ANNUAL REPORT

MARINE SCIENCE INSTITUTE | UC SANTA BARBARA

2014-2015

msi

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Director's Statement

Director's Statement

On January 28, 1969 an oil rig blow-out in the Santa Barbara Channel spilled an estimated 3.4 to 4.2 million gallons of crude oil over a ten-day period. Established in 1969, UCSB's Marine Science Institute is committed to fostering innovative and significant research, to promoting effective stewardship, and to sharing the exciting discoveries of the world's oceans.

On May 19, 2015 the Refugio Oil Spill deposited 142,800 U.S. gallons of crude oil onto one of the most biologically diverse coastlines of the west coast.

Scientists from multiple disciplines at UCSB and elsewhere began collaborating immediately after the spill. Based on lessons learned from studies of earlier spills, and using refined computer models, they predicted the spill spread and dispersion, including impacts on Los Angeles area beaches. They used his information to provide guidance to cleanup agencies and to monitor the effects on the ecosystem

Researchers from the University of California, Santa Barbara, many of them from the Marine Science Institute, began collecting samples within hours of the spill to monitor the impact on the marine environment. Researchers and volunteers returned to the area many times to collect additional samples. Since students and researchers had previously used this area for study purposes, baseline data was available.

David Valentine, a professor in the University's Department of Earth Science and a MSI researcher said, "The discharge of heavy oil at Refugio presents a unique opportunity to discover novel metabolic, genomic and ecological feedbacks among marine microbial communities, heavy oil and ecosystem response. We have the opportunity to study ecosystem changes and microbial reactions from the very early stages through an entire year. It's really rare for scientists to get day zero access to any sort of event like this."

This is just one of many examples of how MSI fosters innovative and significant research, and how that research impacts lives and communities around us. I invite you to read more about the research MSI supports in the annual report that follows.

Sincerely,

Mark Brzezinski, Director
Marine Science Institute

Organizational Charts

MARINE SCIENCE INSTITUTE
2014–2015 ORGANIZATIONAL CHART

Mark Brzezinski
Director

Dan Reed
Deputy Director

Tim Schmidt
Administration Manager

Jim Woods
Systems/Network Administrator

Brian Emery
Server Support

Monica Pessino
Ocean o' Graphics Creative Director

Ryan Vizena
Web Developer

Bonnie Williamson
C & G Admin Manager

Lynne Van Der Kamp
C & G Officer

Deanna Cervantes
C & G Analyst

Joyce Wolever
Personnel Unit Manager

Nicole Zavala
Personnel Analyst

Marisol Hernández
Personnel Analyst

Veronica Perez
Personnel Analyst

Lyndi Swanson
Personnel Analyst

Melia Cutcher
Purchasing Analyst

Casey Morse
Purchasing Analyst

Luisa Velez
Budget Unit Manager

India Morgan
Budget Analyst

Laura Susin
Budget Analyst

Jenny Chu
Budget Analyst

Donna Dobis
Travel Coordinator

MARINE SCIENCE INSTITUTE
2014–2015 ORGANIZATIONAL CHART

Mark Brzezinski
Director

Dan Reed
Deputy Director

Coastal Reseach Center
Russell Schmitt
Director
- Faculty/ Professional Researchers
- Specialists
- Postdoctorals
- Technical Staff
- Graduate Students
- Undergraduate Students

Marine Biotechnology Center
Daniel Morse
Director
- Faculty/ Professional Researchers
- Specialists
- Postdoctorals
- Technical Staff
- Graduate Students
- Undergraduate Students

Ocean & Coastal Policy Center
TBN
Deputy Director
- Faculty/ Professional Researchers

Analytical Laboratory
Georges L. Paradis
Manager
- **William Clinton** Staff Research Assoc.
- Student Assistant

Marine Science Education & Outreach
TBN
- **Scott Simon** REEF Manager
- Student Docents

Other Projects & Activities

Seminars, Workshops, Conferences, and Meetings
July 1, 2014-June 30, 2015

The Marine Science Institute continues to support various seminars, workshops, conferences and meetings. During the 2014-2015 fiscal year 36 events took place, in which a wide range of marine science topics were highlighted.

Dates	Coordinators	Topic
July 1, 2014	Chris Costello	Ground Fish Meeting
July 3, 2014	Carol Blanchette, Scott Simon	Carbon Teaching Experiment. Teacher Development Workshop
July 10, 2014	Andrew Brooks	MCR-LTER UNOLS Cruise Working Group
July 17-20, 2014	Carol Blanchette, Scott Simon	Teaching Environmental Science in a Changing Climate
July 18-25, 2014	Sarah Lester, Michaela Clemence	Fish Forever Strategy and Planning
July 29, 2014	Nate Emery	Meta-Analysis Workshop
July 31, 2014	Dan Reed, Mark Page	SONGS Science Advisory Panel Meeting
August 1, 2014	Robert Miller	REU Poster Session
August 5, 2014	Tim Schmidt	OCTOS Advisory Committee
August 21, 2014	Stephen Proulx	Guest Seminar by Bjorn Ostman
August 22, 2014	Sally Holbrook & Dan Reed, Advisors	Daniel Okamoto, Ph.D. Seminar The role of fluctuating food supply on recruitment, survival and population dynamics in the sea
October 1, 2014	Stephen Proulx	Faculty Symposium
October 1, 2014	Monique Myers	Santa Barbara Area Coastal Ecosystem Vulnerability workshop
October 12-15, 2014	Jennifer Caselle, Carol Blanchette	South Coast Baseline MLPA Workshop
October 16, 2014	Laura Francis, Gay Larsen	Channel Islands National Marine Sanctuary
October 20-24, 2014	Paul Berkman, Oran Young	Arctic Options Working Group
October 23, 2014	Andrew Brooks	MCR-LTER UNOLS Cruise Working Group
October 24, 2014	Shannon Harrer	SBC-LTER Intern Training
November 3, 2014	Gay Larsen	OCTOS Community Outreach Program, Bob Ballard guest

* Non-UCSB personnel

December 10, 2014	Cheryl Briggs, Advisor	Andrea Jani, Ph.D. Seminar Microbial ecology of an infectious disease: Do symbiotic bacteria protect an endangered frog from the fungal pathogen *Batrachochytrium dendrobatidis?*
December 11-12, 2014	Russell Schmitt, Sally Holbrook	MCR-LTER All Investigators Meeting
December 19, 2014	Sally Holbrook, Advisor	Gabriel Rodriguez, Ph.D. Seminar Turnover dynamics of the giant kelp, *Macrocystis pyrifera*
January 14, 2015	Susan Mazer	Training Workshop for California Native Plant Society Members, California Phenology Project & Citizen Science
January 16, 2015	Cheryl Briggs, Advisor	Thomas Smith, Ph.D. Seminar, Ecological impacts of amphibian declines on Sierra Nevada lake communities
February 5-6, 2015	Margaret O'Brien	LTER Network Information Management Executive Committee
February 6, 2015	Armand Kuris, Advisor	Julio Lordo , Ph.D. Seminar, The distribution and abundance of the California horn snail at different spatial scales
February 16-20, 2015	Will McClintock, Grace Goldberg	Marine Spatial Planning Advancement Training
March 23-27, 2015	Barbara Walker	Towards Resilience and Sustainable Seafood Supply Project Meeting
March 26, 2015	Dan Reed, Mark Page, Steve Schroeter	SONGS Science Advisory Panel Meeting
April 9, 2015	Susan Mazer	Training Workshop for Joshua Tree National Park Staff, California Phenology Project & Citizen Science
April 13, 2015	Dan Reed, Mark Page, Steve Schroeter	SONGS Science Advisory Panel
May 11, 2015	Mark Page, Steve Schroeter	SONGS Wetland Workshop
May 16, 2015	Susan Mazer	Training Workshop for Santa Monica Mountains National Recreation Area, California Phenology Project & Citizen Science

* Non-UCSB personnel

June 15, 2015	Susan Mazer	Training Workshop for Sequoia and Kings Canyon National Park staff, California Phenology Project & Citizen Science
June 20-24, 2015	Scott Simon, Carol Blanchette	Math Science Partnership Teacher Professional Development Workshop
June 26-29, 2015	Paul Berkman	Pan-Arctic Options Team Meeting

* Non-UCSB personnel

Coastal Research Center

The Coastal Research Center is an organizational unit within the Marine Science Institute at UCSB. The central theme of the Center is to develop scientific knowledge to gain a more complete understanding of coastal and island ecosystems, which is necessary for sound management of the natural resources within coastal and island regions. The Center links academic scientists from a wide variety of disciplines, enhancing the ability to address marine environmental issues.

While CRC scientists work in marine environments throughout the world, much effort is focused on coastal reefs found in the Santa Barbara Channel region and the coral reefs surrounding the island of Moorea, French Polynesia. These two locations provide excellent model systems for the scientific exploration of a wide range of marine issues and scientists at UCSB have long valued these environments as natural laboratories for scientific study. Both areas are enjoyed by those seeking recreation, support important local fisheries and are faced with growing conflicts amongst different user groups as human population pressures increase, a trend that is common for many marine environments. The nearshore marine environments of California and the islands of French Polynesia are used increasingly as a disposal site for waste products. Renewed exploitation of oil and natural gas reserves has augmented the number of conflicting demands placed upon the Channel resources, while issues related to global climate change have increased concerns about the sustainability of coral reef ecosystems. Local issues related to the sustainability of commercial and sport fisheries in both regions mirror global concerns regarding management of exploited stocks. The cumulative effects of human activities on the natural resources of both of these regions are just beginning to be understood. It is imperative that we learn how to balance the multiple uses of nearshore ocean waters in an environmentally sound manner. Lessons learned by scientists in the Coastal Research Center have wide implications for understanding and resolving present and future problems, and will help local, regional and national regulators develop better management policies.

Development of sound management plans for areas such as the Santa Barbara Channel or the islands of French Polynesia is hampered by scientific uncertainty about the consequences of human activities. To understand and predict natural and anthropogenic disturbances, synthesis of new and existing knowledge of many scientific aspects of coastal marine systems - including biology, ecology, genetics, geology, chemistry and oceanography - will be necessary. Further, the development of new approaches and the use of emerging technologies are needed to resolve fundamental questions, some of which have remained unanswered for many years. Only with these advances will it be possible to make reliable predictions about the consequences of various activities, to develop the ability to restore degraded habitats and conserve valuable resources, and to foster development of environmentally sound policies for use of coastal or island regions in general.

The Center has four major objectives:

- To act as a center for production and integration of basic scientific information to more fully understand coastal and island ecosystems and their natural and exploited populations.

- To evaluate and predict effects of human activities on the marine environment, and to develop measures to ameliorate lost or degraded natural resources.

- To train students in basic research on marine environmental issues that may be applicable to decision-makers.

- To facilitate and promote interdisciplinary research initiatives.

Faculty/Professional Research Participants:

Russell J. Schmitt, Director and Professor of Biology

Alice Alldredge, Professor of Biological Oceanography

Giacomo Bernardi, Professor of Molecular Ecology (UCSC)

Andrew Brooks, Associate Project Scientist

Mark Brzezinski, Professor of Biology

Alison Butler, Professor of Chemistry

Bradley Cardinale, Assistant Professor of Biology

Craig Carlson, Associate Professor of Biology

Robert C. Carpenter, Professor of Biology (CSU-Northridge)

Joseph H. Connell, Research Professor of Zoology

Jenifer E. Dugan, Associate Research Biologist

Peter J. Edmunds, Professor of Biology (CSU-Northridge)

John M. Engle, Associate Research Biologist

A. Russell Flegal, Professor of Environmental Toxicology (UCSC)

Steven D. Gaines, Professor of Biology

Ruth D. Gates, Assistant Research Biologist (University of Hawaii)

Scott Hodges, Professor of Biology

Gretchen Hofmann, Associate Professor of Biology

Sally J. Holbrook, Professor of Biology

Evelyn Hu, Professor of Electrical and Computer Engineering

Ronald Iltis, Professor of Electrical and Computer Engineering

Robert Jacobs, Professor of Biology

Ryan Kastner, Assistant Professor of Electrical and Computer Engineering

Michael I. Latz, Research Biologist, (Scripps -UCSD)

David Lea, Professor of Geology

Hua Lee, Professor of Electrical and Computer Engineering

James J. Leichter, Associate Professor of Oceanography, (Scripps -UCSD)

Hunter Lenihan, Associate Professor of Environmental Science

Milton Love, Research Biologist

Sally MacIntyre, Professor of Limnology and Oceanography

Stéphane Maritorena, Associate Researcher

John Melack, Professor of Biology

Daniel Morse, Professor of Biology

Erik Muller, Assistant Research Biologist

Roger M. Nisbet, Professor of Biology

Henry M. Page, Associate Research Biologist

Daniel C. Reed, Research Biologist

Stephen C. Schroeter, Research Biologist

Hannah Stewart, Postdoctoral Researcher (Un. Washington)

Allan Stewart-Oaten, Professor of Biology

David Valentine, Assistant Professor of Geological Sciences

Libe Washburn, Professor of Geography

Allison Whitmer, Assistant Dean (Georgetown University)

Susan Williams, Professor of Environmental Science and Policy (UCD)

Leslie Wilson, Professor of Biology

Marine Biotechnology Center

UCSB is recognized internationally for its leadership in Marine Biotechnology. This exciting field uses the latest breakthroughs in modern molecular biology, genetic engineering and cell science to solve basic problems in marine resource biology; to improve the production of medical, chemical, food, and energy resources from the ocean; and to develop new products and industries based on more efficient use of the ocean's resources.

The Marine Biotechnology Center is unique in the University of California system. It helps coordinate fifteen different research programs in this area at UCSB, and helps obtain funding for the vitally needed practical training of advanced students and professionals to help meet the future needs and changing requirements of the nation's marine and biotechnology industries. Close interactions with California's biotechnology, aquaculture and pharmaceutical industries provide new products and highly trained scientific personnel to the industrial sector, and provide support from industry for research and training in the University. The state-of-the-art Marine Biotechnology Laboratory Building - the first such facility of its kind in the United States - provides facilities needed to accommodate the rapid growth of research and teaching in Marine Biotechnology on the campus.

Research and training in Marine Biotechnology are focused at UCSB in three inter-related areas: (1) the development of new methods and approaches from molecular and cellular biology to investigate the basic mechanisms controlling life in the oceans and its responses to environmental change; (2) the development of new industries, resources and products from the oceans; and (3) the use of marine organisms as models for biomedical research. Recent progress in these areas is summarized below.

UCSB scientists are using the tools of biotechnology to unravel the ocean's mysteries in environments as diverse as the Antarctic, tropical seas and reefs, the great ocean depths, and California's resource-rich coastline. These investigations include pioneering studies of the molecular mechanisms of photosynthesis and carbon dioxide fixation by the ocean's phytoplankton, effects on these processes caused by the depletion of ozone in the Antarctic atmosphere, and effects of global warming, pollution and other environmental changes. UCSB scientists and students have discovered receptor molecules and chemical signals that control life in the ocean. The discovery of these signals, and of the receptors, transducing molecules and genes that respond to these signals, has shed new light on the underlying processes regulating the reproduction, development and growth of species ranging from tropical corals to valuable marine resources (urchins and abalones) in California waters and around the world.

Researchers in the Marine Biotechnology Center are developing the tools and techniques of molecular and cellular biology to better understand the biodiversity of marine organisms, and how they affect, and are affected by, physical, chemical and geochemical oceanic processes. Marine biota, particularly the microscopic plankton, are dominant mediators of geochemical change on Earth, yet the genetic diversity, abundance and function of these microorganisms in complex communities is still not completely understood. Researchers at the Marine Biotechnology Center are developing new ways to monitor these microscopic communities, and are discovering previously unsuspected diversity and population structure in globally distributed marine microbial populations.

Research at UCSB in the development of new products and industries from marine resources has led to the discovery of promising new diagnostic and therapeutic agents for diseases including cancer, arthritis, epilepsy and Alzheimer's disease, and the development of powerful new enzyme catalysts, novel bioadhesives, and marine microorganisms capable of degrading and detoxifying chlorinated hydrocarbons and other pollutants. Members of the Marine Biotechnology Center are working with researchers in Chemistry, Physics and Engineering through UCSB's new Army-supported Institute for Collaborative Biotechnologies, and through the NSF-sponsored National Materials Research

Laboratory, the California NanoSystems Institute, NIH's Bioengineering Consortium Program, and NASA's Biomolecular Materials program to develop valuable new materials based on the structures made by marine organisms which exhibit exceptional strength, resiliency, hardness and enhanced electrical and optical performance. With the help of the marine biotechnologists' skills in genetic and protein analysis and engineering, and close collaborations with colleagues in Chemistry, Physics and Engineering, the fundamental molecular structures and mechanisms underlying the enhanced performance of these natural materials made by marine organisms are being revealed, and translated into practical engineering solutions for the development of novel advanced materials. Teams are working with experts in the Department of Electrical and Computer Engineering to harness the mechanisms of low-temperature catalysis and molecular recognition of proteins that direct biomineralization in marine organisms to help direct the nanoscale fabrication of ultra-small crystals used for magnetic information storage and semiconductors, to help reduce the size and defect-density of electronic components, and to make new photovoltaic materials with improved efficiency to harness the sun's energy. A new generation of tough, water resistant adhesives and coatings has been inspired by sessile intertidal invertebrates, and the fangs and beaks of marine polychaetes and squids are the pointing the way to new lightweight polymeric materials with the hardness and wear resistance usually associated with ceramics. Research aimed at practical applications with economic value also has led to improvements in the economic efficiency and yield of cultivation of valuable marine fish, shellfish and plants grown for food and pharmaceuticals. These findings have led directly to the growth of new and "environmentally friendly" industries in Santa Barbara that now are producing abalones, urchins and marine algae using innovations in aquaculture technology developed at UCSB.

Research using marine organisms as model systems for biomedical research has led to a host of new and far-reaching discoveries at UCSB. Many marine invertebrates, because of their relatively simple design, and the ease of their maintenance and analysis in the laboratory, have provided a rich source of new information and serve as desirable, non-mammalian models for research. A major area of emphasis is in regard to the genetic control of normal development and of tumor formation. Professor Kathleen Foltz and her students make use of marine model systems to investigate fundamental questions of reproductive biology, cell cycle control, and early development. They discovered that the

molecular recognition processes controlling oocyte maturation and fertilization are highly conserved across species; information gained from studying the eggs and embryos of many marine invertebrates (such as sea urchins, sea stars and sea squirts) can be applied to other animals, including mammals. This research group has been actively involved in the Genome Sequencing Project for the California Purple Sea Urchin, *Strongylocentrotus purpuratus*. Their team is part of an international consortium that completed the first echinoderm genome sequence. The information gained from this genome project is being used to identify and understand the gene networks that regulate early development, and to investigate the evolutionary underpinnings of animal development. The Foltz research team is using the genomic information to describe the egg "proteome" – the identification of all of the proteins present in the egg – and to study their regulation in the first few minutes of fertilization and during the egg to embryo transition.

High-magnification electron micrograph of sea urchin sperm fertilizing an egg

Using a functional proteomics approach, over 250 sea urchin egg proteins that undergo modifications at fertilization have been identified. Most of these proteins are conserved in mammals and thus may provide insight into fertility and contraception.

Another important area of research is water resistant adhesion. Water is the nemesis of practical adhesive bonding, yet the rocky intertidal seashore is home to a host of organisms that spend their lives attached to solid surfaces surrounded and assaulted by water and waves. Professor Waite and his students discovered that the amino acid known as Dopa is a key to the remarkable underwater adhesion in mussels and sandcastle worms. In related studies, discoveries first made at UCSB on the biological mechanisms controlling the nanofabrication and toughness of the abalone shell have now been extended by Professor Paul Hansma and his students to human bone, with profound implications for diseases such as osteoporosis and arthritis.

Ocean and Coastal Policy Center

Ocean and coastal policy issues are becoming increasingly important in California, nationally, and internationally. The University of California, Santa Barbara is in a key position to make significant contributions in research and policy analyses of local, state, national, and international ocean management issues.

The need for programmatic attention on ocean and coastal policy in California has never been greater. California has one of the longest and most valuable coastlines in the nation. Offshore California, significant development of offshore resources takes place and the ocean and coastal zone are used, with increasing frequency, by a wide range of users - including offshore oil and gas extraction, recreation, marine transportation, fishing, and marine research. Offshore oil development and the attendant multiple-use controversies, in particular, have dramatized the need for better methods of ocean policy planning.

The Ocean and Coastal Policy Center (OCPC) is oriented toward problem-solving of significant coastal and ocean policy issues. Work at the center is interdisciplinary, involving perspectives from the different social science disciplines (broadly defined as political science, economics, law, history, anthropology, sociology, geography and aspects of environmental studies) and from the natural and physical sciences. In addition to interdisciplinary research, the Center engages in applied projects which directly relate research to specific marine policy problems. The OCPC is one of the few centers in California focusing on these issues.

Major themes of the center include:

- Coastal watershed management and ecosystem planning
- California marine and coastal policy
- Aquatic and marine biodiversity conservation policymaking
- Studies in ecological restoration

The OCPC has received support from the National Science Foundation, U.S. Department of the Interior, and other governmental agencies. The Center has also produced a "White Paper Series" that includes several essays devoted to ecological and policy-related activities of the Southern California Bight and associated coastal watersheds and wetlands. The special series is available on the center's webpage.

UC Natural Reserve System

The mission of the UC Natural Reserve System is to contribute to the understanding and wise management of the Earth and its natural systems by supporting university-level teaching, research, and public service at protected natural areas throughout California.

The University of California administers 35 natural reserves throughout the state which serve as outdoor classrooms and research laboratories for faculty, researchers, and college students in the field sciences and humanities. Community groups and K-12 classes also benefit from the reserve system through field trips and outreach programs. The reserves are natural areas that represent the ecological diversity of California. Most of the major habitats of California are included in the NRS. Each reserve is managed by a UC campus. UC Santa Barbara oversees seven of these reserve sites with habitats as diverse as coastal wetlands, coastal dunes, rocky intertidal, oak woodlands, grasslands, Monterey pine forest, island marine and terrestrial environments, and the mountain and Great Basin environments of the eastern Sierra. Unlike wilderness areas that are available for public recreation, the University reserves are devoted entirely to teaching and research. The reserves serve as "living laboratories," where researchers, teachers, and students can pose questions of the natural world that can only be answered by studying the natural environment. Access to the reserves is restricted to preserve their natural resources and provide security for long-term research and education projects.

- **Carpinteria Salt Marsh Reserve** is a significant coastal wetland reserve located 20 miles east of UCSB. It consists of 120 acres of south coast estuary, mudflats, beach and intertidal habitats, providing areas for studies on wildlife and fisheries biology, botany, and ornithology (site of several endangered species). The reserve is a part of the 230-acre Carpinteria Salt Marsh, one of the largest remaining coastal wetland habitats in southern California.

Reserve Staff
Andrew J. Brooks. Reserve Director
William Rice, Faculty Advisor

- **Coal Oil Point Natural Reserve** is located on the West Campus of UCSB and is composed of 158 acres of vulnerable and valuable coastal dunes, coastal terrace, south coastal estuarine lagoon, vernal pools, mudflats, beach and rocky intertidal habitats. It provides critical habitat for a number of endangered species including the Western Snowy Plover. This reserve is an ideal location for studies of migratory shorebirds and waterfowl, estuarine plants and animals, water quality and the impacts of human activities on coastal environments. Because of its close proximity to the main campus, the Coal Oil Point Natural Reserve provides a unique and accessible research and teaching resource.

Reserve Staff
Cristina Sandoval, Resident Reserve Director
Carla D'Antonio, Faculty Advisor

- **Kenneth S. Norris Rancho Marino Reserve** lies along the coast just south of Cambria. This 500 acre reserve offers access to offshore giant kelp forests, as well as a very diverse rocky shore. Important terrestrial natural resources include coastal terrace grassland and soft chaparral plant communities. The reserve contains the southern-most remnant of indigenous Monterey pine forest. Overnight facilities are available for research groups and university classes.

Reserve Staff
Don Canestro, Resident Reserve Director
Steven Gaines, Faculty Advisor

- **Santa Cruz Island Reserve,** located 24 miles offshore from Santa Barbara, comprises 46,020 acres of the largest and most topographically diverse of Southern California's offshore islands. Two thirds of the island is owned by The Nature Conservancy and remainder is part of the National Park Service. The island is used by the Natural Reserve System for research and environmental education under a long-term license agreement. The reserve field station is located in the center of the island and provides housing, laboratories, collections, information, a GIS database, and transportation to support research and teaching on and around Santa Cruz Island and neighboring islands in the Channel Island chain.

Reserve Staff
Lyndal Laughrin, Resident Reserve Director
Sally J. Holbrook, Faculty Advisor

- **Sedgwick Reserve** is located less than one hour from the UCSB campus and is an excellent natural study area for classes in biology, botany, zoology, geography, geology, anthropology, agroecology, and environmental studies. Situated in the Santa Ynez Valley, the 5,860 acre reserve includes coast live oak forest, blue oak woodland, valley oak savannah, Ceanothus chaparral, coastal sage scrub, grassland, and willow riparian forest, plus a variety of wetland types, including vernal pools. The reserve's large size and environmental heterogeneity provide an exceptional opportunity for teaching and research on biodiversity and landscape ecology. The extensive repetition of small drainages, distinct geologic and soil regimes (including large areas of unique serpentines), and complete drainage systems make the site uniquely suitable for replicated experimental studies. At least one significant Chumash archeological site is located on the property. The reserve has active K-12 science education and public outreach programs in addition to supporting research and university instruction.

Reserve Staff
Katherine McCurdy, Resident Reserve Director
Joshua Schimel, Faculty Advisor

- **The Valentine Eastern Sierra Reserve** is composed of two reserve sites in the Mammoth Lakes area, SNARL and Valentine Camp.

The Sierra Nevada Aquatic Research Laboratory (SNARL) is located on 51 acres of the eastern slope of the Sierra Nevada and is an ideal base for field research throughout the ecologically and geologically diverse eastern Sierra and Owens Valley. The reserve offers modern housing, including dormitory accommodations for short and long-term use by researchers and classes. Office space and laboratory facilities, including wet labs, controlled-environment rooms, chemistry and radio-isotope labs, and experimental stream channels, as well as meeting and classroom facilities, are offered on a year-around basis. An extensive GIS database, a library, and a computer/communications center are also available. The reserve supports a well-attended public lecture series in the spring and early summer.

Valentine Camp encompasses 152 acres and contains one of the region's few pristine montane meadows. It provides varied habitats, including coniferous forest, chaparral, and sagebrush plains in which to conduct observational and experimental studies. The considerable ecological diversity within the reserve makes it an excellent teaching resource. The facilities include housing and laboratories which are open in the summer and early fall and, on a limited basis, in the winter. A system of foot trails provides access to all of the site's major habitats. The reserve has a very active K-12 outreach program during the summer.

Reserve Staff
Daniel R. Dawson, Resident Reserve Director
John M. Melack, Faculty Advisor
Leslie Dawson, K-12 Education Coordinator

UCSB Natural Reserve System Administration
William W. Murdoch, Director
Susan L. Swarbrick, Associate Director
Donna Moore, MSO

Analytical Laboratory

The MSI Analytical Lab is a professionally managed chemical analysis facility, with the objectives of improving the quality and efficiency of marine-related research efforts, and of providing advanced capabilities for new and expanded research programs. Originally established in 1977 to serve the needs of UCSB marine researchers, the facility is now recognized campus wide as well as nationally as a resource for high-quality analytical services, with a regular user base of over 50 faculty and professional researchers. The major capabilities of the Lab include metals analysis by Inductively Coupled Plasma Mass Spectroscopy, Flame Atomic Absorption Spectroscopy (AAS), and Furnace AAS; bulk elemental analysis of carbon, hydrogen and nitrogen (CHN) by combustion; stable isotope ratio determination of light isotopes (C, N, O, H, S) in biological and geological materials using both continuous-flow and dual inlet Isotope Ratio Mass Spectrometry; and automated determination of nutrients in natural waters using a 5-channel Flow Injection Analyzer. Most of the Lab's current instrumentation was obtained with extramural funding from grants acquired by the Lab manager in conjunction with interested faculty and researchers. The Lab operation is supported largely through user fees. There are currently five full time and three part time staff employed by the Analytical Laboratory. Please visit our Web site at analab.msi.ucsb.edu for more information.

MSI Education and Outreach

It was a year growth for MSI Oceans-To-Classrooms (O2C) Ed/Outreach Programming that included visits to the Research Experience & Education Facility (REEF) and community outreach efforts via the Mobile REEF Unit. Much of the content focused on the growing partnership with the Channel Island National Marine Sanctuary and the construction of the Outreach Center for Teaching Ocean Science (OCTOS). Up over 2,000 from the previous year, our total outreach efforts have provided marine science and ocean awareness to 17,110 (See Figure 1) people within the Tri-Counties (SLO, SB, Ventura) and beyond! This number captures our shift, this year, to capturing ALL students, both on, and off, campus. This is identified in the column P-20, to denote Preschool through Graduate school. Our Saturday, Open Door Program for the General Public had over 1,700 visitors. Our Mobile Efforts alone reached 5,119 community members). None of this would have been possible without our continued growth and collaborations with such groups both on- and off-campus. These groups include the Office of Education Partnerships, The AS Coastal Fund, Santa Barbara Channel Islands National Marine Sanctuary (CINMS) and many others.

MSI Oceans-to-Classrooms
Education and Outreach Effort
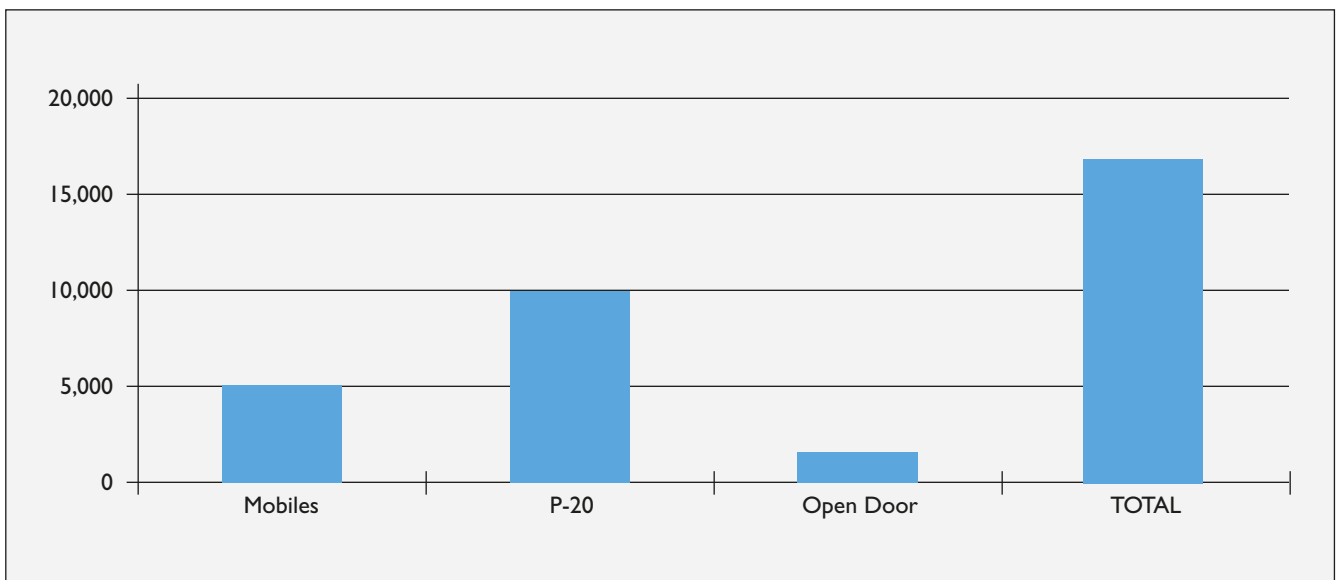### Totals for 2013–2014 (N=17,110)

Figure 1. Graph of total number of participants served through MSI Ed/Outreach Oceans-To-Classrooms (O2C) Programming.

Awards Administered

Awards Administered
2014-2015

ALFRED P. SLOAN FOUNDATION

D. McCauley   9/15/2015-9/14/2017 $50,000
Assessment of Bacterial Water Quality in the Lahontan Region: A study to provide
data on bacterial indicator concentrations and sources of bacteria in surface water

Alfred P. Sloan Foundation Subtotal	**$50,000**

CALIFORNIA COASTAL COMMISSION

M. Myers   6/1/2014-6/30/2015 $28,000
Community Research Education for Students and Teachers about the Ormond Beach
Restoration (Community RESTOR) Project

California Coastal Commission Subtotal	**$28,000**

CALIFORNIA INSTITUTE OF TECHNOLOGY

D. Valentine   3/21/2013-6/30/2015 $105,625
Cracking the Microbial Sulfur Cycle with Novel Cell- and Metabolite-Specific Stable
Isotope Approaches

California Institute of Technology Subtotal	**$105,625**

CALIFORNIA SEA URCHIN COMMISSION

S. Schroeter   7/1/2006-6/30/2015 $32,578
Studies of Sea Urchins Settlement in Southern and Northern California

California Sea Urchin Commission Subtotal	**$32,578**

CALIFORNIA WILDLIFE CONSERVATION BOARD

C. Sandoval, S. Swarbric   6/29/2015-6/30/2017 $505,000
Coal Oil Point Reserve Infrastructure and Facilities Project

California Wildlife Conservation Board Subtotal	**$505,000**

CONSERVATION INTERNATIONAL

S. Gaines   11/1/13-10/31/15 $200,000
Marine spatial planning (MSP) and lobster fishery reform for the Galapagos

Conservation International Subtotal	**$200,000**

DESERT BOTANICAL GARDEN

T. Dudley   3/1/2015-2/28/2018 $157,568
Host plant allocation strategies and mortality in response to a specialist herbivore

Desert Botanical Garden Subtotal	**$157,568**

EXXON MOBIL UPSTREAM RESEARCH COMPANY

D. Valentine   7/1/2013-1/1/2016 $200,000
Development and Testing of Sampling Tools for the Collection of Microbes and
Chemicals from Marine Seeps

Exxon Mobil Upstream Research Company Subtotal — **$200,000**

KOREAN INSTITUTE OF INDUSTRIAL TECHNOLOGY

J.H. Waite, K. Ahn   3/1/2015-12/31/2015 $31,236
Catechol Comprising copolymer synthesis and properties evaluation

Korean Institute of Industrial Technology Subtotal — **$31,236**

LARIMER COUNTY DEPARTMENT OF NATURAL RESOURCES

S. Hodges   5/1/2014-11/2/2015 $2,000
The genetic distinctiveness of Hermit Park's Aquilegia coerulea var. daileyae

Larimer County Department of Natural Resources Subtotal — **$2,000**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

R. Miller   10/1/2014-9/30/2019 $723,818
Demonstrating an effective Marine BON in the Santa Barbara Channel

National Aeronautics and Space Administration Subtotal — **$723,818**

NATIONAL GEOGRAPHIC SOCIETY

J Caselle   4/1/2014-12/31/2015 $10,930
Exploration of apex predators and deepwater biodiversity in an unfished, pristine
atoll

D. McCauley   7/15/2014-7/14/2015 $24,350
Cross-ecosystem linkages created by the common hippopotamus revealed using
satellite tracking

H. Young   5/1/2014-5/1/2015 $13,980
Impacts of fishing on facilitated foraging of seabirds in the Central Tropical Forest

National Geographic Society Subtotal — **$49,260**

NATIONAL PARK FOUNDATION

R. Knapp   5/1/2014-5/30/2015 $17,592
Facilitating Recovery of the Endangered Sierra Nevada Yellow-legged Frog (Rana
sierrae) in Yosemite National Park through Identification of Critical Habitats and
Movement Corridors

National Park Foundation Subtotal — **$17,592**

NATIONAL SCIENCE FOUNDATION

M. Brzezinski   1/1/2015-12/31/2017 $500,866
GEOTRACES Arctic Section: Diagnosing the unique silicon isotope composition of
the Arctic Ocean

M. Brzezinski	8/1/2014-7/31/2016	$147,455
UC Santa Barbara Marine Laboratory SCUBA Compressor Improvement		
J. Dugan, R.J. Miller, J.C. Ohlmann	4/1/2015-3/31/2019	$997,312
Linking nearshore kelp forest dynamics to sandy beach ecosystems		
P. Halpin	1/1/2015-7/31/2016	$30,389
RUI Collaborative Research: Spatial Realism in the Mussel Bed Disturbance Paradigm		
A. Kuris, D. Lopez-Carr S. Sokolow	8/1/2014-1/31/2019	$1,499,897
CNH: Healthy Ecosystems, Healthy People: The Coupled Human Health and Environmental Dynamics of Schistosomiasis in Sub-Saharan Africa		
D. McCauley	10/1/2014-9/30/2016	$74,640
US-Tanzania planning visit: investigating patterns of self-organization in large vertebrates using very high-resolution satellite imagery		
T. Oakley, D. Speiser	5/15/2015-4/30/2018	$370,000
DEB: RUI: Collaborative Research: Evolutionary origins of bioluminescence and complex mating signals: Phylogenomics of Cypridinidae (Ostracoda)		
M. O'Brien, D. Reed	4/1/2015-3/31/2016	$17,158
EAGER: Collaborative Research: Conceptualizing sustained environmental information management in the landscape of current and emerging eco-informatics infrastructure		
H. M. Page, R. Miller	4/1/2010-3/31/2015	$9,025
Sources of Particulate Organic Matter and Their use by Benthic Suspension-Feeders in the Coastal California Ecosystem		
D. Reed, S. Holbrook, J. Melack, D. Siegel,	12/1/2012-11/30/2018	$964,000 $16,000 $147,794
LTER: Land/Ocean Interactions and the Dynamics of Kelp Forest Communities SBC-LTER III		
R. Schmitt, S. Holbrook	9/1/2012-8/31/2016	$924,000 $16,000 $194,040 $24,000 $2,145
LTER: MCR IIB: Long-Term Dynamics of a Coral Reef Ecosystem		
J.H. Waite	6/1/2015-5/31/2016	$76,731
EAGER: Collaborative Research: Mimicking mussel adhesion with periodically sequenced polypeptides		
S. Weldeab	7/1/2015-6/30/2016	$55,237
Investigating seasonal and interannual variability of Central Asia paleo-hydroclimate		
S. Weldeab, D. Lea	7/1/2013-12/31/2016	$30,210
Data synthesis and Evaluation of the Salinity Influence on Mg/Ca Paleothermometry in the Low Latitudes		
H. Young	6/1/2015-5/31/2018	$508,751
Using replicated empirical networks to understand drivers of ecosystem structure and stability		
	National Science Foundation Subtotal	**$6,605,650**

NATIONAL INSTITUTES OF HEALTH, DENTAL

J.H. Waite, J. Israelachvili Translating Mussel Adhesion	9/1/2014-8/31/2015	$412,887
	National Institutes of Health, Dental Subtotal	**$412,887**

NATIONAL INSTITUTES OF HEALTH, GENERAL MEDICAL SCIENCES

E. Ballerini, S. Hodges Dissecting the Genetic Basis of Adaptive Traits in Aquilegia	8/1/2012-7/31/2015	$56,978
C. Briggs EID disease in complex communities: multi-host multi-pathogen interactions	7/1/2014-6/30/2015	$399,237
T. Turner Evolutionary Behavioral Genomics of Drosophila Courtship	8/1/2011-5/31/2016	$287,852 $287,852
	National Institutes of Health Subtotal	**$1,031,919**

NATURE CONSERVANCY (THE)

C. Costello, S. Gaines Making the case for fisheries reform in the East China Sea	9/1/2014-9/1/2015	$101,500
C. Costello Task Agreement #7: Improving the Management of Peru's Anchoveta Fishery	5/1/2015-9/1/2015	$27,500
C. Costello TNC MOU, Task 3 Improving the Management of Peru's Anchoveta Fishery	9/2/2015-9/1/2015	$30,000
S. Gaines, S. Lester TNC Task Agreement 1, Amendment 3, Oceans Program Groundfish Project Summer Intern	5/1/2015-9/1/2015	$9,485
S. Gaines TNC Task Agreement 1, Amendment 4, Graduate Student Support, SNAP framework	5/1/2015-9/1/2015	$3,000
S. Gaines, S. Lester TNC Task Agreement 1, Amendment 2, Staff Research Support	1/1/2015-9/1/2015	$7,574
W. McClintock Software Development of eCatch Mobile Application	11/1/2014-9/1/2015	$180,579 $105,936
	Nature Conservancy (The)	**$465,574**

OCEAN CONSERVANCY

S. Gaines Reimagining fishery management: A joint project to identify breakthrough approaches to fisheries management	7/1/2015-12/31/2016	$258,750
	Ocean Conservancy Subtotal	**$258,750**

OREGON STATE UNIVERSITY

C. Blanchette, J. Caselle, S. Gaines, R. Warner, L. Washburn PISCO Science for an Informed Society	1/1/2015-12/30/2015	$219,415
	Oregon State University Subtotal	**$219,415**

PEPPERDINE UNIVERSITY

J. Dugan,	2/1/2014-1/31/2016	$7,475
A new method for monitoring urban beach ecosystems		

Pepperdine University Subtotal	**$7,475**

RARE

S. Lester, C. Costello	1/1/2014-12/31/2018	$100,000
Fish Forever (Subaward from Waitt Foundation)		$100,000
S. Lester	8/1/2014-9/30/2015	$250,000
UCSB Fish Forever support in Brazil and Philippines		

RARE Subtotal	**$450,000**

ROY F. WESTON, INC.

D. Herbst	5/1/2014-9/30/2015	$197,475
Bio Assessment Study Support for Leviathan Mine Superfund Site, CA		

Roy F. Weston, Inc. Subtotal	**$197,475**

SAN FRANCISCO STATE UNIVERSITY FOUNDATION, INC.

J. Dugan	10/1/2013-3/31/2015	$18,200
Improved Valuation of Impacts to Recreation, Public Access, and Beach Ecology from Shoreline Armoring in California		

San Francisco State University Foundation, Inc. Subtotal	**$18,200**

SWISS FEDERAL INSTITUTE OF TECHNOLOGY (ETH)

M. Brzezinski	9/1/2014-9/30/2015	$7,100
Sedgwick field work		

Swiss Federal Institute of Technology (ETH) Subtotal	**$7,100**

TEXAS A&M UNIVERSITY

U. Passow	7/1/2014-6/30/2015	$159,731
Role of microbial exopolymers in aggregation and degradation of oil and dispersants		

Texas A&M University Subtotal	**$159,731**

THE CORAL REEF ALLIANCE (CORAL)

J. Caselle, R. Warner	7/1/2014-6/30/2015	$96,316
Understanding Coral Reef Resilience to Advance Science and Conservation		

The Coral Reef Alliance (CORAL) Subtotal	**$96,316**

UC AGRICULTURE AND NATURAL RESOURCES

A. Lambert	7/1/2014-6/30/2015	$13,166
Invasive weeds as alternate hosts for the newly introduced cole crop pest Bagrada hilaris		

UC Agriculture and Natural Resources Subtotal	**$13,166**

UC MEXUS

T. Dudley 7/1/2014-6/30/2015 $1,496
Riparian restoration and invasive species control in the Lower Colorado River of
northern Mexico

R. Oono 10/1/2014-9/30/2015 $24,491
Inferring Evolutionary Processes Using RAD-seq Data in Species of Lophodermium,
the Dominant Fungal Endophyte in Pine Needles

	UC MEXUS Subtotal	**$25,987**

UC SAN DIEGO

S. Simon 2/1/2015-6/30/2016 $7,976
Integrating CIMEC Science into the Oceans-to-Classrooms Outreach Program at
UCSB's Marine Science Institute

L. Washburn, M. Brzezinski 6/1/2012-5/31/2013 $348,100
Southern California Regional Coastal Ocean Observing System: Surface Current
Mapping, Harmful Algal Bloom, and Sub-Surface Water Sections

	UC San Diego Subtotal	**$356,076**

UC SANTA CRUZ

C. Blanchette 9/1/2012-8/31/2015 $43,500
Characterization of Rocky Intertidal, Kelp Forest and Deep Rocky and Sandy
Ecosystems at San Clemente Island

J. Caselle 6/24/2014-1/31/2016 $50,235
Scientific collecting permits, rockfish dispersal, and kelp forest monitoring

J. Caselle 11/1/2011-10/31/2016 $31,422
Regional Importance of Manmade Structures as Rockfish Nurseries

S. Mazer 4/1/2015-10/31/2016 $24,969
Using UC Reserves to detect and forecast climate impacts

	UC Santa Cruz Subtotal	**$150,126**

UC SEA GRANT

C. Culver 2/1/2014-1/31/2016 $6,584
Sea Grant Extension Program Funds $10,318

S. Gaines 2/1/2015-1/31/2016 $3,811
Spatial Redistribution of Fishing Effort: Identifying Drivers and Testing Model $45,812
Predictions for Informing Expectations in Marine Spatial Planning

G. Hofmann 2/1/2015-1/31/2016 $24,999
Global Change Ecophysiology of egg masses and juveniles of the kelp forest fish,
Scorpaenichthys marmoratus

H. Lenihan, L. Urbisci 6/1/2014-5/31/2017 $96,249
Developing a new ecosystem-based management approach: using ecosystem models
to calculate a better estimate of population scale for single-species models

D. Reed 2/1/2015-1/31/2016 $86,510
The Spread and Ecological Consequences of the Invasive Seaweed Sargassum homeri

	UC Sea Grant Subtotal	**$274,283**

UNIVERSITY OF GEORGIA

U. Passow   1/1/2015-12/31/2015 $278,251
ECOGIG-2: Ecosystem Impacts of Oil and Gas inputs to the Gulf

University of Georgia Subtotal	**$278,251**

UNIVERSITY OF MIAMI

C. Carlson   2/1/2009-1/31/2014 $126,349
Collaborative Research: Global Ocean Repeat Hydrography, Carbon, and Tracer
Measurements, 2015-2020

University of Miami Subtotal	**$126,349**

UNIVERSITY OF MICHIGAN

T. Oakley   9/1/2013-8/31/2015 $218,377
EFRI-PSBR: Biodiversity & Biofuels: Finding win-win scenarios for conservation and
energy production in the next century

University of Michigan Subtotal	**$218,377**

UNIVERSITY OF MINNESOTA

S. Mazer   10/11/2011-9/30/2015 $29,029
Project Baseline, a living plant genome reserve for the study of evolution $6,715

University of Minnesota Subtotal	**$35,744**

UNIVERSITY OF ROCHESTER

D. Valentine   12/10/2012-2/28/2016 $231,724
Investigating the Chemical and Isotopic Kinetics of Aerobic Methane Oxidation

University of Rochester Subtotal	**$231,724**

UNIVERSITY OF SOUTHERN CALIFORNIA, SOUTHERN CALIFORNIA EARTHQUAKE CENTER

C. Nicholson   2/1/2012-1/31/2016 $38,000
Continuing to Evaluate 3D Fault Geometry in Special Fault Study Areas and to
Improve the SCEC Community Fault Model (CFM)

University of Southern California Subtotal	**$38,000**

US DEPARTMENT OF AGRICULTURE, FOREST SERVICE

D. Herbst   9/24/2012-12/31/2016 $40,000
Aquatic Invertebrate Research for Experimental Watersheds in the Kings River
System

US Department of Agriculture Forest Service Subtotal	**$40,000**

US DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPERIC ADMINISTRATION (NOAA)

M. Brzezinski   9/1/2013-8/31/2014 $15,000
Captive Broodstock Holding Facility Enhancements for the Endangered White Abalone, Haliotis sorenseni

US Department of Commerce, NOAA Subtotal   **$15,000**

US DEPARTMENT OF COMMERCE, NATIONAL MARINE FISHERIES SERVICES (NMFS)

D. Reed   8/1/2014-7/31/2016 $50,000
Experimental investigations on the efficacy of the "Super Sucker" as a device for controlling the spread of non-indigenous seaweeds

US Department of Commerce, NMFS Subtotal   **$50,000**

USDI BUREAU OF OCEAN ENERGY MANAGEMENT

C. Blanchette   7/1/2014-3/31/2015 $2,450
Maintenance, Calibration, and Deployment of a Seafet 97 pH meter

M. Nishimoto   8/14/2014-8/31/2017 $600,000
Potential Impacts of Submarine Power Cables on Crab Harvest

H.M. Page, J. Dugan, R. Miller   7/1/2013-5/31/2016 $25,000
Understanding the Role of Offshore Structures in Managing Potential $272,787

Watersipora Invasions

D. Reed   9/22/2011-3/31/2017 $200,000
DOI Partnership: Distinguishing Between Human and Natural Causes of Changes in Kelp Forests Using Long-term Data from DOI Monitoring Programs

USDI – Bureau of Ocean Energy Management Subtotal   **$1,102,237**

ENVIRONMENTAL PROTECTION AGENCY

A. Larsen, S. Gaines   9/28/2014-9/27/2016 $17,000
What drives pesticide use, and how will quantity and distribution of pesticide use be modified by climate change?

Environmental Protection Agency Subtotal   **$17,000**

USDI FISH & WILDLIFE SERVICE

T. Dudley   11/29/2010-11/29/2015 $101,000
Research and Restoration through the Santa Clara River Reserve: A Proposal to Develop a University of California Research and Education Station

USDI Fish & Wildlife Service Subtotal   **$101,000**

USDI NATIONAL PARK SERVICE

L. Laughrin, S. Swarbrick   8/1/2013-8/30/2015 $7,544
Research Bibliography for Channel Islands National Park - Phase II

S. Mazer   8/30/2010-8/29/2015 $43,716
Facilitation of a Phenology Network to Assess Climate Change Response in
California National Parks

A. Rassweiler   4/8/2013-11/29/2014 $40,000
Analysis and publication of long-term Channel Islands National Park kelp forest
monitoring data

| | **USDI – National Park Service Subtotal** | **$91,260** |

US DN, OFFICE OF NAVAL RESEARCH

J. H. Waite   7/31/2013-7/30/2015 $219,415
Mussel-inspired Under-water Acrylic Adhesives/Coatings $30,719
                                                                                     $187,220

| | **US DN, Office of Naval Research Subtotal** | **$437,354** |

VENTURA COUNTY

J. H. Waite   7/31/2013-7/30/2015 $1,962,430
SC-13: Invasive Plant Removal, Ecosystem Restoration, and Habitat Protection in the
Santa Clara River (Santa Clara River Restoration)

| | **Ventura County Subtotal** | **$1,962,430** |

WAITT FAMILY FOUNDATION

C. Costello, S. Gaines   1/1/2015-12/31/2015 $550,000
Sustainable Ocean Solutions through Rights-Based Management, Fisheries Certification, $11,324
and Marine Protected Areas

| | **Waitt Family Foundation Subtotal** | **$561,324** |

| | **TOTAL 2014-2015 AWARDS** | **$17,977,630** |

Research Summaries
(Contracts/Grants Administered)
July 2014 – June 2015

Evangeline Ballerini   8/1/2012 to 7/31/2015   **$163,110**
Scott Hodges
NIH General Medical Sciences   5F32 GM103154

Dissecting the Genetic Basis of Adaptive Traits in Aquilegia

The ability to pinpoint the causal genetic variation and interpret the related developmental processes that lead to phenotypic variation is critical to our knowledge of how to treat and prevent human disease, improve crop yields, and to increase our understanding of evolutionary processes such as natural selection, adaptation, and speciation. Here we use several techniques to identify the genetic basis of variation in cell anisotropy affecting spur length, an adaptive trait in the genus Aquilegia. Several methods will be used to identify candidate loci for spur length variation. First, whole genome sequencing of 276 F2 progeny of a cross between the medium spurred species, *Aquilegia formosa*, and the long spurred species *A. pubescens*, will be used to map QTL for spur length. We will then use natural hybrid zones between *A. formosa* and *A. pubescens* to take advantage of increased marker recombination in advanced generation hybrids (relative to the F2 progeny used for QTL mapping) to narrow the genomic regions associated with differences in spur length. For these admixed individuals, methods of genome capture will be implemented to selectively sequence genomic regions associated with the previously identified QTL for marker genotyping and association analyses. We will also perform genome-wide scans for selection to identify regions of the genome in each species that show signs of positive selection. Combining these data will allow us to come up with a more refined list of candidate loci affecting spur length than any method independently. Gene expression and functional analyses will then be conducted on candidate genes to confirm and further comprehend their roles in the development of cell anisotropy and spur length variation. These analyses will provide basic information on the genetic basis of adaptive traits, including estimates for the number and genomic distribution of loci involved, the effect size of loci, and whether adaptive trait variation is caused by regulatory or structural genetic changes.

Paul Berkman   9/1/2013 to 8/31/2016   **$1,714,176**
Oran Young, Frank Davis
National Science Foundation   PLR-12693819

Holistic Integration for Arctic Coastal-Marine Sustainability (HIACMS)

Interests are awakening globally to take advantage of extensive energy, shipping, fishing, and tourism opportunities associated with diminishing sea ice in the Arctic Ocean. Responses to this environmental state-change are generating risks of political, economic, and cultural instabilities that will affect societies at local, regional, national, and international levels. Addressing the "common arctic issues" of sustainable development and environmental protection articulated by the Arctic Council, this 3-year project will develop and demonstrate a process that will enhance the practice of governance for sustainability in Arctic coastal-marine systems, balancing national interests and common interests; environmental protection, social equity and economic prosperity, and needs of present and future generations. To achieve this project goal, we will carry out a series of tasks addressing the four ArcSEES themes (Natural and Living Environment; Built Environment; Natural Resource Development; and Governance) and including: interdisciplinary data aggregation; geospatial integration of the data to reveal plausible developmental scenarios; annual workshops to generate infrastructure and policy options, and applications of the findings to current issues of Arctic governance. This sustainability process will be elucidated and demonstrated through case-studies focusing on current 'hot spots' in the Western Arctic - Bering Strait and Beaufort-Chukchi Seas (United States, Canadian and Russian interests) – and the Eastern Arctic - Barents Sea (Norwegian and Russian interests) and West Greenland (Greenlandic, Danish, and Canadian interests). We will engage policy makers in the process from bodies like the Convention for the Protection of

the Marine Environment of the North-East Atlantic, which has a transboundary remit in the Arctic Ocean. To make the process cost effective, we have established links to the SEARCH (Study of Environmental Change: www.arcus.org/search) and ACCESS (Arctic Climate Change, Economy and Society: www.access-eu.org) projects that are supported extensively within the United States and Europe, respectively. We will leverage the capacity, networks and expertise associated with these already-funded research activities. Our international, interdisciplinary, and inclusive project also will add value through partnerships with the National Center for Ecological Analysis and Synthesis (www.nceas.ucsb.edu) in the United States and institutions in France associated with the ACCESS project as well as the Ice Atmosphere Arctic Ocean Observing System project (www.iaoos-equipex. upmc.fr). The holistic process we develop to generate and share options for Arctic coastal-marine sustainability will be memorialized through a video series involving lessons of 'science diplomacy' to further stimulate education by and for the benefit of all stakeholders (i.e., representatives of government agencies, academia, industry, non-governmental organizations, and civil society). The sustainability process we develop and demonstrate in this project focusing on the Arctic Ocean will have implications everywhere on Earth where resources, human activities, and their impacts extend across or beyond the boundaries of sovereign states.

Carol Blanchette ,
Jennifer Caselle, Steven Gaines,
Robert Warner, Libe Washburn
Oregon State University

1/15/2015 to 3/31/2017

$238,188

F08866A-C

PISCO Science for an Informed Society

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) requests funds for Year 1 and 2 of a 5-Year phase project (2015-2019) to: employ our unique set of long-term time series to advance society's understanding of ecosystem change and the consequences, and · apply this new ecosystem knowledge to policy and management of nearshore resources (e.g., fisheries, adaptive management of marine protected areas), and effects of changing climate. Established in 1999, PISCO is a consortium of scientists located at Oregon State University, Stanford University's Hopkins Marine Station, University of California Santa Cruz, and University of California Santa Barbara. Over the years, PISCO has refined and expanded its research program to add expertise and engage collaborators in specific projects. We will capitalize on the trusted relationships that we have built with colleagues in boundary organizations, state and federal agencies, and other academic centers to develop collaborations and partnerships that advance visions of (1) sustaining interdisciplinary, ecosystem science efforts that inform management and policy and (2) combining different but complementary organizational perspectives and approaches to address environmental problems in unique and innovative ways. This renewal request is organized in two major sections: Request for 2015 activities (this document): We aim to continue developing PISCO's ecosystem time series that provide uniquely valuable perspectives on climate change, sustainable ocean resources, and ecosystem☐based management. Our objectives are: 1. Time series advance new understanding about coastal marine ecosystems of the CCLME and inform multiple conservation actions. PISCO ecosystem time series has multiple applications for conservation science and policy, and has been important for leveraging new awards. Due to regional differences in development of time series and leveraging opportunities for co-funding, not all time series activities span this entire temporal or geographic range. But, when combined coast-wide, they provide comprehensive insights into how the CCLME functions. In 2015, we will continue some time series efforts in the intertidal and subtidal, contribute to the development of genomic-based survey methods, and develop products that employ our long-term datasets to gain new insight into ecosystem dynamics and communicate our findings. 2. Apply insights from PISCO time series to key questions for MPA management, nearshore fisheries, and climate change policy. We will apply PISCO ecosystem approaches to key questions relevant for (a) adaptive management of marine protected areas, (b) nearshore fisheries, and (c) climate change. Cornerstones of our MPA and fisheries work will be select exploratory projects that we develop and initiate in 2015 with partners in academia, management, and policy to evaluate feasibility of longer-term and more formal academic-agency partnerships. Besides research and analysis, our climate change work will consist of continued engagement with policy advising processes, product development, and convening scientific exchanges with other research groups about ecosystem impacts along the West Coast. In 2015, we will also meet periodically with DLPF's West Coast team to ensure that our activities are coordinated with

DLPF and partner activities. These activities will determine the path and projects that we pursue in the remainder of this 5-year phase of PISCO.

Carol Blanchette   9/1/2011 to 6/30/2015   **$259,856**
California Sea Grant College Program   R/MPA-22A

Baseline Characterization and Monitoring of Rocky Intertidal Ecosystems for MPAs in the South Coast Region

The goals of this project are to produce a quantitative baseline characterization of the structure of rocky intertidal ecosystems in all of the South Coast MPAs that have accessible rocky intertidal and to provide a quantitative comparison between the rocky intertidal ecosystems in these MPAs and associated reference areas in the South coast region using a combination of biodiversity surveys and targeted species sampling. Researchers will analytically explore the baseline characterizations for potential indicators of the state of the rocky intertidal ecosystems using newly collected data along with historical and contextual data from the region, evaluate the suitability of proposed draft metrics and other metrics for long term monitoring and assess initial changes in size and abundance of targeted species across newly created MPAs, existing MPAs and reference areas.

Carol Blanchette   9/1/2012 to 8/31/2016   **$115,500**
UC Santa Cruz   UCSCMCA 13-004

Characterization of Rocky Intertidal, Kelp Forest and Deep Rocky and Sandy Ecosystems at San Clemente Island

Characterization of Rocky Intertidal, Kelp Forest and Deep Rocky and Sandy Ecosystems at San Clemente Island Our approach to characterizing the baseline conditions of rocky intertidal ecosystems within SCI exclusion and reference sites will be closely linked to the rocky intertidal baseline monitoring approaches used to provide baseline characterization for the California MPA network: South Coast Study Region (Blanchette and Raimondi co-PIs), Central Coast Study Region (Raimondi and Blanchette, co-PIs) and the North-Central Coast Study Region (Raimondi, PI). This tight integration of leadership, personnel, protocols and datasets with sampling programs in other California regions will ensure consistency in methods and data facilitating synthesis and analysis across study regions. Our program will be closely coordinated with the two major existing west coast regional monitoring programs for intertidal ecosystems (where Raimondi and Blanchette are also PI's). The first is MARINe (Multi Agency Rocky Intertidal Network, http://www.marine. gov/), which evolved from the monitoring program initiated by the Channel Islands National Park in the early 1980's (Davis 1985; Richards and Davis 1988). The MARINe monitoring was explicitly directed at detecting temporal changes in the intertidal communities (Raimondi et al 2005). The second is PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans, http://www.piscoweb. org/), which has supported the Coastal Biodiversity Survey program (described in detail below). These biodiversity surveys have been conducted at 130 sites from central Alaska to southern Baja, California, Mexico (Blanchette et al. 2008). While the unified MARINe protocols have proven to be extraordinarily powerful for detecting changes in communities (Minchinton and Raimondi 2005) and particularly in separating anthropogenic from natural dynamics (Raimondi et al 1999), they were not designed to estimate biodiversity. Moreover, we found that geomorphology was tremendously important in determining communities and dynamics of communities. To address these concerns we designed a spatially explicit biodiversity monitoring program. This program has been variously called the SWAT or comprehensive surveys, but herein we will use the term biodiversity surveys. These surveys have been conducted at almost all of the MARINe sites and several non – MARINe sites. Our baseline characterization and monitoring plan will be based on the successful elements from both the MARINe and biodiversity survey programs and aimed at the assessment and understanding of ecological conditions in rocky intertidal ecosystems in this region at or near the time of MPA implementation. Our protocols will be generally aligned with those used in other study regions, and identical to those being used across the south coast study region. Based on our experiences with both the MARINe and PISCO programs, as well as leading the baseline monitoring efforts in both the central and north central regions, we propose to use two separate survey types to characterize rocky intertidal ecosystems of SCI. Both types of surveys will be done in each of the

first two years to establish baseline conditions. These sites will include sites previous sampled in 2009 (Boy Scout Camp and Eel Point). Other specific locations will be determined as part of our coordinated planning meeting, which is intended to produce a joint sampling plan for all projects.

Carol Blanchette	5/1/2015 to 4/30/2017	**$19,681**
UC Santa Cruz		A15-0068-S005

MARINe Rocky Intertidal Survey Program

The Multi-Agency Rocky Intertidal Network (MARINe) is a partnership of agencies, universities and private groups committed to determining the health of the rocky intertidal habitat and providing this information to the public. MARINe, a model partnership in existence for over a decade, is funded entirely by the independent contributions of its members who jointly publish data in peer-reviewed literature. Findings from this extensive and unique long-term monitoring program indicate that many rocky shores along the coast, particularly those near urban centers, are under stress, with some intertidal populations changing significantly over the past several decades. MARINe cooperates closely with PISCO and other intertidal programs, which utilize the monitoring sites for a variety of ecological studies. MARINe funds undergraduate, graduate, and post-doctoral researchers who publish their results in peer-reviewed papers. MARINe regularly presents joint posters and papers on our findings at technical conferences, as well at annual network Workshops. Blanchette will serve as a coordinator to unify the activities of this group in the realm of data collection, management, analysis and in the production of papers. Blanchette will help to train and supervise students and technicians involved in the Biodiversity sampling. Blanchette will also work with other members of the MARINe group to produce reports and manuscripts and present the results of MARINe work at scientific and public conferences and symposia.

Carol Blanchette,	3/22/2013 to 9/30/2015	**$232,045**
Jennifer Caselle, Steven Gaines,		
Robert Warner, Libe Washburn		
Oregon State University		F70767A-C

Understanding the California Current Large Marine Ecosystem under Climate Change: Delivering Sound Science for Policy

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) requests funds for Year 4 of a 5-Year phase project (PISCO-III, 2010-2014). With these renewal funds, we will continue to apply our long-term interdisciplinary ecosystem studies to inform marine policy, improve approaches to marine conservation, and to develop adaptive strategies for climate change. Effective efforts to inform decision makers across the CCLME require a coordinated consortium, which has become the PISCO label and a national model for academic consortia informing coastal and marine policy. The generous support from DLPF provides the cohesion for our group, enables researchers to continue their high-impact roles as advisors and close collaborators with information users in various policy processes, and provides a living legacy of long-term monitoring and research that we believe will define future regional and ecosystem-based ocean science programs. In October 2009, PISCO submitted a full 5-Year proposal for the new, "PISCO-III" phase of the consortium. That proposal summarizes how PISCO's prior experience of implementing large-scale, interdisciplinary research uniquely positions the consortium to understand how ecosystems may change in the future, how these changes affect human well-being, and where effective solutions may lie. Consistent with agreements with DLPF to submit annual renewal requests for continuing funds, this renewal request summarizes our progress, highlights notable achievements as well as challenges, and proposes 2013 (Year 4) activities and budget. In general, the support requested from DLPF will enable the consortium to: · Continue key cross-disciplinary collaborations that make PISCO science particularly transformative, · Continue and further develop essential collaborations with boundary organizations, management agencies, and policy makers to ensure accurate use and support of ocean ecosystem monitoring and assessment, · Use legacy time series data and our expertise in designing and implementing monitoring programs to inform immediate and longer-term management and policy needs, · Maintain cohesion across the continuing new collections of time series data that are funded by multiple agencies, · Integrate research and monitoring to understand the dynamics of

the ocean ecosystem of the US west coast in an era of changing ocean management, emerging ocean uses and climate change, and Continue to provide a model for science-to-policy in other large marine ecosystems of the United States and abroad.

Carol Blanchette   7/1/2014 to 12/31/2015 $4,900
USDI Bureau of Ocean Energy Management   SB150058

Maintenance, Calibration, and Deployment of a Seafet 97pH Meter

Installation of an ocean water monitoring station for the Pacific Regional Intertidal Sampling and Monitoring (PRISM). The PRISM team's monitoring of ocean pH, temperature and salinity is a partnership with broader network of agencies and university groups to track ocean acidification on the Pacific coast. Understanding major ocean changes, such as ocean acidification, necessitates a regional monitoring system with multiple sensors in the Santa Barbara Channel. The groups involved in the collaborative effort surrounding the Santa Barbara Channel have ten sensors deployed. The groups involved in the collective effort surrounding the Santa Barbara Channel are associated in different ways with the University of California, Santa Barbara (UCSB) and are listed below. Dr. Blanchette, Dr. Hoffman and their associates at UCSB have been responsible for installing and servicing the sensors, conducting the chemistry tests to calibrate sensors, and are experienced in the diving methods needed to deploy sensors in the ocean. To fill in existing sensor network gaps, the ideal location for the sensor is on Channel Islands and so we are also proposing work with the Channel Islands National Park Service.

Cheryl Briggs   9/1/2013 to 6/30/2016 $1,209,186
NIH General Medical Sciences   1R01GM109499

EID Disease in Complex Communities: Multi-host Multi-pathogen Interactions

One of the fundamental challenges facing contemporary disease ecology involves understanding infection dynamics within complex communities composed of multiple hosts and multiple pathogens. Hosts in nature are exposed to a 'cocktail' of different pathogens, therefore a central question concerns how interactions between co-occurring pathogens affect disease severity and pathogen transmission in host communities. Most research to date has been focused at a single level, examining either how multiple infections influence individual host pathology or using population surveys to identify correlations in pathogen co-occurrence within a host population. This 'disconnect' in scales (i.e., within-host vs. between- host) omits a critically important question – namely, how do pathogen interactions within hosts 'scale up' to influence between-host processes, such as transmission and disease dynamics? The primary goal of this project is to understand how interactions among three virulent pathogens at different scales of biological complexity, including within hosts, between species, and among communities, combine to influence disease dynamics in amphibians, a group of globally threatened vertebrates. This project combines cross-sectional field surveys of wetland communities with controlled laboratory and mesocosm experiments to determine (1) how amphibian pathogens covary in occurrence and intensity across multiple spatial scales (individual hosts, host species, wetland communities), (2) the individual and combined effects of each pathogen on host pathology and pathogen infection success, and (3) the net effects of variation in host and pathogen community structure for pathogen transmission and host-pathogen dynamics. A stochastic, simulation-based modeling framework uniquely focused on individual hosts will be used to interpret experimental results and link field distributions of pathogens with underlying mechanisms. This project focuses on three pathogens that have been widely implicated in causing amphibian pathology: the chytrid fungus *Batrachochytrium dendrobatidis*, the trematode *Ribeiroia ondatrae*, and the viral genus *Ranavirus*.

Mark Brzezinski   10/1/2013 to 9/30/2015 $106,104
USDI Geological Survey   G13AC00397

Wave Energy Sensor Development and Deployment

The overall goal of this study is to increase our understanding of how wave energy affects nearshore environments, especially kelp forest ecosystems. This first phase will be in preparation to determine

how marine communities (specifically kelp plants) respond to variation in wave exposure. The specific objectives are: Determine the distribution of wave period and amplitude across the study region, Determine how wave model predictions compare to empirical observations along a depth gradient

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Mark Brzezinski   7/1/2013 to 11/30/2015   **$36,219**
Dauphin Island Sea Lab   2507JK-UCSB-01

Collaborative Research: Understanding the Role of Picocyanobacteria in the Marine Silicate Cycle

The laboratory work for this project will be conducted by PI Krause at Dauphin Island Marine Laboratory. Final field experiments are scheduled out of Bermuda during the summer of 2013. Brzezinski (Lead PI) will continue his intellectual involvement in the project through regular conference calls regarding the design and execution of those experiments. He will also be directly involved in data reduction, data analysis and publication of the results of both laboratory and field measurements of Si acquisition by Synechococcus.

Mark Brzezinski   9/1/2014 to 9/30/2015   **$7,100**
Swiss Federal Inst of Technology-Dba Eth (Switzerland)   SB150133

Sedgwick Field Work

The Laboratory Assistant, Dillon Polito, will execute field and laboratory duties for research projects conducted at UC Sedgwick Reserve in the Santa Ynez Mountains and Midland School in Santa Barbara, CA. Some of the tasks include data collection, weeding, seed collecting, weighing, counting and data entry. Dillon will also help set up new experiments as necessary and will perform seed viability testing with standard procedures.

Mark Brzezinski   9/15/2011 to 8/31/2015   **$248,737**
National Science Foundation   OCE-1129227

Coupling of Silicon Isotope Distributions to Meridional Overturning Circulation of the North Atlantic

We propose to collaborate with GEOTRACES which is scheduled to sample a section across the North Atlantic in October 2011. Among the water masses sampled will be surface and mode waters, the southward flowing North Atlantic Deep Water, and it's northward flowing counterparts: Antarctic Intermediate Water and Antarctic Bottom Water. In addition, overflow waters from high latitudes may have a significant impact, as preliminary data indicate that waters from the Arctic basin have a uniquely heavy Si isotope signature.

Mark Brzezinski   12/1/2012 to 11/30/2016   **$349,538**
National Science Foundation   OCE-1233028

GEOTRACES Pacific Section: Resolving Silicon Isotope Anomalies in the Eastern Pacific

We propose to measure silicon isotope distributions along the US GEOTRACES section from Peru to Tahiti scheduled for the Fall of 2013. The silicon isotope proxy is increasingly being used to assess the role of diatoms and silicic acid in past shifts in ocean productivity and their implications for climate. It is becoming clear that successful application of the silicon isotope proxy for diatom productivity requires a mechanistic understanding of how the silicon isotopic composition of ventilating waters masses varies in time and space. Model results suggest control through the fractionation of isotopes of Si during silica production and during silica dissolution coupled to the movement of Si by biological pump and the meridional overturning circulation. Empirical support for model predictions is equivocal. The very few full ocean depth profiles of $\delta30Si(OH)_4$ reveal systematic variations among ocean basins that can be understood in terms of thermohaline circulation patterns, but in the eastern Pacific the relationship between $\delta30Si(OH)_4$ and $[Si(OH)_4]$ in deep waters are the opposite of what current models predict. The spatial resolution of the present data set is inadequate to resolve conflicting hypotheses regarding the mechanisms driving large-scale $\delta30Si(OH)_4$ distributions in this region, but we hypothesize that the North Pacific Silicic Acid Plume plays a critical role. We propose

to test model predictions regarding δ30Si(OH)4distributions within key water masses in the Pacific. Among the water masses sampled will be Lower Circumpolar Deep Water flowing from the south that should each be isotopically light due to incomplete nutrient depletion in the Southern Ocean. North Pacific Deep Water that flows into the region from the North should carry the signature the North Pacific Silicic Acid Plume. We will also investigate the influence of hydrothermal inputs along the East Pacific Rise. The strong gradient in productivity within surface waters between the Peru Shelf and Tahiti is also of interest as surface waters off Peru become preferentially depleted in silicic acid relative to nitrate. This strong decoupling of N and Si use by phytoplankton should result in contrasting N and Si isotope distributions allowing an empirical test of the ability of Si and N isotopes to predict relative nutrient depletion patterns as is assumed in paleo-applications of these proxies. We also propose to expand our current modeling to construct the first numerical model that will incorporate the influence of the North Pacific Silicic Acid Plume that may account for the anomalous Si isotope patterns in the Pacific. Broader Impacts - While we can test hypotheses regarding the controls on Si isotope distributions using the proposed ocean section it is clear from anomalies in the current global δ30Si(OH)4data set that a comprehensive test will require spatially resolved δ30Si(OH)4data from multiple oceans basins. International GEOTRACES sections completed or planned by Canada, Great Britain, France, Germany, Sweden and India include δ30Si(OH)4measurements that will compliment those proposed here. While Si isotopes are not a core GEOTRACES parameter all data collected as part of this project will be submitted to the GEOTRACES database to aid this larger global synthesis. The PI supplies both secondary standards as well as reference seawater samples to all PI's measuring Si isotopes as part of International GEOTRACES. The research will also involve undergraduates who will be trained to assist in verification of [Si(OH)4] of each sample using colorimetric methods, data entry and data management.

Mark Brzezinski   8/1/2014 to 7/31/2016   **$147,455**
National Science Foundation   DEB-1418738

UC Santa Barbara Marine Laboratory SCUBA Compressor Improvement

The UCSB marine laboratory supports the largest research diving program in the United States with faculty and students conducting National Science Foundation (NSF) funded research across a variety of campus departments including: Ecology, Evolution and Marine Biology (EEMB), Molecular, Cellular and Developmental Biology (MCDB), Geography, Geology, Physics, and Engineering as well as the Marine Science Institute, Bren School of Environmental Science and Management, and the Earth Research Institute. An upgraded SCUBA air compressor that provides air and nitrox gas will dramatically increase the safety of the campus diving program, produce more educated and capable research divers and increase the efficiency of research by allowing for longer bottom times and shorter surface intervals between research dives. Nitrox diving requires added training in physiology, safety, and equipment. Having this resource available allows the campus diving program to increase its level of American Academy of Underwater Sciences (AAUS) diver training above industry standards as well as improve our training collaborations with other educational institutions.

The UCSB marine diving community that will be supported by the new SCUBA compressor collaborates with local non□profits, educational institutions, county and state authorities, and community outreach organizations. Providing a safer and more accessible research diving program at UCSB through upgraded equipment has far reaching effects on a local, regional, and even global scale. Research divers work in a myriad of specialties that include ocean acidification, kelp forest ecology, biomaterials, fisheries, management and sustainability. The lab also provides resources to visiting researchers, both domestic and foreign, and contributes to a multitude of education and outreach programs as far reaching as Japan. As the scientific world evolves the UCSB marine lab and diving program continues to stay at the forefront helping to support new and often logistically difficult research programs.

Mark Brzezinski, Scott Simon   8/1/2014 to 7/31/2016 $15,000
NOAA   NA14NMF4690262

Captive Broodstock Holding Facility Enhancements for the Endangered White Abalone, *Haliotis Sorenseni*

During the 2011 Capitol Hill Oceans Week, former NOAA Administrator Dr. Jane Lubchenco offered that the health of the Ocean is everyone's business. The United Nations defines Ocean health as, "the condition of the marine environment from the perspective of adverse effects caused by anthropogenic activities, in particular, changes in biodiversity, genetic loss, habitat loss and alteration in ecosystem structure and processes." (International Oceanographic Commission. 2001). It is, therefore, critical to ocean health and socio-ecological resiliency that species, and the ecosystems in which they live, are protected, and studied, long-term to better understand the steps needed to maintain our most valuable resource-the Ocean. On the brink of extinction, the white abalone, *Haliotis rufescens*, was once a prolific marine snail that ranged from Point Conception, California, USA to Baja Abreojos, Baja California, Mexico (Hobday et al. 2001). Historical records and artifacts indicate that the abalone played a major socio-ecological role in the lives of the Chumash, the maritime Native Americans found from San Luis Obispo, California to Malibu, California, USA. And, until 1996, when the fishery was closed, white abalone was a major component of local commercial fisheries (Hobday et al. 2001). Due to the lack of long-term ecological data, and the threat ocean health and climate change may pose to white abalone, it is critical to preserve and propagate current, captive broodstock. This proposal request $15,000 for the maintenance and improvement of the current holding facility and capabilities of the Marine Science Institute at UCSB based on recommendations from CDFW and BBML. This is in support of the captive propagation efforts lead by the Bodega Bay Marine Lab (BBML), the California Department of Fish and Wildlife (DFW), along with the supporting efforts of the Ty Warner Sea Center-Santa Barbara Museum of Natural History (TWSC-SBMNH), the Cabrillo Aquarium in San Pedro, Ca, and the Aquarium of the Pacific in Long Beach, California. These funds will support work being conducted from Fall 2014-Fall 2015 This will be done through updates and enhancement of the current life support, sea water system and holding tanks at MSI, and salary support for research staff and an undergraduate lab assistant.

Mark Brzezinski   10/3/2014 to 12/31/2017 $500,866
National Science Foundation   OCE-1434305

GEOTRACES Arctic Section: Diagnosing the Unique Silicon Isotope Composition of the Arctic Ocean

Overview– This is a proposal to examine the mechanisms controlling silicon isotope dynamics in the Arctic Ocean as part of the US GEOTRACES Arctic section scheduled for 2015. Full-ocean depth profiles of the silicon isotopic composition of silicic acid in seawater are proposed along with measures of the Si isotopic composition of diatoms from the water column and from sea ice. These data will be used to test hypotheses regarding the biogeochemical controls on Si isotope distributions in the Arctic Ocean as well as the role of sea ice diatoms in regional Si isotope dynamics. Among the water masses sampled will be surface melt water and Pacific halocline waters that are influenced by the Bering Sea and Chukchi Sea, Atlantic waters which dominate intermediate depths throughout the Arctic, and bottom waters of the Canada and Makarov Basins. Two full-depth profiles of the isotopic composition of diatoms will test for the effects of fractionation of Si isotopes during silica dissolution.

Mark Brzezinski   9/1/2013 to 8/31/2016 $484,536
National Science Foundation   OCE-1334387

Collaborative Research: Linking Physiological and Molecular Aspects of Diatom Silicification in Field Populations

Diatoms, unicellular, eukaryotic photoautotrophs, are one of the most ecologically successful and functionally diverse organisms in the ocean. Despite accounting for <1% of Earth's biomass, diatoms are estimated to contribute ~20% of total global primary productivity. In addition to being a key component of the global carbon cycle, diatoms are also tightly connected to silicon (Si) biogeochemistry because of their obligate requirement of Si for cell wall formation and growth. It is estimated that diatoms process over 240 Teramoles of biogenic silica each year and that each

molecule of silicon is cycled through a diatom 39 times before being exported to the deep ocean. This proposal seeks to understand Si regulation of diatom productivity in the sea at the molecular level through a unique combination of state of the art tracer methods and assessments of silicon transporter expression and diversity. Success will provide new insights into the physiological basis of Si limitation in the sea and the molecular mechanisms involved.

Deron Burkepile   5/1/2015 to 4/30/2020   **$177,744**
National Science Foundation   OCE-154795

CAREER: Fish-Derived Nutrients in a Coral Reef Ecosystem-Impacts on Benthic Communities and Importance for Coral

Overview: Dramatic changes in ecosystem function often follow changes to top-down and bottom-up forcing. Importantly, alterations of both top-down and bottom-up processes may be mediated through changing the abundance of consumers. That is, in addition to altering primary producer abundance through consumption, consumers may be a significant source of limiting nutrients via their excretion. Despite the important role of both consumers and nutrients in influencing community dynamics on coral reefs, the role of bottom-up forcing by fish excretion has generally been ignored as a mechanism for altering benthic community structure.
Objectives: The goal of this proposal is to quantify how nutrients from fish excretion impact coral reef community structure and how this effect varies across environmental context. Specifically, I outline research to focus on three general sets of objectives that we will ask on reefs in the Florida Keys, USA: 1. Assess how fish-derived nutrients influence benthic community structure and coral growth and health both across and within reefs and how this influence varies with abiotic context. 2. Test how the physiology and growth of individual corals and algae respond to the different nutrient sources in fish excretion vs. anthropogenic nutrient loading. 3. Examine how fish-derived nutrients impact coral restoration and how to design restoration programs to take advantage of important of fish-derived nutrients for coral growth. I will address these questions with: (1) a field monitoring program (Objective 1), (2) mechanistic nutrient enrichment experiments (Objective 2), and (3) coral restoration experiments (Objective 3).

Craig Carlson, Emma Wear   9/1/2012 to 3/30/2016   **$90,000**
NASA   NNX12AO13H

Exploring the Role of Photobleached Dissolved Organic Matter on Bacterial Community Activity and Carbon Export Potential in Upwelling-Driven Case II Waters
Graduate Student Fellowship

I will investigate the importance of photobleaching modification of dissolved organic matter (DOM) availability to heterotrophic bacterial activity in the upwelling-driven Santa Barbara Channel (SBC), an example of episodically terrestrially-influenced case II waters in which this phenomenon has not been well studied. Impacts of photobleaching will be examined across the four dominant DOM types within the SBC: terrestrially-derived sediment plumes, phytoplankton blooms, previously degraded phytoplankton DOM such as is present during summer stratification, and aged DOM brought to the surface by upwelling. I will quantify the importance of photobleaching to DOM quality in both field samples from the SBC and laboratory-produced DOM sources using remineralization bioassays. In this approach, both photobleached and non-bleached treatments are inoculated with native bacterioplankton, and changes in dissolved organic carbon concentrations, bacterial abundances, and chromophoric dissolved organic matter (CDOM) properties (both absorption and Excitation Emission Matrix spectra) are measured intensively over days to weeks. By combining these experimental results with satellite imagery analysis of the relative abundance of DOM sources in the system (derived from ocean color and sea surface temperature analyses), I will estimate the net annual importance of photoeffects in promoting heterotrophic remineralization of DOM, as opposed to sequestration in recalcitrant forms, and attempt to assign a carbon value to those effects within the Santa Barbara Channel. I will expand on the characterization of bacterial dynamics in previous studies by examining the impact of DOM photomodification on bacterial growth efficiencies (bacterial partitioning of carbon uptake between biomass and respiration) and by designing complementary experiments to track these effects into changes in bacterial community composition.

This study directly addresses NASA's goals of quantifying and understanding an important component of the global carbon cycle, and in particular addresses outstanding questions on interactions between physical processes and oceanic biogeochemical cycles, and between terrestrial and marine systems, as identified in NASA's Pre-Aerosol, Clouds, and ocean Ecosystem (PACE) mission plan.

Craig Carlson   **8/15/2008 to 9/30/2014**   **$803,765**
National Science Foundation   OCE-0801991

MO: Collaborative Research: Transitions in the Surface Layer and the Role of Vertically Stratified Microbial Communities in the Carbon cycle - An Oceanic Microbial Observatory

The focus of this proposal is the role of bacterioplankton microbial community stratification in the ocean carbon cycle. Complex biological, chemical and physical processes control the efficiency of carbon transfer from the euphotic zone ocean to the deep sea, where sequestration is a possibility. Most organic carbon exported from the euphotic zone never leaves the surface 500m, with approximately ninety percent of the exported organic matter being remineralized in the mesopelagic zone (140-1000 m). Microbial communities are vertically stratified in the oceans, particularly in the surface layer (0-300m), which spans the region of deep mixing events and transition from the euphotic zone to the upper mesopelagic - the region of highest carbon remineralization activity. The premise of this proposal is that stratified bacterioplankton clades engage in specialized biogeochemical activities that can be identified by integrated oceanographic and microbiological approaches.

Craig Carlson   **2/1/2009 to 1/31/2015**   **$706,338**
University of Miami   P148822

Collaborative Research: Global Ocean Repeat: Hydrography, Carbon, and Tracer Measurements, 2009-2014

Dissolved organic matter (DOM), represents one of the largest exchangeable carbon reservoirs on earth. The global dissolved organic carbon (DOC) pool is estimated to be 685 Pg C, a value comparable to the mass of inorganic C in the atmosphere. Small perturbations in the production or sink terms of the oceanic DOC pool could strongly impact the balance between oceanic and atmospheric CO2. In this global ocean repeat hydrograph, carbon and tracer program D. Hansell (University of Miami) and C. Carlson of UCSB will be responsible for at sea sampling and analyses of dissolved organic carbon (DOC) and nitrogen (DON) measurements. The proposed program includes 18 legs 13 cruised conducted in various ocean basins from 2009-2014.

In this proposal, our collaborative effort is focused on collecting samples for inorganic and organic carbon on the U.S. GEOTRACES Eastern Pacific Zonal Transect will provide data between Peru and Tahiti in the eastern Pacific Ocean. Due to the influence of pH on redox chemistry, speciation and ligand-particle-TEI interactions, this region provides suitable ranges of marine seawater carbonate chemistry to investigate controls on the kinetics and dynamics of TEI's through the water-column. DOM found in natural waters includes humics, cellular exudates and organic colloidal material that contain carboxylic, phenolic and other functional groups that serve as binding sites that play a role in the complexation of some metals. Specifically, we will sample for dissolved inorganic carbon (DIC) and total alkalinity (TA), and DOC, with subsequent laboratory analyses of these samples. Highly precise and accurate measurements of DIC, TA and DOC will be provided that meet the high-bar criteria set for CLIVAR-Repeat hydrography program and U.S. time series efforts (i.e., BATS and HOT). These data allow calculation of pH and seawater carbonate chemistry (e.g., saturation sate for calcium carbonate minerals, W). Our contribution to the U.S. GEOTRACES Eastern Pacific Zonal Transect will comprise high-quality discrete water column observations of seawater inorganic and organic carbon, specifically:

Seawater Carbonate Chemistry Measurements
- Total alkalinity (TA); water-column hydrocast
- Dissolved Inorganic Carbon (DIC); water-column hydrocast
- pH (by calculation)

Seawater Organic Carbon Measurements
- Dissolved Organic Carbon (DOC); water-column hydrocast

In total, we anticipate 900 DIC and TA and up to 2000 DOC samples will be collected for this cruise with DIC and TA being analyzed at BIOS and DOC samples analyzed at UCSB. Post-analysis, the entire dataset will undergo standard QC/QA protocols, calculations of pH undertaken and subsequently entrained into the core dataset for the project. The US GEOTRACES Guidelines (http://www.usgeotraces.org/html/Proposal_Prep_Docs.html) lists a set of priority parameters to be measured in the Peru-Tahiti section. Both DIC/TA and DOC are included as essential parameters required by TEI investigators to help constrain removal, complexation and speciation of the TEIs.

Broader Impacts: It is widely agreed that the ocean biogeochemical research community needs a global view of the key and ancillary GEOTRACES properties. The major impact of this project will be its contribution to the U.S. GEOTRACES Eastern Pacific Zonal Transect through measurements of inorganic carbon. This contributes broadly to improved understanding of the inorganic and organic carbon cycle in the Eastern Pacific Ocean. Although no graduate student is supported, this award will support improved skills of two research technicians, and data will be incorporated into a teaching module about the ocean carbon cycle for the Nippon Foundation-POGO centre of excellence at BIOS and UCSB undergraduate and graduate curriculum.

Analyses of Dissolved Organic Carbon and Total Nitrogen for the Hawaii Ocean Time-series (HOT) Program

Since 1988, the Hawaii Ocean Time-series (HOT) program has provided information on time variability in biogeochemical and physical processes in one of Earth's largest ecosystems, the North Pacific Subtropical Gyre (NPSG). The program is built around interdisciplinary shipboard sampling and data collection at near monthly intervals (10 cruises/year) at the open ocean site Station ALOHA (22.75N, 158W). The multi-investigator program is based at the University of Hawaii (UH), with key long-term partners at Oregon State University (OSU), Montana State University (MSU), Scripps Institution of Oceanography (S10), and more recently (since 2004) Woods Hole Oceanographic Institution (WHOI). Measurements conducted by HOT continue to transform our view of linkages between ocean biogeochemistry, plankton ecology, and physical processes in the NPSG. Foremost among the program objectives are to quantify time-varying (seasonal to decadal) changes in

reservoirs and fluxes of carbon (C) and associated bioelements; and identify processes controlling air-sea C exchange, rates of C transformation through the planktonic food web, and fluxes of C into the ocean's interior. This subcontract will support regular program analyses of dissolved organic carbon and total dissolved nitrogen in seawater samples collected on near monthly HOT cruises. In addition, the subcontract includes funds for analyses of several years of samples previously collected by HOT to establish a new analytical baseline for these inventories of carbon and nitrogen. University of California Santa Barbara

Craig Carlson   1/1/2015 to 2/28/2021 $429,467
University of Miami   S15-49

Collaborative Research: Global Ocean Repeat Hydrography, Carbon, and Tracer Measurements 2015-2020

Summary: DOM is one of the largest of the bioreactive pools of carbon in the ocean (680-700 Pg C; Williams and Druffel, 1987; Hansell and Carlson, 1998, Hansell et al., 2009), second only to TCO2. The size of the reservoir (comparable to that of atmospheric CO_2), as well as its role as a sink for autotrophically fixed carbon, as a substrate to heterotrophic microbes (Carlson, 2002; Carlson and Hansell 2014), and as a sink/source of carbon involved in climate variations over long time scales (Sexton et al. 2011), highlights the importance of DOM in the ocean carbon and nitrogen cycles. DOC exports 1.9 PgC yr-1 out of the epipelagic zone, contributing ~20% to the biological pump via meridional overturning circulation (Hansell et al. 2002; Carlson et al., 2010). Mechanisms that control DOM accumulation, allowing it to persist and be transported to the regions of overturn, are still poorly understood. Small perturbations in the production or sink terms of the oceanic DOC pool could strongly impact the balance between oceanic and atmospheric CO_2. In this global ocean repeat hydrography, carbon and tracer program D. Hansell (University of Miami) and C. Carlson of UCSB will be responsible for at sea sampling and analyses of dissolved organic carbon (DOC) and nitrogen (DON) measurements. The proposed program includes 14 legs over 11 cruises conducted in various ocean basins from 2015 – 2020. The tentative break down of Carlson's cruise coverage is as follows:

Year	Cruise	At sea participation
2015	P16N Leg 2	Yes
2016	I08S, I09N, I01E	Yes- all legs
2017	P06 leg 1	Yes
2018	I05	Yes – all legs
2019	I06S	Yes
2020	S4P	No –sample analyses only

Sample throughput will track that of the dissolved inorganic carbon and total alkalinity measurements. DOC will be measured by high temperature combustion using a Shimadzu TOC-V or TOC –L systems with auto injection (CV of 1.5-2.5%). DON is calculated as the difference between total dissolved nitrogen concentrations this group will measure and dissolved inorganic nitrogen, measured by the hydrographic team. Oversight of project management for the UCSB component will be under the direction of C. Carlson. Sample analyses for each cruise takes approximately 9 – 16 months from receipt of samples depending on the length of the cruise. The at sea sampling personnel will be covered through a combination of PI, senior technician and student participation. Sample analyses for each cruise takes approximately 9 – 16 months from receipt of samples depending on the length of the cruise.

Jennifer Caselle   4/1/2014 to 12/31/2015 $10,930
National Geographic Society   W311-14

Exploration of Apex Predators and Deepwater Biodiversity in an Unfished, Pristine Atoll

Northern California's coast has many long and pocket beaches located within the boundaries of the region's newly established MPAs. These ecosystem elements have regionally important ecological, cultural, recreational and commercial facets and are important indicators of coastal ecosystem health. The objective of this project is to provide a comprehensive baseline assessment of the biodiversity,

structure and ecosystem state of sandy beaches and surf zones at the time of MPA implementation. We will 1) provide the first comprehensive, baseline description of the diversity and community structure of northern California's sandy beaches and surf zones (including wrack, macroinvertebrates, surf zone fishes and marine birds, as well as people and their activities); 2) collaborate with Smith River Rancheria and train tribal interns in monitoring methods and species identification to conduct baseline ecosystem assessment and long-term monitoring of culturally important species in their ancestral territories; 3) engage local environmental educators, schools and community volunteers (e.g., Mattole Restoration Council, Mattole Triple Junction High School, the Mattole Union Elementary School (grades 4-8) Mendocino High School), including recreational fishers (Humboldt Area Saltwater Anglers Association, Recreational Fishing Alliance), county/state agencies (Humboldt Bay Harbor Recreation and Conservation District, Mendocino Fish and Game Commission, California Department Fish and Wildlife), and commercial fishers (California Commercial Beach Fishermen's Association) to help with sandy beach and surf zone monitoring; and 4) interpret the important ecological links among sandy beach species for use in evaluating the effectiveness of northern California's MPAs in conserving the structure and function of sandy beach ecosystems.

Jennifer Caselle   6/24/2014 to 4/30/2016   **$85,281**
UC Santa Cruz   UCSCMCA-14-009

Scientific Collecting Permits, Rockfish Dispersal, and Kelp Forest Monitoring

Background and Objectives: We propose to continue monitoring surveys of kelp forests inside and outside of a subset of MPAs in central and southern California initiated during the baseline characterization in 2007/2008 and 2012/2013, respectively. The proposed funding from CDFW will enable PISCO to maintain kelp forest surveys that are critical for informing MPA management, and detecting the impacts of major ecological events, such as a recent coast-wide sea star wasting event. In 2013-2014, an outbreak of sea star wasting syndrome of unprecedented geographic extent was observed from Alaska to the Mexican border. Since the first observations of mass wasting were made in central Oregon, in April of 2013, subsequent observations have shown the wasting syndrome to be widespread (if spatially heterogeneous) and to impact a number of different sea star species that occur in the rocky intertidal and subtidal kelp forests. There is also some anecdotal evidence that the wasting syndrome may be impacting urchin species, including the commercially important red urchin. Echinoderms can play an important role in structuring marine communities and when their abundances decrease by natural or anthropogenic causes (i.e. overfishing, disease), communities can experience phase shifts that may impact the abundance of a variety of commercially and recreationally important fish and invertebrate species. To date, most of the work on sea star wasting has occurred in the rocky intertidal. We propose to fill existing knowledge gaps by characterizing the short-term impacts of the wasting event in kelp forest ecosystems in central and southern California

The objectives of the work are twofold:

1. To fill existing knowledge gaps by characterizing the patterns of sea star decline in kelp forest systems in central and southern California.

2. To simultaneously survey the kelp forest community at existing PISCO sites to contribute to long-term monitoring of MPAs

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Jennifer Caselle, Carol Blanchette   9/1/2011 to 12/31/2015   **$265,000**
UC Sea Grant College Program   R/MPA-23

Integrative Assessment of baseline ecological and socioeconomic conditions and initial changes within the South Coast MPA region

The SCSR of the Marine Life Protection Act is unique from other regions in several aspects. First, southern California marine ecosystems are among the best studied anywhere in the state (and, arguably, the West Coast). Second, the South coast study region is the third region in the MLPA process (after the central and north-central regions) and also follows the successful implementation of a network of MPAs in the northern Channel Islands in 2003 and now part of the MLPA network. More than other MLPA regions, a large body of both ecosystem monitoring data and a wealth of

contextual data exist (e.g. oceanographic and water quality data, remotely sensed data, habitat maps). However, many of these datasets have yet to be analyzed outside of the context for which they were originally created and even monitoring data from similar habitats have yet to combined into synthetic measures of ecosystem health. Here we have the opportunity to create the partnerships and data products that will be required in order to step up from single location or single habitat analyses and for the first time, move towards cross ecosystem syntheses to support measures of ecosystem health and MPA performance. We have developed a collaborative group that has committed to the goals of synthesis among our various individual projects. The key innovation of our proposed approach is the collaborative nature of the program, which should carry forward in the design, databases and analyses for a more comprehensive and integrated long-term monitoring program. The collaborative and integrated characterizations of separate ecosystem features will also facilitate outreach efforts that transcend individual features and, by including collaborations with the fishing (consumptive) and recreational (consumptive and non-consumptive) sectors, strengthen collaborations of future monitoring programs.

Jennifer Caselle   9/1/2011 to 6/30/2015   **$269,804**
UC Sea Grant College Program   R/MPA-27B

South Coast MPA Kelp and Shallow Rock Ecosystems: Baseline Data Collection and Long-term Trends Using Historical Data

Our approach to creating a baseline characterization of kelp and shallow (0-30m depth) ecosystems in the MLPA South Coast Study Region (SCSR) involves (1) new surveys of targeted elements of kelp forest and rocky reef ecosystems using SCUBA and (2) analysis of existing historical datasets on rocky reef communities. Sampling will address all kelp and shallow rock ecosystem Vital Signs (Ecosystem Feature Checkup) and Key Attributes (Ecosystem Feature Assessment) as designated by the Monitoring Enterprise (ME) in the Monitoring Plan for the South Coast MPA Baseline Program with the exception sea otters and predatory birds. Our proposed sampling design and protocols are a geographic extension of comparable design and protocols that are being used to generate baseline characterizations of kelp and shallow rock ecosystems in the Central Coast Study Region (CCSR) and the North Central Coast Study Region (NCCSR). Further, the study design and protocols were also employed in the network of MPAs in the Northern Channel Islands (NCI), which were implemented in 2003 and now form part of the SCSR. Results from these methods were incorporated into the successful five-year data review of the NCI MPAs (Airame and Ugoretz 2008; Hamilton et al. 2010). We propose to maintain similarities in the design and protocols to maintain standardization across the Study Regions until necessary changes in design or sampling protocols are identified.

Jennifer Caselle, Robert Warner   9/24/2012 to 12/31/2015   **$269,968**
The Coral Reef Alliance (CORAL)   SB130041

Understanding Coral Reef Resilience to Advance Science and Conservation

By developing a novel reef resilience model—based on synthesis of existing data and targeted new observations, and informed by a systematic analysis of management and conservation needs—scientists will have a critical new understanding of coral reef ecology and resource managers will be poised to apply this knowledge for improved conservation outcomes.

Jennifer Caselle   3/30/2012 to 12/31/2015   **$525,000**
Marisla Foundation   1-12-065/3

Coral Reef Research in a Rare, Undisturbed Ecosystem: UCSB and Palmyra Atoll

The Marine Science Institute at UCSB requests continued funding to remain a member of the Palmyra Atoll Research consortium for 2012-2014 in order to continue and expand our research programs focusing on coral reef ecosystem resilience and conservation. The major outcomes will be a better understanding of how healthy coral reef ecosystems function in the face of climate change and knowledge to inform conservation practices globally.

Jennifer Caselle   4/1/2012 to 3/31/2015   **$212,846**
UC Santa Cruz   UCSCMCA 12-005

Regional Importance of Manmade Structures as Rockfish Nurseries

1) Assist in Establishing Sampling Design for Field Surveys Using the geodatabase developed by USGS and the recommendations obtained from the workshop on best approaches and statistical methods for geospatial analyses, the subcontractor (UCSB) will assist USGS in developing a field sampling design to determine, at the appropriate regional scale, the relative importance of nursery habitat created by offshore energy structures for commercially important rockfishes. 2) Conduct Field Surveys The subcontractor (UCSB) shall oversee field surveys conducted according to the sampling design established in Task 1. The field survey data shall be incorporated into the geodatabase. The field surveys shall collect biological information, and in particular juvenile fish density, concurrent with geological data. At each sampling unit "visual vouchers" shall be collected by recording underwater site characteristics with photographic images. These images can be linked to the geodatabase and referenced at a later date to determine if geological features influence patterns or rates of long term change in biological communities.

Celia Churchill, Todd Oakley   4/1/2014 to 3/31/2016   **$9,654**
Australian Museum, Lizard Island Research Station   SB14014

Interactions between a Crustacean and an Alga: The First Marine Arthropod with Photobionts?

Relationships between marine invertebrates and photobionts (photosynthetic endosymbionts) are not only fascinating biologically, they can comprise the energetic foundations of marine ecosystems (1, 2). Representatives of many invertebrate metazoan phyla house photobionts, yet while this evolutionary strategy appears successful over a wide taxonomic breadth, the number of times it has evolved is rare (3). Because of their often critical ecological roles and sensitivities to environmental perturbations, photosynthetic holobionts serve as ecosystem indicators (4). On a recent trip to Lizard Island Research Station, I found an undescribed philomedid ostracod (Ostracoda: Philomedidae) that appears to have photosynthetic endosymbionts (Fig. 1a). Upon initial examination, this species has an unusually colorless and translucent carapace, and a greenish hue is present both on the inner carapace membrane and on the ostracod's body. Removing one of the shells reveals that each fossa of the carapace has an associated spot of green algae on the inner carapace membrane (Fig. 1b), and that the spots on the body are not in the gut, but around the gut (Fig. 1c) and in some of the limbs (Fig. 1d). To date, there are no known photosynthetic holobionts involving a marine arthropod. A postdoctoral fellowship to conduct field work at LIRS so that I may characterize the type of algae present in this remarkable ostracod, and test whether the ostracod sources nutrition from the alga.

Jennifer Caselle   3/30/2012 to 12/31/2015   **$525,000**
Marisla Foundation   1-12-065/3

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Chris Costello, Steven Gaines 9/1/2014 to 9/1/2015 **$101,500**
The Nature Conservancy SB150055

Making the Case for Fisheries Reform in the East China Sea

Working with the Conservancy, the University will, data permitting, assess the current status of fisheries in the East China Sea and explore the economic case for fisheries management reform. This analysis will be comprised of the following key activities: Evaluation of the current biological status of the fishery: the availability of detailed fisheries information will determine the analytical methodology used for this analysis. If extensive data for individual fish species are available, the University will develop assessments at the species level for as many target species for which adequate data are available and as time allows, starting with the highest value fisheries. If data at the species level are more limited (e.g., catch data are not reported by species but as landings of miscellaneous marine fish), the University will apply the method from Costello et al. (2012) to the East China Sea data. The output of this method is the current biomass relative to the biomass at Maximum Sustainable Yield for each fishery, which gives an indication of the exploitation status of the stocks. Evaluation of the case for economic reform of Chinese fisheries: the University will evaluate the economic case for reform by quantifying the lost revenues and food production implications of overexploited fisheries and the potential upside of recovery. The detail and extent to which these economic projections can be derived will depend on the availability of data on fishing effort and fishing costs.

Christopher Costello 5/1/2015 to 9/1/2015 **$27,500**
Nature Conservancy SB150157-7

Improving the Management of Peru's Anchoveta Fishery, Task #7

In collaboration with The Nature Conservancy, the Sustainable Fisheries Group at the University of California, Santa Barbara will develop tools to allow key decision makers and stakeholders to explore the economic and social consequences of different scenarios for quota allocations within the anchoveta fishery of Peru. Assessment Tool: The main deliverable of the project will be a management assessment tool provided in non-technical software, such as Microsoft Excel. This tool is intended as an interactive platform to inform the decision-making process when setting and distributing quota amongst the sectors in the fishery. It will be designed to be used by a variety of user groups with diverse technical backgrounds to facilitate exploration of the likely consequences of different management decisions. The users will be able run a comprehensive model that incorporates both the estimated natural state of the fish stock and the socio-economic dynamics within different components of the fishery. As outputs, this model is expected to produce the following projections under a variety of management scenarios:

- Expected harvest and profits at both aggregate and sector levels.

- Expected effects on price for both fishmeal and human consumption markets.

- Incentives for illegal extraction.

- Tradeoff analysis between fleets.

This set of indices should allow decision makers to explore a wide dimension of impacts in the industry when setting quotas and their allocation in across the fleets. The model should be flexible enough so managers are able to correctly assess the end point effects of different management strategies, as well as the advantages and disadvantages of further regulation schemes and modifications

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Global Fishery Status: Current Synthesis and Future Projections

Executive Summary We propose generating the most comprehensive snapshot of the health of global fish stocks by integrating RAM Legacy, FAO, Unassessed, and NEI analyses. Background There is considerable and growing interest in the status, projected trends, and solutions for global fisheries. Yet somewhat surprisingly, no database or analysis provides a globally comprehensive picture of the current biological status of global fisheries that covers both large and small stocks and uses the detailed information available for the better studied fisheries of the world. Previous attempts to provide global summaries have relied only on the catch data from FAO (Pauly et al. 2007, Halpern et al. 2012) which by itself does not provide a reliable estimate of stock status (Branch et al 2011). In 2009, with a global analysis of about 300 fisheries that contain stock assessments, Worm et al. (2009) provided the first credible analysis with global extent using the RAM Legacy database. The authors found a large range of status –some fisheries were heavily over-exploited with biomass levels well below levels that would produce maximum yield (e.g., in Europe), while others appeared to be well-managed (e.g., in the western United States and New Zealand). While incredibly informative, that analysis provided only a limited global picture; stock assessments are expensive and labor intensive and as such, these fisheries constituted less than 20% of global catch and only a minute fraction of the world's fisheries. Thousands of developing world and/or relatively small stocks, which are important for conservation and local food security, are largely overlooked by assessments. The FAO SOFIA database covers 395 stocks covering a larger fraction of the world's catch by providing qualitative rather than quantitative assessments of stock status. But similar to RAM Legacy, SOFIA also focuses on larger scale, industrial fisheries and has almost no coverage of small-scale developing world fisheries. In response, Costello et al. (2012) developed a method to estimate stock status (B/Bmsy) for thousands of unassessed fisheries using data that are widely available, including species' life history, catch, and fishery development data. This study found that small unassessed fisheries are in substantially worse condition than assessed fisheries, but that large unassessed fisheries may be performing nearly as well as their assessed counterparts. It also found that both small and large unassessed stocks, however, are on a continued trajectory of decline. However, even this database, which dramatically expands the number of fisheries for which we have stock status estimates, leaves out many fisheries, particularly very small-scale fisheries and fisheries for which catch is reported as mixed species. Despite the contributions of these three databases, there are still several important limitations to our understanding of global fish stock status. First, there has been no attempt to combine these databases into a unified database that would provide the most comprehensive view to date of global stock status. Second, as highlighted above, there are a number of types of fisheries that none of these databases cover. These missing fisheries include large (roughly 30% of reported catch) fisheries whose catch is reported to the FAO in very large taxonomic aggregates(e.g., "Marine Fishes NEI,"an aggregate group consisting of potentially hundreds of species), very small stocks (catches less than 3,000 tons per year) for which the FAO catch data are considered very unreliable, and illegal, unreported and unregulated (IUU) fisheries for which we have no data. Third, the potential of global fisheries need to be comprehensively evaluated. There is a need for reliable forecasts of what fish catches and stock status will look like in the coming years if we continue with the status quo versus implement changes to fishing practices, regulations and institutions. The objective of this project is to address these three important shortcomings and produce a globally synthetic view of the current status and potential trajectory of fisheries around the world. Goals and Objectives Researchers from the Sustainable Fisheries Group at UC Santa Barbara and from the University of Washington, with input from California Environmental Associates, will develop the most comprehensive global database of fishery stock status and fishing pressure, and use this database to provide an assessment of current fishery status and trends given status quo management.

Christopher Costello, Steven Gaines	12/31/2012 to 12/31/2016	$2,261,324
Waitt Family Foundation		SB130076

Sustainable Ocean Solutions through Rights-Based Management, Fisheries Certification, and Marine Protected Areas

The Sustainable Ocean Solutions (SOS) project, made possible by the generous support of the Waitt Foundation, combines three important tools for ocean sustainability – rights-based management reform, marine protected areas, and demand-side incentives – into novel solutions for the world's fisheries challenges. When employed individually, these three instruments can only successfully tackle a small percentage of ailing fisheries worldwide. A central challenge is to develop fisheries management systems to facilitate synergies among these approaches, thus capitalizing on their complementary strengths while overcoming their individual weaknesses. Although the necessary elements may differ across fisheries and settings, by combining changes that affect the supply of fish (such as catch shares), with conservation measures (such as MPAs), and tools that change consumer demand (such as fisheries certification), fisheries, communities, and ecosystems can simultaneously prosper. Our approach This project uses a two-pronged approach, focusing on 1) research and development, determining how and in what contexts to combine the sustainability tools of marine protected areas, property-rights based management, and demand-side incentives, and 2) demonstration projects, strategically selected as proofs of concept, which, if successful, will be scalable across the globe. The demonstration projects will link our research and development expertise with innovative partners who have proven skills at implementing reform in national and international settings.

Christopher Costello Steven Gaines, Robert Deacon	2/1/2012 to 9/30/2014	Core - $126,077 Trainee - $80,211
Washington Sea Grant		R/SOC-01-F-1/2

Social and Economic Effects of ITQs on the West Coast Groundfish Fishery: Solving the Weak Stock/ Bycatch Problem

The objectives of the proposed work dovetail with several key WSG priorities: (1) Maintain the vitality of coastal communities, particularly balancing economic growth with sustainable use of fishery resources: Our modeling analysis will examine social, economic and ecological outcomes of different management approaches to identify options that meet this important triple bottom line for fishing communities along the West Coast. (2) Identify social and economic impacts and benefits of fishing: Our empirical analyses will identify the short-term social and economic impacts and benefits of a transition to IFQ management in the West Coast Groundfish fishery, while our modeling work will suggest likely longer term impacts and benefits of this and other key management changes (consolidation caps, spatial closures, etc.). (3) Understand ecosystem effects of fishing: Bycatch of weak stocks compromises the health of marine ecosystems and our modeling results will demonstrate the range of circumstances under which risk pools or other shifts in fleet behavior can overcome this challenge. Both our empirical and modeling work will inform effective internal rules for risk pools. This will result in a novel contribution to the scientific literature and a practical and cost-effective approach to protecting ecosystem integrity. (4) Evaluate alternative management approaches for fisheries: Our simulation modeling of "policy experiments" will inform near-term management changes for the West Coast Groundfish fishery, while also providing a framework for other US fisheries that may similarly benefit from reform. We will communicate the results of this project through numerous scientific publications and presentations to fishery managers, fishermen, and regulators. This project will also provide training in cutting-edge science at the interface of bioeconomic modeling, empirical analysis and fishery management to two graduate students.

Christopher Costello	9/1/2011 to 8/31/2016	$125,705
University of Washington		UWSC6489

CNH: Diversification, Portfolio Effects, and the Sustainability of Fishing Communities

This project concerns the bioeconomics of fishery management under uncertainty, a topic that Professor Costello has focused on for his past 11 years at UCSB. Costello's primary role will be to develop

and implement analytical and statistical models to address the research proposal's key themes. Specifically, Costello will play a leading role in developing and implementing models of salmon fishery management strategies that explicitly cope with environmental variability, tradeoffs between ecosystem sustainability and economic performance of salmon fisheries management, and how capital investment in salmon fisheries is influenced by environmental stochasticity. What follows is a brief description of Costello's role in each of these themes: Theme 1: Salmon Management with Environmental Variability. The key research question here concerns how management decisions can influence the ecological and economic consequences of a variable environment. Alaska's salmon fisheries are notoriously variable, largely due to highly stochastic interannual and decadal-scale fluctuations in the environment that affect reproduction, recruitment and growth. Ignoring this variability in the determination of management strategies can have severe consequences to both fishermens' livelihoods and to fish stocks themselves. Costello's role will be to develop and implement dynamic stochastic optimization models that predict and inform optimal management of this bioeconomic system. These models will be parameterized with data from other aspects of the project and will be implemented in Matlab. Theme 2: Tradeoffs between sustainability and economic performance. Any given management strategy will deliver both an ecosystem outcome and an economic performance. This theme concerns the tradeoff between those two. It is sometimes argued that these two always go hand-in-hand: higher economic performance is always coupled to positive ecological outcomes. While it is widely acknowledged that a collapsed fishery cannot produce optimal economic outcomes, it is not so obvious that a fishery managed for optimal economic performance results in strong ecological condition. Costello will develop stochastic models of decision-making under uncertainty to address this theme. He will also develop a tradeoff analysis which provides a graphical depiction of the tradeoff between ecological and economic objectives for different strategies for managing salmon fisheries in Alaska. These are analytical and computation approaches, and Costello will develop both theoretical insights and practical solutions for this particular study region. Theme 3: Capital Investment in Stochastic Fisheries. Salmon fisheries are notoriously capital intensive. Processing salmon requires large plants that depreciate rapidly. These plants are expensive to build and maintain, and must be sufficiently large to handle the large volumes of fish that are landed in short periods of time. This theme addresses the question of how much harvest capacity is efficient, and how much harvest capacity would we expect from the private sector. Risk and variability in harvest size over time both influence these questions. Costello's role will be to model capacity investment in Alaska's salmon fisheries and to predict the capacity investments we would expect from the private sector under different management approaches. The results of these models will inform management of Alaska's salmon fisheries. This work is both analytical and computer-based. Costello will work by himself to accomplish these tasks. Pending other funding sources, there may be funds to hire a PhD student or post-doc to work with Costello on these items. Costello will also be a central player in the larger research team. He will travel to Alaska annually, and will collaborate with other personnel to achieve the broader goals of this ambitious research project.

Carolynn Culver   7/1/2012 to 3/31/2015 $220,907
Stephen Schroeter
UC Sea Grant College Program   R/OPCCFRW-2A-S

Integrating Collaborative Data Collection with Management: A Lobster Fishery Test Case

This project addresses the critical need for cost-effective ways to gather essential fisheries information for managing California's fisheries. Our team of fishermen, managers and scientists will work together to test the feasibility of integrating a collaborative at-sea sampling program, where fishermen collect data at sea and are engaged in its interpretation and forming associated recommendations, with the fisheries management process. Our objectives include: 1) determining the key regulatory, administrative and operational features of established collaborative fisheries data collection programs, 2) developing a robust sampling design with associated protocols for the lobster fishery, 3) designing, testing and modifying the components of a collaborative at-sea sampling program, and 4) developing a plan for sustaining the program into the future. By addressing these objectives we will utilize established programs to inform development of a program appropriate to California; develop sampling protocols that ensure appropriate, accurate data are collected; develop data management protocols for handling and sharing the collected data; and identify ways to fund and administer the program for the long term. Such an accomplishment may move collaborative fisheries research to a

new level, where it can provide continuous, high-quality information for managing diverse fisheries, not solely to address a specific management question.

Carolynn Culver   4/11/2014 to 12/31/2014   **$32,400**
United Water Conservation District   SB140158

Assisting with Quagga Mussel Management Activities in Lake Piru

We propose to assist with the management of quagga mussel infestation at Lake Piru using an integrated pest management (IPM) approach. While eradicating may be achieved down the line, the goal of these efforts is to greatly reduce the quagga mussel population to minimize recolonization of mussels throughout the lake.

Carolynn Culver   8/1/2011 to 1/31/2016   **$58,295**
UC Sea Grant College Program   A/EA-14CC-F-1

Sea Grant Extension Program Funds

Sea Grant Extension Program Funds This award is in support of Dr. Culver's Sea Grant Extension program. This program is focused on discovering and transferring science-based knowledge to help California and its residents better balance the competing needs of using and conserving coastal and marine resources for future generations. Funds will be used to support activities and operating expenses for her research, education and extension program. Some funds are allocated toward support staff that will assist Culver with program activities, including undergraduate assistance with assembling and processing of samples and office support. General operating expenses are also included for such things as telephone, duplication, IT support.

Carolynn Culver   12/1/2011 to 9/30/2014   **$25,000**
Collaborative Fisheries Program   12-54

Developing a Collaborative Volunteer Network for Expanding Biotoxin Monitoring in California: Improving Seafood Safety

The goal of this project is to improve seafood safety of commercial and recreational fisheries in California by improving monitoring of biotoxins. Objectives are fourfold: 1) develop a coordinated network of collaborators to expand biotoxin sampling in southern California; 2) develop effective, efficient, user-friendly sampling, communication and reporting protocols, 3) train collaborators and pilot test network program, and 4) identify needs for HAB outreach materials for the fishing community. The overarching research question is: Can the existing CDPH monitoring program be expanded and enhanced through the development of a collaborative network of volunteers from fishing and coastal communities?

Carolynn Culver, Andrew Brooks   9/1/2011 to 8/31/2014   **$99,447**
USDA   2011-34103-30856

Minimizing Impacts to Urban, Agricultural and Natural Water Systems: Evaluating Biocontrol Agents for Invasive Eurasian Mussels

This research project addresses integrated pest management for invasive quagga (*Dreissena bugensis*), and potentially zebra (*D. polymorpha*), mussels that impact agricultural, urban and natural freshwater systems throughout the Western Region. Our goal is to evaluate the feasibility of fish predators as site specific (not system-wide) biological control agents for quagga mussels. Objectives include: 1) determining whether the planktivorous threadfin shad, *Dorosoma petenense*, can minimize mussel infestations through predation of larval mussels and 2) evaluating whether the carnivorous redear sunfish, *Lepomis microlophus*, can reduce mussel infestations through predation of juvenile and adult mussels. We will contain these fishes in experimental cages with substrates and quantify mussel infestations on the substrates over time. Differing substrate orientations, water depths and mussel densities will be examined to address variability in mussel infestations in the Western

Region. Commonly used mussel control methods (mechanical removal, chemical applications) are problematic for systems in the Western Region that largely serve as water sources for humans and/or are open systems. Biocontrol agents offer an ecologically sound solution for minimizing pesticide use, as well as human contact required to remove mussels mechanically. This approach supports W-RIPM program priorities by investigating methods that protect environmental quality, reduce health risks associated with application of management strategies to drinking water and irrigation systems, and provide an additional tool that targets multiple life stages of a pest through an integrated management program. It also addresses a high priority research need identified by the Western Regional Panel of the federal Aquatic Nuisance Species Task Force.

Carla D'Antonio   9/1/2010 to 8/31/2015   **$587,453**
National Science Foundation   DEB-1029168

Long Term Impacts of Grass Invasions and Fire on Community Change and Plant Soil Feedbacks

Ecologists generally lack knowledge about the long-term effects of biological invasions, and how invader-induced changes in ecosystem processes may alter the potential trajectory of a site. While it is often assumed that invasions exist in persistent alternative stable states, it may also be the case that the impacts of invaders will shift over time such that exotic species no longer reinforce their own dominance. In Hawai'i Volcanoes National Park (HAVO), exotic grasses invaded seasonally dry forests in the 1960s, altering plant communities both via direct competitive interactions with native species and by promoting a new type of disturbance, fire. In the short-term, N-limited grasses facilitate themselves by establishing higher N cycling rates and fire frequencies. Therefore, exotic grasses maintain their dominance through suppression of native species recruitment early in succession, creating a stable condition in which restoration is extremely difficult. This proposal hypothesizes, that in the long-term, a lack of native species lowers plant uptake of N, leading to overall N losses from the system, especially in the absence of fire. This scenario would lower soil nitrogen availability ultimately leading grasses to decrease their own dominance via changes in ecosystem function. In essence, positive feedbacks between invaders and ecosystem function may change to negative feedbacks. If this has occurred, it is unclear whether the lower N availability will favor recovery of native species or invasion by a new suite of invaders. The research will evaluate species composition and nitrogen cycling in burned grass-invaded sites that were studied in detail in the 1990s but which have not yet burned again. To ask how N cycling has changed over time, net soil N fluxes, as well as plant net primary productivity and N uptake, will be tracked over two years in burned and unburned sites. These data will then be compared to historical data taken between 1994 and 1996 offering a rare test of the long-term ecosystem impacts of biological invasions. Next, this proposal evaluates the long-term effects of fire and invasion on plant community composition with a set of competitor removal, fertilization, and seedling outplanting experiments. These specifically ask how changes in soil N cycling alter the ability of invaders to remain dominant, for new invaders to establish, or for native species to re-establish.

Carla D'Antonio, Nathan Emery   7/1/2013 to 12/31/2015   **$16,766**
National Science Foundation   DEB-1311605

Dissertation Research: Fog and the Fire Regime in Southern California Shrublands

Research objectives: Fire is a well-studied disturbance that has had important ecological and evolutionary influences on species and environments around the world. One region with regular fire disturbance is the Mediterranean-type climate region of California. Characterized by cool, wet winters and prolonged summer drought, wildfire in these areas is typically high intensity and has dramatic ecological and economic consequences. A common climatic event along the coast of California is seasonal fog which may provide additional moisture for shrubs during the summer drought. My dissertation research will take a multi-scale approach evaluating how fog affects key variables controlling the fire regime focusing on shrubs in the Santa Barbara region and on regional scale patterns along the California coast. As part of understanding how fog influences the fire regime, the proposed research will focus on two main questions: (1) Do chaparral and coastal sage scrub species in this region use fog water? and (2) How can we improve the soil water evaporation correction applied by studies of plant water relations using stable isotopes of Hydrogen and Oxygen?

Methods and Analysis: To address the first question, I will extract water from soil and plant samples collected in 2011, 2012 and 2013 and send them to UC Berkeley for stable isotope analysis. I will chose which samples to extract and analyze based on my field data quantifying fog deposition and live fuel moisture of the shrub species at my field sites. I will compare changes in xylem water signatures between dates with substantial versus minimal fog deposition. The isotopic data will be corrected for soil water evaporation and analyzed with a two-part mixing model to determine the proportion of fog water use for the each species. For the second question I will follow protocol of previous studies but sample from deeper into the soil profile to establish the depth at which soil evaporation fractionation occurs. This sampling will focus on three times of year, and will establish separate soil evaporation corrections based on depth and time of year. All of these samples will be extracted in a cryogenic vacuum extraction system and analyzed at the Stable Isotope Facilities at UC Berkeley. The results will be used to calculate proportional fog water use (Question 1) and determine the accuracy of this type of correction. Intellectual Merit: Understanding fire disturbance regimes in Southern California is a high priority for science and society because of the high costs of fighting and recovering from fire. My dissertation will establish the relationship between fog and fire while informing the greater scientific community about the controls on fire patterns in coastal California. This study will effectively connect changes in source water to changes in live fuel moisture content, a critical component of the National Fire Danger Rating System as well as numerous fire modeling efforts. The soil water evaporation correction is used for studies of water isotopes in semi-arid ecosystems. The proposed research will improve upon this established technique to further the field of stable isotope ecology. Lastly, this study will be the first attempt to connect a rarely studied climatic event, fog, to disturbance regimes. Broader Impacts:(1) The results from this study will enter the scientific discourse through publications and conference presentations at the local and international scale. (2) I plan on submitting my isotopic data to the Global Network for Isotopes in Precipitation. (3) I will present my work at local and regional venues where fire managers will be present (e.g. Santa Barbara Botanic Garden lecture series and working groups on fire). (4) I have a deep commitment to involving undergraduates in research and mentoring them, especially underrepresented groups. In addition to mentoring undergraduates, I will continue to work with outreach programs offered through UCSB for mentoring young scientists including high school students. The proposed research will involve several undergraduate interns and high school mentees in the lab during the school year and in the field during the summer season.

Daniel Dawson, Susan Swarbrick   7/6/2012 to 6/30/2016   **$1,412,000**
Department of Cal Ra Fish and Game   WC-1183CF

Infrastructure and Facility Improvements at the Sierra Nevada Aquatic Research Laboratory (SNARL)

The Sierra Nevada Aquatic Research Laboratory (SNARL) is a unit in the University of California Natural Reserve System (NRS) administered by UC Santa Barbara (UCSB) and located near Mammoth Lakes, California, along the eastern escarpment of the Sierra Nevada mountains. The station was established in 1935 and has served as an experimental site and as a base of operations for research across a large part of the Sierra Nevada, eastern California and western Nevada. Researchers from throughout the US are regular users of the facilities, and the studies range widely among the life and physical sciences. By commonly used metrics (user-days, publications in peer-reviewed journals) the station is very well used, highly productive, and of national caliber. Facilities at SNARL are possibly the most extensive in the UC NRS and are generally in excellent or very good condition. The laboratory building, constructed in 1962 with an addition in 1987 was remodeled this year as part of this project. This $529,275 project was funded by a combination of U.S. National Science Foundation and donor funds and is part of the match for this proposal. Valentine Camp, another unit in the UC NRS is located approximately 15 miles west of SNARL adjacent to the Town of Mammoth Lakes. The two sites are jointly administered as Valentine Eastern Sierra Reserve (VESR). Dan Dawson, the Principal Investigator on this project, has been the Director of the two sites since 1979. Valentine has different attributes and habitats that make it an excellent complement to SNARL. As the facilities at SNARL support activities at Valentine, a portion of accumulated Valentine endowment funds are available for this project. With this project we propose to complete Phase 2 of our Master Plan by replacing some aging infrastructure and constructing a single new building at SNARL. Specifically

we propose to:

- Replace the concrete control structures in Convict Creek that are part of our one-of-a kind experimental stream system;
- Grind, reshape, and repave our existing asphalt roadway and parking areas;
- Install a new water line and power line under the road and parking areas;
- Construct a new classroom/lecture hall adjacent to other facilities.

Thomas Dudley   **11/29/2010 to 11/29/2015**   **$476,000**
USDI Fish and Wildlife Service   F11AC00779

Research and Restoration through the Santa Clara River Reserve: A Proposal to Develop a University of California Research and Education Station

The objective of the Santa Clara River Reserve project is to build a multi-functional station to provide facilities, infrastructure and an institutional framework to carry out environmental studies and natural resource policy research that integrates existing information with newly acquired data to support conservation of biodiversity, ecosystem processes and agricultural sustainability in the SCR watershed. The broad mission of our University of California program in the Santa Clara watershed consists of three general objectives: Research Station Development: Build the organizational structure to locate, design and develop the financial basis for, and implement the construction of the dedicated research station and reserve; Research and Education: Develop a research program that integrates existing resource information and undertakes or facilitates new research and monitoring initiatives that promote biodiversity conservation and agro-ecosystem sustainability; Riparian Restoration: Evaluate and implement comprehensive restoration programs, in concert with regional partners, to reduce impacts of invasive species, biological pollutants, and other stressors to enhance the structure and function of floodplain ecosystems and protect habitats for native terrestrial and aquatic species.

Thomas Dudley, Carla D'Antonio   **3/1/2015 to 2/28/2018**   **$157,568**
Desert Botanical Garden   UCSB 03012015

Host Plant Allocation Strategies and Mortality in Response to a Specialist Herbivore

UCSB will provide via the post□doctoral associate identified in this grant the co□ordination of all field and laboratory elements of the project, including oversight of experimental plant propagation facilities at Boulder City, NV and Yuma, AZ. He/she will have primary responsibility for ensuring sampling regimes are implemented according to plan, and that sample analyses and data management are collated into format suitable for data analysis and report preparation. Post□doc will work directly with PD and Cooperating scientists to develop and implement experimental protocols, as well as providing oversight of other personnel associated with field elements of the project. Dudley will also travel to participate in field activities and UCSB□associated travel costs will be borne by the sub-contract to UCSB, and he will provide supervision along with D'Antonio for the post□doctoral researcher."

Thomas Dudley   **7/1/2014 to 9/30/2015**   **$1,496**
UC MEXUS   SB150006

Riparian Restoration and Invasive Species Control in the Lower Colorado River of Northern Mexico

This project is intended, then, to provide the tools and the information necessary for understanding and responding to the anticipated arrival of the Tamarisk Leaf Beetle and its potential impacts to non-native vegetation in the Lower Colorado River/Delta region. While we will focus in this project on short-term (1-2 years) implications of tamarisk biocontrol in riparian systems, it is intended as an initial step toward what we visualize as a long-range (minimum 10 years) collaborative program to manage and restore riparian ecosystems and associated biodiversity and economic values in this globally important landscape. The basis for riparian restoration and sustainable management is being developed by an interactive U.S./Mexican team of managers and scientists, but at this time there is no substantive consideration of what tamarisk biocontrol may mean for ecosystem services in this landscape. Thus, the proposed work would be essential to restoration planning and implementation, for which the regional community is simply not prepared. Although not identified at this time,

the intent is to use this period to select and start training at least one graduate-level student to coordinate field information, ideally as part of a joint graduate study program between UCSB and an appropriate Mexican institution, e.g. Ensenada Center for Scientific Research and Higher Education (CICESE) or UNAM Hermosillo. The Objectives of this proposed effort are to: 1. Organize and conduct a meeting in the Mexico (Ensenada, BC or San Luis, Sonora) with Mexican scientists to provide comprehensive explanation of the process and implications of tamarisk biocontrol, and of the need for restoration planning in advance of arrival of the Tamarisk Leaf Beetle in the Lower Colorado River/Delta region; 2. Visit a series of field sites, with Mexican cooperators, along the Lower Colorado to better understand where there are major tamarisk infestations as well as where natural resources benefits can be effectively achieved; 3. Establish a series of 3 to 6 field stations where we will initially apply an ecosystem monitoring protocol characterize the status of riparian vegetation, wildlife habitat, hydrology and soil conditions, and restoration potential in anticipation of near-term tamarisk biocontrol; 4. Install and maintain sentinel pheromone traps (sticky traps with chemical attractant specific to Diorhabda) at points within, and particularly north of the project area (Morelos Dam/Yuma, AZ to Davis Dam, Laughlin, NV/Bullhead City, AZ) to detect colonization and establishment of Diorhabda, thereby providing timely information on movement rates so that we can predict when beetles will arrive in the Mexican project area; 5. Develop information materials outlining the need to protect riparian resources and how environmental rehabilitation will also lead to enhanced socioeconomic values in the region. This will consist of both printed materials and on-line resources to be disseminated by Mexican collaborators; 6. Based on initial meetings, develop the long-range funding mechanisms that could support subsequent restoration planning, implementation and assessment, and graduate students who can focus on these processes.

Jenifer Dugan, Robert Miller   4/1/2015 to 3/31/2019   **$997,312**
National Science Foundation   OCE-1458845

Linking Nearshore Kelp Forest Dynamics to Sandy Beach Ecosystems

Overview: Page A The proposed research seeks to understand trophic connectivity between a donor ecosystem, kelp forests, and a recipient ecosystem, sandy beaches, with two primary goals: 1) an evaluation of how variation in kelp wrack input affects patterns and processes in beach ecosystems and 2) a quantitative understanding of trophic connectivity through physical transport and input of drift kelp from kelp forests to sandy beaches. The project begins with two years of intensive work at a well-studied kelp forest, Mohawk Reef, and 10 km of adjacent coastline, where we will measure community structure over time in response to variability in kelp inputs. To assess effects of variation in wrack input on ecosystem function, we will measure kelp consumption and secondary production rates of consumers. We will directly observe kelp fate and transport from Mohawk Reef using complimentary approaches: 1) tracking kelp plants tagged using GPS; and 2) tagging large numbers of kelp plants (2000) with 'drift cards'. Ending distributions of recovered drift cards and drifter tracks along the shoreline will then be computed. These data will be used to inform and validate a kelp forest-to-beach drift kelp transport model based on numerical simulations of coastal surface currents from the Regional Oceanic Modeling System (ROMS). Using predicted kelp beaching rates from this model run regionally, we will then survey community structure and kelp wrack at a larger set of beaches spanning 100 km of the southern California shoreline to test the generality of our results. This combination of fate and transport observations, beach sampling, and modeling will allow characterization of temporal variability in kelp resource inputs and the consequences of this variability for community structure and function of recipient beach ecosystems.

Jenifer Dugan   2/1/2014 to 1/31/2017   **$12,601**
Pepperdine University   SB150118

A New Method for Monitoring Urban Beach Ecosystems

Task 1: Develop a list of indicators suitable for use in volunteer-based beach monitoring Task 2: Develop methods and field test protocols for volunteer-based beach monitoring of selected indicators Participate in meetings of the project team during 2014 to identify and select indicators and to develop non-invasive methods and protocols for monitoring selected indicators. Participate in field testing of monitoring protocol for selected indicators: work with the project team to assess beaches

using the new protocols in 2014, with comparisons and discussion of reliability for quality control. Contribute to production of overall project deliverables: List of indicator species/taxa for southern California beaches Set of field protocols suitable for use by volunteers in monitoring beaches Task 3: Develop draft field guides, protocols and materials for use by volunteers in monitoring Work with project team and a graduate student (sea grant trainee) to develop and produce materials to be incorporated in a field guide and protocol manual for beaches With project team, evaluate and test field guide and protocol manual Participate in revising and refining draft field guide and protocol manual based on feedback from field testing Contribute to production of overall project deliverables: A draft field guide and protocol manual for use by volunteers in monitoring beaches

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Jenifer Dugan   5/1/2009 to 12/31/2016   **$37,500**
California Coastal Commission   SB090092

Evaluating Status and Trends in California's Sandy Beach Ecosystem

California's beaches are highly valued for recreation and tourism. Less appreciated is the role of beaches as ecosystems that support unique and rich biodiversity. The fate of California's beaches in the face of rising sea levels and continuing population growth prompts this research. This research project will investigate ecological changes in sandy beach ecosystems in southern California over the past 30 years and evaluate potential causes using comparisons of historic and modern information on ecological communities of beaches. This project will calibrate historically used and modern sampling methods, collect new data at a subset of historically sampled beach sites and archive the historic and more recent physical and ecological data needed to evaluate the status and trends in biodiversity and ecological conditions of sandy beach ecosystems in California. These comparisons will be used to provide baseline information needed for management and assessment of the impacts of climate change and human activities on sandy beach ecosystems.

Jenifer Dugan   2/1/2014 to 1/31/2017   **$45,000**
UC Sea Grant College Program   R/MPA-38D

The Ecological State of Northern California's Sandy Beaches and Surf Zones: A Baseline Characterization for MPA

Northern California's coast has many long and pocket beaches located within the boundaries of the region's newly established MPAs. These ecosystem elements have regionally important ecological, cultural, recreational and commercial facets and are important indicators of coastal ecosystem health. The objective of this project is to provide a comprehensive baseline assessment of the biodiversity, structure and ecosystem state of sandy beaches and surf zones at the time of MPA implementation. We will 1) provide the first comprehensive, baseline description of the diversity and community structure of northern California's sandy beaches and surf zones (including wrack, macroinvertebrates, surf zone fishes and marine birds, as well as people and their activities); 2) collaborate with Smith River Rancheria and train tribal interns in monitoring methods and species identification to conduct baseline ecosystem assessment and long-term monitoring of culturally important species in their ancestral territories; 3) engage local environmental educators, schools and community volunteers (e.g., Mattole Restoration Council, Mattole Triple Junction High School, the Mattole Union Elementary School (grades 4-8) Mendocino High School), including recreational fishers (Humboldt Area Saltwater Anglers Association, Recreational Fishing Alliance), county/state agencies (Humboldt Bay Harbor Recreation and Conservation District, Mendocino Fish and Game Commission, California Department Fish and Wildlife), and commercial fishers (California Commercial Beach Fishermen's Association) to help with sandy beach and surf zone monitoring; and 4) interpret the important ecological links among sandy beach species for use in evaluating the effectiveness of northern California's MPAs in conserving the structure and function of sandy beach ecosystems.

Jenifer Dugan, Mark Page 9/1/2011 to 6/30/2015 $260,897
UC Sea Grant College Program R/MPA-24A

Sandy Beach Ecosystems: Baseline Characterization and Evaluation of Monitoring Metrics for MPAs along the South Coast of California

Sandy beaches and adjacent surf zones are important foraging areas for shore birds and fishes that feed on intertidal invertebrates. The amount of wrack and plankton cast onto beaches is dynamically linked to adjacent ecosystem features, ocean climate and the reproductive output of invertebrates. The condition of beach ecosystems is also linked to the reproductive success of beach-nesting fishes and birds. These links are the critical pathways through which direct and indirect effects of MPA implementation and variation in ocean climate will cascade, making sandy beaches an important target for long-term monitoring to assess ecosystem condition and functioning of the SC region. Sandy beaches are also used extensively for a variety of recreational activities, including shore-based fishing, clamming and bait collection, beachcombing, dog-walking, jogging, sunbathing, surfing, swimming, volleyball and other sports, birding, and picnicking. We will: provide a comprehensive, baseline description of the biodiversity of sandy beaches of the SC region using both new and historical/ existing data develop informative ecosystem indicators and a plan for long-term monitoring of the network of MPAs involving citizen scientists (e.g., students, LiMPETs, recreational fishers, members of conservation clubs) and collaborations with similar established volunteer groups in the region (e.g., Audubon etc), and interpret the important ecological links among the components of this and other ecosystem features, including humans, for use in evaluating the effectiveness of the network of MPAs.

Jenifer Dugan 7/15/2013 to 7/28/2016 $50,000
USDI National Park Service P13AC00900

Wave-Exposed Sandy Beach Invertebrate Staining and Mark-Recapture

The primary objectives for the proposed study are to: Objective 1:NPS and UCSB to conduct reconnaissance surveys of beaches near Santa Barbara to identify the locations most likely to yield invertebrates and the species of invertebrates available from these areas for use in the project. The field reconnaissance surveys will be conducted by both NPS PM and UCSB PI or their appointed representatives, likely with a small net like a 8 or 10 inch aquarium net and/or corers and mesh bags, unless NPS travel restrictions prevent NPS participation. This objective should occur during June, July or August 2013, unless NPS travel restrictions delay the travel into FY2014. Objective 2:UCSB to perform stain trials on a variety of California sandy beach crustaceans to eliminate species that do not take up and retain the stain well and those with high mortality resulting from stain exposure; stain trials will attempt to include one (1) to three (3) species each of isopods, amphipods, mysid shrimp, and mole crabs [20 individuals per species, 20 minute stain exposure to 50 mg L-1 neutral red, stain retention and mortality evaluated against controls after 72 to 96 hours]. Objective 3:NPS and UCSB to rank the available invertebrate species as to suitability for further research based on the reconnaissance and stain trials. Ranking with include stain & mortality suitability (%), order of magnitude abundance (10x), distance-cost to location (km), simplicity to locate and sample, and ease to identify. Objective 4:UCSB to develop a stain procedure in the laboratory that can later be tested for field mark-recapture studies of top ranked sandy beach invertebrate(s) based on staining methods of Drolet and Barbeau 2006. Objective 5:UCSB to determine the speed and variation in burrowing time for top ranked invertebrate released onto wet native beach sand under varying submergence conditions in a laboratory setting. Objective 6:Conduct field mark-recapture population estimates that determine how wide ranging in distance, time and invertebrate density (as indexed by CPUE) the staining can be effectively used for mark-recapture of the top ranked invertebrate. Objective 6 may require pilot studies close to the laboratory facility to test and refine field methods. Objective 7:Make and provide rate of dispersal, population estimate and CPUE calculations and regression for top ranked invertebrate(s). Objective 8:Compare the efficiency of size based sorting techniques for live invertebrates at beach sampling location vs. a controlled setting, specifically speed and accuracy of sorting adults from recruits in beach population samples. Objective 8 to be conducted during a time period when some recruits are present in the population. UCSB will conduct the sampling and counting; NPS will consult on sampling design and assist as requested on statistical analysis and short report. The controlled location could be a laboratory, motel room, vehicle or tent where invertebrates

could be held and sorted carefully, and by dissecting microscope if necessary. Cold temperatures and anesthetics will be utilized to slow the animals for counting in preference to killing the organisms for counting. Objective 9:Compare the efficiency of determining reproductive status in samples of live invertebrates at the beach sampling location vs. a controlled setting, specifically the speed and accuracy of determining reproductive status of the top ranked invertebrate adults in sandy beach population samples. Objective 9 to be conducted during a time when > 5% of adult females are carrying young or eggs. UCSB will conduct the sampling and counting; NPS will consult on sampling design and assist as requested on statistical analysis and short report. The controlled location could be a laboratory, motel room, vehicle or tent where invertebrates could be held and sorted carefully, and by dissecting microscope if necessary. Cold temperatures and anesthetics will be utilized to slow the animals for counting in preference to killing the organisms for counting. Objective 10:Prepare and present a webinar on sandy beach invertebrate ecology and mark-recapture population estimates to NPS staff, academics and interested public. (Note: webinar will be posted on NPS website for future viewing by interested parties.) Objective 10 will occur after Objectives 1-7. Objective 11:Conduct pilot training of sampling techniques developed during this project at one NPS site. Participants in the training exercise will include project partners, NPS staff and university students. Travel to a park, likely Golden Gate National Recreation Area or Point Reyes National Seashore, and spend 12 hours demonstrating and training participants in field staining, CPUE, and mark-recapture of sandy beach organisms; size based sorting and determination of adult reproductive condition. Training would include a first attempt at participants collecting actual data in a park (i.e., CPUE and mark-recapture regression, size-sorting and reproductive data). Objective 11 will occur after objective 1- 10 unless the ATR determines otherwise. An outcome of training will be a documented training approach that can be shared with researchers, land managers and the public. Objective 12:Share results of this project with the public, NPS units and other interested parties through the NPS Water Resources Website and the NPS Integrated Resource Management Applications (IRMA) Portal https://irma.nps.gov/App/Portal.

Jenifer Dugan   **10/1/2013 to 3/31/2015**   **$18,200**
San Francisco State University Foundation   S13-0008

Improved Valuation of Impacts to Recreation, Public Access, and Beach Ecology from Shoreline Armoring in California

Task 1: Kick Off Meeting 1. Conduct an in person kick off meeting with all consultants and Commission staff involved in the project to discuss project objectives, deliverables, schedule, and the expectations of the consultants. Task 2: Development of Ecological Valuation Method 2.1 Conduct a review of: a) The ecological components and features of beaches and the existing information on qualitative and quantitative responses (losses) of these ecological resources to impacts imposed by shoreline armoring. A report that identifies the ecological resources and features of beaches that respond to shoreline armoring and qualitatively describes the state of existing knowledge on impacts to (losses of) these ecological resources that occur when a shoreline is armored, identifying information gaps and needs. b) The tools/models/methods that have been or could be applied in the valuation of beach ecological resources (identified in 2.1 (a)) to account for the quantitative and qualitative impacts to (losses of) these resources that can result from shoreline armoring (identified in 2.1 (a)). The tools, models, and methods could include (but are not limited to) Natural Capital Project InVEST models, Habitat Equivalency Analysis, Standard Assessment Methodology, Compensatory Mitigation Value-Transfer, Hedonic Analysis, and Spatial Analysis. A report that describes the various tools, models, and methods that could be applied in the valuation of the beach ecological resources and the impacts to (losses of) these resources from shoreline armoring. For each method detail the analytical steps, an assessment of the data needs and feasibility of obtaining that data, describe the parameters that must be measured for use in the analysis, and describe the output that results from the method 2.2 Meeting/Consultation: Present to/consult with Commission staff on the outcomes of 2.1 (a) and (b) and the conclusions regarding the best approach to pursue for a beach ecological valuation method. Get direction from Commission staff on the feasibility and utility of the chosen approach. 2.3 Ecological Valuation Method: Based on the outcomes of 2.1 & 2.2, initiate development of an ecological valuation method to estimate the ecological value of California beaches that can be used to assess the ecological impacts/losses (as a

quantifiable currency; e.g. USD, number of acres, amount of larvae, biomass) associated with specified changes to the beach resulting from shoreline armoring. Armoring changes could include direct loss of the beach from encroachment, loss of new sand to the beach and littoral cell from preventing inland erosion, or progressive loss of the beach due to sea level rise against a fixed back beach. Document the rationale supporting the chosen approach including the feasibility and utility of the proposed approach for economically valuing beach ecology. Depending on the state of the ecological method development, show application of the method through one or more case studies that are not active Coastal Commission projects A report of the ecological valuation method and rationale for the method, including the analytical steps, the parameters that must be measured for use in the analysis, how to obtain the necessary measurements, and the outputs that will result from the method. If feasible based on the state of the ecological method development, include a write-up of one or more case studies demonstrating application of the method to specific situations Write Up Final Report The team will write up a final report incorporating memos and research discussed above. The report will be thorough enough to cover clearly all issues and information required by this Scope of Work.

John Engle   **4/14/2010 to 4/30/2015**   **$186,269**
UC Santa Cruz   M10AC20000

Shoreline Assessment of changes in Southern California Rocky Intertidal Communities

This project comprises the UCSB portion of a multi-campus Minerals Management Service (MMS) program to assess long-term changes in rocky intertidal habitats in California. The primary Cooperative Agreement exists between MMS and UCSC, with subcontracts extended to other State of California institutions. The UCSB portion of the MMS Rocky Intertidal Program will be conducted by the Principal Investigator (PI), with help from a laboratory assistant. The work will consist of coordinating communications for the Multi-Agency Rocky Intertidal Network (MARINe), providing network information to others, maintaining standards for network protocols, overseeing network database operations and websites, and facilitating other interactions between MMS and MARINe. As the MMS/MARINe coordinator, the PI will interface with network Steering Committee, Data and Science Panels, and participating organizations to enhance productivity by organizing meetings and resolving technical issues, including species taxonomy and survey methodology. In addition to coordinating MARINe information management to promote analysis, synthesis, and publication, the PI also will maintain the network internal website, plan updates to the public website, and assist MARINe members in testing and implementing field surveys as well as laboratory, and data management procedures. The principle product of this project is coordination and facilitation of activities by others who will produce and update a variety of products including a standardized data management system, private and public internet sites, reports, publications, and oral presentations. In addition, the principal investigator will produce the following: Minutes of meetings of Steering Committee, Science Panel, and Data Panel meetings. Updated information for placement on MARINe websites. Updated summary lists of MARINe presentations, reports, and scientific publications. Updated field data entry forms for core MARINe protocols. Updated Unified Protocol Handbook for MARINe.

Melanie Fewings, Libe Washburn   **7/22/2010 to 7/21/2014**   **$634,694**
NASA   NNX10A094G

Satellite and Land-Based Remote Sensing of Atmoshperic Wind Relaxations and the Oceanic Response in the California Current Large Marine Ecosystem

Along the West Coast of North America in the California Current Large Marine Ecosystem, episodic relaxation of prevailing summertime upwelling-favorable winds causes warm water to propagate northward along the coast. These wind relaxations are an important characteristic of coastal upwelling systems worldwide. Although atmospheric wind relaxations have an important influence on coastal ocean dynamics, no description exists of the regional atmospheric patterns that lead to wind relaxations in central and southern California. We will use NASA remote sensing and reanalysis products, together with existing oceanographic observations, to describe the evolution of the atmosphere and coastal ocean color, temperature, and currents during upwelling relaxation events in this region.

Steve Gaines   11/1/2013 to 2/28/2016 $228,125
Conservation International Foundation   64762

Marine Spatial Planning (MSP) and Lobster Fishery Reform for the Galapagos

The purpose of this project will be to provide lasting solutions for marine spatial planning and fisheries management in the Galapagos. A key component of the marine spatial planning project will be to assess the long-term planning needs of the Galapagos and provide recommendations for the development of tools to best address these needs. Given these needs, we will help guide stakeholders towards a useful next step in the MSP process, whether though training in our own models or through exploring the development of user-friendly tools in a web-based marine spatial planning tool. Training workshops will be held as part of this product to ensure local technicians are capable of independently conducting ongoing MSP work using the tools developed through this grant. Under the fisheries management component of this project, it is unlikely that sufficient capacity exists among the local stakeholders to replicate formal stock assessments on an annual basis. As such, the goal of our data-poor assessment work will be to design fishery management tools that can feasibly be continued without SFG's ongoing involvement given local capabilities. By helping identify critical types and quantities of data required to provide science based management of the lobster fishery, this project will help make the current monitoring system more efficient and cost effective. The result will be a tool specifically intended for long-term use in fishery management by local stakeholders. Training workshops will be held as part of this product to ensure local technicians are capable of independently conducting ongoing data-poor assessment work using the tools developed through this grant.

Steven Gaines, Sarah Lester   1/1/2015 to 9/1/2015 $163,299
Nature Conservancy   SB110192

TNC Task Agreement 1, amendment 2 & 3

Collaboration with Dr. Jono Wilson of The Nature Conservancy and the Bren School at UC Santa Barbara, the UCSB staff researcher will: 1) Write a report / white paper that explores which fisheries in California are amenable to data-poor stock assessments and/or data-poor harvest strategies (for the top 20 fisheries in California). This will be done in collaboration with both Dr. Jono Wilson and with Bren School Ph.D. student Sean Fitzgerald. 2) If time permits, perform data-poor stock assessments (e.g. DCAC and/or DBSRA - depletion corrected average catch and depletion based stock reduction analysis) for 1-2 fisheries (e.g. red sea urchin and/or sea cucumber) at coast-wide scales and smaller spatial scales and summarize and report out on the findings.

Steven Gaines,   2/1/2014 to 1/31/2016 $8,227 Core, $89,894 Trainee
UC Sea Grant College Program   R/ROC-03B-F

Spatial Redistribution of Fishing Effort: Identifying Drivers and Testing Model Predictions for Informing Expectations in Marine Spatial Planning

This project will identify and test factors affecting the redistribution of fishing effort following marine protected area (MPA) establishment at CA's Northern Channel Islands, and develop an empirically-validated model of fishing effort redistribution that can be used in calculating expectations of ecological and socioeconomic effects of MPAs, including the new MPAs in CA that are undergoing their first review process this decade. The proposed investigations will consist of the following main steps: 1. Develop hypotheses from theory and syntheses of literature for the factors affecting redistribution of fishing effort following MPA establishment. 2. Gather, organize and process data for CA Northern Channel Islands, including data for the factors hypothesized to affect distributional patterns of fishing effort (fish density and habitat data), and observed patterns of fishing effort (boat monitoring data). 3. Construct multivariate models for hypotheses developed in item 1. 4. Test the hypotheses through performance evaluation, and identify the model(s) expected to be most useful for estimating and forecasting MPA effects on fishing effort redistribution. 5. Synthesize and communicate findings with interested scientists, managers and stakeholders at conferences and meetings, and through a peer-reviewed publication.

Ben Halpern   2/26/2014 to 11/14/2014   **$123,323**
UNESCO   4500231601

GEF Transboundary Waters Assessment Programme: Large Marine Ecosystems and Open Oceans

GEF Transboundary Waters Assessment Programme (TWAP): Large Marine Ecosystems and Open Ocean Components The work being conducted for the TWAP project includes the following tasks and outputs:

1. Description of Work performed by CMAP (at UCSB)

   i.   Summarize cumulative human impact scores for individual LMEs, using primarily the existing data (to be updated where feasible);

   ii. Calculate area-weighted averages of country OHI scores to produce scores for each LME;

   iii. Update cumulative human impact scores for Open Ocean areas (dependent on how many new data layers are available), with projections where possible (physical climate projections will be available from WCRP, fish catch potential projections will be available from Sea Around Us, and other layers as possible);

   iv. Calculate Ocean Health Index scores for the Open Ocean (High Seas), if possible;

   v.   Participate in working group meetings and teleconferences as required (travel for one expert will be covered under a separate budget);

   vi. Draft required text for the individual (LME and OO) assessment reports; and contribute to finalization of the reports based on peer review comments.

Patricia Halpin   1/1/2015 to 7/31/2016   **$30,389**
National Science Foundation   1543663

RUI Collaborative Research: Spatial Realism in the Mussel Bed Disturbance Program

The project aims to test a hypothesis explaining landscape patterns of ecological disturbance using mussel beds on rocky shores as the study system. The working hypothesis maintains that mussel bed disturbances -- gaps torn in the continuous cover of mussels -- result from internal processes: certain sub-regions of the landscape develop remarkably thick covers of mussels that differentiate into layers. Superficial layers smother and suppress the interior layers causing them to lose firm attachment to the rock surface and rendering the entire aggregation susceptible to dislodgement during wave stress. Thus, under the hypothesis, large propagating gaps form only in thickened sub-regions; thin mono-layers remain intact.

The differences in layering result from spatial variation in the intensity of limiting factors. At the lower vertical margin of the beds predation is intense and limits the beds to a mono-layer of very large, predator-resistant mussels. At the upper vertical margin of the bed physical stress and resource scarcity limit the cover to a mono-layer of small stunted mussels. However, at the middle shore levels of the bed predation and physical stress are negligible, and consequently mussel cover grows thick, differentiating into layers as the effects of crowding intensify. Thus, the internal processes that hypothetically drive disturbance arise from intraspecific competition and self-limitation.

Stephanie Hampton   9/15/2011 to 8/31/2015   **$348,737**
National Science Foundation   DEB-1136637

Dimensions: Collaborative Research: Lake Baikal Responses to Global Change: The Role of Genetic, Functional and Taxonomic Diversity in the Plankton

Anthropogenic global chance in profoundly altering most Ecosystems on Earth. Understanding how ecological communities will re-organize under global change is one of the main challenges facing ecologists today. Responses of communities will depend on the underlying genetic and functional diversity within and across species, as well as on the taxonomic diversity within communities. Here we will characterize these different aspects of diversity in the plankton of Lake Baikal, the

oldest, largest (by volume) and most diverse lake in the world. Lake Baikal's planktonic food web is dominated by endemic species that are sensitive to changing climate and other anthropogenic stressors. These organisms fuel the rest of Baikal's incredibly diverse biota making responses of the plankton crucial to understanding how Lake Baikal ecosystem will respond to global change. We will repeatedly sample Lake Baikal to characterize the spatial, seasonal and interannual variability of each of three aspects of biodiversity (taxonomic, genetic and functional). For taxonomic diversity, we will compare microscopic and molecular approaches and genetic diversity, we will assess the population structure of the ecologically important endemic and cosmopolitan species of both phytoplankton and zooplankton. We will characterize key functional traits for different species and strains (i.e., cell/body size distributions, growth rate responses to temperature, light and nutrients, grazer susceptibility and grazing rates) and compare these traits to the genetic diversity of endemic vs. cosmopolitan species. The genetic information and functional trait distributions of focal plankton species will then be used to parameterize novel mathematical models of plankton communities, allowing us to predict how they will reorganize in the future. We will explore whether, due to limited genetic and functional diversity and narrow thermal niches, endemic species will be unable to adapt to changing conditions and be replaced be cosmopolitan species, resulting in a shift in size structure and energy transfer efficiency. A unique 60-year dataset on plankton dynamics will be used to test the models, independently infer ecological preferences of species, and relate species replacements to environmental drivers and community composition. The results and approach of this project will be applicable to other systems with high diversity and endemism, as well as to other polar and subpolar aquatic environments undergoing rapid warming.

David Herbst, Scott Cooper   9/24/2012 to 12/31/2016 $185,000
USDA Forest Service   12-JV-11272139-070

Aquatic Invertebrate Research for Experimental Watersheds in the Kings River System

Samples of benthic invertebrates will be collected from the lower regions of the streams draining the experimental headwater catchments in June of 2013, using a standard D-frame collection net (30 cm wide, 250 μm mesh). This is the spring following the summer (2012) that thinning treatments will be put in place. If funding is available, we will also sample stream invertebrates in treated and control basins in June of 2014, September 2014, and June 2015, after both tree thinning and controlled burn treatments have been completed. As in previous collections, invertebrates will be gathered from riffle habitats by pooling the contents of three cross-channel D-net samples from each of three separate riffles within a defined 100-meter reach (total area = 9 square feet or 0.81 square meters), and from pool habitats by combining single D-net samples from each of 3 separate pools within the reach (total area = 3 square feet or 0.27 m2). Each square-foot (30 x 30 cm) area is sampled for a standard 60 seconds, by turning and rubbing rock and debris surfaces in riffles, with the current carrying all dislodged material and organisms into the downstream net, and by stirring bottom pool substrata and using sweeping hand motions to sweep dislodged and suspended pool material and organisms into the D-net. Each of the composited riffle and pool samples are processed in the field by rinsing, cleaning and discarding rocks, leaves, wood, moss, and lichens after collecting any clinging invertebrates, elutriating remaining material to collect invertebrates, then hand-picking the remaining sand to remove mineral-case caddisflies, mollusks, and any other heavy invertebrates. These processed samples are preserved in 90% ethanol and stained with Rose Bengal to aid in later laboratory sample sorting. Each composited riffle and pool sample is subsampled in the laboratory using a rotating-drum sample splitter to sequentially divide the sample into fractions to obtain 500 to 1000 organisms which are then sorted, identified and counted. All invertebrates are identified to the level of genus or species (including midges and water mites) with the exception of oligochaetes (segmented worms) and ostracods (seed shrimp), which are not further distinguished. These studies are conducted in collaboration with the Pacific Southwest Research Station of the US Forest Service in Fresno (Carolyn Hunsaker, project leader). The annual and seasonal data collected over the pre-treatment period forms a baseline for establishing current, natural variability in stream invertebrate communities. These data are currently being analyzed and prepared for publication. The proposed research, then, will allow us to compare statistically these pre-treatment baseline data to post-treatment data to determine how stream invertebrate communities respond to tree thinning in their basins.

David Herbst   2/8/2013 to 12/31/2014   **$150,000**
Cal EPA Water Control Board   12-074-130

Pajaro River Contract #12-074-130

Pajaro River Sediment-Bioassessment Study Plan: The goal of this project is to provide a comprehensive picture of aquatic health of the Pajaro River and its tributaries with respect to sediment loading. This will be accomplished through aquatic invertebrate bioassessments and associated measures of stream bed substrate particle distributions, sediment deposition, and embedded rock. Variations in the level of fine+sand (FS) deposition at reach- and patch-scales within 25 sites in the watershed (and adjacent drainages) will be used to provide guidance for developing numeric targets of water quality attainment. How these FS levels relate to associated benthic macroinvertebrate metrics (diversity, etc) will be used to assess impairment of biological integrity. Selection of 25 sample sites, covering nearly all perennial tributaries and portions of the main stem river are located to cover existing monitoring areas and to represent the watershed. In addition, existing data from the San Lorenzo River and adjacent drainages can be used for reference purposes. The biological monitoring plan involves collection of 11 composited benthic macroinvertebrate samples from standard locations as a SWAMP-standard reach-wide benthos over multiple habitats within the study reach (fixed 50 m length). Quadrat grid-counts (25-point) of substrate size classes (up to cobble size) will be taken at each sampling location prior to the sampling of invertebrates. In addition, 4 patch-scale samples covering the full range of FS cover (0-25 quadrat point-counts) will be taken at each of the 25 sites, for a total of 100 of these as a finer-scale resolution of the effects of sediment deposition. These samples will allow biological effects of sediments to be evaluated between and within study sites.

David Herbst   9/1/2015 to 6/30/2016   **$56,268**
AMEC (Great Britain)   C013105571

Biomonitoring of Leviathan Creek Watershed for Fall 2015

Scope of Work. Tasks are partitioned by season of collection (September 2015 in this case), with completion of each subtask at the listed task deliverable date: Task 1: September 2015 Leviathan Creek field sampling for biomonitoring of stream condition, consisting of 5 replicate samples collected at each of 7 Leviathan Creek monitoring stations (35 total samples). Field protocols will be as detailed in previous biomonitoring reports, taking each replicate as 3 combined riffle areas of 1 square foot collected each for each sample, using a 250 micron mesh D-frame net, processed in the field to remove organic debris, gravel and sand (elutriated from buckets, serial washed and sorted in trays). Sample preservation in ethanol in 500 mL containers. Work to be performed by David Herbst and Bruce Medhurst of the University of California, Sierra Nevada Aquatic Research Laboratory (SNARL) during week of September 21, 2015. Deliverable: sample collections log sheet of dates and sites. Due Date: September 30, 2015. Task 2: September 2015 Leviathan Creek Aquatic Invertebrate Sample Processing, Identifications and Enumerations: David Herbst and Bruce Medhurst of SNARL will perform laboratory work for macroinvertebrate processing, sorting, identifications and counts from 5 replicate samples collected at each of 7 Leviathan Creek monitoring stations (35 total). These data will support preparation of annual reporting updates as conforms with previously prepared reports by the Contractor. SubTask 2.1: Sample processing September 2015 samples. Sample processing will include sample homogenization, subsampling, removal of invertebrates from stream debris, and preliminary sorting into taxonomic groups. Quality control includes checks on sample processing (splits, count minimum), condition of specimens, removal efficiency, and sample coding for each of the collections from the Leviathan Creek watershed. · Deliverables: Processing log sheets. · Due date: no later than June 30, 2016. (anticipated March 31, 2016) SubTask 2.2: September 2015 Bioassessment Data Benthic macroinvertebrate (BMI) identifications from sorted samples will be made to the lowest taxonomic level consistent with previous Leviathan data (usually genus or species), including small midges and mites requiring use of slide mounts and 400X compound microscope. All sample identifications will incorporate quality control for taxonomy and counts through confirmations both by the primary lab taxonomist (Herbst) and cross-checks by staff of the Sierra Nevada Aquatic Research Laboratory (Medhurst). The Contractor will compile data in Excel spreadsheet format for Leviathan stream BMI counts and taxonomic identities consistent with existing biomonitoring data from Leviathan Creek watershed, and submit to AMEC, AR, US EPA and US ACE contacts.

David Herbst   **5/1/2014 to 12/31/2015**   **$246,993**
Roy F. Weston, Inc   0087111

Bio Assessment Study Support for Leviathan Mine Superfund Site, CA

The overall Objective of this agreement is to provide technical services to support the US Army Corps of Engineers (US ACE) and the US Environmental Protection Agency Leviathan Mine Superfund project for Biological Assessment of Leviathan Creek. Tasks include supporting EPA sampling for aquatic biological assessment using stream benthic macroinvertebrates, quality assurance of laboratory enumeration of collected samples, and consulting with the government on taxonomy and field sampling. These data will form the basis for evaluating the progress and success of stream ecological recovery associated with remediation activities undertaken on the mine site and runoff from treatment facilities into Leviathan and Aspen Creeks. All reporting associated with data analysis will be performed under separate contract.

Scott Hodges   **5/1/2014 to 1/31/2016**   **$2,000**
Larimer County Department of Natural Resources   SB150154

The Genetic Distinctiveness of Hermit Park's Aquilegia Coerulea var. Daileyae

1. Project Description - The goal of our project is to determine how genetically distinct Hermit Park's columbine, *Aquilegia coerulea* var. daileyae, is from nearby normal-flowered populations of *Aquilegia coerulea*. Ever since Charles Darwin proposed that natural selection was responsible for how one species became two, scientists have been intensely interested in understanding the process. A conundrum has been that early in the process, when populations of a species just start to become different, it is not clear whether speciation will ultimately occur. Conversely, when we study two species that are clearly each other's closest relative, the process has already completed. I believe that *Aquilegia coerulea* var. daileyae occurring in Hermit Park may provide us with the opportunity to study the very earliest stages of the process of speciation. The purpose of our proposal is to obtain funding for preliminary genetic analysis to determine how divergent *A. coerulea* var. daileyae in Hermit Park is from nearby populations of the normal variety of *A. coerulea* and to use these findings in applying for a National Science Foundation (NSF) grant for a more comprehensive analysis. *Aquilegia coerulea* var. daileyae is a striking mutant form of the Colorado columbine where the flower petals, which form the characteristic long nectar spurs, are replaced by a second set of sepals (see Fig). There is also an intermediate morphology where the normally white portion of the petals becomes blue and sepal-like and the spurs are shortened with aborted nectaries (see Fig; I refer to both of these varieties hereafter as var. daileyae). This radical change in flower morphology likely causes a major change in how and which pollinators visit the plants and thus initiates the speciation process. This variety is usually very rare; often a single individual is found in a population of otherwise normal individuals. At Reynolds Park (Jefferson County) there is a population where the variety occurs at ~22%. However, at Hermit Park near the Homestead Meadows Parking and Connector Trail we found hundreds of individuals of var. daileyae and only a single plant with normal flowers. Similarly we found hundreds of var. daileyae individuals on the Homestead Meadow trail just outside of Hermit Park and only five normal individuals (see Map Figure). We know of no other populations of var. daileyae where they occur in such abundance and to the near exclusion of normal-flowered plants. In striking contrast, less than two miles away we found a population of completely normal individuals (see Map Figure). This shift from normal to mutant populations over such a short distance suggests that these populations are no longer exchanging genes (through either pollen or seed dispersal) and thus var. daileyae may be in the initial stages of becoming a new species. We hypothesized that a mutation to a particular gene could cause the var. daileyae morphology and have now sequenced this gene from three individuals from the Hermit Park population. We found a mutation in all three individuals that would cause this gene to no longer function. We also found two different mutations to the same gene in var. daileyae individuals from Reynolds Park. Thus, differences in this single gene could be the cause of var. daileyae. However, we do not know if mutations to other genes may also be correlated with morphology and thus whether or not var. daileyae has other important differences from normal *A. coerulea*. The funding we are requesting would allow us to sequence the entire genome from a set of normal and var. daileyae individuals and to identify which genes have fixed differences and thus how genetically distinct var. daileyae is from

normal *A. coerulea*. We would then use these data to motivate a more detailed grant proposal to the NSF to study the extent of where var. daileyae occurs in abundance, the genetic basis of the change in morphology, how natural selection may be affecting its distribution, and how pollinators react to the remarkable change in flower morphology. Currently, we have some funding that can help pay for the preliminary data I envision for an NSF grant proposal. This funding is from small UCSB funds for training undergraduate and graduate students. The SGCP would provide enough funding for us to produce compelling data for the exceptionally competitive NSF grants. Such funding would also obviously provide the opportunity to showcase this remarkable natural resource preserved through Larimer County Open Spaces.

Scott Hodges   6/15/2015 to 7/31/2018 $355,705
National Science Foundation   1456317

Collaborative Research: The Aquilegia Petal as a Model for the Elaboration and Evolution

All plants build their bodies via the repetitive production of a small number of fundamental building blocks, one of which is the lateral determinate organ. While many aspects of lateral organ development appear to be highly conserved, there exists enormous morphological variation both within the plant body and among flowering plant taxa. In order to understand the basis for this variation, we need to address a series of questions: How does the interplay of cell division and expansion sculpt organ shape? How is complex shape generated from a developmental perspective and what genes control these processes? How do novel organ shapes first evolve? What types of developmental and genetic changes are associated with morphological variation between taxa? The dramatic development of the Aquilegia nectar spur, a complex three dimensional structure that is both recently evolved and highly variable between species, provides a rich context to investigate all of these fundamental questions. The specific aims of the current proposal are: 1) Elucidate major players in spur development from genetic, hormonal and biomechanic perspectives. 2) Use high-resolution genetic mapping approaches to identify additional genes controlling the initiation, length and shape of the petal spur. 3) Use evolutionary genomic and functional approaches to identify selective sweeps associated with nectar spur development. The initial analysis of the development and evolution of the Aquilegia petal spur demonstrates that it can serve as a powerful model for investigating the control and evolution of complex organ shape. In this case, an early phase of localized, oriented cell divisions create the prepatterned spur cup, which is then followed by a period of highly anisotopic cell elongation that gives rise to the final length and shape of the spur. Among the closely related and interfertile species of Aquilegia, variation in spur length and shape is generated by changing several developmental parameters: length is primarily controlled by cell anisotropy, which is in turn controlled by the duration of cell elongation; curvature is generated by varying cell elongation between the distal vs. proximal compartments of the spur; and circumference is controlled both by changes in cell anisotropy and cell number in the radial orientation. Thus, if the development and evolution of Aquilegia spurs can be understood, we will gain insight into all of these fundamental aspects of lateral organ development, which can provide new perspectives on the evolution of lateral organs more broadly across the angiosperms. The proposed Aims seek to integrate multiple lines of study drawn from the fields of developmental genetics, evolutionary genomics/genetics, and biophysics. Specifically, we will seek to understand the fundamental genetic control of petal spur development, explore the roles of hormonal signaling and biomechanical strain in controlling spur development, and use QTL-based approaches to identify the genes involved in the diversification of spur shape. Broader Impacts : This proposal brings together a range of techniques drawn from development, molecular genetics, evolutionary genomics and biophysics, creating a unique training opportunity for postdoctoral, graduate and undergraduate students. PI Kramer is working with Science Club for Girls (http://scienceclubforgirls.org/) to develop a research experience that would be based on performing VIGS and characterizing resultant phenotypes. These projects would involve morphological studies, RNA preparation, and qRT-PCR analyses. All students will, at the very least, prepare their own first author manuscripts for the Journal of Emerging Investigators (JEI; http://emerginginvestigators.org/). PI Hodges will employ groups of 6-8 undergraduates for phenotyping of F2 individuals using a range of microscopy and imaging analysis techniques. Students will be encouraged to identify additional phenotypes segregating in the F2 population and create their own mapping project for this trait. Upon completion of the project, they will be mentored through writing

the work up for publication, whether in a primary scientific journal or JEI. Special efforts will be made to recruit female and underrepresented minority students to this research program.

Dissertation Research: Causes and Consequences of Flower Color Variation in Aquilegia Coerulea

Intellectual merit: A thorough understanding of the evolution of ecologically important traits is a major goal of evolutionary biology. For any phenotype, there are three broad questions that a research program aimed at this goal should address: one, what are the relevant loci; two, are those loci experiencing natural selection; and three, what factors contribute to natural selection? Exploring these questions in the context of a geographically varied environment is particularly important, as spatially varying selection has been linked to both the maintenance of variation within species as well as the sorting of variation into diverging lineages. My dissertation research asks whether the adaptive significance of flower color variation in Rocky Mountain columbine, *Aquilegia coerulea*, might be determined by a trade-off between pathogen resistance and drought resistance along a geographical gradient of environmental variables including precipitation. Beyond understanding the evolutionary trajectory of a single trait, there is much interest in the relative importance of different evolutionary processes in determining the origins and fate of biodiversity. By sequencing the genomes of multiple *A. coerulea* individuals from across the species range, I will assess the relative importance of neutral versus adaptive processes for shaping nucleotide diversity; I will further categorize genomic regions with evidence of selection according to the kind of selection, e.g., spatially varying or positive. Broader impacts Understanding the evolutionary origins of adaptation and maintenance of biodiversity is a fundamental goal of evolutionary biology. My dissertation research illustrates how genomic methods can be applied to systems representing important ecological characteristics that are underrepresented in the literature; e.g., long-lived or perennial organisms in their native habitat. This work also generates and tests novel hypotheses about the potential for flower color to contribute to a trade-off between resource use and pathogen defense, a topic of broad interest. And, considering anthropogenic impacts on habitat and climate change, these questions are also highly relevant in assessing conservation concerns for species of interest and biodiversity as a whole. During the preliminary research that motivates the proposed research, I mentored several UCSB undergraduates. I am currently working with one continuing student, and will be recruiting two additional interns to work with me on the greenhouse experiment. They will work with me, but will also be encouraged to develop their own projects with the hybrid population.

Ocean Acidification Seascape: Linking Natural Variability and Anthropogenic Changes in pH and Temperature to Performance in Calcifying Antarctic Marine Invertebrates

Intellectual Merit: Ocean acidification (OA) has emerged as a major research area in the study of marine ecosystems and ocean change. From an organismal perspective, the goal of the research community has been to identify the physiological tolerances and/or vulnerabilities of key calcifying marine organisms. However, in most cases, the present-day $pH/pCO2$ dynamics that most marine organisms experience in their respective habitats are relatively unknown. This is a significant data gap as the resilience of organisms is closely related to the physical conditions to which they are adapted. Thus, data regarding the 'OA seascape" would greatly facilitate organismal research; laboratory experiments could be performed in an environmental context and investigators would have a better baseline from which to project pH dynamic changes in the future that are driven by anthropogenic ocean acidification. The central focus of the current proposal is to better frame the study of the response of Antarctic marine organisms to OA conditions by measuring the annual pH dynamics in Antarctic coastal waters and performing organismal experiments that are parameterized using these field observations. The project has two main activities: (1) we will deploy autonomous pH sensors called SeaFETs in four sites in McMurdo Sound and at a nearshore Palmer site (the Palmer LTER Station A) in order to continuously record pH time series data; the sensors can be programmed to record all year and can be deployed on the benthos, below the sea ice and will not be interfered

with by changes in sea ice coverage; (2) using these field observations of annual variation in pH dynamics, we will perform lab experiments using environmentally relevant pHs and pCO2 to study the resilience and tolerance of a key marine invertebrate, the Antarctic pteropod *Limacina helicina antarctica*. In these lab experiments, we will also examine the interaction of ocean warming and ocean acidification, two potentially interacting anthropogenic stressors that could drive ocean change in the future. For the pteropod exposure studies and temperature x CO2 combinations, we will measure the following: (1) examination of shell morphology using calcein staining, (2) oxygen consumption via respirometry as an indirect measure of metabolic rate, (3) organismal thermotolerance, and (4) gene expression patterns 454 pyrosequencing to obtain a normalized and annotated library of sequences following by the use of custom microarrays that are prepared using sequence data from the pteropod 454 sequence data. Importantly, the proposed research represents a new development in 'biophysical coupling' studies in Antarctic ecosystems research, and brings relatively new ocean sensor technology to Antarctic marine ecosystem science. The project also provides multidisciplinary training for postdoctoral researchers and graduate students in the study of global change biology of the Antarctic marine ecosystem. Broader Impacts: In addition to supporting the training of undergraduates, graduate students and postdoctoral researchers, we plan to have a significant informal public education element in this project. In collaboration with the Aquarium of the Pacific (AOP) in Long Beach, California, we plan to contribute to their education and outreach activities. The AOP recently opened an exhibit on polar ecosystems -entitled "Arctic & Antarctic: Our Polar Regions in Peril" and we plan to contribute to the development of materials for the Antarctic portion of the exhibit. The major focus of the polar exhibit is climate change and the public audience for the materials is large. In addition, in 2010, the Aquarium staff served 219,000 students in outreach classroom activities; these are on-site classroom activities for visiting K-12 students from the Los Angeles metro area. We will work to engage these students via live feeds, guest teaching and lectures by lab members, and by using our research results to create teaching materials for these on-site teaching events.

Gretchen Hofmann	**2/1/2015 to 1/31/2017**	**$24,999**
UC Sea Grant College Program		R/HCME-13

Global Change Ecophysiology of Egg Masses and Juveniles of the Kelp Forest Fish, *Scorpaenichthys marmoratus*

The goal of this proposal is to examine the response of the developmental physiology of early-life stage marine fish (Cabezon, *Scorpaenichthys marmoratus*) to conditions of ocean acidification, thermal stress, and hypoxia. This project will be framed with a biophysical coupling perspective, using data from deployed oceanographic instruments to design experiments that test for responses to present-day natural variability in abiotic conditions in kelp forests, as well as to future conditions. The project is not only supported by the existing equipment and techniques for ocean acidification research at the Hofmann Lab, but also by a novel experimental system designed by the Ph.D. graduate student (Umihiko Hoshijima) that allows for variable ocean acidification and hypoxia treatments.

Gretchen Hofmann,	**10/1/2012 to 9/30/2015**	**$320,491**
Carol Blanchette, Libe Washburn		
National Science Foundation		OCE-1220359

Ocean Acidification: Collaborative Research: OMEGAS II - Linking Ecological and Organismal Responses to the Ocean Acidification Seascape in the California Current System

With one year of funding, the aspects of the overall project carried out by UCSB PIs and personnel will remain as proposed for year one in the original renewal request, and the budget will also remain unchanged. Specifically, we will: (1) continue the sensor deployments on the shore and on the PISCO moorings, thereby continuing our time series that will allow quantification of the carbonate chemistry of the upwelling transition zone spanning Point Conception. Washburn and Blanchette serve as the lead investigators of this component. A value-added aspect of this component of the project is that we have recently deployed five new pH sensors in the Santa Barbara Channel as part of the separately NSF-funded Santa Barbara Coastal Long Term Ecological Research (SBC-LTER) project; Washburn is an associate investigator on the SBC-LTER along with several other investigators not in OMEGAS. (2) PI Blanchette will collaborate with OSU PI Menge and postdoc Gouthier to develop an

ecological model to examine the community-level effects of geographic variation in OA conditions. (3) Blanchette and the UCSB field team will collaborate with PIs Sanford, Gaylord, Menge, and Raimondi to carry out the Year 1 deployment of juvenile mussel outplant experiments aimed at testing how mussel growth, shell thickness and strength, and anti-predator defense is affected by differing regimes of ocean acidification. (4) PIs Hofmann and Blanchette will lead a separate set of physiological assessments aimed at understanding the mechanisms underlying differences in performance in juvenile mussels (harvested from field transplants) using an array of physiological techniques (respiration rates, lipid microanalysis, calcification rates, enzyme assays and thermotolerance trials). (5) PI Hofmann will lead the exploration of how patterns of gene expression are affected by temporal variability and high frequency variation in seawater chemistry, and (6) all UCSB PIs will actively engage in public outreach efforts with a variety of state and national partners and they will continue outreach efforts through public presentations, workshops and professional development experiences for teachers.

Gretchen Hofmann   10/1/2010 to 9/30/2014   **$473,354**
Carol Blanchette, Libe Washburn
National Science Foundation   OCE-1041229

Ocean Acidification: Category 1: Collaborative Research: Acclimation and Adaptation to Ocean Acidification of Key Ecosystem Components in the California Current System

We will investigate the impacts of ocean acidification (OA) on two ecologically important, calcification-dependent marine invertebrates in relation to local-to-coastal variation in carbonate chemistry (e.g., pH and aragonite saturation) in the California Current Large Marine Ecosystem (CCLME). An interdisciplinary team of investigators with expertise in physical and chemical oceanography, marine ecology, biochemistry, molecular physiology, and molecular genetics will carry out an integrated, lab and field, multi-site investigation of the ecological, physiological, and evolutionary responses of sea urchins and mussels to spatial and temporal variation in OA. The research will take place in the context of a mosaic of variable oceanography, including recently documented latitudinal variation in carbonate chemistry along the upwelling-dominated US west coast. Variation in upwelling regimes from Washington to southern California generates spatial and temporal gradients in concentration of CO_2 that shoal to surface waters during upwelling events, extending shoreward into the inner shelf region. Through well-known chemical pathways, influxes of CO_2 cause present-day declines in pH in coastal ecosystems that are lower than values forecast for the ocean in general in the year 2200. Lower than "normal" pH can influence organisms by altering intracellular biochemistry, and especially, for calcification-dependent marine organisms, interfere with formation of hard parts as the aragonite saturation state falls near or below 1.0. Because calcifiers in the upwelling-dominated CCLME have historically experienced persistent regional variation in pH, populations are likely differentially acclimatized and/or adapted to a variable carbonate chemistry environment. The new challenge to these organisms is that with global change and the resulting increase in seawater CO_2, they already may be close to their acclimatization or adaptational capacity, and thus may have limited ability to respond to additional increases in CO_2. It is this challenge, the mechanistic ability of calcifying invertebrates to acclimate or adapt to increasing CO_2 and aragonite saturation states < 1.0 that we address here.

Gretchen Hofmann   9/1/2010 to 8/31/2016   **$604,534**
National Science Foundation   IOS-1021536

Synergistic effects of climate-related variables on larval sea urchins: Performance to gene expression

The central goal is to characterize the response of larval purple sea urchins (*Strongylocentrotus purpuratus*) to the synergistic interaction of two climate change-related factors: ocean acidification and ocean warming. Due to increasing levels of anthropogenic carbon dioxide (CO_2), ocean acidity and ocean warming are predicted to change dramatically by the end of the 21st century. Specifically, increased dissolved CO_2 concentrations in the global ocean are predicted to reduce the pH of surface ocean waters from 8.1 now to ~7.8 by the year 2100 (IPCC 2007). Additionally, the average surface seawater temperatures are predicted to increase by anywhere from +1ºC to +6ºC by the

year 2100. In manipulative laboratory experiments, I propose to raise cultures of larval sea urchins under varying CO2 and temperature conditions that reflect future ocean change conditions. In order to characterize the metabolic status of the larvae and the costs associated with development under varying pCO2 and temperature conditions, the following physiological processes will be measured: (1) respiration rate, (2) lipid content, (3) calcification rates, (4) total protein content, (5) tolerance of acute thermal stress and (6) morphometric analysis of the larval endoskeleton. Additionally, gene expression profiling will be performed using an oligonucleotide DNA microarray and 'next-generation' RNA sequencing (Illumina mRNA-seq) to explore transcriptome dynamics in response to a changing conditions. This transcriptomic approach will provide mechanistic understanding into how the larvae respond to environmental change in a multiple stressor scenario.

Gretchen Hofmann   8/1/2010 to 7/31/2014   **$613,812**
National Science Foundation   ANT-0944201

Effect of Ocean Acidification on Early Life Stages of Antarctic Sea Urchins (*Sterechinus neumayeri*)

The central focus of this project is to examine the effects of ocean acidification (OA) on embryos and larvae of a contemporary calcifier in the coastal waters of Antarctica, the sea urchin *Sterechinus neumayeri*. Ocean acidification is the process whereby the pH of seawater is driven down by the uptake of CO2 from the atmosphere. Since the industrial revolution, anthropogenic sources of CO2 have already resulted in the lowering of ocean pH by ~0.1 units and future atmospheric and oceanic CO2 levels are predicted to further acidify surface seawater, driving ocean pH to levels well below the current day pH of ~8.1 by perhaps as much as 0.5 pH units. The effect of future ocean acidification is projected to be particularly threatening to calcifying marine organisms in cold water, high latitude seas, making tolerance data on these organisms a critical research need in the Antarctic marine ecosystems. Due to a high magnesium (Mg) content of their calcitic hard parts, echinoderms, the focus of this proposal, are especially vulnerable to dissolution stress from OA because these organisms are already existing in seawater that is barely at the saturation level to support biogenic calcification. Thus, cold-water, high latitude species with a high Mg-content in their hard parts are considered to be the 'first responders' to chemical changes in the surface oceans. Studies in this proposal will use several metrics to examine the physiological plasticity of contemporary urchin embryos and larvae to CO2-acidified seawater, to mimic the OA scenario as defined by IPCC emission scenarios (Meehl et al. 2007) and by analyses of future acidification predicted for the Southern Ocean (McNeil & Mateur 2008). In a final study, we hope to learn about the biological consequences of developing under conditions of OA and further, whether embryos and larvae of S. neumayeri are affected by synergistic interactions of two converging climate change-related stressors – CO2-driven ocean acidification and ocean warming. For these experiments, sea urchins will be raised in culture at the habitat temperature for S. neumayeri (-1.8 °C) at different CO2 partial pressures that are consistent with IPCC predictions of future levels of atmospheric CO2. Then, we will perform a series of measurements on the early life history stages. We will: (1) assess the effect of CO2-acidified seawater on the development of early embryos and larvae, (2) using morphometrics, examine changes in the larval endoskeleton in response to development under the high-CO2 conditions of ocean acidification, (3) using a DNA microarray, profile changes in gene expression for genes involved in biomineralization and other important physiological processes, and (4) measure costs and physiological consequences of development under conditions of ocean acidification.

Gretchen Hofmann   2/1/2012 to 1/31/2016   **$12,090**
National Science Foundation   OISE-1219542

International: The Energetic Cost of an Acidic, Warm Environment: Changes in Lipid Consumption of *Pocilopora Damicornis* Larvae

Emily Rivest, a graduate student advised by Dr. Gretchen Hofmann at the University of California Santa Barbara, will collaborate with Dr. Peter Edmunds (CSUN) to incubate larvae of the coral *Pocillopora damicornis* in seawater of combinations of CO2¬ concentration and temperature. The treatment levels used in this experiment approximate current and end-of-the-century conditions experienced by these larvae in the surface ocean. Emily will collaborate with Drs. Chii-Shiarng Chen and Hsing-Hui Li at the National Museum of Marine Biology and Aquarium, who will provide access to the necessary

equipment and training to perform analyses to analyze the lipid content and composition of these larvae. From the data, we can then better understand how elevated CO2 and temperature interact to challenge the energy budget of these larvae, facilitating predictions of effects on planktonic duration and settlement success. Emily will also use a SeaFET pH sensor to measure the variation of pH on the natal reef of the coral used in this study, working with Dr. Tung-Yung Fan at NMMBA.

RAPID: How Does Nutrient Availability Alter Coral Bleaching, Mortality, and Recovery on Moorea Coral Reefs?

Overview: The predicted worldwide coral bleaching event of 2015-16 provides an unparalleled opportunity to leverage the Moorea Coral Reef (MCR) LTER site to (1) test explicit hypotheses regarding the influence of human- versus fish-derived nutrients in altering the susceptibility of three major genera of corals to bleaching, (2) map island-wide patterns of bleaching onto landscape scale patterns of nutrient availability, and (3) ultimately link these short-term patterns to longer-term consequences to resilience of the benthic community and rates of key ecosystem processes. This RAPID proposal will enable scientists associated with the MCR LTER to obtain crucial "pre-bleaching" data from field surveys and satellite imagery that will be paired with subsequent "post-bleaching" data to explore bleaching patterns in relation to gradients in nutrient availability on the reef complex that surrounds Moorea. In addition, RAPID funds will be used to initiate a field experiment prior to the warm-water anomaly to explicitly test the hypothesis that different forms of nitrogen will have contrasting effects on the bleaching probability a coral colony.

Intellectual Merit: Nutrient enrichment is a major anthropogenic force altering coastal ecosystems worldwide, particularly in oligotrophic systems such as coral reefs. Based on differences in how ammonium versus nitrate enrichment affect the physiology of corals, some coral reef biologists have speculated that under stress, nitrate enrichment from anthropogenic sources should weaken the coral-dinoflagellate symbiosis, whereas recycled nitrogen excreted by reef fishes could be beneficial. Thus, different forms of nitrogen (nitrate vs. ammonium) and different sources of nutrients (fish-derived vs. anthropogenic) can have fundamentally different effects on coral biology, which may lead to contrasting effects on how they alter the susceptibility of coral to bleaching from warm-water anomalies. Further, spatial heterogeneity in nutrient availability could shape landscape scale patterns in the intensity of bleaching and subsequent community consequences. Thus our proposed research will assess the interaction of two major global change drivers on coral reefs - elevated sea surface temperature and nutrient pollution.

Broader Impacts: Results from this work can inform resource managers and policy makers regarding the effects of nitrogen enrichment in two different forms (nitrate vs. ammonium) from two different sources (human- vs. fish-derived) on altering the probability different types of corals will bleach during a major warm-water anomaly. Human activities can enhance nitrate pollution directly, and lower ammonium enrichment indirectly (via fishing or destruction of nursery habitat), both of which might adversely affect corals by increasing the probability they will bleach during warm-water events. As such, the project can provide much-needed information about how human activities can impact coral reefs around Moorea that will help inform local risk-reduction strategies and planning for sustainable development. Results will be presented to the Government of French Polynesia, as well as to other Tahitian stakeholders via meetings held with the local community at the Te Pu Atiti'a Center on Moorea. Outcomes also will be incorporated into MCR's ongoing LTER School Yard and other outreach and public education activities. With respect to training, two MCR LTER graduate students will assist with the initial (RAPID) phase of the project, and we anticipate that several more will become involved in follow-on studies conducted as part of the MCR LTER program.

Coastal SEES (Track 1) Collaborative: Adaptive Capacity, Resilience, and Coral Reef State Shifts in Socio-Ecological Systems

This project presents an unparalleled opportunity to assess resilience in a coral reef social-ecological system (SES). Over the last several decades members of our research team associated with the Moorea Coral Reef Long-Term Ecological Research site have documented how reefs around the Pacific island of Mo'orea, French Polynesia, have been impacted by major perturbations but have consistently reassembled to coral dominance. This resilience to disturbance is a key component of coastal sustainability, as it maintains the reefs in a state capable of providing critical ecosystem services. The resilience of reefs in Mo'orea is particularly striking, given that coral reefs in many regions have experienced abrupt and potentially irreversible shifts from a coral dominated state, with complex structure and a rich fish community, to a macroalgae dominated state with fewer fish. The central aim of this proposal is to better understand the adaptive capacities of Mo'orea's SES that enable the coral reefs to return to coral dominance following large-scale disturbances. To do this, an integrative social and natural science approach will be employed that addresses place-based questions about resilience, sustainability and adaptive capacity of coastal systems, while developing a framework for addressing more complex questions about the Mo'orea SES, as well as providing a model for the integration of ecology and social science in other coastal systems. The dynamics of state shifts are fundamental to understanding the resilience and long-term sustainability of coral-reef social-ecological systems, yet the interplay between anthropogenic and ecological feedbacks are poorly understood in these systems. SESs with high population densities, widespread coastal development and intense resource exploitation typically show declines in the critical adaptive capacities that underpin resilience to local environmental variability, but Mo'orea has maintained its resilience despite rapid development. This project will explore how the complex feedbacks in a coral reef SES maintain its capacity to withstand large-scale ecological disturbances. By its very nature, this study requires substantial interdisciplinary collaboration between social and natural scientists. Anthropological fieldwork focusing on the human dimensions of coral reef use, traditional governance, and indigenous ecological knowledge, will document how local communities perceive, respond to, and manage changes in ecosystem state. Ecological models will describe the dynamics of coral, algal and fish communities, including the feedbacks that make these communities susceptible to abrupt shifts in ecosystem state. These components will be integrated in a systems modeling framework that includes feedbacks both within and between the human and natural communities, quantitatively modeling how humans change their behavior as a function of ecosystem state and how the ecosystem is affected in turn by human activities. A key objective is to bridge the gap between the data collected by social scientists and the dynamic ecosystem models developed by ecologists, as this is crucial to understanding the resilience and long-term sustainability of coastal SESs worldwide. This project will contribute to more sustainable management of coral reefs by identifying pathways that confer resilience, highlighting emerging vulnerabilities, and suggesting policy initiatives in areas such as integrated coastal zone management and sustainable development planning. We will simulate possible future scenarios, providing information about ways resilience might be maintained or eroded by potential changes in management and fishing practices. Finally, this research will evaluate the effects of specific current management actions such as MPAs on resilience, and compare the effectiveness of these actions to alternative strategies. Collaborative science and learning and stakeholder workshops will 1) ensure that local communities, NGOs, and government agencies have access to our findings, 2) improve local awareness of environmental feedbacks, and 3) foster interaction between local Mo'orea institutions and between local institutions and others at higher levels. This project will promote interdisciplinary research into coastal sustainability around the globe. The framework for bridging anthropology and ecology developed here will have applicability in a broad range of coastal SESs. We will train an interdisciplinary work force through workshops and the involvement of graduate students in all its phases.

MRI: Acquisition of a Flow Sorter Cytometer to Advance Marine Research and Education

Intellectual Merit. The MRI requested is a BD Influx sorter cytometer that enables the identification, enumeration and sorting of cells with subtle differences in their optical signatures. The novelty of this state-of-the-art instrument is its unparalleled modular system, sensitivity and sorting power, provided by its manual adjustment of detectors to distinguish varying ranges of spectral bands, fluorescence intensities and other optical parameters (e.g., polarized forward scatter). This instrument will revolutionize marine research and education at UCSB for the following reasons: Pushing the frontiers of microbial oceanography. Acquiring this instrument will enable building a flow cytometry facility (FCF) to test hypotheses where adaptable manual control of parameters (e.g., alignment of laser beams, detectors and filters) is required to (1) identify cells with subtle differences in their optical properties; and (2) sort cells/viruses for further genotyping/phenotyping. The PI has successfully used this approach to distinguish degrees of biomineralization between strains of the same species[1] that are differentially selected under climate stress. The Influx will make it possible to diagnose and forecast shifts in biogeochemically important functional types, by studying populations in a dynamic context.

Synergy between disciplines: The broad range of questions and applications, using different cell types and diagnostic tools will stimulate cross-fertilization of ideas across UCSB and extended community. The FCF will be of tremendous benefit to seven research groups located in the Marine Science Institute, and the Depts. of Earth Science and Ecology, Evolution and Marine Biology (EEMB). The PIs and broader teams will use the FCF extensively to pursue research on phytoplankton and bacterioplankton population physiology, ecology, biogeochemistry, genetics and evolution as well as host-virus interactions.

Training the next generation of UCSB marine scientists: Iglesias-Rodriguez has funding for a technician, who will be trained to use and manage the FCF. The PI and two more EEMB technicians will also be trained by BD to coach the next generation of marine scientists. The FCF will represent a tremendous benefit to UCSB and its maximized use is guaranteed from the start given the large number of marine science programs, students and interested teams within and outside the UCSB marine community.

Long-term maintenance of FCF state-of-the-art features: To guarantee the FCF success, it must benefit from new technological advances. Firstly, its modular system is ideally designed to incorporate new technology. Secondly, a close collaboration with Prof van den Engh, the inventor of the instrument, will ensure that its utility and development are maximized. He will work closely with the team in the research implementation or instrument development and the PI will submit regular feedback to BD.

BROADER IMPACTS. A series of research and teaching programs are planned or underway to investigate single-cell responses to their environment to quantitatively study microbial ecosystems. Acquiring the BD Influx will profit from the Iglesias-Rodriguez's lab success in distinguishing degrees of calcification between/within species that are key to marine carbon sequestration. Biomineralization will also be studied in silicate-producing phytoplankton using fluorescent probes. The BD Influx will also assist in elucidating the role of viral infections on microbial evolution and partitioning of organic carbon.

Promoting state-of-the-art technology in research, teaching and training the broader community: As a research-lead institution, UCSB promotes bringing research into the classroom. A new undergraduate and postgraduate course: "Flow Cytometry Applications in Modern Microbial Oceanography" will be at the interface between bio-optics, microbial ecology and molecular biology and will equip the next generation of oceanographers with the modern tools to ask molecular, physiological, ecological, biogeochemical and evolutionary questions. We anticipate that 100 undergraduates, 20 postgraduates and 12 postdoctoral scientists will use the flow cytometry facility every year. Induction courses and a two-day workshop will be offered to UCSB and other Californian research institutions and industry. This program will impact directly on

evolutionary biologists, biogeochemists, chemical and biological oceanographers and climate scientists, as well as providing advance to biomedical, marine biotechnology, private and public sectors and in outreach programs.

Matthew Jones   1/15/2014 to 12/31/2014   **$13,635**
National Science Foundation   ACI-1419139

Collaborative Project: Software Sustainability: An SI2 PI Workshop

Software is an integral enabler of computation, experiment and theory and a primary modality for realizing the Cyberinfrastructure Framework for 21st Century Science and Engineering (CIF21) vision. Software is directly responsible for increased scientific productivity and significant enhancement of researchers' capabilities. The SI2 program has the overarching goal of transforming innovations in research and education into sustained software resources that are an integral part of the cyberinfrastructure. A goal of SI2 is the development of sustainable software communities that transcend scientific and geographical boundaries and are vibrant partnerships among academia, government laboratories, and industry, including international entities. It further recognizes that integrated education activities will play a key role in sustaining the cyberinfrastructure over time. In this workshop we propose to focus on several related topics. The topics serve to inform the attendees of emerging best practices, and stimulate thinking on new ways of achieving sustainability and of ensuring that the foundation laid by SI2 is preserved into the future. An objective of the workshop is to gather experiences and shared sense of best practice and for the PIs, Plale, Thain, and Jones to write a report from the workshop for broader dissemination of results. To facilitate full participation, we propose to use a shared document for live annotation and note-taking.

Matthew Jones, Mark Schildhauer   8/1/2008 to 7/31/2014   **$599,999**
Joshua Madin, Margaret O'Brien
National Science Foundation   DBI-0743429

Semantic Enhancements for Ecological Data Management

The wide range of relevant data and the lack of standard methods used in ecological studies hinder current techniques for managing ecological data. This data heterogeneity creates several major informatics challenges that impede the sharing of data collected by individuals, institutions, and scientific communities. While current data management approaches include the use of structured metadata (e.g., EML - the Ecological Metadata Language) and community-wide data networks (e.g., KNB - the Knowledge Network for Biocomplexity), software tools are still needed that address the often-subtle and implicit semantics of ecological data. Such tools in particular must encode and utilize the semantics of scientific observations to directly confront issues impending broad-scale discovery, access, interpretation, and synthesis of data by ecologists. The development and use of formal ontologies has become more prevalent within ecology and the environmental sciences. However, efforts towards ontology standardization and development of production software systems to leverage these advances and facilitate adoption by the broader community are still needed, especially when compared to the benefits gained by similar efforts in other scientific disciplines such as molecular biology and biomedicine. The investigators propose to reduce this gap by leveraging existing ontology standardization efforts within the community, developing reference implementations of these standards, and incorporating these implementations into existing production systems for managing ecological data.

Matthew Jones, Stephanie Hampton   8/1/2009 to 10/31/2014   **$3,023,094**
University of New Mexico   63014-873R

DataNetONE: Observation Network for Earth

NCEAS hosts the second Coordinating Node and supports three of the ten Working Groups. Co-PI Stephanie Hampton initially co-leads the DataNetONE community engagement and outreach activities until the AD CE&O is hired and, thereafter, serves as a co-leader of the Community Engagement and Education Working Group. She also will oversee integration of Best Practices modules into existing informatics presentations to all NCEAS working groups, reaching hundreds of scientists and students

during the first phase of DataNetONE. Co-I Matthew Jones serves on the Core CI Team and acts as co-leader of the research and development activities during year 1 until the AD D&O is hired. UC Santa Barbara and NCEAS, as part of their commitment to DataNetONE, provide the 24/7 operational environment for the Coordinating Node and high-speed bandwidth access, as well as furnishing office space and conference facilities for the Node staff, students, and three Working Groups. NCEAS, through the leadership of Deputy Director Hampton and Director of Informatics Research and Development Jones, has extensive experience facilitating training, outreach, and interdisciplinary collaborative research by hundreds of scientists each year in its world class facilities. Furthermore, Co-I Jones provides leadership in earth observational science metadata standards, data management software, and scientific workflow systems.

Matthew Jones, Mark Schildhauer   **10/1/2012 to 9/30/2014**   **$582,660**
National Science Foundation   OCI-1216894

Conceptualizing an Institute for Sustainable Earth and Environmental Software (ISEES)

Planning Process: The project will undertake a one-year community-driven process to develop a strategic plan for the creation and operation of ISEES. Our diverse research constituency includes earth, life, and environmental scientists and experts from software engineering, computer science, informatics, and library sciences. A series of design workshops that use proven, formal planning and assessment methods will meet in three topical clusters to conceptualize and articulate a grand vision and strategy for how ISEES will transform the software lifecycle and galvanize the research community. A Science Cluster collates and articulates grand challenges within earth observational sciences that focus and drive ISEES' software activities and define exemplary collaborative science activities that support detailed requirements analysis. A Software Cluster analyzes requirements for scientific software and proposes approaches for ISEES to address these via improvements across the full science software lifecycle. And, a Sustainability and Adoption Cluster examines sustainability and governance challenges, and proposes models for engaging the research community, governing ISEES, and developing an effective workforce that can sustain the portfolio of science software curated through ISEES. Community experts lead each working group and collectively comprise a Steering Committee that synthesizes recommendations, presents these results and gathers feedback at a Town Hall co-located at a major science conference, and combines this with recommendations from an open call for comments on the Internet to create the final Strategic Plan describing the mission, design, and impact of ISEES.

Intellectual Merit: The strategic planning process will define a mission for ISEES that spans thecreation, interoperability, and sustainability of a compelling suite of software systems that will transform earth and environmental scientific research. The strategic plan will articulate and compare the strengths of various organizational models and activities in terms of their ability to resolve issues that are prevalent in scientific software, such as code complexity and opacity, lack of scalability, lack of openness and interoperability, and lack of formal versioning and management of software evolution for sustainability. In addition, the strategic plan will provide a compelling framework for workforce development, creation of community software frameworks, and community governance of ISEES.

Broader Impacts. Results from software lifecycle modeling and sustainability and governance modeling will be broadly applicable to software ecosystems outside of the earth and environmental sciences. The diverse community of participants engaged in the planning process will have a strong impact on the views of multiple science communities about critical issues in the scientific software lifecycle. ISEES workforce development plans will significantly advance the training and education agenda outlined under NSF's CIF21 agenda, and create a pathway for software careers for underrepresented groups. Finally, many diverse participants, students, and postdocs will participate in planning workshops and activities, thus improving their use of complex software to conduct science.

Carrie Kappel, Benjamin Halpern,   8/17/2012 to 10/28/2016 $1,883,774
Kim Selkoe
Gordon and Betty Moore Foundation   2897.01

Ecosystem Thresholds and Indicators for Marine Spatial Planning

Marine spatial planning is emerging as a primary tool for implementing ecosystem-based management and an important directive of US National Ocean Policy. As decision-makers begin to develop marine spatial plans they face the problems of how to define management targets at the ecosystem level, how to understand the cumulative effect of human activities within the ecosystem, and how to evaluate whether the management actions they take are working towards their objectives. They confront these tasks with the knowledge that marine ecosystems can exhibit complex behaviors, including the possibility of crossing thresholds and changing rapidly into a new set of conditions. Our research goals are to (1) identify thresholds in marine ecosystems by synthesizing existing data, (2) examine possible indicators of pending transformation within the ecological system and coupled social systems, (3) develop analytical tools to allow for marine spatial planning based on knowledge of ecosystem thresholds, (4) identify and demonstrate regulatory and policy vehicles that could apply ecosystem thresholds and indicators to marine management, and (5) communicate our results clearly and effectively to managers and policymakers. In Phase One of the project (September 2012-September 2014) we will focus on reviewing and analyzing existing data on the application of ecosystem thresholds in management, examples of thresholds in coastal and marine ecosystems, and nonlinear responses of ecosystem components to key stressors relevant to our case study locations. We will analyze single sector case examples where an understanding of thresholds could lead to better management and begin to build models of tradeoffs in ecosystem services that take into account ecosystem thresholds. In Phase Two (September 2014-September 2016), a suite of research activities will develop the science needed to apply ecosystem thresholds and indicators to single and multi-sector problems in our case study locations: Haida Gwaii, British Columbia and the Humpback Whale National Marine Sanctuary in Hawaii. During this phase we will conduct the legal and policy analysis needed to reveal the most likely routes for these concepts, results and tools to make it into management decision-making. We will tie together the results of Phase One and Two into a toolbox and general framework for setting target multi-sector activity levels within the context of ecosystem thresholds.

Lydia Kapsenberg   6/1/2011 to 8/31/2015 $19,987
Gretchen Hofmann
University of Washington   SB110188

Assessment of Ocean Acidification in the Channel Islands National Park and its Impact on Local Marine Species

Ocean acidification (OA), the decline in surface seawater pH as a direct result of anthropogenic CO_2 dissolving into surface oceans, is expected to affect many marine species, especially calcifying organisms. The result of these biological impacts will likely alter community structure of key marine ecosystems. Upwelling systems, such as the California Current Large Marine Ecosystem, already experience periods of low pH that were not expected for several decades and may therefore be sensitive to further OA. The Channel Islands National Park (CINP) spans a temperature gradient associated with the California Current Large Marine Ecosystem seasonal upwelling, however, there are no data regarding the local near-shore carbonate chemistry. This research proposal involves (1) the assessment of current pH conditions and (2) its effect on marine species in the CINP along an upwelling gradient. Deployment of two autonomous pH sensors at Santa Cruz Island pier and Anacapa Island pier will assess current pH in the CINP, for the first time. Using these data and the CO_2-mixing system in the Hofmann lab that was designed to study OA, I will test the effect of OA on fertilization of two sea urchins species (*Strongylocentrotus purpuratus* and *S. franciscanus*) from each island and evaluate the variation in tolerance with respect to pH. The results of this research will provide insight into the evolutionary history of sea urchins and their potential to tolerate or adapt to future OA. This project will advance CINP resource management by initiating a pH monitoring program within the Park's waters and by documenting near-shore carbon chemistry for the first time as well as advancing understanding of the effects of OA on local marine organisms.

This project will help provide information that may focus climate change management efforts, in order to preserve and protect the CINP for future generations.

Roland Knapp, Cheryl Briggs   8/1/2012 to 12/31/2014 $121,077
National Science Foundation   IOS-1244804

Collaborative Research (RAPID): Testing Intervention Strategies to Change the Outcome of Disease-caused Mass-mortality Events in a Declining Amphibian

During summer 2012, the largest remaining mountain yellow-legged frog population will suffer a mass-mortality event caused by the recent arrival in the area of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd). In mountain yellow-legged frog populations the arrival of Bd in a naïve population typically results in frog population extirpation, and the goal of the proposed study is to change the outcome to long-term persistence. This disease intervention will take the form of a field experiment in which the effectiveness of antifungal drug and bacterial augmentation treatments are quantified at the scale of an entire frog population. This large-scale experiment will provide a unique opportunity to also test several specific hypotheses regarding the mechanisms underlying treatment effectiveness, including the role of the adaptive immune system, effect of the microbiome present on the skin of frogs, and rapid evolution in frogs during Bd epizootics. To initiate the experiment, frogs will be treated with Itraconazole, the symbiotic skin bacterium *Janthinobacterium lividum*, or both. Untreated control frogs will also be included. Following treatment, frogs will be released into the study lake and the Bd load and frog survival quantified during the remainder of the summer and fall using frog skin swabs and frog capture-recapture techniques. The effect of the frog microbiome on frog susceptibility to Bd will be investigated by quantifying relationships between microbiome composition (determined by pyrosequencing) and frog Bd load over the course of the experiment. The dynamics of natural selection in the frogs will be described using genomic tools applied to frog tissue samples collected from frogs in all treatments before and after the frog mass-mortality event.

Roland Knapp, Craig Nelson   10/19/2012 to 3/31/2015 $130,000
Cal EPA Water Control Board   12-067-160

Assessment of Bacterial Water Quality in the Lahontan Region: A study to provide data on bacterial indicator concentrations and sources of bacteria in surface waters

The project will be performed primarily at the Sierra Nevada Aquatic Research Laboratory and at UCSB, with field collection of samples to occur throughout the eastern Sierra Nevada and other possible locations around the Lahontan Region. The State Water Board and the Lahontan Regional Water Quality Control Board regulate the quality of California's surface waters, in part via the adoption and enforcement of water quality standards for bacterial indicators. The Water Boards' current bacterial indicators and standards are decades old. The Water Boards need modern tools and information regarding bacterial indicators in order to amend and update existing water quality standards for bacteria, to adopt new or complementary water quality standards for bacterial indicators, to develop appropriate numeric targets for Total Maximum Daily Loads (TMDLs) for bacteria and pathogens, and to list or de-list water bodies as impaired pursuant to Section 303(d) of the Clean Water Act, as appropriate. This study will examine the relative concentrations of various bacterial indicators in surface waters of the Lahontan Region, using modern as well as traditional methods. The UCSB principal investigators will conduct field sampling and analysis of water samples using quality control methods and processes approved by the State Water Board's Contract Manager. 1. At not fewer than eight watersheds, the UCSB research team will conduct longitudinal stream surveys for bacterial indicators. At each selected watershed, not fewer than ten water samples will be collected and transported to the appropriate laboratory (SNARL and/or UCSB) for analysis. Records of the sampling sites will be maintained, including date and time of sampling and GPS coordinates for latitude and longitude. 2. Using USEPA-approved methods, not fewer than 80 water samples will be analyzed in the laboratory for fecal coliform bacteria and Escherichia coli. In addition to the standard membrane filter methods for fecal coliform bacteria and E. coli, a preliminary source tracking assessment will be conducted (on not fewer than 50 samples, from a range of potential bacterial exposures) using newly developed qPCR probe/primer sets for differentiating human and

bovine sources of Bacteriodales. Specificity of widely used assays of Bacteroides spp. and Enterococcus spp. will be contrasted to develop ratio-based metrics of relative source levels (human vs. bovine). The PIs will submit all bacteria and laboratory metadata to SWAMP and/or CEDEN databases and will prepare quarterly and final reports for the State Water Resources Control Board.

Roland Knapp	**11/15/2012 to 5/31/2016**	**$275,003**
USDA Forest Service		13-DG-11272170-002

Effectiveness of Reintroductions and Probiotic Treatment as Tools to Restore the Endangered Sierra Nevada Yellow-legged Frog (*Rana sierrae*) to the Lake Tahoe Basin

Emily Rivest, a graduate student advised by Dr. Gretchen Hofmann at the University of California Santa Barbara, will collaborate with Dr. Peter Edmunds (CSUN) to incubate larvae of the coral Pocillopora damicornis in seawater of combinations of CO2¬ concentration and temperature. The treatment levels used in this experiment approximate current and end-of-the-century conditions experienced by these larvae in the surface ocean. Emily will collaborate with Drs. Chii-Shiarng Chen and Hsing-Hui Li at the National Museum of Marine Biology and Aquarium, who will provide access to the necessary equipment and training to perform analyses to analyze the lipid content and composition of these larvae. From the data, we can then better understand how elevated CO2 and temperature interact to challenge the energy budget of these larvae, facilitating predictions of effects on planktonic duration and settlement success. Emily will also use a SeaFET pH sensor to measure the variation of pH on the natal reef of the coral used in this study, working with Dr. Tung-Yung Fan at NMMBA.

Sally Holbrook,	**10/1/2013 to 9/30/2016**	**$247,089**
Andrew Rassweiler		
National Science Foundation	OCE-1325652	

Coastal SEES (Track 1) Collaborative: Adaptive Capacity, Resilience, and Coral Reef State Shifts in Socio-Ecological Systems

The Sierra Nevada yellow-legged frog (*Rana sierrae*) was until recently a common inhabitant of the central and northern Sierra Nevada, including the Lake Tahoe Basin. Because of its abundance, *R. sierrae* played an important role in structuring aquatic and adjacent terrestrial ecosystems, with strong effects on nutrient cycling and food web dynamics. Unfortunately, due primarily to the introduction of non-native fish and a novel (but widespread) amphibian pathogen (*Batrachochytrium dendrobatidis*), *R. sierrae* is now absent from more than 90% of its historical range and may be extirpated from the Lake Tahoe Basin. Reversing this decline will depend critically on the removal of introduced fish from key habitats and on frog reintroductions. *B. dendrobatidis* infection has limited the success of previous *R. sierrae* reintroduction efforts, but a recently developed probiotic treatment against *B. dendrobatidis* may provide an effective method of minimizing disease impacts. In this study, we propose to test the effectiveness of reintroductions and probiotic treatment as tools to restore *R. sierrae* to the Lake Tahoe Basin. The frog treatment will involve augmenting the microbial community that inhabits the skin of *R. sierrae* with *Janthinobacterium lividum*, a bacterium that in recent laboratory and field trials was found to strongly inhibit the growth of *B. dendrobatidis* on amphibians, including *R. sierrae*. *J. lividum* is common in soil and water, and is found naturally at low density on the skin of *R. sierrae*. In the first year of the project, 10 adults and 160 juveniles will be translocated from source populations on the Eldorado National Forest to two lakes on the adjacent Lake Tahoe Basin Management Unit. The reintroduction lakes were recently returned to their natural fishless condition and contain high-quality habitat for *R. sierrae*. Prior to release at the reintroduction sites, some of the frogs will be treated with *J. lividum* and the remainder will serve as untreated controls. An additional 160 juveniles will be treated and translocated during the second year of the project. Following frog treatment and release, the effect of *J. lividum* treatment on disease status and survival of frogs will be quantified over a two year period using capture-recapture methods and radio-telemetry. This research will provide critical insights into the effectiveness of *J. lividum* treatment in increasing the survival of *R. sierrae*. If the treatment is effective, the study results could markedly increase the success of future *R. sierrae* reintroduction efforts and have broad implications for the recovery of this declining species in the Lake Tahoe Basin and throughout the Sierra Nevada. Project justification This proposal addresses issues in the Watershed, Water Quality, and Habitat Restoration theme, and specifically in Subtheme 2c: Increase our understanding of special status

species and communities. The Sierra Nevada yellow-legged frog (*Rana sierrae*) is a special status species that was historically abundant in the central and northern Sierra Nevada, including the Lake Tahoe Basin. As a consequence of its precipitous decline, it is increasingly the focus of conservation and restoration efforts led by both federal and state agencies. These include (1) an ongoing multi-agency effort led by the U.S. Fish and Wildlife Service (USFWS) to develop a Conservation Strategy for *R. sierrae*, (2) the pending listing of *R. sierrae* under the U.S. and California Endangered Species Acts, (3) ongoing efforts by the California Department of Fish and Game (CDFG) to develop Aquatic Biodiversity Management Plans for watersheds throughout the Sierra Nevada (including a recently completed plan for the Desolation Wilderness) that identify restoration opportunities for *R. sierrae* and other native amphibians, and (4) efforts by the National Park Service (NPS), U.S. Forest Service (USFS), and CDFG to remove non-native fish populations from key habitats to recover *R. sierrae* populations. This latter effort includes recent fish removal projects in the Desolation Wilderness portion of the Lake Tahoe Basin Management Unit (LTBMU). The proposed project would provide critical information and guidance on the effectiveness of frog reintroductions as a means to reestablishing R. sierrae populations in areas from which they were previously extirpated.

Roland Knapp	4/7/2014 to 4/30/2016	**$295,200**
Cal EPA Water Control Board		13-054-160

Assessment of Bacterial Water Quality in the Lahontan Region: A Study to Provide Data on Bacterial Indicator Concentrations and Sources of Bacteria in Surface Waters

The Water Boards regulate the quality of California's surface waters in part via the adoption and enforcement of water quality standards for bacterial indicators. Numerous water bodies within the jurisdiction of the Lahontan Region have been determined to be impaired due to bacteria and/or pathogens. The Water Boards must identify the source(s) of the bacteria in impaired surface waters before they can develop effective remedial strategies to address these impairments. This project will collect information and assist the Water Boards in identifying the source(s) of bacteria in surface water bodies that have been shown to exceed standards for fecal indicator bacteria.

Roland Knapp	6/10/2015 to 6/20/2020	**$89,087**
USDI National Park Service		P15AC01412

Restoring Rare Frogs in Yosemite National Park

The goal of this study is to expand the distribution of the endangered Sierra Nevada yellow-legged frog (*Rana sierrae*) in Yosemite National Park. This will be accomplished using translocations of adult frogs collected from populations that are persisting despite ongoing infection with the frog-killing chytrid fungus *Batrachochytrium dendrobatidis* (Bd). Translocations will be conducted as carefully-monitored experiments to allow as much as possible to be learned from implementation of the conservation measures, and will include the following elements: (1) use of mark-recapture methods to describe the population sizes and trends of several naturally-occurring *R. sierrae* populations that may serve as sources of frogs for future translocations, (2) use of mark-recapture methods to describe the population sizes and trends of several frog populations that were established during previous translocations conducted between 2006 and 2014, (3) conduct several supplemental and new translocations to continue the effort to reestablish frog populations at several sites from with they were previously extirpated, and (4) conduct amphibian visual encounter surveys at additional sites to assess the status of particularly important populations. New potential source populations include those at Mono Pass, Unicorn Pond, and Gallison Basin. If these and other source populations are large enough to allow collection of adults, translocations and/or mark-recapture monitoring will be conducted at Skelton Lake, Miller Lake, Soldier Lake, Upper Mattie Lake, two South Lyell Lakes, Dog Lake, Ardeth Lake, Miwok Lake, Budd Lake, Gallison Basin, and Roosevelt Lake. To the extent possible, mark-recapture monitoring will be conducted using a robust design to allow the accurate estimation of frog population sizes.

Roland Knapp   5/1/2014 to 5/30/2015   **$17,592**
National Park Foundation   SB150003

Facilitating Recovery of the Endangered Sierra Nevada Yellow-legged Frog (Rana sierrae) in Yosemite National Park through Identification of Critical Habitats and Movement Corridors

The Sierra Nevada yellow-legged frog (*Rana sierrae*) was once the most abundant vertebrate in the mountains of California, but steep population declines during the past century have pushed this species to the brink of extinction. To improve the effectiveness of conservation actions undertaken to recover this frog, including habitat restoration and frog reintroductions, we propose a frog tagging and radio-tracking study in Yosemite National Park designed to identify critical habitats and migration corridors used by *R. sierrae.* The proposed project will provide youth and college students with hands-on experience in conservation research, and the study results will be essential for the design and implementation of future conservation actions in Yosemite and across the range of this iconic species.

Roland Knapp   6/4/2012 to 7/30/2014   **$116,146**
USDI National Park Service   P12AC10522

Preventing the Extirpation of Mountain Yellow-legged Frog Populations in Sequoia and Kings Canyon National Parks Following Disease-caused Mass-mortality Events

Mountain yellow-legged frogs (*Rana muscosa and Rana sierrae*) are highly susceptible to amphibian chytrid fungus (*Batrachochytrium dendrobatidis*; "Bd"), and most populations are extirpated following Bd arrival at a site. Skin swabs collected from Spur Basin in Sequoia and Kings Canyon National Parks on two occasions in 2011 indicated the onset of Bd and increasing prevalence and infection intensity. These patterns indicate that a frog die-off is likely sometime during 2012. Field trials using anti-fungal treatment and augmentation of beneficial bacteria both show promise in changing the outcome of Bd outbreaks from frog population extinction to persistence. With the impending Bd outbreak in Spur Basin, we have an opportunity to markedly increase the chances of frog population persistence, and be able to compare the relative effectiveness of different Bd treatments. We will treat hundreds of frogs in several adjacent populations, thereby potentially changing the outcome from likely extirpation of these populations to long-term coexistence between frogs and Bd. This study will have important implications for future disease interventions that will be important in conserving the remaining mountain yellow-legged frog populations across their respective ranges.

Roland Knapp   4/8/2013 to 6/30/2015   **$50,000**
USDI National Park Service   P13AC00124

Sierra Nevada Yellow-Legged Frog Genetic Analysis for Yosemite National Park

This collaborative project between investigators at the University of California, Santa Barbara-Sierra Nevada Aquatic Research Laboratory (UCSB) and National Park Service (NPS) staff at Yosemite National Park (YOSE) is designed to support efforts to recover the Sierra Nevada yellow-legged frog (*Rana sierrae*) by conducting genetic analysis of frog tissue samples. Approximately 93% of the Sierra Nevada yellow-legged frog populations have been extirpated over the past 100 years, with declines escalating since the late-70s(Phillips 1994; Vredenburg et al. 2010). Most of remaining populations are much smaller and more isolated than those that occurred historically (Knapp 2005).Consequently, this species is listed as Threatened by the State of California, and it is proposed for listing as Endangered by the U.S. Fish and Wildlife Service (USFWS). YOSE, US Fish and Wildlife Service (FWS), U.S. Forest Service (USFS), Sequoia and Kings Canyon National Park (SEKI), and the California Department of Fish and Wildlife (CDFW) are collaborating to develop a range-wide conservation strategy to "ensure self-sustaining, long-term viability, and evolution of mountain yellow-legged frog populations in perpetuity that represent their historic geographical range and genetic and ecological diversity". This multi-agency group has identified translocations as one of the primary tools for bringing the Sierra Nevada yellow-legged frog back from the brink of extinction and for protecting genetic diversity as a key component of frog recovery. However, our knowledge of the genetic structure of Sierra Nevada yellow-legged frog populations is limited, and much more detailed information is needed to guide

future translocation efforts. Results from this genetic project at YOSE will be integrated into the range-wide conservation strategy for the Sierra Nevada yellow-legged frog.

Roland Knapp   **7/1/2013 to 9/30/2016**   **$59,000**
USDI Geological Survey   G13AC00154

Factors Influencing the Reintroduction Success of the Endangered Mountain Yellow-Legged Frog

Objectives: Six reintroductions of MYL frogs are proposed within SEKI and YOSE using methods that will allow the detailed quantification of temporal patterns of Bd infection intensity, survival rates, and fates of individual frogs. By combining information from this study with that collected during a previous reintroduction study (Knapp et al. 2011) we will also be able to evaluate the role of habitat conditions on the outcome of reintroductions. Collectively, this information will allow us to assess the importance of disease, stochasticity, and habitat in influencing the success of reintroductions. The results will be used to develop a reintroduction protocol to guide future reintroduction efforts conducted throughout the range of the MYL frog. Methods Site selection: During a five-year period starting in 1997, my research group surveyed all aquatic habitats in SEKI and YOSE for amphibians, fish, and habitat attributes (Knapp et al. 2003, Knapp 2005). Since this initial survey, I have conducted repeated resurveys of all MYL frog populations in both parks to describe the distribution and spread of Bd, and its impact on these populations (Rachowicz et al. 2006, Vredenburg et al. 2010, Knapp et al. 2011). The resulting data set provides a detailed view of the status and trend of MYL frog populations at an unprecedented spatial scale. For the proposed reintroduction research, we used this data set to identify six MYL frog source populations (three in SEKI and three in YOSE) that experienced Bd-caused population die-offs during the past 5-15 years but that have at least partially recovered despite ongoing chytridiomycosis. All six populations are large enough (≥200 adult frogs) to allow the removal of small numbers of adult frogs for reintroductions without negatively affecting their viability. Results from previous reintroductions in YOSE indicate that removal of approximately 20% of the adult frogs from the source population resulted in a large pulse of recruitment in subsequent years that compensated for the removals (Knapp et al. 2011). The six proposed reintroduction sites are paired with the six source sites (i.e., each pair contains one source and one reintroduction site), and sites in each pair are located within 10 km of each other. Until recently, each of the proposed reintroduction sites contained a robust MYL frog population, but all six of these populations were extirpated following the arrival of Bd. The reintroduction sites are all lakes predicted to be of very high habitat suitability (Knapp et al. 2003).

Reintroductions: The six reintroductions will be conducted in mid-summer of FY13 using methods proven to be effective in previous reintroductions of MYL frogs (Knapp et al. 2011). We will collect twenty adult MYL frogs from each source population (10 males, 10 females) using hand nets. All frogs will be tagged with 8mm PIT tags, measured, weighed, and sexed. PIT tagging was successfully used in numerous previous studies of MYL frogs and does not affect frog survival (Briggs et al. 2010). To characterize the Bd infection intensity of individual frogs, we will collect a skin swab from each frog using standard methods (Hyatt et al. 2007, Vredenburg et al. 2010) and analyze them using real-time quantitative PCR (qPCR; Boyle et al. 2004). Following capture at the source sites, frogs will be held individually in small plastic containers (with ventilation holes), and transported to each reintroduction site via helicopter (Knapp et al. 2011). Prior to release at the reintroduction site, each frog will be fitted with a miniature radio-transmitter (Matthews and Pope 1999). Given the general rule that transmitters not exceed 10% of body mass (Heyer et al. 1994), only frogs weighing more than 10 g will be used. Radio-telemetry was successfully used on MYL frogs in several previous studies and the associated techniques are well-developed (Matthews and Pope 1999; Knapp, unpublished data). The use of radio-transmitters provides a means to overcome a major limitation of past reintroductions by facilitating the recapture of every live frog and retrieval of dead frogs during each site visit, thereby allowing accurate determination of frog status (alive or dead) and regular quantification of Bd infection intensity. To allow direct comparison between frogs at the reintroduction and source sites, we will also attach radio-transmitters to ten frogs in each source population.

Population monitoring: Following release of transmittered frogs, we will revisit each source and reintroduced population once per week for one month (i.e., the battery life of the transmitter). During
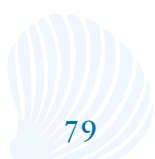
each visit, all frogs will be located using radio-telemetry. The status of each frog will be determined (alive or dead), and live frogs will be measured, weighed, and swabbed. Frogs will be released at the site of capture. Just prior to battery failure, all transmitters will be removed from frogs. Subsequent monitoring in FY 13 will rely solely on periodic recapture of frogs, identifiable via their PIT tags. This monitoring will be conducted during twice-monthly site visits, during which as many frogs as possible will be captured, identified, measured, weighted, swabbed, and released. In the two years following the reintroduction (FY 14, 15) we will again visit each reintroduction and source population approximately every two weeks throughout the summer active season, and will monitor each population using only capture-recapture methods based on PIT-tagged frogs (Knapp et al. 2011). Although the capture-recapture methods will not provide the detailed information on infection intensities and fates of individual frogs possible using radio-telemetry, they will allow estimation of site-specific detection and survival rates and measurement of infection intensities on recaptured frogs (Knapp et al. 2011). During each visit we will conduct shoreline visual encounter surveys of all life stages. Any adults observed will be captured, identified via their PIT tag, measured, weighed, swabbed, and released. The presence of tadpoles or juveniles at the reintroduction sites in FY 14 and/or 15 would provide evidence of successful reproduction, and these life stages will also be measured, weighed, and swabbed at both the reintroduction and source sites.

Jeffrey Krause   4/1/2012 to 3/31/2017 $453,487
National Science Foundation   OCE-1155663

Group-Specific Diatom Silica Production in a Coastal Upwelling System

This project seeks support to understand the variability in the contribution of individual diatom groups to total silica production in a field diatom population as a function of dissolved silicon availability. The value of the ecological and biogeochemical insights that would be gained from knowledge of the performance of individual groups has inspired several attempts, but the partitioning of silica production among different diatom groups has never been done in the field. Bulk measures of silica production have been made in all types of marine environments. When silica production studies also have taxonomic data, the lack of information on the performance of individual species makes it impossible to allocate the measured rates among cells. The assignment of the most numerically abundant diatom as the highest contributor to bulk silica production potentially leads to erroneous conclusions given interspecific differences in cell size and Si uptake kinetics. Quantitative estimates of the contribution of individual diatom taxa to total silica production would improve our understanding of the major biological and ecological drivers of silica production and identify key diatom species for inclusion in food-web and biogeochemical models. The proposed work will test hypotheses related to the general theme of using species-specific data to improve our understanding of the factors regulating diatoms' role in elemental cycles and marine food webs. By combining bulk measures of silica production using the radioisotope 32Si with measures of silicon deposition rates by individual cells using the fluorescent probe 2-(4-pyridyl)-5((4-(2-dimethylaminoethyl-aminocarbamoyl)-methoxy)phenyl)oxazole or PDMPO, quantitative estimates of the contribution of individual diatom taxa to total silica production will be determined for the first time. This study will assess differences in the distribution of silica production among diatom species along gradients in dissolved silicon concentration in a coastal upwelling system, evaluate the role of cell size, abundance and Si uptake capacity in determining the contribution of individual diatom taxa to total silica production, and determine species-specific kinetic parameters for Si uptake which govern the ability of individual species to compete for dissolved silicon.

Jeffrey Krause, Mark Brzezinski   1/1/2012 to 12/31/2014 $256,128
National Science Foundation   OCE-1131788

Collaborative Research: Understanding the Role of Picocyanobacteria in the Marine Silicate Cycle

We propose to pursue our discovery of significant accumulation of silicon by marine picocyanobacteria of the genus Synechococcus to assess the contribution of these organisms to the cycling of biogenic silica in the ocean. Oceanographers have long assumed that diatoms are the dominant marine organisms controlling the cycling of silica in the ocean. Si cycling by diatoms is coupled to their processing of other nutrient elements with consequences for the sequestration of

carbon in the deep sea. Recently, however, single-cell analyses of picocyanobacterial cells from field samples surprisingly revealed the presence of substantial amounts of silicon within Synechococcus. The contribution of Synechococcus to biogenic silica often rivaled that of living diatoms in the two systems examined. Moreover, size fractionation of biogenic silica indicates that up to 25% of biogenic silica can exist in the picoplanktonic size fraction. Given that picocyanobacteria dominate phytoplankton biomass and primary production over much of the world's ocean, these findings raise significant questions about the factors controlling the marine silica cycle globally, as well as the proper interpretation of biogenic silica measurements, Si:N ratios in particulate matter, and ratios of silicate and nitrate depletion. It also suggests that picocyanobacterial populations may be subject to previously unknown constraints on their productivity. The proposed work will have both laboratory and field components. Because cellular Si varies substantially among the field-collected samples and laboratory strains so far analyzed, the laboratory component will document variability in Si uptake and cellular Si concentrations, while determining what role physiological and phylogenetic factors play in this variability. We propose using strains of the cyanobacterium Synechococcus for which there are existing genomes. Three separate laboratory components will 1) use 32Si radiotracer uptake experiments to assess the degree of variability in Si content and Si uptake kinetics among strains of Synechococcus acclimated to different levels of silicate , 2) characterize the intracellular distribution and chemistry of silicon within cells using fractionation techniques, density centrifugation, electron microscopy and x-ray absorption spectroscopy, and 3) use bioinformatic analyses of published genomes to determine whether uptake of Si can be predicted based on phylogenetic relationships, to identify candidate genes for inactivation and to develop probes for community structure that can be related to cellular Si content. Field work at the Bermuda Atlantic Time Series (BATS) site will assess the contribution of Synechococcus and diatoms to total biogenic silica in surface waters at times of the year when the former are typically dominant. Field measurements will include size fractionation of biogenic silica biomass and Si uptake, and synchrotron-based x-ray fluorescence microscopy. We will also attempt to characterize Synechococcus communities using various molecular approaches to help explain the substantial spatial and temporal variation in expression of this trait.

Armand Kuris, Ryan Hechinger, Kevin Lafferty   8/1/2011 to 7/31/2016 $2,149,227

National Science Foundation   OCE-1115965

Collaborative Research: Modeling Infectious Diseases: How much Ecological Complexity Must We Address?

This project focuses on how ecological complexity influences infectious disease dynamics and how we should best go about predicting disease dynamics. Ecological systems are undeniably complex and to fully understand their dynamics we must first take their complexity into consideration. One of the most complex aspects of ecology is how biodiversity interacts in ecological networks. Ecologists have been making strides toward describing and analyzing complex ecological networks, but are only very recently considering the role of infectious diseases. Particularly challenging is that infectious diseases affect ecological networks while ecological networks affect infectious diseases. The research will not only increase our understanding of infectious disease dynamics, but also illuminate the general role of infectious processes in ecological systems, helping ecological science better address the fundamental and overlooked implications of parasitism.

Armand Kuris, Kevin Lafferty   6/1/2012 to 5/31/2015 $36,000

University of Tromso

The Role of Parasites in Food-Web Topology and Dynamics of Subarctic Lakes

UCSB will give assistance in the project work with field sampling of parasites from the Norwegian lake sites involved in the study, taxonomical analyses of sampled parasites, and quantitative analyses of collected data on food-web topology and functioning (June 2012 – Dec. 2014); host the postdoc candidate during a research visit at UCSB (Sept. 2013 – May 2014); and participate in the dissemination and publication of findings from the Project (June 2012 – May 2015).

Armand Kuris, Susanne Sokolow,   8/1/2014 to 1/31/2019   **$1,499,897**
David Lopez-Carr
National Science Foundation   BCS-1414102

Healthy Ecosystems, Healthy People: The Coupled Human Health and Environmental Dynamics of Schistosomiasis in Sub-Saharan Africa

Ecological damage caused by human activity can directly influence infectious diseases and human health. Yet, public health campaigns rarely turn to ecological solutions to mitigate infectious disease risk, instead favoring traditional approaches such as vaccine development or drug treatment. Here, we propose an experimental investigation of a novel disease control strategy for schistosomiasis, one of the most prevalent parasitic diseases in the world. The proposed strategy will mitigate the ecological damage caused by dam building on a river in sub-Saharan Africa, and thereby reduce the transmission of this disease that emerged and spread to epidemic levels following dam completion. We propose the novel integration of bio-economics, aquaculture, social science, ecology, and epidemiology to develop and test an unprecedented, ecology-based solution. More than 700 million people are at risk of schistosomiasis worldwide, mostly children in poor, rural villages, and Africa contains 97% of the world's infected population. Schistosomes are waterborne parasites that require aquatic snails as obligate intermediate hosts. There is convincing evidence that dam construction has increased habitat for, and decreased native predators of, medically important snail hosts in the Senegal River, contributing to the emergence of human schistosomiasis. *Macrobrachium vollenhovenii* is a large, edible, native crustacean that has suffered dramatic declines in the Senegal River ecosystem. Causes and consequences of the decline have not been previously recognized or studied. Our preliminary research reveals that prawns probably declined due to dam construction: prawns are currently in low abundance below the dam and nearly extirpated above the dam. Prawns are predators of snails. Therefore, we propose to test environmental re-introduction of the native prawn, *M. vollenhovenii*, using village-based aquaculture, as a socially and economically sustainable control strategy for schistosomiasis. Our proposed research will test two hypotheses: (1) that we can mitigate the ecological disruption of aquatic food webs to greatly reduce disease transmission, and (2) that this mitigation will be sustainable in the long-term, given fusion of mitigation with an aquaculture enterprise.

Adam Lambert   9/30/2014 to 6/30/2020   **$1,962,430**
Ventura County   SB150130

SC-13: Invasive Plant Removal, Ecosystem Restoration, and Habitat Protection in the Santa Clara River

This project consists of an arundo control and habitat restoration program in the Santa Clara River floodplain on properties between Sespe Creek and Santa Paula Creek. This project will restore between 150 and 170 acres of riparian habitat by removing arundo and other invasive plant species and implementing native re-vegetation efforts. Removal of water-intensive invasive species will conserve approximately 3,500 AFY of water, reduce flood and fire risk, and improve riparian habitat for sensitive species.

Adam Lambert, Tom Dudley   9/1/2012 to 12/31/2014   **$99,930**
USDA National Institute for Food and Agriculture   2012-34103-20193

Evaluating the Efficacy and Impacts of *Tetramesa Romana*, a Wasp Introduced for Biological Control of *Arundo Donax* (Giant Reed)

Arundo donax (giant reed) is a large invasive grass in riparian areas across the southern United States, especially in the arid Southwest. A biological control program is being implemented using specialist herbivores of European origin, and several of these insects have been released or are already present in the US. However, field evaluation of their impacts has not yet been conducted. Our work is intended to complement and facilitate the ongoing USDA biocontrol program by providing additional and unique information about the impacts of herbivores released for biocontrol, as well as new techniques for large-scale development and implementation. Our proposed research addresses multiple program priorities and integrates basic scientific investigations and outreach activities. We

propose to document the impacts of Arundo IPM adoption by measuring the effects of herbivorous wasps and other insects on Arundo growth and architecture in field populations in California [priority (a)]. Further, we propose to develop and fine tune methods for mass rearing wasp biocontrol agents [priority (g)] and evaluate whether insects can be redistributed over a greater range where Arundo is problematic [priority (e)], including multiple states (CA, NV, and AZ). We will work to promote understanding and acceptance of this program by the public by disseminating information about Arundo biocontrol through our website and informational materials provided to cooperative extensions, land managers, and weed management areas. Our ultimate goals are to evaluate the risks associated with and facilitate large-scale implementation of the Arundo biocontrol program.

Adam Lambert   7/1/2014 to 6/30/2016 $26,032
UC Agriculture and Natural Resources   SA14-2254-06

Invasive Weeds as Alternate Hosts for the Newly Introduced Cole Crop Pest *Bagrada Hilaris*

This project will examine the biology and interactions with weeds of a new invasive insect pest (*Bagrada hilaris*) of cole crops in Ventura County and provide information for reducing its economic impact on agriculture in the region. Specifically, the project will determine the extent to which invasive mustards in riparian areas, which are alternative hosts for *B. hilaris*, support bug populations and facilitate the spread of this pest into cropping systems. Bug populations will be monitored on weeds adjacent to agricultural fields to evaluate life history characteristics, such as phenology, growth, and reproduction, and population dynamics over the growing season. Cole crops commonly grown in Ventura County will also be evaluated in an agricultural plot to determine their susceptibility to *B. hilaris*. The project will be conducted at the Hansen Agricultural Center and field sites in Ventura County, and in our lab at UC Santa Barbara, but will have implications for management of this insect across its introduced range. This research project will directly address the Endemic and Invasive Pests and Diseases and Sustainable Food Systems initiatives of ANR, as well as the Hansen goal of assuring the economic viability of agriculture to sustain agriculture's contribution to a healthy Ventura County.

Ashley Larsen, Steven Gaines   9/28/2014 to 9/27/2016 $17,000
Environmental Protection Agency   FP-91762601-0

What Drives Pesticide Use, and How Will Quantity and Distribution of Pesticide Use be Modified by Climate Change?

There is a well-established consensus that climate change will affect temperature and precipitation on a global scale. Temperature and precipitation are direct inputs into agriculture production and affect the development and survival of numerous pest species. However, there are currently no substantiated predictions of the sign and magnitude of the effect of climate change on pesticide use using sub-state level data. To predict the distribution of the numerous human health and biodiversity externalities of pesticides we must first understand what is driving pesticide use. This knowledge will be instrumental to policy makers, public health officials, agricultural industries and the public alike. Additionally, identifying the determinants of pesticide application will identify the drivers of the pest themselves, Given the food requirements of the increasingly large and wealthy human population, understanding how pests will be impacted is important to ensuring food supply increases to meet demand. The research proposed here will provide instrumental insight into the casual drivers of pesticide use and how pesticide use will be modified by climate change.

Lyndal Laughrin, Susan Swarbrick   8/1/2013 to 8/30/2015 $13,581
USDI National Park Service   P13AC01131

Research Bibliography for Channel Islands National Park

In this project, the National Park Service (NPS) and University of California, Santa Barbara (UCSB) will collaborate on compiling and updating bibliographic references for natural and cultural resource research studies within and in the vicinity of Channel Islands National Park (CHIS). The compiled park research bibliographies will provide a variety of users, from park staff to students, teachers, and scientists, with useful references for understanding the scope of previous research and as a baseline

for understanding where to direct future research efforts. This project is planned for multiple phases. Phase 1 will focus on compiling easily sourced natural resource related references for CHIS in an electronic database and completing an assessment of information gaps for planning future project phases. A longer term goal of this project is to provide public access to park bibliographic information through an easy to use web interface and one that consolidates information across jurisdictions. Project partners will explore the possibility of working jointly with the University of California, Natural Reserve System in the development of a web-based research portal for parks, natural reserves and other protected areas in the state. Future phases of this project would be implemented through modification of this Task Agreement and are dependent upon the availability of funding and need.

David Lea   7/1/2013 to 12/31/2014 $10,000
UC MEXUS   SB140018

Yucatan Peninsula Hydrological Sensitivity to Radiative Forcing by Greenhouse Gases: Paleoclimate Perspective

We propose to extend the climate record of the Yucatan Peninsula (YP), which currently goes back 10 thousand years before present (BP), to at least 320 thousand years BP, by analyzing the chemical composition of stalagmite deposits found in underground caverns from this region. By exploiting recently developed tools for paleo-rainfall reconstruction, we aim to provide a regional view of past climate variability in the YP region, investigate the role of climate in shaping the history of the Maya civilization, and offer quantitative estimates of the sensitivity of regional rainfall variability to changes in the atmospheric content of greenhouse gases. The problems that we propose to address here are particularly important considering recent model estimates suggesting regional rainfall reductions of up to 50% by the end of this century, and the considerable impact that drought has on the livelihood of local populations.

Ira Leifer   9/1/2010 to 8/31/2014 $224,088
National Science Foundation   ARC-1023600

Collaborative Research: The East Siberian Arctic Shelf as a source of Atmospheric Methane: First Approach to Quantitative Assessment

We propose to study methane (CH4) release over the East Siberian Arctic shelf (ESAS), the largest (~10% of the world ocean shelf area) and the shallowest shelf (mean depth <50 m) of the world ocean. Until recently, the ESAS was not considered a CH4 source due to subsea permafrost's impermeability, which completely isolated it from modern biogeochemical cycles. The ESAS stores the world's largest hydrocarbon stocks, mostly as shallow Arctic hydrates, and thus represents an enormous potential CH4 atmospheric source that could result from global warming-triggered permafrost degradation. Increased CH4 fluxes could occur as numerous weak seeps or strong bubble plumes over large areas. Due to the shallow nature of the ESAS, the majority of ESAS CH4 likely avoids oxidation and escapes to the atmosphere. To assess whether sudden, large-scale CH4 release occurs or is likely to occur in the future, we will investigate the migration pathway characteristics and identify the controlling factors of CH4 flux from the seabed, in the water column, and to the atmosphere.

Hunter Lenihan, Erik Muller   2/1/2016 to 1/31/2017 $106,480
UC Sea Grant College Program   R/HCME-24

Impact of Neonicotinoid Pesticides on Estuaries and Coastal Streams

The overall goal of this project is to provide meaningful data to the City of Santa Barbara along with State and Federal agencies about potential coastal and estuarine ecological impacts of neonicotinoid pesticides in urban and agricultural run-off.

The specific objectives are:

1. To determine the temporal [wet and dry season] patterns of imidacloprid and five related neonicotinoid insecticides as well as several major metabolites in stormwater feeding coastal streams and estuaries in agricultural and urban areas.

2. To test the hypothesis that streams receiving runoff from urban land uses and agricultural (nursery) land uses have different concentrations or loading rates of imidacloprid.

3. To test the hypothesis that samples from creek and estuaries in Santa Barbara will exhibit toxicity when neonicotinoid-sensitive test species and assays are used.

4. To produce pilot-scale data on transport mechanisms of neonicotinoids to urban streams.

5. To test the hypothesis that two species of aquatic organisms [Chironomus riparius and Leptocheirus plumulosus] develop lethal and/or sublethal responses when exposed to field-relevant concentrations of neonicotinoid insecticides in modified routine controlled laboratory sub-chronic [10 day] and chronic [28 day life cycle] bioassays.

6. To predict the individual and population level impacts from field-relevant concentrations of imidacloprid, using Dynamic Energy Budget (DEB) models.

Hunter Lenihan, Laura Urbisci   **6/1/2014 to 5/31/2017**   **$96,249**
UC Sea Grant College Program   E/PD-13-F-R

Developing a New Ecosystem-Based Management Approach: Using Ecosystem Models to Calculate a Better Estimate of Population Scale for Single-Species Models

Exploitation of renewable marine resources provides for many of the world's human needs, and this dependence is unlikely to change in the future. Exploited fish stocks are especially important in providing sources of protein as well as employment to millions of people world-wide. Without appropriate management that is based on high quality science and adequate enforcement, sustainable fishing is difficult to maintain (Hutchings and Myers 1994). Most managed stocks rely on single-species stock assessments to provide the necessary information to support sustainable harvest. Dynamic stock assessment models range from simple biomass dynamics models to complex age and sex-structured models (Pope and Shepherd 1985; R. Methot 1989; Hilborn 1990; R. D. Methot 1990). Modern integrated stock assessment models are capable of utilizing a wide range of data types from traditional fisheries monitoring (e.g. catches, surveys, composition) in addition to environmental data. In a statistical framework, population level processes (i.e. recruitment, mortality) are used to govern the estimation of dynamics (i.e. changes in abundance through time), which in turn are then used to compare the model predications to the data. However, single-species models stop short of understanding broader ecosystem concepts, because they do not adequately incorporate energy transfer through food-webs and species interactions. Ecosystem models on the other hand can generate critical information that so far has limited the power of single species stock assessments. To meet the needs of more comprehensive management and assure sustainable fishing, integrated ecosystem models are being developed to address broader ecosystem level processes, such as the total fish biomass that can be produced for a given level of primary production. We use single-species models to manage quotas for individual stocks. These models rely heavily on estimates of population "scale", another term for population abundance used by stock managers. Population scale is a critical metric because it used to estimate the virgin stock biomass, against which sustainable removals through fishing, as stipulated in annual quotas, are calculated. As such, sustainable fishing is heavily reliant on good estimates of population scale that was present prior to the initiation of the fishery. Of course, actual scale measures are not possible, so are backed out of the available stock biomass data generated from catches through time. For apex predators, such as tunas, sharks, and swordfish, estimates of virgin stock biomass are difficult to generate because their population scale is heavily dependent on the state of the ecosystem, specifically in terms of prey availability (i.e., biomass in low trophic levels) and thus primary Laura Urbisci NMFS Fellowship Application: Project Proposal production, as well as environmental features, especially temperature, which helps determine their spatial distribution. My project is designed to utilize information from ecosystem models, specifically potential secondary production of apex predators and environmental conditions, to generate more robust estimates of population scale for use in single species stock assessment. This project will therefore make a very important contribution to ecosystem-based fishery management. Sharks and other chondrichthyan species are apex predators that we fish heavily in many fisheries worldwide. However, as apex predators sharks appear to be highly susceptible to overfishing due primarily to their low reproductive rate (i.e. slow growth, late maturity and low fecundity)(Holden

1974; Holden 1977). In low production species, only a relatively small portion of the population can be removed annually if the catches and populations are to remain sustainable. Populations of sharks are therefore difficult to manage in single-species stock assessments because the estimate of virgin biomass, "population scale", is so critical in estimating sustainable catches. Apex predators are also of major importance in ecosystem-based fishery theory because of their role in controlling the abundance of prey species that are also fished or are utilized by other species as prey. Thus overfishing of apex predators can lead to the destabilization of food web dynamics (Friedlander and DeMartini 2002).Destabilization of food web dynamics may alter the relationship between the apex predator and the trophic system through poorly understood ecosystem feedback mechanisms. As such, developing a more sustainable approach to managing apex predators is of major concern to fishery managers at NMFS and elsewhere. Shortfin mako sharks (*Isurus oxyrinchus*) are a highly migratory apex predators that are widely distributed in tropical and subtropical waters and are commercially fished across the globe (Compagno 2001). Despite their importance to both fisheries and trophic dynamics, considerable uncertainty remains in their stock status, productivity and resilience to heavy fishing and natural disturbance, as well as the influence of ecosystem changes (biological and environment) on their population dynamics and regulatory mechanisms. The focus of my research will be on integrating alternative estimates of population scale size from ecosystem models into single-species models to improve the reliability and reduce uncertainty of the current stock assessment models. The objectives of my proposed study are to compare results of two different theoretical approaches to modeling shortfin mako population dynamics. In the first approach, I will create a traditional fisheries single-species dynamic model. In the second approach, I will develop an alternative ecosystem model that includes non-traditional data and ecological process allowing for understanding of alternative and higher level population regulation mechanisms. I plan on comparing both the model performance and key drivers of population dynamics from the two approaches. I intend to focus on the strengths and shortcoming of both methods as well as how to use our ecosystem level understanding to improve shortcomings in the single-species approach (i.e. calculating population scale size)

Sarah Lester   **6/1/2013 to 5/31/2015**   **$83,146**
Rare   SB140049

Fish Forever: Subaward from MacArthur Foundation

Background: Environmental Defense Fund, Rare, and the Sustainable Fisheries Group at UCSB formed the Fish Forever partnership to launch a global initiative to protect and recover nearshore fisheries, curb overfishing and safeguard the food security and economies of thousands of communities in the developing tropics. Fish Forever's theory of change is that by aligning the social and economic interests of fishermen with conservation, fishermen become agents of long-term change because they reap direct rewards. Central to our approach is the proven TURF-Reserve system that combines spatial property rights with marine reserves where fishing is off-limits. This system gives fishermen a built-in incentive to defend reserves because the reserves replenish fisheries and the rights-based system ensures that good management is in the self-interest of local communities. Fish Forever brings together three experienced organizations that are uniquely positioned to achieve lasting, scalable conservation solutions across multiple communities and countries. All have strong track records of success. Environmental Defense Fund (EDF) is a global leader in transforming fisheries through rights-based management, and provides technical expertise and practical experience in designing and launching these systems. Rare specializes in engaging developing country communities to adopt more sustainable behaviors, and builds the capacity of organizations and governments to generate support for change through Pride campaigns. University of California, Santa Barbara (UCSB) brings expertise in fisheries science and innovative biological and economic assessment and management techniques, including for data-poor stocks. Together, we are poised to begin on-the-ground work in Indonesia and the Philippines, and to launch additional pilot projects in Belize. Launching pilot sites in Belize, Philippines and Indonesia: During the grant period of June 2013- May 2015, the Fish Forever team will create or build on TURF-reserve pilot sites in three countries (Indonesia, Philippines, and Belize) and assess these R&D sites in order to adapt, analyze and document lessons learned from this initial phase. These sites will serve as working laboratories to produce tangible results but also test a variety of new tools and approaches. They will serve as model

sites where others can come to see the program in action. Learning at these sites will inform the program development and enhancements. The Sustainable Fisheries Group (SFG) at UCSB will serve a key role in providing the scientific analysis and guidance needed to make sure these pilot sites are successful. See Deliverables (Exhibit B) for specific scientific contributions that SFG will make during the launch of pilot sites in these three countries.

Sarah Lester, Steven Gaines,   **9/1/2012 to 8/31/2014**   **Core $414,420**
Chris Costello, Libe Washburn   **Trainee $72,123**
COM National Oceanic and Atmospheric Administration   R/AQ-134-F-R-1/2

Maximizing the Value of Offshore Aquaculture Development in the Context of Multiple Ocean Uses

The overarching goal of the proposed project is to develop a framework to inform marine spatial planning for offshore or open ocean aquaculture such that the value and success of aquaculture development is optimized in the context of a suite of ocean uses and environmental impacts. Planning for aquaculture without consideration for other competing uses (e.g., fisheries, shipping) is likely to result in conflicts and stakeholder and political opposition, and could preclude this new avenue for sustainable seafood and coastal economic development. We assert that strategic marine spatial planning can significantly reduce impacts from aquaculture and increase its value and compatibility with other ocean uses. Furthermore, successful planning requires an explicit consideration for how dynamic processes in marine ecosystems, such as oceanographic currents and human response patterns, drive interactions among aquaculture, other competing uses, and the environment. Therefore, we will develop an innovative dynamic spatial analysis framework for examining economic and environmental tradeoffs among aquaculture and other ocean uses in order to identify spatial plans that achieve a diversity of objectives and minimize environmental impacts. We hypothesize that our dynamic spatial analysis approach will out-perform static spatial siting models (i.e., that do not account for dynamic processes) and single sector planning decisions (i.e., that focus on maximizing a single use). This will allow us to assess if and how value is added by our approach and the losses that are likely to be incurred by moving forward with aquaculture development in its absence.

Sarah Lester, Steven Gaines   **10/4/2013 to 8/29/2014**   **$25,000**
The Nature Conservancy   FY13-G-BH-Waitt-UCSB

Economic Benefits of Proposed Marine Protected Areas in the Bahamas

1) Background: The economic, cultural, and political variables that shape individual behavior ultimately structure the development, management and performance of Marine Protected Areas (MPAs). TNC is interested in evaluating the economic contribution of natural resources (and the associated environmental goods and services they provide) to the economy and people in the Bahamas. 2) Objective of the Study: The overall objective of the grant is to document the economic contribution of the natural resources within proposed marine protected areas to the Bahamian economy and to the social development of its population. The results of the economic valuations are expected to form the basis for mobilizing support for natural resource conservation and sea use planning from political leaders, decision-makers, the private sector and the general public. 3) Specific Objectives for the evaluation of 5 proposed priority MPAs in the Bahamas: 1. Construct a conceptual model of all existing interactions between natural resources in currently proposed MPAs and the national economy of The Bahamas (preferably divided along productive sectors). The model should be concise and descriptive rather than analytical or mathematical. In particular, emphasis should be put on differentiating indirect and direct benefits from goods and services generated by ecosystems in the proposed areas, as well as direct and indirect uses in those ecosystems. 2. Based on the conceptual model, identify actual and potential environmental benefits that the natural resources of proposed MPAs specifically provide to the Bahamian economy. This analysis should be divided by sector and place special emphasis on the economic sectors associated with the ecosystems services selected. 3. Again based on the conceptual framework, identify actual and potential environmental goods and services that the proposed areas provide to humans, such as natural disaster protection, water supply, property values, recreation, and overall social welfare effects not

covered by sectorial analysis of the previous specific objective. 4. Prepare a set of simple and strong economic and political messages which are backed up by credible data and the results from the above analysis.

Sarah Lester, Christopher Costello   **1/1/2014 to 12/31/2018**   **$100,000**
Rare   SB150042

Fish Forever (Waitt Foundation)

During the grant period, the Sustainable Fisheries Group at UCSB (SFG), under the direction of Project PIs Lester and Costello, will design and refine analytical tools and provide technical support to improve project implementation and capture learning on how to adapt and improve future strategies and tactics across Fish Forever sites in the Philippines, Indonesia, Belize and Brazil. Specifically, SFG will be responsible for:

1. Providing scientific guidance on site assessment and selection, including assisting with the application of a Rapid Site Assessment tool.

2. Providing technical support in the development of global and regional monitoring and evaluation plans and baseline assessments, including data collection protocols and guidance on the development of a data management platform.

3. Performing data analysis and modeling to inform implementation decisions such as TURF-reserve design and adaptive fisheries management, including the use and development of new data-limited fisheries assessment methods; assistance with setting harvest controls; tracking and evaluating progress towards our stated goals for the program; and providing technical expertise on barrier removal strategies.

4. Writing scientific papers, to be submitted to peer-reviewed journals, based on research related to Fish Forever, when appropriate.

5. Participating in the Fish Forever Science and Design team, including attending regular meetings.

6. Assisting with the development of Fish Forever curriculum on technical/scientific topics, including attending Fish Forever Training Team meetings.

7. Participating in the development of strategic plans for Fish Forever.

Sarah Lester, Christopher Costello   **8/1/2014 to 9/30/2015**   **$250,000**
Rare   SB150028

UCSB Fish Forever Support in Brazil and Philippines

During the grant period, the Sustainable Fisheries Group at UCSB (SFG), under the direction of Project PIs Lester and Costello, will design and refine analytical tools and provide technical support to improve project implementation and capture learning on how to adapt and improve future strategies and tactics across Fish Forever sites in the Philippines and Brazil. Specifically, SFG will be responsible for:

1. Providing scientific guidance on site assessment and selection, including assisting with the application of a Rapid Site Assessment tool and participating in site visits in Brazil.

2. Providing technical support in the development of global and regional monitoring and evaluation plans and baseline assessments, including data collection protocols and guidance on the development of a data management platform.

3. Performing data analysis and modeling to inform implementation decisions such as TURF-reserve design and adaptive fisheries management, including the use and development of new data-limited fisheries assessment methods; assistance with setting harvest controls; tracking and evaluating progress towards our stated goals for the program; and providing technical expertise on barrier removal strategies.

4. Writing scientific papers, to be submitted to peer-reviewed journals, based on research related to Fish Forever, when appropriate.

5. Participating in the Fish Forever Science and Design team, including attending regular meetings and connecting team products to Rare staff in the Philippines and Brazil.

6. Assisting with the development of Fish Forever curriculum on technical/scientific topics, including attending Fish Forever Training Team meetings.

7. Participating in the development of strategic plans for Fish Forever.

| Jonathan Levine | 10/21/2004 to 9/30/2014 | $675,000 |
| David and Lucile Packard Foundation | | 2004-27672 |

Understanding Biological Invasions from Introduction through Impact

Biological invasions are a leading threat to natural ecosystems and cost the American economy tens of billions of dollars annually. At the same time, invasions can be regarded as large scale perturbations to ecological communities, providing unique opportunities to understand how these systems are structured. This proposal outlines a research program applying principles of population, community, and ecosystem ecology to understand the factors controlling the success and impacts of biological invasions. The proposed research couples mathematical models with field experiments to understand such fundamental questions as how many new invaders we should expect over the coming decades, and what factors regulate the impact of invaders once they have established. By examining key questions at the introduction, establishment, spread, and impact stages, the proposed research aggressively pursues a rigorous understanding of the entire invasion process.

| Lorraine Lisiecki | 10/1/2010 to 9/30/2014 | $157,017 |
| National Science Foundation | | OCE-1025444 |

CMG Collaborative Research: Probabilistic stratigraphic alignment and dating of paleoclimate data

Stratigraphic alignment is the primary way in which long marine climate records (105 – 107 years) are placed on a common age model. However, currently there are no techniques for quantifying the uncertainty associated with these alignments. We propose to build probabilistic models of an automated stratigraphic alignment algorithm for paleoclimate records [Lisiecki & Lisiecki, 2002] as a means of characterizing this uncertainty. The development of this uncertainty analysis is important because the relative timing of climate responses (derived from stratigraphic alignment) is frequently used to evaluate causal relationships within the climate system. Therefore, we will also assess the effects of alignment uncertainty on these evaluations. Additionally, we will develop a probabilistic algorithm for age model development through orbital tuning. The improved accuracy and error estimates for paleoclimate age models that result from this work will improve estimates of the climate system's sensitivity to changes in radiative forcing [e.g., Hansen et al., 2007; Meyers et al., 2008]..
The original software developed by PI L. Lisiecki uses dynamic programming to find the optimal alignment of paleoclimate records based on user-defined parameter settings and produces one best-fit alignment with no uncertainty analysis. The new version will provide users with alignments sampled in proportion to their probability and will provide error bars for the estimated relative ages at each point in the alignment. Specifically, we will develop two probabilistic versions of the alignment algorithm (pairwise and multiple) in the form of (pair and profile) Hidden Markov models (HMM) and develop a probabilistic HMM for creating orbitally tuned age models for paleoclimate data. The algorithm for age model development will incorporate knowledge gained about sedimentation rate variability from the pair and profile HMM algorithms. All three algorithms will be applied to create a new stack model of benthic $\delta18O$ records (a proxy for global climate) with uncertainty estimates which include data noise, alignment uncertainty and age model uncertainty. This "probabilistic stack" is scientifically important because it will yield uncertainty estimates for a widely used measure of past climate change. For example, the deterministic $\delta18O$ stack of Lisiecki & Raymo (2005) has >300 citations. We also propose to develop statistical methods to characterize the shapes of the posterior distributions of stratigraphic alignments and orbital tuning. This alignment problem is in a large class of discrete high dimensional problems that often have complex multimodal solution spaces

which are difficult to characterize. To date the characterization of these spaces has been limited to a point estimate(s) and Bayesian confidence limits around these high-D estimates. In this project we propose to develop novel methods for the identification of clusters from multiple modes in these high-D spaces and characterize them as specific probabilistic models using both direct samples from the posterior distribution and the probabilities of each sampled value. Given the limited utility of point estimates and confidence limits in such high-D spaces, these probabilistic characterizations of posterior spaces will greatly improve our ability to describe such posterior spaces.

Lorraine Lisiecki   9/1/2011 to 8/31/2016   **$303,207**
National Science Foundation   OIA-1125181

CDI-Type II: Collaborative Research – 4 Dimensional Visualization of Past Ocean Circulation from Paleoceanographic Data

One of the fundamental challenges in the study of climate change is how to combine models of past oceanographic circulation (as reconstructed from sparse geochemical data taken from deep sea sedimentary cores) with modern ocean circulation models (as constructed from modern oceanographic observations and computer simulations) to yield insight into the processes governing ocean circulation throughout the last glacial cycle from 150,000 years ago to the present. Similarly, a major challenge in computational data analysis and visualization is how to extract topological/structural information from sparse, time-varying 4D datasets, and how to effectively combine human-in-the-loop analysis of data (computational thinking) with automated data analysis, to extract new knowledge about features and processes. Our multidisciplinary and multi-institutional project will bring together computer scientists, physical oceanographers, paleoceanographers, and computational geophysicists to develop an innovative suite of visualization and analytical tools to explore fundamental questions about changes in global ocean circulation. This project will merge innovations in flow-dependent data approximation and reconstruction and topology-based analysis of ocean flow with 40 years of paleoceanographically relevant geochemical data from deep sea sedimentary cores in order to gain new insights into features of past ocean circulation change that were not previously possible. Our research will take advantage of the unique analytical resources and unique interdisciplinary collaboration provided by the UC Davis KeckCAVES (W.M. Keck Center for Active Visualization in the Earth Sciences). The KeckCAVES provides a visualization instrument and collaborative environment that exploits the human capacity to visually identify meaningful patterns in complex datasets and to interact with the data through pattern recognition, change detection algorithms, human-in-the-loop computing, and computational thinking. In this unique collaborative environment, we will develop methods based on flow fields that improve data interpolation, develop techniques to automatically extract flow patterns and detect changes in flow over time, and develop interactive means of visualizing and interacting with those large and time-dependent datasets.

Milton Love   9/22/2011 to 4/29/2016   **$1,232,660**
USDI Bureau of Ocean Energy Management   M11AC00008

Renewable Energy in situ Power Cable Observation

The BOEM requires information concerning the level of impacts of electromagnetic field (EMF) on some marine species. Submarine transmission cables that power offshore oil platforms in the Pacific Region provide an opportunity to assess potential behavior and reaction of electromagnetic sensitive species to industry activities. By comparing the fishes and invertebrates that associate with 1) an energized power cable, 2) an unenergized power cable, and 3) nearby seafloor, it will be possible to determine how some marine organisms relate to an EMF. The information will be applicable to all renewable energy power cable EMF considerations and will determine effectiveness of the commonly proposed mitigation of cable burial.

Milton Love   6/4/2012 to 9/30/2015   **$625,000**
USDI Minerals Management Service   M12AC00004

Analysis of Fish Population at Platforms off Summerland, California

The purpose of this award is to use BOEM-funded pre-existing methodology, applied through

SCUBA and Remotely Operated Vehicle (ROV) surveys, to obtain observations of fish assemblages at eight very closely grouped platforms, within the Dos Cuadras oil field, off Summerland, Santa Barbara County, California. The detailed purpose is to characterize the fish assemblages around the platforms, describe the spatial and temporal patterns of fish diversity, density and size distribution among platform habitat types, complete analyses and synthesis documents for the eight platforms themselves and within the context of the manned submersible data from other Pacific platforms and natural reefs, complete standing stock (biomass) and fish productivity modeling for each platform when compared to other nearby natural reefs for which similar production estimates are readily available, and compare production estimates in the literature of other marine ecosystems. The issue of platform decommissioning and decisions related to decommissioning and possible reefing will be decided on a platform by platform basis with each of the platforms judged on its own merits as far as ecological value is concerned. The eight platforms off Summerland California, Platforms C, B, A, Hillhouse, Henry, Houchin, Hogan and Habitat have been in operation for over four decades and are expected to be some of the first to be in line for decommissioning. Information is needed as soon as possible for the use by the State of California to consider for decommissioning options under the California legislation AB 2503 (the California Marine Resources Legacy Act). The Act requires California to consider reefing OCS oil and gas platforms, if their ecological value warrants, before decommissioning and potential removal. This study will also extend the application of the methodology to develop results applicable specifically for BOEM management decisions so that BOEM can specify requirements to industry or other interested parties when decommissioning occurs. Using the results, BOEM can ensure that specified criteria can be properly evaluated during the decommissioning process pursuant to the federal regulations at 30 CFR 250.1730 and the State of California can ensure proper evaluation under the California Rigs-to-Reefs Program law AB 2503 (the California Marine Resources Legacy Act). Thus, the overarching purpose of this research is to provide those responsible for making decommissioning decisions with a much more detailed assessment of the fish assemblages of these eight platforms (and by extension a more accurate picture of their ecological importance) than is currently available.

Circulation and Respiration in Ice-covered Arctic Lakes

For approximately nine months of each year, the waters of arctic lakes are under ice. Although wind no longer acts directly on the water surface setting it in motion, the waters of arctic lakes are not still. Respiration occurs in the water column and within the sediments with rates temperature dependent. Classical studies have demonstrated circulation is induced by sediments heating the overlying water and by decomposition processes which create localized increases in salt content which further modify density. Gravity currents flow to deeper depths and an overall convective circulation results. The lower water column may become anoxic and greenhouse gases accumulate. A large fraction of snow melt waters exits lakes without mixing. Spring heating induces vertical convective mixing. Over the last several years we have collected a unique time series of under ice temperature and conductivity data from arctic lakes of different sizes. These data show departures and extensions of the classical picture described above which warrant further investigation both by analysis of the existing data and by studies which link the hydrodynamics under the ice, during melting, and just after ice off to biogeochemistry. Based on these observations, we hypothesize that lake morphometry and geological setting cause between lake differences in the magnitude of cryoconcentration, respiration and sediment temperatures and thus differences in resistance to the convective mixing induced by spring time heating with consequences for persistence of anoxia and evasion of greenhouse gases. Internal waves contribute to mixing of snowmelt water with its high concentrations of CO_2, labile organic matter, and nutrients so important for a lake's productivity in spring and summer. We propose time series studies to 1) quantify physical controls on under ice thermal structure and circulation, mixing of snow melt waters, mixing during spring and fall, 2) to quantify respiration rates in arctic lakes of differing morphology and on different geological substrates, and 3) to illustrate the linkages and feedbacks between these physical and biogeochemical processes. Measurements will include temperature and conductivity, meteorology, sediment temperatures, ice thickness, snow cover, and respiration with newly developed oxygen

and pCO2sensors. Winter limnological studies are rare, and rarer still in the Arctic with its harsh environment. The proposed research, with its goals of better understanding physical limnology under the ice and controls on winter respiration and spring time gas evasion will fill a major gap in limnological understanding of high latitude lakes.

Susan Mazer, Cheryl Briggs   **4/1/2015 to 10/31/2015**   **$24,969**
UC Santa Cruz   UCSCMCA-15-001

Using UC Reserves to Detect and Forecast Climate Impacts

As a member of the Executive Board, Susan Mazer will oversee the distribution of funds for GSR projects at UC NRS sites, and also supervise the distribution of funds among UC NRS collaborators in southern California, and potentially supervise postdoctoral research projects if the ISEECI board distributes a postdoc to her laboratory. In addition, as an ISEECI researcher Mazer will also conduct ISEECI funded projects directly related to her lab's research program.

Susan Mazer   **8/30/2010 to 8/29/2015**   **$430,436**
USDI National Park Service   P10AC00487

Facilitation of a phenology network to assess climate change response in California National Parks

In this project, investigators from the University of California, Santa Barbara (UCSB) will collaborate with National Park Service (NPS) staff and the director and staff of the National Coordinating Office of the USA-National Phenology Network to develop a phenological monitoring network emphasizing NPS units in California. The activities to be developed include: (1) identifying compelling scientific questions that can be addressed by park-based phenological monitoring programs, that apply to multiple California parks and nearby state or federal landholdings and preserves, and that may apply to national parks across the United States (a particular focus will be on using phenology to assess climate change response); (2) selecting charismatic, ecologically important, and/or keystone species, that address scientific questions of interest, for phenological monitoring within and across California national parks; (3) designing and testing park-specific as well as park-wide species-sampling schemes and monitoring protocols; (4) designing, testing and evaluating activities to engage national park visitors, including families, institutional groups, and school groups in conducting phenological observations; (5) developing in collaboration with park-based educators informal science education programs and curricula for the public that can be implemented in each of the California national parks and with nearby schools; (6) developing a monitoring framework for all NPS units in CA in which species and protocols are identified and packaged; (7) training park staff to implement phenological monitoring and educational programs; (8) developing written materials and manuals that can be used by park staff to engage the public and to maintain consistent and high standards for phenological data acquisition; (9) creating a CA phenology network website for information and reference materials to be readily accessible to project participants and the public; (10) developing protocols to assure high quality data accumulation, archiving, and accessibility; and (11) assessing programmatic success with follow-up visits to participating parks, participating staff and members of the public. Partnerships will also be developed with the directors and staff of the University of California Natural Reserve system's field stations and sister federal agencies who wish to participate in the design and implementation of a statewide phenological monitoring network. Depending upon future needs and funding availability this task agreement may be modified in future years.

Susan Mazer   **10/15/2011 to 9/30/2016**   **$317,917**
University of Minnesota   D002520602

Project Baseline, a Living Plant Genome Reserve for the Study of Evolution

The goal of this project is to collect seeds from multiple populations of each of 30-40 wild species of plants native to or introduced to California; these seeds will then be archived in the National Germplasm Resources Lab in Fort Collins, Colorado. In the future, these seeds will be distributed to evolutionary biologists so that they can compare them to seeds obtained from the same populations in order to assess the degree and kind of evolutionary change that has occurred due to environmental

change. Dr. Susan Mazer will direct all field components of this project that will be based in California and coordinate UCSB's research activities with collaborators in Minnesota and New York. The other collaborators (Dr. Julie Etterson [University of Minnesota-Duluth] and Dr. Steve Franks [Fordham University, New York]) will direct the field components to be performed in parallel in the Midwest and in New England. In addition, the activities of all collaborators will be integrated by a Project Director who will be based in Duluth. Susan Mazer's responsibilities include a variety of tasks that will require 1.5-2.0 months of activity per year, including: Recruitment of Assistant Specialist, who will perform many of the day-to-day activities of this project; assisting with species selection and the choice of collection locations in California; coordinating with the Project Director at UMN-Duluth and the Assistant Specialist at UCSB to plan the annual collecting route and collection sites; designing the most efficient collection schedule for the selected taxa; soliciting, writing, editing, and disseminating contributions to Project Baseline eNewsletter that reports each region's progress in the collection of seeds and provides communication among teachers, park staff, reserve docents, and citizen scientists about educational programs involving seed collection, seed preservation, and phenology; supervising the Assistant Specialist's adherence to Project Baseline protocols and data management plant; collation and organization of environmental data to be transmitted to the Project Director; designing and participating in training workshops to introduce the public, graduate students, and other scientists to the principles and methods of Project Baseline.

Douglas McCauley   **7/15/2014 to 7/14/2015**   **$24,350**
National Geographic Society   9538-14

Cross-Ecosystem Linkages Created by the Common Hippopotamus Revealed Using Satellite Tracking

The common hippopotamus (*Hippopotamus amphibius*), unlike Africa's other iconic large mammals, has never had its movements tracked. The hippopotamus plays a key role in African ecosystems by shaping vegetation patterns on land with its nightly grazing forays, and fertilizing aquatic ecosystems by defecating in them during the day. The hippopotamus is also considered to be Africa's most dangerous animal, and with the intensification of land use, conflict with people has led to declines in hippopotamus numbers. We propose to use global positioning system (GPS) technology to track hippopotamuses in Kenya's Ewaso N'giro River basin. We will gather detailed movement tracks that will help us answer three questions: 1) How far do hippopotamus range during nightly feeding forays?, 2) How are hippopotamus home ranges structured around water refuges, vegetation cover and land use types?, and3) How do hippopotamus move through natural and anthropogenic features in their environment? Answering these questions will help us understand the role hippopotamuses play in African ecosystems, the ecological consequences of their declining populations, and will also provide information needed to plan for their conservation and reduce conflicts with the people. We have designed and successfully tested a GPS tag that overcomes the hurdles that have prevented researchers from tracking hippopotamuses in the past. We will work closely with our local partners to share the results of our study to support community-based efforts to reduce conflict between hippos and people.

Douglas McCauley   **10/1/2014 to 9/30/2016**   **$74,640**
National Science Foundation   IIA-1427740

US-Tanzania Planning Visit: Investigating Patterns of Self-Organization in Large Vertebrates Using Very High-Resolution Satellite Imagery

The purpose of this proposal is to catalyze a new international collaboration between researchers in the departments of Ecology, Evolution, and Marine Biology and Electrical and Computer Engineering at University of California Santa Barbara (UCSB) and the laboratory of Dr. Benezeth Mutayoba at Sokoine University in Tanzania. The aim of this partnership will be to creatively adapt existing very high resolution satellite technologies to study patterns of self-organization (i.e. the process by which global patterns emerge from individual interactions in multi-member systems; Camazine et al. 2001) in large-bodied vertebrates at large spatial scales. Despite rapid advancements in the accuracy of publically available satellite-based imaging technologies (i.e. ≤50 cm resolution quality; Fig. 1), biologists have been slow to utilize this tool for directly observing and studying

patterns in animal ecology and behavior. With our proposed collaborators in Tanzania, we will undertake this task through a focused study of self-organization in wildebeest (*Connochaetes taurinus*) aggregations in the Greater Serengeti Ecosystem (GSE) in northern Tanzania. We propose in the first year of this international partnership to 1) illustrate the utility of this tool for asking new spatially and conceptually ambitious questions about self-organization in large vertebrates; 2) to develop novel, efficient, and accurate tools for the computer- assisted extraction of data on the geometry of large animal aggregations directly from satellite imagery; and 3) to generate a demonstration paper which characterizes the architecture of wildebeest herds and compares patterns of self-organization in these large-bodied vertebrates to patterns observed in better studied smaller-bodied animal aggregations (Parrish et al. 2002; Couzin and Krause 2003). With these outputs in hand, our ultimate purpose is to generate a body of preliminary data that can be used to launch a more advanced exploration of the mechanisms that shape herd self-organization in our wildebeest model system, and more broadly, the general principles that control the geometry of animate aggregation. This effort would take form as a full submission to the NSF Division of Integrative Organismal Systems (IOS). To begin working towards these goals we propose herein to organize a first, multi-investigator, multi-student planning visit to Tanzania in Nov 2014. During this planning visit all five researchers in the collaboration will split time between conceptual development and data analysis at Sokoine and preliminary data collection in the GSE. The IOS pre-proposal and our group's first publication on wildebeest herd architecture will be largely written on site during this visit.

Will McClintock   11/1/2014 to 12/31/2015   **$286,515**
Nature Conservancy   SB150073

Software Development of eCatch Mobile Application

The University proposes to re-write and enhance the existing eCatch application. eCatch is a tool developed by TNC that provides a simple way for fishermen to collect, map and share their fishing information. It evolved from the Conservancy's work in Morro Bay, California. In that project, TNC quickly realized that one of the most difficult aspects of fisheries management is the collection of good data, particularly location data, in a manner that would allow for in-season adaptive management and thus built eCatch to address the problem. The overall goal of the eCatch Project is to develop a more accurate, effective and readily adopted mobile application that will better solve these problems than the existing application for iPad. The Parties hope to: (a) re-write the application to be used on iPhone mobile devices and improve the accuracy of the location manager; (b) add functionality, such as catch photo records and offline map use; (c) redesign the application with a more marketable visual identity. Post-development, by the Spring of 2015, the eCatch Project will test the application within the fishing community and revise. After testing, the Parties will submit the application to the Apple App Store, and work to prepare the application for release with necessary revisions

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Robert Miller, Mark Page   7/1/2013 to 6/30/2016   **$58,354**
National Science Foundation   IIA-1318469

Sources of Particulate Organic Matter and Their Use by Suspension-feeders in New Zealand Kelp Forests

Understanding trophic connections and the effect of resource variability on consumers is necessary to predict how food webs may shift in the face of environmental change. Macroalgae and phytoplankton support highly productive marine ecosystems on shallow coastal reefs. The objectives of our proposed research is to determine: 1) the contribution of phytoplankton and kelp detritus to the pool of suspended particulate organic matter (POM) available to reef consumers, and 2) how different components of the POM are used as food by reef suspension feeders. Our work in giant kelp (*Macrocystis*) forests off California thus far suggests that phytoplankton dominates POM composition and suspension feeder diets. Nevertheless, work done in other regions suggests that other species of kelp degrade differently and may provide a more significant source of detritus. *Ecklonia radiata* is an excellent example of a highly productive understory kelp that is common throughout the temperate southern hemisphere, including Africa, Australia, and New Zealand. We propose to extend our work to examine the role of kelp detritus in this very different kelp forest system. We will use stable isotopes and polyunsaturated fatty acids (PUFA) to trace kelp carbon through the food web, and test

the hypothesis that kelp detritus represents a significant source of carbon to suspension feeders living in the extensive Ecklonia kelp forests of New Zealand. New Zealand has an older more extensive network of marine reserves in place compared to California, which provides a gradient in kelp abundance that is a perfect natural experiment we can use to address this hypothesis. Like Macrocystis, Ecklonia abundance and primary production is predicted to decline with continued climate change. Collaborations with southern hemisphere scientists will be needed to achieve a general understanding of the effects of climate change on temperate reef ecosystems. Nicholas Shears, a Lecturer at the University of Auckland, would be our partner in this work. Dr. Shears has the intellectual background and field experience that will make the work possible. He is an international leader in the science of marine reserves, and has demonstrated top-down effects on Ecklonia through his work across the network of marine reserves in New Zealand. Superimposed on these reserve effects are gradients in sedimentation and light levels that shape the productivity of New Zealand kelp forests, and this topic is a major area of Dr. Shears' present research. Our collaboration would make use of the knowledge and technical expertise obtained from our NSF funded work in southern California to connect his work on Ecklonia to consumers in the kelp forest, with the primary goal of determining the extent to which variability in Ecklonia production affects the reef food web. We will benefit from Dr. Shears' expertise in the use of reserves and physical gradients to examine top-down versus bottom-up effects on the kelp forest food web, while Dr. Shears and his graduate students will benefit from our perspective on the role of kelp in the food web and our expertise in the use of stable isotopes and other tracers of material transfer. This interchange would continue from the fieldwork to data analysis and writing. A major benefit of this project to our research program, and one that we will continue by seeking further funding, is a new focus on the trophic consequences of marine reserves. This focus will be particularly timely with the recent (Jan 2012) establishment of a large network of marine reserves off southern California, where research is needed to inform natural resource managers of the community-level consequences of reserves. We intend to continue working with Dr. Shears to continue comparative work on marine reserve ecology between our regions. Without CNIC catalysis this collaboration will most likely not develop. Broader impacts of this project will also include educational benefits to our graduate student, Christie Yorke, who is the first person in her family to attend college. The project will serve to expand her research and perspective to include a very different kelp forest system and introduce her to the value of international collaborations through mentoring by Dr. Shears and his group. Results of this research will be disseminated widely through scientific publications but also through our undergraduate teaching and public lectures at venues such as the Santa Barbara Museum of Natural History.

Robert Miller   10/1/2014 to 9/30/2019   **$1,411,551**
NASA   NNX14AR62A

Demonstrating an Effective Marine BON in the Santa Barbara Channel - NASA

Although we spend millions annually monitoring marine resources, these efforts are uncoordinated and have major information gaps. We propose to develop a scalable and transferable demonstration Biodiversity Observation Network (BON) in the test bed of the Santa Barbara Channel (SBC), one of the most monitored areas of the world. This BON will network existing monitoring efforts and fill the major remaining information gaps. Our focus on SBC allows us to effectively cover the complete spectrum of biodiversity from ecosystems to microbes within a reasonable scope of funding. This is due to the profusion of existing biological monitoring and research programs by our partners including government agencies, universities and NGOs. Yet there are significant gaps in our knowledge of even this relatively well-studied area, such as microbial diversity. We propose to use a pincer strategy to attack these issues, using optical and acoustic imagery to approach diversity from ecosystem scales downwards and genetics to assess diversity from genes and microbes upwards. Expanded use of imagery will be facilitated using cutting-edge machine learning image analysis techniques developed by the UCSB Center for BioImage Informatics. The Scripps Institution of Oceanography's Whale Acoustics Lab will develop signal-processing algorithms to identify marine mammals from noise passively collected in SBC. Metabarcoding and eDNA analyses will benefit from state-of-the-art molecular biology labs at the NOAA Southwest Fisheries Science Center and UCSB. Our overall objective is to provide a complete picture of biodiversity in SBC using a transferable system that integrates and augments existing monitoring programs including the NSF-funded SBC

LTER program and the Channel Islands National Park. Products created by SBC BON will include geographically-integrated time-series metrics of biodiversity and ecosystem health, a transferable BON data management system, a sampling cost-benefit optimization framework that can be used to design a BON anywhere, and dissemination of products and results to a wide range of end users from scientists to schoolchildren. Partners: Channel Islands National Marine Sanctuary, Channel Islands National Park, USGS San Nicolas Island Monitoring, SCCOOS, Plumes and Blooms, Southern California Coastal Water Research Project, Santa Barbara Coastal Long-Term Ecological Research Program, Gray Whales Count, San Onofre Nuclear Generating Station Mitigation Monitoring Program, BOEM, NASA

William Murdoch, Susan Swarbrick   8/26/2010 to 12/31/2014   **$960,000**
Dept of California Fish and Game   WC-1014CF

Sedgwick Reserve Infrastructure and Facilities Project: Phase 2

Sedgwick Reserve has all the attributes of a world-class field site for university research and teaching, except that its facilities are wholly inadequate. This proposal is for the development of basic infrastructure. It follows an initial phase and is prelude to a subsequent phase. The three phases, collectively, will create the needed facilities. The aim of the entire project is to create the facilities and infrastructure needed to serve Sedgwick's current and projected needs and to turn it into a world-class natural reserve and field station. The Reserve currently supports 40 research projects including a number of long-term externally-funded programs investigating environmental problems important to preserving and managing California's natural living resources. About 400 students in 20 university courses use the reserve each year. The reserve has vigorous K-12 educational programs, including field trips for more than 700 students (many from under-served groups) from 23 schools and an environmental science program for 150 4th and 5th graders. There is a very active and large docent program, and partnerships with many local agencies. Our aim is to greatly increase research use and to fill out the teaching and outreach programs. The major facilities to be added over the entire project include the following: fully adequate infrastructure housing for the reserve director and the reserve steward a research center with accommodation for several researchers, kitchen, dining room, offices and wet/dry lab (remodel of existing Ranch House) a 12-bed dormitory for researchers and students a meeting house (capacity 75) with offices for the NRS staff an astronomical observatory with 1-meter telescope linked to a global telescope array a workshop, storage facilities, and a heritage center (refurbished existing hay barn) an upgrade of the existing Art Studio (capacity 30) for meetings and conferences. In preparation for the project, in 2004 through 2006 we developed a Master Plan and completed an EIR, improved the mile-long entrance road and repaired the Ranch House roof. In Phase 1, during the past few years, we constructed a solar-power-generating system, a pipeline that brings potable water into the reserve from the adjacent Woodstock community, an electronically-controlled entrance gate (essential for security), and an outdoor meeting area. Funding for 99% of this development came from private donors (total value $1,088,472). The current proposal (implementation of Phase 2) will create the basic infrastructure needed for future facilities plus one emergency renovation. Infrastructure development includes: construction of the wastewater system distribution of a potable water supply upgrade of the electrical supply and distribution system and communications repair of fencing for controlled grazing & vehicle traffic emergency renovation of the Art Studio roof construction of a maintenance shop removal of 2 existing buildings. During the final phase, Phase 3, we will construct the two residences, the dormitory, the meeting house, and the astronomical observatory renovate the Ranch House (to create the research center), the Art Studio and the Heritage Barn. The complete project will increase both the quantity and quality of research and teaching at Sedgwick Reserve. Regarding quantity, we will triple the number of researchers and students that the reserve can accommodate overnight. The increase in student numbers will come mainly from University level classes. Regarding quality, the main changes will be increased quality of life for overnight-users, reserve staff and others working on the reserve, the ability of university classes to stay for longer periods, and, most important, the ability of researchers both to stay for long periods and to have the security to carry out long-term projects lasting a decade and more.

Monique Myers   6/1/2014 to 4/30/2016 $28 000
California Coastal Commission   WT-13-36

Community Research Education for Students and Teachers about the Ormond Beach Restoration (RESTOR) Project

The RESTOR Project is a year-long watershed education project based on the Ormond Beach restoration for low-income, multicultural 6th-12th grade students and their teachers. It involves a tiered mentoring approach and promotes social-ecological resilience by including City Corps youth, CSUCI students, local non-profit organizations, university researchers and volunteers.

Monique Myers, Daniel Reed,   7/1/2013 to 1/31/2016 $99,999
Jenifer Dugan, Mark Page
National Oceanic and Atmospheric Administration   NA13OAR4170155

Santa Barbara Area Coastal Ecosystem Vulnerability Assessment for Local Communities

Project Abstract The Santa Barbara Area Coastal Ecosystem Vulnerability Assessment for Local Communities (SBA CEVALC) has both local and far-reaching goals. We will create a vulnerability assessment of coastal ecosystems (beaches, wetlands and watersheds) for southern Santa Barbara County to assist the Cities of Santa Barbara, Carpinteria, and Goleta and the County of Santa Barbara in planning for adaptation to climate change. The SBA CEVALC will be developed from the work of three of the state's leading ecological and climatological research programs: UCSB's Santa Barbara Coastal Long-Term Ecological Research (LTER) Program, the UCSD Scripps Institution of Oceanography's (SIO) California and Nevada Applications Program Regional Integrated Science and Assessment (CNAP RISA) Program, and USGS Coastal Storm Modeling System (CoSMoS) and accompanying coastal change monitoring program. The SBA CEVALC document will be developed in close collaboration with the three cities and County. Community input will be integral to the project and coordinated, along with all other aspects of the project by California Sea Grant Extension Program (CASGEP). To ensure the project results are useful to decision-makers' needs, staff from all relevant city/county departments will participate in project workshops and draft document review. CASG will guide development of the SBA CEVALC planning guidance document, work with community partners to distribute results locally and ensure wide distribution outside the Santa Barbara area. This work is novel: while some coastal states and cities or counties are developing climate change vulnerability assessments, most focus on impacts to physical and built environments; they do not provide a comprehensive assessment of impacts to ecological resources. Incorporating ecosystems in local climate vulnerability planning is important since the majority of land-use planning decisions are made at the local level. Local governments regulate general land use and development activity for the majority of the land in California, where over half the land is owned privately. Local planning that does not consider ecosystems can result in fragmentation and degradation of ecosystem services. The SBA CEVALC is an important step toward ecosystem-based adaptation planning at the local level. Specifically, project results may be incorporated in new Climate Action Plans (CAPs) for the City of Goleta, City of Goleta and Santa Barbara County; the Gaviota Coast Plan; the City of Carpinteria's Coastal Land Use Plan; the Goleta Slough Management Plan, as well as General Plan and CAP updates. Our work will bring together the best available climate and ecological research resources to provide a sophisticated coastal ecosystem vulnerability assessment, aimed at informing local land-use decisions. A broad archive of ecological, climatic and physical coastal data is available for the Santa Barbara region allowing for a detailed assessment of climatological impacts to coastal ecosystems. The team has an unusual breadth of expertise that spans from upland watersheds to the shore zones. Beaches constitute the majority of the coastline in the Santa Barbara area and, along with wetlands and watersheds, are a critical component to the vulnerability assessment. Key historical climate patterns and possible climatic changes and other impacts to the Santa Barbara area will be evaluated (e.g. temperature, precipitation, sea level rise, wave action, sediment movement). Downscaled climate data, to monthly and daily time scales, will be employed. As well as multi-decadal variability, extreme events are a particularly important driver of physical and biological elements in these ecosystems—the project will include hydrologic models to simulate effects of drought and floods, as well as fire and coastal physical impact models. When possible we will leverage the work of the USGS Coastal Storm Modeling System (CoSMoS), which predicts inundation/flooding, wave height, beach erosion

and cliff failure and is useful for informing climate impacts to beach ecosystems. The proposed SBA CEVALC will address California Sea Grant's Strategic Plan focus areas 'Effective Response to Climate Change' and 'Resilient Coastal Communities' as well as NOAA's Next Generation Strategic Plan mission to enhance sustainability and resilience of ecosystems, communities and economies by providing information that coastal communities can use to plan for climate change impacts to ecosystems (as well as the physical components of the coastline). Practical information detailing how to create a coastal ecosystem vulnerability assessment for a city/county also will be incorporated in the final SBA CEVALC document. We anticipate study results will have broad implications since the SBA CEVALC is an important and novel step toward implementing ecosystem-based adaptation planning. This work should serve as a model for other coastal cities/counties in California, the United States and, potentially, other countries.

Monique Myers, Jenifer Dugan, Mark Page, John Melack
NOAA

9/1/2013 to 8/31/2016

$178,721

NA13OAR4310235

Santa Barbara Area Coastal Ecosystem Vulnerability Assessment

Abstract: NOAA CSI Coastal and Ocean Climate Applications (COCA) The Santa Barbara area coastal ecosystem vulnerability assessment (SBA CEVA) has both local and far-reaching goals. We will create a vulnerability assessment of coastal ecosystems(beaches, wetlands and watersheds) for southern Santa Barbara County to assist the Cities of Santa Barbara, Carpinteria, and Goleta and the County of Santa Barbara in planning for adaptation to climate change. The SBA CEVA will be developed from the work of three of the state's leading ecological and climatological research programs: UCSB's Santa Barbara Coastal Long-Term Ecological Research (LTER) Program, the UCSD Scripps Institution of Oceanography's (SIO) California and Nevada Applications Program Regional Integrated Science and Assessment (CNAP RISA) Program, and USGS Coastal Storm Modeling System (CoSMoS) and accompanying coastal change monitoring program. All project components will be coordinated and results compiled into a planning guidance document by the California Sea Grant (CASG) Extension program. This work is novel: while some coastal states and municipalities are developing climate change vulnerability assessments, most focus on impacts to physical and built environments; they do not provide a comprehensive assessment of impacts to ecological resources. Incorporating ecosystems in local climate vulnerability planning is important since the majority of land-use planning decisions are made at the local level. Local governments regulate general land use and development activity for the majority of the land in California, where over half the land is owned privately. Local planning that does not consider ecosystems can result in fragmentation and degradation of ecosystem services. The SBA CEVA is an important step toward ecosystem-based adaptation planning. Our work will bring together the best available climate and ecological research resources to provide a sophisticated coastal ecosystem vulnerability assessment, aimed at informing local land-use decisions. A broad archive of ecological, climatic and physical coastal data is available for the Santa Barbara region that will allow for a detailed assessment of climatological impacts to coastal ecosystems. The team has an unusual breadth of expertise that spans from upland watersheds to the shore zones. Beaches constitute the majority of the coastline in the Santa Barbara area and, along with wetlands and watersheds, are a critical component to the vulnerability assessment. Key historical climate patterns and possible climatic changes and other impacts to the Santa Barbara area will be evaluated (e.g. temperature, precipitation, sea level rise, wave action, sediment movement). Downscaled climate data, to monthly and daily time scales, will be employed. As well as lower frequency multi-decadal variability, extreme events are a particularly important driver of physical and biological elements in these ecosystems—the project will include hydrologic models to simulate effects of drought and floods, as well as fire and coastal physical impact models. Particularly important to the immediate coastal zone is the CoSMoS model, which predicts inundation/flooding, wave height, beach erosion and cliff failure. NOAA's Next Generation Strategic Plan includes a mission to create enhanced resilience in ecosystems, communities and economies. The proposed SBA CEVA, will contribute to resilient and sustainable ecosystems by providing information that coastal communities can use to plan for climate change impacts to ecosystems. As a decision support process and instrument aimed at enhancing coastal ecosystem resilience and coastal decision-maker's understanding of ecosystem vulnerability to climate change,

the SBA CEVA is directly relevant to the objectives of the COCA program. Furthermore, because this work focuses on coastal ecosystems, it will be innovative, broadly applicable, and transferable not only within southern California but elsewhere in California, the US and, potentially, abroad.

Monique Myers	9/1/2012 to 8/31/2015	**$109,996**
Department of Commerce		NA12NOS4290040

Research and Education for Students and Teachers about the Ormond Beach Restoration (RESTOR) Project

Fifteen teachers, 500 predominantly multicultural middle and high school students, 15 City Corps youth and five local university students will learn about their local watershed and wetland through classroom activities and meaningful outdoor experiences in their local wetland. The focus of the project is the Ormond Beach wetland restoration, the largest wetland restoration project in southern California. Teachers, university students and City Corps youth volunteers will collect base-line scientific water quality monitoring data for the restoration and act as mentors for students and each other. Participation of students of different ages and academic levels, all mostly from multicultural heritage, will allow for student-student mentoring. The diverse partners participating in the project and importance of the project to the quality of life of local residents make this an exciting educational effort that reaches beyond the classroom. In 2012-2015 the project will shift to serve older students than previous years with an emphasis on middle and high school students. New components of the program this year include the tiered mentoring approach, which allows broader community impact, a new emphasis on climate change and marine debris, and an end-of-the-year external sharing community event. To complete their understanding of how activities in watersheds can affect the ocean, students will participate in an essay contest and winners will travel to the Channel Islands.

Craig Nelson, Roland Knapp	9/1/2012 to 3/31/2016	**$56,000**
Sierra Business Council		SB130011

Grazing Management Practice Implementation and Assessment in One or More Targeted Watersheds in the Lahontan Region

Task 1. Project Administration and Management 1.1 Provide all technical and administrative services as needed for Contract completion; monitor, supervise, and review all work performed; coordinate budget, and schedule, to assure that the Contract is completed within budget, on schedule, and in accordance with approved procedures, applicable laws and regulations. 1.2 Ensure that contract requirements are being met through completion of progress reports submitted to the Sierra Business Council's Contract Manager by the tenth (10th) of the month following the end of the calendar quarter. Task 2. Prepare a Quality Assurance Plan Prepare a quality assurance plan that specifies the quality assurance and quality control (QA/QC) methods and processes to be used for the field and laboratory elements of the project. Field sampling shall not commence until the quality assurance plan has been accepted by the Sierra Business Council's Contract Manager in consultation with Lahontan Water Board staff. Task 3. Conduct Field Sampling & Laboratory Analysis of Water Samples 3.1 Receive water samples delivered to the Sierra Nevada Aquatic Research Laboratory (SNARL) by Lahontan Water Board staff. Following the procedures specified in the quality assurance plan, analyze 125 water samples collected under Task 3.1 for fecal coliform bacteria (membrane filter method) and Escherichia coli (membrane filter method).

Craig Nicholson	12/1/2013 to 5/31/2015	**$49,996**
USDI Geological Survey		G14AP00006

Continuing to Map the 3D Geometry of Active Faults in Southern California

I propose to continue various ongoing studies of seismicity in both space and time to help identify and map active subsurface 3D fault surfaces accommodating crustal deformation in southern California. The current project, which just began, will focus on active structures in and around San Gorgonio Pass and the principal strands of the southern San Andreas and San Jacinto fault zones. This project will extend this work farther west along the Transverse Ranges towards Los Angeles, Ventura and Santa Barbara, and will largely consist of detailed kinematic analysis of accurate relocated

earthquake hypocenters and focal mechanisms to resolve active 3D fault geometry and patterns of strain accommodation. Where available, other sets of geologic and geophysical data, including surface topography, seismic reflection, well, and geologic mapping data will be used. The resulting digital 3D fault surfaces will be incorporated into both the Southern California Earthquake Center (SCEC) Community Fault Model (CFM) and the USGS Quaternary Fault database, and thus accessible as inputs for dynamic rupture propagation models, for improved predictions of strong ground motion, and for ultimately upgrading the USGS National Earthquake Hazard Maps. This effort is directly related to specific goals, objectives, and research priorities of Program Elements I and III for Southern California, as specified in the USGS FY2013NEHRP Announcement.

These include:

• Determine the activity of faults in southern California. Of particular interest are investigations of the San Andreas and San Jacinto faults, ...fault zones in the Transverse Ranges, and fault zones whose role in regional tectonics is not well understood or that could host earthquakes large enough to contribute to hazard in urban regions

• Develop new, improved, or alternative models of 3D fault representations and seismic velocity. These models may be refinements or extensions of the existing SCEC Community Fault and Velocity Models;

• Use seismic data to determine earthquake source parameters and crustal structure, .including further development and testing of 2-and 3D structural models;

• Develop regional models of active deformation and of fault and earthquake interactions

• Characterize the behavior of active fault segments and evaluate seismogenic thickness.

Results from this project will help improve earthquake hazard assessments (and thus reduce expected earthquake losses) in southern California by improving our understanding of the location, orientation, 3D geometry and sense of slip of active subsurface faults, and thus the accuracy of rupture propagation and ground motion predictions for potential earthquakes these faults may produce Results from this project will help improve earthquake hazard assessments (and thus reduce expected earthquake losses) in southern California by improving our understanding of the location, orientation, 3D geometry and sense of slip of active subsurface faults, and thus the accuracy of rupture propagation and ground motion predictions for potential earthquakes these faults may produce.

Craig Nicholson 　　　　　　　　**2/1/2012 to 1/31/2017** 　　　　　　　　**$190,000**
University of Southern California 　　　　　　　　　　　　　　　　　　　　Y81716

Updating Active 3D Fault Geometry in Special Fault Study Areas and to Improve the SCEC Community Fault Model (CFM)

I propose to continue conducting detailed studies of active faults along major fault zones in southern California. The primary focus would be to generate new and improved 3D fault models of principal slip surfaces, especially in designated or soon-to-be-designated Special Fault Study Areas, and to incorporate these new fault representations into CFM in collaboration with Andreas, John, Egill and other members of the SCEC CFM Working Group. This includes evaluating earthquake hypocenters and focal mechanisms, developing new digital 3D fault surfaces for inclusion in CFM, and evaluating existing alternative fault representations. In 2011, we made substantial progress in developing revised 3D fault models for the San Andreas, San Jacinto, Elsinore-Laguna Salada and other fault systems [Nicholson et al., 2011]. For 2012,we plan to largely focus on revising 3D models for other complex fault areas within the Transverse Ranges region and in specific Special Fault Study Area's to insure greater compatibility and consistency with the Q fault database and the relocated seismicity at depth. In addition, Andreas and I will complete the re-organization of the CFM-v.4.0 fault database to allow for a more systematic naming, numbering and database search system that can account for the increasing variety and complexity of multi-stranded principal slip surfaces, adjacent secondary faults, and alternative fault representations that have been, or are now currently being developed for CFM. Nominal travel funds have been included in the budget to allow Andreas and I to collaborate on and complete this CFM re-organization project.

Roger Nisbet, Erik Muller   6/1/2015 to 5/31/2018   **$576,751**
Environmental Protection Agency   83579701

Dynamical Systems Models Based on Energy Budgets for Ecotoxicological Impact Assessment

Objective: We propose theoretical and experimental research that uses Dynamic Energy Budget (DEB) models to inform ecological risk assessment by determining how the effects of exposure to chemical stressors are expressed across levels of biological organization. Approach: We will: (i) develop new modular DEB models with explicit feedbacks representing regulatory processes in response to toxicant exposure in an organism; (ii) determine how genomic data on two model organisms (the waterflea Daphnia and the estuarine fish Fundulus) experiencing combined food and chemical stress relate to parameters in DEB models; (iii) predict organismal and population "tipping points" caused by failure of physiological and population regulatory processes ; (iv) develop models of adaptation to stress in chronically polluted environments; and (v) evaluate the applicability of our findings to non-model organisms. Expected results: The anticipated outcome is an enhanced and improved ability to identify key toxic mechanisms at various levels of biological organization and to predict the implications for the sustainability of populations. Outputs will include new, rigorously tested, systems models relating organism performance to suborganismal information. The models will provide a quantitative basis for Adverse Outcome Pathway analyses. Models will be tested on two model animals using both literature data and data from this project. We will conduct the first test of the ability of a bioenergetic model with toxicokinetics and toxicodynamics to predict population dynamics and adaptation in response to a chemical stressor. If the models have demonstrated predictive value, the research will enhance the capacity for using organismal and sub-organismal information for evaluating potential ecological effects of manufactured chemicals entering the environment. If predictions require additional information, the required higher level data will be defined, thereby helping design of cost-effective studies to support ecological risk assessment. Supplementary key words: Individual-based model; DEBtox; systems biology; metabolism; ecology; ecosystem; scaling; toxics.

Mary Nishimoto   8/14/2014 to 8/31/2017   **$600,000**
USDI, Bureau of Ocean Energy Management (BOEM)   M14AC00027

Potential Impacts of Submarine Power Cables on Crab Harvest

The Bureau of Ocean Energy Management (BOEM) requires information concerning the level of impacts from seafloor power cables on marine fisheries. West coast fishermen have expressed concern over the potential effects of renewable energy power cables on their ability to harvest target species of rock and Dungeness crabs (OCN 2008; PFMC 2010). Fishermen are concerned that electromagnetic fields (EMF) associated with renewable energy power cables will present an electrified fence on the seafloor that their resource will not cross. If true, their ability to catch crab species near power cables could be negatively impacted, as well as potentially affecting crab home range. This study is designed to test the fear of crab fishermen that their target species will not traverse power cables, even in response to baited traps. Combined with the assistance of professional fishermen, submarine transmission cables that electrify communities and offshore oil platforms in the Pacific Region provide an opportunity to test the harvest of crab species across power cables. The information will be applicable to consideration of offshore renewable energy projects.

Margaret O'Brien, Daniel Reed   4/1/2015 to 3/31/2016   **$17,158**
National Science Foundation   1500572

EAGER: Collaborative Research - Conceptualizing Sustained Environmental Information Management in the Landscape of Current and Emerging Eco-Informatics Infrastructure

Scope of Work The contribution of O'Brien to this project will be to: • Assist with planning and logistics for the proposed information gathering exercise • Provide support for workshop planning and preparation and, and coordinate community workshop activities, • Lead the conceptual development and coordinate the preparation of one of the research products (white papers)

Todd Oakley   5/15/2015 to 4/30/2018 $370,000
National Science Foundation   1457754

DEB: RUI: Collaborative Research: Evolutionary Origins of Bioluminescence and Complex Mating Signals: Phylogenomics of Cypridinidae (Ostracoda)

Statement of Work: UCSB. Oakley will serve as Co-PI and two graduate students (Ellis and Hensley) will be involved. UCSB researchers will help plan and execute 5 field collection trips to collect and preserve 45 species of cypridinid ostracods. Hensley will also assist PI-Gerrish with collecting video recordings on luminescent displays during the field work. They will also help plan and participate in a taxonomy workshop, to be held in San Francisco. Oakley and Ellis will collect Illumina sequencing data from the collected species and conduct phylogenetic analyses from those data, combining it with previously published data.

Todd Oakley, Daniel Speiser   1/15/2014 to 3/31/2017 $350,000
National Science Foundation   DEB-1354831

RUI: Collaborative Research: Timing and Molecular Origins of Recently Evolved Chiton Shell-Eyes: Phylogenomics of Chitonia

Overview: To establish how many times, when, where, and how 'shell' eyes evolved in chitons (Mollusca: Polyplacophora), the following proposal will reconstruct a data rich phylogeny of Chitonina using fossil calibrations, preliminary 16S/COI data, new transcriptomes, and new sequences of conserved gDNA. Chitons are the target for study because most species have photosensory organs (known as aesthetes) yet ancestrally lack image-forming eyes. Nevertheless, at least one lineage within Chitonina contains species that have hundreds of eyes embedded in their dorsal shell plates. These 'shell' eyes provide spatial vision and are the only eyes known to focus light using lenses made of aragonite. Chitons are an excellent system in which to study the origins of eyes because eyes evolved recently in this group, behavioral and molecular experiments are tractable, and certain extant taxa may act as morphological intermediates that link species with and without eyes. Using dense molecular and taxonomic sampling, combined with divergence time estimates of nodes using fossil and molecular clock calibrations, the following proposal will test the prediction that the eyes of chitons originated within the last 56 mya. The proposal seeks three years of funding to: (1) Produce an unparalleled dataset for resolving relationships within Chitonina by adding to existing 16S/COI data for 126 estimated species: a) transcriptome data for 17 species of chitons (9 already completed) and b) gDNA Target Enrichment (gTE)regions from 126 species across Chitonina; (2) Combine 16S/COI, transcriptomes, and gDNA sequences from gTE to achieve dense taxon sampling and produce a robust phylogeny of Chitonina; (3) Estimate divergence times for Chitonina using fossil and biogeographic records; (4) Analyze transcriptome data to find the ancestral source(s) of genes employed by chiton eyes; (5) Implement existing tools and new analysis scripts in Galaxy, an open source bioinformatics platform. Intellectual Merit: Establishing a data rich phylogeny for Chitonina (the group of chitons that includes species with 'shell' eyes) will be important to systematists, evolutionists, paleontologists, and other scientists who are using a phylogenetically-informed approach to study non-model organisms. Co-PI Oakley will develop new scripts for bioinformatics and implement existing tools for estimates of divergence time in Galaxy (an open source bioinformatic platform). PI Eernisse and Co-PI Oakley will also develop methods for using transcriptome data to design probes for the multi-gene sampling of genomic DNA through gTE. Additionally, Co-PI Speiser will refine methods for assigning specific identities to the gene fragments produced by assembly programs, a necessary step in the study of the origin of complex traits. Current annotation methods depend on BLAST similarity scores, which do not necessarily correspond to phylogenetic relatedness. Instead, Co-PI Speiser will develop a tree-based framework for annotating transcriptomes that is more specific, informative, flexible and objective than current methods. Broader Impacts: Research on the 'shell' eyes of chitons will benefit society by advancing the field of biomaterials. To learn more about how mollusks build precisely shaped structures through biomineralization, Co-PI Speiser and Senior Collaborator Brooker are using transcriptome data to identify genes in chitons that are associated with the development of their aragonite lenses. Studying the origins of chiton eyes will help counter popular misconceptions about evolution by demonstrating how complex traits evolve through stepwise processes. Therefore, all of the PIs

will continue to engage the public by submitting articles to popular publications such as Scientific American, contributing to biodiversity websites like iNaturalist, and collaborating with science blogs such as EarthSky, Wired, and Discover Magazine. To help develop a diverse, globally competitive STEM workforce, PI Eernisse will train three undergraduate students from CSUF (at 15-20 hours per week for 2.5 years) who will curate voucher specimens and use cutting-edge molecular techniques to sequence conserved segments of gDNA from chitons. These students will present their work at the Society for the Study of Evolution and will co-author publications. With 33% of its students self-identifying as Hispanic, CSUF has been a noted Hispanic-Serving Institution since 2004; CSUF ranks No. 1 in California and fourth in the nation among top colleges and universities awarding bachelor's degrees to Hispanics.

Todd Oakley   10/1/2010 to 9/30/2015   **$682,498**
National Science Foundation   DEB-1046307

Dimensions: Collaborative Research: Can evolutionary history predict how changes in biodiversity impact the productivity of ecosystems?

While a spectacular variety of life is perhaps the most defining feature of our planet, loss of this biological diversity is one of the most pronounced forms of environmental change in the modern era. Researchers have made great strides in understand how changes in biodiversity impact essential biological processes, such as the efficiency by which ecological communities capture limited resources and produce new biomass. However, we still do not understand the mechanisms by which diversity affects the productivity and sustainability of ecosystems, or which dimensions of biodiversity matter most. We believe this is partly due to the fact that most prior work has been preoccupied with variation among species as our primary measure of biodiversity. But 'species' are little more than a form of packing for all the genetic, functional, and trait variation that influence the efficiency and metabolism of an organism, and these differences are themselves shaped by patterns of evolutionary history and common ancestry. If we want to understand the functional consequences of diversity loss, we must first understand the evolutionary processes that generate and maintain diversity at levels spanning genes to communities. Here we propose a collaboration that will integrate phylogenetics, genomics, and community ecology to test the hypothesis: Evolution leads to genetic differentiation among species that controls the strength of niche partitioning and, in turn, how efficiently communities capture the limited resources needed to produce biomass. Using a group of algae that are among the most widespread and ecologically important in lakes throughout North America, we will: Create a new molecular phylogeny that can be used to test whether assemblages of freshwater planktonic green algae are more genetically diverse than predicted by chance. Experimentally manipulate the evolutionary and genetic divergence of species to assess how these aspects of biological diversity control niche differences and community productivity. Conduct transcriptome analyses to identify the genetic basis of niche differentiation among species, and relate these to the production of biomass by phytoplankton communities.

Todd Oakley   6/1/2012 to 5/31/2015   **$361,927**
National Science Foundation   DEB-1146337

Collaborative Research: Eye Evolution in Sarsielloidea (Crustacea: Ostracoda): An Integrative Approach Based on Philogenetics, Developmental Genetics, Behavior, and Optics

The genetic basis of phenotypic evolution is a topic of long-standing interest that has become approachable with new genomic technologies. We propose to resolve a species-level phylogeny for Sarsielloidea (Crustacea: Ostracoda), which will enable us to understand both the functional and genetic bases of an evolutionarily convergent phenotype. Multiple sarsielloid ostracods exhibit an amazing sexual dimorphism where only males have image forming eyes. Preliminary phylogenies indicate the dimorphism evolved at least twice. Further resolving the phylogeny likely will point to additional convergent evolution. Preliminary manipulative experiments show that differential reproductive roles drive this dimorphism: Males use eyes to evade predators, which they are more likely to encounter than females because males leave the sediment more often in search of mates. In addition, the genetics of eye development is well understood in model arthropods, indicating candidate genes for the developmental control of eye dimorphisms in sarsielloids. By resolving sarsielloid phylogeny, two collaborating labs will be in a position to establish a foundation for

a valuable and integrative research program to understand the genetic and functional bases of convergent characters. Therefore, we will be able to address fundamental evolutionary questions, such as whether the same ecological functions drive convergent phenotypes, and whether convergent developmental genetics underlie those phenotypes.

| **Todd Oakley** | 9/1/2013 to 8/31/2016 | $424,787 |
| University of Michigan | | 3002735491 |

EFRI-PSBR: Biodiversity & Biofuels: Finding Win-Win Scenarios for Conservation and Energy Production in the Next Century

UCSB researchers in Oakley's lab will complete Objective 3 described in the preproposal. Oakley, a postdoctoral researcher, and laboratory technician will measure genetic complementarity of biofuel synthesis in multi-species combinations. They will extract RNA from algae growing in co-cultures, prepare libraries for high throughput sequencing, and perform data analysis to quantify expression levels of genes in the cultures. They will be involved in scientific publication of the results.

| **Ryoko Oono** | 10/1/2014 to 9/30/2015 | $24,491 |
| UC MEXUS | | PD 14-5 |

Inferring Evolutionary Processes Using RAD-seq Data in Species of Lophodermium, the Dominant Fungal in Pine Needles

Inferring Evolutionary Processes Using RAD-seq Data in Species of Lophodermium, the Dominant Fungal Endophyte in Pine Needless Rodolfo Salas-Lizana Endophytic fungi live inside virtually all land plants in which they perform functions that may include protection against pathogens. Species from the genus Lophodermium dominate the fungal endophytic community inside pine needles. Moreover, these fungi are in part responsible for inducing host resistance against white pine blister rust. In order to take advantage of potential applications derived from these fungi is necessary to deepen our knowledge about its evolution with respect to their hosts. In this project we propose to study with detail the phylogeography and demographic history of Lophodermium species inhabiting species of soft pines (subgenus Strobus) in the Californian Floristic Province. For this purposes, we will employ genomic data from next generation sequencing technologies (NGS), particularly restriction-site-associated DNA sequencing (RAD-seq). The resulting data will allow us to investigate if there is an association between Lophodermium diversity and the evolutionary history of their hosts, if there are cryptic species, and if particular genetic patterns arise when different species of Lophodermium co-inhabit the same host. Further, the large amount of data obtained will allow us to extent the research to address questions regarding natural selection and adaptation to their hosts.

Mark Page, Dan Reed,	1/1/2014 to 12/31/2015	$4,715,399
Stephen Schroeter		
Simpson and Simpson		SB140086

San Onofre Nuclear Generating Station Mitigation Project Monitoring Program

Background Condition D of coastal development permit for the operation of SONGS Units 2 & 3 requires the permittee (SCE) to fund scientific and support staff retained by the California Coastal Commission to oversee the site assessments, project design and implementation, and monitoring activities for the mitigation projects designed to compensate for the past and ongoing adverse effects of .SONGS operations on coastal marine resources. Implementation Structure Scientific expertise is provided to the Commission by a small technical oversight team hired under contract. The technical oversight team members include three Research Biologists from UC Santa Barbara (Principal Scientists): Stephen Schroeter, Ph.D., marine ecologist, Mark Page, Ph.D., wetlands ecologist (half time), and Daniel Reed, Ph.D., kelp forest ecologist (half-time). A part-time senior administrator (Lane Yee) completes the core contract program staff. In addition, a science advisory panel advises the Commission on the design, implementation, monitoring, and remediation of the mitigation projects. Current science advisory panel members include Richard Ambrose, Ph.D., Professor, UCLA, Peter Raimondi, Ph.D., Professor, UC Santa Cruz, and Russell Schmitt, Ph.D., Professor, UC Santa Barbara.

Mark Page, Robert Miller   4/1/2010 to 3/31/2017 $899,463
National Science Foundation   OCE-0962306

Sources of Particulate Organic Matter and Their use by Benthic Suspension-Feeders in the Coastal California Ecosystem

Understanding trophic connections and how resource variability affects consumers is necessary if we are to predict how food webs may shift in the face of environmental change. Macroalgae and phytoplankton support highly productive marine ecosystems. Research based on stable isotope analyses has supported the idea that macroalgal detritus, especially that of giant kelp Macrocystis, is a major source of dietary carbon to benthic suspension-feeders. However, our recent findings from a four-year stable isotope study suggest that phytoplankton, not kelp, are the main food resource for benthic suspension-feeders on reefs in the Santa Barbara Channel, and that variation in phytoplankton abundance, combined with feeding selectivity and the scale of consumer tissue turnover times, may drive variability in consumer isotope values. Our results suggest that a key assumption made in 'snapshot' isotope studies of coastal ecosystems over the past 20 years, that the isotope signature of coastal phytoplankton can be represented by that of offshore phytoplankton, could be incorrect. This assumption has been made because of the difficulty in separating phytoplankton from detritus to obtain an uncontaminated isotope signature, a problem in freshwater systems also. Our objectives are to 1) determine the contribution of phytoplankton and giant kelp detritus to the pool of suspended reef POM and whether POM composition varies with distance from kelp forests, and 2) evaluate how different components of the POM are used as food by reef suspension feeders. We propose to explore the contribution of phytoplankton and kelp detritus to POM in coastal waters using two complementary approaches: an advanced flow cytometry and cell-sorting system to separate phytoplankton from bulk POM, and analysis of essential polyunsaturated fatty acids (PUFA) in POM and consumers. We have obtained preliminary data that demonstrate the feasibility of both of these methods. Isotope values of isolated inshore phytoplankton and kelp, and compound-specific PUFA, will be used in mixing models to estimate contributions of these two major primary producers to suspension feeder diets. We will also test two hypothesized mechanisms that may influence isotopic composition of consumers: selective feeding on particular fractions of POM, and tissue turnover times. This project will provide new insights into the trophic support of benthic suspension feeders, an ecologically and economically important guild in coastal ecosystems. Our results will test the general hypothesis that giant kelp detritus is an important source of carbon to suspension feeders, a commonly accepted idea that needs re-evaluation in light of key assumptions that have been made in its support. Stable isotope analyses are an ideal tool for testing this hypothesis given the spatial and temporal scales of variability that exist in the abundance of phytoplankton and giant kelp at our study sites. Our proposal sampling scheme combined with longer-term data on producer biomass provided by the Santa Barbara Coastal LTER will enable us to capture this variability, which is generally missed by studies based on 'snapshot' stable isotope analyses.

Mark Page, Jenifer Dugan,   7/1/2013 to 5/31/2018 $738,710
Robert Miller
USDI Bureau of Ocean Energy Management M13AC00007

Understanding the Role of Offshore Structures in Managing Potential Watersipora Invasions

The purpose of this award is to survey offshore oil and gas platforms in the Santa Barbara Channel/ Santa Maria Basin and San Pedro Basin, other artificial structures, and natural reefs for the non-indigenous species (NIS) Watersipora subtorquata, measure the reproductive seasonality of this species and identify potential vectors for dispersal among platforms and between platforms and natural habitat, propose mitigation measure(s) that may be employed to manage Watersipora, and to incorporate this information into environmental reviews regarding managing the spread of Watersipora at ongoing operations, during decommissioning of oil and gas platforms, and at potential renewable energy facilities. The need for this information is to elucidate the role that offshore artificial structures may have in affecting biological communities. Information is needed for use by the State of California to consider for decommissioning options under the California legislation AB 2503 (the California Marine Resources Legacy Act). The Act requires California to consider reefing OCS oil and gas platforms, if their ecological value warrants, before decommissioning and

potential removal. The information is also needed to comply with the duties of Federal agencies that are outlined in Section 2 of Executive Order 13112 (Invasive Species). BOEM will use study results for environmental reviews concerning ongoing operations and decommissioning alternatives of offshore oil and gas platforms and potential marine renewable energy facilities. The issue of platform decommissioning and decisions related to decommissioning and possible reefing will be decided on a platform by platform basis with each of the platforms judged on its own merits as far as ecological value is concerned. This study will also extend the application of existing methodology to develop results applicable specifically for Bureau of Safety and Environmental Enforcement (BSEE) management decisions so that BSEE can specify requirements to industry or other interested parties when decommissioning occurs. Using the results, the State of California can ensure proper evaluation under the California Rigs-to-Reefs Program law AB 2503 (the California Marine Resources Legacy Act), and BSEE can ensure that specified criteria can be properly evaluated during the decommissioning process pursuant to the federal regulations at 30 CFR 250.1730 . Thus, the overarching purpose of this research is to collect information on Watersipora for environmental reviews regarding managing the spread of Watersipora during decommissioning of oil and gas platforms for the State of California.

Will high CO2 conditions affect production, partitioning and fate in organic matter?

The ocean has taken up ~30% of anthropogenic carbon, and future changes in marine biogeochemical cycling of carbon, and especially in the functioning of the biological carbon pump, will determine whether or not the ocean continues to be a strong sink for carbon. IPCC scenarios assume continued uptake of CO2 by the ocean, but currently even the direction of change in the biological pump in response to increases in CO2 is unresolved and controversial. Coastal waters are already experiencing episodic exposure to carbonate conditions that were not expected until the end of the century making understanding the response to these episodic events as important as understanding the long-term mean response. Among the most striking examples are those associated with coastal upwelling along the west coast of the US, where the pH of surface waters may drop to 7.6 and pCO2 can reach 1100 μatm. Upwelling systems are responsible for a significant fraction of global carbon export making them prime targets for investigations on how ocean acidification is already affecting the biological pump today. It is the goal of this proposal to investigate the potential effects of ocean acidification on the strength of the biological pump under the transient increases in CO2 experienced due to upwelling. Increases in CO2 are expected to alter the path and processing of carbon through marine food webs thereby strengthening the biological pump. Increases in inorganic carbon without proportional increases in nutrients result in carbon overconsumption by phytoplankton. How carbon overconsumption affects the strength of the biological pump will depend on the fate of the extra carbon that is either incorporated into phytoplankton cells forming particulate organic matter (POM), or is excreted as dissolved organic matter (DOM). POM and DOM follow very different paths through the pelagic ecosystem. POM is exported primarily through gravitational sinking. DOM can either form exopolymer particles that facilitate aggregation accelerating sedimentation rates of POM, or, in its dissolved form DOM export occurs when DOM that has accumulated in surface waters is carried to depth by physical processes. There is evidence that carbon overproduction leads to more carbon rich POM and to a rise in exopolymer formation, increasing particle aggregation and export. Carbon overconsumption may additionally enhance the production of low quality (high C:N) exudates that resist microbial degradation allowing a greater fraction of DOM produced under high CO2 to accumulate in surface waters and eventually be transported to depth. Thus, ocean acidification may enhance the export of both POM and DOM strengthening the biological pump and accelerating the rate at which increases in atmospheric CO2 are transferred to the deep ocean. Results from mesocosm experiments demonstrate that the mechanisms controlling the partitioning of fixed carbon between the particulate and dissolved phases, and the processing of those materials, are obscured when both processes operate simultaneously under natural or semi-natural conditions. Here, POM and DOM production and the heterotrophic processing of these materials will be separated experimentally across a range of CO2 concentrations by conducting basic laboratory

culture experiments. In this way the mechanisms whereby elevated CO2 alters the flow of carbon along these paths can be elucidated and better understood for use in mechanistic forecasting models.

Uta Passow   **1/1/2015 to 12/31/2016**   **$497,701**
University of Georgia   RR100-047 / 5054876

ECOGIG-2: Ecosystem Impacts of Oil and Gas Inputs to the Gulf

Sedimentation: In collaboration with Vernon Asper, six time series sediment traps (4 deep and two shallow) will be deployed at 3 main ECOGIG sites in association with other moored gear. We will support the recovery and deployment efforts of the traps, and the ordering and organizing of these field trips. Samples from these six sediment traps (2 shallow, 4 deep at 3 stations) will be fractionated and processed. Sample fractions will be shipped to interested collaborators. Basic biogeochemical parameters (dry weight particulate organic carbon and particulate organic nitrogen) will be analyzed in all trap samples in my lab. Depending on those results and on results from water column work, more detailed analysis will be conducted on selected traps / cups, including stable or radio isotopes, biogenic or lithogenic silica, particulate inorganic carbon, transparent exopolymer particles, microscopical enumeration. Data sheets will be prepared and submitted to GRIDCC and scientific publications will be written in collaboration with our colleagues. Within ECOGIG strong collaborations with the water column work, the resuspension work and the trap camera will be fostered. Besides the close collaboration with our colleagues within ECOGIG we will especially seek the collaboration with other "trappers", like N. Prouty (USGS) and C. Germane (WHOI) to develop a spatial and temporal understanding of sedimentation events in the GoM. Aggregation mechanisms: Targeted laboratory experiments that address the formation of oil-containing, sinking, marine snow are another focus of our ECOGIG work. We will conduct a series of rolling table experiments investigating the conditions under which oil a) may inadvertently be integrated into sinking aggregates and b) may cause the formation of sinking aggregates. Experiments will be conducted jointly with the Arnosti lab to look at degradation patterns of aggregates. These rolling table experiments will be conducted in close collaboration with modeling studies that investigate the relative importance of different types of aggregate formation, and simulate the sedimentation event observed in fall 2010 to spring 2011. The goal is to integrate this mechanistic small scale model into larger scale models on particle distributions in the GoM (collaboration with ECOGIG modelers). Collaborations with microbiological colleagues in ECOGIG will look at the fate of such marine snow and the role of microbes for marine snow formation. Collaborations with Bill Lehr (NOAA) should provide input to ADIOS 3 or similar models, developed for rapid response planning. We will prepare and submit the data to GRIDCC and write scientific publications in collaboration with our colleagues.

Uta Passow   **9/1/2011 to 12/31/2015**   **$822,745**
University of Mississippi   SB120113

Ecosystems Impacts of Oil and Gas Inputs to the Gulf (ECOGIG)

Together with collaborators Asper and Diercks we will deploy 4 deep times series sediment traps to collect time integrated samples throughout the year. The deployments must be put together, currently only 1 trap deployment exists. These traps will be deployed at strategic positions at the main sampling sites and will be turned at least around annually. Trap samples (20 per year per trap) will be analyzed for particle composition (microscopically), POC, PON, TEP, dry weight, PO13C, PO15N, oil (PAH) and corexit (doss). Biogenic minerals and Al or a different marker for resuspended material will also be measured. At the time of deployment and retrieval of traps the water column parameters, especially the distribution of marine snow will also be analyzed. This data will be put into context of sediment and water column data, which will also be collected within the project. Moreover, a series of experiments on the formation of marine snow in the presence of oil and / or dispersant and on the characteristics of this snow will be performed. Natural material and fresh oil, or aged oil with or without dispersant etc. will be incubated and the formation of flocks monitored. This series of experiment will test all the different parameters potentially affecting flock formation – e.g. the aging of oil bacterially or by light. Sinking velocity of flocks, as well as composition, size and density will be characterized. The hypothesis that these flocks do not form by aggregation or from feeding structures is to be tested. In collaboration with Arnosti I will investigate the fate of such flocks, and

the role of specific bacteria and changes in the bacterial community composition. During aging the change s in carbon, nitrogen, TEP etc. will be monitored and the partitioning between phases tracked. Bacterial activity and turnover will be assessed. For this in situ and experimental work, we will be working at different sites, representing different types of releases of oil and gas. The above described measurements will be conducted at the different site to compare the impact of the release on flock formation and sedimentation.

Uta Passow   1/1/2015 to 12/31/2016 $320,837
Texas A&M   10-S151007

Role of Microbial Exopolymers in Aggregation and Degradation of Oil and Dispersants

In the presence of oil and / or dispersants, many microbes release high molecular weight exudates, variously called EPS, TEP and micro-gels, which physically protect the microbes, aid in their attachment, or emulsify and solubilize oil products, thus increasing the bioavailability of diverse components of oil. The physico-chemical properties of these exudates will significantly determine the fate of hydrocarbons and their distributions in marine systems. We suggest that the evolution of the microbial community will be towards a state that increases the output of amphiphilic EPS, which is most important in removing oil by dispersion, aggregation, chemical bonding or degradation mechanisms. We will use a hierarchical approach of increasingly larger and more complex experiments to investigate the response of different microbes to oil in terms of EPS production. Experiments range from first level evaluations using microchips (mL scale) to a large mesocosm study (100's Liter) to determine the roles of exopolymeric substances for the fate of oil. The Passow lab will analyze TEP concentrations in samples from microchip experiments. We will set up and conduct some of the planned roller table experiments based on the results of these microchip experiments. We will measure various parameters and collect samples for colleagues to analyze. Early in year three we will support and participate in the mesocosm experiment conducted in Texas. We will participate scientifically in regular calls and meetings. Data submission, preparations of scientific publications and outreach activities will take place during all three years.

Stephen Proulx, Joao Hespanha   9/1/2011 to 8/31/2016 $608,274
National Science Foundation   EF-1137835

The Evolution of Dynamic Response Strategies: Optimal Control and Evolutionary Dynamics

Organisms are constantly responding to change. The abiotic environment fluctuates, physiological processes are noisy, and other individuals behave unpredictably. The dynamic changes in conditions over time contain information that can be sensed, remembered, processed, and acted upon. We define the dynamic response strategy of a genotype as the dynam¬ical system they use to produce a response given a time series of sensed inputs. This project will develop theoretical approaches based on optimal control theory and population genetics to understand biological scenarios involving sensed environmental input and a dynamic response. Specific focus will be given to determining how the reliability of sensory input and the tempo of environmental variation relate to the optimal strategies for gathering, processing, and responding to information. The focus is on cellular dynamic response systems including simple gene regula-tion, regulation of interacting genes in a network, cellular sensory mechanisms, and competitive foraging. For each biological system, the mechanistic details of the dynamic response will be mod¬eled and population genetic techniques will be used to determine the evolutionary outcomes. The optimal control solutions define an upper bound to fitness and can be compared to the biologically constrained evolved strategies. This comparison will show how well biological systems can ap¬proximate the optimal solutions, explain the general principles behind the evolution of dynamic response strategies, and address whether the optimal solutions are evolutionarily achievable. This project has the potential to be transformative because our methods apply equally well to single cell responses, developmental responses, physiological responses, and behavioral responses.

Palmer LTER Zooplankton 1993-2008: Synthesis and Integration of Time-Series Data, Zooplankton Aggregation Structure and Secondary Production of Antarctic Krill

The Palmer Long-Term Ecological Research (LTER) program is focused on the marine pelagic ecosystem west of the Antarctic Peninsula, one of most rapidly warming regions on the planet. The study region is composed of coastal, shelf and slope regions midway down the Antarctic Peninsula, in an area influenced by the Antarctic Circumpolar Current with warm Upper Circumpolar Deep Water flooding the shelf. Changes in seasonal sea ice dynamics, the heat content of the shelf and populations of a key predator, Adélie penguins, have been documented. Although the phytoplankton and zooplankton community have shown some changes in composition and production during the time series, most are not yet significant. The sampling design included an annual summer cruise (large spatial, short temporal scale) and seasonal sampling within 3.7 km of Palmer Station on Anvers Island (small spatial, long temporal scale). In the Southern Ocean, larger mesozooplankton and micronekton, particularly Antarctic krill (*Euphausia superba*) form the primary link between primary producers and upper-level predators, serving as both a grazer and prey. The overall goal of this proposal is to undertake a synthesis of zooplankton and micronekton data collected from 1991 through 2008 as part of this multi-disciplinary program, specifically to investigate spatio-temporal variability on multiple scales and to test hypotheses on the underlying causes of the variability documented. Data include community composition, abundance and biomass, from net tows and bioacoustic transects, and life history information for both Antarctic krill and the salp (*Salpa thompsoni*), the biomass dominants for zooplankon > 2 mm. Net and bioacoustic data are complimentary, and should be integrated. Net data yield samples for community composition, population demography and experiments, and serve for target identification of sound scatterers. Bioacoustic data yield data on smaller scales relevant to the ecology of the different sound scatterers and their predators, both biomass and aggregation characteristics. In addition, in situ rates of secondary production (growth, spawning and egg production) were measured experimentally for the key species Antarctic krill in order to estimate secondary production. This zooplankton data set combined with the coherent multi-disciplinary data sets collected by the Palmer LTER is uniquely suited for studies of spatio-temporal variability and mechanisms underlying that variability, partially due to the fact that the time period spans three full cycles of recruitment in Antarctic krill and variability in primary production. Focus areas for the data synthesis proposed include: (1) A Principal Components Analysis and Canonical Correlation Analysis (PCA-CCA) approach, as recently used to document zooplankton abundance and distribution patterns, will be used for analysis of the time-series 1993-2008 of zooplankton and the biological-biological and biological-physical linkages. Three workshops will be convened with colleagues with complimentary hydrographic, sea ice and phytoplankton data to test hypotheses and produce manuscripts. (2) After full restoration, the bioacoustic data will be analyzed for patterns and/or trends in biomass and aggregation characteristics, and relationships to environmental factors and ecosystem function. With the British Antarctic Survey (BAS), zooplankton (Antarctic krill and other sound scatterers) biomass and aggregation characteristics within the Palmer LTER study region will be compared to the South Georgia region. These data will be archived in a format easily used by future investigators as a consensus on such variables as target strength emerges. (3) Secondary production experimental data will be modeled as a function of environmental variables such as food quantity and quality and individual size and sexual maturity, then integrated with acoustic biomass data to estimate secondary production rates and production:biomass ratios (turnover) and their spatio-temporal variability throughout the study region. In addition funds will bring to fruition separate collaborative efforts on somatic growth and life cycle timing for salps in this region (P. Kremer), and the use of Antarctic krill length frequency data to explore linkages among populations around the continent (BAS). Included are resources for multiple data base activities: completion of sample analysis and data submittal for the 0708 field season, interactions with the Palmer LTER information manager, and submittal to the LTER data directory of completed derived products as described above.

Andrew Rassweiler   8/30/2013 to 12/31/2016 $34,000
UC Santa Cruz   UCSCMCA-14-006

Mediterranean Coast Network Kelp Forest Monitoring: Protocol Review and Data Synthesis

Channel Islands National Park (CHIS) initiated kelp forest (KF) monitoring in 1982 to better
understand the long-term dynamics of these important ecosystems. Monitoring data have been
collected continuously for 31 years with a total of 33 sites currently being sampled annually.
The purpose of the KF monitoring program is to understand the natural variation within these
communities and collect baseline data for comparing resources inside and outside of marine
protected areas, and to better understand the dynamic nature of these communities so that it
can be properly conserved for current and future generations. In 1994, a detailed review of the
CHIS KF monitoring program was conducted by a scientific panel (Schroeter and Dixon 1994).
Several adjustments were made to the monitoring protocols following the 1994 review. With
the establishment of new marine protected areas in 2003, KF monitoring at CHIS was extended
to several new locations resulting in a greatly expanded monitoring effort. This resulted in
an increase in monitoring from 16 original sites in 1982 to 33 sites in 2005 in order to monitor
and assess the new marine protected areas. As a result of these changes an in-depth review of
monitoring protocols and sampling design is needed to identify recommendations for prioritizing
monitoring efforts, streamlining protocols, and evaluate the monitoring effectiveness for marine
protected area evaluation. In addition, an updated synthesis and interpretation of the long-term
KF monitoring dataset is needed to support the protocol review and to share KF monitoring results
with scientists, resource managers and the interested public. KF monitoring data are currently
available on the web at http://pyrifera.marinemap.org. CHIS staff and others have authored a
data paper for Ecology (Kushner et al. In Press) that summarizes the KF methodology and data set.
These KF data resources will be updated as part of this project.

Andrew Rassweiler   8/15/2014 to 7/30/2016
$40,000
USDI National Park Service
P14AC01661

**Analysis and Publication of Long-term Channel Islands National Park Kelp Forest Monitoring
Data**

Project Abstract: Channel Islands National Park (CHIS) implemented the long term Kelp Forest
Monitoring Program (KFMP) in 1982. The KFMP now has 32 years of data for over 70 species of
algae, invertebrates and fish, as well as data from all species of fish observed since 1996. There
have been over 25 scientific papers utilizing KFMP data, but many of these papers are about single
species or disease events. While these are important, they have minor relevance to larger marine
management actions, such as the recent implementation of Channel Islands marine protected
areas, direction of future management actions or the monitoring program itself. In this project,
UCSB investigators and CHIS staff will collaborate to analyze KFMP data and will coauthor at
least two papers and publish the results in well-known scientific journals. The project will result
in the analysis of three topics that are the focus of public interest and present relevant information
regarding marine resource monitoring and protection efforts in similar environments. At least
two and likely three peer-reviewed publications will result from these analyses. Unless otherwise
mutually agreed upon by UCSB and CHIS the analysis and papers will consist of: 1) A paper using
CHIS data to document changes in the size distribution of fish inside and adjacent to the no-take
marine protected areas; 2) A paper using CHIS data to describe the cascading effects of reserve
protection on kelp and other non-fished species in the park; and 3) A complete evaluation of the
parks fish monitoring techniques including accounting for the tradeoff between precision and
completeness in visual census of fish. The first two listed are identified as the top priority as they
have high public interest. Depending upon the outcome of the analyses future phases of work may
be needed to refine understanding of specific aspects of the KFMP dataset. Future phases would be
added through modification of this Task Agreement and is dependent upon availability of funding.

Dan Reed, Sally Holbrook, Carolynn Culver	2/1/2014 to 1/31/2017	$172,360
UC Sea Grant		R/HCME-07-F

The Spread and Ecological Consequences of the Invasive Seaweed *Sargassum horneri*

Sargassum horneri is a fast growing brown alga native to shallow reefs of Japan and Korea. It has spread aggressively in southern California since first being discovered in 2003 and poses a major threat to the sustainability of native marine ecosystems in this region. While numerous groups collect data on S. horneri as part of their routine monitoring, the ecology and impact of this invader in southern California are poorly known. Of particular note is the manner in which the spread of S. horneriis influenced by the recent increase in Marine Protected Areas (MPAs), which were established to harbor protected assemblages of native species that may offer biotic resistance to invasion. We propose quantitative surveys and experiments inside and outside of MPAs aimed at determining the causes and ecological consequences of the invasion of this recently introduced seaweed. Our objectives are to: (1) identify the physical and biological factors that promote characteristics of habitats that promote the growth and reproduction of S. horneri and thus its potential to spread, (2) determine the consequences of S. horneri invasion on the structure and diversity of native communities, and (3) determine the mechanisms by which MPAs might confer biotic resistance to invasion by S. horneri. These objectives directly address two of the three Strategic Focus Areas identified in California Sea Grant's 2014 call for proposals: Healthy Coastal Marine Ecosystems (Goals 1& 2) and Resilient Coastal Communities (Goal 1). Moreover, our research will support the common mission of both the state and national Sea Grant organizations to provide integrated research on coastal ecosystems that informs and fosters the responsible use and conservation of marine resources.

Daniel C. Reed, Sally Holbrook, Carolynn Culver	2/1/2014 to 1/31/2016	$172,360
UC Sea Grant		R/HCME-07-F

The Spread and Ecological Consequences of the Invasive Seaweed Sargassum homeri

Sargassum horneriis is a fast growing brown alga native to shallow reefs of Japan and Korea. It has spread aggressively in southern California since first being discovered in 2003 and poses a major threat to the sustainability of native marine ecosystems in this region. While numerous groups collect data on *S. hornerias* part of their routine monitoring, the ecology and impact of this invader in southern California are poorly known. Of particular note is the manner in which the spread of *S. horneriis* influenced by the recent increase in Marine Protected Areas (MPAs), which were established to harbor protected assemblages of native species that may offer biotic resistance to invasion. We propose quantitative surveys and experiments inside and outside of MPAs aimed at determining the causes and ecological consequences of the invasion of this recently introduced seaweed. Our objectives are to: (1) identify the physical and biological factors that promote characteristics of habitats that promote the growth and reproduction of *S. horneri* and thus its potential to spread, (2) determine the consequences of *S. horneri* invasion on the structure and diversity of native communities, and (3) determine the mechanisms by which MPAs might confer biotic resistance to invasion by *S. horneri*. These objectives directly address two of the three Strategic Focus Areas identified in California Sea Grant's 2014 call for proposals: Healthy Coastal Marine Ecosystems (Goals 1& 2) and Resilient Coastal Communities (Goal 1). Moreover, our research will support the common mission of both the state and national Sea Grant organizations to provide integrated research on coastal ecosystems that informs and fosters the responsible use and conservation of marine resources.

Dan Reed, Sally Holbrook, John Melack, David Siegel	12/1/2012 to 11/30/2018	$3,039,794
		REU support $48,000
National Science Foundation		OCE-1232779

LTER: Land/Ocean Interactions and the Dynamics of Kelp Forest Communities, SBC-LTER III

Intellectual Merit: The Santa Barbara Coastal LTER (SBC) is an interdisciplinary research and education program established in April, 2000 to investigate the role of land and ocean processes in structuring ecosystems at the land-sea margin. Our study main area is the Santa Barbara Channel and

the steep coastal watersheds, small estuaries and sandy beaches that drain into it. The focal ecosystem of our research is giant kelp forests, a diverse and highly productive marine ecosystem that occurs on shallow rocky reefs at the interface of the land-sea margin in the Santa Barbara Channel and other temperate regions throughout the world. The major emphasis of our proposed work is developing a predictive understanding of the structural and functional responses of giant kelp forest ecosystems to environmental forcing from the land and the sea. The amount of nutrients and organic matter delivered to the kelp forest from land and the surrounding ocean varies in response to changes in climate, ocean conditions and land use. Variation in the supply of these commodities interacts with physical disturbance to influence the abundance and species composition of kelp forest inhabitants and the ecological services that they provide. The overarching question motivating our proposed research is: How are the structure and function of kelp forests and their material exchange with adjacent land and ocean ecosystems altered by disturbance and climate? To address this question our research will focus on three themes: (1) biotic and abiotic drivers of kelp forest structure and function, (2) material exchange at the land-ocean margin, and (3) movement and fluxes of inorganic and organic matter in the coastal ocean. The relevance of our research is far reaching as we address fundamental questions pertaining to biodiversity and ecosystem function, vulnerability and resilience of communities to climate change and fishing, the roles of land use and fire on landscape change and watershed hydrology, and the physics of dispersal in the little studied coastal waters of the inner continental shelf. The dynamic nature of kelp forests, including their frequent disturbance and rapid regeneration coupled with high productivity and diverse food webs make them ideal systems for investigating ecological questions that require decades to centuries to address in other ecosystems. Our research will utilize a variety of approaches including: (1) coordinated long-term measurements, (2) manipulative field experiments, (3) measurement-intensive process studies, and (4) integrated synthetic analyses and modeling that allow for predictions beyond the spatial and temporal scope of our measurements, and help guide future research. SBC's information management system, which focuses on data organization, integrity, preservation and web-based public access geared for a variety of end users will facilitate these efforts.

Broader Impacts: Education and training are tightly integrated into all aspects of our research. We have successfully developed a multifaceted, interdisciplinary approach to education and outreach that highlights research interests of SBC investigators, students, and the general public. Our programs include active links with K-12 students and teachers that target historically under-represented groups from underserving, low-achieving schools. We are also very proactive in undergraduate and graduate student training, direct public outreach, and productive interactions with the media, government agencies and local industries. We will continue these outreach and education programs and maintain our efforts to attract additional funding to support them. We are committed to sharing our research results with resource managers, decision makers, stakeholders, and the general public who are interested in applying our findings to policy issues concerning natural resources, coastal management, and land use.

Dan Reed   8/1/2014 to 7/31/2016 $50,000
COM National Marine Fisheries   NA14NMF4690295

Experimental Investigations on the Efficacy of the "Super Sucker" as a Device for Controlling the Spread of Non-Indigenous Seaweeds

Invasive species are one of the greatest agents of human-induced change to ecosystems (Pejchar and Mooney 2009). Coastal marine systems are especially vulnerable to introductions of nonindigenous species via trans-oceanic shipping, aquaculture and the aquarium trade, which have greatly extended the distribution of many marine species outside of their native habitats (Carlton 1989). Marine invasions have steadily increased over the past two centuries and are expected to continue to rise as global trade expands (Ruiz et al. 2000). Costs associated with the impact and management of invasive species are high, totaling over $1 billion annually in the US (Pimentel et al. 2005), while resources available for management are limited. Therefore, agencies tasked with controlling invasions must be efficient in their management strategies. Exploration of techniques which may be used to help control marine invasive species is urgently needed.

A new tool that has been developed to help control algal invasions is an underwater suction device, called the "Super Sucker" (Conklin et al., unpublished data). The device was used on coral reefs

in Oahu, Hawaii to reduce densities of the invasive red alga *Gracilaria salicornia* below a threshold level such that herbivores could maintain low densities of the invader. A similar device intended to aid control of southern California marine invasions was recently constructed through a partnership between Los Angeles Waterkeeper, Santa Barbara Channelkeeper, and NOAA's National Marine Fisheries Service. It has been used in trial runs to transport material from the ocean floor up to a platform on the surface with the aid of divers feeding material into the suction hose. However, the effectiveness of this device in controlling marine invasive species requires further investigation.

A seaweed recently introduced to southern California presents an opportunity to test the efficacy of the Super Sucker in controlling the spread of invasive species. *Sargassum horneri* is a large, annual brown alga native to shallow reefs of Japan and Korea. The species was first discovered in the eastern Pacific in Long Beach Harbor in 2003. Since then it has spread aggressively across 700 km primarily at offshore islands and its current range extends from Santa Cruz Island south to Isla Natividad in Baja California, Mexico. Because *S. horneri* can be locally very abundant and highly persistent, its continued expansion in the eastern Pacific poses a major threat to the sustainability of native marine ecosystems. We propose to remove *S. horneri* from areas of varying size at Catalina Island to assess: 1) the effect of clearing size on the capacity of *S. horneri* to reinvade areas where it has been removed, and 2) the efficiency of removing *S. horneri* using the Super Sucker compared to removing it by hand.

Daniel Reed   **9/1/2012 to 8/31/2016**   **$264,575**
National Science Foundation   OCE-1233283

Collaborative Research: The Effect of Inbreeding on Metapopulation Dynamics of the Giant Kelp,
Macrocystis pyrifera

Understanding the causes for populations to fluctuate in space and time is of great interest to ecologists and knowledge on this topic has widespread application for conservation and environmental management. The recognition that many species live in highly fragmented landscapes led to the development of metapopulation theory, which is widely applicable to both terrestrial and marine systems. In its simplest form the concept of a metapopulation represents the idea that habitat patches suitable for local populations are either occupied or not and that connectivity among patches acts to "rescue" extinct local populations. Several recent studies on inbreeding have challenged the traditional belief that ecological factors are the primary causes of local population reduction and eventual extinction. However, to date there have been few investigations of the extent to which inbreeding depression drives local population dynamics in a metapopulation. The giant kelp, *Macrocystis pyrifera*, is an ideal system for testing metapopulation theory because it occurs in discrete patches that undergo frequent local extinctions and recolonizations on time scales of a few years. Here we propose to test five related hypotheses aimed at determining whether the metapopulation of the giant kelp in the Southern California Bight is regulated at least in part by repeated and asynchronous episodes of inbreeding depression. Our proposed research is motivated by our previous findings on patterns of local population extinction and recolonization with respect to patch size and degree of isolation, patterns of spore dispersal and genetic connectivity, and the adverse consequences of inbreeding depression to kelp reproduction. In the proposed research we will: (1) Assess the extent and pattern of inbreeding in populations of giant kelp in the Southern California Bight, and (2) Determine the extent that inbreeding depression via decreased reproduction contributes to the pattern of metapopulation patch dynamics of giant kelp in the Southern California Bight. Our research will be greatly facilitated by our recent developments of: (1) highly polymorphic microsatellite markers for characterizing the population genetics of giant kelp, and (2) a novel method for estimating effective population size for all discrete patches of giant kelp in the Southern California Bight using Landsat satellite imagery.

Daniel Reed   **9/22/2011 to 3/31/2017**   **$449,927**
USDI Bureau of Ocean Energy Management (BOEM)   M11AC00012

DOI Partnership: Distinguishing Between Human and Natural Causes of Changes in Kelp Forests Using Long-term Data from DOI Monitoring Programs

Monitoring and predicting the potential impacts of outer continental shelf (OCS) energy production on nearshore ecosystems requires an ability to distinguish between changes caused by natural

processes and those caused by human activities. This ability is often hampered by the lack of long-term data to describe natural variation. Offshore southern California, two Department of the Interior (DOI) monitoring programs that focus on kelp forest communities have the potential to provide considerable insight into the patterns and causes of change in kelp forest ecosystems. Analysis of these data sets (which span 25+ years) will enable scientists and managers to evaluate possible impacts from offshore oil and gas and renewable energy activities and develop options to mitigate these impacts. This is especially important in light of global climate change and the need to understand the cumulative impacts of multiple projects on the OCS.

Cristina Sandoval, Susan Swarbrick   6/29/2015 to 6/30/2017 $505,000
California Wildlife Conservation Board   WC-145BC

Coal Oil Point Reserve Infrastructure and Facilities Project

The entire infrastructure and facilities project will be completed in two phases. Phase 1 has just been completed and will provide matching funds for the funding we are requesting from the Wildlife Conservation Board (WCB). The infrastructure improvements in Phase 1 include: ·reconstruction of the entrance road to the COPR field station, ·installation of an electronic gate on the entrance road, ·expansion and resurfacing of the field station parking lot, ·replacement of the culvert under the road accessing the northern and western sections of COPR with a bridge to span Devereux Creek, ·installation of two new storage buildings and a workshop at the field station to replace the aforementioned 50-year old sheds, and ·electrical upgrades at the field station. Phase 2 of the infrastructure and facilities project will complete the renovation of a 5,390 square ft. building adjacent to the Reserve that will serve as the new Reserve headquarters. The proposed headquarters building is not on COPR property but is located on UCSB property next to the eastern edge of the Devereux slough only 50 ft. from the Reserve boundary. Reserve users and staff will be able to readily access the Reserve directly from the headquarters building. The building has an adjacent parking lot to accommodate Reserve users, including school buses. UCSB has approved a 25-year commitment for use of the building by COPR.

Cristina Sandoval, Susan Swarbrick   6/30/2015 to 1/31/2017 $300,000
California Coastal Conservancy   14-094

Education Center at Coal Oil Point Reserve

Coal Oil Point Reserve (COPR), located adjacent to the University of California, Santa Barbara, includes rare native coastal dune and wetland habitats that provide key opportunities for research and university-level teaching. The reserve is also broadly recognized for its conservation value with five endangered and threatened species and diverse bird populations. Currently about 20 research projects and university classes use the reserve annually. A large volunteer docent group assists with management of the threatened snowy plover, extensive restoration projects, and public environmental education programs. COPR users, and the programs that support them, require a basic infrastructure of buildings for administration, maintenance of the reserve, research and monitoring, and education gatherings.

Cristina Sandoval, Susan Swarbrick   6/29/2011 to 6/30/2015 $250,000
California Coastal Conservancy   10-112

Access Improvements and Restoration at Coal Oil Point Reserve

Staff is recommending that the Conservancy provide up to $250,000 to the Regents of the University of California ('grantee") for coastal access improvements (the "COPR Access Project" or "the project") at the Coal Oil Point Reserve ("the Reserve" or "COPR") adjacent to Devereux Slough and owned by the Regents of the University of California("Regents"), and managed by the University of California, Santa Barbara ("UCSB"), whose campus is nearby. The proposed COPR Access Project is a Tier One project on the Southern California Wetlands Recovery Project Work Plan and is recommended for priority funding. It is also the first project to implement the vision of the Ellwood-Devereux Open Space Management Plan to create a large coastal open space to serve the community and

protect sensitive habitats. The project will enhance the quality of public access within the Reserve while providing increased protection for its natural resources. The Reserve is located near a large population center and the UCSB campus, is known for its scenic and ecological values, and is heavily used for recreation. The Reserve and surrounding open spaces are among the few natural coastal sites in Santa Barbara County that offer public access for recreation while simultaneously managing for protection of threatened and endangered plants and wildlife. Access improvements are needed to protect fragile habitats and ensure human activity occurs only in appropriate areas within the Reserve. The project will encourage visitors to stay on authorized trails and to avoid sensitive habitat areas using various approaches such as improving access points, closing and restoring unapproved trails, making improvements to the interpretive Pond Trail, replacing old fences and gates, and installing fencing and no-horse barriers in specified areas to reduce human impacts to sensitive areas. Trespassing has been successfully reduced on the northern and eastern perimeter of the Reserve by creating a "green fence". All of the green fencing planted and planned for this project is on disturbed habitat and will replace exotic vegetation with native vegetation typical of the habitat. Thus the green fence serves as habitat restoration in addition to encouraging appropriate access. The proposed access improvements will be further enhanced by other improvements being implemented at the Reserve including the installation of 20 interpretive signs and development of a downloadable podcast to provide self-guided tours along Reserve trails. In addition, fundraising has begun to create an interpretive nature center on a nearby site recently acquired by the University and to take over management of the Cliff House. Collectively, these projects will provide unique and important opportunities to enjoy and learn about this special area. The Reserve proposes to construct access improvements at four sites within the Reserve and at one site outside the Reserve boundary on adjacent land owned by the University. Access improvements will be constructed at the public accessway at Sands beach (see Exhibit 2, Figure 4, Access B). An existing gate and 86 feet of aging chain-link fence will be replaced by a three-rail Woodcrete fence. The fence will be built in exactly the same position as the existing fence and the accessway through the fence will mimic the shape and location of the existing accessway to allow only pedestrian access to the beach. In addition, a six foot gate will be installed but kept locked to be used for emergencies, such as removing injured people and marine mammals from the beach.

The proposed project also includes several improvements along the Pond Trail (Exhibit 1). The Pond Trail follows the western edge of the Devereux Slough mouth (Access C) to the Reserve's northern access point, where it meets the Coastal Trail and the De Anza Trail. The main Pond Trail will remain in its current location, but other existing informal branching trails will be closed to protect sensitive habitat areas. To keep hikers on the designated Pond Trail wood log borders will be laid along each side of the trail. Shrubs and other native plants appropriate for the habitat will be planted outside of the log borders to eventually create a green fence around the trail. If the logs are removed or vandalized by people at any specific location along the trail, a post-and cable fence will be installed. At the northern boundary of the Pond Trail, an L-shaped trail entrance (similar in design to the entrance for Access B, described above) will be installed where none currently exists to allow pedestrians but prevent horses and bicycles from entering the trail. A 32-foot section of Woodcrete fencing will be installed on each side of the entrance. The southern end of the Pond Trail bisects the dune swale that connects the dune pond to the slough. During the rainy season this portion of the trail can flood. To allow continued access through this area during the rainy season a roll-out boardwalk will be laid out over the flooded section of the trail. This temporary boardwalk will not prevent people from stepping on water when the area is flooded but it will encourage people to stay on the path rather than walking on wetland vegetation. In addition, approximately six inches of fill on the trail will be removed to restore the hydrological connection of the dune swales on each side of the trail. The westernmost access point (Access D) is located on UC Santa Barbara's South Parcel on North Campus, just outside the western boundary of the Reserve. At this access point, the trail from the bluff to the beach will be regraded to remove existing erosion ditches and control future erosion. In addition, the iceplant around this access point will be removed. The beach and bluffs will be revegetated with locally sourced native plants. A 760-foot long Woodcrete three-rail fence will be installed on the Reserve side of the western trail access to reduce unauthorized access to the dunes and wetlands from this area. Coal Oil Point Natural Reserve is owned and managed by the University of California as part of its Natural Reserve System ("The NRS"). The Coal Oil Point Reserve Director lives on the site and coordinates all Reserve activities . The Director will be

responsible for supervising this project. The Reserve is unique among the NRS sites because of its proximity to a large urban population, requiring a significantly higher level of management. Active habitat restoration at the Reserve has been carried out for over ten years and all projects have had successful outcomes. A large number of students and community members participate in restoration on the Reserve. In 2009, 900 volunteers participated in restoration workdays. Utilizing volunteers is cost-effective and helps the Reserve achieve its outreach and education goals.

Mark Schildhauer 9/1/2013 to 8/31/2014 **$165,877**
University of Arizona 155005

The iPlant Collaborative: Cyberinfrastructure for the Life Sciences

The geospatial analyst will develop a set of global raster environmental layers to meet the needs of plant biologists and ecologists seeking to understand the interaction between plants and their broad, geospatial environmental context. Attention will be paid to making this data product and the technologies supporting it extensible to accommodate analyses relevant to the marine environment and non-plant organisms. Key deliverables will include: 1) developing an integrated information resource merging daily ground-based weather station data with satellite based measurements of weather; 2) creating select, derived products based on the above, that provide climate, extreme temperature and moisture events (such as return times or 50 year extreme temperatures), and bioagricultural variables such as growing degree days and AET; 3) producing a global, high-resolution terrain model that uses a digital elevation model and derives variables that are biologically relevant such as slope, aspect, slope position, soil moisture and insulation; 4) incorporating some additional layers to be determined, relating to land cover, vegetation and soils. The GA's focus will be to develop a usable, initial version of these integrated layers, while keeping careful track of the workflows used in their creation. The GA will then coordinate with developers based at iPlant to make these workflows scalable and repeatable as a resilient part of CI (cyberinfrastructure) for plant biology.

Mark Schildhauer 8/1/2008 to 7/31/2014 **$750,000**
National Science Foundation DBI-0753144

INTEROP: A Community-Driven Scientific Observations Network to Achieve Interoperability of Environmental and Ecological Data

Advances in environmental science increasingly depend on information from multiple disciplines to tackle broader and more complex questions about the natural world. Such advances, however, are hindered by data heterogeneity, which impedes the ability of researchers to discover, interpret, and integrate relevant data that have been collected by oth¬ers. A recent NSF-funded workshop on multi-disciplinary data management concluded that interoperability can be significantly improved by better describing data at the level of observa¬tion and measurement, rather than the traditional focus at the level of the data set. That is, for systems to interoperate effectively, the scientific community must unify the various existing ap¬proaches for representing and describing observational data. A community-sanctioned, unified data model for observational data is thus needed to enable interoperability among existing data resources, which will in turn provide the necessary foundation to support cross-disciplinary synthetic research in the environmental sciences. The investigators propose the Scientific Obser¬vations Network to initiate a multi-disciplinary, community-driven effort to define and develop the necessary specifications and technologies to facilitate semantic interpretation and integra¬tion of observational data. The technological approaches will derive from recent advances in knowledge representation that have demonstrated practical utility in enhancing scientific com¬munication and data interoperability within the genomics community. This effort will consti¬tute a community of experts consisting of environmental science researchers, computer scien¬tists, and information managers, to develop open-source, standards-based approaches to the semantic modeling of observational data. Subgroups of Network experts will also engage in extending this core data model to include a broad range of specific measurements collected by the representative set of disciplines, and a series of demonstration projects will illustrate the ca¬pabilities of the approaches to confederate data for reuse in broader and unanticipated contexts.

LTER: MCR IIB: Long-Term Dynamics of a Coral Reef Ecosystem

Intellectual Merit: The Moorea Coral Reef (MCR) LTER is an interdisciplinary research and education program that was established in 2004, to explore the joint effects of climate and disturbance on the structure and function of coral reefs. Our study area is the reef complex that surrounds the island of Moorea in French Polynesia. Our initial focus (MCR I) was to advance understanding of major controls of processes that modulate ecosystem function, shape community structure and diversity, and determine abundance and dynamics of constituent populations. We build on this foundation by adapting a unifying conceptual framework (US LTER 2007) and developing a set of research themes to organize the MCR II research program and facilitate cross-site collaboration. Coral reef ecosystems appear especially vulnerable to changes in abiotic drivers associated with Global Climate Change (GCC). These arise from two mechanisms related to increasing concentrations of atmospheric CO_2: rising seawater temperature due to greenhouse warming, and changing seawater chemistry known as Ocean Acidification (OA). A paradigm shift occurred within the past decade regarding the relative importance of these climate-related drivers to coral reefs. The focus initially was on rising seawater temperature because it triggered several large-scale, conspicuous coral bleaching (i.e., loss of the endosymbiont Symbiodinium) events. There now is widespread recognition that OA and its interaction with rising temperature have the potential to cause even more sweeping changes. These drivers occur against a backdrop of other press (e.g., fishing) and pulse (e.g., storms) perturbations. During MCR I, a brief outbreak of crown-of-thorns seastars (COTS) resulted in the death of virtually all coral on the fore reef of Moorea, bringing issues related to state change, resilience (recovery), interactive effects and indirect cascades to the forefront. The fundamental question that we address in MCR II is: How do drivers that operate over different spatial and temporal scales interact to influence the structure and function of coral reef ecosystems? Our three organizing themes are: (i) interactive effects among drivers, (ii) indirect effects arising from structure – function linkages, and (iii) resilience and resistance in relation to structure – function feedbacks. The six goals of MCR II are to: (a) continue our long-term datasets on physical drivers, community dynamics and ecosystem processes; (b) maintain a long-term resilience experiment; (c) contribute to understanding of how Global Climate Change drivers will affect coral reefs and what factors influence resistance and resilience; (d) develop and test general ecological theory; (e) continue to improve our information management system to more fully meet the needs of the LTER network and broader scientific community; and (f) enhance our outreach components.

Broader Impacts: Coral reefs are not just ecologically important - they yield upwards of $375 billion annually in goods and services (most of it in the developing world) that are vulnerable to human activities and climate forcing. Hence our research has relevance and application to resource managers, policy makers and stakeholders worldwide. Broader impacts arising from our educational activities include postdoctoral mentoring, research that integrates undergraduate and graduate training, progress towards an ethnically diverse MCR student community, active participation of K-12 teachers in MCR research, incorporation of MCR findings in teaching curricula, participation of MCR faculty and graduate students in the Three Seas Program, and involvement of faculty and students from predominately undergraduate and minority-serving institutions. Additional impacts are realized by our outreach efforts, including partnerships with three local schools that serve socio-economically disadvantaged and minority students, and with the Atitia Center on Moorea to reach Tahitians. While our information-rich web site will continue to be a primary outreach portal, we plan to develop a partnership with another web-based entity to target middle-school students.

LTER: MCRIIB: Long-term Dynamics of a Coral Reef Ecosystem, LIDAR Supplement

Outline of Work Plan In May/June 2015 a SHOM subcontractor is scheduled to conduct an airborne LIDAR bathymetry survey of the northeast corner of Moorea, covering about 20% of the island's shallow reef. The goal of the planned SHOM survey is to map the highly developed coastal areas on Moorea and Tahiti for cyclone/tsunami risk assessment, leaving the currently undeveloped areas

unsurveyed. The proposed additional coverage around the remainder of Moorea would be surveyed by the same contractor, LIDAR system, and data specifications required by SHOM and thus produce a continuous data product for all of Moorea. We have obtained a formal quote from the subcontractor to SHOM (Fugro LADS Corporation Pty Ltd) to perform the additional coverage required. The quote includes 5 days of flight time for the LIDAR surveys, 1 contingency flight day, and all data processing and post-processing. The deliverables include the original raw data, an edited form of the data, and both 1- m x 1-m and 5-m x 5-m gridded DEM products that can readily be used for science questions and modeling. The quote stipulates the final processed data products will be delivered to the MCR LTER by September 2015. Further technical details of the LIDAR system, operational plan, and data products are in the attached quote

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Russell Schmitt, Sally Holbrook 9/1/2012 to 8/31/2016 **$125,214**
National Science Foundation OCE-1236905

LTER: MCR IIB: Long-Term Dynamics of a Coral Reef Ecosystem, UNOLS Supplement

The cruise plan includes two main components (1) mapping of the large scale bathymetry, circulation and water column properties surrounding the islands of Moorea and Tahiti, and (2) high resolution sampling along a set of radiative transects extending from the Moorea reef to 50 km offshore. Both components will include measurements of bathymetry, circulation, and hydrography as well as water sample collection for chemical and biological analyses. For the radiative transects, shipboard measurements from the R/V Kilo Moana will be coordinated with simultaneous sampling from small boats based on Moorea. For these transects, water samples will be collected in a dense array both horizontally and vertically to obtain high resolution measurements of chemical and biological gradients from the reef to offshore. High resolution bathymetry will be obtained from multi-beam sonar measurements from the R/V Kilo Moana (deep water) and R/V Ahi (shallow water). A shipboard ADCP will be used to measure currents around the islands and CTD profiles will be made to obtain synoptic hydrography (salinity, temperature) measurements. CTD profiles will also provide information about important water column parameters including dissolved oxygen, pH, Chlorophyll a, and turbidity. These measurements will also be accompanied by optical water column properties including light transmission and reflectance. Water column samples will be analyzed for biogeochemical constituents including nutrients and carbon system parameters (NO3, NH4, PO4, POC, DIC, POC+PON, DOC+DON, DIC) across depths from the surface to ca 500 m. Microbial sampling will include measurements of Chl a, bacteria production, bacteria abundance, bacteria DNA, and primary production.

Russell Schmitt, Sally Holbrook 9/1/2010 to 8/31/2014 **$27,000**
National Science Foundation OCE-1026851

LTER: MCR II - Long-Term Dynamics of a Coral Reef Ecosystem - RET Supplement

Research Experiences for Teachers (RET) We are requesting funding to enable two K-12 teachers to participate in partnership with MCR LTER site investigators to (1) develop new classroom science curricula using published MCR core databases, (2) design a series of follow-up classroom activities to be used in reinforcing lessons learned during MCR LTER sponsored educational field trips to the REEF (Research Experience & Education Facility) on the UCSB campus and (3) design a series of classroom activities to be used in combination with our soon to be published book, "Kupe and the Corals", a volume in the LTER Schoolyard Book Series. (1) Development of inquiry-based lesson plans on coral reef ecosystems using MCR LTER site data: (2) Development of follow-up activities for the REEF: (3) Development of classroom materials to accompany the book "Kupe and the Corals", a new children's book in the LTER Schoolyard Book Series:

Stephen Schroeter 7/1/2006 to 6/30/2016 **$103,978**
California Sea Urchin Commission SB070019

Studies of Sea Urchins Settlement in Southern and Northern California

The patterns of settlement of red (*Strongylocentrotus franciscanus*) and purple (*S. purpuratus*) sea urchins may have important impacts on the commercial fishery and provide an important fishery-

independent measure of stock health. The investigators have monitored weekly to bi-weekly sea urchin settlement at multiple sites in southern and northern California since February 1990. Studies to date have identified spatial and temporal patterns in sea urchin settlement (including the effects of periodic *El Niños* and *La Niñas*) and have identified some of the likely mechanisms responsible for these patterns. They have added value to their work by volunteering their time and collaborating with University researchers and private industry. In particular, work done in collaboration with Jan Svejkovsky of Ocean Imaging has given important insights into the effects of large-scale oceanographic forcing on sea urchin settlement patterns, while collaborative work on population genetics with Dr. Ron Burton has shed light on the structure of parental source populations during a heavy settlement event. Perhaps most importantly, their long-term and geographically extensive record of sea urchin settlement continues to provide the only integrated, fishery independent index of the condition of the breeding stock, since larval supply and settlement are a function of the effective breeding population. The value of this inexpensive tool for monitoring the health of the sea urchin resource in California increases each year the study is continued.

Scott Simon, Mark Brzezinski   2/1/2015 to 6/30/2016 $7,976
UC San Diego   NA10OAR4320156

Integrating CIMEC Science into the Oceans-to-Classrooms Outreach Program at UCSB's Marine Science Institute

The Marine Science Institute (MSI) at the University of California Santa Barbara operates several outreach programs that align with CIMEC (Cooperative Institute for Marine Ecosystems and Climate) goals. We currently serve approximately 18,000 K-12 students per year with an emphasis on grades 6-8. The portion of the CIMEC FY15 Task 1B Education and Outreach funds allocated to UCSB for 2/1/15 – 6/30/15 is $7,976. The Oceans to Classrooms (O2C) program at MSI is run by Staff Research Associate, Scott Simon, and employs undergraduate docents that serve as mentors and role models to students from grades 6 – 8. Instruction is done at the Research Experience and Education Facility (the REEF) located adjacent to the beach at UCSB and through the Mobile REEF which is the focus of this increment of funding. In the O2C program students learn about the marine ecosystems off southern California and the environmental and socio-economic challenges that they face. Experiences include learning the natural history of key species that are of ecological and economic importance thorough hands-on experiences with live animals and student-designed experiments on climate impacts on ecosystems including responses to ocean acidification and warming. The current funding will be used integrate current CIMEC research into relevant learning experiences for students and their teachers. Local teachers will be informed of CIMEC, its goals and current research during teacher professional development activities. Integration is straightforward as CIMEC's mission and research naturally aligns with existing approaches within O2C. This increment of funding will focus on the Mobile REEF. The Mobile REEF brings the O2C also experience to classrooms who cannot visit the REEF on the UCSB campus. The equipment for students to conduct experiments and live animals are brought to classrooms. The Mobile REEF program will use the same CIMEC research themes and examples to convey the importance and societal relevance of CIMEC research to students and teachers.

Thomas Turner   8/1/2011 to 5/31/2017 $1,151,408
NIH General Medical Sciences   5R01 GM098614-04

Evolutionary Behavioral Genomics of Drosophila Courtship

Genome-wide association studies hold the promise of comprehensive and systematic identification of the genetic basis of natural trait variation. By quantifying how genetic polymorphisms induce large, small, precise, general, or conditional effects on traits, we can unlock a vast reservoir of natural variation that will help us understand how biological systems function and evolve. However, good statistical power to identify variants with low population frequencies or modest effects requires sample sizes that are generally prohibitive. Here, we develop a new approach, "Evolve and Resequence" (E&R), that overcomes this barrier using the genetic model system Drosophila. We have re-purposed experimental evolution of *D. melanogaster*, which has been used for over 100 years to address fundamental questions in population genetics, and adapted it for use in genome-wide mapping. Together with high-throughput behavioral quantification and various statistical

approaches, our technique will be used to build models of behavior based on genotype. The predictive power of these models will tell us a great deal about the nature of genetic information and the molecular systems that translate this information into behavioral output. The long-term goal of this research is to characterize the genetic and environmental influences that result in variation in courtship behavior, for both males and females, in multiple Drosophila species. This work begins with characterization of male courtship song production: during courtship, a Drosophila male extends a single wing and "twangs" this wing repeatedly to produce a wing vibration song consisting of a series of pulses. These traits are among the best characterized of Drosophila behaviors, both in *D. melanogaster* and across the genus, and they are currently the focus of intensive efforts in neurobiology and molecular genetics. As such, these traits serve as a model system for studying the genetic basis of behavior in animals. Specifically, this proposal aims to 1) locate and characterize the genetic variants affecting courtship song in *D. melanogaster*, 2) do the same for the closely related *D. simulans*, to compare and contrast results from multiple species, and 3) begin molecular genetic investigation of the genes and gene systems discovered in aims 1 and 2.

David Valentine   **10/1/2013 to 9/30/2016**   **$341,714**
National Science Foundation   OCE-1333162

Collaborative Research: Oxygenation of Hydrocarbons in the Ocean

Collaborative Research: Oxygenation of Hydrocarbons in the Ocean Overview More than 400,000 tons of petroleum hydrocarbons are released annually into the ocean, with human activities and natural seepage contributing comparable amounts. Once in marine environments, hydrocarbons are subject to physical, chemical and biological processes, collectively referred to as weathering, that are well established to remove select hydrocarbons from the ocean. However, little attention has been given, mainly due to analytical limitations, to the ubiquitous residues left by oil's weathering. Recent studies from oil spills point to the importance of hydrocarbon oxygenation, the incorporation of oxygen into hydrocarbons, as an important process in forming major constituents of recalcitrant tar. Furthermore, other oxyhydrocarbons could dissolve into ocean water, and several studies suggest that oxygenated hydrocarbon compounds can be toxic. This proposal seeks to lay a scientific foundation for understanding which processes control the formation of oxygenated hydrocarbons, the rates of these processes, the identity of the major products, the rates at which they are formed and destroyed, and for distinguishing photochemical oxygenation from biological oxygenation. The primary hypotheses driving this study are that (i) hydrocarbon oxygenation in the ocean is controlled by a balance between photooxidation and biodegradation, with each process leading to distinct suites of products and (ii) oxygenation produces both terminal recalcitrant products, which dominate the mass of tar in the environment, and lesser amounts of dissolved organic carbon. The approach involves a series of field and laboratory studies that include using hydrocarbon seeps as natural laboratories and oil spills (Deepwater Horizon oil spill 2010, and Cosco Busan spill 2007) as individual experiments. Laboratory experiments will isolate photochemical and biological oxygenation, whereas field studies will assess changes and patterns of oxygenation in natural slicks at the sea surface and biodegraded oils from underlying natural seeps. To identify specific oxidation processes and recalcitrant products, labile and recalcitrant oxygenation products will be identified using ultra-high resolution mass spectrometry (FT-ICR-MS) and comprehensive two-dimensional gas chromatography (GCGC), and changes in the stable oxygen isotopic composition characteristic of biological and photooxidation will be determined. These are novel approaches not previously applied to oxygenation of hydrocarbons. Intellectual Merit The results from these experiments will contribute to a better understanding of the petroleum oxygenation processes and the environmental fate of understudied oxygenation products. Thereby, characteristic changes in bulk, molecular, and isotopic composition of weathered petroleum seep and spill samples collected by the PIs will be linked to photooxidation and biodegradation processes. Overall, this study promises to reveal the composition, source, and fate of oxygenated hydrocarbons that result from petroleum released in marine systems by natural seepage or anthropogenic discharge. Broader Impact. This study provides for several undergraduates and two postdoctoral scholars to be trained in innovative analytical and experimental techniques. The proposed oceanographic expedition in the Gulf of Mexico will double as a course offered at UCSB that will bring undergraduates to sea and provide a rich and integrated research and learning experience; undergraduate students from the University of Mary Washington will also be incorporated into the laboratory and oceanographic

phases. Furthermore, the results of this effort will help regulatory agencies to define new analytical methods and target compounds for oil spill research. The involved PIs have built a strong relationship with federal and industry oil spill scientists in order to communicate and apply these results. Last, the iconic 2010 Deepwater Horizon spill has drawn attention to a wider audience of marine scientists studying cycling of organic matter in the ocean, beyond traditional oil spill research. The proposed study will add to their efforts to understand the fate and impacts of hydrocarbons released into the ocean.

David Valentine   **7/1/2013 to 1/1/2016**   **$400,000**
Exxon Mobil Upstream Research Company   EM08119

Development and Testing of Sampling Tools for the Collection of Microbes and Chemicals from Marine Seeps

Based on the limitations of the existing technologies used by the petroleum industry, there are clear opportunities for the development of new cost effective sampling, analyses, and interpretation techniques. Moreover, the ability to collect uncontaminated samples is critical in order to use the chemical and microbial signatures of seeps to reduce the uncertainty of hydrocarbon occurrence materially in the subsurface. This project will develop tools and methods to collect pristine chemical and microbiological samples from hydrocarbon seeps in the marine environment (i.e. fluids and sediments). Of particular interest are samples of the seep fluids (gas, oil, and water) and the microbes contained therein. The primary sampling challenge is to minimize contamination during sample collection and retrieval (e.g. air intrusion or through the involvement of seawater rich in atmospheric noble gases, anthropogenic bio-contamination, etc.). Development of tools will be led by UCSB, with the fabrication being conducted jointly with ExxonMobil Upstream Research Company, and initial testing performed by UCSB at the shallow (~20 m deep) hydrocarbon seeps at Coal Oil Point, Santa Barbara Channel, using SCUBA divers. The apparatus and methods developed here will be designed for eventual deployment by remotely operated vehicles (ROVs), for sampling of seeps in the deep marine environment. The goal of this activity is to successfully collect samples for chemical and microbiological analyses, with minimal levels of contamination. UCSB Objectives: This project aims to: (1) develop appropriate devices and protocols for sampling gas and oil from hydrocarbon seep environments, in a manner that avoids unacceptable levels of chemical and microbial contamination, and (2) demonstrate the utility of the developed devices and protocols for collecting samples free of contamination.

David Valentine   **12/10/2012 to 2/28/2016**   **$231,724**
University of Rochester   416111-G

Investigating the Chemical and Isotopic Kinetics of Aerobic Methane Oxidation

Year 1: The research team at UCSB will participate on the planned cruise to the Gulf of Mexico and will coordinate the sampling for bacterial identity and for oxidation rate measurements using the tritium method. The research team at UCSB will initiate the molecular analyses for microbial community structure on samples collected during the two cruises. This will include sequencing of 16SrRNA genes using a clone library approach. Year 2: The research team at UCSB will complete the molecular analyses for microbial community structure on samples collected during the first cruise, and select other samples provided by the lead PI from incubation studies. Year 3: The research team at UCSB will participate on the planned cruise to the Atlantic Ocean and will coordinate the sampling for bacterial identity and for oxidation rate measurements using the tritium method, should the latter be needed. The research team at UCSB will complete the molecular analyses for microbial community structure on samples collected during the second cruise, and select other samples provided by the lead PI from incubation studies. We budgeted for sequencing of 1000 clones in total, to be used on the initial samples and on time points of the incubation time series. The depth of sequencing for each of the ~24 samples expected will be determined based on initial T-RFLP results, as we have done previously, allowing us to best allocate the funds for sequencing across the time series.

David Valentine   1/1/2011 to 12/31/2016   **$924,127**
National Science Foundation   OCE-1046144

Dimensions: The Role of Viruses in Structuring Biodiversity in Methanotrophioc Marine Ecosystems

The proposal first seeks to assess viral activity in situ by extending established stable isotope probing techniques to quantify rates of viral production at sea floor methane seeps. The same techniques will be used to track the flow of carbon from methane to microbes to viruses and to isolate genetic material from just those organisms that actively cycle methane-derived carbon, enabling the production of microbial and viral metagenomes that are anchored in ecosystem function. Comparisons among these metagenomes will reveal any functional sequences in transit between organisms, providing the basis for an evaluation of the relationships between functional and genetic diversity. At the same time, single-cell whole-genome amplification will pinpoint individual cells for comparison with the microbial and viral assemblages, permitting assessment of the relationships between taxonomic and genetic diversity. Last, the comparison of genomic and metagenomic data both within and across distinctive marine methanotrophic ecosystems will enable analysis of the relationship between functional and taxonomic diversity.

David Valentine   3/21/2013 to 3/31/2016   **$335,419**
California Institute of Technology   65Q-1094175

Cracking the Microbial Sulfur Cycle with Novel Cell- and Metabolite-Specific Stable Isotope Approaches

Personnel at UCSB will work closely with the collaborating scientists on the following topical areas: 1) Contribute experimental expertise to develop techniques to measure low abundance sulfur-containing compounds from whole cells, as well as metabolic intermediates using novel inductively coupled plasma mass spectrometry (ICP-MS) techniques. 2) Contribute to the development of experimental methods to link phylogenetic identity to metabolic activity of sulfur cycling microbes using fluorescence in situ hybridization coupled to mass spectrometry (FISH-nanoSIMS) 3) Conduct collaborative experiments to track the flow of isotope labeled sulfur through extracellular metabolite pools as well as within intracellular pools. 4) Conduct aerobic and anaerobic pulse chase time course experiments using seafloor incubation chamber at Coal Oil Point. 5) Contribute to the development of new methods for using molecules containing more than one rare isotope species to track multiple sources and sinks of methane in cultures of microbes 6) Contribute to a synthesis paper on tracking activity and interactions of sulfur cycling microbes at the cellular level. 7) Contribute toward in-situ incubations involving for sulfur isotope tracking and metaproteomics.

David Valentine   6/1/2012 to 5/31/2016   **$388,632**
National Science Foundation   OCE-1155855

Development and Application of a Radiotracer Rate Method for Ethane and Propane Consumption

Ethane and propane are released in abundance to the ocean through natural seepage, as byproducts of photosynthesis, and by the petroleum industry. For example, ethane and propane together constituted greater than 5% of the total mass release during the Deepwater Horizon event, and were the primary drivers of oxygen decline in the deep waters of the NE Gulf of Mexico during the spill. Despite the importance of these gases, little is known about their release into the ocean, the capacity of marine bacteria to consume them, or the fate and impacts of the carbon and energy they store. This proposal will specifically address the consumption of ethane and propane in the ocean by developing, validating and applying highly sensitive tracer techniques to quantify consumption rates for these gases in ocean waters. Two specific hypotheses will be tested with the goal to better understand the factors controlling ethane and propane consumption in the ocean. Hypothesis 1: The capacity for ethane and propane oxidation is ubiquitous throughout the upper ocean and along continental margins, with constitutive rates that depend on regional input and total bacterial abundance; Hypothesis 2: Propane and ethane consumption are readily inducible beyond a basal level on the timescale of days, propane consumption more so than ethane consumption. The proposed research will address these hypotheses in two steps. The first step will entail the development of a method

to quantify the consumption rates for ethane and propane, including the laboratory synthesis of radiolabeled ethane and propane, purification of the products, systematic investigations of tracer storage to minimize effects of autoradiolytic exchange, and validation of the measurement through inter-comparison. The second step is the application of the method to interrogate the rates of ethane and propane consumption in the ocean, including the coastal ocean and along the continental margin off California. The field component of the research will take place during a series of short cruises in the Santa Barbara Basin, and during one value added cruise aboard a UNOLS vessel.

Herb Waite   6/1/2015 to 5/31/2017 $76,731
National Science Foundation   1508717
EAGER: Collaborative Research: Mimicking Mussel Adhesion with Periodically Sequenced Polypeptides

Marine mussels use the catecholic amino acid 3,4 dihydroxyphenylalanine (Dopa) in mussel foot proteins to mediate robust wet adhesion in the turbulent intertidal zone. The objective of this EAGER proposal is to quantitatively explore the role of high fidelity sequence periodicity in a Dopa-rich polypeptide on the dynamics of coating and adhesion. Moreover, we propose a non-biological synthetic protocol for the synthesis of a high molecular weight periodic sequence with a low polydispersity, allowing us to synthesize bulk-scale inexpensive polymer. Our approach is based on the application of a transport-limited polycondensation reaction to define both the periodicity and the polydispersity. Subsequently, we propose to quantify the coating dynamics and work of adhesion as a function of the sequence parameters. We can use our synthetic protocols to precisely control the role of Dopa / proline frequency and the spatial distribution of peptides. Our team has established expertise in both the synthetic methods and the characterization tools, but the proposed work aims at EAGER funding because the vision of marrying polymer-scale synthetic tools and biomimetic adhesion is untested and involves a radically different approach. Intellectual Merit The proposed work blends the PIs' experience in interfacial science and marine biology to understand the fundamental behavior of non-toxic biomimetic adhesives. Our proposed macromolecular system is unique in its ability to precisely define the presentation of Dopa. Moreover, the SFA is well suited to quantitatively define the dynamic roles of hydroxyproline in coating and Dopa in adhesion and cohesion. The narrative describes our rationale for the initial periodically sequenced Dopa-rich polypeptides, and we describe our plan to rapidly iterate between the materials characterization and new sequences that allow us to validate our hypotheses on the balance between coating and binding in wet-adhesion. Broader Impacts The proposed work is in line with an NSF-defined priority to emphasize discoveries in bioadhesion, which has the potential to have "far reaching effects" in a number of technologies. Moreover, the ability to generate a significant quantity of a non-toxic biomimetic adhesive has excellent potential for STEM education, where simple demonstrations can be developed to engage students in fundamental science questions as well as the engineering of materials. Additionally, CCNY is a Minority Serving Institution, and the proposed interdisciplinary work is ideal for engaging students at the high-school, undergraduate and graduate levels. The PI has developed a 'community' of science teachers at Harlem area schools, where area teachers can work together with high school students in the research lab during the summer and school year. Taken together, the proposed work can both broaden participation in the local STEM community as well as lead to a significant impact in the adhesion and interfacial science community.

Herb Waite, Kollbe Ahn   3/1/2015 to 12/31/2015 $31,236
Korean Institute of Industrial Technology   SB150164

Catechol Comprising Copolymer Synthesis and Properties Evaluation

Beginning in 1981 with the characterization of the first mussel adhesive protein, the structure-properties relationships of more than 20 mussel- and sandcastle worm-derived adhesive proteins have been determined. Translation of these relationships is providing new insights for designing and engineering the next generation of polymers that could perform well in wet environments as do in dry conditions. The catecholic amino acid, i.e. 3,4-dihydroxyphenylalanine (DOPA), was identified as a main functional group to build strong adhesion to metal oxide surfaces under aqueous conditions and to form a coordination complex, and the catehcol chemistry inspired a generation of scientists to transplant catechol functionalities to various synthetic platforms. However, most previous

reports used dopamine (3,4-dihydroxyphenethylamine) as a DOPA analogue that is not economically viable for industrial applications due to its high price (sold at ~$90.00/lb) compared to conventional adhesives/coatings/coatings (e.g., high tack 3M pressure-sensitive adhesives sold at $11.95/lb.). The team at University of California Santa Barbara has established technology to convert plant phenolics for mussel-inspired catechols for underwater adhesive/coating/paint applications. In this proposed project, we will utilize this technology for more practical underwater adhesives. The goal of this project is to utilize plant phenolics to develop high-performance adhesives. The key objectives of the proposed research are 1) to prepare plant phenolic-based bio-inspired catecholic precursor, and 2) to prepare catechol-functionalized copolymers, and 3) to investigate the mechanical properties such as bonding performance of the materials in particular, and 4) evaluate the products for practical applications.

Herb Waite, Jacob Israelachvili   8/4/2008 to 6/30/2014   **$2,224,158**
NIH Dental and NIH Research, National Institutes of Health   R01 DE018468

Translating Mussel Adhesion

Moisture is the nemesis of strong polymer adhesion to metals and minerals. Most engineered adhesive polymers require extensive prior surface cleaning, drying, and sometime even chemical modification for effective adhesion to polar surfaces. Such surface preparation is difficult in vivo since biomineralized tissues and implant material surfaces are necessarily hydrated within the body. Various marine organisms have evolved highly effective adhesive strategies for wet surfaces. The broad goal of this proposal is to obtain mechanistic information about marine adhesion in order to translate it into effective applications for restoration and repair of hard tissues. While the discovery of 3,4-dihydroxyphenylalanine (Dopa)-protein involvement in adhesion has already inspired several new biomedical materials, Dopa is not the only bioinpired theme. The specific aims here are to determine using mass spectrometry whether and to what extent phosphoserine and 4-hydroxyarginine are linked to mussel adhesion on different surfaces, characterize the specific protein-protein interactions during adhesive cross-linking, and to explore how factors such as mass, primary sequence, and side-chain functionalization influence the coating or bridging behavior of mfp-1 on surfaces such as titanium and hydroxyapatite using the surface forces apparatus. Bio-inspired adhesives and sealants are much needed in dentistry and orthopaedics not just to improve the strength and durability of bonding to hard tissues, but also to emancipate the present technology, particularly in dentistry, from reliance on highly reactive and toxic organic formulas.

J. Herbert Waite   9/1/2013 to 8/31/2016   **$496,954**
NIH Dental and NIH Research, National Institutes of Health   2R01DE018468-06

Translating Mussel Adhesion

Polymer adhesion to wet mineral surfaces is typically limited by the lack of polymer-surface interactions strong enough to compete with water. Marine mussels overcome this limitation by using a suite of specific DOPA-containing proteins that chemically bind even to wet, atomically smooth surfaces. Protein biochemistry and surface physics are combined in this proposal to investigate the adhesive strategies of mussels on surfaces of hydroxyapatite - the mineral of tooth and bone. In the first aim, mass spectrometry and molecular surface sensors will be used to interrogate the proteins, pH, redox, and water fastness of adhesive secretions deposited onto hydroxyapatite. In aim 2, hydroxyapatite-specific proteins will be tested for adhesion in the surface forces apparatus using the pH and redox conditions used in mussel adhesion. In the third aim, a 3-dimensional surface forces apparatus will be introduced to measure the effect of multidirectional motion on the dynamic adhesion of mussel-derived proteins to dentinal and enamel surfaces.

Herbert Waite, Kolbe Ahn   7/31/2013 to 1/29/2016   **$577,836**
Department of Navy, Miscellaneous Bases & Agencies   N00014-13-1-0867

Mussel-Inspired Underwater Acrylic Adhesives/Coatings

Mussels have evolved their adhesion to wet mineral, metal, and metal oxide surfaces over 500 million years. Beginning in 1981 with the characterization of the first mussel adhesive protein by Waite

(PI), the structure-properties relationships of more than 20 mussel- and sandcastle worm-derived adhesive proteins have been determined. Translation of these relationships is providing new insights for designing and engineering the next generation of polymers for wet adhesion. In our preliminary work, the technical feasibility of our experimental approach has been demonstrated and emphasizes the potential for marine and submarine applications. Briefly, 1) mussel-inspired catechol-acrylate monomers were synthesized using eugenol (inexpensive sustainable precursor); 2) the monomers were UV polymerized and exhibited excellent wet-tack strength (2.6 N/cm2) underwater comparable to dry-tack strength (2.5 N/cm2) of commercial Scotch tape (3M, St. Paul, MN) under ambient conditions. We will also investigate surface physics of this new polymeric material using the surface forces apparatus (SFA) and will optimize its adhesion/cohesion properties by controlling catechol activation rates and pre-polymerization techniques. Finally, we will develop underwater adhesives/coatings that adhere to/coat marine surfaces using our expertise in mussel-inspired wet-adhesion technology at UCSB. This innovation will empower the Navy (1) to perform naval boat/ship maintenance at sea without dry docking, (2) to adhere devices to surfaces undersea, and (3) to coat/paint/seal and/or mark/note to surfaces undersea with a possible extended application of invisible magic marker (only visible in certain wavelength of light) using fluorescent dyes.

Barbara Walker, Carolynn Culver,   2/1/2012 to 3/31/2015   **$164,072**
Kimberly Selkoe
University of Washington   R/SOC-2-F-1/2

Toward Resilience and Sustainable Seafood Supply: Assessing Direct Marketing Approaches for the West Coast Fishing Communities

The overarching project goals are to contribute to the social science literature on fisheries and social change in local food systems, and generate information and tools to better enable West Coast fishing communities to determine whether and how they might use various types of DMAs. Project objectives are to: 1) rigorously evaluate the patterns, processes, and impacts associated with seafood DMAs, and 2) integrate this knowledge into practical tools for use by West Coast communities in DMA decision-making. Combining applied social science research and engagement with fishing communities, we will produce a comparative case study of selected DMAs in two regions of the U.S. (the Carolinas, Washington State), and develop and pilot test a DMA assessment toolkit in two West Coast communities (Santa Barbara, CA, Coos Bay, OR). These products are expected to increase knowledge and inform decision-making about DMAs in the pilot test communities, supporting their resilience and contributing to sustainable seafood supply in the short term, and other such communities over the long term. In addition, the project will help build social science research capacity that can be used to further document and explore the social processes underlying coastal community change.

Robert Warner   3/1/2013 to 2/28/2017   **$29,317**
Boston University   4500001274

An Integrative Investigation of Population Connectivity Using a Coral Reef Fish

Work on this grant assigned to UCSB consists of two parts:
1. Field research in Belize. In the field, we will oversee the collection of recruits of the sponge goby *Elacatinus lori* in stratified plots that correspond to specified distances from the prospective parents (who have been individually identified through DNA analysis).
2. Otolith analysis at UCSB: In the Warner lab at UCSB, we will extract sagittal otoliths from the heads of recruits that we successfully assign to parents using parentage analyses. Otoliths will be extracted, cleaned, dried and mounted on plastic slides; sagittae will be polished with a lapping wheel and diamond polishing film to expose growth layers and core (Bergenius et al. 2002; Standish et al. 2008). Otoliths will be viewed under immersion oil with a compound microscope and polarized light at 1000x magnification. The number of increments along the longest axis of the otolith will be counted with the aid of an image analysis system (e.g., Image Pro Plus, version 4.5; Media Cybernetics 2001). The pelagic larval duration (PLD) will be estimated by counting the number of increments between the core of the otolith and the settlement mark, which has been shown to reflect PLD whenever the assumption has been tested (Thorrold & Hare 2002).

Libe Washburn   10/1/2011 to 9/30/2014   **$195,928**
CODAR Ocean Sensors   SB120053

HF Radar Calibration with Automatic Identification System Ships of Opportunity

In collaboration with Codar Ocean Sensors, Ltd., we will develop an operational product by implementing methods developed in our SBIR Phase I project to obtain HF radar antenna pattern calibrations by using backscatter from ships and position data from Automatic Information System broadcasts. The UCSB work plan for this research is outlined in the Phase II objectives: 1) Refine algorithms to calibrate antenna patterns automatically in real-time as a substitute for expensive, infrequent ship-based calibrations; 2) Develop quantitative indicators of the quality of the ship-derived antenna patterns; 3) Expand the azimuthal coverage of antenna pattern measurements and increase the number of patterns produced over time. 4) Apply the ship-based antenna pattern method to other commonly used frequency bands including those operating at frequencies around 5 MHz, 25 MHz, 42 MHz. UCSB personnel Brian Emery (Computer Network Technologist II) and Libe Washburn (Professor of Oceanography) will participate in the SBIR Phase II project. Emery will be responsible for the computer programming, algorithm development, and analysis of results. Washburn will work with Emery to develop algorithms and analyze results of the software for automatic measurement of antenna patterns.

Libe Washburn, Mark Brzezinski   6/1/2010 to 5/31/2016   **$1,582,297**
UC San Diego   NA11NOS0120029

Southern California Regional Coastal Ocean Observing System: Surface Current Mapping, Harmful Algal Bloom, and Sub-Surface Water Sections

A network of HF radar systems for measuring ocean surface currents is being developed and operated with funding from the California State Coastal Conservancy and NOAA which leverages several preexisting HF hardware and data management systems. The surface current mapping network will aid in remotely sensed measurement of ocean surface currents for purposes of assessing and mitigating impacts of impaired water quality, tracking oil spills, assisting search and rescue efforts, and monitoring the physical environment for purposes of understanding ecosystem change. The Southern California Coastal Ocean Observing System (SCCOOS) proposes to maintain and improve the network to ensure continued distribution of near real-time surface currents along the coast of Southern California. Funds obtained from this program will support continued operation and maintenance of HF Radar systems including supporting infrastructure. This Statement of Work is the UCSB component of the SCCOOS HF radar system. The systems operated by Washburn's research group at UCSB are deployed from Nicholas Canyon in the south (site to be installed in 2010) to Point Sal in the north as shown in the table below. Currently, two of the sites are maintained jointly with Cal Poly, San Luis Obispo (SLO, PI is Mark Moline): Pt. Sal and Pt. Conception. A third jointly-operated site will be installed at Pt. Arguello in 2010. The overall objective of the UCSB group will be to maintain HF radar operations of all sites. Site inspections will be conducted routinely to evaluate and maintain system health. Activities during the inspections include replacement of local backup data storage; inspection of antennas and cables; and maintenance of data acquisition computer, air conditioners, data transmission equipment, and power supply equipment such as UPSs and transformers. Antenna pattern measurements will be conducted in coordination with other groups to reduce costs. HF radar data will be transmitted to the central SCCOOS data management system at SIO/UCSD.

Libe Washburn   9/15/2010 to 8/31/2016   **$698,120**
National Science Foundation   OCE-1031893

Collaborative Research: The Propagating Response of the Inner Shelf to Wind Relaxations in a Coastal Upwelling System

Poleward flows that rapidly develop over the continental shelf and slope following relaxations of upwelling-favorable winds (relaxation flows) are common but intermittent features of wind-driven upwelling systems in eastern boundary currents. These buoyant flows are important in coastal upwelling systems because they advect momentum, heat, dissolved materials, and water-borne

particles poleward, opposite to the direction of mean transport. The relaxation flows may also produce significant cross-shelf exchange of these quantities. Existing studies of buoyant coastal currents focus on flows resulting from persistent buoyancy inputs with large density contrasts, such as river outflows [Hickey, 1998b; Hill, 1998; Lentz and Limeburner, 1995; Lentz et al., 2003; Rennie et al., 1999] or flows driven by low-salinity water masses originating far from the coastal currents they drive (e.g. Shcherbina and Gawarkiewicz, 2008; Sutherland and Pickart, 2008). Previous observations of relaxation flow have been based on serendipitous observations from sparse cross-shelf arrays of moorings for observing other shelf processes. We propose a comprehensive observational and analytical program to examine the dynamics and source waters of the relaxation flows in a coastal upwelling system on the central California coast. Using autonomous vehicles, high-frequency radars, moorings, and drifters, we will acquire pressure, density, and velocity data relevant to the relaxation flows. The spatial and temporal coverage will be sufficient to determine spatial scales of the flows, cross-shore density structure, cross-shore and alongshore velocity fields, pressure gradients, and the region of contact with the sea floor. Our study will extend previous results since the propagating relaxation flows fall in a buoyant flow regime that has only been described in numerical modeling and laboratory studies. Our research will: 1) evaluate the roles of barotropic and baroclinic pressure gradient forcing, 2) identify regions where ageostrophic flows dominate the cross-shore and alongshore momentum balances, 3) determine source waters for the relaxation flows, and 4) examine the inner shelf circulation response to wind relaxations over an extensive coastal region (the northern part of the Southern California Bight) by analyzing extensive regional data sets collected over many years. The proposed work is also timely and important because ocean circulation models have increasing resolution and are better able to resolve flows, such as these relaxation flows, very near coastal boundaries.

Investigating Seasonal and Interannual Variability of Central Asia Paleo-Hydroclimate

Central Asia is classified as a climate change Hot-Spot, a term coined to highlight the vulnerability and responsiveness of a regional climate to global warming. Climate model simulation projections of the next century suggest dramatic changes in the seasonal and interannual variability of Central Asian hydroclimate that is primarily controlled by mid-latitude Westerlies and storm tracks. The magnitude of the projected seasonal changes, however, differs significantly between the various model simulations. Consequently, the IPCC 2013 WG1,5th assessment report concludes that there is substantial uncertainty and thus low confidence in projecting changes in northern hemisphere winter storm tracks and Central Asia hydroclimate. To assess and improve climate model capability, seasonally resolved observational data from past episodes of rapidly warming climate are crucial. For Central Asia, these observational data are lacking and there is a dire need of them. The PI has secured access to a number of stalagmites, an absolutely datable climate archive, from Central Asia. The initial screening reveals that the resolution and quality of stalagmites is exceptionally high. The proposed exploratory study will focus on establishing robust age models of the potentially seasonal-resolved climate archives from Central Asia and evaluate and improve the robustness of the proxies. This exploratory work is crucial toward laying the foundation for a follow-up NSF proposal and study that will combine sub-micron resolved time-series measurements of hydroclimate proxies and multi-model simulation approaches to better understand the physical mechanism of the of Central Asia hydroclimate and, more generally, mid-latitude semi-arid region response to rapidly increasing radiative forcing. To achieve this goal, the following strategy will be pursued during the exploratory study: First, an age screening of the large number of stalagmites will be carried out. A continuous collection of drip water and continuous recording of cave micro-climate coupled with analysis of stable isotope and trace elements in the drip water and actively growing stalagmite will elucidate proxy sensitivity and their incorporation from drip water into the stalagmite calcite. A targeted, submicron-resolved analysis of stable oxygen and carbon isotopes, trace elements, and fluorescence emission and intensity in selected sections of the high quality stalagmites will be carried out. The establishment of seasonally resolved climate records from Central Asia will play a pivotal role in facilitating potentially transformative knowledge and discovery of regional climate behavior to accelerated rise of radiative forcings.

Intellectual Merit : The Westerlies are the main atmospheric system that determines seasonal precipitation over the mid-latitudes, a climatically sensitive region. Seasonal and interannual hydroclimate response of the Westerlies to rapidly increasing meltwater input in the North Atlantic, and North Atlantic Oscillation during rapidly warming climate is poorly constrained, impeding the capability to assess the role of the ocean circulation and greenhouse gas changes on the mid-latitude climate. The strategy adopted here will improve the understanding of mid-latitude hydroclimate response to rapid climate changes on a variety of timescales.

Broader Impacts : A well-informed long-term societal response to climate change requires an in-depth understanding of regional hydroclimate sensitivity to radiative and external forcings. The proposed research will strongly contribute to this task. The proposed study will provide training for two Hispanic-American undergraduate students who are already working in the PI's lab as research assistants. The results of the project will be disseminated broadly through publication in leading journals, presentations at conferences, and archiving of the resulting paleo data on NOAA's NCDC. The potential benefits of the proposed activity to society at large will include an increased confidence in understanding hydroclimate changes under rapidly varying external boundary conditions; such reconstructions are an integral part of model assessments of past climate sensitivity.

Syee Weldeab, David Lea   7/1/2013 to 12/31/2016 $366,804
National Science Foundation   OCE-1260696

Data Synthesis and Evaluation of the Salinity Influence on Mg/Ca Paleothermometry in the Low Latitudes

Intellectual Merit: Foraminiferal Mg has become an important tool that paleoceanographers use to deduce past ocean temperatures. It is one of three methods that can be used in the low latitudes, and it has proven especially powerful in deducing changes in the tropical warm pools over time scales of hundreds to tens of millions of years. The co-occurrence of Mg and oxygen isotopes in foraminifera links these two important proxies in time and space, extending their usefulness. Recently three papers based on core-top data have argued that salinity is an overlooked and dominant influence on foraminiferal Mg. If correct, this inference would require recalibration of Mg paleothermometry as well as reinterpretation of existing and future paleoceanographic records, because salinity has varied sufficiently in the past, in concert with ice volume and hydrological shifts, to significantly shift the magnitude and timing of reconstructed temperature changes. The large magnitude of the hypothesized salinity influence from these three studies, however, is in conflict with a much smaller influence in published foraminifera culturing data, and therefore is not well established within the paleoceanographic literature. The goal of this proposal is to test the magnitude of the salinity influence using a three-pronged strategy: 1) a targeted analysis of sediment trap and core-top samples from three key regions with large salinity gradients – Arabian Sea, Bay of Bengal and NW Africa; 2) a synthesis of available core-top, plankton tow and sediment trap Mg/Ca data from the low latitudes, harmonized for differences in species morphotype, size fraction and sample preparation; and 3) an evaluation of the potential contribution of secondary diagenetic (i.e., post-depositional) Mg to foraminifera in high salinity regions. These three research products will then be used to systematically evaluate the magnitude of the salinity influence relative to temperature and other known influences – such as seasonality and seafloor dissolution – on foraminiferal Mg, by elucidating individual mechanisms and through the use of multivariate techniques to assess their influence. The culminating component of the proposal is a community workshop to be held in the second year, with the goal of developing a community paper that can guide the Mg paleotemperature community forward on this challenging problem. The workshop will also facilitate data and knowledge sharing. Although this proposal addresses an established, widely used climate proxy, if successful it will be as transformative for the paleoceanographic community as the development of a completely novel proxy.

Broader Impacts: The proposed project broadens the participation of underrepresented groups by providing an opportunity for a young black faculty member at UCSB to pursue his first NSF-funded project. It integrates research and education … by promoting teaching, training, and learning by 1) pairing a senior and junior PI, with ample opportunity for sharing of experience and mentorship; and 2) by giving a post-doctoral scholar a central role in the project, which will enable him/her to broaden their skills by combining analytical work with database integration, analysis and interpretation.

Furthermore, the proposed project will enhance … research networks, and partnerships by including a community workshop that will enable the paleoceanographic community to use the Mg/Ca proxy more effectively. The results of the project will be disseminated broadly to enhance scientific and technological understanding through publication in leading journals, development of a searchable online sediment trap and core-top Mg/Ca database, and archiving of data at NOAA's National Climatic Data Center. The potential benefits of the proposed activity to society at large include increased confidence in low latitude temperature reconstructions for the past; such reconstructions are an integral part of model assessments of past climate sensitivity.

Allison Whitmer   10/1/2008 to 9/30/2015 $2,379,943
Colorado State University   G-3062-7

MSP: Culturally Relevant Ecology, Learning Progressions, and Environmental Literacy

Implement an environmental education program for middle and high school students at Goleta Valley Junior High School, Santa Barbara Junior High School, and Santa Barbara High School. As a component of this programming, we will administer assessments connected with research objectives associated with our environmental literacy framework development and culturally relevant, place-based education assessments. We will recruit one teacher per year to serve as our teacher-in-residence who will assist in mentoring graduate and undergraduate students placed in K12 classrooms. We will recruit teachers to participate in our Research Experience for Teachers summer program. We will also be responsible for recruiting scientists and students from the Santa Barbara Coastal Long-term Ecological Research (SBC LTER) program and the Marine Science Institute to support and participate in local programming.

Hillary Young, Kevin Lafferty   6/1/2015 to 5/31/2018 $529,143
National Science Foundation   1457371

Using Replicated Empirical Networks to Understand Drivers of Ecosystem Structure and Stability

Despite a long history of inquiry, we still lack a clear understanding of the drivers of community structure and the ways this structure affects ecosystem stability. In this project, we will examine how ecosystem size and productivity structure ecological networks. To do this, we will assemble and compare high-resolution interaction networks replicated across a series of 23 islets in the central Pacific (Palmyra Atoll) that vary independently in size and productivity. Our preliminary data suggest that these basic environmental properties drive strong variation in community structure across these islets. Next, we will predict how this variation in community structure should affect network stability, measured using multiple metrics of network stability. We will then test if models can predict system responses to a perturbation by comparing expected persistence to observed changes in empirical networks before and after system-wide rat (Rattus rattus) eradication. Finally, we will use path analyses to evaluate the relative importance of ecosystem size, productivity, and network structure, in predicting system stability. All together, these efforts will help identify not only how environmental characteristics structure communities but also the extent to which they drive system-level responses to perturbation.

Intellectual Merit: Ecological complexity makes it difficult to identify general patterns in nature, such as community stability. To understand what drives stability, one could measure changes in systems over time across environmental gradients. Another approach has been to consider how system structure (e.g., their complexity) affects community stability. However, it is unlikely that structure and environmental gradients are independent, because environmental factors might alter system structure as well as their stability. Here, we address how system size and productivity affect structure, how system size and productivity affect stability, and the extent that size and productivity drive stability through their effects on system structure Although these topics seem simple, they remain largely unanswered and it thus remains challenging to predict how removing a single species will affect an ecosystem due to the potential for indirect effects to cascade through complex ecological networks. This can be investigated in mesocosms and with dynamical and structural models, but there are few such studies from replicated natural systems, and none that measure more than a few interacting species. Likewise, although several studies assess and model food-web stability, there are no systematic empirical tests of these findings in natural settings. Systematic comparisons are also

difficult because current published networks comprise different ecosystems collected by different authors with different methods, making it unclear whether the variation seen among networks is due to ecology or disparate methodologies. The methods we propose thus represent many conceptual advances. We will create the best-replicated, high-resolution ecological networks to date; these will range across relevant ecological gradients, but be within the same system and location; and they will be subject to an experimental perturbation so we can test model predictions and measure the extent to which productivity, system size, and system structure affect stability.

Broader Impacts: This project will train multiple graduate students, undergraduates, and a postdoctoral researcher, with a focus on underrepresented groups. Furthermore, through partnerships with the UCSB KIN program, we will also reach grade school children, and train elementary school teachers in ecology and invasive species. Because invasions and removals are important challenges for resource managers, we will also position our general results in an applied context. Specifically, our in-depth biological characterization will allow better management and restoration of an isolated and important National Wildlife Refuge. This work should also produce broad management insight on the importance of environmental characteristics on species removals and invasions, greatly improving our capacity to predict and prioritize conservation actions. We will also publish open-access publications and make presentations at national and international meetings on our research results and data. By making our data freely available, we will also create opportunities for other researchers to repeat our analyses as well as ask novel questions.

Hillary Young   6/1/2014 to 5/30/2016   **$107,954**
Morris Animal Foundation   D14ZO-308

Effects of Land-Use on Tick-Burden and Tick-Borne Diseases in Wild Dogs (*Lycaon pictus*)

Study Design: This project will take place in northern Kenya, where we have extensive preliminary data and a well-instrumented field team, and where there is a mosaic of different land-use types in close proximity. The first part of the project will examine variation in questing tick abundance and infection prevalence in ticks in known wild dog habitats with differing human use. We will conduct stratified random sampling of habitats by land-use type for tick abundance and infection prevalence, allowing us to assess landscape level risk across habitats. We will screen ticks and dogs for a suite of tick-borne pathogens that preliminary data show are present in wild dogs in this region. The second part of this project will estimate tick burdens and prevalence of tick-borne pathogens in wild dogs, and examine the effects of land-use and livestock density on these response metrics. We will use existing blood and tick samples, supplemented with additional tick collections from new dogs captured during this period (~15 animals) for these analyses. We will screen blood samples from the dogs and engorged ticks taken off the dogs for both tick transmitted pathogens as well as other pathogens for comparison. We will then analyze the relationships between individual habitat usage and both tick burden and pathogen prevalence.

Hillary Young   5/1/2014 to 5/1/2015   **$13,980**
National Geographic Society   9320-13

Impacts of Fishing on Facilitated Foraging of Seabirds in the Central Tropical Forest

Background & Objectives: The Central Tropical Pacific (CTP), by virtue of its relative isolation from both terrestrial and at-sea human influences, is suggested to be one of the word's healthiest ecosystems (Stevenson et al. 2007, Allain et al. 2011). It provides critical nesting habitat for at least 19 seabird species, including an approximate 4.5 million nesting birds, in addition to being a primary foraging region for many migratory species (Maxwell & Morgan in review). Yet, in comparison to most other oceanic environments, the CTP is highly oligotrophic and resource availability is both patchy and highly unpredictable (Bertrand et al 2002, Young et al 2010a), a combination of factors that create significant foraging challenges for these seabirds. As a result, all the resident seabird species in the CTP are predominantly surface (or shallow subsurface) foragers and many have physiological or behavioral adaptations for extremely long distance foraging (Spear et al 2007). Furthermore, in the CTP, seabirds are hypothesized to be particularly dependent on subsurface predator facilitated foraging - in which large pelagic predators, drive prey to the surface where they are made available to seabirds. At least 14 of the resident seabird species in the CTP have been observed to forage in

association with subsurface predator aggregations (e.g. tuna, sharks, cetaceans) and many species may have obligate commensal relationships with subsurface predators (Ashmole and Ashmole 1967, Au and Pitman 1986, Jaquemet et al. 2005, Spear and Ainley 2005, Spear et al. 2007, Hebshi et al. 2008). It has further been suggested that subsurface predator facilitated foraging in the CTP is driven almost exclusively by tuna species (quite different from other regions such as the Eastern Tropical Pacific and Indian Ocean where the interaction is driven by a number of dolphin, whale, and shark species in addition to tunas) (Burger 1988, Jaquemet et al. 2005, Ballance et al. 2006).Strong and growing fisheries demand for large pelagic predators - particularly high value tuna and shark - is increasingly pushing these fisheries into remote parts of the CTP, and threatening the long-term persistence of seabird-tuna interaction (Juan-Jorda et al 2011, Maxwell & Morgan 2011). Yet, the likely impact for seabirds from increased fishing pressure on other pelagic predators in this region is unclear. While in many fisheries, seabirds are thought to be able to sustain normal populations with upwards of 60% declines in prey fish (Cury et al 2011), in the low-productivity, unpredictable, and heterogenous environment of the CTP, seabirds may be particularly vulnerable to changes in subsurface predators. Following a recent review conference on seabirds in the CTP, better information on the importance, nature, and identity of species involved in these interactions has been identified as a major conservation priority for seabird in the CTP (Maxwell & Morgan 2011). In this project we will (1) examine the extent to which seabird foraging in the CTP is obligatedly related to subsurface predators, (2) determine if tuna are the primary or exclusive commensal subsurface predator species in the CTP using Crittercams to capture imagery of feeding events, (3) identify if there are characteristic subsurface predator foraging behaviors that can be identified through GPS tracking, and (4) compare the importance of subsurface facilitated foraging across seabird species. To achieve these objectives we will use high-resolution tracking and monitoring equipment combined with the use of NGS developed "Crittercams" to identify subsurface predators. We will then complement this tracking data with more standard gut content analysis and stable isotope analysis for both seabirds and subsurface predators. All work will be done from Palmyra Atoll National Wildlife Refuge, located in the minimally impacted Pacific Remote Islands Marine National Monument.

Space

Marine Science Research Building
Bldg. No. 520 - 1st floor
06/2015
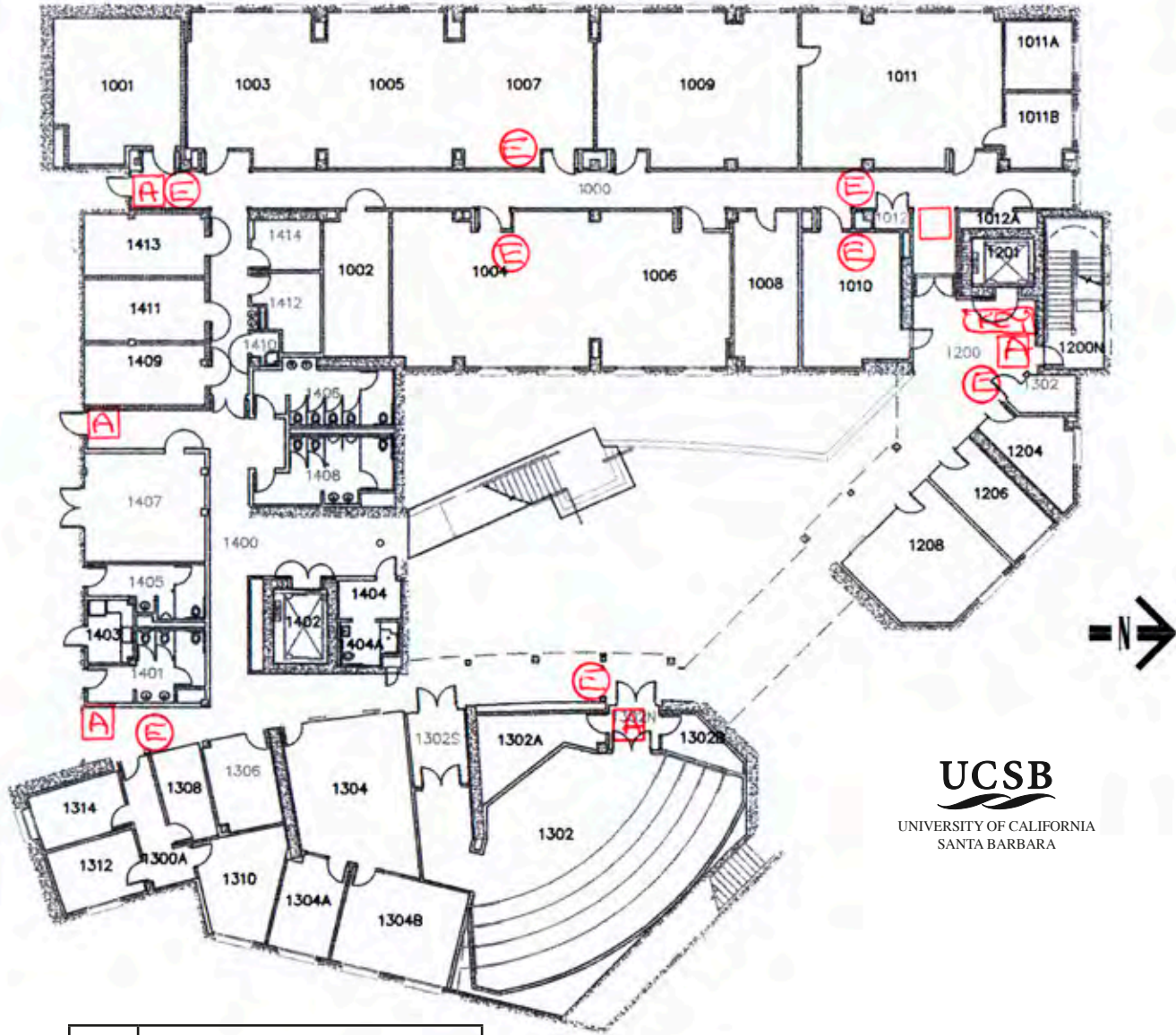
UCSB

UNIVERSITY OF CALIFORNIA
SANTA BARBARA

1001	Seawater workroom
1002	Common support laboratory
1003	Valentine laboratory
1004	Page/Dugan laboratory
1005	Valentine laboratory
1006	SONGS
1007	Siegel laboratory
1008	Hacker laboratory
1009	Analytical laboratory
1010	Hacker laboratory
1011	Analytical laboratory
1204	Graduate Student office space
1206	Graduate Student office space

1208	Graduate student office space
1302	Auditorium
1304	Graduate student office space
1304a	Graduate student office space
1304b	Graduate student office space
1308	Copier room
1310	Carrie Culver & Monique Myers
1312	Postdoc office space
1314	Postdoc office space
1409	Seawater workroom
1411	Seawater workroom
1413	Seawater workroom

Marine Science Research Building
Bldg. No. 520 - 2nd floor
06/2015
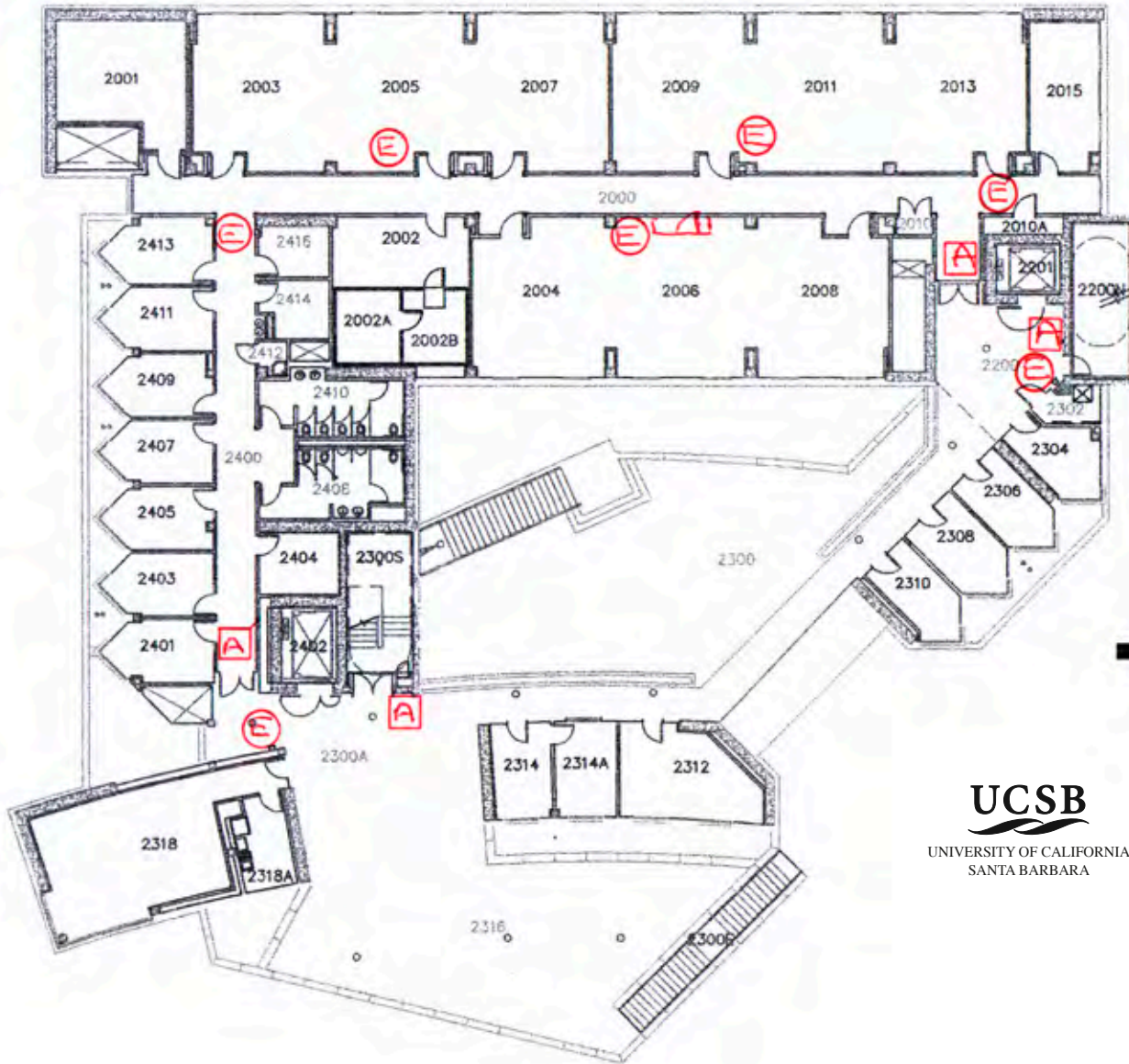
UCSB
UNIVERSITY OF CALIFORNIA
SANTA BARBARA

Room	Description
2001	Seawater workroom
2002	Common support laboratory
2002a	Environmental room
2002b	Environmental room
2003	Hofmann laboratory
2004	Miller laboratory
2005	Hofmann laboratory
2006	Ocean Acidification
2007	Hofmann laboratory
2008	Shared laboratory
2009	Burkepile laboratory
2011	Burkepile laboratory

Room	Description
2013	Burkepile laboratory
2015	SONGS project
2304	Postdoc office
2306	Postdoc office
2308	Kevin Lafferty
2310	Bob Miller
2312	Natural Reserve System/ Donna Moore
2314	Natural Reserve System/ Trish Holden
2314a	Natural Reserve System/ Sue Swarbrick
2318	Conference room

Room	Description
2401	Mark Page
2403	Jenifer Dugan
2404	Storage
2405	Langdon Quetin
2407	Robin Ross
2409	Todgham/Place
2411	Gretchen Hofmann
2413	Postdoc office

Marine Science Research Building
Bldg. No. 520 - 3rd floor
06/2015
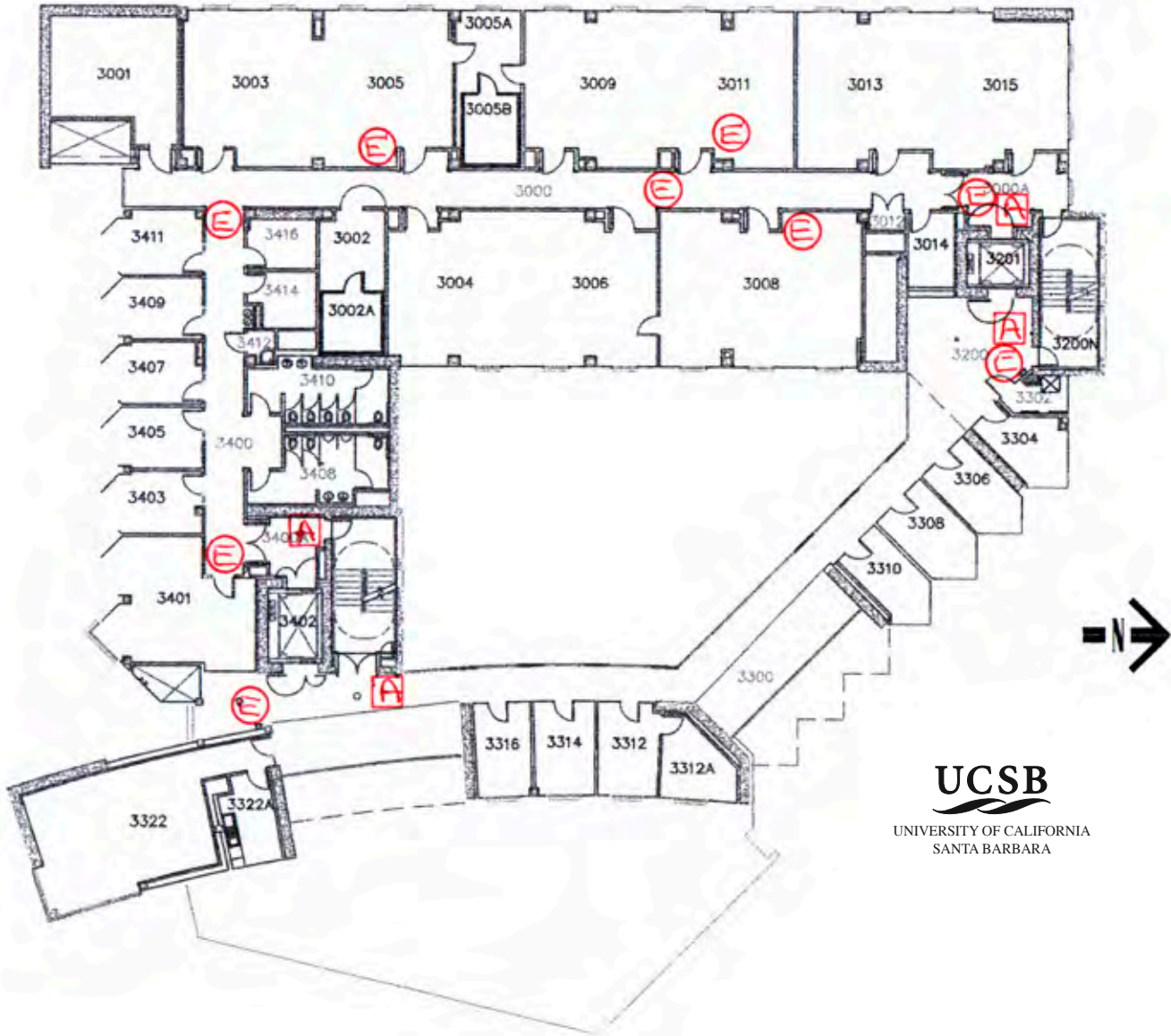
UCSB
UNIVERSITY OF CALIFORNIA
SANTA BARBARA

3001	Seawater workroom	3014	Storage	3401	Margaret O'Brien – Mary Gastil-Buhl
3002	Common support laboratory	3015	MacIntyre laboratory	3403	Kolbe Ahn
3003	Reed laboratory	3304	Postdoc office	3405	BON
3004	Holbrook laboratory	3306	Postdoc office – Rassweiler	3407	BON
3005	Reed laboratory	3308	Dan Reed	3409	Ross-Quetin
3005a	Common support laboratory	3310	Andrew Brooks	3411	Researcher office
3006	Schmitt laboratory	3312	Postdoc office		
3008	Blanchette laboratory	3312a	Postdoc office		
3009	Warner laboratory	3314	Russell Schmitt		
3011	Caselle laboratory	3316	Sally Holbrook		
3013	Washburn laboratory	3322	Conference room		

Marine Science Research Building
Bldg. No. 520 - 4th floor
06/2015

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SANTA BARBARA
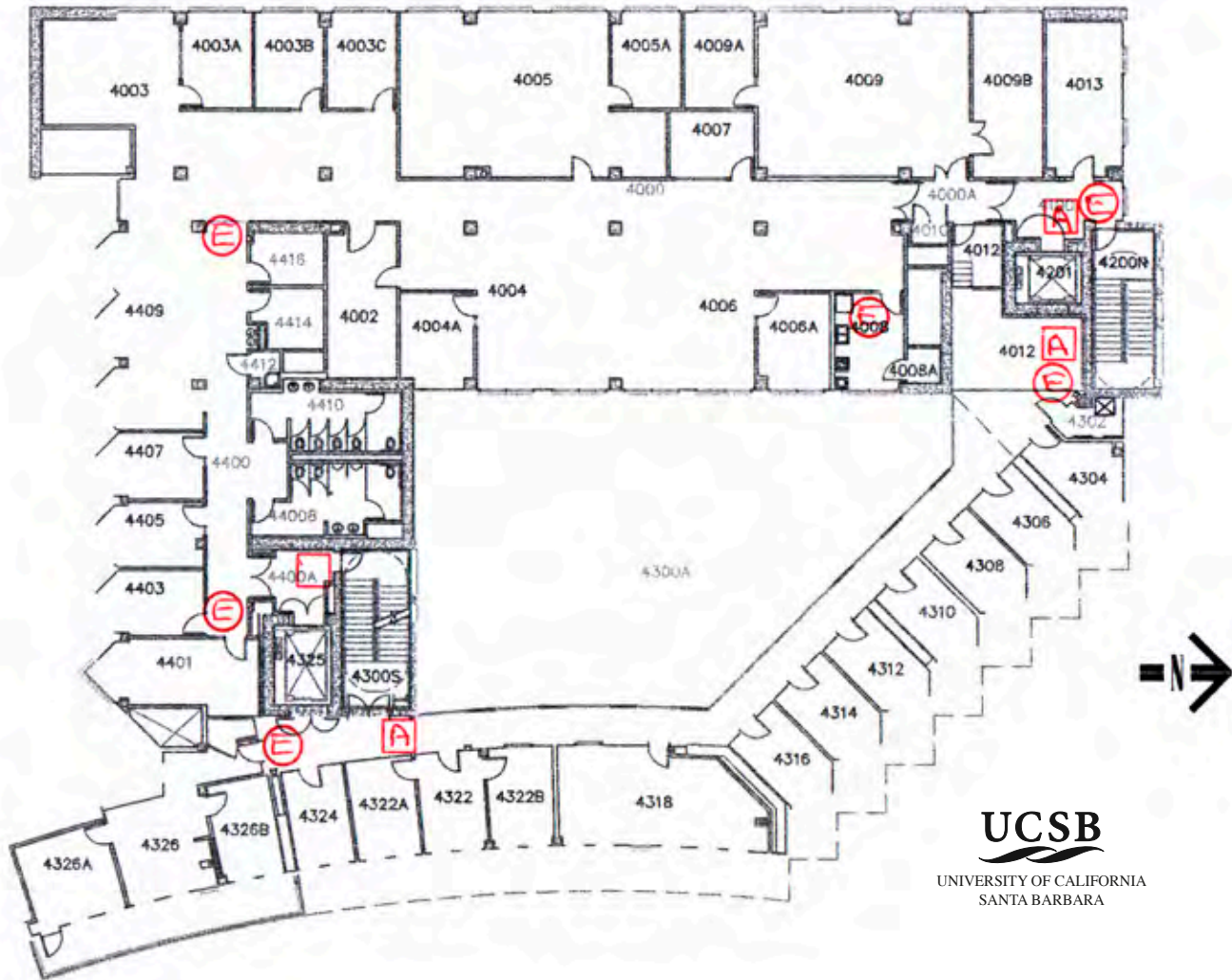
4002	Receiving
4003a	Ocean o'Graphics – Monica Pessino
4003b	Unassigned
4003c	Development
4004a	File Room
4004c	Casey Morse
4004d	Melia Cutcher
4005a	Nicole Zavala
4005a	Marisol Hernandez
4005b	Veronica Perez
4005c	Lyndi Swanson
4006a	India Morgan
4006a	Laura Susin
4006b	Jenny Chu
4007	Mail room

4008	Break room
4009a	Jim Woods
4009b	Marine Map
4009d	Brian Emery
4012	Server room
4013	Marine Map
4304	Will McClintock
4306	Libe Washburn
4308	Sally Macintyre
4310	Gretchen Hoffman
4312	Deron Burkepile
4314	Jen Caselle
4316	Carol Blanchette
4318	Conference Room
4322	Michaela Clemence

4322a	Sarah Lester
4322b	Robert Warner
4326b	Gay Larsen
4326	Development
4326a	MSI Director
4401	Tim Schmidt
4403	Joyce Wolever
4405	Luisa Velez
4407	Bonnie Williamson
4409a	Lynne Van Der Kamp
4409b	Deanna Cervantes
4409C	Donna Dobis

Marine Science Institute
Trailers

319-a	Jack Engle
319-b	Jack Engle
319-c	Jack Engle
319-d	Herb Waite
319-e	Herb Waite
325-a	John Richards
325-b	Craig Nicholson
325-c	Craig Nicholson
325-d	Jack Engle
325-e	Jack Engle
334-a	Scott Simon
334-b	REEF
334-c	REEF

Statistical Summary

Research Support Summary
2014-2015

	Awards	Percentage of Total
Federal Agencies		
National Aeronautics and Space Administration (NASA)	$723,818	4.03%
National Science Foundation-NSF	$6,605,650	36.74%
National Institutes of Health (NIH)	$1,444,806	8.04%
USDA, Forest Service	$40,000	0.22%
USDC National Oceanic and Atmospheric Administration (NOAA)	$15,000	0.08%
US Dept of Commerce, NOAA, National Marine Fisheries Service	$50,000	0.28%
US Navy, Office of Naval Research	$437,354	2.43%
USDI Bureau of Ocean Energy Management	$1,102,237	6.13%
USDI Fish and Wildlife Service	$101,000	0.56%
USDI National Park Service	$91,260	0.51%
US Environmental Protection Agency	$17,000	0.09%
Federal Totals	**$ 10,628,125**	**59.12%**
State		
California Coastal Commission	$28,000	0.16%
California Wildlife Conservation Board	$505,000	2.81%
UC Agriculture and Natural Resources	$13,166	0.07%
UC MEXUS	$25,987	0.14%
UC San Diego	$356,076	1.98%
UC Santa Cruz	$150,126	0.84%
UC Sea Grant College Program	$274,283	1.53%
State Totals	**$ 1,352,638**	**7.52%**

Private

Alfred P. Sloan Foundation	$50,000	0.28%
California Institute of Technology – Cal Tech	$105,625	0.59%
California Sea Urchin Commission	$32,578	0.18%
CORAL (The Coral Reef Alliance)	$96,316	0.54%
Desert Botanical Garden	$157,568	0.88%
ExxonMobil Upstream Research Company	$200,000	1.11%
Korean Institute of Industrial Technology	$31,236	0.17%
Larimer County Department of Natural Resources	$2,000	0.01%
National Geographic Society	$49,260	0.27%
National Park Foundation	$17,592	0.10%
Nature Conservancy (The)	$465,574	2.59%
Ocean Conservancy	$258,750	1.44%
Oregon State University	$238,188	1.32%
Pepperdine University	$7,475	0.04%
Rare. Inspiring Conservation	$450,000	2.50%
Roy F. Weston, Inc.	$197,475	1.10%
San Francisco State University Foundation, Inc.	$18,200	0.10%
Swiss Federal Inst of Technology-Dba Eth	$7,100	0.04%
Texas A&M University	$159,731	0.89%
University of Georgia	$278,251	1.55%
University of Miami	$126,349	0.70%
University of Michigan	$218,377	1.21%
University of Minnesota	$35,744	0.20%
University of Rochester	$231,724	1.29%
University of Southern California (So. Calif. Earthquake Center)	$38,000	0.21%
Ventura County	$1,962,430	10.92%
Waitt Family Foundation	$5,996,867	33.36%
Private Totals	**$ 9,634,764**	**46.96%**
Total	**$17,977,630**	**100.00%**

Statistical Summary for the Marine Science Institute
2014-2015

	MSI	NRS	TOTAL
1. Academic personnel on payroll			
a. Faculty	26	1	18
b. Professional Researchers (including Visiting)	23	0	34
c. Project Scientists	9	0	20
d. Specialists	37	1	35
e. Postdoctoral Scholars	28	0	36
f. Postgraduate Researchers	0	0	0
g. Academic Coordinators	2	0	5
TOTAL	**125**	**2**	**148**

	MSI	NRS	TOTAL
2. Graduate Students on payroll			
a. Employed on contracts and grants	51	0	47
b. Employed on other sources of funds	0	0	0
c. Participating through assistantships	0	0	0
d. Participating through traineeships	0	0	0
e. Other- students at other campuses	0	0	0
TOTAL	**51**	**0**	**47**

	MSI	NRS	TOTAL
3. Undergraduate Students on payroll			
a. Employed on contracts and grants	110	11	140
b. Employed on other funds	0	0	0
c. Number of volunteers, & unpaid interns	0	0	0
TOTAL	**110**	**11**	**140**

	MSI	NRS	TOTAL
4. Participation from outside UCSB: (optional)			
a. Academics (without Salary Academic Visitors)	0	0	0
b. Other (specify)	0	0	0
TOTAL	**0**	**0**	**0**

	MSI	NRS	TOTAL
5. Staff (Univ. & Non-Univ. Funds):			
a. Technical	101	23	167
b. Administrative/Clerical	19	14	46
TOTAL	**120**	**37**	**213**

6. Seminars, symposia, workshops sponsored	-	-	0
7. Proposals submitted	161	0	161
8. Number of different awarding agencies dealt with*	73	-	
9. Number of extramural awards administered	231	-	231
10. Dollar value of extramural awards administered during year**	$85,077,878	-	$85,077,878
11. Number of Principal Investigators***	126	-	126
12. Dollar value of other project awards ****	$742,393	$1,831,704	$2,574,097
13. Number of other projects administered	64	29	93
14. Total base budget for the year (as of June 30, 2010)	$1,643,266	$1,122,698	$2,765,964
15. Dollar value of intramural support	$86,223	$1,302	$87,525
16. Total assigned square footage in ORU	38,807	-	38,807
17. Dollar value of awards for year (2010 Total)	$18,017,630	$0	$18,017,630

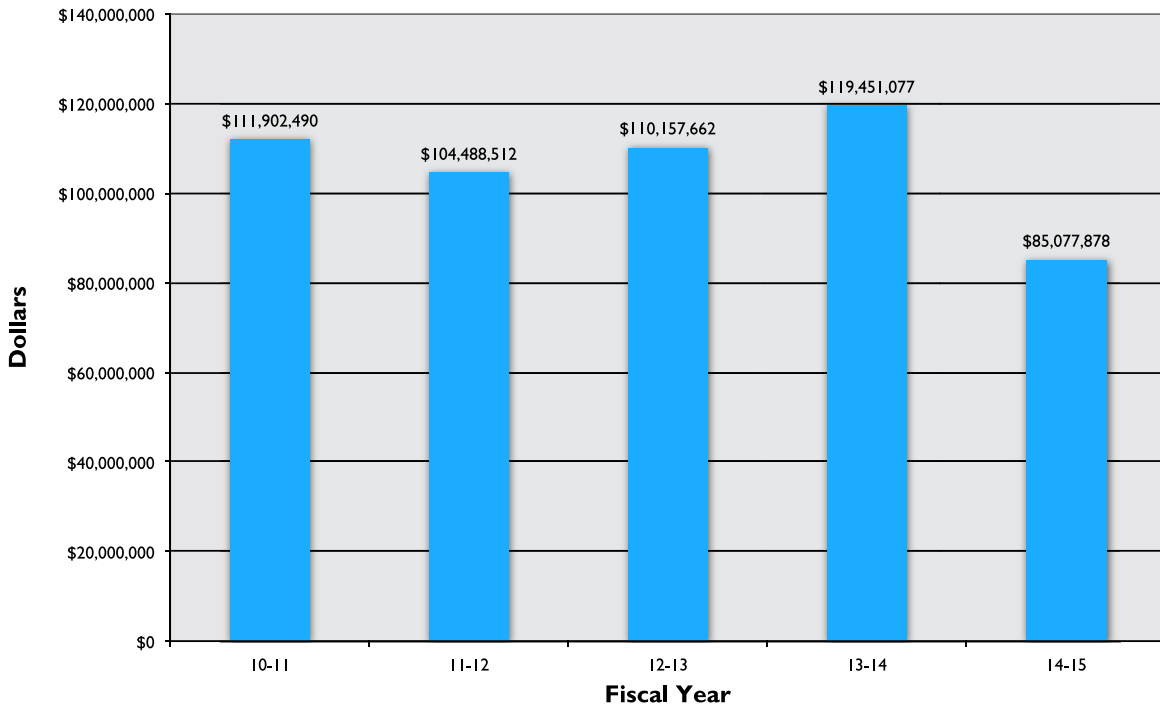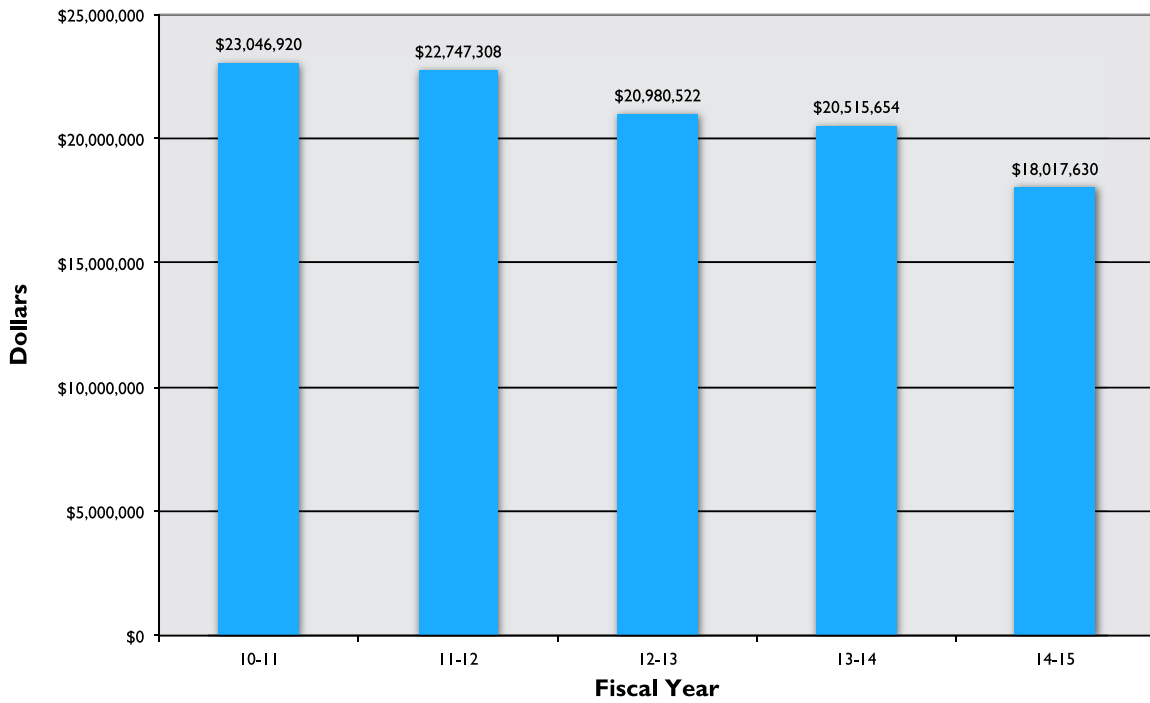| |
|---|
| * Count each agency only once (include agencies to which proposals have been submitted). |
| ** If the award was open during the year, even if for only one month, please include in total. |
| *** Number of PIs, Co-PIs and Proposed PIs (count each person only once.) |
| **** Other projects - such as donation, presidential awards, fellowships, anything that isn't core budget, extramural, or intramural. |

Five-Year Statistical Summary 2010-2015

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
1. Academic personnel engaged in research					
a. Faculty	24	25	19	18	27
b. Researchers/Project Scientists	52	47	58	58	32
c. Visiting Researchers					
d. Specialists/Academic Coord/Academic Admin.	49	48	46	40	40
e. Postdoctorals/ Postgraduates	50	47	37	36	28
Total	**175**	**167**	**160**	**148**	**127**
2. Staff (Univ. & Non-Univ. Funds)					
a. Technical	174	167	175	167	125
b. Administrative/Clerical	68	58	58	46	36
Total	**242**	**225**	**233**	**213**	**161**
3 Graduate students employed by MSI	53	45	54	47	51
4. Undergraduate students employed by MSI	154	147	146	140	122
5. Publications	1**	1**	1**	1**	1**
6. Seminars, symposia, workshops, etc., sponsored by MSI					
7. Proposals submitted	181	187	142	159	161
8. Annual extramural awards	$23,046,920	$22,747,308	$20,980,522	$20,515,654	$18,017,630
9. Extramural awards administered	257	251	247	262	231
10. Other project awards	$3,156,683	$4,479,085	$4,042,529	$3,953,513	$2,574,097
11. Other projects administered	95	99	80	34	93
12. MSI base budget	$1,238,532	$1,085,010	$919,082	$1,406,831	$1,643,266
13. Intramural support	$993,488	$623,925	$726,518	$88,978	$87,525
14. Total Funds Administered	**$119,525,463**	**$112,733,656**	**$117,642,277**	**$126,564,018**	**$90,505,464**

**Only Departmental Publications

Marine Science Institute - Total Value of Awards Administered

Bar chart showing Dollars by Fiscal Year:
- 10-11: $111,902,490
- 11-12: $104,488,512
- 12-13: $110,157,662
- 13-14: $119,451,077
- 14-15: $85,077,878

Marine Science Institute - Value of Extramural Awards Received Annually

Bar chart showing Dollars by Fiscal Year:
- 10-11: $23,046,920
- 11-12: $22,747,308
- 12-13: $20,980,522
- 13-14: $20,515,654
- 14-15: $18,017,630

Value of Proposals Submitted Annually by MSI & NCEAS
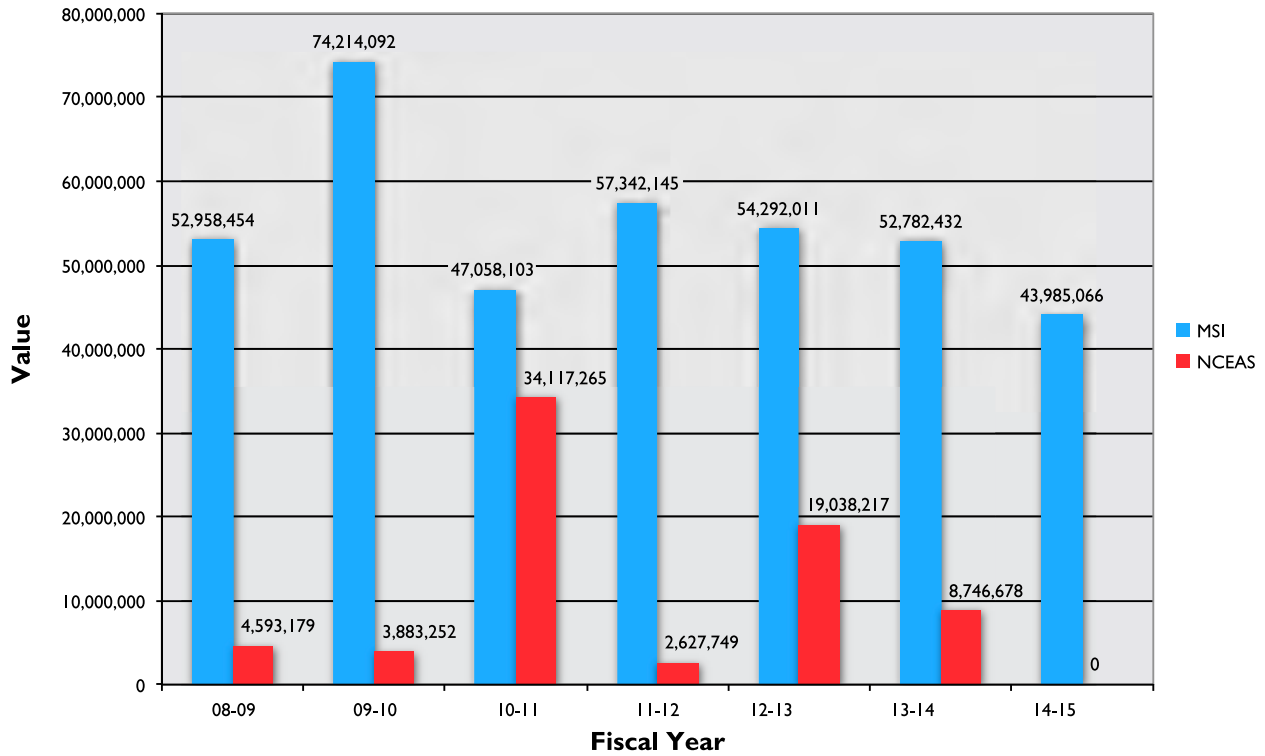
Number of Proposals Submitted Annually by MSI & NCEAS
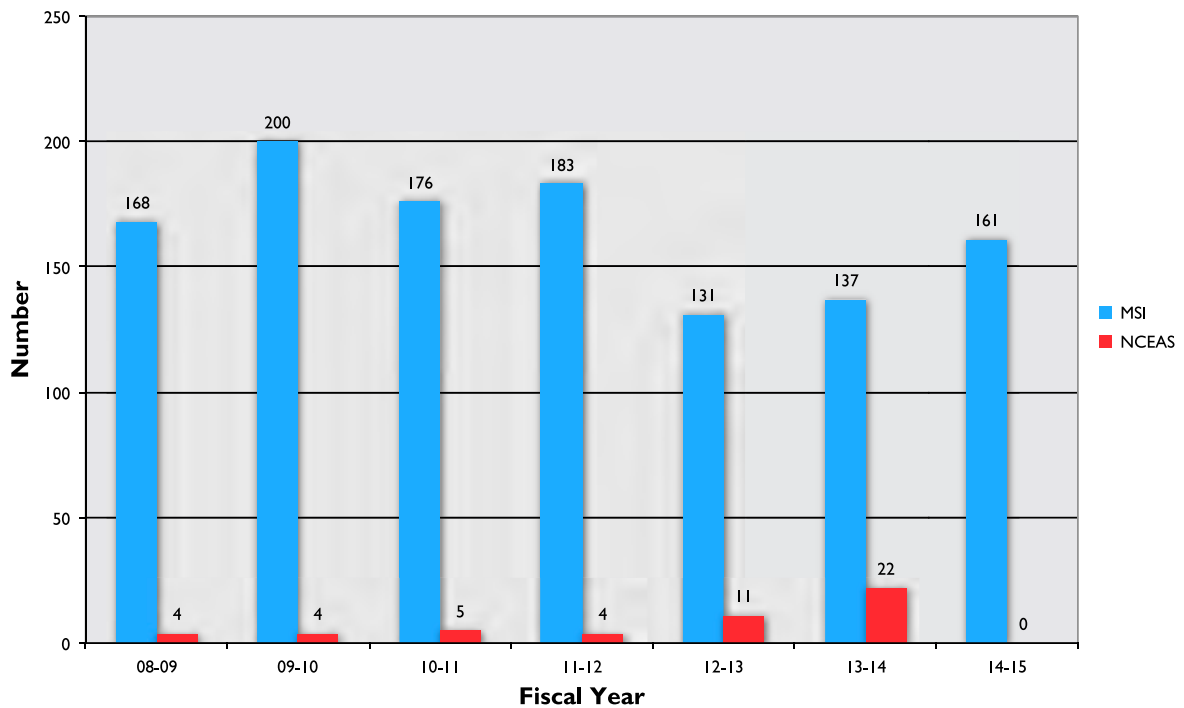
Funding Agencies
2014-2015

Alfred P. Sloan Foundation

Arthritis Foundation

Australian Museum

Boston University

California Coastal Commission

California Coastal Conservancy

California Department of Fish and Wildlife

California EPA Water Resources Control Board, Lahontan

California EPA Water Resources Control Board, Pajaro

Cal EPA Pesticide Regulation

California Institute of Technology (CalTech)

California Sea Urchin Commission

California Wildlife Conservation Board

Coastal Fund (UCSB Assoc. Students)

CODAR Ocean Sensors

Collaborative Fisheries Program

Colorado State University

Conservation International Foundation

Consortium for Ocean Leadership

Coral Reef Alliance, The (CORAL)

County of Santa Barbara

Dauphin Island Sea lab

David and Lucile Packard Foundation (The)

Deep Carbon Observatory

Desert Botanical Garden

East Carolina University

ExxonMobil Upstream Research Company

Gila Watershed Partnership

Gordon and Betty Moore Foundation

Gulf of Mexico Research Initiative

Korean Institute of Industrial Technology

Larimer County Dept of Natural Resources

Louisiana State University

Marisla Foundation

MBC Applied Environmental Sciences

Mohamed Bin Zayed Species Conservation Fund

Morris Animal Foundation

National Aeronautics and Space Administration

National Fish and Wildlife Foundation

National Geographic Society

National Institutes of Health, NIH General Medical Sciences

National Institutes of Health, NIH Dental and Research

National Institutes of Health, Public Health Services

National Park Foundation

National Science Foundation-NSF

Nature Conservancy, The

Ocean Conservancy

Oregon State University

Pepperdine University

Rare

Roy F. Weston, Inc.

Safari Club International

San Diego State University

San Francisco State University Foundation, Inc.

Scripps Clinic And Research Foundation (Incl Scripps Research Instit.)

Sierra Business Council

Simons Foundation

Simpson and Simpson Business and Personnel Services, Inc.

Society for Conservation Biology

Swiss Federal Inst Of Technology-Dba Eth (Switzerland)

Texas A&M University

The Belmont Forum Secretariat

The Coral Reef Alliance (CORAL)

Tulane University

UC Agriculture and Natural Resources

UC MEXUS

UC Multicampus Research Programs and Initiatives

UC Office of the President

UC San Diego

UC Santa Cruz

UC Sea Grant College Program

United Nations Educational, Scientific & Cultural Org (UNESCO)

United Water Conservation District

University of Arizona

University of Georgia

University of Hawaii

University of Idaho

University of Miami

University of Michigan

University of Minnesota

University of Mississippi

University of Nebraska

University of Rochester

University of Southern California

University of Tromso, Norway

University of Washington

US Dept of Commerce, National Marine Fisheries Service

US Dept of Commerce, National Oceanic and Atmospheric Administration

US DoD Navy

USDA Forest Service

USDA National Institute for Food and Agriculture

USDI Bureau of Ocean Energy Management, Regulation

USDI Fish and Wildlife Service

USDI Geological Survey

USDI National Park Service

USDI, NPS, Channel Islands National Park

USDI, NPS, Kings Canyon and Sequoia National Parks

USDI, NPS, Yosemite National Park

US Environmental Protection Agency

Ventura County

Waitt Family Foundation

MSI Advisory Committee, Administrative, Professional & Technical Staff

Marine Science Institute
2014-2015

CHANCELLOR	HENRY T. YANG
EXECUTIVE VICE CHANCELLOR	DAVID MARSHALL
VICE CHANCELLOR FOR RESEARCH	MICHAEL WITHERELL
DIRECTOR	MARK A. BRZEZINSKI
DEPUTY DIRECTOR	DAN REED

Advisory Committee

Jenn Caselle, MSI
Frank Doyle, Chemical Engineering
Ben Halpern, Bren
Sally Holbrook, EEMB
Debora Iglesias-Rodriguez, EEMB
David Lea, Earth Science
Hunter Lenihan, Bren
Sally MacIntyre, Committee Chair, EEMB
Uta Passow, MSI

Ex-Officio Members –

Mark Brzezinski, Director, MSI
Frank Davis, Director, NCEAS
Gretchen Hofmann, Director, Ocean Acidification Center
Patricia Holden, Director, Natural Reserve System
Daniel Morse, Director, Marine Biotech Center
Dan Reed, Deputy Director, MSI
Tim Schmidt, Manager, MSI
Russell Schmitt, Director, Coastal Research Center

Marine Science Institute
Administrative, Professional and Technical Staff

Director, Mark Brzezinski

Deputy Director, Dan Reed

Manager, Tim Schmidt

Budget Unit Manager, Luisa Velez

Budget Analyst, Jenny Chu

Budget Analyst, India Morgan

Budget Analyst, Laura Susin

Contracts & Grants Manager, Bonnie Williamson

Contracts & Grants Officer, Lynne Van Der Kamp

Contracts & Grants Officer, Deanna Cervantes

Development Officer, Gay Larsen

Development Officer, Kiya Gornick

Education & Outreach, Scott Simon

Graphics Manager, Monica Pessino

Web Developer, Ryan Vizena

IT Manager, Jim Woods

Server Support, Brian Emery

Payroll/Personnel Unit Manager, Joyce Wolever

Personnel Unit Coordinator, Nicole Zavala

Personnel Analyst, Marisol Hernandez

Personnel Analyst, Veronica Perez

Personnel Analyst, Lyndi Swanson

Purchasing Analyst, Melia Cutcher

Purchasing Analyst, Casey Morse

Travel Coordinator, Donna Dobis

Marine Science Institute Principal Investigators 2014-2015

Marine Science Institute
Principal Investigators
2014-2015

Adam, Thomas	Assistant Researcher	Marine Science Institute
Ahn, Kollbe	Assistant Researcher	Marine Science Institute
Alldredge, Alice	Emeritus Research Professor	Ecology, Evolution & Marine Biology
Amiri, Sarah	Graduate Student Researcher	Ecology, Evolution & Marine Biology
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Briggs, Cheryl	Professor	Ecology, Evolution & Marine Biology
Brooks, Andrew	Project Scientist	Marine Science Institute
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Burkepile, Deron	Associate Professor	Ecology, Evolution & Marine Biology
Carlson, Craig	Professor	Ecology, Evolution & Marine Biology
Caselle, Jennifer	Associate Researcher	Marine Science Institute
Churchill, Celia	Postdoctoral Researcher	Marine Science Institute
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Costello, Christopher	Professor	Bren School of Envir. Sci. & Management
Culver, Carrie	Associate Researcher	Marine Science Institute
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Dawson, Daniel	Reserve Manager	Natural Reserve System
Deacon, Robert	Distinguished Professor	Economics
Dereig, Nathan	Graduate Student Researcher	Ecology, Evolution & Marine Biology

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Going, Barbara	Postdoctoral Researcher	Marine Science Institute
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Hampton, Stephanie	Academic Coordinator	Nat'l Ctr for Ecol. Analysis & Synthesis
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Hofmann, Gretchen	Professor	Ecology, Evolution & Marine Biology
Holbrook, Sally	Distinguished Professor	Ecology, Evolution & Marine Biology
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Lambert, Adam	Assistant Research Biologist	Marine Science Institute
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Miller, Robert	Assistant Researcher	Marine Science Institute
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O'Brien, Margaret	Specialist	Marine Science Institute
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Orr, Devyn	Graduate Student Researcher	Marine Science Institute
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Wilson, Emily	Graduate Student Researcher	Ecology, Evolution & Marine Biology
Wood, Chelsea	Postdoctoral Researcher	Marine Science Institute
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