CALIFORNIA SEA GRANT

PROGRAM DIRECTORY

2001–2002

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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.

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Message from the Director…

These are exciting times of change and opportunity for California Sea Grant. After a search this past year, I am pleased to become the next director of the program. My arrival in itself brings about a measure of change. In addition, many of the activities initiated by interim director Winant continue through the transition of my arrival. With change comes opportunity and this is a time of many opportunities for California Sea Grant.

The needs of the residents of California in the coastal marine environment are tremendous—clean water, safe aquaculture, healthy fisheries, and high-quality resources. These needs transcend the traditional boundaries of research and outreach and require a variety of skilled professionals to make a difference. California Sea Grant will strive to make a difference with the activities described in this program directory. This publication contains information on new and exciting research projects initiated throughout California, and also a renewed commitment to link that research to outreach.

One of the important distinctions of a Sea Grant program is the ability to function as an integrated whole embracing research and outreach. The changes begun a year ago have made a strong step in that direction for California Sea Grant. As the new director, I wish to raise this concept to new heights so that research, education, and outreach mutually benefit from one another as much as possible.

Changes abound for California Sea Grant and opportunities are everywhere. California Sea Grant wants you to know what we are doing to help improve the coastal marine environment. Likewise, we want you to tell us what we can do to achieve that same result. As we embark on the first steps of that new journey, I encourage you to join us. I look forward to an exciting future for the program.

Russell A. Moll
Director

Contents

California's Sea Grant Institutions

Since 1968, Sea Grant in California has supported a unique combination of marine research, education, and outreach activities at a number of California universities and marine laboratories. These institutions have included:

Bodega Marine Laboratory
California Institute of Technology
California Polytechnic University
California State University, Fresno
California State University, Fullerton
California State University, Hayward
California State University, Long Beach
California State University, Los Angeles
California State University, Monterey Bay
California State University, Northridge
California State University, San Marcos
Claremont College
Hopkins Marine Station
Humboldt State University
Moss Landing Marine Laboratories
Occidental College
San Diego State University
San Francisco State University
San Jose State University
Southern California Ocean Studies Consortium
Stanford University
University of California, Berkeley
University of California, Davis
University of California, Irvine
University of California, Los Angeles
University of California, Riverside
University of California, San Diego
University of California, San Francisco
University of California, Santa Barbara
University of California, Santa Cruz
University of San Diego
University of Southern California

What is Sea Grant?

The National Sea Grant College Program is dedicated to enhancing the understanding, conservation, and sustainable use of the nation's coastal and marine resources. It is a network of 30 university-based programs with facilities and staff in every coastal and Great Lakes state. Activities are funded principally by the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce, with matching funds from the individual states, and additional support from a variety of private sources.

Today, the Sea Grant programs are focused on making the United States a world leader in marine research and the sustainable development of marine and coastal resources. Sea Grant produces and makes available a wealth of information on marine and coastal topics, from school curriculum materials to the most advanced scientific research.

California Sea Grant College Program is the largest of the 30 Sea Grant programs and draws on the talents of scientists and engineers at public and private universities throughout the state. It is administered by the University of California and is based at Scripps Institution of Oceanography in San Diego.

Through the research it sponsors, the Program contributes to the growing body of knowledge about coastal and marine resources and helps solve contemporary marine-related problems. Through its Extension and Communications components, California Sea Grant transfers information and technology developed in its research efforts to industry, government and the public. The nine marine advisors and specialists form a direct link for two-way communication between the university, industry, and the public. California Sea Grant supports graduate education by funding trainees to work with marine scientists and engineers on a wide range of topics.

Projects are selected on the basis of competitive, peer-reviewed proposals and address a wide range of problems and opportunities. The following pages provide summaries of the new and continuing projects funded in 2001 by California Sea Grant. Further information on any of these projects is available by contacting the California Sea Grant offices or visiting the program website at http://www-csgc.ucsd.edu.

Participating Institutions and Researchers 2001–2002

BML **Bodega Marine Laboratory**
Bodega Bay, California 94923
Aquaculture Research
• R/A-114: R.P. Hedrick, K.D. Arkush
Environmental Marine Biotechnology
• R/CZ-169: P.A. Conrad, I.A. Gardner, M.A. Chechowitz, K.D. Arkush

CBMT **CalBio Marine Technologies**
Carlsbad, California 92009
Sea Grant Technology Program
• R/MP-86: B. Javor

CSULB **California State University**
Long Beach, California 90840
Aquatic Nuisance Species Research and Outreach
• R/CZ-163: A. Wijte

CSUMB **California State University, Monterey Bay**
Seaside, California 93933
Fisheries Habitat
• R/F-181: R. Kvitek

CSUSM **California State University, San Marcos**
San Marcos, California 92096
Sea Grant Technology Program
• R/MP-86: J. Trischman

HMS **Hopkins Marine Station**
Pacific Grove, California 93950
New Marine Products
• R/MP-89: D. Epel

HSU **Humboldt State University**
Arcata, California 95521
Fisheries Research
• R/F-187: D.G. Hankin, S.C. Hackett

MBARI **Monterey Bay Aquarium Research Institute**
Moss Landing, California 95039-9644
Fisheries Research
• R/F-185: C. Farwell

MLML **Moss Landing Marine Laboratories**
Moss Landing, California 95039
Fisheries Research
• R/F-182: G.M. Cailliet, K.H. Coale,
Fisheries Habitat
• R/F-181: H.G. Greene

NMFS **National Marine Fisheries Service**
Silver Spring, Maryland 20910
Coastal Ocean Research
• R/CZ-173: C. Currin

SDSU **San Diego State University**
San Diego, California 92182
Fisheries Research
• R/F-188: T. Anderson

SFSC **Southwest Fisheries Science Center**
La Jolla, California 92038
Marine Ecological Reserves Research Program
• R/M-2: R. Vetter

SIO **Scripps Institution of Oceanography**
University of California, San Diego
La Jolla, California 92093
Coastal Ocean Research
• R/CZ-177: P.K. Dayton, M.J. Tegner
• R/CZ-166: R.T. Guza
• R/CZ-172: C.B. Lange, A.L. Weinheimer
• R/CZ-164: J.L. Largier
• R/CZ-173: L.A. Levin

Fisheries Research
• R/F-178: R.S. Burton
• R/F-180: D.M. Checkley, M.M. Trivedi
New Marine Products
• R/MP-87: D.J. Faulkner
• R/MP-88: M. Haygood
• R/MP-91: R.E. Shadwick
• R/MP-93: S.W. Taylor

SJSU **San Jose State University**
San Jose, California 95192
Fisheries Research
• R/F-182: G.M. Cailliet, K.H. Coale
Aquatic Nuisance Species Research and Outreach
• R/CZ-161: J.B. Geller
Fisheries Habitat
• R/F-181: H.G. Greene

SU **Stanford University**
Palo Alto, California 94305
Fisheries Research
• R/F-185: B.A. Block
New Marine Products
• R/MP-89: D. Epel

TSRI **The Scripps Research Institute**
La Jolla, California 92037
New Marine Products
• R/MP-90: S.P. Mayfield, S.E. Franklin

UCB **University of California, Berkeley**
Berkeley, California 94720
Coastal Ocean Research
• R/CZ-170: M.T. Stacey, T.M. Powell
Aquaculture Research
• R/A-111: T.B. Hayes

UCD **University of California, Davis**
Davis, California 95616
Coastal Ocean Research
• R/CZ-176: D.R. Strong
Environmental Marine Biotechnology
• R/CZ-168: M.J. Snyder, G.N. Cherr, F. Griffin
Aquaculture Research
• R/A-111: E.S. Chang
• R/A-115: C.S. Friedman
• R/A-114: R.P. Hedrick, K.D. Arkush
• R/A-116: R.H. Piedrahita, D.E. Conklin
• R/A-117: R.A. Tjeerdema, C.S. Friedman, M.R. Viant
Fisheries Research
• R/F-187: C.M. Dewees
• R/F-177: R.K. Grosberg
• R/F-184: D. Hedgecock
• R/F-179: J.E. Wilen
Marine Affairs
• R/MA-41: J.E. Wilen, L.W. Botsford
Environmental Marine Biotechnology
• R/CZ-169: P.A. Conrad, I.A. Gardner, M.A. Chechowitz, K.D. Arkush

UCLA **University of California, Los Angeles**
Los Angeles, California 90095
Coastal Ocean Research
• R/CZ-171: K.D. Stolzenbach, J.C. McWilliams
• R/CZ-175: M.I. Venkatesan
New Marine Products
• R/MP-93: R.I. Lehrer

UCLA (continued)

Marine Biotechnology
• R/CZ-152: R.K. Zimmer
Sea Grant Technology Program
• R/CZ-167: C. Brunk

UCSB **University of California, Santa Barbara**
Santa Barbara, California 93106
Coastal Ocean Research
• R/CZ-174: J.E. Dugan, H.M. Page, A.M. Wenner
• R/CZ-178: M.S. Love, R.R. Warner, L. Washburn
Fisheries
• R/F-183: P.M. Collins
New Marine Products
• R/MP-92: D.E. Morse
• R/MP-91: H. Waite
Aquatic Nuisance Species Research and Outreach
• R/CZ-160: J.E. Dugan
• R/CZ-162: A.M. Kuris, J.H. Goddard
Sea Grant Technology Program
• R/MP-85: R.S. Jacobs

UCSC **University of California, Santa Cruz**
Santa Cruz, California 95064
Fisheries Research
• R/F-186: B.B. Marinovic, D.A. Croll
Education
• E/UG-6: J.S. Pearse, J.B. Heffington

UCSD **University of California, San Diego**
La Jolla, California 92093
Ocean Engineering
• R/OE-37: S.A. Ashford
Oyster Disease/Sea Grant Technology
• R/A-112, 113: J.C. Burns

UCSF **University of California, San Francisco**
San Francisco, California 94143
Environmental Marine Biotechnology
• R/CZ-168: H. Peeke

Coastal Ocean Research

- **Alongshore Coherence of Nearshore Temperature Variability**

  R/CZ-164
  J.L. Largier/UCSD, SIO

Temperature is an important determinant of habitat for marine organisms and spatio-temporal patterns of temperature reflect the same dispersion processes that act on plankton, nutrients, and other water-borne material. In this research, existing data will be collated and analyzed to resolve the patterns of temperature variability for the coastal waters off California. Special attention will be given to the spatial uniformity of changes in temperature at different time scales. Temperature links will also be examined to determine causes of variability and influences on ecosystems and communities. This study has relevance not only to the contemporary discussion of environmental change, but also to the management of marine resources.

- **Surfzone Drifters: A New Tool for Observing Nearshore Circulation**

  R/CZ-166
  R.T. Guza/UCSD, SIO

Coastal tourism is the largest economic component of ocean-related industries in California. However, many sandy California shorelines are eroding and pollution from land runoff and outfalls frequently results in beach closures. Despite the enormous economic and recreational value of beaches, models for their behavior are crude and the underlying relationships between waves, currents, and sediment response are poorly understood. Abruptly changing coastline orientation, irregular bathymetry (e.g., headlands and submarine canyons) and man-made structures are believed to cause particularly strong and complex surfzone circulation, but these flows are largely unstudied. This project proposes to develop and test drifters designed specifically to survive and function in breaking surfzone waves.

- **Observation of Physical Fluxes Between an Estuary and the Ocean**

  R/CZ-170
  M.T. Stacey, T.M. Powell/UCB

An estuarine ecosystem is strongly driven by two boundary conditions: freshwater from the river systems upstream, and fluxes from the open ocean. In San Francisco Bay the ecological role of the relationship between the coastal ocean with the Bay is largely unknown, but considered important. Achieving an understanding of the role the ocean plays in the estuarine ecosystem, and how that role varies seasonally and tidally is the goal of this project. The salinity of the estuary and the concentration of contaminants in the estuary are strongly linked to the level of exchange with the coastal ocean. Although some initial exploration into these processes has been undertaken, the researchers propose to examine in more detail how the exchange between the estuary and the ocean varies on the tidal, spring-neap, and the seasonal influences.

- **Modeling of Water and Sediment Quality in Impacted Coastal Embayments**

  R/CZ-171
  K.D. Stolzenbach, J.C. McWilliams/UCLA

Coastal waters receive a variety of materials related to human activities along the shoreline. These materials include sewage, industrial, and nonpoint sources from urban and agricultural watersheds. The effect of such influences is particularly concentrated in highly developed coastal embayments—characterized by irregular shorelines, relatively shallow water depths, and weak exchange of water with the open ocean. Input from humans can be relatively slow to disperse and consequently associated with increased plankton growth and accumulation of contaminants in deposited sediments. Although coastal embayments with this problem have often been studied, a need exists for models capable of forecasting water and sediment for use by environmental managers.

- **Exploring the 1990s: Investigation Into Factors Controlling Siliceous Microplankton Distribution in the Santa Barbara Channel**

  R/CZ-172
  C.B. Lange, A.L. Weinheimer/UCSD, SIO

Radiolarians and diatoms are siliceous microfauna and flora whose distribution is controlled by circulation and upwelling. As a result, they have proved valuable in monitoring seasonal marine variability and circulation. Unfortunately, their responses to subseasonal variations in circulation are not well understood—in part because of lack of datasets with sufficient temporal resolution. The researchers will be working with detailed oceanographic observations from buoys, drifters, and meteorological and pollution stations to evaluate surface circulation in the Santa Barbara Channel over a ten-year period. In addition, variations in radiolarian and diatom production will be determined from sediment trap samples. From these studies, they not only hope to improve understanding of biological responses to physical changes and nutrient supply within the channel, but to provide a model that can be applied in other coastal regions.

- **Recovery of Trophic Function in a Restored Pacific Coastal Wetland**

  R/CZ-173
  L.A. Levin, C. Currin/UCSD, SIO, NMFS

Loss of habitat in the coastal salt marsh is a widespread problem in Southern California and continues in the face of conservation efforts. Marsh restoration and creation have become standard mitigation measures to compensate for such losses in California and elsewhere, despite some uncertainty about their success. A major component of California salt marshes is trophic support (food web architecture, interaction strengths, and complexity) for shellfish, fish and birds, but this has received little attention in restored wetlands. There is general recognition that to be effective, marsh restoration must achieve recovery of key ecosystem functions (productivity, decomposition, food chain support) in addition to structural attributes—natural species abundance and composition. This research will employ natural abundance- and tracer-level stable isotopic analyses to focus on the factors that promote development of food webs in natural and created marshes, an understanding that is urgently needed for wetland management.

- **Ecological Impacts of Beach Grooming on Exposed Sandy Beaches**

  R/CZ-174
  J.E. Dugan, et al./UCSB

The researchers will identify and test hypotheses concerning the impacts of beach grooming on the structure and function of sandy beach ecosystems in Southern California. Grooming to remove macrophyte wrack and other debris is a widespread and institutionalized practice on heavily used beaches throughout the world. However, despite the prevalence and importance of beaches as coastal resources for both humans and wildlife, little information exists on the effects of this practice. Providing new information on the effects of grooming will give managers the tools needed to improve management and develop informed and ecologically sound policies for sandy beaches.

- **Fate and Transport of Planar and Mono-Ortho Polychlorinated Biphenyls and Polychlorinated Napthalenes in Southern California Sediments**

  R/CZ-175
  M.I. Venkatesan/UCLA

Coastal sediments in Southern California receive contributions of organic pollutants from a variety of sources such as sewage outfalls, storm runoff, dredge disposal, industrial wastes, etc. Historical studies of sedimentary chemistry have resulted in stringent laws as well as improved technologies that curtail waste disposal of toxic chemical contaminants into ocean waters. Polychlorinated biphenyls (PCBs) are industrial pollutants whose residues are found in many parts of the global ecosystem, including marine sediments. “Planar” or “non-ortho” PCB congeners are present in lower concentrations than other PCB congeners yet, they can account for a significant part of the toxicity in environmental samples. The researcher will investigate more comprehensively the historic distribution and fate of these toxic compounds in the Southern California Bight sediments to assess the contaminant status of the coastal ecosystem.

- **Dynamics and Ecosystem Threats of Bidirectional Cordgrass Hybridization in San Francisco Bay**

  R/CZ-176
  D.R. Strong/UCD

Hybrids between alien cordgrass, *Spartina alterniflora*, (introduced in the 1970s) and the native California cordgrass, *S. foliosa* are a menace to the ecology of San Francisco Bay. They are spreading widely and in aggressive fashion, invading open mud areas, displacing native species and threatening their extinction, hindering flood control, navigation, and other habitat uses. Determining the key ecological element of this hybrid invasion is the project goal and is important to a broad range of stakeholders. Proposed strategies to restore baylands are currently being undermined by these invasions of hybrid cordgrass.

- **The San Diego–La Jolla Ecological Reserve: Implications for the Design and Management of Marine Reserves**

  R/CZ-177
  P.K. Dayton, M.J. Tegner/UCSD, SIO

While marine reserves are popular in principle, the underlying mechanics involved in making them work are poorly understood. The researchers propose to use a small, well-protected intertidal and subtidal reserve (the San Diego–La Jolla Ecological Reserve) for their study, with the goal of defining the microhabitat components of sources, mortality, and survivability for key species in kelp forest communities. In addition, the advantages of protection and enhancement of populations in the reserve will be quantified, as there are little data of this kind in existence at the present time. This type of information is essential for resource managers in the selection and evaluation of reserves.

- **Linking Early Fish Growth and Transport to Circulation Using Otolith Microstructure and Microchemistry**

  R/CZ-178
  M.S. Love, R.R. Warner, L. Washburn/UCSB

Marine conservation and management decisions are often dependent on estimating the degree of connectivity among local and distant areas through larval dispersal. Unfortunately, this scale is unknown for coastal marine species with pelagic larvae. The project objectives are to determine if pelagic juvenile fish collected within an area originate from more than one larval source, and also to determine if upstream locations of larval sources can be identified. A multifaceted approach will be used to reconstruct larval transport pathways in relation to dynamic coastal circulation and mesoscale features such as fronts and eddies that limit dispersal. Of particular interest is the transport history of shortbelly rockfish collected at extraordinarily high densities in a persistent eddy observed in the Santa Barbara Channel during spring 1998. The study will incorporate analyses of the microchemistry and daily growth increment series of otoliths from these juveniles and larvae from upstream sources. Further analyses will be conducted of sea surface currents and other oceanographic data from remote-sensing coastal-based high frequency radar.

Aquaculture Research and Development

- **Collaborative Studies with the University of Hawaii: Studies Addressing the Growth-Stimulating Potential of Recombinant Bovine Growth Hormone in the Aquaculture of Tilapia and Shrimp**

  R/A-111
  E.S. Chang, T.B. Hayes/UCD, UCB

This proposal aims to determine whether recombinant bovine growth hormone (rbGH) can be used to stimulate the growth of important aquaculture species, tilapia (*Oreochromis mossambicus*) and shrimp (*Penaeus vannamei* and *Sicyonia ingentis)*, and if its effectiveness in promoting growth is influenced by the age of the animal or by environmental salinity. An examination of the influence of rbGH treatment on the ability of the tilapia to adapt to fresh water or salt water is planned, in addition to the development of practical methods and strategies for the delivery of rbGH in these animals. It is hoped that this will lead to a greater understanding of the regulation of growth and development in fish and crustaceans, thereby producing benefits of both a practical and fundamental value.

- **Control of Rickettsial Infections in White Seabass (*Atractoscion nobilis*)**

  R/A-114
  R.P. Hedrick, K.D. Arkush/UCD, BML

Rickettsial infections are emerging as key problems for hatchery-reared fish worldwide. Significant impacts on aquaculture of salmonids and, most recently, white seabass, point to the need to detect, prevent, or control these infections. The knowledge gained in this study should also be applicable to related rickettsial agents such as those found in salmon, tilapia and European seabass.

- **Tools for Management of Withering Syndrome in Abalone, *Haliotis* spp.: PCR Detection and Feed-Based Therapeutic Treatment**

  R/A-115
  C.S. Friedman/UCD

Withering syndrome in abalone is caused by a rickettsiales-like prokaryote (WS-RLP) and has become a key constraint to the viability and expansion of abalone aquaculture, and a threat to our natural marine resources. Management of the spread and impact of this disease requires tools for sensitive detection of the prokaryote in infected animals and for the production of healthy abalone. In addition, the development of a treatment for this disease is essential for the success of abalone aquaculturists located in WS-endemic areas. This strategy is vital not only for the promotion of the abalone aquaculture industry, but also for the protection of remaining stocks of wild black and red abalone.

- **Development of a Recirculation System and Diet for the Culture of California Halibut (*Paralichthys californicus*)**

  R/A-116
  R.H. Piedrahita, D.E. Conklin/UCD

The development of diets and culture techniques for California halibut, which is found along the Pacific Coast from Baja California to British Columbia, is the focus of this project. Development of culture techniques for this species would create new opportunities for the aquaculture industry and for restocking and research efforts on the West Coast, and especially in California. The aim of this project is to develop a recirculation system that takes into account the utilization of protein and other feedstuffs under various nutritional regimes for the California halibut. The information generated on the proposed recirculation system design and its operation will have application for culturing other commercially important marine species.

- **Characterizing the Role of Environmental Stressors in the Development of Withering Syndrome in Red Abalone**

  R/A-117
  R.A. Tjeerdema, et al./UCD

While withering syndrome (WS) has decimated black abalone populations throughout most of California, both wild and cultured red abalone have shown resilience under relatively optimal environmental conditions. Surprisingly, red abalone can harbor the causative bacteria without developing clinical signs of this syndrome. The changes in seawater temperature and food availability associated with El Niño events may, however, stimulate the pathogenesis of the disease in these infected animals. This study attempts to elucidate the role that these environmental stressors play in WS development, which could be a key factor for the proper management of the disease by both private aquaculturists and state resource managers.

Fisheries Research and Development

- **Molecular Genetic Analyses of Recruitment Patterns in the Dungeness Crab, *Cancer magister***

  R/F-177
  R.K. Grosberg/UCD

The Dungeness crab, *Cancer magister*, undergoes dramatic cycles that are synchronized in an area extending from the coastlines of central California through Washington state. While this widespread, synchronized population dynamic may indicate that it represents a single management unit, recent physical oceanographic studies suggest that the species is likely to be subdivided demographically. The data generated from this research project will provide an essential empirical foundation for identifying management units and for the development of sustainable harvest plans.

- **Patterns of Recruitment in Red Sea Urchins: A Population Genetics Approach**

  R/F-178
  R.S. Burton/UCSD, SIO

Over the past two decades, sea urchin fisheries have rapidly developed along the coasts of Northern and Southern California. Proper management of these valuable resources requires basic information

concerning patterns of recruitment that replenish harvested populations. The researcher will employ multiple micro-satellite markers to document spatial and temporal patterns of genetic differentiation in young urchins, and then use that information to infer patterns of recruitment and dispersal distances. This study will provide data of direct relevance to management decisions that could directly benefit all involved in California urchin fisheries.

- **Spatial Management of Fisheries**

  R/F-179
  J.E. Wilen, et al./UCD

Marine reserves and other spatial management policies have been some of the most frequently appearing topics in management literature, despite the fact that we have almost no information with which to judge their efficacy. Most research on spatial management measures employs simplifying assumptions about two key processes: larval transport, and harvester behavior over time and space. This project will develop an integrated model that embodies flexible assumptions about both processes, enabling the researchers to test some general propositions about how more realistic assumptions affect conclusions. In addition, the model will be calibrated to conditions that best describe California's red sea urchin fishery, and forecast the implications of various spatial management options.

- **Pelagic Fish Egg Abundance and Mortality Estimation by CUFES and Real-Time Machine Vision**

  R/F-180
  D.M. Checkley, M.M. Trivedi/UCSD, SIO

Pelagic eggs of fish are used to assess abundance and distribution of the spawning stock for management and research purposes. Small pelagic fish, including sardine, anchovy, mackerel, and menhaden, are economically and ecologically important to the U.S. and the world. The Continuous Underway Fish Egg Sampler (CUFES) is being used in the U.S. and elsewhere in the world for this purpose. Automation of egg counting in CUFES would be of direct use to resource managers and researchers in this country, and managers of anchovy and sardine stocks off the coasts of California and Spain have indicated their intent to use project results, when available. Additional applications may include assessment of other, aggregated, surface-dwelling plankters, and egg mortality data for fisheries scientists using the Daily Egg Production Method to estimate spawner biomass.

- **Radiometric Age Validation and Demographic Analysis of Commercially Important, Long-Lived Rockfishes**

  R/F-182
  G.M. Cailliet, K.H. Coale/SJSU, MLML

Rockfishes (*Sebastes* ssp.) support one of the most economically important fisheries in the Northeastern Pacific Ocean. For management strategies to play a significant role in sustaining these fisheries, they must rely heavily on information such as growth rates, age structure, and longevity. The researchers have established a radiochemistry laboratory at Moss Landing where a radiometric aging technique has been successfully applied to determine the age structure and longevity of several fish species. This study has produced validated age, growth and longevity estimates for the yelloweye (*S. ruberrimus*) rockfish using samples collected during an earlier project, and for two additional species: the blackgill (*S. melanostomus*) and canary (*S. pinniger*) rockfishes.

- **Assessment of the Reproductive Potential of Nearshore Rockfish and the Impact of Environmental Conditions**

  R/F-183
  P.M. Collins/UCSB

The objectives outlined in the state Marine Life Management Act of 1998 will be addressed in this project. The Keeley Bill recognized the need to regulate nearshore fisheries stocks while acknowledging that information on targeted species and their habitats was often incomplete. A series of longitudinal and cross-sectional studies of the ovaries will be conducted to establish the normal course of embryonic development in grass rockfish (*Sebastes rastrelliger*) and to identify and quantify periods of oocyte and embryonic attrition. By reference to this data, the effect of individual environmental factors (food availability, temperature variations, and pollutants) on reproductive output will be determined in grass rockfish and other species of nearshore rockfish. Agencies charged with the development of effective fisheries management plans will benefit from understanding the reproduction of live-bearing nearshore rockfish species.

- **Quantifying and Minimizing Risk That Hatchery-Enhancment Will Reduce Genetic Diversity of White Seabass**

  R/F-184
  D. Hedgecock/UCD

This research will document for the first time, the genetic risk of large-scale hatchery-enhancement of marine fisheries. Hatchery enhancement of highly fecund marine fishes may reduce genetic diversity of a fishery by swamping it with the offspring of a relatively small number of parents. In California, a large enhancement program for white seabass was started in 1994 under a memorandum of agreement between the California Department of Fish and Game, California Coastal Commission, Ocean Resources Enhancement and Hatchery Program (OREHP), and Southern California Edison. The genetic risk of this program is unknown but depends on the sizes of natural and hatchery stocks and on the proportion of wild fish that are of hatchery-origin. The main objectives of this research are to provide and to validate a predictive model for evaluating the impact of hatchery operations on the genetic diversity of natural populations and to identify practical hatchery protocols for monitoring genetic impacts and minimizing risks to biodiversity.

- **Migratory Movements of Pacific Bluefin Tuna Off California**

  R/F-185
  B.A. Block, C. Farwell/SU, MBARI

This research seeks to examine movements of Pacific bluefin tuna within the California exclusive economic zone (EEZ). The goal is to determine the migratory patterns, residency time, behavior, and environmental preferences of the species while in the Eastern Pacific. Over a period of two seasons, the researchers will generate fundamental knowledge of how bluefin tuna populations are structured temporally and spatially in relation to oceanographic conditions. Not only will this study increase their baseline of knowledge about this economically important tuna species, but the data received will provide a framework for future management of Pacific bluefin tuna in the EEZs of the United States and Mexico.

- **Assessing the Impacts of Climate Change on the California Squid Fishery: An Integrated Ecosystem Approach**

  R/F-186
  B.B. Marinovic, D.A. Croll/UCSC

Changes in coastal ecosystems resulting from global climate variations may be on the increase in the years ahead and the upwelling regions along the California coast are considered particularly sensitive to these changes. The project objectives will be to establish the nature and magnitude of the relationship between physical oceanographic and food web dynamics and to model the socioeconomic consequences of predicted climate changes. Market squid (*Loligo opalescens*), the most valuable single species commercial fishery in California, is an ideal selection for such a model as it matures, spawns, and dies in one year. Thus, it is thought that a strong link may exist between climatic variability and squid production.

- **California's Dungeness Crab: Conserving the Resource and Increasing the Net Economic Value of the Fishery**

  R/F-187
  D.G. Hankin, et al./HSU, UCD

In the Pacific Northwest (CA/OR/WA), the historical mainstays of the fishing industry have been the Pacific salmon, groundfish and Dungeness crab fisheries. However, recent cuts in allowable landings of salmon and groundfish have shifted fishing effort toward crab. Diminished fishing opportunities in salmon and groundfish in California will further increase fishing effort on Dungeness crabs, resulting in the fishing density that now characterizes the fishery and imposing increased pressure on stocks at deeper depths. Projected increased fishing effort will also likely create new biological conservation concerns for Dungeness crab populations, and diminish its net economic value. In this project, researchers will produce biological information critical for the management of this increasingly intense fishery, and they will develop and explore the potential performance of alternative management regimes that could increase its net economic value and safety.

- **Fisheries Habitat: Recruitment, Growth, and Survival of Coastal Fishes on an Experimental Artificial Reef**

  R/F-188
  T. Anderson/SDSU

Previous studies of artificial reefs and their contribution to fish production have been the target of criticism for various reasons. A unique large-scale experimental reef system deployed in Southern California waters addresses many of the concerns raised. Recruitment, growth, and survival of economically important and other nearshore fishes will be compared among replicated treatments of habitat structure.

New Marine Products Research and Development

- **The Biomedical Potential of California Marine Organisms**

  R/MP-87
  D.J. Faulkner/UCSD, SIO

The literature of marine natural products reveals that most studies of metabolites from California's marine organisms were performed during the 1970s. Few compounds were systematically evaluated for their biological or pharmacological activity, but rather for the novelty of the structures. Furthermore, the main focus of marine organism collections was on tropical environments, that provided greater biodiversity, than on California waters. This project plans to revisit California waters and to screen extracts of marine organisms found there in bioassays far superior to those used in earlier investigations. In addition, the researcher seeks to provide data that will help in the assessment of the potential value of California's marine invertebrates and algae.

- **Investigation of Anti-Cancer Compounds in the Marine Bryozoan, *Bugula pacifica***

  R/MP-88
  M. Haygood/UCSD, SIO

The marine bryozoan *Bugula pacifica* has never been investigated for bioactive metabolites. It is a close relative of *Bugula neritina*, the source of the bryostatins—a family of macrolides that are in clinical trials for treatment of cancer. Both *B. pacifica* and *B. neritina* have unusual bacterial symbionts. In previous

studies by this researcher, it was shown that the symbiont of *B. neritina* is the likely biosynthetic source of the bryostatins. The researcher hypothesizes that *B. pacifica* contains compounds related to, but distinct from, the bryostatins. This project will test this hypothesis through a combination of approaches: natural products chemistry, microbiology and molecular biology. The results may be new drug candidates and biosynthetic genes that can be used to develop an economical and environmentally sound method of production.

- **Environmental Effects on Anti-Microbial Activity of Bacterial Symbionts in the Reproductive System of Squid**

  R/MP-89
  D. Epel/SU, HMS

Fungal and bacterial infection is an increasing problem in medicine, aquaculture, and veterinary medicine and new pharmacological agents are needed. The complex bacterial symbiotic community in association with the squid egg case protects these embryos from infection by other bacteria and fungi during the month-long development of the squid on the ocean floor. This project provides new approaches to studying symbiotic bacteria and bacterial products. The principles learned from this research will be relevant for microbiologists and pharmaceutical companies interested in exploiting the novel synthetic capabilities of bacteria.

- **Expression of Recombinant Proteins in Microalgae**

  R/MP-90
  S.P. Mayfield, S.E. Franklin, TSRI

The production of heterologous proteins in terrestrial plants such as corn and soybeans has received considerable research attention in the past several years in response to the increasing demand for economical and valuable biopharmaceuticals. This technology offers the promise of making antiviral therapies available that were previously ignored because of their prohibitive production expense. Higher plant systems used to produce protein complexes even on a small scale have the added drawback of often requiring several years from the initial transformation event to their evaluation and production. The focus of this proposal is to explore a new system for recombinant protein expression using the eukaryotic green algae *Chlamydomonas reinhardtii*. The choice of *C. reinhardtii* is based upon its possession of a number of key criterion (fast growth rate, high cell densities, large scale culture, low contamination risk, etc.) in addition to being the focus of extensive molecular genetic analysis for the past twenty years.

- **Marine Natural Materials: Novel Biological Elastomers from Marine Invertebrates**

  R/MP-91
  R.E. Shadwick, H. Waite/UCSD, SIO, UCSB

The diverse marine life in coastal California offers great opportunity for discovery of such materials and new insights for their design based on biological models. By combining techniques of materials science and protein chemistry, the researchers propose the development of a program to characterize structural protein polymers-—principally elastomers—-that have unusual mechanical properties. A detailed molecular and mechanical description of novel biopolymers, comprising egg capsules of marine snails, will be the focus. The application potential of this project is mainly in areas related to human tissue engineering or construction of novel engineering materials. For example, the energy-absorbing and self-healing properties exhibited by egg capsule material are desirable features for medical implants such as the repair of ligaments and tendons. These studies may also help in the design of strategies for encapsulating pharmaceutical agents for use in targeted drug delivery, one of the most challenging problems in today's pharmaceutical industry.

- **New High-Performance Nanocomposite Materials from Marine Biomineralization: Biotechnological and Interdisciplinary Approach**

  R/MP-92
  D.E. Morse/UCSB

There is a wide and increasing range of applications for high-performance composites that may be used in advanced microelectronic, optical, and medical devices. To meet these needs, materials engineers are turning to "bio-ceramics" produced by marine organisms, as these offer a unique combination of strength, precise structural control, and biocompatibility, all of which are essential in such applications. New discoveries by the researcher, coupled with recent advances in biotechnology, sophisticated instrumentation, and the chemistry of self-assembling structures, now bring these high-performance

materials and their mechanisms of action within reach. This project will involve collaboration with industrial colleagues from three world-renowned biotechnology and chemical manufacturing corporations in the development of commercially valuable silicon-based products.

- **Novel, Post-Translationally Modified Peptide Antibiotics from Solitary Tunicates ("Sea Squirts")**

  R/MP-93
  R.I. Lehrer, S.W. Taylor/UCLA, UCSD, SIO

Resistance to antibiotics is an ever-increasing problem, in part resulting from their overuse in animal husbandry and medical practice. Alternative strategies to fight infection are a high priority. The innate immune systems of invertebrates have recently been shown to contain various molecules with antibiotic properties, including gene-encoded antimicrobial peptides. This research will center on sea squirts—simple marine invertebrates that are believed to be ancestral to vertebrates. Three species of tunicates (*Styela clava*, *Styela plicata*, and *Ciona intestinalis*) that occur in abundance at San Diego's docks and marinas will be studied. Not only do these tunicates possess potentially useful antimicrobial peptides, they have novel metabolic pathways that modify the structures of these peptides to enhance their potency.

Ocean Engineering and Instrumentation

- **Mitigation of Coastal Bluff Instability in San Diego County, California**

  R/OE-37
  S.A. Ashford/UCSD

There is a long history of bluff failures causing death and property damage in San Diego County. Moreover, there is currently no information source in San Diego County that local residents, city officials, or the California Coastal Commission can use to evaluate the effectiveness of bluff stabilization alternatives. To address the need for critical evaluation of bluff stabilization measures, this study will develop recommendations for mitigating the hazard of coastal bluff instability and for the evaluation of bluff stabilization alternatives in San Diego County. The researcher will first develop a detailed inventory of current mitigation approaches, including use of seawalls, rock anchors, and dewatering and then conduct finite difference analyses to determine

the effects of each of these measures on bluff stability. The evaluations of bluff stabilization alter-natives will provide clear and up-to-date information for local and state government agencies faced with regulating land use in the vicinity of these slopes, in both beach access below and residential and commercial use above. Though the study will concentrate on San Diego County, the results will be applicable to similar bluffs found along the Pacific Coast.

Marine Affairs

- **Building Marine Policy Analysis Capabilities in California**

  R/MA-41
  J.E. Wilen, L.W. Botsford/UCD

New legislation adopted under California's Marine Life Management Act signals a strong commitment to scientifically-based management policies. In order to forecast and understand the implications of manage-ment options, it will be important to add modeling, stock assessment, and the capability of policy analysis to agencies responsible for marine management. This proposal contains a short-term plan to bridge the gaps in expertise, combined with a longer-term training program designed to enhance the ranks of marine policy analysts and stock assessment modelers. Management agencies, the fishing industry, general public, and other direct-user stakeholder groups will all benefit from enhanced capacity to analyze marine policy decisions.

Rapid Response

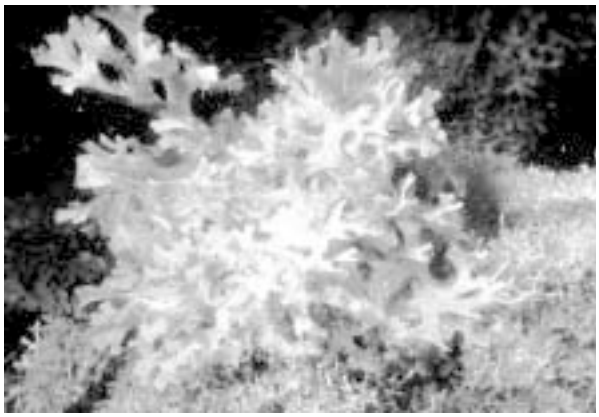
- **Rapid Response**

  R.A. Moll/UC-SG

Because conditions in the marine sphere can change rapidly as a result of both human and natural causes, problems that need immediate attention can arise unexpectedly. The rapid response project allows prompt support for short-term marine-related research projects as needs arise.

Special Competitions

Marine Biotechnology



- **Identification of Natural and Synthetic Peptides for Controlling Marine Larval Set**

  R/CZ-152
  R.K. Zimmer/UCLA

Chemical cues, or inducers, in the marine environment are known to trigger settlement and metamorphosis of marine molluscs, including the larvae of abalones and oysters. This scientist seeks to develop new methods for designing inducer compounds. Specifically, he will identify natural compounds that control these processes and develop mathematical models for predicting the structure of synthetic compounds. Laboratory and field tests will then be used to identify the most potent natural or synthetic analogs for enhancing animal production. He will also seek to identify the inducers for barnacle larvae, as a critical step towards control.

- **Environmental Marine Biotechnology: Development of Molecular and Cellular Tools for the Detection of Environmental Endocrine Disruption in Aquatic Invertebrates**

  R/CZ-168
  M.J. Snyder, et al./UCD, UCSF

A number of xenobiotics are known to have direct or indirect effects on the endocrine systems of higher organisms. Toxicants of this type have been termed environmental endocrine disruptors (EDs). Some of the most widely studied examples of ED effects in wildlife are cases of sexual malformities in reptiles, reproductive abnormalities in birds, and production of female yolk protein in male fishes. Though much is known about effects of ED in fish and amphibians, there are few examples for invertebrates. The most widely cited reports are those of masculinization (imposex) and other sex organ abnormalities in mollusks, but little information exists concerning ED-like phenomena in the aquatic and marine environments. The results of this work, to be conducted in collaboration with the U.S. Environmental Protection Agency and the California Department of Fish and Game, will be of substantial interest to environmental decisionmakers and scientists working on aquatic invertebrates. Research findings will be freely shared with members of these policy and enforcement agencies.

- **Environmental Marine Biotechnology: Molecular and Bioassay-based Investigation of Bivalves as Transmission Vectors of Protozoal Encephalitis in Southern Sea Otters**

  R/CZ-169
  P.A. Conrad, et al./UCD, BML

Emerging infectious diseases, sometimes called “pathogen pollution,” are some of the major causes of species extinction, along with habitat loss, and alien species invasions. Protozoal encephalitis, thought to play a role in illness and mortality rises in southern sea otters, may be symptomatic of a larger environmental problem—one that may be revealed through identification of risk factors for infection. This research seeks to provide new tools (molecular and serodiagnostic tests) for studying the ecology of *Toxoplasma gondii*—a ubiquitous protozoal parasite—in the coastal marine ecosystem. The goal is to provide information on geographic and demographic risk factors for use by wildlife biologists involved in the management of southern sea otters, as well as by veterinarians caring for otters in captivity.

Aquatic Nuisance Species

- **Aquatic Nuisance Species Research and Outreach: Evaluating the Health Risk Posed by the Invasive Chinese Mitten Crab**

  R/CZ-160
  J.E Dugan/UCSB

The San Francisco Bay and associated watershed has been extensively invaded by the nonindigenous Chinese mitten crab. Numerous governmental agencies, including the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and the California Department of Water Resources, are responsible for managing this area. They are currently attempting to determine the necessity for control of the mitten crab, and appropriate management strategies. However, resource managers lack certain information needed to make these decisions. The determination of human health risks posed by the possible presence of infectious lung flukes in the mitten crab population is of critical importance, as it will influence not only the need to implement control, but which strategies to employ. The project results will allow these agencies to make informed decisions, and to determine what risks might be involved in commercial and sportfishing of mitten crabs.

- **Aquatic Nuisance Species Research and Outreach: Post-Invasion Genetic Structure of European Green Crab Populations on the U.S. West Coast and Its Implications for Their Control**

  R/CZ-161
  J.B. Geller/SJSU

Marine invasions are occurring at an accelerating pace, and result in ecosystem disruption, collapse of fisheries, and damage to other economic activities. The European green crab, *Carcinus maenas*, is an important marine pest in the U.S. and other countries. The present range of this voracious predator stretches approximately 800 miles from Morro Bay, California, to Willapa Bay, Washington, making implementation of a coordinated control program a difficult task. While San Francisco Bay was invaded in 1989, Morro and Willapa Bays were not colonized until 1998 and 1999, respectively. The researcher will test the hypothesis of population differentiation to support the feasibility of control by a process of progressive removal.

- **Aquatic Nuisance Species Research and Outreach: Biological Control of Invasive Green Crabs: A New, Rapid and Reliable Safety Test of a Proposed Control Agent**

  R/CZ-162
  A.M. Kuris, J.H. Goddard/UCSB

The green crab, *Carcinus maenas*, is a rapidly spreading marine pest along the Pacific Coast of the North American continent and other regions of the world. Biological control has been proposed to reduce populations and minimize the impact of *C. maenas*. However, because many native crabs, having both ecological and economic importance, share the same habitat as this nonindigenous species, it is necessary to conduct carefully controlled host specificity tests to determine the safety of possible biological control agents. The researchers propose to inject potential host crabs with *Sacculina carcini* larvae that have initiated formation of the infective stage. A further goal is to provide a set of guidelines for assessing the safety of biocontrol agents for introduced marine pests in general.

- **Aquatic Nuisance Species Research and Outreach: Combating *Arundo donax* and Other Rhizomatous, Aquatic and Estuarine Nuisance Grasses by Exploiting Their Ecophysiological Characteristics**

  R/CZ-163
  A. Wijte/CSULB

Nonindigenous species in North American ecosystems are changing native species composition and diversity. Aquatic and estuarine habitats are particularly susceptible to these invasions because the water that defines them adds logistical obstacles to large-scale eradication efforts, and it plays an important role in transport and propagation success of invading species. Expansions of three nonindigenous rhizomatous grasses, *Spartina alterniflora*, *Arundo donax*, and *Phragmites australis* have occurred in waters off both Eastern and Western Coasts of the U.S. The researcher seeks to establish an alternative to the existing mechanical and chemical eradication methods presently employed, and to improve the timing of herbicide treatments by linking them to the physiology of the plants.

Oyster Disease

- **National Oyster Research Program: Toward the Genetic Engineering of Disease Resistance in Oysters**
  R/A-112
  J.C. Burns, C. Friedman/UCSD, UCD

Cultivation of the oyster, *Crassostrea virginica,* was once a flourishing industry in bays along the Eastern seaboard, but the fishery has been decimated by protozoal infections. This proposal offers an innovative solution through introduction of foreign genes that will protect hatchery-raised oysters against these infections. Establishing that expression of a heterologous antimicrobial peptide in oyster cells can be used to protect against infection with *Perkinsus marinus* may lead to a patentable invention that could be of economic benefit to U.S. aquaculture companies.

Sea Grant Technology

- **Sea Grant Technology Program: Genetic Engineering of a Shrimp Cell Line with Pantropic Retroviral Vectors**
  R/A-113
  J.C. Burns, K. Klimpel/UCSD, Supershrimp Group

Viral diseases currently threaten the sustainability and economic success of the shrimp aquaculture industry worldwide, and potential future introductions of exotic viruses from Asia (e.g., white spot and yellow head) could have a catastrophic effect on the shrimp fishery. Development of transgenic technology for shrimp and the creation of a shrimp cell line are critical to the growth of shrimp aquaculture. An important component of research on shrimp viruses includes the development of diagnostics and research into control strategies. However, testing these strategies without a shrimp cell line is time-consuming, expensive, and cumbersome. While this project focuses on the infectious-disease aspects of shrimp aquaculture, future applications proposed by the researchers may need to be broadened to include introduction of growth-accelerating genes (e.g., growth hormone) and enzymes that will allow utilization of nonfish proteins and lipids.

- **Sea Grant Technology Program: Pharmacological Adaptation of Protoctista as Novel Models to Study Inflammation**
  R/MP-85
  R.S. Jacobs/UCSB

There is a great need to understand the phylogenetic relationships between the genesis of pain and inflammation in vertebrates and their ancestral counterparts in nature. Evidence would suggest that the biochemical processes are conserved in unicellular eukaryotes and the composite function of these processes appears to have undergone adaptation and specialization with evolution. The researcher will investigate these microorganisms in three species of protoctists, with the goal of stimulating new pharmaceutical development in the field of pain and inflammation. He further seeks to gain knowledge of the basic function of natural products in order to characterize their primary mechanisms of action.

- **Sea Grant Technology Program: Antiviral Drugs from Marine Bacteria**
  R/MP-86
  B. Javor, J. Trischman/CBMT, CSUSM

Currently, there are less than 20 FDA-approved antiviral drugs in the U.S. and those drugs are only effective against some viral infections. This project aims to discover new antiviral drugs in secondary metabolites of marine bacteria by novel induction techniques under unique culture conditions. This proposed induction approach is innovative and is based on the largely unknown metabolic potential of the marine bacterial resource.

- **Sea Grant Technology Program: PCR Quantitative Assay for Marine Bacteria**

  R/CZ-167
  C. Brunk/UCLA

Monitoring of bacterial pollution currently relies on culture plate assays. These assays are restricted to bacteria that can only be readily grown under laboratory conditions and therefore cannot always provide an accurate measurement of samples from other environmental pollution sources. However, with the use of quantitative polymerase chain reaction (QPCR) assays, bacteria from specific pollution sources can be measured. The researcher will seek to determine which of two different QPCR techniques is most appropriate for detecting bacterial pollution in coastal marine waters. A major objective of this project is to establish a protocol allowing for QPCR analysis of specific bacteria that can be performed under general monitoring conditions as well as in the research laboratory.

Fisheries Habitat

- **Fisheries Habitat: Characterization of the California Continental Margin: Identification, Quantification and Synthesis of Existing Information**

  R/F-181
  H.G. Greene, R. Kvitek/SJSU, MLML, CSUMB

The researchers will identify, catalogue, digitize, reinterpret, and archive existing geophysical data for the purpose of providing critical fish habitat classification maps of the California continental margin. This work will include side-scan sonar mosaics, subbottom seismic profiles, and depth measurements from industry sources not previously available to the general scientific community. Focus will be on priority areas of fish habitat selected at the strategic planning meeting of the California Marine Habitat Task Force in January 2000. Compiled datasets of these areas will be processed into marine habitat GIS themes. In areas where information from industry is lacking, the researchers will use the state-of-the-art seafloor mapping facility at California State University, Monterey Bay to acquire and process new data over the period of the project.

Marine Ecological Reserves Research Program

- **Egg and Larval Production from Marine Ecological Reserves**

  R/M-2
  R. Vetter, et al./SFSC

This study will assess the effectiveness of the Vandenberg and Big Sycamore Canyon reserves as sources of fish eggs and larvae that will disperse to adjacent areas. Researchers will map habitat types and measure general and fine-scale current flows that influence egg and larval dispersal. Surveys of resident adult and juvenile fish will also be conducted.

Education

- **Sea Grant Trainees**
  E/G-2
  R.A. Moll/UC-SG

Sea Grant's commitment to furthering marine-oriented education is met by the Sea Grant trainee project. Graduate students participate in research and work on problems relating to marine resources while fulfilling thesis requirements. This experience prepares them to enter positions in academia, government, and industry.

- **California Sea Grant State Fellowship Program**
  E/G-9
  R.A. Moll/UC-SG

The State Fellowship Program, modeled after the Dean John A. Knauss Marine Policy Fellowship, provides graduate students with training in the development and implementation of policy. Interns are assigned to a state agency, legislative committee, or office concerned with marine resource issues.

- **John D. Isaacs Memorial Sea Grant Scholarship**
  E/UG-4
  R.A. Moll/UC-SG

The John D. Isaacs Memorial Sea Grant Scholarship was established in 1981 to recognize excellence in research by high school seniors, to encourage interest in marine science at the high school level, and to encourage pursuit of scholastic excellence in higher education. Each year a California high school senior who presents an outstanding marine science project at the California State Science Fair receives a scholarship to study at a college or university in California.

- **Assessing Sanctuary Shorelines: A Role for Volunteers, Particularly High School Students, in Resource Management**
  E/UG-6
  J.S. Pearse, J.B. Heffington/UCSC

This project addresses two increasingly recognized problems. While marine biota undergo changes in response to environmental conditions, monitoring programs to document these actions are poorly developed. In addition, long-term programs are particularly difficult to establish and maintain. The researcher plans a practical ongoing procedure for quantifying the abundance of selected marine species in the Monterey Bay National Marine Sanctuary with the help of high school students and local volunteers. In order to gain an appreciation of the natural world and how it works, the general public needs more exposure to real-life experiences with nature, including the marine environment. The goal is to engage residents in rich and diverse marine habitats, thereby providing them with the hands-on experience of gathering and interpreting data on its biota.

Management

- **Management**

  M/A-1
  R.A. Moll/UC-SG

The California Sea Grant management project develops and coordinates research, education, and outreach activities. Effective management allows continued development of the California Sea Grant program, ensures fiscal control and efficient program administration, encourages the development of cooperative activities and scientific workshops, and permits liaison with local, state, and national agencies, industries, and the National Sea Grant College Program.

- **Planning and Development**

  M/P-1
  R.A. Moll/UC-SG

California Sea Grant sponsors marine science projects that have local, national, and international impact. Through these projects, Sea Grant is able to meet the changing needs of user groups through responsive planning and development. The planning and development project provides staff support for advisory committees, supports educational programs, promotes the wise use and conservation of coastal and marine resources, and assists government regulatory agencies and industry in applying research results.

Outreach

- **Communications Program**

  A/P-1
  R.A. Moll/UC-SG

Disseminating research results and information on marine resources is the task of Sea Grant's communications and publications program. Audiences include scientists, technical researchers, academicians, legislators, user groups, industry, and the general public.

- **Sea Grant Extension Program**

  A/EA-1
  C. Dewees/UC-CE

One of Sea Grant's major objectives is to provide marine-related information to the people of California, particularly those who depend on oceanic and coastal resources for their livelihoods and those who use the ocean for recreational purposes. Through the Sea Grant Extension Program, citizens learn the latest scientific information on the management, utilization, and conservation of the state's marine resources.

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