

California Sea Grant College Program

Annual Report 1999 – 2000





The research reported in this document was supported by the National Sea Grant College Program of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration under NOAA grant number NA06RG0142, project number A/P-1 through the California Sea Grant College Program, and in part by the California State Resources Agency.

The views expressed herein do not necessarily reflect the views of any of those organizations.

Sea Grant is a unique partnership of public and private sectors, combining research, education, and outreach for public service. It is a national network of universities meeting changing environmental and economic needs of people in our coastal, ocean, and Great Lakes regions.



*CALIFORNIA SEA GRANT
COLLEGE PROGRAM
ANNUAL REPORT
1999-2000*

*California Sea Grant College Program
University of California
La Jolla, California 92093-0232
Publication No. R-048
www-csgc.ucsd.edu*

IN MEMORIAM

Michael Mahlon Mullin (1937–2000), Professor of Oceanography, Marine Life Research Group, Scripps Institution of Oceanography

Dr. Mullin had been both a Sea Grant investigator and a valued member of the scientific Sea Grant Committee. His research featured studies of the dynamics of phytoplankton, zooplankton, and larval fish in the marine food web. In addition to his teaching and research, Mullin served in a number of administrative positions at the Scripps Institution of Oceanography, including chairman of the Graduate Department, Director of the Marine Life Research Group, and Associate Dean for Academic Affairs.

Dr. Mullin's work on scales of variability in ocean dynamics and its effects on fisheries in the California Current is a major contribution to the state and its marine resources. As coordinator for the California Cooperative Oceanic Fisheries Investigations, Mullin played an important role in researching the relationships between natural variability of both physical and biological phenomena in the California Current. In many cases his research contributed pivotal understanding of biological oceanographic patterns.

Mia Jean Tegner (1947–2001), Research Marine Biologist, Scripps Institution of Oceanography

Dr. Tegner was a California Sea Grant researcher and served for many years as the University of California's representative to the Resources Agency's Sea Grant Advisory Panel. Her research focused on the ecology of kelp forest communities and nearshore marine resources.

Tegner's work was well known and highly respected in San Diego and throughout the state of California. Tegner's most current research included studies of the effects of El Niño and La Niña events on the plants and animals of the kelp ecosystem. Her studies continue to be directly relevant to the management of state fisheries and coastal water quality issues such as sewage treatment and its effects on the nearshore environment.

J. David Ptak (1949–2001), Vice President and General Manager of Chesapeake Fish Company San Diego.

A long-time Sea Grant supporter and friend, Ptak served California Sea Grant since 1986, both as a member and chair of several advisory committees. He most recently chaired Sea Grant's Marine Resources Committee, and served on the program's Board. He was a member of the Pacific Marine States Fisheries Commission. In addition, he served as president of the California Fisheries and Sea Food Institute (CFSI) from 1991–1992, chairman of the CFSI Board in 1993 and 1994, and had been their treasurer since 1995.

Ptak's commitment to public service was exemplary. He was an articulate and effective liaison between the private sector and the California Sea Grant College Program. His support and sound advice for many years provided an invaluable contribution to the well being of the program.

TABLE OF CONTENTS

<i>INTRODUCTION</i>	6
<i>ALIEN CORDGRASS</i>	7
<i>INVADING WORM EVICTED</i>	9
<i>SEEKING HELP FOR THE KELP FORESTS</i>	11
<i>PREDICTING FLOW IN SEMI-ARID WATERSHEDS</i>	13
<i>COASTAL CLIFF EROSION</i>	15
<i>PREDICTING WAVE ACTION IN HARBORS</i>	17
<i>SUSTAINING NEARSHORE ROCKFISH</i>	19
<i>DETERMINING AGE IN SLOW-GROWTH BOCACCIO ROCKFISH</i>	21
<i>UPWELLING AND CARBON-14 LEVELS IN JUVENILE ROCKFISH</i>	23
<i>RESTORING SEA URCHINS</i>	25
<i>RX FOR OYSTERS</i>	27
<i>NEW BUILDING BLOCKS FOR TOMORROW'S HIGH-TECH MATERIALS</i>	29
<i>MARINE RESEARCH YIELDS NEW WEAPONS AGAINST INFLAMMATORY DISEASES</i>	31
<i>CALIFORNIA SEA GRANT EXTENSION PROGRAM</i>	33
<i>COMMUNICATIONS</i>	48
<i>EDUCATION: OUR COMMITMENT TO THE FUTURE</i>	51
<i>SOURCES OF FUNDING</i>	53
<i>DIRECTORY OF PROJECTS BY INSTITUTION</i>	54
<i>HONORS AND AWARDS</i>	57
<i>COMMITTEES</i>	58

INTRODUCTION

This annual report presents the results of research and outreach activities undertaken by California Sea Grant from March 1999 through February 2000. Its purpose is to highlight achievements for the general public and provide a summary record for individuals in government, industry and academia over this period of time.

For readers unfamiliar with California Sea Grant, it is the largest of 30 programs underway in coastal and Great Lakes states. Our mission is "to increase the understanding, assessment, development, and conservation of the nation's coastal and marine resources by providing assistance to promote a strong educational base, responsive research and training activities, and broad and prompt dissemination of knowledge and techniques."

During the time frame covered by this report, a number of noteworthy events took place that have bearing on the program's direction. The Marine Life Management Act (AB 1241) was passed by the state's Legislature in 1998, mandating the development and implementation of management plans based on the best available science for California's fisheries. In 1999, the state enacted the Marine Life Protection Act, which requires the design of a network of no-take reserves for state waters. California Sea Grant's extension staff and research scientists are actively participating in the design and implementation of both measures.

A new strategic plan was developed for the program in 1999 with the assistance of many of Sea Grant's researchers. This plan covers the period 2001–2005 and provides broad guidelines on the future direction of the program.

In 2000, Governor Gray Davis and Secretary for Resources, Mary Nichols, supported the largest increase to Sea Grant's state budget since the program's inception in 1973. In the fall of that same year, Russell Moll, former director of Michigan Sea Grant, joined California Sea Grant as its new director.

This report provides a glimpse into the many areas in which California Sea Grant is making a contribution to the management of our shared coastal resources and a preview of the program's ambitious agenda for the state of California in the new millennium. The pages that follow describe, among other examples, research designed to assist with the management of rockfishes, predict and control the spread of nonindigenous species, understand coastal erosion, and develop new materials and drugs for human use from ocean sources. They also describe many outreach efforts to assist government agencies to coordinate fisheries management plans and implement new initiatives on marine protected areas, educate the public and the shipping industry with the latest technical and policy information in ballast management, provide information on water quality to coastal users, and educate industry on seafood safety.

In a period of just several weeks, as we were preparing this report, California Sea Grant lost three of its best and most loyal friends. Their stewardship for many years shaped the program in large part. This report is dedicated to Michael Mullin, Mia Tegner, and David Ptak. We owe them much; they will be missed.

Dolores Maria Wesson
Deputy Director
California Sea Grant

ALIEN CORDGRASS

In this case the “alien” is an East Coast relative of the native West Coast cordgrass, *Spartina foliosa*. The spread of the Atlantic saltmarsh smooth cordgrass, *Spartina alterniflora*, has the potential to alter the California coastal landscape through its ability to replace native cordgrass and encroach on open mudflats.

Sea Grant researcher Dr. Don Strong and his colleagues have been working since 1994 to determine ways to identify and eliminate the non-native smooth cordgrass, *Spartina alterniflora*, from the coastal mudflats and wetlands around San Francisco Bay.



Professor Don Strong and his “cordgrass crew” at Bodega Marine Laboratory, University of California, Davis.

The alien was first introduced to the West Coast in the late 1970s in an attempt to restore coastal wetlands that had been damaged or eliminated by human activities such as road and building construction, dredging, and filling, to name a few. The East Coast plant was considered a good choice at the time because of its ability to spread rapidly. What started out as a good idea eventually proved to have its drawbacks.

The transplanted East Coast species has a bad habit of crossing with the native, which leads to a fast-growing hybrid that replaces the slower growing native, *Spartina foliosa*. The hybrid significantly alters the physical characteristics of the wetlands it occupies. West Coast wetlands are characterized by vast, open mudflats, that serve as important nursery grounds and year-round habitat for birds and fish species, many of



“...the immense human population along the southern California coast (> 16 million people) has produced one of the highest rates of habitat loss and some of the most fragmented and altered wetland remnants. The typical salt marsh has been filled at its upper limit and dredged at its lower limit. It is criss-crossed by transportation corridors, as well as sewer and power lines, receives urban runoff, and is visited daily by recreationists.”*



Sea Grant trainee, Katy Zaremba, standing in a circular clone of hybrid cordgrass (*Spartina foliosa* x *alterniflora*). The right half was treated with Rodeo® herbicide while the left half was left untreated.

which are unique to the California coast. The alien also poses a threat to marine invertebrates and commercial fish populations.

There are other effects as well. *Spartina alterniflora* has already played a role in flooding in Alameda and Contra Costa counties in California by blocking flood-control channels.

Strong's lab at Bodega Marine Laboratory, a research unit of the University of California, Davis, is a greenhouse for this tall grass and has been home to numerous experiments. The researchers have used DNA techniques to learn that the alien species and the hybrid (which exhibit the same characteristics as the alien) will quickly and densely cover any open mudflat where they are planted or where coastal currents carry their seeds. End result? The alien effectively eliminates the native species in short order. Given enough time, the native species would become extinct.

Researchers have been successful in identifying physical characteristics, such as size, stem width and the timing of flowering, that can help wetland managers spot the smooth cordgrass and its hybrid among the native species so they can be removed. They use DNA techniques to track the spread of the smooth cordgrass in an area. They have also experimented with herbicides that can be used in certain instances to eliminate the alien.

Strong recommends that only pure strains of native California cordgrass, from marshes that have not been invaded by hybrid or smooth cordgrass, should be used in restoration projects on the West Coast. Resource managers from the U.S. Fish and Wildlife Service, the Audubon Society, the California Department of Fish and Game, and San Francisco Bay area parks are using Strong's results to control and eliminate the smooth cordgrass.



The Tijuana River Estuary, where the native California cordgrass, *Spartina foliosa*, does not encroach on the habitat of open mudflats, which are essential breeding and feeding grounds for many fish and bird species.

For more information on Strong's research, visit the *Spartina* Lab on the web at <http://www-bml.ucdavis.edu/spartina/home.html>.

* "Handbook for Restoring Tidal Wetlands," Joy B. Zedler, editor, CRC Press, Boca Raton, FL. 2001.

INVADING WORM EVICTED

Invasive species transplanted from other habitats or ecosystems are a growing concern. This is particularly true in the oceans where biologists had thought that attempts to get rid of introduced pests were futile.

According to Dr. Armand M. Kuris, Professor of Zoology at UC, Santa Barbara, scientists had never before eradicated an established marine pest population. That is until Kuris and his colleagues solved the problem of a tiny invading worm from South Africa – one that settles on the shells of abalone and other mollusks. The worm first appeared in California in 1993.

This parasitic worm does not invade abalone meat, so it has never been a health threat. Instead, it attaches itself to the developing shell of the abalone, deforming the growth of the shell and therefore preventing the normal growth of the abalone. Instead of being a tough material, the infected shell becomes brittle and crumbles easily.

When Kuris first inspected some ailing abalone in 1993, he discovered the microscopic worm. At that point it had not even been named, so Kuris and his associate, Carolyn Culver, simply referred to it as a type of worm, “the sabellid pest,” with no idea whether the worm was local or imported. Eventually they learned that this pest was imported in the 1980s in a shipment of South African abalone. The South Africans were not aware of the worm because their abalones are more resistant to it.



Left: cultured red abalone heavily invested by sabellid worms. Right: uninfested cultured red abalone.

Unfortunately, the worm quickly spread among the 18 or so abalone farms in California. Funded by the California Sea Grant Program, Kuris and Culver set out to study the problem and discovered which types of marine animals were susceptible to these worms.



California abalone once supported huge commercial and sport fisheries. Now only red abalone north of San Francisco Bay may be harvested by sport divers, and only under restrictions of gear, daily catch limits and annual maximum catches. Commercial production of abalone in California is currently focused on aquaculture, the farming of marine organisms.

By 1997, the invader from South Africa had caused significant economic damage to the California abalone aquaculture industry. It also posed an environmental threat of unknown magnitude, because it had been unintentionally released with wastewater from an aquaculture site and had become established in at least one natural location. An estimated 2.5 million worms infested the native snails and abalone along the shore.

This stimulated a letter to then California Governor Pete Wilson, signed by 90 prominent ecologists, calling for immediate action against the sabellid worm and other introduced marine pests.

Kuris and Culver devised an eradication plan, and their results have been impressive. Since 1997, no sabellid worms have been recovered from the former heavily infested site. “Early detection and very aggressive action can lead to eradication of even well-established pests,” Kuris says.

The basis of their eradication plan was the threshold of transmission theory: a certain density of hosts is required to maintain a rate of transmission sufficient for a parasite population to persist. Kuris and his team broke this threshold by removing large numbers of the most susceptible hosts.

The researchers determined that in addition to abalone, another mollusk, the black turban snail, was the most abundant and highly susceptible host, and the larger, older ones were most vulnerable. So Kuris and his research team removed large numbers – about 1.5 million 10-year-old snails – from their intertidal home.

They were assisted by staff from a local abalone farm, biologists at the California Department of Fish and Game, and teams of volunteers, many from the University of California, Santa Barbara, and Cuesta College in San Luis Obispo. The success of the project is monitored every six months by surveys that check for worm infestations.

SEEKING HELP FOR THE KELP FORESTS

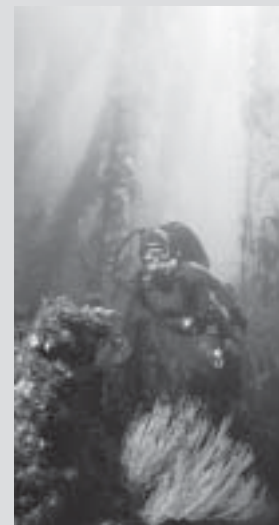
A six-mile strip off the Point Loma Peninsula in San Diego, California is home to giant kelp forests – highly productive and economically important plant communities. To Sea Grant researcher Dr. Mia Tegner, it had become apparent that oceanographic processes such as strong El Niños could devastate the forest biomass and result in substantial losses.

Tegner, who was a scientist in the Marine Life Research Group at Scripps Institution of Oceanography had, for many years, focused on the population dynamics of kelp. El Niños have a major impact on these underwater forests because of the warm, nutrient-depleted waters that are a characteristic of such events. The giant kelp, *Macrocystis pyrifera*, requires nutrients called nitrates in order to thrive. These nutrients are associated with cooler, upwelled waters.

Surface temperature is the best explanation for the productivity of the *Macrocystis* canopy. But, subsurface temperatures and internal wave activity most likely control the height to which plants die back in El Niño conditions. With Sea Grant funding, Tegner installed four chains of temperature-gauge arrays across the center of the Point Loma kelp forest, choosing this approach over the more expensive procedure of measuring nutrients. The use of temperature measurements relied on the strong, inverse relationship between temperature and nitrate availability. These instruments have been in place since the fall of 1997 with retrieval and downloading of data occurring approximately every two months. The 1997–1998 El Niño ended, and a cold-water, nutrient-rich La Niña event developed in late 1998–1999. This phenomena provided an opportunity to compare kelp population dynamics under two extremes of ocean climate.

In a parallel study, Tegner examined sea urchins. Her goal was to monitor larval settlement and relate this data to temperature and depth, thereby providing an

In addition to monitoring natural changes in the kelp forest, the research team often conducts a variety of experiments to learn more about the forces that dictate the overall health of this underwater ecosystem. Long-term observations have paid the greatest dividends.



important component of larval spatial and temporal variability.

Between March and December 1998, sea urchin settlement data was collected along the outer edge of the Point Loma kelp forest. Settlement was highest during a warm period, which did not support an earlier hypothesis that larval supply and settlement are related to cold isotherms.

Tegner worked on the Point Loma kelp forest since 1974. She also directed efforts towards clean water issues, fisheries management and restoration potential. In 1998, Tegner was awarded the prestigious Pew Fellowship for Marine Conservation for her work with abalones. In August 2000, the Ecological Society of America honored Tegner and co-authors Paul Dayton, Peter Edwards, and Kristen Riser with the Cooper Ecology Award for their monograph paper on kelp-climate interactions. This was the first Cooper award given to scientists for research on ocean systems.



Sea urchins grazing on kelp.

PREDICTING FLOW IN SEMI-ARID WATERSHEDS

The rivers in Southern California and Baja California are frequently contaminated, posing a threat to human health. They are also subject to seasonal flash-flooding from storms, resulting in a physical hazard for people, animals and property. In order to predict the likelihood of these hazards, scientists need mathematical models that incorporate all the pertinent data.

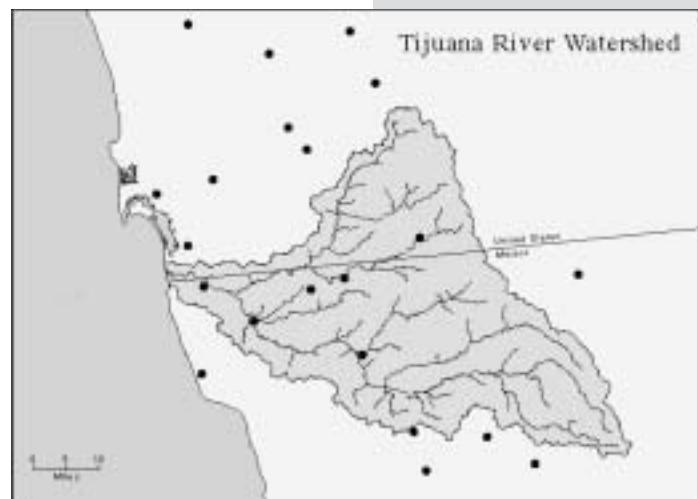
Sea Grant researchers Drs. Richard Wright and Allen Hope of San Diego State University have been developing a database to describe hydrologic processes on both sides of the San Diego-Tijuana border. This area has wet winters, dry summers, and vegetation typical of so-called Mediterranean-type ecosystems (MTE). Because river flow is one of the key elements affecting the riparian and coastal wetland ecosystems, predictions of river flow are important for planning purposes and scientific study. However, few hydrologic models have been developed specifically for MTEs, and none for the chaparral-dominated coastal watersheds of California and Baja California.

Wright and Hope's goal was to adapt and test an existing physically sound hydrologic model to predict monthly river flow volumes in coastal watersheds of this region. They focused on the sub-watersheds of the binational Tijuana River Watershed (TRW) and began by collecting information to develop hydrological and meteorological databases to test the selected model.

They obtained precipitation and temperature data from stations in or near the TRW. From this they compiled an 18-year daily precipitation and temperature database for all U.S. stations, and 18-year records for the monthly precipitation and temperature stations located in Mexico.



New models are needed for predicting water flow in Mediterranean-type ecosystems, which have extremes of wet and dry periods. This project is linked to ongoing GIS database development in the region, funded by NOAA and EPA.



• Precipitation gauging station

The researchers selected the Campo Creek watershed (220 km²) in eastern San Diego County, for which there was reliable hydrometeorological data for the period 1980–1990. Several factors complicated their efforts: the semi-arid and intermittent nature of the system (river flow is not continual), the geology in the watershed, and the water diversion of the system into the Otay drainage area for the city of San Diego.

There were no available models to satisfy their project goal of developing a simple monthly model, so they developed the Physical Hydrology Simulator (PHYDROS) as a simple water balance model for simulating monthly river flows. The PHYDROS model calculates storm flow, base flow and actual evapotranspiration at daily time steps to simulate total river flow for each month. The data inputs are daily rainfall, potential evaporation, and observed river flow. Both soil and groundwater storages are represented as a combined quantity. While the results from PHYDROS were easier to interpret than those from the original model, neither performed well when calibrated on one watershed and tested on another.

Wright and Hope identified two additional watersheds within the Southern California chaparral region for model tests: Santa Cruz Creek (192 km²) north of Santa Barbara in the San Rafael Mountains, and Malibu Creek (272 km²) north of Point Dume in the Santa Monica Mountains.

“Models developed for conditions in other climates or ecosystems are unlikely to provide resource managers in Southern California or Baja California with reliable river flow predictions,” says Wright. “And in order to monitor water quality,” he adds, “you first need to be able to model the quantity so you know what you have to work with.”

Wright and Hope continue to expand and enhance their databases, as well as test more sophisticated hydrologic models. Currently, there are at least 10 other projects in the San Diego–Tijuana border region that will benefit from the information generated by this Sea Grant project.

COASTAL CLIFF EROSION

California has 1,770 km of coastline, 86 percent of which is actively eroding. The most populous state in the country, 80 percent of California's 33 million residents live within 50 km of the coast. Making matters worse, at least half of the coastline is relatively inaccessible. "So what's available is less than half-an-inch per person," says Gary Griggs, Ph.D., director of the Institute of Marine Sciences at the University of California, Santa Cruz, and principal investigator of a California Sea Grant study on coastal erosion.

This conflict between the desire to live on the shore and the inherent geological instability of coastal bluffs, dunes, and beaches has greatly increased the risk of coastline and sea cliff erosion. This conflict can produce significant property loss and depreciation of property values.

In an effort to better understand the interaction between human activities and naturally occurring coastal processes, the Federal Emergency Management Agency (FEMA) commissioned a long-range study to assess the feasibility and economics of including ocean-front property in the National Flood Insurance Program.

Part of this study involved the creation of accurate coastal erosion hazard maps. Differences between the sandy beaches, typical of the East Coast, and the cliffs that characterize the rugged West Coast, had to be taken into consideration. Therefore, every coastal state, including Hawaii, was represented in the national study which had the goal of estimating 60-year erosion hazards. The California Sea Grant portion of the study focused on two heavily urbanized shoreline areas, located primarily in Santa Cruz and San Diego counties.

To collect data as accurately as possible, the California Sea Grant team employed a variety of aerial and land-based technologies – many of them state-of-the art and available only in a handful of laboratories in the country. One of the new technologies is softcopy photogrammetry, which allows the precise analysis of aerial photos



"There's a long-standing interest in determining how coastlines erode. Unfortunately, measurement techniques have not always been accurate. In the past, you'd compare an old aerial photo to a new photo, get out a ruler, and make the best measurement you could."

– Dr. Gary Griggs

that have been corrected for photographic distortion. These highly accurate images are then used to generate three-dimensional, Digital Terrain Maps (DTM). When viewed with 3-D glasses, researchers can “see” where a cliff drops off. In this study, DTMs were created from images taken of the same coastal areas in the 1940s and 1990s. The results provide highly accurate calculations of how much erosion has taken place historically and will aid in predictions about coastal erosion 60 years into the future.

An intriguing question arises: why do patterns and rates of erosion vary from location to location? For example, the community of La Jolla experiences relatively slow erosion, while nearby Del Mar is losing its cliffs at a faster rate. Conventional wisdom is that the primary influence on sea cliff erosion is wave erosion (impact, abrasion, and quarrying) at the base of the cliff. In addition, many researchers have reported sea cliff erosion by groundwater and surface runoff. “We have shown in San Diego County that the strength and structural weaknesses of sea cliff materials are equally important, if not more significant, than marine and non-marine agents in influencing the long-term stability of sea cliffs,” says Griggs.



The team mapped, observed, and quantified erosion variables at eight San Diego County cliff sites and evaluated their relationships to long-term erosion rates. They were successful in defining intrinsic variables as physical properties (such as the strength of intact rock and cliff structure) that directly affect sea cliff stability. This finding is important as scientists gain an increased understanding of the natural retreat of the shoreline.

“There’s a lot of pressure to build on the remaining undeveloped coastal lands,” says Griggs. “Before investing one’s life savings in oceanfront property, however, it’s important to know how long the property may be there.”

PREDICTING WAVE ACTION IN HARBORS


There is a type of wave whose action may be compared to the energetic sloshing motions of waves in a bathtub. Transfer this situation to a harbor and you have more than rubber duckies bobbing about. Known as seiches, these are standing long waves that oscillate, typically with a resonant period of 0.5 to 30 minutes. At these periods, waves reflected from walls along a harbor's perimeter can initiate ship motions that cause serious damage to boats, piers, and other harbor facilities, and interfere with harbor operations.

Sea Grant researchers Dr. Michele Okihiro and Dr. Robert T. Guza at the Scripps Institution of Oceanography at U.C. San Diego, have been directing a project to increase knowledge of harbor seiche dynamics and consequently improve the capability to design and utilize harbors. Development of models that predict the resonant periods, spatial patterns, and magnitude of harbor seiche would enable coastal engineers to minimize seiche problems in new and existing harbors.

The researchers began by analyzing field data sets from three harbors. Observations were used from Barbers Point and Kahului in Hawaii, both deep-draft harbors in islands surrounded by coral reefs, and Oceanside harbor, used mostly by small recreational boats and surrounded by a mildly sloping sandy beach on the continental shelf of Southern California.

They found that the energy necessary to create harbor seiches was dependent on the wave period. Ocean swells were found to be the primary energy source for seiches at periods of 0.5 to 10 minutes; meteorological disturbances, tsunamis, and other processes accounted for motions at longer seiche periods, 10 to 30 minutes. After analyzing the field data, Okihiro and Guza tested harbor seiche prediction models and compared their model results with field observations.

Initial testing began using an existing harbor seiche model (HARBD) used by the U.S. Army Corps of Engineers' Coastal Engineering Research Center (CERC).



"We expect that comparisons between these observations and model results will lead to improved models and ultimately to harbors with reduced seiche problems."

—Dr. Michele Okihiro



Concurrent with research using HARBD, a new harbor seiche model called CGWAVE was developed by Drs. V. Panchang at the University of Maine and Z. Demirbilek at CERC. A collaboration between the Scripps researchers and Drs. Panchang and Demirbilek was formed to test and evaluate CGWAVE then ultimately apply it to the three harbors.



Kahului harbor, Hawaii.

The new model was found to be superior to HARBD; however, like the older model, it was limited in its treatment of offshore bathymetry. The slope and characteristics of the offshore bathymetry are critical because they affect the amplification of wave energy within the harbor. The model was improved by incorporating a one-dimensional, constant-slope bathymetry value in contrast to the previous requirement of a constant depth. While recognizing that a one-dimensional specification is still limiting, "It is often times," says Okihiro, "a reasonable approximation for field conditions and an improvement over previous model requirements." Other improvements to CGWAVE include a better treatment of incoming and outgoing waves at the model boundaries and added capabilities to construct grids with depth-dependent resolution.

Encouraged by the model's performance with the idealized bathymetries, the researchers have been applying the CGWAVE model to the three harbor sites, and are modeling runs simulating seiche in these harbors. Reliability of wave predictions for harbor projects is important for commerce, shipping, risk analysis, dredging, and recreational boating.

The researchers have presented the results of this study in seminars and talks before the U.S. Army Corps of Engineers, as well as meetings and conferences of coastal engineers and scientists.

SUSTAINING NEARSHORE ROCKFISH

The grass rockfish, *Sebastes rastrelliger*, has become one of the principal species fished in the live-fish fishery, where fish are kept alive as they are sold to retailers.

This species is nonmigratory, shallow-dwelling and found along kelp and eelgrass beds from Baja California to Oregon. It is currently experiencing intense fishing pressure as annual landings have dramatically increased from 4,000 to 104,000 pounds during the 1990s.

Due to late maturity, nonmigratory behavior, and large variations in annual reproductive success, rockfish are extremely vulnerable to over-fishing. Information on the extent to which local populations are self-replenishing or rely on larvae drifting from distant locations is essential for proper management of the grass rockfish fishery.

Sea Grant researchers Drs. John Hunter and Russ Vetter of the Southwest Fisheries Science Center, La Jolla, California, are using genetic techniques to determine the extent of local population replenishment and larval dispersal.

Over a period of two years, the scientists collected a total of 300 fin-clip samples of *S. rastrelliger* along the coast from San Diego in the south to Fort Bragg in the north. They extracted



A typical live-fish fishing operation showing a single fisher working from a small boat. Multiple hook rigs are set in a kelp bed, checked regularly, small fish released, and legal fish placed in a small live tank onboard.



Recently enacted law, the Marine Life Management Act, in California requires the state to manage fisheries by species with the best available science. This project provides valuable data for managing rockfish in California.

and compared the DNA from the samples and discovered significant genetic variance among them.

Looking at genetic variation among populations is the only feasible way of examining larval dispersal and retention, since rockfish larvae cannot be studied by tag-recapture methods and adults are not

migratory. If nearshore rockfishes show distinct population structures along the California coast, it suggests that groups of the fish are isolated and sufficient brood stock should be maintained within a region to sustain the population.

According to Hunter, their data suggest that the grass rockfish of California are structured into at least two populations, and that gene flow is limited along the coast.



Live fish fishers transport their catch to a licensed receiver on land. Here gopher rockfish are being kept in tanks prior to transport to markets in large urban centers.

Since adults are nonmigratory, events occurring at the larval stage determine how far the larvae disperse. Vetter hypothesizes that it is possible that (1) the larval drift period is shorter than previously assumed, (2) larvae that drift for long periods perish, or (3) larvae are retained within local areas.

Hunter and Vetter also obtained samples of copper rockfish (*S. caurinus*) black and yellow rockfish (*S. chrysomelas*) and gopher rockfish (*S. carnatus*) from up and down the coast. Copper rockfish also showed limited gene flow and hence limited dispersal capacity. There also has been a debate as to whether black and yellow and gopher rockfish are one species with two color morphs or two distinct species. The genetic results clearly showed that throughout their range in California, the two forms are non-interbreeding species.



Many receivers sell directly to local customers.

All four species of rockfish – grass, copper, black and yellow, and gopher – are targets of the live-fish fishery and show genetic structure along the California coast. While this is remarkable for a commercial marine species with oceanic larvae, Hunter and Vetter stress that regardless of the mechanism of larval retention, the information that the regions are distinct is important to state and federal agencies attempting to manage the harvest and long-term survival of these species.

DETERMINING AGE IN SLOW-GROWTH BOCACCIO ROCKFISH

Bocaccio rockfish (*Sebastes paucispinis*) constitute an important California fishery. Their numbers, however, are in serious decline. As annual landings have plummeted from more than 6,000 tons in the 1970s and 1980s to less than 1,200 tons currently, research efforts have been increasing in order to provide essential information for fishery management and bocaccio recovery.

Although age information is an important factor in fishery management, recent and historic longevity estimates for the bocaccio rockfish have ranged from less than 20 years to greater than 50 years. Addressing this disparity, Sea Grant researchers Drs. Gregor M. Cailliet, Kenneth H. Coale, Allen H. Andrews, and Erica J. Burton at the Moss Landing Marine Laboratories (MLML) have been using radiometric techniques to determine and validate their age.

One of the traditional techniques for determining age in fish has been to study growth increments in otoliths (calcified structures of the inner ear), with the assumption of an annual periodicity of growth increments. This technique, however, has been shown to have limited applicability to deepwater or long-lived fish and can lead to serious underestimation of longevity. To validate age estimates for these fish, Cailliet and his colleagues turned to a radiometric process that measures lead-210 and radium-226 in the otoliths of the rockfish.

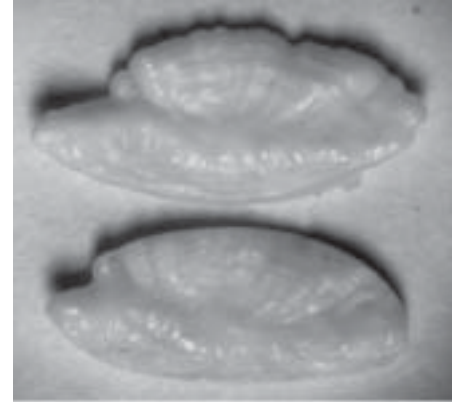
Sets of bocaccio otoliths, collected in 1983 and 1984 off the central coast of California, were available for radiometric analysis. One otolith from each set had been previously aged by the Southwest Fisheries Science Center at Tiburon, California, using a traditional technique. The other otolith was used for radiometric age determination at Moss Landing Marine Laboratories. The range of measured radium-226 activity in the bocaccio otoliths was the lowest observed in this laboratory or reported in the literature.



The radiometric aging results in this study indicate bocaccio can reach an age of 28.7 years for males and an age of 29.9 years for females.

Whole juvenile otoliths were analyzed to determine the baseline activity levels of ^{210}Pb and ^{226}Ra . Using annulus- (growth ring) derived age estimates, the otoliths were divided into two juvenile and 10 adult groups.

The radiometric ages of the juveniles were close to the average ages of the samples estimated to be between two and three years old. Otolith weight was used to determine which otoliths could be grouped as adults. Because of the wide age range, 12 to 16 years, two age groups were formed for each sex based on estimated age and otolith weight. Radiometric age determinations for each group indicated that the “high” otolith weight groups were underestimated by about four to 16 years, and the “low” otolith weight groups were overestimated by about one to five years.



Whole juvenile bocaccio otolith (top; 3 yr. estimated age) with a cored adult bocaccio otolith (bottom; 28 yr. estimated age).

A direct comparison of radiometric age with annulus-derived age displayed poor agreement of some samples. Two possible sources of error that could account for the disagreement of the two methods are: (1) radiometric age determination functioning near its limit for the ^{210}Pb levels encountered, and (2) incorrect traditional annulus-derived age estimates. The greatest discrepancies in age occurred among the oldest otolith sections, a difference of 12 years between the two techniques.

The radiometric ageing results determined by this study indicate the bocaccio can reach an estimated age of 28.7 years (23.8 to 34.6 year range) for males and 29.9 years (24.3 to 36.8 year range) for females. These results will provide a concrete basis for the determination of population demographics and strategies for managing the bocaccio fishery. Additionally, the successful application of the improved radiometric ageing technique provides a basis for further application of the technique to other fish species.

UPWELLING AND CARBON-14 LEVELS IN JUVENILE ROCKFISH

A scientific paper by S.W. Robinson that lay forgotten nearly 20 years after its publication has caught the attention of Sea Grant researcher Dr. Greg Rau. “For some reason, Robinson’s paper has been ignored all these years,” said Rau, of the Institute of Marine Sciences, U.C. Santa Cruz. “I immediately saw an application.” He believes it presents valuable means for ecologists and fisheries managers to study the effects of upwelling on economically important species.

In coastal regions, upwelling can be a seasonal phenomenon in which nutrient-rich subsurface coastal waters rise in the water column and mix with surface waters. This can result in increased plant and invertebrate life that, in turn, may benefit the development of juvenile fish populations. This includes the juvenile rockfish *Sebastes*, one of the most economically important species of the U.S. West Coast groundfish fishery. Commercial rockfish harvesting in 1997 amounted to 23,700 metric tons, valued at \$26.2 million.

In Robinson’s 1981 paper, he observed that large seasonal upwelling cycles bring waters with low levels of the radioactive isotope carbon-14 to the surface. This is in contrast to the higher levels normally present in surface waters, which are due in part to above-ground atomic weapons testing in the 1950s and 1960s.

Because this upwelling-induced lowering of carbon-14 in surface waters occurs at the same time that juvenile rockfish are growing and developing, Rau predicted that the presence and amount of carbon-14 depletion in fish tissue could serve as a measure of upwelling experienced by the fish.

Rau set out to establish whether there was a correlation between juvenile rockfish carbon-14 and upwelling intensity. In addition, he explored whether variations in carbon-14 (upwelling) are related to differences in the health and condition of the

“To our knowledge, this is the first demonstration of a link between upwelling, carbon-14, and the use of such a link to explore the effects of upwelling on fish condition.”

—Dr. Greg Rau

fish. His research team evaluated fish collected over a three-year period from Monterey Bay during usual upwellings in late spring and summer.

As anticipated, Rau found a relationship between juvenile rockfish carbon-14 and seasonal upwelling intensity. But, contrary to expectations, there was no obvious connection between upwelling and three separate measures of the fish's health and condition.



The results of this study point to factors other than upwelling as being important determinants of rockfish health and survival. It is likely that these techniques will be useful in studying other fish species. For example, Rau has received National Science Foundation (NSF) funding for a similar study of juveniles of another economically important species – salmon. The work is being carried out under the auspices of GLOBEC with Dr. Ed Casillas and colleagues at the National Marine Fisheries Service, NOAA, Seattle. The joint NOAA-NSF program is looking at links among fish population size, health, oceanography, and climate.

RESTORING SEA URCHINS

Red sea urchins are one of the most valuable in-shore fisheries in California and are second only to squid in commercial value. They are prized for their roe, most of which is exported to Japan (where it is known as uni) and used in sushi. However their stocks have been declining and, increasingly, more effort is required to harvest the same quantity.

Dr. Ronald S. Burton, at U.C. San Diego's Scripps Institution of Oceanography, has been studying red sea urchins (*Strongylocentrotus franciscanus*) since 1994. Burton is a population geneticist interested in the causes of genetic similarities and differences among populations of marine organisms spread over broad geographic ranges.

Starting in 1997, with support from Sea Grant, he has been studying adult urchins from 12 geographically separated populations in Northern and Southern California. His goal was to find where they come from, and how they reproductively interact with each other.

"We wanted to determine if declines in any one region," says Burton, "are likely to impact the availability of young urchins both within that region and in other areas." The results of this research will be useful in developing a species management plan of strategies to maintain productive populations of red urchins.

Burton began by carrying out a large-scale survey of California red urchin populations to determine the extent of genetic variation within and between geographic populations. He found significant genetic variation within natural populations of the red urchin. Genetic differences did not appear to be related to any geographic pattern. "Neighboring populations," says Burton, "were often more genetically differentiated than distant populations."

Research suggests that several small, spatially separated reserves might be more successful than one large reserve for replenishing harvested urchins.



Burton found that young urchins often differed genetically from adults collected in the same locale, and genetic variation in time and space among the young was higher than would be predicted from a well-mixed planktonic larval pool.



Trainee Jonathan Flowers, preparing to amplify DNA from sea urchins.

This was a surprising finding, considering sea urchins of the genus *Strongylocentrotus* have a long planktonic larval stage that could be expected to show high levels of dispersal with little genetic differentiation among populations. Three processes are likely to account for the high genetic diversity among young urchins: (1) chance differences in the adult reproductive success, (2) variation in source populations, and (3) pre- or post-settlement natural selection. Burton believes it likely that all three processes are at work. Currently available data do not suggest an answer.

In terms of management implications, the data suggest that several small, spatially separated protected areas might be more successful in replenishing harvested urchins than a single, large area.

Burton and his colleagues have participated in Sea Grant Extension activities including a sea urchin fishery workshop, where they discussed the implications of their research results for fisheries management.

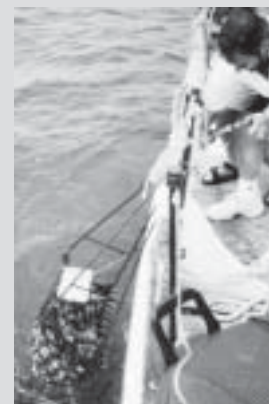
Rx FOR OYSTERS

For most people, summer is a great time of year. Not so for oysters; their mortality is highest in summer, as much as 65 percent in Northern California. Elevated temperatures and phytoplankton blooms are among the major factors affecting them and leading to significant commercial losses from the reduced harvest.

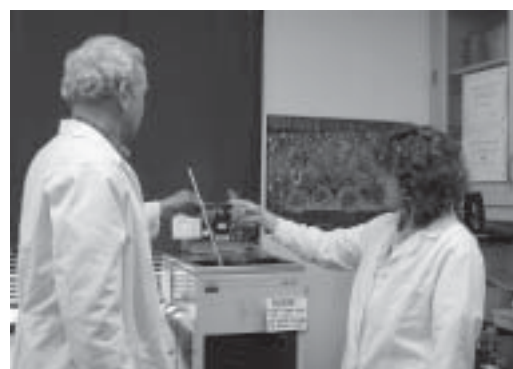
Over a three-year period, a team of Sea Grant researchers, Drs. Carolyn Friedman, Gary Cherr, and James Clegg, have been conducting laboratory and field studies of Pacific (*Crassostrea gigas*) and East Coast (*Crassostrea virginica*) oysters focusing on their response to multiple stressors. These stressors induce the production of proteins known as heat shock proteins (HSP). Friedman, Cherr, and Clegg have been testing the hypothesis that HSP induction is associated with tolerance to otherwise lethal temperatures and may be a mechanism for increasing the survival of these shellfish.

The researchers collaborated with the Pacific Shellfish Institute to study three sites in South Puget Sound. They found that oysters could be induced to tolerate a lethal increase in temperature following a one-hour exposure (heat shock) to a nonlethal increase in temperature. The increase in their thermotolerance, i.e., their ability to survive an otherwise lethal temperature, coincides with the expression of HSPs.

In studying the effects of low salinity and pathogens and their relation to heat shock, researchers found that the stress response was delayed in oysters acclimated to low salinity, and the magnitude of induced thermal tolerance lessened in oysters subjected to bacterial infection (Nocardiosis), which contributes to mass mortalities in the Pacific Northwest and Japan.



Researchers are investigating the underlying cause(s) of mass summer mortality of Pacific oysters. They have demonstrated that oysters can be made more tolerant to higher water temperatures by subjecting them to one-hour (heat shock) exposure to a sublethal temperature.



Dr. James Clegg and Ms. Susan Jackson heat shocking Pacific oysters in a temperature-controlled water bath.

During laboratory studies, researchers were able to identify an important biomarker (known as HSP 69) of thermal stress. This biomarker, says Friedman, “may be produced by other marine invertebrates, particularly bivalves, under stressful conditions.”

Through basic research, “We’ve gained a better understanding,” says Friedman, “of the dynamics of thermal stress and are now moving on to practical applications.” Friedman has shared the results of her research with oyster growers and is working with them to attempt to apply heat-shock conditions to oyster beds in order to reduce their summer mortality.

This research team also has presented their research at national and international conferences, including a Pollution and Fisheries Conference, 1996; the National Shellfisheries Association Meeting, 1997; and the International Shellfish Restoration Conferences, 1996 and 1998.

Their laboratories are located at the Bodega Marine Laboratory, a research unit of the University of California, Davis. For further information, contact Dr. Friedman at csfriedman@ucdavis.edu, Dr. Cherr at gnccherr@ucdavis.edu and Dr. Clegg at jsclegg@ucdavis.edu or see: <http://www-bml.ucdavis.edu/bmlresearch.html>.



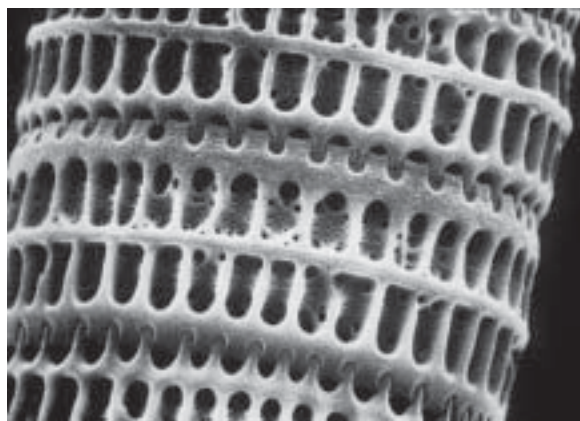
Drs. Gary Cherr and Carolyn Friedman examine oyster tissue using the scanning laser confocal microscope. The image shows foci of *Nocardia* infection and the corresponding heat shock protein expression surrounding these sites.

NEW BUILDING BLOCKS FOR TOMORROW'S HIGH-TECH MATERIALS

An interdisciplinary group of Sea Grant scientists led by Dr. Daniel Morse at the University of California, Santa Barbara (UCSB), is studying the high-performance “bio-ceramics” found in the shells and skeletons of marine organisms. Dr. Morse and his team have identified the principal protein, which they named “silicatein,” that is responsible for directing silicon dioxide nanofabrication (the process of building at the molecular or atomic level) in the marine sponge.

The resulting ceramic-like composites of proteins and minerals offer unique combinations of remarkable strength, precise structural control, and biocompatibility. These qualities make them especially attractive starting points for designing new construction materials and new electronic, optical, and medical devices.

Silicon is widely used in commercial applications: as a desiccant to absorb moisture and prevent corrosion and mold growth; as an insulating material for heat and noise reduction; as pure fibers to transmit light; and in semiconductor devices.



Electron micrograph of genetically-controlled nanoscale architecture of the silicon dioxide wall of the marine diatom *Paralia sulcata*, 30 μm in diameter.

Morse’s team has isolated the proteins and developed synthetic peptides that catalyze and spatially direct the growth of silicon-based materials at low temperature and neutral pH. This is in contrast to the high-temperature, high-pressure and extreme pH environment currently needed to produce these compounds in industry. Morse’s team is using these mechanisms to



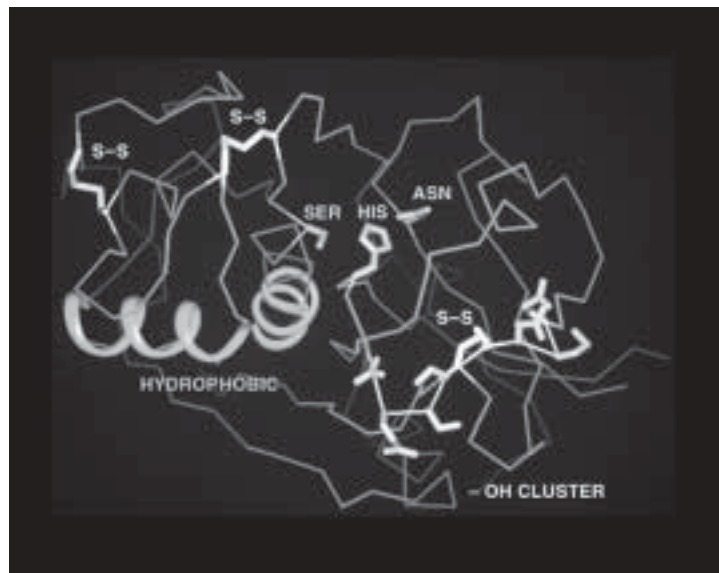
Imagine the usefulness and miracle of man-made “bone” that could be grown onto human bones where replacements are needed following accidents or surgery, or a silicon chip so small that it can be implanted in the retina of a blind person’s eye to restore sight. These and other technological advances may not be far off.

develop new strategies to synthesize high-performance composite materials for the future.

The Morse team combines genetic techniques with advanced imaging technologies. This includes the latest developments in atomic force microscopy, X-ray diffraction, solid-state NMR (nuclear magnetic resonance) and immunohisto-chemistry. These methods reveal the mechanisms controlling the creation of the high-performance mineralized composites of shells, pearls, coral skeletons, and the silicon dioxide structures made by marine sponges and diatoms. Discoveries by the team have demonstrated that these mechanisms can be harnessed for the development of environmentally benign new routes to synthesize high-performance materials.

Potential applications include new optoelectronic, microelectronic and catalytic devices. These mechanisms may enhance the next generation of DNA chips used to diagnose viral and microbial diseases.

More information about Morse's research may be found by going to his web site at <http://www.lifesci.ucsb.edu/MCDB/>



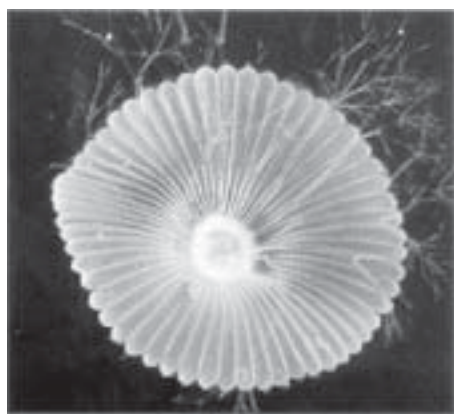
Molecular model of silicatein, the protein that controls biomineralization with silicon. Genetic engineering yields altered proteins to make enhanced silicon-based materials.

MARINE RESEARCH YIELDS NEW WEAPONS AGAINST INFLAMMATORY DISEASES

Now that the basic description of the human genome has been completed, many researchers are turning their attention to treating disease conditions at the molecular level as scientists learn which genes cause debilitating symptoms in acute and chronic diseases, such as cancer and rheumatoid arthritis.

This is a path along which Sea Grant researcher Dr. Robert Jacobs at the University of California, Santa Barbara, has already traveled. An internationally known expert in marine pharmacology, Jacobs and his research team have investigated the anti-inflammatory properties of more than 1,000 marine compounds received from collaborators around the world over the past 25 years. Currently, 11 pharmaceutical and cosmetic companies are participating in the development of several new compounds initially studied in Jacobs' lab. His work is based on the hypothesis that marine life represents a vast, ancient genetic pool that must be explored.

One of these marine natural products, pseudopterosin A (PsA), is being marketed topically in skin creams containing retinoic acid, a form of vitamin A. Adding PsA to the product blocks the rash and flushing that occurs



Giant unicellular organism (*Acetabularia*) believed to be at least 300-500 million years old contains biochemical elements of the human inflammation pathway. Individual cells are 1-2 inches long.

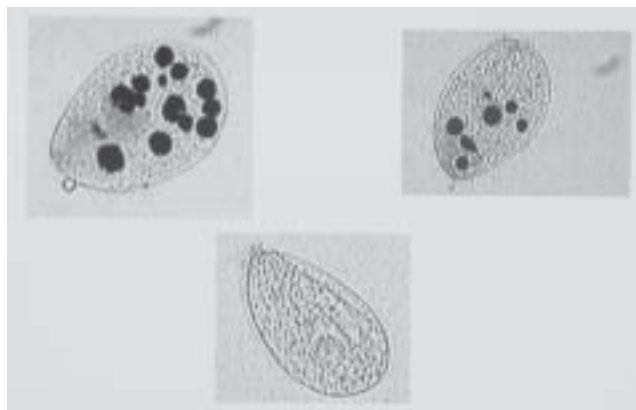
among users allergic to retinoic acid. Work in Jacobs' lab continues to seek synthetic sources for this popular compound that is derived from a Caribbean soft coral. A pharmaceutical company and a dermatology firm are both interested in exploring additional applications for PsA.



Eighty percent of all life forms on earth inhabit the oceans. In 1979 California Sea Grant began the first systematic effort in the U.S. to discover and develop new drugs from marine plants, animals and bacteria. CSG scientists lay claim to having discovered and described more than 1,000 compounds, and 14 patents have been awarded to the University of California for this work. Marine-derived compounds have the potential to treat many widespread diseases.

Preliminary work in Jacobs' laboratory on another anti-inflammatory compound, scytonemin, has led to an industrial fellowship between Sea Grant and SmithKline Beecham Pharmaceuticals. Scytonemin is derived from a blue green alga and is aimed at development for the treatment of pre-cancerous colon polyps and early colon cancers.

Dr. Jacobs and his colleagues are studying the function of these compounds in the species from which they are derived. They have discovered that elements of the mammalian inflammatory biochemical process are present in a green alga, an ancient amoebocyte, and a giant, single-cell chlorophyte. In addition to searching for marine natural products, Jacobs' team has found a promising substitute laboratory subject. They have targeted a protozoa as an alternative to the use of vertebrate animals to study pain and inflammation in the laboratory. This unicellular animal has a biochemical process of inflammation and pain pathways that are similar to those in humans, making it ideal for laboratory study.



Protozoa (*Tetrahymena*) being developed as an alternative to use of vertebrate animals to study pain and inflammation. Dark spots represent phagosomes whose formation are blocked by morphine and the anti-inflammatory pseudopterosins.

Another significant benefit from Jacobs' research has been the support and training of 25 graduate students who have worked with him as they earned advanced degrees in marine pharmacology. These young scientists will play an important role in the coming decades as they explore the oceans.

Dr. Jacobs predicts that future drugs will be more effective, have fewer side effects, and reduced toxicity. Patients will benefit from decreased pain and suffering and increased productivity. He cautions, however, that the health and stability of the environment is a serious problem that must be dealt with in the 21st century. At the bottom of the food chain is a diverse population of unicellular life whose physiological function in response to the environment is potentially at risk. Factors affecting the mechanisms of adaptation, mutation, and growth are important investigations for the near future. The information contained in these organisms' genomes, some of which can serve as important templates for the design of new drugs, will be lost if they become extinct.

CALIFORNIA SEA GRANT EXTENSION PROGRAM

SUMMARY OF ACCOMPLISHMENTS

MARCH 1, 1999–FEBRUARY 29, 2000

Increasing demands on coastal and marine resources have led to unprecedented needs for the timely dissemination and coordination of research-based information. This is an essential component of the on-going management and wise stewardship of California's valuable coastal resources. Resolution of resource problems often requires a blend of research information, new policies, and public education.

The Sea Grant Extension Program (SGEP) was established in 1972 with a mission to apply research-based information to the development of practical and acceptable solutions in the areas of marine and coastal resource concerns. This mission is carried out by a talented and expert team of coastal county-based marine advisors and two campus-based technical specialists who target local, state, and national issues. Locally, SGEP advisors work directly with the diverse marine community, conduct educational and applied research programs, and help identify community needs for university and agency research.



SGEP staff also regularly meet to discuss important state and national concerns that will affect most Californians, and to identify ways of working together for resolution of these larger issues.

SGEP is the primary arm of the California Sea Grant College Program for providing the citizens of California with marine-related information with special emphasis on resource management, utilization, and conservation.

MARINE FISHERIES

Christopher M. Dewees – Marine Fisheries Specialist and Sea Grant Associate Director for Extension

Chris Dewees served on the California Department of Fish and Game (CDFG) Restricted Access Committee that drafted the first comprehensive fisheries restricted access policy. After an extensive peer and public review, the policy was adopted by CDFG Commission in June 1999. The policy is already being applied in the development of long overdue restricted access management plans in the pink shrimp, spot prawn, squid, ridgeback shrimp, and other nearshore fisheries. In the long run this policy should lead to reduction in overcapitalization, improved probability of resource sustainability, and improved economic performance in California's marine fisheries.



Dewees assisted the state with implementation of the Marine Life Management Act (MLMA). This major legislation mandates major changes in the management of California's living marine resources. Dewees provided two days of training on management of nearshore fisheries to the entire CDFG Marine Region staff in June 1999. He assisted the state and the National Fish and Wildlife Foundation with implementing the processes mandated by the Act for involving constituents, and provided leadership in the writing of the "Status of the Fisheries Report," an expanded and revised version of CSG's publication, "California's Living Marine Resources," 1992.

The training resulted in improved capabilities of CDFG staff as they undertake MLMA implementation. Sea Grant assistance with designing the constituent-involvement process should lead to better fishery management plans, increased compliance with regulations, and increased agency, university, and constituent collaboration in research and resource management. The "Status of the Fisheries Report" will provide an excellent marine education tool for the legislature, CDFG, the California Fish and Game Commission, scientists, and other interested constituents.

Publications: Boydston, L.B., B. Heneman, C.M. Dewees, M. Melchiorre, J. Oltmann, M. Chrisman, R. Treanor, and J. Duffy. 1999. Fish and Game Commission policies regarding restricted access in commercial fisheries. Adopted by Fish and Game Commission, June 18, 1999.

James B. Waldvogel – Sea Grant Marine Advisor, Del Norte, California and Curry, Oregon Counties

Jim Waldvogel was awarded a CDFG grant through the Smith River Advisory Council to hire a writer for the Smith River Anadromous Fish Action Plan, which is to be completed

by June 2001. The action plan will provide management guidelines and directions for the restoration of the Smith River salmonid populations. Del Norte County industries (e.g., timber, agriculture, gravel, sport fishing) and CDFG will utilize the plan recommendations.

Waldvogel completed the 20th year of the Mill Creek (Smith River) Chinook salmon spawning escapement study, which chronicles the habitat and fishery populations stability of a healthy salmonid stock. The database shows the biological variation and effects of El Niño events and drought conditions. CDFG and a private timber company are using the data for HCP (habitat conservation plan) development. This is the longest salmonid escapement study site on a major river in California.

Publications: Smith River Anadromous Fish Action Plan; poster presentation at National Extension Natural Resources Conference in South Lake Tahoe. Final report in progress, and publication anticipated in the Journal of the American Fisheries Society.

Richard M. Starr – Sea Grant Marine Advisor, Santa Cruz and Monterey Counties

In 1999, Rick Starr and colleagues published several papers related to species-habitat associations, techniques for tracking marine fishes, and the use of marine reserves as a fishery management tool. Additionally, he was an invited speaker at several national and international symposia related to the use of marine reserves in fisheries management. He participated in a panel of scientists who wrote a paper on the value of marine reserves. He was co-organizer, with Chris Dewees, of a workshop to help CDFG design management plans for nearshore species. Starr also served on a statewide squid fishery advisory committee. Starr worked with community leaders to develop an ocean science camp for children. He is chair of the Board of Directors of S.E.A. Lab Monterey Bay, a new community-based organization that is trying to incorporate the many educational opportunities in Monterey Bay into a residential camp for children.

In the spring of 1999, Starr became one of six scientists to be trained to use a one-person submersible to explore the depths of the Monterey Bay National Marine Sanctuary as part of the Sustainable Seas Expedition funded by the National Geographic Society, the Ronald Goldman Foundation, and NOAA.

In the summer of 1999, Starr worked with graduate student Jason Felton and researchers from the Monterey Bay Aquarium, Moss Landing Marine Lab, and the Pfegler Institute for Environmental Research to develop methods for placing sonic tags on prickly sharks at the head of the Monterey Submarine Canyon. Relatively little information is known about the habitat use of this rare shark. Starr and colleagues tagged and tracked prickly sharks moving from shallow water near the beach to depths of more than 1000 feet, five miles offshore. This work is an example of Starr's efforts to organize a variety of researchers to collect information on essential fish habitats.

In December 1999, Starr began a two-year research project to evaluate the effectiveness of marine reserves to conserve stocks of spawning lingcod. Lingcod provide the basis of an extremely valuable sport and commercial fishery, but populations have declined by 80 percent in the past 20 years. The project, funded by the David and Lucile Packard Foundation, is designed to determine if marine reserves can stem the dramatic decline of lingcod populations on the West Coast.

From March to December 1999, Starr gave nine talks on a variety of topics including rockfish and movements of marine fishes to a total of 990 participants. Live internet uplink on prickly shark biology was made available to a total of 1500 participants.

Publication: Murray, S., R. Ambrose, J. Bohnsack, L. Botsford, M. Carr, G. Davis, P. Dayton, D. Gotshall, D. Gunderson, M. Hixon, J. Lubchenco, M. Mangel, A. McCall, D. McArdle, J. Ogden, C. Pomeroy, J. Roughgarden, R. Starr, M. Tegner, and M. Yoklavich. 1999. No-take reserves: Sustaining fishery populations and marine ecosystems. *J. Amer. Fish. Soc.* 24:11-25.

SEAFOOD TECHNOLOGY

Robert J. Price – Food Science and Technology Specialist

Bob Price is co-editor of the Seafood HACCP Alliance publications and provides extensive training for seafood processors and HACCP instructors. Food-borne illness in recent years has heightened public awareness and concern for the safety of the nation's food supply. Federal response to seafood safety has included the Hazard Analysis and Critical Control Point (HACCP) inspection system. Processors engaged in interstate commerce of seafood are receiving necessary training to comply with HACCP implementation thanks to the educational efforts of the National Seafood HACCP Alliance, which is nationally represented by numerous federal, state, academic, and industry organizations.

The Alliance has certified more than 525 trainers, and more than 8,500 participants have completed courses in basic HACCP training. Based on a 1999 national survey conducted by New York Sea Grant, 78 percent of the 727 respondents indicated that they would not have been able to develop a HACCP plan to comply with the FDA regulations without the Alliance training course. Current new avenues of Alliance training include sanitation control procedures, a prerequisite for HACCP programs. Dr. Price and the National Seafood HACCP Alliance received the 1999 U.S. Secretary of Agriculture's Group Honor Award for Public Service for efforts to improve seafood safety.

Through the internet, Price and Program Representative Pamela Tom have maintained two unique, effective seafood technology information programs to deliver technical information to a variety of audiences.

The Seafood HACCP listserv (e-mail discussion list) consists of about 860 worldwide subscribers in industry, government, and academia. The listserv provides immediate information exchange through e-mail on a variety of seafood technology, safety, and HACCP inquiries and updates.

The Seafood Network Information Center (NIC) home page (<http://seafood.ucdavis.edu/home.htm>) continues to be updated on a weekly basis. The SeafoodNIC averages about 70,000 hits monthly, and is designed as a primary information source on seafood technology issues including research, processing guidelines and regulations, marketing resources, sanitation, publications, industry events, and consumer information. It is an effective and economical tool to communicate current seafood information to industry, regulatory agencies, academia, and consumers.

Through the use of Web Trends (a web site monitor), statistical results show that the SeafoodNIC web site's most frequented pages include: the Seafood HACCP Alliance; Generic Model HACCP Plans; HACCP Information; Compendium of Fish and Fishery Product Processes, Hazards and Controls; Guidelines and Regulations; and Consumer Information. The HACCP information is an especially important resource for the seafood industry and regulatory agencies.



Both the HACCP mailing list and SeafoodNIC are excellent media for free and immediate outreach to international audiences. The seafood HACCP mailing list has at least 48 countries subscribed. On an average day, the SeafoodNIC is accessed by more than 40 countries. The international impact of the Seafood HACCP Alliance's training has benefited more than 31 countries. The Compendium of Fish and Fishery Product Processes, Hazards and Controls is used by governments and industry worldwide in referencing seafood hazards and their control to ensure safe products for consumption.

Publications: The Compendium of Fish and Fishery Product Processes, Hazards and Controls is an excellent compilation of biological, chemical, and physical hazards identified by the U.S. Food and Drug Administration. Backgrounds on the hazards with guidelines for processors on how to control these hazards are on the web (<http://seafood.ucdavis.edu/haccp/compendium/compend.htm>). As editor, Dr. Price annually updates this comprehensive guide.

The HACCP training manual, "Ensuring Food Safety...the HACCP Way: An Introduction to HACCP and a Resource Guide for Retail Deli Managers," can be found at <http://nsgd.gso.uri.edu/source/cuimrh93001.pdf> and the Spanish version is available at <http://nsgd.gso.uri.edu/source/cuimrh95001.pdf>. Access to either file requires Adobe Acrobat Reader available from <http://www.adobe.com/products/acrobat/readstep.html>.

Michael Morrissey, editor of the *Journal of Aquatic Food Product Technology*, featured a review of both the mailing list and web site. Dr. Morrissey writes that, "The U.C. Davis Seafood Information Center dispels one's doubts about how useful (and fast) good information can be. Sign up for the listserv and put your thoughts on-line and discuss practical information or the latest science data with seafood people around the world. The authors of this web site are to be commended for bringing all of us in seafood research and industry a little closer to virtual reality in its true sense."

COASTAL AND MARINE RESOURCES MANAGEMENT

Jodi Cassell – Sea Grant Marine Advisor, San Francisco Bay Counties

The goal of Jodi Cassell's West Coast Ballast Outreach Project, funded by California Sea Grant and the CalFed Bay-Delta Program, was to facilitate information exchange between the maritime industry, regulators, and researchers on the subject of managing ballast water to prevent the introduction of aquatic nuisance species (ANS). A diverse advisory committee was assembled for the project, which addressed domestic and international issues.

Cassell and the project staff organized a series of eight forums held in various locations. These meetings included formal presentations by respected experts from the various interest groups, and provided the audience with an opportunity to learn about the latest issues in ballast management from a technical, legal, and industry perspective. The forums were well attended. Cassell has also attended and provided information at various industry meetings.

The project also developed a biannual newsletter on ANS and ballast management issues, which reached more than 4,000 people in the U.S. and overseas. Cassell also planned a color brochure and poster for distribution and posting on ships. The newsletter and meetings have received excellent reviews. The staff maintained regular contact with industry and government representatives. Cassell was frequently invited to participate in national and regional management efforts and ANS programs.

Cassell hosted a video-conference with colleagues in Australia that included downlink sites in six major U.S. cities and facilitated improved collaboration between U.S. and Australian leaders in ANS management. She also participated in International Maritime Organization meetings related to ballast water. The brochure, poster, and the newsletter will be circulated internationally.

Paul Olin – Sea Grant Marine Advisor, Sonoma and Marin Counties

In Northern California, the Russian River and its tributaries provide habitat for steelhead trout, coho and chinook salmon, all of which are federally listed as threatened under the Endangered Species Act. Recovery of these species is largely in the hands of private landowners who own 89 percent of the land in the watershed. Marine Advisor Paul Olin wrote a successful grant and designed the Russian River Restoration and Landowner Outreach project to increase the knowledge among 140 riparian landowners about anadromous fish habitat requirements. The project encouraged them to complete habitat restoration projects identified through stream surveys. The program provided training in habitat restoration techniques and sources of assistance in both designing and funding projects. Twelve restoration projects were completed as part of the program.

The information conveyed in the program workshops is being used by landowners to improve salmon habitat. Participants have become valued resources in their communities promoting stewardship of riparian land and anadromous fish habitat in the watershed. Salmon habitat was improved in the Russian River and its tributaries primarily through erosion control and reductions in sediment delivery to spawning areas. This will aid in the recovery of these threatened species and, if successful, will prevent endangered listings that would have significant impacts on local economies and water availability.

Shellfish growing waters in Tomales Bay, California, are periodically closed to harvest when high loads of coliform bacteria from agricultural animal waste enter the estuary following winter rains. Livestock and dairy producers in the region were largely unaware of their contribution to this water quality problem. They lacked information on the environmental fate of coliform bacteria and on steps they might take to reduce this load. This program monitored water quality in the region and educated landowners about important water quality variables and sources of coliform bacteria. An ongoing research component is tracking coliforms in the watershed and evaluating management practices that will reduce their entry into surface waters.

The results are being used by dairy and livestock operators to reduce bacterial, nutrient, and sediment contamination that are impacting shellfish growing waters.

Pollution of coastal waters by agricultural animal waste is a problem throughout the world. Best management practices and an animal waste HACCP plan are being



Restoration project to stabilize an eroding stream bank by constructing a willow wall and recontouring the slope of the creek bank.

developed as a part of this project and will have wide application.

Olin coordinated two workshops in California: (1) 64 people attended “Getting in Step – Outreach in Your Watershed,” co-sponsored with For the Sake of Salmon, in Eureka; (2) 48 people attended “Hatchery versus Wild Steelhead Management Issues,” co-sponsored with the Smith River Advisory Council and the Del Norte Fish and Game Commission, in Crescent City.

Olin trained watershed council leaders in communicating with the media and other constituents and provided biological, social, management, and economic information to the public about hatchery versus wild salmonid populations.



Boulder weir constructed to channel stream energy, enhance coho salmon habitat and reduce erosion.

Presentation: Olin, P.G., and J.K. Moore, 1999. Russian River Tributary Restoration and Landowner Outreach. Natural Resources Continuing Conference, U.C. Bodega Marine Laboratory, Bodega, California.

Richard M. Starr – Sea Grant Marine Advisor, Santa Cruz and Monterey Counties

Rick Starr provided technical and policy support for the Monterey Bay National Marine Sanctuary. Graduate assistant Kate Stanbury and Starr provided the staff of the sanctuary with a CD that contained spatial information related to the sanctuary. In addition to the computer programs and files, they also provided a lengthy documentation of the data sets and protocols used in the geographic information system (GIS), as well as training in its operation. In March 1999, Starr gave a talk on marine protected areas to 150 people; and in November he gave a talk on GIS technology to 300 people. Additionally, Stanbury wrote a tutorial for the program and data sets.

Publication: Stanbury, K.B., and R.M. Starr. 1999. Applications of geographic information systems (GIS) to habitat assessment and marine resource management. *Oceanologica Acta*. 22:(6) 669-703.

Deborah McArdle – Sea Grant Marine Advisor, San Luis Obispo and Santa Barbara Counties

McArdle was nominated by a fishery representative at CDFG, and the Center for Marine Conservation (CMC) to serve on the Channel Islands National Marine Sanctuary (CINMS)/ CDFG Marine Reserve Stakeholder Committee in June 1999. The committee submitted a

proposal to the Fish and Game Commission to create a series of no-take reserves around the Channel Islands in Santa Barbara and Ventura Counties. As a result, CDFG and CINMS are developing a science-based process to design a system of reserves for the Channel Islands.

The National Center for Ecological Analysis and Synthesis (NCEAS), affiliated with U.C. Santa Barbara, facilitates integrative research aimed at synthesizing existing data and information, and subsequently makes these data available in accordance with its data policy. The center also has the mission of organizing and synthesizing ecological information in a manner useful to researchers, resource managers, and policymakers addressing important environmental issues. McArdle served as a member of the reserve working group (comprised of approximately 25 researchers from around the world) to develop a sound theoretical basis for the design and implementation of marine reserves. She also served as a Visiting Researcher and Center Associate at NCEAS beginning in June 1999. McArdle helped the group organize a compilation of papers for the journal, *Ecological Applications*, and organized a Resource Manager/Researcher meeting in November 1999.

One of the problems with the historical process used to establish marine reserves is the lack of interagency coordination and communication. Recognizing this, the governor of California called for a workgroup to be formed that would consist of representatives from all the state agencies responsible for creating reserves in California. The goal of the group was to establish a more effective classification scheme for reserves, as well as a science-based process that would form a network of reserves in California. McArdle served on the Marine Managed Areas Working Group of the California Resources Agency since fall 1999. The group used the CSG publication, "California Marine Protected Areas," authored by McArdle, as the foundation to evaluate the existing system of reserves.

The product of this effort will be a plan that will describe and recommend how to create reserves using a science-based approach.

McArdle has served on the Pacific Ocean Conservation Network (POCN) Scientific Advisory Panel since spring 1999. This panel was convened by a consortium of CMC, the Natural Resources Defense Council, the Environmental Defense Fund, and the National Audubon Society. The panel was sponsored by a grant to CMC from the David and Lucile Packard Foundation, and its mission was to



The Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa). These islands, and Santa Barbara Island, are within CINMS, Biosphere Reserve and National Park.

analyze the potential of marine reserves for the improvement of fisheries and marine conservation with emphasis on the U.S. Pacific Coast.

Publication: Murray, S., R. Ambrose, J. Bohnsack, L. Botsford, M. Carr, G. Davis, P. Dayton, D. Gotshall, D. Gunderson, M. Hixon, J. Lubchenco, M. Mangel, A. McCall, D. McArdle, J. Ogden, C. Pomeroy, J. Roughgarden, R. Starr, M. Tegner, and M. Yoklavich. 1999. No-take reserves: Sustaining fishery populations and marine ecosystems. *J. Am. Fish. Soc.* 24(11): 11-25.

James B. Waldvogel – Sea Grant Marine Advisor, Del Norte, California and Curry, Oregon Counties

Jim Waldvogel authored two chapters of Oregon Extension’s “Watershed Stewardship Education Program” curriculum (Salmon Biology and Stream Ecology/Monitoring), and received the “Outstanding Leadership in Educational Programming” Search for Excellence Award from Oregon State University. The curriculum guide is being used by watershed councils in Oregon and California to train watershed volunteers and community restoration leaders.

Leigh Taylor Johnson – Sea Grant Marine Advisor, San Diego County

Leigh Johnson partnered with the U.S. Coast Guard Marine Safety Office and the Coast Guard Auxiliary in San Diego to train 30 Coast Guard Reserves and Auxiliarists to educate boaters on pollution prevention with a special focus on vessel sewage pumpout stations and hazardous materials disposal. A survey of 42 boaters at the San Diego area seminars found that 60 to 90 percent learned new information on environmental impacts of boating pollution and on laws, disposal, and maintenance tips related to vessel sewage, holding tanks, and hazardous waste; 83 percent improved their ability to operate a pumpout station or call a mobile service. An adaptation by Johnson of the Texas Sea Grant Extension Program publication, “Here’s the Poop...Don’t Pollute! A Potti-Training Manual for Boaters,” was published by the Coast Guard Auxiliary, using a Clean Vessel Act grant from the California Department of Boating and Waterways.

Johnson chaired the County of San Diego Watershed Working Group (WWG) that was established by the County’s Deputy Chief Administrative Officer for Land Use and Environment. The WWG educated over 1,340 county inspectors, rangers, other staff and volunteers on how to recognize watershed, nonpoint source pollution, and stormwater problems during their daily activities, when to educate and when to regulate, and provided them with educational



A sewage-pump-out station being checked for efficiency. Waste pumped from boats goes into the local sewage treatment system.

materials for this purpose. The WWG identified watershed organizations and made a directory available on the Internet: <http://commserv.ucdavis.edu/CESanDiego/Seagrant/watershed.htm>. They also identified six major watershed management issues that needed policy-level attention and provided them to the Deputy Chief Administrative Officer. Johnson assisted in planning the National Watershed Outreach Conference and a workshop, "San Diego County Watershed Forum 2000: Incorporating Regulatory Considerations in Your Watershed Plan." Johnson co-chaired the San Diego Bay Watershed Task Force that completed a Watershed Management Plan for San Diego Bay. During this effort, Johnson succeeded in training staff of the San Diego Unified Port District in public participation and the direct use of stakeholder expertise in developing a watershed management plan.

Watershed management is in early stages of development in San Diego County. Watershed managers, and agencies that must interact with them need to learn the principles of watershed management and assistance in developing skills in outreach, financial tool development, cooperation among competing watershed groups, public participation, and how to incorporate the high level of demographic diversity that exists in the area. SGEP's efforts have fostered the beginnings of this critical process of infrastructure development and assisted in developing a regional perspective that was much needed in a region with many small watersheds.

Watershed management in Southern California is interconnected to watershed management in Baja California, Mexico. The ability to take a regional approach through SGEP's connection to county government will enhance the resolution of trans-boundary issues of watershed management. SGEP also serves on the binational, Bight of the Californias pilot project, which is facilitating international cooperation on coastal watershed management in the region. SGEP is communicating with the Tijuana River National Estuarine Research Reserve to plan a series of training programs for watershed managers.

Johnson obtained funding from U.C. Davis, California State University, Long Beach, and the San Diego Bays Foundation and Renewable Resources Extension Act to support the development of a review paper, a working conference, and a brochure for boat owners on nontoxic alternatives to heavy metal-based, antifouling paints for recreational boats. Johnson and Program Representative Jeremy Haas began the development of the review paper and surveyed boating industry members, boaters, regulators, and environmental interests. Johnson also obtained funding from the State Water Resources Control Board and the U.S. Environmental Protection Agency to conduct a high-profile demonstration of nontoxic antifouling coatings for recreational boats during 2000–2003.

Heavy metal-based, antifouling paints on recreational boat hulls are a significant source of copper pollution in the water and sediments in partially enclosed, poorly flushed boat basins. Intense regulatory scrutiny is underway and the San Diego Water Quality Control

Board is considering phasing in a ban on metal-based boat bottom paints. Survey respondents indicate that regulatory attention is likely to spread throughout the United States within five to 10 years. Current alternative antifouling coatings are expensive or provide new, technical challenges. This project will benefit the boating industry, boaters and coastal ecosystems by fostering development and use of superior, nontoxic hull coatings, thus increasing the supply of effective alternatives as existing materials are regulated or banned. A review paper and a brochure for boaters will be published and distributed when this project is completed.



Survey respondents have indicated that some boaters are taking their boats to repair yards in Mexico, Canada, and the Caribbean to obtain tri-butyl tin (TBT) based bottom coatings that are banned in the United States because of toxicity for boats under 25 meters long. A Mexican scientist reported that TBT levels in the Port of Ensenada increased after it was banned in the United States for use on smaller vessels.

SGEP provides downloadable publications at the San Diego County web site: <http://seagrant.ucdavis.edu> on pollution prevention and severe weather preparedness for marinas and recreational boaters, and the Watershed Organizations Directory for San Diego County. This web site also provides links to NOAA, Sea Grant and other web sites with resources on aquaculture, coastal recreation and tourism, coastal water quality and watershed management, fisheries, nonindigenous nuisance species, San Diego Bay, seafood quality, and youth marine education and career exploration. SGEP web site is now recognized as a source for research-based information on pollution prevention for marinas and recreational boats.

Boating pollution prevention publications, including downloadable and other materials, have been provided to international audiences in response to requests from Canada, England, Wales, Australia, New Zealand, the Philippines, and Singapore.

AQUACULTURE

Susan McBride – Marine Advisor, Humboldt and Mendocino Counties

Susan McBride's sea urchin nutrition and reproduction research focused on commercially important sea urchin species in California and the Mediterranean. Experiments were completed on the effects of density, food ration, and food type for the red sea urchin, *Strongylocentrotus franciscanus*. Research investigating the effects of algal and prepared diets,

photoperiod, and temperature on gonad production and biochemical studies on carotenoid pigment biochemistry were completed with *Paracentrotus lividus* by McBride while she was on sabbatical leave in Eilat, Israel.

Sea urchins are a candidate species for aquaculture in California and the Mediterranean countries because of declines in fishery landings and continued high demand for the sea urchin roe product. Applied research is essential to allow development of a sea urchin aquaculture industry.

McBride conducted nonindigenous green crab research in Humboldt Bay, in collaboration with Paul Olin, Marine Advisor for Sonoma and Marin Counties, which resulted in an 18-month survey of the distribution and abundance of the European green crab in that area. Early information on the abundance and distribution of this ubiquitous species in Humboldt Bay will allow oyster culturists and natural resource managers to determine impacts, if any, of this introduced crab on aquaculture and important fishery species such as Dungeness crabs.

Paul Olin

The introduced green crab, *Carcinus maenas*, is a concern along the West Coast where it has dispersed from central California as far north as British Columbia. The crab has the potential to prey on the commercially important Dungeness crab and has caused losses as high as 30 percent through predation on cultured clams. This predation occurs primarily when crab larvae settle into mesh clam culture bags and subsequently grow to a size at which they become trapped in the bags and prey on cultured clams. This project monitored crab abundance and patterns of larval settlement in Tomales Bay and Humboldt Bay, California. The project included experiments to identify relative levels of predation based on crab size and clam seed size.

Information on areas with high crab densities and the relative abundance of larvae and the timing of larval settlement were determined. These results can be used by growers to identify growing areas and periods of time when crab megalops (i.e., larvae) are settling from the plankton. Research results can also be used in purchasing clam seed by sizing seed to reduce mortality from smaller young-of-the-year crabs.



The European green crab, *Carcinus maenas*, is a rapidly spreading marine pest in many regions.

Leigh Taylor Johnson – Sea Grant Marine Advisor, San Diego County

Johnson facilitated agreement among members of the Agua Hedionda Lagoon Shellfish Technical Advisory Committee (TAC) to conduct demonstration research that would quantify effects on fecal coliform levels by excluding seabirds from Carlsbad Aquafarms. She wrote a successful proposal to the California Coastal Conservancy and the Cabrillo Power Company to retrofit the mussel farm's flotation system, as well as in-kind support for labor and laboratory analysis by Carlsbad Aquafarms, San Diego Regional Water Quality Control Board, and the State Water Resources Control Board. The Agua Hedionda Lagoon foundation accepted responsibility for managing the funds on behalf of the TAC. San Diego County and local cities continued their study of watershed coliform sources that will provide a context for the mussel farm- and seabird-focused research.

The study will help the TAC to identify how much coliform pollution can be mitigated by seabird exclusion and how much must be addressed by watershed pollution management. This will allow the TAC to fulfill their legal mandate and assist the mussel farmer, the Regional Water Quality Control Board and Cities of Carlsbad and Vista to determine appropriate procedures for mitigating pollution sources that affect the status of the Shellfish Growing Area in Agua Hedionda Lagoon. Carlsbad Aquafarms estimates that it can cut shellfish depuration times in half and achieve significant cost savings, if the growing area can be reclassified as Conditionally Approved. Contamination of shellfish growing areas by seabirds is a problem wherever flotation systems have structural materials that rise above the waterline. Therefore, results of this research have the potential of solving a problem affecting shellfish industries internationally.

EDUCATION**Susan McBride – Marine Advisor, Humboldt and Mendocino Counties**

Susan McBride assisted with developing the Humboldt Bay Natural Resource Management Plan, which included education and outreach for watershed and coastal landowners, residents, agencies, and Native American tribes. Agendas were prepared targeting minority participation in the Bay Management Plan process. Ongoing educational tours and workshops were organized for committee members. The planning process was essential to protect natural resources and allow economic development within the region. It helped to integrate many disparate efforts and focused the community on concerns and opportunities around the Bay. McBride gave three seminars and one lecture on her sea urchin research; two seminars on her activities as a Marine Advisor with the Sea Grant Extension Program were given while on sabbatical leave in Israel. Students, researchers and faculty at Israeli universities and government research laboratories learned of McBride's research and how the Sea Grant Extension Program operates in California.

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CALIFORNIA SEA GRANT COMMUNICATIONS

Wise decision-making about coastal and marine-resource utilization by citizens and policy makers rests on adequate information and awareness. CSG Communications Office seeks to promote a broad understanding of state, regional, and national marine resource issues; to improve information dissemination between marine researchers and user communities; and to foster greater understanding of the Sea Grant concept and its accomplishments. The Communications Office advises and assists program management and extension personnel with communications planning and implementation. The office prepares material to satisfy information requests from the National Sea Grant Office (NSGO) and other Sea Grant programs. The Communications Office interprets, prepares and distributes Sea Grant publications to the program's user communities and fills numerous requests for information and publications from a variety of audiences concerned with marine resource issues. Key audiences include: federal, state and local legislators; resource managers and administrators; industry people such as fishers and seafood processors; members of nongovernmental and conservation organizations; researchers, faculty and students concerned with marine resource issues; reporters and editors of print and electronic media; recreational users of marine resources; and the general public.

The goals of CSG Communications Office are to increase program recognition and support by informing key audiences and users about the activities and accomplishments of the state, regional, and National Sea Grant programs; to educate key audiences and users about critical marine resource issues; and to counsel and support the communications needs of program management and NSGO, thereby contributing to Sea Grant's visibility and effectiveness.

The major functions of CSG Communications Office are (1) production of Sea Grant publications (educational, reference, and technical series); (2) public information and media relations activities; (3) dissemination of reprints and other technical publications produced by the program's researchers (see table, p. 52); (4) development of content for CSG's web site; (5) high school and graduate student outreach for the program's Isaacs Scholarship, national, state, and industrial fellowships, and education sites on web; and (6) miscellaneous program support activities (graphic displays for conferences, etc.).

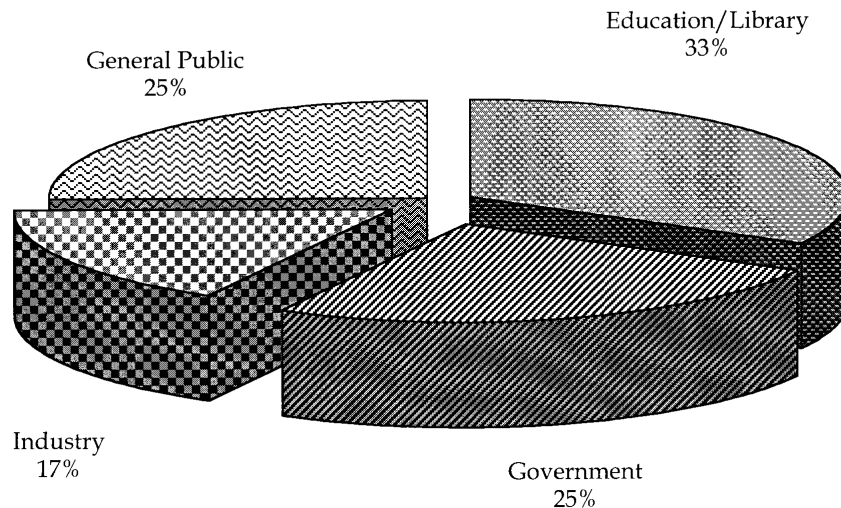


COMMUNICATIONS PUBLICATION TITLES BY SUBJECT AREA 1999-2000

Subject Areas	Sea Grant Series	Journal Articles	Conference Papers	Theses	Proceedings	Misc.	Extension	Total	Percent
Education/Reference	3	-	-	-	-	1	1	5	6
Consumer/Industry	-	-	-	-	1	-	14	15	19
Aquaculture	-	5	-	4	-	-	-	9	11
Coastal Ocean	-	7	1	4	1	-	-	13	16
Fisheries	-	4	-	5	1	-	-	10	12
Marine Affairs	-	2	-	-	-	1	-	3	4
New Marine Products	-	19	1	4	-	-	-	24	30
Ocean Engineering	-	1	1	-	-	-	-	2	2
Total	3	38	3	17	3	2	15	81	
Percent	4	47	4	21	4	2	18	-	100

An ongoing and important function of the Communications Office is to disseminate the results of research, education and outreach projects. The table above shows the new publications available during the previous grant year, listed by subject area and type of publication.

PERCENTAGE OF COMMUNICATIONS PUBLICATIONS REQUESTED BY AUDIENCE 1999-2000



The graph above indicates the major sources of requests for information by audience.

COMMUNICATIONS HIGHLIGHTS

The California Sea Grant Communications staff have accomplished the following:

- expanded content on the California Sea Grant Program's web site, such as a feature story on Isaacs Scholarship past winners; a feature story with photos about Sea Grant Marine Advisor Rick Starr; converted program directory and strategic plan for web site; created forms to enable researchers to submit annual, completion and trainee reports on-line;
- wrote feature articles on selected research projects for the program's annual report, which will also serve as one of the primary handouts used to inform colleagues, as well as the general public, about research and marine issues;
- expanded the use of email to communicate more quickly and less expensively with the program's various audiences;
- assisted NOAA and NSGO with planning and publicizing the Recreational Fishing Symposium that was co-sponsored by NSGO and the National Marine Fisheries Service, held June 2000 in San Diego;
- co-sponsored the Harmful Algal Blooms On-Line Workshop conducted by the University of Southern California Sea Grant Program, and collaborated with other Sea Grant programs to create a report on the various research and outreach projects that had been conducted on aquatic nuisance species.

EDUCATION: OUR COMMITMENT TO THE FUTURE

GRADUATE TRAINEESHIPS

Research projects funded by California Sea Grant generally include a stipend for at least one graduate student trainee, who assists the project leader. The work done by the students is often the basis for their thesis. More than 900 graduate students have participated in the California Sea Grant trainee program since its inception in 1968.

FELLOWSHIPS

Fellowships in government provide first-hand training in solving today's ocean and coastal resource problems. California Sea Grant's fellowship programs provide unique educational opportunities for graduate students interested in marine resource policy. Fellows benefit legislative committees and government agencies by providing scientific knowledge of ocean and coastal resources.

KNAUSS FELLOWSHIP

California Sea Grant's Knauss Fellows have been placed with a variety of host offices, including the Ocean Studies Board of the National Research Council, the Office of Fisheries Affairs of the U.S. Department of State, the Division of Ocean Sciences of the National Science Foundation, the U.S. Fish and Wildlife Service, the House Committee on Resources, and NOAA Office of Global Programs.

In 1999, Ashley Simons was awarded a Knauss Fellowship to work at the Bureau of Insular Affairs on coral reef conservation. Simons worked closely with the U.S. Coral Reef Task Force, contributing to working groups and serving as a liaison between federal and island representatives. She also assisted in combining all the Task Force recommendations into the National Action Plan to Conserve Coral Reefs.

STATE FELLOWSHIP

California Sea Grant sponsors a State Fellowship Program, which places graduate students interested in statewide marine policy issues with host offices in the California legislature or state resource management agencies. State Fellows have worked with the state Joint Committee on Fisheries and Aquaculture, the Subcommittee for River Protection and Restoration, the Pacific Fisheries Legislative TaskForce, the Monterey Bay National Marine Sanctuary, the California Regional Water Quality Control Board, and the California Coastal Commission.



Ashley Simons, 1999
Knauss Fellow

JOHN D. ISAACS SCHOLARSHIP

California Sea Grant awards a four-year college scholarship each year to a high school senior or junior in California who shows a particular aptitude in marine science. The \$12,000 award has been sponsored annually since 1981 to honor the memory of John D. Isaacs, former professor of oceanography at Scripps Institution of Oceanography and director of the University of California's Institute of Marine Resources.

In 1999, the John D. Isaacs Memorial Sea Grant Scholarship in Marine Science was awarded to Sarah Reiver of La Quinta High School, Riverside County. Reiver sought to identify concentrations of iron and other nutrients that promote optimal growth of the microscopic phytoplankton, *Emiliana huxleyi*. Her project further attempted to evaluate whether the species could be manipulated to reduce the amount of carbon dioxide in the earth's atmosphere, exploring its potential as a tool for mitigating global warming. Reiver is now a sophomore at the University of California, San Diego.

OUTREACH

California Sea Grant sponsors modest pre-college education efforts aimed at enhancing K-12 marine science education within the state, and several Sea Grant Marine Extension Advisors play active roles within their local school districts. Sea Grant also collaborates with the UCLA Ocean Discovery Center (ODC) and the Boys' and Girls' Clubs of Santa Monica to provide experiential learning programs about the marine environment for urban youth.

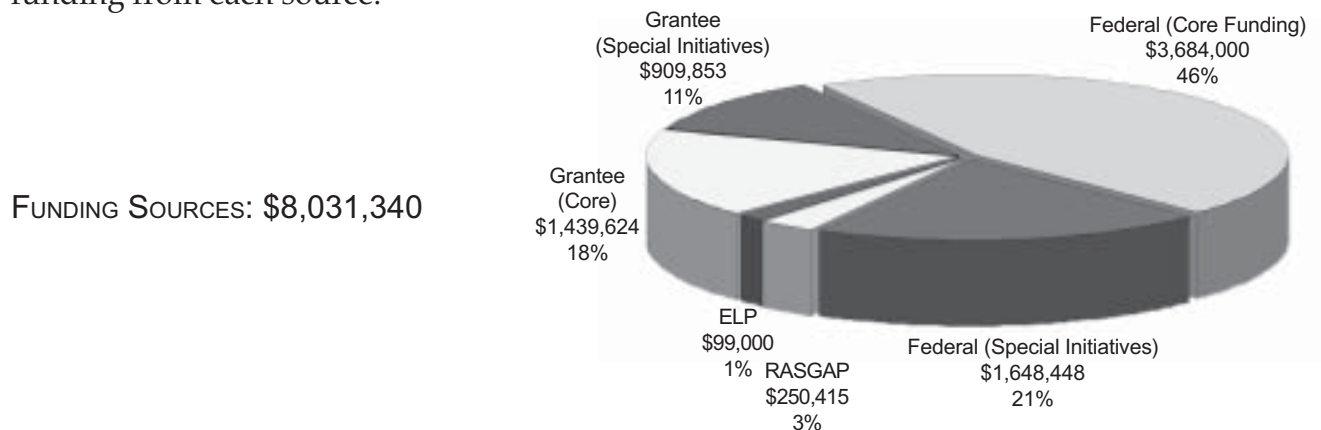
In addition, California Sea Grant has provided expertise and funding for the development of a marine science camp aimed at elementary and high school students. S.E.A.Lab Monterey Bay is an ocean science camp modeled after NASA's Space Camp. Its goal is to introduce students to the work environment and career opportunities of coastal and marine scientists and policymakers.

California Sea Grant is represented annually at the Educational High Technology Symposium or "Tech Fair" for high school students organized by Congressman Randy "Duke" Cunningham since 1996. The fair enhances students' appreciation of science and technology and provides insights about career opportunities.

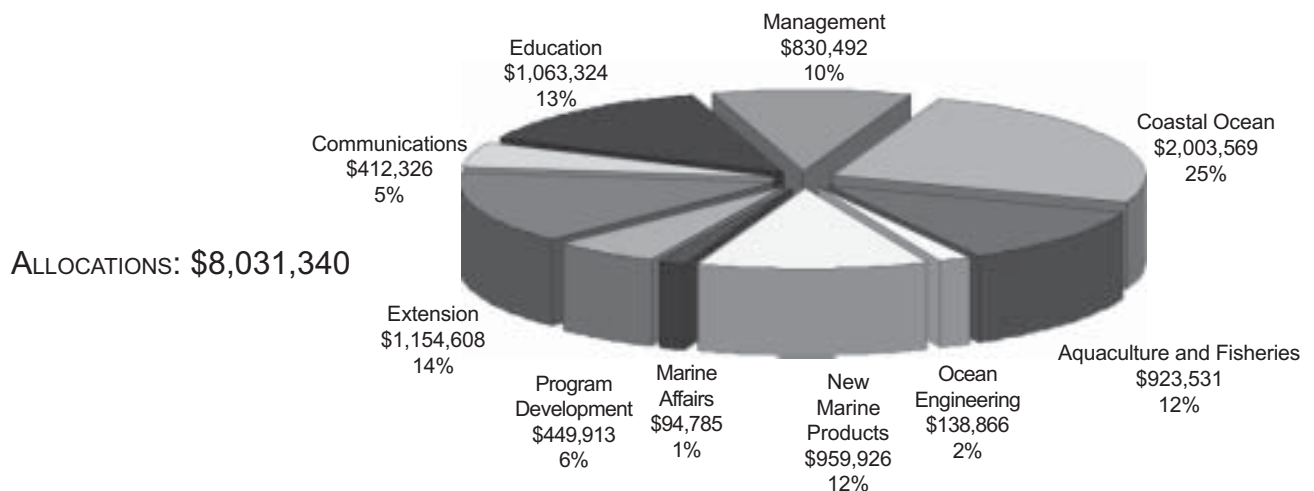
More information about California Sea Grant's education programs appears on the web site at <http://www-csgc.ucsd.edu> (follow the "Education" link).

SOURCES OF FUNDING 1999–2000

California Sea Grant receives the majority of its funding from the National Sea Grant College Program, part of the National Oceanic and Atmospheric Administration (NOAA) in the U.S. Department of Commerce. Core funding applies to projects selected by California Sea Grant for funding through the annual, competitive peer review process. Resources Agency Sea Grant Advisory Panel (RASGAP) funding is from the state of California's Resources Agency, which oversees state agencies that manage natural resources, such as the Department of Fish and Game. ELP is funding from the state of California's Environmental License Plate income that is allocated in support of the Sea Grant Extension Program. The special initiative category refers to separate competitive grant awards that are run by the National Sea Grant Office. The Grantee share refers to matching funds, generally in the form of a researcher's time, that is contributed by the home institution to the project. The following graph shows the relative proportions of funding from each source.



The graph below shows the relative percentage of funds allocated to different activities and subject areas of the program. These amounts change from year to year as a result of the competitive peer review process that is used in the evaluation of all proposals, and in concert with the priorities defined by CSG, the National Sea Grant College Program, and the RASGAP panel.



CALIFORNIA SEA GRANT DIRECTORY OF PROJECTS BY INSTITUTION 1999–2000**California Institute of Technology**

- R/CZ-146 Speciation of Metal Inputs to Coastal Waters: Consequences for Metal Transport and Bioavailability (J.G. Hering)
R/MP-75 Molecular Biology of Sea Urchin Skeletogenesis (E. Davidson, R.A. Cameron)

California State University, Fullerton

- W99-6PD Identifying the Invasion Potential of Aquarium Seaweeds in Changing Southern California Coastal Waters (S. Murray, P. Dayton, M. Tegner)

California State University, Long Beach

- R/CZ-151 Eradicating *Arundo donax* from California Ecosystems: Establishing the Most Effective Timing for Mechanical and Chemical Procedures (A. Wijte)

California State University, Monterey Bay

- R/E-36PD Strategic Planning for SeaCamp, Monterey Bay (R. Starr, S. Hansch)

Humboldt State University

- R/CZ-155 Ecosystem and Restoration Analysis of the Smith River Estuary, California, with Emphasis on Anadromous Salmonids (T.J. Mulligan, et al.)
R/F-35PD Size-Specific Molting Probabilities of Female Dungeness Crabs Following the 1997–1998 El Niño. (D. Hankin)

Midwestern University

- R/MP-83 Neuroinflammation, Microglia, and Marine Natural Products (A.M. Meyer)

Oregon State University

- R/AS-53PD Regional Library of Seafood Technology: A Proposal for Phase I Planning (E. Kolbe, J. Webster)

Pacific States Marine Fisheries Commission

- R/W-56PD "Sardine Symposium" (D. Hanson, M. Mullin)

San Diego State University

- R/CZ-136 A GIS-Based Monthly River Discharge Model for Coastal Watersheds in Southern California-Baja California (R.D. Wright, A.S. Hope)

San Jose State University/Moss Landing Marine Laboratories

- R/CZ-137 The Effects of Coastal Fog on Planktonic Production and Food Web Structure (N.A. Welschmeyer)
R/CZ-144 Domoic Acid Biosynthesis in Marine Diatoms: Biochemical Pathways and Environmental Regulation (G.J. Smith)
R/F-29PD The Status of Shark and Ray Fishery Resources in the Gulf of California (G. Cailliet)
W99-2PD 19th Annual Scientific Diving Symposium, Santa Cruz, CA (J. Heine)

Santa Monica Bay Restoration Project

- R/E-38PD "Water Friendly Boating" – a video (M. Yamaguchi, C. Katsumata)

Stanford University/Hopkins Marine Station

- R/CZ-143 Molecular Biomarkers for Detecting Pollution and Its Remediation (D. Epel)
R/MP-79 Molecular and Biochemical Characterization of Microbial Symbionts and Their Bioactivities in Sepiid and Loliginid Squids (D. Epel, M.R. Kaufman)
R/F-33PD Aerobic Capacity, Physiological Ecology and Migratory Movements of Captive and Wild Pacific Bluefin Tuna (B. Block)

University of California, Berkeley

- R/OE-35 The Feasibility of Large-Scale Floating Runways (W. Webster)
 R/OE-36 Wave Climate Risk Analysis: Seasonal Triple Annual Maximum Frequency Analyses, with Intensity-Duration-Frequency Summaries (R.J. Sobey)
 R/MA-40 The New Regionalization in International Fisheries Law and Management (H.N. Scheiber)
 R/W-41PD Conference on Law of the Sea and Implications for U.S. Ocean Policy – “A Year of the Ocean” (H.N. Scheiber)
 R/C-30PD Public Access to the California Coast: Measuring Effectiveness and Assisting in the Design of a Monitoring and Evaluation System (R. Twiss, J. Sorensen)

University of California, Davis

- R/CZ-154 Characterizing Vegetation-Hydrology Interactions for Tidal Marsh Restoration (T.C. Foin, et al.)
 R/A-106 Enhancing Spawning Performance of White Sturgeon (S.I. Doroshov, G.P. Moberg)
 R/A-108 Biotechnological Techniques to Improve Crustacean Aquaculture (M.J. Snyder, E.S. Chang)
 R/A-109 Preservation of Genetic Variation Within Aquacultural Stocks of the White Sturgeon (B.P. May)
 R/F-169 Bioeconomic Management Model of a Metapopulation: The Red Sea Urchin (L.W. Botsford, et al.)
 R/A-32PD Microencapsulation as a Potential Control Technique Against Sabellid Worms in Abalone Aquaculture (C. Friedman, P. Olin)
 R/F-42PD Assess *Carcinus maenas* Impacts on Cultured Shellfish in Tomales Bay and Monitoring Population Dynamics in Humboldt and Tomales Bays (S. McBride, P. Olin)
 R/F-43PD Examination of the Geographic Distribution of Rickettsiales-like Procarvates in Red Abalone in Central and Northern California (C. Friedman)
 R/W-42PD Interactive Approach Towards Long-term Cooperative Management of the Sea Urchin Fishery (C. Dewees)
 R/E-45PD Clean Boater Videotape (J. Cassell, D. Jensen)
 W98-5PD Zebra Mussel Conference (P. Olin)

University of California, Irvine

- R/C-46PD Detection of Human Viruses and Male-Specific Coliphages in Coastal Waters of Southern California (S. Jiang)

University of California, Los Angeles

- R/CZ-153 Quantitative PCR Assay for Marine Bacteria (C.F. Brunk)
 R/CZ-156 Integrated Modeling of the Southern California Coastal Ocean: Biogeochemistry and Particulate Dynamics (K.D. Stolzenbach, J.C. McWilliams)
 R/F-171 Trace Elemental Fingerprinting of Otoliths Using ICP-MS to Determine the Population Structure of Marine Fishes (G. Forrester)
 R/F-48PD Design Criteria for Larval Squid Investigations (W. Hamner)
 R/C-49PD Ongeim'l Tketau (Jellyfish Lake) Assessment and Monitoring Program (W. Hamner)

University of California, Los Angeles Marine Center

- R/E-51PD Urban Youth and the Ocean (S. Strand, P. Ahuja)
 R/E-52PD Urban Youth and the Ocean (A. Young)

University of California, San Diego

- R/A-107 Genetic Engineering to Create a Transformed Oyster Cell Line (J.C. Burns)

University of California/Scripps Institution of Oceanography

- R/CZ-138 Interdecadal Change in California Current Zooplankton – Retrospective Analyses by Optical Plankton Counter (M.M. Mullin)
 R/CZ-140 Faunal Recovery in Restored Wetlands (L.A. Levin, P.K. Dayton)
 R/CZ-141 Effect of Spore Abundance on Recruitment and Maintenance of Subtidal Kelp Populations (P.K. Dayton)
 R/CZ-150 Contrasting Effects of Ecosystem Alteration by Two Exotic Wetland Invertebrates (L.A. Levin)

- R/F-170 Recruitment Patterns in Red Sea Urchins: A Population Genetics Approach (R.S. Burton)
R/F-172 Real-Time Assessment of Pelagic Fish Eggs at Sea (D.M. Checkley, M.M. Trivedi)
R/MP-72 Addressing Cellular Processes Using Marine Natural Products (V. Malhotra, D. John Faulkner)
R/MP-77 Marine Natural Materials: Novel Biological Elastomers from Marine Organisms (R.E. Shadwick)
R/MP-80 Antiviral Drugs from Deep-Sea Marine Microorganisms (W.H. Fenical)
E/G-11PD Dissertation Fellowships on Marine Policy (S. Haggard, D. Carson)
E/G-12PD An Atlas of Oceanic Productivity (W.H. Berger)
R/C-47PD Historical Changes in Climate and Diatom Diversity Off California During the Last Century (C.B. Lange)
R/CZ-57PD Restoration of Coastal Wetlands: Colonization Enhancement and Evaluation of Trophic Function (L. Levin)

University of California/Stephen Birch Aquarium

- R/E-58PD An Educational Project to Encourage High School Students to Better Appreciate, Study and Manage Our Oceans (L. Winant, M. Glasgow)

University of California, Santa Barbara

- R/MP-69 Polyunsaturated Fatty Acid Oxidases in Marine Algae (A. Butler)
R/MP-76 Marine Enzymes and Siderophores: A Biochemical and Bioorganic Approach to Marine Pharmacology (A. Butler)
R/MP-81 Marine Inflammation Research Program 1. Pharmacological and Biochemical Studies of Inflammatory Processes (R.S. Jacobs)
R/MP-82 New High-Performance Composite Materials from Marine Biomineralization (D. Morse)
R/CZ-147 Containment of Sabellid Pests of California Abalone: Assessment of Habitats and Hosts at Risk of Infestation (A.M. Kuris)
R/CZ-148 Safety and Efficacy of Green Crab Biological Control (K.D. Lafferty)
R/E-54PD Translating Research Into K-12 Education: Genuine Research Experiences for Pre-College Students and Sharing With Classmates, Teachers and Families (M. Polne-Fuller)
R/F-59PD Potential Fecundity and Realized Reproductive Output in the Grass Rockfish, *Sebastes rastrelliger* (P. Collins)

University of California, Santa Cruz

- R/CZ-142 Direct *In Vivo* Measurements of Enzyme Reaction Rates in Red Abalone as Indices of Sublethal Toxic Effects (R. Tjeerdema)
R/CZ-145 Assessing Environmental Control of Domoic Acid Production by the Planktonic Diatom *Pseudo-nitzschia australis* in California Coastal Waters (D.L. Garrison, et al.)
R/MA-39 Socioeconomic Organization of the California Market Squid Fishery: Assessment for Optimal Resource Management (C. Pomeroy, M. FitzSimmons)
R/W-44PD Fourth U.S.-Japan Symposium on Bioorganic Chemistry, Santa Cruz, CA (P. Crews)

University of Cape Town, South Africa

- W99-7PD Fourth Annual Abalone Symposium (P. Cook)

University of Hawaii

- W98-3PD 9th Pacific Congress on Marine Science and Technology (PACON 2000) The Pacific Century (N. Saxena)
W99-1PD 1999 Marine Ornamentals Conference (C. Helsley)
R/C-50PD Design Criteria for Chill House Using Deep Ocean Water (C. Helsley, P. Helfrich)

University of Utah

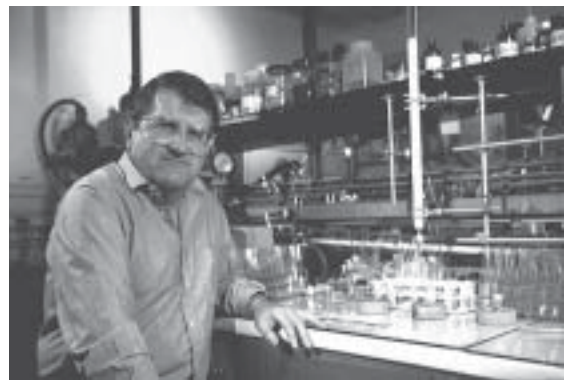
- R/MP-68 Technology for Discovery of Anticancer Drugs from Marine Sources (L.R. Barrows, C.M. Ireland)

University of Washington

- W99-8PD National Shellfisheries Association Meeting, Seattle, WA (K. Chew)

CALIFORNIA SEA GRANT COLLEGE PROGRAM HONORS AND AWARDS

- **Robert J. Price** and the National Seafood HACCP Alliance received the 1999 U.S. Secretary of Agriculture's Group Honor Award for Public Service for their efforts to improve seafood safety. Price is the California Sea Grant Extension Program Seafood Specialist, and works in the Department of Food Science and Technology at the University of California, Davis. He is a member of the National Seafood HACCP Alliance Steering Committee.
- **Seana Davidson**, a trainee with **Margo Haygood**, associate professor in the Marine Biology Research Division at Scripps Institution of Oceanography, received the Western Society of Naturalists Award for excellent student presentation.
- **Lisa Levin**, a Professor of Biological Oceanography in the Marine Life Research Group at Scripps Institution of Oceanography, was nominated for the PEW Conservation Fellowship. Sea Grant trainee **Drew Talley** received the Visiting Scientist's Award from the National Institute of Water and Atmospheric Research, New Zealand.
- **Greg Rau**, a researcher at the Institute of Marine Sciences, UC Santa Cruz, was nominated a Fellow of the American Association for the Advancement of Science.
- A California Geographic Information Association Award went to **Richard Wright**, a Professor of Geography at San Diego State University, for outstanding contributions to geographic education and partnerships.
- **D. John Faulkner**, a Professor of Marine Chemistry at Scripps Institution of Oceanography, received the Paul J. Scheuer Award in Marine Natural Products for Outstanding Contributions to the Field.
- California Sea Grant was awarded a certificate of appreciation from Congressman Randy "Duke" Cunningham in honor of outstanding commitment to the community, the education of youth, the promotion of science, and exceptional dedication in support of the Ninth Annual Education High Technology Symposium. The "Tech Fair" for high school students seeks to enhance students' appreciation of sciences and technology, while providing insights about career opportunities in these fields. It has been organized annually by Congressman Cunningham since 1996.



D. John Faulkner

CALIFORNIA SEA GRANT COMMITTEES 1999–2000**SEA GRANT ADVISORY BOARD**

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*Committee was renamed and reformed as the Marine Resources Committee in Fall, 1999 under the chairmanship of J. David Ptak.



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Please take a few moments to complete this survey. The information you provide will help us to better meet your needs.

What is your occupation?

- Scientist
- Legislator
- State or federal agency staff
- Marine industry
- News media
- Educator (K-12)
- Educator (College)
- Student _____
(grade)
- General Public
- Other _____

What issues are of greatest concern to you?

- Aquaculture
- Aquatic nuisance species
- Biodiversity
- Chemical and oil spills
- Coastal development
- Coastal engineering
- Conservation and marine reserves
- Fisheries management
- Global climate change
- Wetland restoration
- Marine biotechnology
- Marine education
- Salmon habitat restoration
- Seafood safety
- Sea-level rise
- Water quality and marine pollution
- Watershed management
- Endangered species
- Marine policy
- Other _____

How much of this California Sea Grant annual report did you read?

- All
- Most
- Some
- Little or none

About **how many people**, in addition to yourself, have read, or will read, this report?

- I'm the only reader
- 1 or 2 others
- 3-5 others
- More than 5

How would you rate the **content** of this report?

- Too technical
- Informative
- Too simple

How would you rate the **length** of the feature articles?

- About right
- Too short
- Too long

Has this report provided you with information that you find **interesting**?

- Very interesting
- Moderately interesting
- Not interesting

Has this report provided you with **information** that you can use?

- Very useful
- Moderately useful
- Not useful

Has this report helped you to better **understand** California Sea Grant?

- Very helpful
- Moderately helpful
- Not helpful

We welcome your comments.

Thank you for taking the time to complete this survey. This card is already stamped for your convenience.

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Cover: Polychaete worms, *Potamilla reniformis*, photographed in the Bahamas at a depth of 10 meters by Christine Salomon, MRD, SIO.

The "feathery" tentacles are gills used to filter nutrients and particles from the water.

p. 9 (lower right): D. Ayres; p. 11: Matt Newnham; pp. 11, 27 (sidebars): Sherry Ballard; p. 13: Eric Hanauer; p. 20: National Ocean Service; p. 29 (sidebar): Mary Hollinger, NODC, NOAA; p. 31: G. Hallegraeff; p. 36: California Department of Water Resources; p. 39: Illinois-Indiana Sea Grant; pp. 41, 42, 47: Paul Olin; p. 43: Wm. B. Dewey, p. 44, Leigh Taylor Johnson; p. 46: Norm Hughes; all others, CSG or researcher's archival photos.