean Technology

*Research improves what we build, how we move, what we see out there*

*As the nation grows increasingly dependent on the development of marine resources and the transportation of petroleum products to and from our shores, the need to operate safely and effectively in the ocean becomes critical. Questions are being raised regarding the safety of major ocean structures such as breakwaters and offshore platforms. Ship casualties raise questions about vessel design and operating characteristics. Continued deep-sea exploration and ocean structure construction rely on advanced remote visual imagery, which is severely limited by water turbidity. These are just a few of the issues addressed by Sea Grant researchers in the increasingly important field of Ocean Technology.*

## Ships Helped Through Tricky Harbors

BERKELEY—In a study of the navigability of harbor entrances, **UC Berkeley** researchers Dr. William Webster and Dr. Robert Wiegel developed a theoretical model and an experimental procedure to determine the cause and magnitude of significant currents observed in nonestuarine harbor entrances. Part of their research involved measuring the forces exerted on a ship as it enters a harbor with an uneven bottom topography. The results of this project should be extremely valuable to harbor constructors (the **Army Corps of Engineers**), and to the naval architecture community, since it may have implications for the design of both harbors and the ships that use them. (R/OT-2)

## New Underwater TV Shows Ocean in 3-D

LA JOLLA—A TV-sonar display to improve underwater observation and manipulator control is being developed by Dr. Victor Anderson at **UC San Diego**. Preliminary development of the system occurred in the first year, with a fabrication of both the TV interface and the 2-dimensional scanning sonar system.

Once the display system is operational, the researchers will evaluate the effectiveness and manipulator control of the composite display. The display should improve perception of underwater objects in turbid water and add depth perception to a mono-view TV image—both important to maintaining safety and efficiency in underwater work. Specific industry applications will include improved remote work and observation in deep offshore oil fields and in seabed disposal studies. (R/OT-3)

## Model Predicts Quake Effects on Ocean Structures

BERKELEY—A mathematical model to calculate earthquake-induced forces on nonaxisymmetric offshore

oil structures and bulk terminals has been developed by Dr. Robert Wiegel and associated researchers at **UC Berkeley**. The mathematical model was programmed on a digital computer and the results compared well with model tests conducted on the earthquake simulator.

The tests yielded much information about the magnitude, frequency dependence, and coupling related to submerged tanks and caissons; the numeric model successfully predicts the earthquake-induced loads on axisymmetric large offshore structures. The results of this project should be extremely valuable in the design of ocean structures subject to seismic loadings, especially structures that are nonaxisymmetric. (R/OT-1)

### Sea Grant's Projects in Ocean Technology

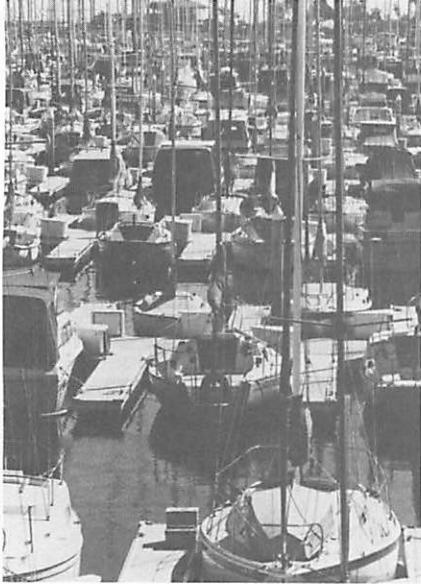
	FY79	FY80	FY81
Earthquake Loading on Large Offshore Structures in Deep Water: A Study for the Correlation of Analytic and Physical Models (R/E-14, Wiegel)	R	—	—
Earthquake Loading on Large Offshore Structures: An Application of Experimental Data to Practical Structure Forms (R/E-14, Penzien)	R	C	—
Seismic Hazards to the Development of Offshore Oil Resources (R/E-15, Prothero)	C	—	—
Side-Scan Sonar Mapping and Computer-Aided Interpretation of the Geology of the Santa Barbara Channel (R/E-18, Luyendyk/Simonett)	O	C	—
A Condensing Turbine for the Distillation of Seawater (R/E-22, Manalis/Lee)	N	C	—
Temperature Tolerances of Benthic Marine Invertebrates and Their Relationship to Regulatory Requirements for Thermal Effluent (R/E-23, Ford/Van Olst)	N	C	—
Bioelectric Toxicity Assaying (Phase I) (R/NP-1-9M, Anderson)	—	N	C
Application of Advanced Methods of Magnetic Reconnaissance (R/NP-1-10A, Macdonald/Miller)	—	—	N
Earthquake-Induced Forces on Nonaxisymmetric Offshore Structures (R/OT-1, Wiegel)	—	—	N
Hydrodynamics of Harbor Entrances and the Maneuverability of Ships Moving Through Entrances (R/OT-2, Webster)	—	—	N
TV/Sonar Imaging System (R/OT-3, Anderson)	—	—	N

C = Completed; N = New; O = Ongoing; R = Restructured



# Marine Affairs

*Marine science know-how needed in decision-making realm*



J. Sorensen/Sea Grant

*In recognition of both the increasing importance of research in marine resources policy making and the need to better coordinate broad public-policy-related research in other subject areas, last year Sea Grant formed a new subject area in marine affairs. The new area brings together public-policy projects previously associated with coastal resources, aquaculture, fisheries development, and ocean technology. As a result of the reorganization, these projects bring to light the socioeconomic implications of new scientific and technological research information and make this information available to policy makers responsive to marine issues.*

## Prices Vary for Same Fish

DAVIS—Dr. Leon Garoyan and associates at **UC Davis** have analyzed the industrial organization of commercial Pacific marine fisheries in **California, Oregon, and Washington** to determine the existence of price differences paid to fishermen. Their preliminary analysis shows that prices fishermen receive for the same species during the same week vary among nearby ports—a fact the researchers feel needs to be made known to industry representatives

and research economists. In the second phase of study, a statistical model will be developed to explain these price differences. (R/MA-4)

## Economic Model Shows Impact of California's Fishing Industry

SAN DIEGO—The first large-scale model of California fisheries and seafood industries to determine the direct, indirect, and induced economic impacts of those industries has been designed and constructed by Dr. Dennis King at **San Diego State University**. The model links California's fishing and seafood industries with the rest of the state's economy and can be used to evaluate the effects of economic, biological, and regulatory changes on seafood industries. For example, using the model, researchers have shown that changes in fishery management policy resulted in a 25 percent increase in salmon landing in the **Fort Bragg** area last year. This increase generated an additional \$3 million in economic production and income for the state. Similar preliminary data and analyses are being used by federal and state fishery agencies as well as industry trade organizations representing both harvesters and processors. (R/MA-5)

## Monterey Fishermen Affected by Policy

SANTA BARBARA—Historically, how have commercial fishermen in **Monterey Bay** responded to policy decisions that have affected their livelihood? **UC Santa Barbara** researcher Dr. W. Elliot Brownlee is finding answers to this question by studying problems of social mobility and their relation to the fishing community, the demise of the sardine industry, and the early history of Oriental fishermen in Monterey Bay. Results from this project should help predict the socioeconomic impacts of future changes in fishery public policy. (R/MA-7)

## Biology and Environment Affect Salmon Catch

DAVIS—To improve salmon fishery management in California, Drs. James Wilen and Louis Botsford at **UC Davis** are studying physical and biological factors that influence salmon abundance and social, biological, and economic factors that influence salmon behavior. Last year researchers analyzed the cyclic fluctuations in salmon catch and determined that more intense crab fishing during years of high crab abundance is not associated with lower salmon yield; fluctuations are linked to environmental and biological influences. Since the cycles can represent fluctuations of 50 percent of the average catch level, discovering the cause of these cycles will aid predictions of salmon abundance. (R/MA-3)

## Transit Options Surveyed in Coastal Zone

SAN DIEGO—A survey of existing coastal transit services in California has been completed by Drs. James Banks and Frederick Stutz at **San Diego State University**. Using information provided by 50 organizations in the state, including the park service, departments of transportation, park agencies, local governments, planning agencies, and transit operators, the researchers have drafted tentative planning guidelines that will help coastal zone planners design transit services for coastal recreation areas. (R/MA-10)

## Theory Predicts Where, What, and How Much Fishermen Catch

DAVIS—Statistical forecasting techniques have been used by Sea Grant researchers Drs. James Wilen and Richard Howitt at **UC Davis** to develop a theory of fishermen behavior strategy that will aid fisheries enhancement and management. The California pink shrimp fishery was selected as a case study, and data on location, effort, catch, and

boats were tabulated. Researchers plan to produce a statistically estimated set of probabilities from this data that will allow prediction of fishermen location and estimates of producer surplus and expected catch. (R/MA-1)

### Study Documents West Coast Salmon Canning

LA JOLLA/BERKELEY—A historical study of technological change in west coast salmon canning from 1890-1930 is near completion by UC Berkeley professor Harry Scheiber. The investigation, begun at UC San Diego, included intensive study of government records, company archives, newspapers, trade journals, and private manuscript collections. The study presents historical data on technological innovation, labor markets, business organizations, and public policy of an industry that is an important part of the Pacific coast's regional heritage. This study should contribute much to our understanding of technological change and its impact. (R/MA-6)

### Sea Otters vs. Shellfish Fisheries

SANTA BARBARA—A Sea Grant study into the administrative and political problems involved in managing marine mammal and fisheries interactions resulted in last year's conference, "Management of Sea Otters and Shellfish Fisheries in California: Policy Issues and Management Alternatives." Dr. Biliiana Cicin-Sain of UC Santa Barbara conducted the research and organized the conference.

More than 300 participants came from across the United States and abroad to discuss the complex issues that surround sea otter and shellfish fisheries conflicts in California. The conference was cosponsored by the California Sea Grant Marine Advisory Program and the Santa Barbara Museum of Natural History. (R/MA-9)

### Indochinese Get Help Adapting to California Fishing Regulations

SANTA CRUZ—At UC Santa Cruz, Dr. Michael Orbach is investigating Indochinese refugee adaptation to the Monterey Bay fishing industry

in the second phase of this project. Preliminary investigations were conducted on the relationships among the Monterey Bay fishing industry, Indochinese immigrants, and organizations designed to serve the fishing industry and the Indochinese.

In a related cooperative effort, Sea Grant's marine advisors worked together to provide the Indochinese

fishermen with California Fish and Game regulations translated into several Indochinese languages. As a result of preliminary studies, Dr. Orbach has been asked to attend several meetings sponsored by the Refugee Resettlement Assistance Program of the Department of Health and Human Services in Washington, D.C. (R/NP-1-9N)

Sea Grant's Projects in Marine Affairs	FY79	FY80	FY81
A Preliminary Survey of the Impact of Limited Entry Regulations upon California Fishermen (R/NP-1-9K, Petterson/Bailey)	—	N/C	—
A Preliminary Investigation of Indochinese Refugee Adaptation to the Monterey Bay Fishing Industry (R/NP-1-9N, Orbach)	—	N	C
The Deep Seabed Hard Mineral Resources Act: Was There a Need to Precede the Development of International Law Through U.S. Unilateral Action? (R/NP-1-9"O", Lynch)	—	N/C	—
Statistical Forecasting Methods for Fisheries Management (R/MA-1, Wilen/Howitt)	—	—	N
The Politics and Policy Implications of Deep Seabed Mining: U.S. Options (R/NP-1-8I Mann)	—	N/C	—
Demographic Analysis of Porpoise Populations Subject to Time-Varying Tuna-Net Mortality (R/F-56 Goodman)	—	—	N
Technological Change in the Salmon Canning Industry: Blaine, Washington, 1890-1930 (R/MA-6, Scheiber)	—	—	N
Management of Multispecies Systems: The Pacific Hake Example (R/MA-2, Goodman)	—	—	N
Analysis of Industrial Organization of Commercial Pacific Marine Fishery Markets (R/MA-4, Garoyan)	—	—	N
A Study of Direct and Indirect Economic Linkages Associated with the California Seafood Industry and an Analysis of Their Impacts on the Employment, Income, and Level of Economic Activity in California (R/MA-5, King)	—	—	N
A History of the Commercial Fishermen of Monterey Bay—The Role of Public Policy (R/MA-7, Brownlee)	—	—	N
The Role of Individual Perception and Structural Position in the Development of Fishery Management Policy (R/MA-8, Orbach)	—	—	N
Marine Mammals/Fisheries Conflicts: Emphasis on Sea Otter/Shellfish Fisheries Conflicts in California (R/MA-9, Cicin-Sain)	—	—	N
Coastal Transit Service Options and Policy (R/MA-10, Banks/Stutz)	—	—	N

C = Completed; N = New



# Rapid Response

*Unexpected marine problems require fast action*

*Sea Grant's rapid response capability supports short-term projects that respond to unanticipated or immediate marine or coastal problems, thus avoiding the long lead time required of projects submitted for funding in the annual proposal. A summarized sampling of the 22 rapid response projects funded in 1980-81 follows. (Rapid response projects are represented in the project lists according to subject area.)*

## U.S. Has Policy Options in Deepsea Mining

SANTA BARBARA—Dr. Dean Mann at **UC Santa Barbara** conducted a four-part study, "The Politics and Policy Implications of Deep Seabed Mining: U.S. Options," which provided valuable information in recent congressional deliberations on ocean mining. The study included an analysis of the ocean mining industry, U.S. Government actions regarding international ocean resource problems and policies, the support of a New International Economic Order at the Third U.N. Conference on the Law of the Sea, and possible precedents for management regimes for Antarctica and outer space. The final report has been used by the **House Merchant Marine and Fisheries Committee** and by the **Ocean Mineral Company** in policy considerations for developing ocean mining activities. (R/NP-1-81)

## Marine Van Reaches 10,000+, Rest Will Wait

LONG BEACH—A mobile marine science outreach program was designed and used by Roger Bauer and staff at **California State University at Long Beach** last year. They renovated and outfitted a mobile van display unit with specially-designed marine science display materials, and they took the van on 37 visits to schools, shopping centers, and civic groups, involving more than 10,000 individuals during the year.

The response to the van has been

tremendous; researchers estimate it will take more than 3 years to visit all of the schools that are presently on the waiting list, given the van's current schedule of one visit per week during the school year. The School of Natural Sciences at CSU Long Beach will continue funding the van visits now that the initial development and implementation are complete. The researchers are pursuing additional funding sources to increase the number of van visits per week and improve the van's effectiveness by linking its displays more closely with school curricula. (R/NP-1-9J)

## Individuality of Policymakers Affects Fishery Decisions

SANTA CRUZ/SANTA BARBARA—Researchers at **UC Santa Cruz** and **UC Santa Barbara** teamed up to study the role of individual perception and structural position of policymakers in the development of fish-

ery management policy. Drs. Michael Orbach and Bilianna Cicin-Sain defined the way in which individuals with differing perceptions, resources, and constraints affect the development of fishery management. They outlined the issues involved in the development of the Northern Anchovy Fishery Management Plan of 1978 and reconstructed the course of policy formulation and the individuals involved in the policy-making process. The researchers have uncovered some interesting and unexpected properties of policy development that will be applicable to fishery management policy in general. (R/MA-8)

## Software Helps Gov't and Industry Geologists

SANTA BARBARA—A software package for advanced magnetic modelling for geological science research and instruction has been developed by Dr. Ken Macdonald at **UC Santa Barbara**. Research geo-



*Students and interested residents examine the shark "grabber" display, just one of many displays the 27-foot mobile marine museum takes to schools, shopping centers, and service organizations throughout the year.*

physicists have used the magnetic modelling on propagating rift geometries, on data from the Red Sea, and for a proposed study of the Vena Fracture Zone intersection with the Mid Atlantic Ridge.

Information from this project will be used by geologists and geophysicists in industry and in government agencies concerned with the hazard and resource potential of the southern California borderlands. Mining and petroleum companies will be able to use the advanced magnetic modelling techniques for inexpensive land reconnaissance. (R/NP-1-10A)

### **Coastline Retreats in Humboldt and Del Mar**

**HUMBOLDT**—**Humboldt State University** researcher Dr. Derek Rust and associates investigated the coastline retreat in Humboldt County and monitored several active coastal earthflows in the Trinidad area. They produced geologic and geomorphic maps of the **Trinidad** and **Shelter Cove** areas—the first comprehensive work of its kind in this coastal area. (R/NP-1-10F)

**LA JOLLA**—Drs. Reinhard Flick and B. Walton Waldorf at **Scripps Institution of Oceanography** have installed benchmarks and surveyed the horizontal and vertical location of the recently installed Longard Tube—a beach erosion control alternative being tested in **Del Mar**. Future changes in these data points can now be quantified and used to assess the tube's erosion control effectiveness. (R/NP-1-10G)



SIO



# Activity Budget 1980-1981

	NOAA Grant Funds	Matching Funds
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<b>Marine Resources Development</b>		
Aquaculture	\$ 437,842	\$ 521,256
Living Resources	236,626	169,030
Mineral Resources	10,022	23,900
Marine Biomedicinals & Extracts	171,478	112,333
 <b>Socioeconomic and Legal Studies</b>		
Marine Economics	130,205	96,482
Marine Recreation	31,059	21,869
Sociopolitical Studies	25,560	22,025
 <b>Marine Technology Research and Development</b>		
Ocean Engineering	66,802	60,034
Resources Recovery and Utilization	70,269	95,594
Transportation Systems	50,756	36,448
 <b>Marine Environmental Research</b>		
Research and Studies in Direct Support of Coastal Management Decisions	20,737	25,426
Ecosystems Research	77,095	51,596
Environmental Models	79,403	31,959
 <b>Marine Education and Training</b>		
Other Education	477,360	49,140
 <b>Advisory Services</b>		
Extension Programs	587,684	253,916
Other Advisory Services	188,255	114,903
 <b>Program Management and Development</b>		
Program Administration	266,907	229,350
Program Development	221,940	45,267
<b>TOTAL</b>	<b>\$3,150,000</b>	<b>\$1,960,528</b>

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# Matching Funds Sources 1980-1981

State of California:	
California Resources Agency	\$ 392,500
Department of Fish and Game	31,733
Aquarium-Museum Docents	30,262
Bristol-Myers	7,860
California Seafood Institute	21,150
Counties of: Monterey, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara, and Sonoma	50,640
Donations	38,948
Hydro Products Inc.	6,460
Johnson Oyster	2,010
Marine Colloids	12,640
Meredith Fish Company	2,620
P&R Systems	2,000
Syntex Corporation	45,195
TransFresh Corporation	5,930
Zoecon	1,500
California Institute of Technology	8,900
Humboldt State University	23,677
Humboldt State University Foundation	753
San Diego State University	90,189
San Diego State University Foundation	3,260
San Jose State University/Moss Landing Marine Laboratories	32,966
Stanford University	16,350
University of Arizona	4,950
University of California	1,125,064
University of North Carolina	2,971
<b>TOTAL</b>	<b>\$1,960,528</b>

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