

# ANNUAL REPORT

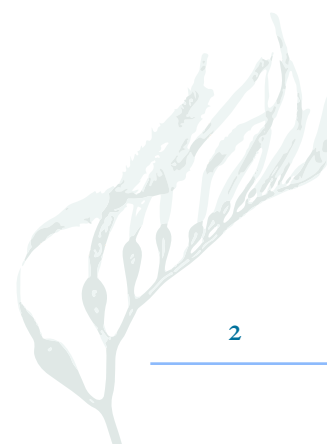
Marine Science Institute | UC Santa Barbara

2015-2016

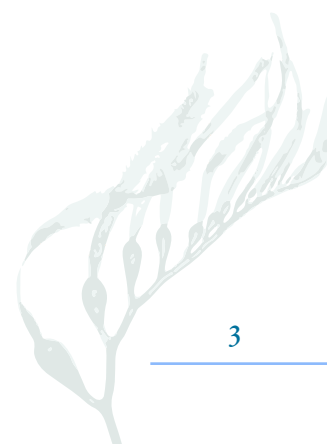


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# DIRECTOR'S STATEMENT



## Director's Statement

As we move towards MSI's 50th anniversary in 2019 the Marine Science Institute our scientists continue on a trajectory of engaging in cutting edge research and of solving pressing problems in ocean science. Our research portfolio continues to diversify with an ever growing set of funders representing a very large array of government agencies, private industry, non-profit foundations and individuals. Discoveries by MSI researchers are revealing wondrous new aspects of ocean systems from new insights into the ecology of coral reefs to the effects of ocean acidification. This new knowledge continues to improve our basic understanding of the seas and the wide range of services that they provide to society. I am proud of the contribution that our scientist make to society's knowledge as these discoveries continually teach us how to be better stewards of the ocean realm. While ocean discovery is key to our mission, MSI researchers also act on this knowledge to solve pressing issues associated with the constructive use of ocean resources.

Our investigators continue to provide inspiring research experiences to undergraduates at UCSB and they are actively training the next generation of marine scientists through their mentorship of talented graduate students and post-doctoral associates. MSI's commitment to enhancing public education remains strong through our Research Experience and Education Program (REEF) that hosted over 15,000 students from K-12 classrooms over the past year. Our partnership with Bob Ballard's Nautilus Live program has now extended the reach of the REEF program by using telepresence to connect research activities from the exploration vessel Nautilus directly into the classroom using highly engaging interactive technology. The REEF program is designed for K-12 students but it is of immense benefit to UCSB's undergraduates who serve as the docents, aquarists and logistics officers that make the REEF program possible.

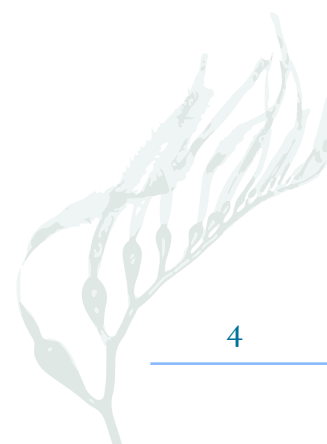
MSI researchers continue to enjoy outstanding level of service from the MSI administrative staff who supply high quality service in proposals preparation and post award administration. As research and regulatory environments become more complex the MSI staff maintain the expertise that eases the burden on our researchers so that they can focus on their science.

The scientists, staff and students makes MSI an incredibly dynamic and exciting place to conduct marine research. I am looking forward to another year of ocean discovery.

Sincerely,

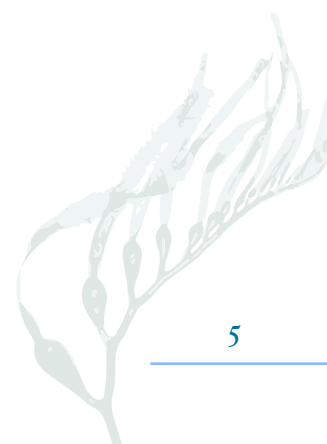


Mark Brzezinski, Director  
Marine Science Institute

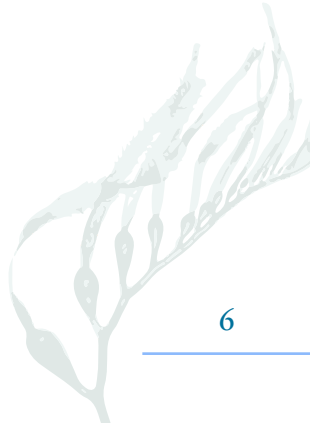
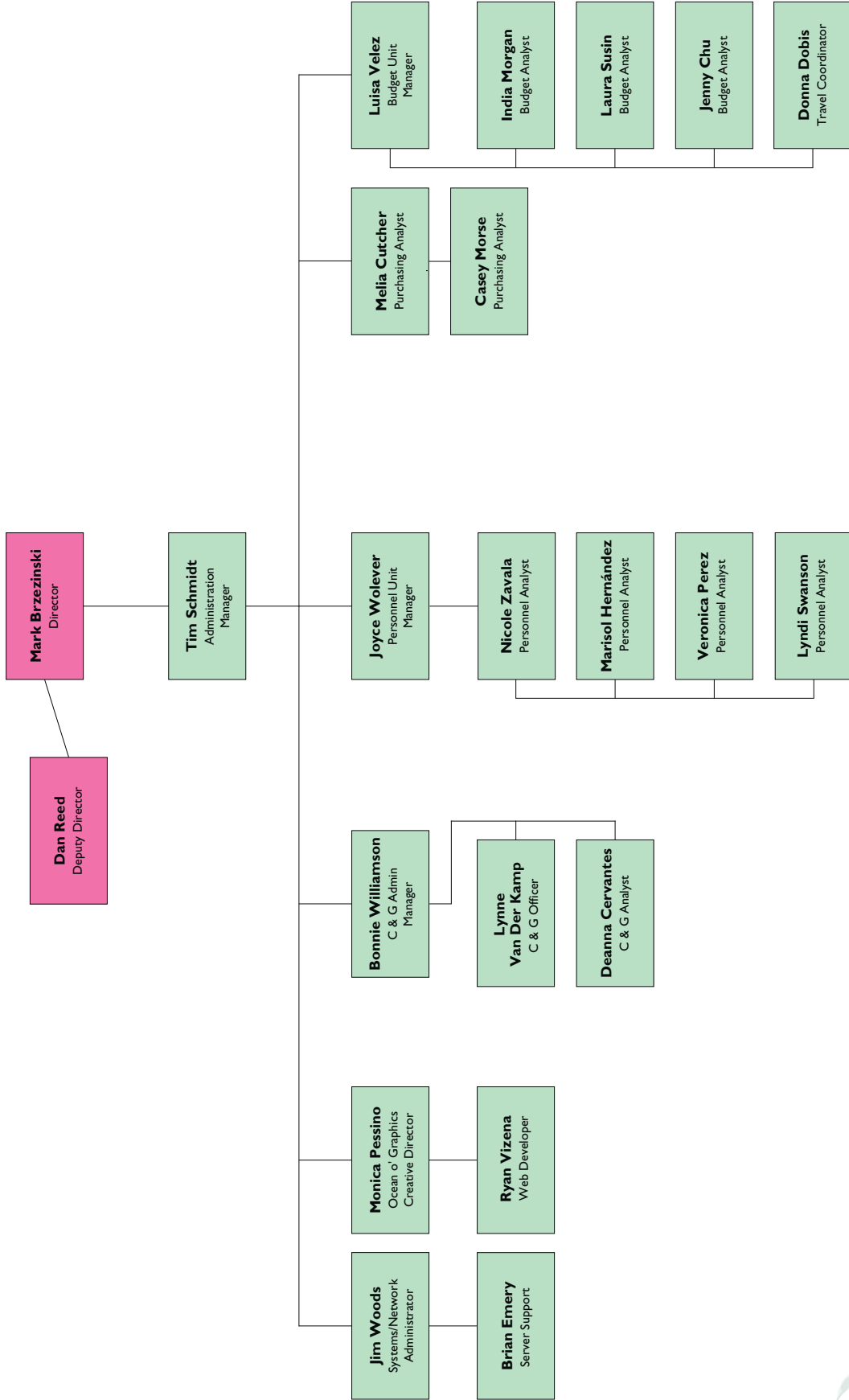




# ORGANIZATIONAL CHARTS

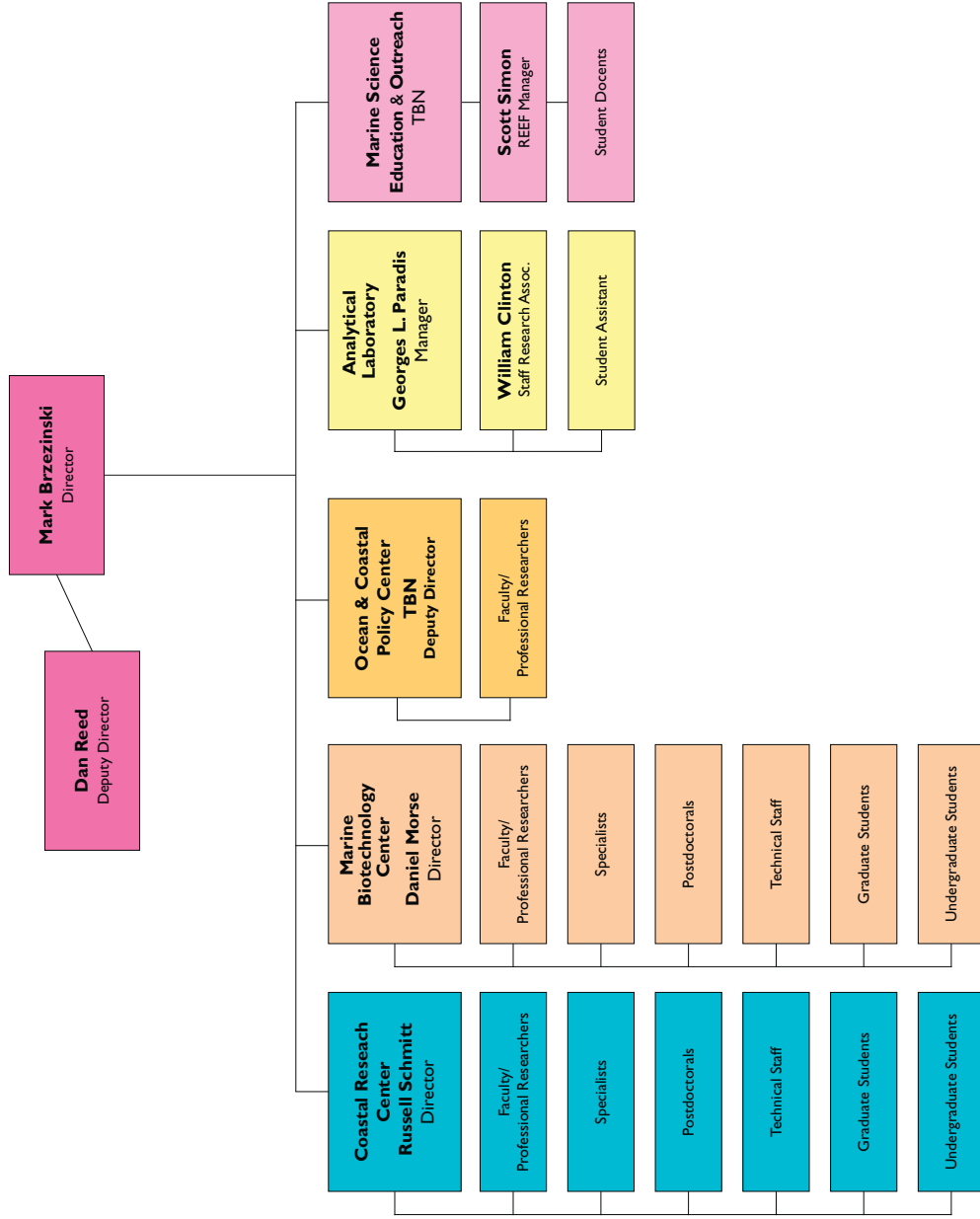


# MARINE SCIENCE INSTITUTE 2015-2016 ORGANIZATIONAL CHART

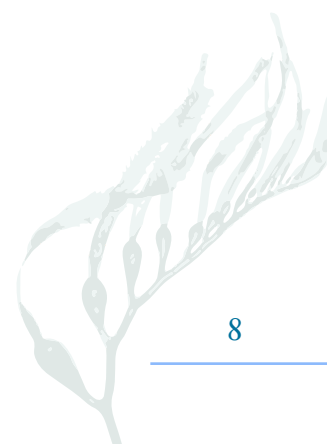


# MARINE SCIENCE INSTITUTE

## 2015-2016 ORGANIZATIONAL CHART



# OTHER PROJECTS & ACTIVITIES



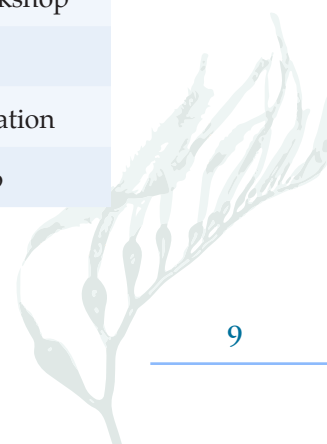


## Seminars, Workshops, Conferences, and Meetings July 1, 2015-June 30, 2016

The Marine Science Institute continues to support various seminars, workshops, conferences and meetings. During the 2015-2016 fiscal year 51 events took place, in which a wide range of marine science topics were highlighted.

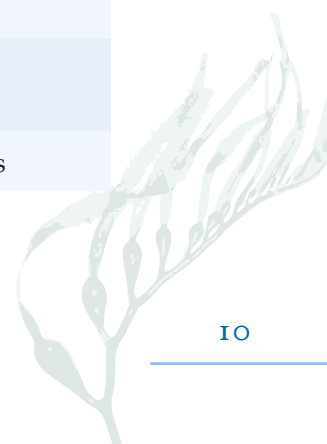
Dates	Coordinators	Topic
July 1, 2015	Chris Costello, Sarah Lester	Marine Aquaculture
July 5, 2015	Scott Simon, Gay Larsen	Nautilus-Live, Santa Barbara Channel
July 8, 2015	Scott Simon	Campus Point Jr. Life Guards
July 10, 2015	Scott Simon, Gay Larsen	Nautilus-Live, Santa Barbara Channel
July 14, 2015	Scott Simon	Scholastic Expeditions
July 23, 2015	Scott Simon, Gay Larsen	Nautilus-Live, Santa Barbara Channel
July 29, 2015	Gretchen Hofmann	Graduate Student Research Posters
July 30, 2015	Scott Simon, Gay Larsen	Nautilus-Live, Santa Barbara Channel
August 5, 2015	Scott Simon	Campus Point Jr. Life Guards
August 7, 2015	Gretchen Hofmann	Lydia Kapsenberg PhD Seminar
August 13-14, 2015	Scott Simon	K-12 Outreach
August 16, 2015	Eric Hessell	Dive First Aid, CPR, & Safety Class
August 18, 2015	Steve Gaines	Laura Dee PhD Seminar Becca Selden PhD Seminar
September 3, 2015	Steve Gaines, Sarah Lester	Sustainable Fisheries, accomplishments and future research
September 10-11, 2015	Scott Simon	K-12 Outreach
September 17-18, 2015	Steve Gaines, Chris Costello	Food From the Sea Conference
September 25, 2015	Shannon Harrer	SBC Graduate Student Workshop
September 29, 2015	Scott Simon	K-12 Outreach
October 9, 2015	Dan Reed, Shannon Harrer	SBC Undergraduate Orientation
October 16, 2015	Monique Myers	RESTOR Teacher Workshop

\* Non-UCSB personnel



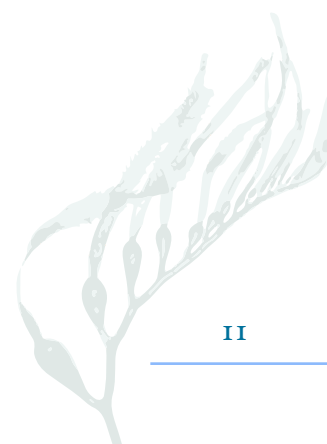
October 19-21, 2015	Darcy Bradley	Graduate Student Writing Workshop
October 20-22, 2015	Dan Reed, Jenny Dugan	SBC Midterm Review
October 24, 2015	Monique Myers	RESTOR Teacher Workshop
November 9-11, 2015	April Ridlon	Graduate Student Writing Workshop
December 2, 2015	Monique Myers	SBA CEVA Watershed Workshop
December 10-11, 2015	Russel Schmitt, Sally Holbrook	Annual MCR-LTER All Scientists Meeting
January 22-24, 2016	Doug McCauley, Paul DeSalles	Plastics and Our Ocean Project
January 28, 2015	Michael Smith	Grey Whale Monitoring Project
February 5, 2016	Doug McCauley	Meetings with Prospective Graduate Students
February 12, 2016	Doug McCauley	Meeting with Executive Director of the Monterey Bay Aquarium
March 9, 2016	Chris Costello, Michaela Clemence	Catalyzing and Connecting with International Fisheries Scientists and Economists
March 11, 2016	Carla D'antonio	Nathan Emery PhD Seminar
March 17, 2016	Monique Myers	SBA CEVA Watershed Workshop
March 23, 2016	Eric Hessell	Dive First Aid, CPR, & Safety Class
March 24, 2016	Robert Miller	Introductory Meeting for the Santa Barbara Channel-Marine Biodiversity Observing Network (SBC-MBON)
April 6 2016	Steve Gaines	The Nature Conservancy's California
April 17, 2016	Avery Parsons-Field	Santa Barbara Coastal Field work
April, 22, 2016	Eric Hessell, Keith Seydel	Field First Aid, CPR and Safety course
April 26-27, 2015	Jennifer Caselle	Channel Islands Marine Protected Area Meeting
April, 29, 2016	Eric Hessell, Keith Seydel	Field First Aid, CPR and Safety course
May 11, 2016	Robert Miller	SBC-MBON project updates

\* Non-UCSB personnel



May 18, 2016	Andy Brooks	MCR-LTER Schoolyard Outreach Washington School
May 23, 2016	Shannon Harrer	SBC Undergraduate Research Presentations
May 23, 2016	Scott Simon	REEF Outreach
May 27, 2016	Steve Gaines	Louise Stevenson PhD Seminar
May 31-June 3, 2016	Steve Gaines, Michaela Clemence, Chris Costello	Sustainable Fisheries Group: Indonesia Workshop
June 2, 2016	Dan Reed, Shannon Harrer	SBC-LTER Undergraduates BBQ
June 4, 2016	Gretchen Hofmann	World Ocean's Day Educational Program
June 9, 2016	Margaret O'Brien	Santa Barbara MBON Data Management
June 13-14, 2016	Avery Parsons-Field	PISCO Internship Field Training
June 13-17, 2016	Scott Simon	Teacher Professional Development Workshop

\* Non-UCSB personnel



# Coastal Research Center

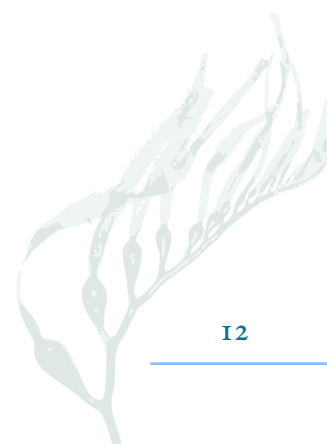
The Coastal Research Center is an organizational unit within the Marine Science Institute at UCSB. The central theme of the Center is to develop scientific knowledge to gain a more complete understanding of coastal and island ecosystems, which is necessary for sound management of the natural resources 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. Lutz**, 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

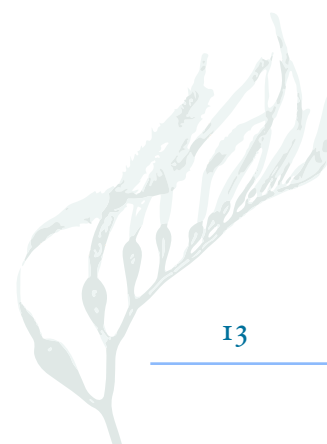
**David Valentine**, Assistant Professor of Geological Sciences

**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. 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.



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

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.

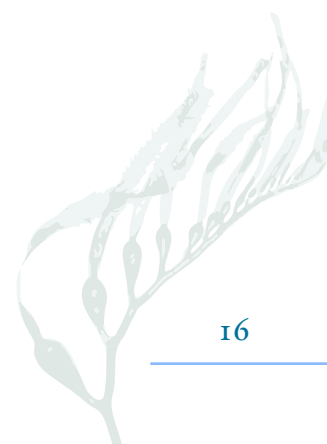
The need for programmatic attention on ocean and coastal policy in California has never been greater. California has one of the longest and most valuable coastlines in the nation. Offshore California, significant development of offshore resources takes place and the ocean and coastal zone are used, with 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.

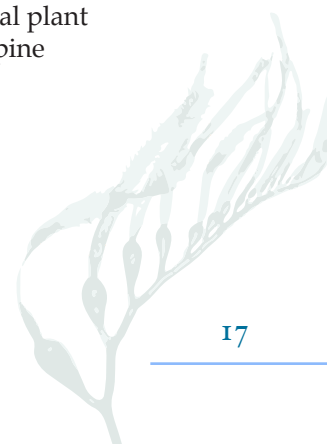
Reserve Staff

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

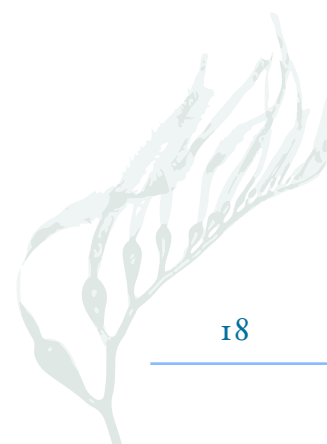
Leslie Dawson, K-12 Education Coordinator

#### **UCSB Natural Reserve System Administration**

William W. Murdoch, Director

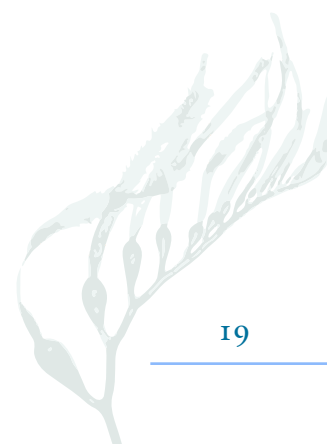
Susan L. Swarbrick, Associate Director

Donna Moore, MSO



## Analytical Laboratory

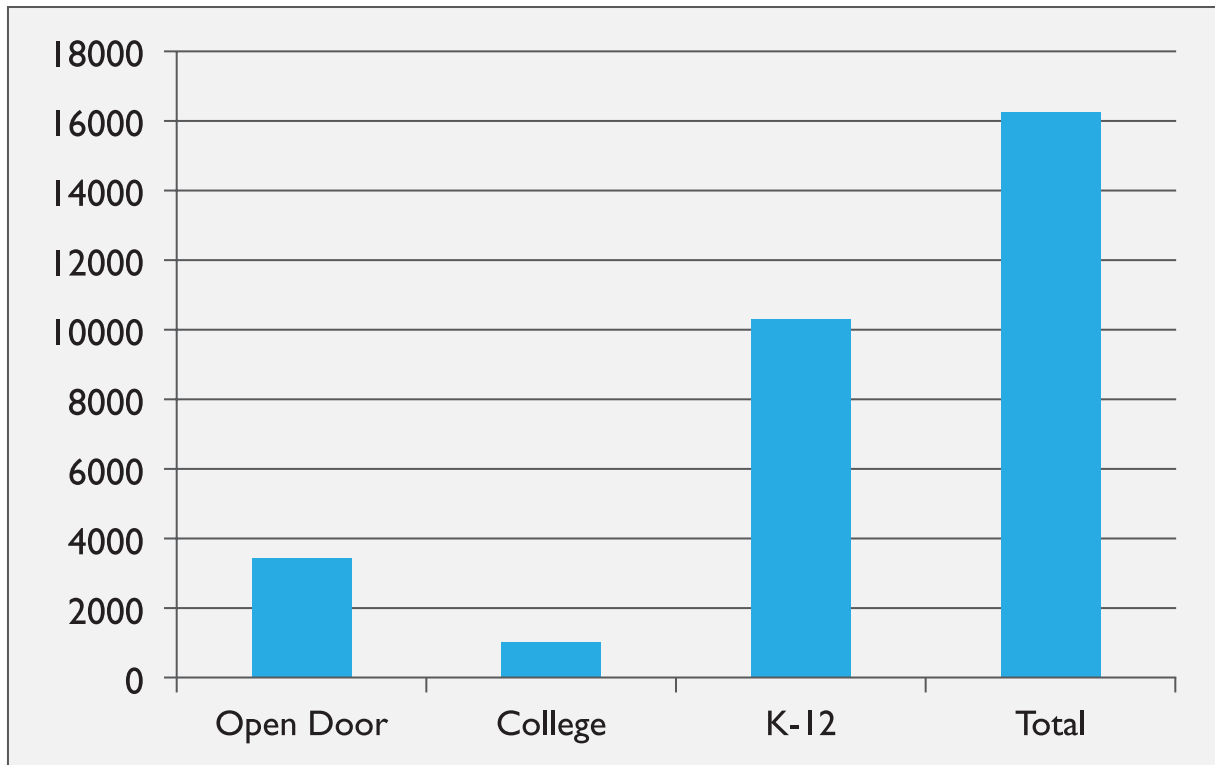
The MSI Analytical Lab is a professionally managed chemical analysis facility, with the objectives of improving the quality and efficiency of marine-related research efforts, and of providing advanced capabilities for new and expanded research programs. Originally established in 1977 to serve the needs 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](http://analab.msi.ucsb.edu) for more information.



# MSI Education and Outreach

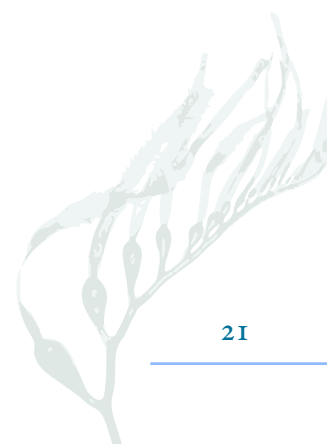
2015 was a very busy year for MSI Oceans-To-Classrooms (O2C) Ed/Outreach Program including visits to the Research & Education Facility (REEF) and community outreach efforts via the Mobile REEF Unit. While most were from San Luis Obispo, Santa Barbara and Ventura Counties, we had schools from Kern County (Bakersfield and Ridgecrest), as well as numerous schools from the greater Los Angeles Area. Though slightly down from last year (17,110), our total outreach efforts have provided marine science education and awareness to over 16,000 people from across California. This was mainly due to the decrease in number of Mobile REEF efforts to public events/ festivals. Outreach efforts with K-12 education exceeded 10,000 students, our largest group of participants to date. University of California Santa Barbara (UCSB), as well as other universities, include the REEF as part of their curriculum, which allowed us to reach almost 1,000 university students. Our Open Door Program, on Saturdays, available to the General Public, had over 3,400 visitors (double the amount from the previous year). 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, The Office of Early Academic Outreach and Preparation (EAOP), Santa Barbara Channel Islands National Marine Sanctuary (CINMS) and many others.

**MSI Oceans-to-Classrooms  
Education and Outreach Effort  
Totals for 2015–2016 (N=16,258)**



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

# Awards Administered



## Awards Administered 2015-2016

### AMEC (GREAT BRITAIN)

D. Herbst	9/1/2015-6/30/2016	\$56,268
Biomonitoring of Leviathan Creek Watershed for Fall 2015		

<b>AMEC (Great Britain) Subtotal</b>	<b>\$56,268</b>
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### BERMUDA INSTITUTE OF OCEAN SCIENCES

C. Carlson	11/1/2015-10/30/2020	\$219,480
BIOS-SCOPE - A collaborative program for the study of microbial oceanography in the North Atlantic Subtropical Gyre		

<b>Bermuda Institute of Ocean Sciences Subtotal</b>	<b>\$219,480</b>
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### CALIFORNIA COASTAL CONSERVANCY

C. Sandoval	6/30/2015-1/31/2017	\$300,000
Education Center at Coal Point Reserve		

<b>California Coastal Conservancy Subtotal</b>	<b>\$300,000</b>
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### CAL STATE UNIVERSITY CHICO

D. Herbst	2/1/2016-1/31/2017	\$50,759
Public Education and Monitoring related to Climate Change and Drought in Sierra Nevada Water Resources		

<b>Cal State University Chico Subtotal</b>	<b>\$50,759</b>
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### CALIFORNIA ARTIFICIAL REEF ENHANCEMENT (CARE)

M. Love	6/1/2016-5/31/2018	\$150,000
Coal Oil Point Reserve Infrastructure and Facilities Project		

<b>California Artificial Reef Enhancement Subtotal</b>	<b>\$150,000</b>
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### CALIFORNIA INSTITUTE OF TECHNOLOGY

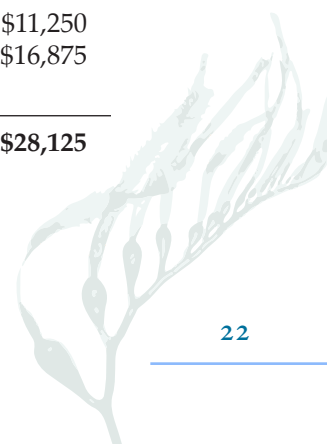
D. Valentine	3/21/2013-3/31/2017	\$119,897
Cracking the Microbial Sulfur Cycle with Novel Cell- and Metabolite-Specific Stable Isotope Approaches		

<b>California Institute of Technology Subtotal</b>	<b>\$119,897</b>
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### CONSERVATION INTERNATIONAL

S. Gaines	11/1/13-10/31/15	\$11,250
Marine spatial planning (MSP) and lobster fishery reform for the Galapagos		

<b>Conservation International Subtotal</b>	<b>\$28,125</b>
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## CSU SAN DIEGO STATE UNIVERSITY

R. Miller 8/18/2015-8/31/2017 \$76,836  
Archaeological and Biological Assessment of Submerged Landforms in the Pacific Coast

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**CSU San Diego State University Subtotal \$76,836**

## DAVID AND LUCILE PACKARD FOUNDATION (THE)

C. Costello 6/13/2016-6/12/2017 \$250,000  
Benefits of Fisheries Sustainability in Indonesia: Collaborative Modeling to Inform Strategic Institutional and Policy Reform in Indonesia

C. Costello 10/13/2015-01713/2016 \$50,000  
Benefits of Fisheries Sustainability in Indonesia: Understanding and Customizing an Analytical Framework

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**The David and Lucile Packard Foundation Subtotal \$300,000**

## ENVIRONMENTAL PROTECTION AGENCY

R. Nisbet, E. Muller 6/1/2015-5/31/2008 \$576,751  
Development and Testing of Sampling Tools for the Collection of Microbes and Chemicals from Marine Seeps

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**Environmental Protection Agency Subtotal \$576,751**

## MARISLA FOUNDATION

J. Caselle 3/22/2016-3/22/2019 \$175,000  
Coral Reef Resilience in a rare, undisturbed ecosystem: UCSB and Palmyra Atoll

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**Marisla Foundation Subtotal \$175,000**

## NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

R. Miller 10/1/2014-9/30/2019 \$40,000  
Demonstrating an effective Marine BON in the Santa Barbara Channel \$647,733

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**National Aeronautics and Space Administration Subtotal \$687,733**

## NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

S. Simon 8/1/2015-7/31/2016 \$59,968  
Oceans-to-Classrooms Watershed Education and Training Program \$40,000

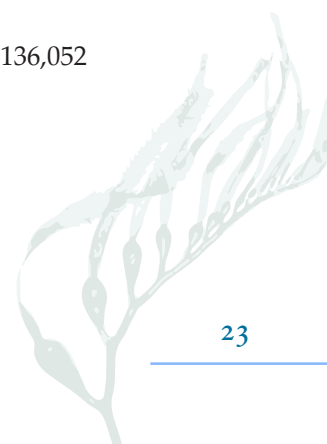
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**National Oceanic and Atmospheric Administration Subtotal \$99,968**

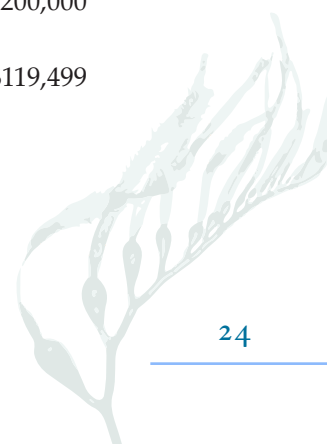
## NATIONAL SCIENCE FOUNDATION

C. Briggs, R. Knapp 8/15/2015-7/31/2018 \$120,500  
Collaborative Research: Linking causes of variation in the amphibian skin microbiome with consequences for disease risk \$185,575

C. Briggs, R. Knapp 5/1/2015-4/30/2021 \$136,052  
LTREB : Collaborative Research: Long-term dynamics of amphibian populations following disease-driven declines



M. Brzezinski	1/1/2016-12/31/2018	\$485,970
Collaborative Proposal: A field and laboratory examination of the diatom N and Si isotope proxies: Implications for assessing the Southern Ocean biological pump		
D. Burkepile	7/1/2015-4/30/2020	\$177,744
CAREER: Fish-Derived nutrients in a coral reef ecosystem-impacts on benthic communities and importance for coral restoration		
C. Carlson	1/1/2015-11/30/2018	\$382,543
Collaborative Research: Dissolved organic matter feedbacks in coral reef resilience: The genomic & geochemical basis for microbial modulation of algal phase shifts		
C. Carlson	9/1/2015-8/31/2019	\$661,501
Tracking the temporal and spatial variability of dissolved organic matter, its diagenetic state and bioavailability during various bloom states in the North Atlantic		
D. Dawson, P. Holden	7/15/2015-6/30/16	\$99,403
FSML: Establishing A Modern Molecular Diagnostics Facility to Support Microbiology Research in the Sierra Nevada Ecoregion		
J. Dugan, R. Miller, C. Ohlmann	9/1/2015-8/31/2019	\$10,225
Linking nearshore kelp forest dynamics to sandy beach ecosystems - REU Supplement 2016		
S. Hodges	8/1/2015-7/31/2018	\$355,705
Collaborative Research: The Aquilegia petal as a model for the elaboration and evolution of organ shape		
S. Holbrook, D. Burkepile, R. Schmitt	3/1/2016-2/28/2017	\$199,988
RAPID: How does nutrient availability alter coral bleaching, mortality, and recovery on Mo'orea coral reefs?		
A. Kuris, S. Weinstein	6/1/2016-5/31/2017	\$19,550
Dissertation Research: Understanding effects on climate change on parasitism in small mammals		
T. Oakley	9/1/2015-8/31/2018	\$136,241
Collaborative Research: Evolutionary origins of chiton shell-eyes: Integrating structure, function, and gene expression within a phylogenetic context		
U. Passow	10/1/2015-9/30/2018	\$663,945
Collaborative Research: Effects of multiple stressors on marine phytoplankton		
J. Pruitt	10/1/2016-5/31/2018	\$81,346
Collaborative Research: The effects of keystone individuals on collective behavior		
D. Reed, M. Page, R. Miller, C. Carlson, J. Melack	2/1/2016-1/31/2017	\$199,500
RAPID: Tracing the origin and fate of particulate organic matter in nearshore marine sediments		
D. Reed, S. Holbrook, J. Melack, D. Siegel,	12/1/2012-11/30/2018	\$980,000
LTER: Land/Ocean Interactions and the Dynamics of Kelp Forest Communities		
SBC-LTER III		
R. Schmitt, S. Holbrook	9/1/2012-8/31/2016	\$200,000
LTER: MCR IIB: Long-Term Dynamics of a Coral Reef Ecosystem		
H. Young	5/1/2016-4/30/2019	\$119,499
SG Collaborative Research: The Changing Role on Watering holes in Concentrating Parasites in a Changing Climate		



H. Young	6/1/2015-5/31/2018	\$20,392
Using replicated empirical networks to understand drivers of ecosystem structure and stability		

<b>National Science Foundation Subtotal</b>	<b>\$5,612,386</b>
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**NATIONAL INSTITUTES OF HEALTH, DENTAL**

J.H. Waite, J. Israelachvili	9/1/2015-8/31/2016	\$374,123
Translating Mussel Adhesion		

<b>National Institutes of Health, Dental Subtotal</b>	<b>\$374,123</b>
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**NATIONAL INSTITUTES OF HEALTH, GENERAL MEDICAL SCIENCES**

C. Briggs	7/1/2014-6/30/2015	\$464,248
EID disease in complex communities: multi-host multi-pathogen interactions		

<b>National Institutes of Health Subtotal</b>	<b>\$464,248</b>
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**NATURE CONSERVANCY (THE)**

J. Caselle	2/10/2016-2/9/2017	\$65,000
Task Agreement #5: Scientific and strategic support of TNC Oceans initiatives		

C. Costello	1/1/2016-9/30/2016	\$39,000
Task 7:A decision Support Tool to analyze the socio-economic performance of management scenarios in the Peruvian Anchoveta Fishery		

C. Costello	9/2/2015-9/1/2020	\$9,973
Task 1: University Internships, Post-doctoral Positions, and Student and Staff Researcher Projects		

C. Costello	10/1/2015-5/31/2016	\$49,029
Task 4: Making the case for fisheries reform in the East China Sea		

H. Lenihan	3/20/2016-3/19/2017	\$40,000
Task Agreement #6: Survey and assessment of California Rock Crab		

W. McClintock	9/2/2015-6/30/2016	\$296,146
Task 2-Software Development of eCatch Server and Mobile Application		

<b>Nature Conservancy (The)</b>	<b>\$499,148</b>
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**OCEANA, INC.**

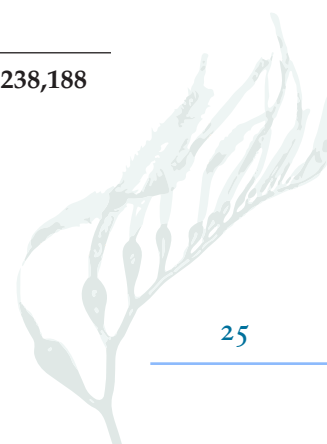
C. Costello, S. Gaines	1/1/2016-12/31/2016	\$187,270
Forecasting the Impacts of Marine Conservation Interventions		

<b>OCEANA, Inc. Subtotal</b>	<b>\$187,270</b>
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**OREGON STATE UNIVERSITY**

C. Blanchette, J. Caselle, S. Gaines, R. Warner, L. Washburn	1/1/2015-3/31/2017	\$238,188
PISCO Science for an Informed Society		

<b>Oregon State University Subtotal</b>	<b>\$238,188</b>
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## PEPPERDINE UNIVERSITY

J. Dugan, A new method for monitoring urban beach ecosystems	2/1/2014-1/31/2017	\$5,126
<b>Pepperdine University Subtotal</b>		<b>\$5,126</b>

## PHOENIX ZOO

D. McCauley Promoting hippopotamus conservation and management through research on the ecology of hippopotamus habitat use	1/1/2016-12/31/2016	\$3,000
<b>Phoenix Zoo Subtotal</b>		<b>\$3,000</b>

## RARE

S. Gaines Fish Forever	3/1/2016-12/31/2016	\$50,000
<b>RARE Subtotal</b>		<b>\$50,000</b>

## ROY F. WESTON, INC.

D. Herbst Bio Assessment Study Support for Leviathan Mine Superfund Site, CA	5/1/2014-12/31/2015	\$49,518 \$49,518
<b>Roy F. Weston, Inc. Subtotal</b>		<b>\$99,036</b>

## SAFARI CLUB INTERNATIONAL

D. McCauley Promoting sustainable hippopotamus management through research on the ecology of hippopotamus habitat use	7/1/2015-6/30/2016	\$40,000
<b>Safari Club International Subtotal</b>		<b>\$40,000</b>

## SANTA BARBARA FOUNDATION

C. Sandoval, S. Swarbrick Coal Oil Point Natural Reserve Nature Center	10/23/2015-10/22/2016	\$25,000
<b>Santa Barbara Foundation Subtotal</b>		<b>\$25,000</b>

## SIMONS FOUNDATION

D. Valentine D. Iglesias-Rodriguez, R. Miller The Refugio Oil Spill as a Microbial Laboratory	7/1/2015-3/31/2017	\$588,041
<b>Simons Foundation Subtotal</b>		<b>\$588,041</b>

## SIMPSON AND SIMPSON BUSINESS & PERSONNEL SERVICES, INC.

D. Reed, S. Schroeter, M. Page San Onofre Nuclear Generating Station Mitigation Project Monitoring Program, 2016-2017	1/1/2016-12/31/2017	\$5,362,124
<b>Simpson and Simpson Business and Personnel Services, Inc. Subtotal</b>		<b>\$5,362,124</b>

## SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT (SCCWRP)

R. Miller 6/1/2016-12/31/2016 \$36,669  
Develop techniques to batch-identify ichthyoplankton larvae

**Southern California Coastal Water Research Project Subtotal \$36,669**

## TEXAS A&M UNIVERSITY

U. Passow 7/1/2014-12/31/2016 \$161,106  
Role of microbial exopolymers in aggregation and degradation of oil and dispersants

**Texas A&M University Subtotal \$161,106**

## U.S.-ISRAEL BINAT'L SCIENCE FOUNDATION (BSF)

J. Pruitt 10/1/2015-9/30/2016 \$24,767  
Stress, development and behavioral syndromes

**US-Israel Binat'l Science Foundation Subtotal \$24,767**

## UC AGRICULTURE AND NATURAL RESOURCES

A. Lambert 7/1/2015-6/30/2016 \$12,866  
Invasive weeds as alternate hosts for the newly introduced cole crop pest *Bagrada hilaris*

**UC Agriculture and Natural Resources Subtotal \$12,866**

## UC MEXUS

T. Dudley 2/1/2016-7/31/2017 \$1,499  
Surveys of Insect Communities in the Colorado River Delta

R. Oono 7/1/2015-12/31/2016 \$16,400  
Foliar fungal endophyte assemblage and diversity compared across multiple host phylogenetic scales – a study on pine hosts of California and Mexico

**UC MEXUS Subtotal \$17,899**

## UC SAN DIEGO

S. Gaines, C. Szuwalski 7/1/2015-6/30/2016 \$65,818  
Fixing retrospective biases in stock assessment and implication for management targets

L. Washburn, M. Brzezinski 6/1/2015-5/31/2017 \$396,761  
Southern California Regional Coastal Ocean Observing System: Surface Current Mapping, HF Radar Quality Control, and Harmful Algal Bloom

**UC San Diego Subtotal \$462,579**

## UC SANTA CRUZ

C. Blanchette 5/1/1512-4/30/2017 \$19,681  
MARINe Rocky Intertidal Survey Program

J. Caselle 6/24/2014-4/30/2016 \$35,046  
Scientific collecting permits, rockfish dispersal, and kelp forest monitoring

S. Mazer	1/1/2015-12/31/2018	\$25,642
Using UC Reserves to detect and forecast climate impacts		
<b>UC Santa Cruz Subtotal</b>		<b>\$80,396</b>
 <b>UC SEA GRANT</b>		
H. Lenihan	2/1/2016-1/31/2017	\$150,363
Impact of Neonicotinoid Pesticides on Estuaries and Coastal Streams		
<b>UC Sea Grant Subtotal</b>		<b>\$150,363</b>
 <b>UNIVERSITY OF GEORGIA</b>		
U. Passow	1/1/2016-12/31/2016	\$100,889
Oil-Marine Snow-Mineral Aggregate Interactions and Sedimentation during the BP Oil Spill		
U. Passow	1/1/2015-12/31/2016	\$219,450
ECOGIG-2: Ecosystem Impacts of Oil and Gas inputs to the Gulf		
<b>University of Georgia Subtotal</b>		<b>\$320,339</b>
 <b>UNIVERSITY OF HAWAII</b>		
C. Carlson	1/1/2015-7/31/2016	\$137,718
Analyses of dissolved organic carbon and total nitrogen for the Hawaii Ocean Time-series (HOT) program		
<b>University of Hawaii Subtotal</b>		<b>\$137,718</b>
 <b>UNIVERSITY OF MIAMI</b>		
C. Carlson	3/15/2015-2/28/2021	\$152,046
Collaborative Research: Global Ocean Repeat Hydrography, Carbon, and Tracer Measurements, 2015-2020		
<b>University of Miami Subtotal</b>		<b>\$152,046</b>
 <b>UNIVERSITY OF MINNESOTA</b>		
S. Mazer	10/11/2011-9/30/2016	\$7,375
Project Baseline, a living plant genome reserve for the study of evolution		
<b>University of Minnesota Subtotal</b>		<b>\$7,375</b>
 <b>UNIVERSITY OF SOUTHERN CALIFORNIA, SOUTHERN CALIFORNIA EARTHQUAKE CENTER</b>		
D. Valentine	4/1/2016-3/31/2017	\$87,802
Using a targeted metagenomic approach to examine adaptive protein diversification by microorganisms and their viruses in seafloor sediments		
C. Nicholson	2/1/2012-1/31/2017	\$38,000
Continuing to Evaluate 3D Fault Geometry in Special Fault Study Areas and to Improve the SCEC Community Fault Model (CFM)		
<b>University of Southern California Subtotal</b>		<b>\$125,802</b>

## US DEPARTMENT OF AGRICULTURE, FOREST SERVICE

S. Cooper	5/9/2016-5/08/2021	\$123,500
Evaluating the status of South Central and Southern California Steelhead populations and stream habitat conditions on the LPNF through data acquisition and analysis		
C. D'antonio	4/20/2016-4/19/2021	\$57,500
Evaluating the status and trends of southern California Forest Service lands through long-term monitoring		
D. Herbst	9/24/2012-12/31/2016	\$15,000
Aquatic Invertebrate Research for Experimental Watersheds in the Kings River System		

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**US Department of Agriculture, Forest Service Subtotal** **\$196,000**

## USDI BUREAU OF OCEAN ENERGY MANAGEMENT

C. Blanchette	4/1/2015-12/31/2016	\$4,900
Maintenance, Calibration, and Deployment of a Seafet 97 pH meter		
M. Love	8/20/2015-8/19/2018	\$208,367
Synthesis of Pacific Platform Research		
H.M. Page, J. Dugan, R. Miller	7/1/2013-5/31/2018	\$61,290
Understanding the Role of Offshore Structures in Managing Potential Watersipora Invasions		
R. Miller	7/7/2015-6/30/2020	\$500,000
A Demonstration Marine Biodiversity Network (BON) for Ecosystem Monitoring		

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**USDI – Bureau of Ocean Energy Management Subtotal** **\$774,557**

## USDI FISH & WILDLIFE SERVICE

R. Knapp	8/20/2015-8/19/2018	\$140,000
Preventing Extirpation of Frog Population Following Arrival of the Frog-killing Fungus <i>Batrachochytrium dendrobatidis</i>		
R. Knapp	8/20/2015-8/19/2018	\$10,000
Treatment and prevention of infection by Bd in two species of mountain yellow-legged frogs		
C. Sandoval, S. Swarbrick	9/22/2015-6/30/2020	\$61,920
Exhibits for the Coal Oil Point Reserve Nature Center		
T. Dudley	9/12/2015-5/21/2020	\$129,944
Research and Restoration through the Santa Clara River Reserve: A Proposal to Develop a University of California Research and Education Station		

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**USDI Fish & Wildlife Service Subtotal** **\$341,864**

## USDI GEOLOGICAL SURVEY

M. Brzezinski	9/1/2015-8/31/2016	\$96,263
Wave energy in kelp forests		
R. Knapp	7/1/2013-6/30/2016	\$20,900
Factors influencing the reintroduction success of the endangered mountain yellow-legged frog		



R. Knapp	6/1/2016-5/31/2017	\$34,750
Understanding and Ameliorating Predation on Reintroduced Mountain Yellow-legged Frogs by Terrestrial Garter snakes in the Sierra Nevada		
C. Nicholson	3/1/2016-2/28/2017	\$48,933
An Integrated Onshore-Offshore Re-Evaluation of 3D Fault and Fold Geometry, Coastal Uplift and Seismic Hazard in the Santa Barbara-Ventura Area		
D. Wilson	5/1/2016-4/30/2017	\$32,482
Synthesis of Mendocino Ridge regional Geologic Framework, Tectonic and Magmatic Processes and Margin Evolution in Support of US Extended Continental Shelf Assessments		
<b>USDI Geological Survey Subtotal</b>		<b>\$233,328</b>
<b>USDI NATIONAL PARK SERVICE</b>		
R. Knapp	6/10/2015-6/10/2020	\$89,087
Restoring rare frogs in Yosemite National Park		
<b>USDI – National Park Service Subtotal</b>		<b>\$89,087</b>
<b>VENTURA COUNTY</b>		
A. Lambert	8/1/2016-7/31/2020	\$1,349,008
Santa Clara River upstream of Balcom Canyon wash habitat restoration project		
<b>Ventura County Subtotal</b>		<b>\$1,349,008</b>
<b>WAITT FAMILY FOUNDATION</b>		
C. Costello, S. Gaines	12/31/2015-12/31/2016	\$600,000
Sustainable Fisheries Group: Sustainable Ocean Solutions through Rights-Based Management, Fisheries Certification, and Marine Protected Areas & Aquaculture Scope		
<b>Waitt Family Foundation Subtotal</b>		<b>\$600,000</b>
<b>WORLD WILDLIFE FUND, CANADA</b>		
W. McClintock	12/18/2015-12/31/2015	\$19,491
Assistance with WWF-Canada's Cumulative Impact Model in Seasketch		
<b>World Wildlife Fund Subtotal</b>		<b>\$19,491</b>
<b>TOTAL 2015-2016 AWARDS</b>		<b>\$21,681,767</b>

# Research Summaries

## (Contracts/Grants Administered)

### July 2015 – June 2016

**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.

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**Paul Berkman,** 9/1/2013 to 11/30/2015 \$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

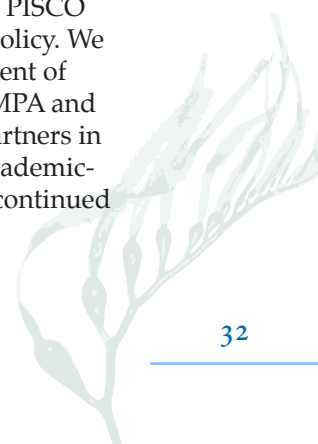
engage policy makers in the process from bodies like the Convention for the Protection of the Marine Environment of the North-East Atlantic, which has a transboundary remit in the Arctic Ocean. To make the process cost effective, we have established links to the SEARCH (Study of Environmental Change: [www.arcus.org/search](http://www.arcus.org/search)) and ACCESS (Arctic Climate Change, Economy and Society: [www.access-eu.org](http://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](http://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.iaaos-equipex.upmc.fr](http://www.iaaos-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.

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<b>Carol Blanchette, Jennifer Caselle,</b>	<b>1/15/2015 to 3/31/2017</b>	<b>\$238,188</b>
<b>Steven Gaines, Robert Warner, Libe Washburn</b>		
Oregon State University		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 DLPPF's West Coast team to ensure that our activities are coordinated with DLPPF and partner activities. These activities will determine the path and projects that we pursue in the remainder of this 5-year phase of PISCO.

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<b>Carol Blanchette</b> UC Santa Cruz	<b>9/1/2012 to 8/31/2016</b>	<b>\$115,500</b> UCSCMCA 13-004
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### **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.

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<b>Carol Blanchette</b> UC Santa Cruz	<b>5/1/2015 to 4/30/2017</b>	<b>\$19,681</b> A15-0068-S005
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### **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 as 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.

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<b>Carol Blanchette</b>	<b>7/1/2014 to 12/31/2015</b>	<b>\$4,900</b>
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.

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<b>Cherie Briggs, Roland Knapp</b>	<b>8/15/2015 to 7/31/2018</b>	<b>\$185,575</b>
National Science Foundation		1457265

#### **Collaborative Research: Linking Causes of Variation in the Amphibian Skin Microbiome with Consequences for Disease Risk**

Overview: This project has two objectives: to understand the factors that shape symbiotic microbial communities, and to understand how symbiotic microbial communities interact with invading pathogens. Animals serve as habitats to complex symbiotic microbial communities (referred to as the microbiome). The microbiome may interact with pathogens encountered by the host, and this interaction can affect disease resistance and/or alter the species composition of the microbiome. This project will examine microbiome assembly and microbiome-pathogen interactions in a wildlife disease system consisting of a frog species, the symbiotic bacteria inhabiting its skin, and a fungal pathogen. Molecular methods (16S amplicon sequencing and metagenomics of bacterial communities; microsatellite analysis of host genotypes) will be combined with field surveys and laboratory experiments to understand the relative influence of environment and host on microbial community composition. Mathematical models will be used to identify processes underlying patterns of community assembly. Field, experimental, and modeling approaches will then be used to investigate the interactions between the microbiome and the pathogen, to determine whether microbiome composition determines resistance to the pathogen, and/or if the invading pathogen disrupts microbiome composition and function.

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

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

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<b>Cheryl Briggs</b>	<b>7/1/2015 to 12/31/2016</b>	<b>\$17,100</b>
UC MEXUS		SB160014

***Batrachochytrium dendrobatidis* in Northwestern Baja California: An Examination of Incidence and Prevalence in Three Anuran Communities**

Project Goals

Assess inter-specific dynamics of *Batrachochytrium dendrobatidis* infection in three anuran communities in northwestern Baja California.

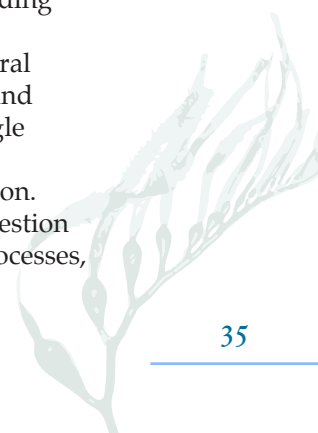
Project Objectives

1. Examine *Batrachochytrium dendrobatidis* infection prevalence and intensity between frog and toad species in three communities (*Rana draytonii*, *Anaxyrus boreas*, *Anaxyrus californicus*, *Spea hammondi*, and *Pseudacris hypochondriaca*).
2. Examine *Batrachochytrium dendrobatidis* infection prevalence and intensity between seasons.
3. Determine if there is a relationship between temperature and *Batrachochytrium dendrobatidis* infection prevalence and intensity among seasons.
4. Determine if the exotic species American Bullfrog is acting as disease reservoir for *Batrachochytrium dendrobatidis*.
5. Determine the phylogenetic origin of *Batrachochytrium dendrobatidis* strains currently present in Baja California.

<b>Cheryl Briggs</b>	<b>9/1/2013 to 6/30/2016</b>	<b>\$1,209,186</b>
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*.

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<b>Mark Brzezinski</b>	<b>10/1/2013 to 9/30/2015</b>	<b>\$106,104</b>
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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<b>Mark Brzezinski</b>	<b>7/1/2013 to 11/30/2015</b>	<b>\$36,219</b>
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*.

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<b>Mark Brzezinski</b>	<b>9/1/2014 to 9/30/2015</b>	<b>\$7,100</b>
Swiss Federal Inst of Technology-DbA Eth (Switzerland)		SB150133

**Sedgwick Field Work**

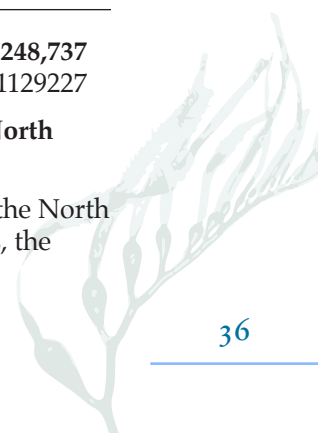
The Laboratory Assistant, Dillon Polito, will execute field and laboratory duties for research projects conducted at UC Sedgwick Reserve in the Santa Ynez Mountains and Midland School in Santa Barbara, CA. Some of the tasks include data collection, weeding, seed collecting, weighing, counting and data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

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<b>Mark Brzezinski</b>	<b>9/15/2011 to 8/31/2015</b>	<b>\$248,737</b>
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 its 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.

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Mark Brzezinski  
UC San Diego

6/1/2016 to 5/31/2017

\$47,300  
NA16NOS0120022

#### **Southern California Regional Coastal Ocean Observing System: Harmful Algal Bloom (HAB)**

To facilitate the effort outlined for the HAB component of water quality the Brzezinski lab at UCSB will carry out a set of observations at Stearn's Wharf in Santa Barbara, paralleling the observational set taken by the other four HAB monitoring groups. The full set of regional sites for the harmful algal bloom monitoring include San Luis Obispo, Santa Barbara, Santa Monica Bay, San Pedro Bay, and San Diego. A SCCOOS automated pier sensor is located at Stearn's wharf providing a continuous data record of temperature, salinity, and chlorophyll fluorescence. Stearn's Wharf has been sampled as part of the SCCOOS HABS since the inception of the SCCOOS HABS effort. We will continue to sample this core site during the next five years. With the proposed budget augmentation Brzezinski's laboratory will also be collecting sample for flow cytometric analysis of small phytoplankton and providing these to professor Debora Iglesias-Rodriguez (UCSB) for analysis. In addition Brzezinski will provide nutrient analyses for all five SCCOOS HAB sites.

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Mark Brzezinski  
National Science Foundation

12/1/2012 to 11/30/2016

\$349,538  
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  $\delta^{30}\text{Si}(\text{OH})_4$  reveal systematic variations among ocean basins that can be understood in terms of thermohaline circulation patterns, but in the eastern Pacific the relationship between  $\delta^{30}\text{Si}(\text{OH})_4$  and  $[\text{Si}(\text{OH})_4]$  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  $\delta^{30}\text{Si}(\text{OH})_4$  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  $\delta^{30}\text{Si}(\text{OH})_4$  distributions 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  $\delta^{30}\text{Si}(\text{OH})_4$  data set that a comprehensive test will require spatially resolved  $\delta^{30}\text{Si}(\text{OH})_4$  data from multiple oceans basins. International

GEOTRACES sections completed or planned by Canada, Great Britain, France, Germany, Sweden and India include  $\delta^{30}\text{Si}(\text{OH})_4$  measurements 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  $[\text{Si}(\text{OH})_4]$  of each sample using colorimetric methods, data entry and data management.

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**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.

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**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.

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<b>Mark Brzezinski</b>	<b>10/3/2014 to 12/31/2017</b>	<b>\$500,866</b>
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.

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<b>Mark Brzezinski</b>	<b>9/1/2015 to 8/31/2016</b>	<b>\$96,263</b>
USDI Geological Survey		G15AC00439

**Wave Energy in Kelp Forests**

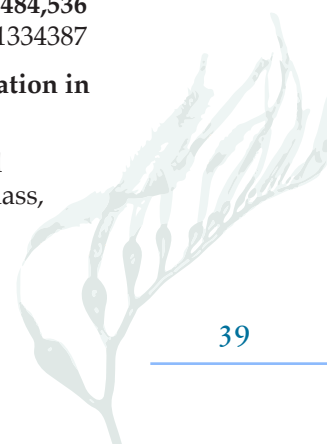
BOEM, a client of USGS, seeks ways to better understand the ecological dynamics of nearshore ecosystems. A particular research gap is the effect of wave energy. For the past years, UCSB has been collaborating with USGS to build and deploy wave sensors at several sites throughout the channel. UCSB proposes to complete these measurements and the analysis of the associated data. b. Objectives. We plan to determine how marine communities (specifically kelp plants) respond to environmental variation. Two specific goals of interest are (1) determine the distribution of wave period and amplitude across the study region of the nearshore environments off the central California coast by using in-situ wave sensors in kelp forests, and (2) determine how wave model predictions compare to empirical observations field observations and the predicted wave energy from the CDIP Nowcast models. This comparison will indicate the extent that CDIP Nowcast models provide accurate wave energy information from BOEM and the extent to which they need to be corrected for future ecological analyses.

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<b>Mark Brzezinski</b>	<b>9/1/2013 to 8/31/2016</b>	<b>\$484,536</b>
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.

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**Mark Brzezinski**

1/1/2016 to 12/31/2018

\$485,970

National Science Foundation

OCE-1341432

**Collaborative Proposal: A Field and Laboratory Examination of the Diatom N and S Isotope Proxies: Implications for Assessing the Southern Ocean Biological Pump**

Diatom nitrogen and silicon isotopes,  $\delta^{15}\text{NDB}$  and  $\delta^{30}\text{SiBSi}$ , respectively, are important paleoceanographic tools used to investigate the role of the Southern Ocean biological pump in regulating atmospheric  $\text{CO}_2$  concentrations. Existing calibrations, including culture experiments, surface sediment data and downcore reconstructions, all suggest that nutrient utilization is the primary driver of  $\delta^{15}\text{NDB}$  and  $\delta^{30}\text{SiBSi}$  in the Southern Ocean. However, a strong species effect is implied by recent culture results. Moreover, field and laboratory studies present contradictory results on the relative importance of interspecific variation and diagenetic alteration of the nutrient isotope signals to isotope records. We propose a first-order test of the N and Si nutrient paleo-proxies using both field and laboratory studies. Field work will evaluate species effects at 13 stations across the Antarctic Circumpolar Current measuring the concentration and isotopic composition of nutrients, bulk particulates, water-column diatom frustules and sedimentary diatoms relative to changes in diatom species composition to investigate species-related variability in fractionation and its relationship to surface nutrient fields. Field work will also address alteration during early diagenesis by collecting multicores at each station. For N we will test the hypothesis that observed isotopic differences between fresh material and sedimentary material reflects syndepositional processing that fractionates diatom-bound organic matter. For Si isotopes we will investigate alteration of the primary isotope signal by dissolution in the water column and in sediments to determine the relative importance of congruent dissolution of all frustules versus the complete loss of some species on sedimentary  $\delta^{30}\text{SiBSi}$ . Culture studies will evaluate the importance of interspecific variation in N and Si isotope fractionation to sediment records by targeting diatom species that dominate Southern Ocean sediment records.

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**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).

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**Craig Carlson, Emma Wear**  
NASA

9/1/2012 to 3/30/2016

\$90,000  
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.

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**Craig Carlson**  
National Science Foundation

2/1/2013 to 1/31/2016

\$164,589  
OCE-1235024

**Collaborative Research: Seawater Inorganic and Organic Carbon Measurements for the US GEOTRACES Eastern Pacific**

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 state for calcium carbonate minerals,  $\omega$ ). 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](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.

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**Craig Carlson**  
University of Hawaii

1/1/2015 to 7/31/2016

\$137,718  
MA150018

**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 (SIO), 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 9/1/2015 to 8/31/2019 \$661,501  
National Science Foundation 1537943

**Tracking the Temporal and Spatial Variability of Dissolved Organic Matter, its Diagenetic State and Bioavailability During Various Bloom States in the North Atlantic**

Overview—The North Atlantic phytoplankton bloom is among the most conspicuous biological events annually recorded (McClain, et al., 1990; Siegel, et al., 2002; Yoder, et al., 1993). This bloom represents a “hot spot” of biological activity during which a significant fraction of net community production (NCP) can be partitioned into the dissolved organic matter (DOM) phase (Duursma, 1963; Williams, 1995). Recent work examining the spatial (horizontal and vertical) gradients of DOM in the north Atlantic coupled to measurements of mixing or water mass ventilation rates has estimated that as much as 81 Tg C as DOM is vertically exported out of the surface 100 m each year (Carlson, et al., 2010). DOM export in the North Atlantic can contribute to as much as 20 % of export production; thus, representing an important contributor to the biological pump. However, missing from these data sets is the valuable temporal resolution necessary to investigate the mechanisms that control DOM production, accumulation, and change in DOM quality as a result of changing bloom state and phytoplankton phenology.

Craig Carlson 12/1/2015 to 11/30/2018 \$382,543  
National Science Foundation 1538428

**CR: Dissolved Organic Matter Feedbacks in Coral Reef Resilience: The Genomic and Geochemical Basis for Microbial Modulation of Algal Phase Shifts**

Overview:

Coral reef degradation, whether driven by overfishing, eutrophication, declining water quality, or other anthropogenic factors, is associated with a phase shift towards a benthic habitat dominated by fleshy algae (Hughes 1994, McCook 1999, Fabricius 2005). Nearly a decade of research by our team in coral reef ecosystems of the Pacific has demonstrated that these trajectories toward increasing algal dominance are restructuring microbial community composition and metabolism by fundamentally altering the dynamics and quality of dissolved organic matter (DOM). The resilience of reefs to these phase shifts is a critical question in coral reef ecology, and managing reefs undergoing these community shifts requires that we develop an understanding of the role of microbial-DOM interactions in facilitating algal overgrowth and altering reef ecosystem function. This proposal will integrate DOM geochemistry, microbial genomics and ecosystem process measurements at ecologically-relevant spatial and temporal scales to test hypothetical mechanisms by which microbially-mediated feedbacks may facilitate the spread of fleshy algae on Pacific reef ecosystems. A key product of this research will be understanding how the composition of corals and algae on reefs interact synergistically with complex microbial communities to influence reef ecosystem resilience to algal phase shifts.

Craig Carlson 11/1/2015 to 10/31/2030 \$234,000  
Bermuda Institute of Ocean Sciences 424UCSB

**BIOS-SCOPE - A Collaborative Program for the Study of Microbial Oceanography in the North Atlantic Subtropical Gyre**

BIOS-SCOPE is a cross disciplinary program in microbial oceanography with a primary focus on the interactions between microbial processes and DOM concentration and composition. The overarching goal of the BIOS-SCOPE is to form and foster collaborations of cross disciplinary science that utilizes a broad suite of genomic, ecological, oceanographic and biogeochemical approaches to evaluate microbial process, structure and function on various scales. Of particular interest to the BIOS-SCOPE team is better understanding the sources, sinks and transformation of dissolved organic matter (DOM) and the interaction between complex DOM substrates and how they are incorporated, oxidized and transformed by distinct microbial communities at the Bermuda Atlantic Time-series Study (BATS) site.



The BATS site ideally suits the BIOS-SCOPE vision of understanding carbon cycle transitions by applying time-series statistical methods to biological and chemical data, and applying insights gained from metagenomics and plankton cell biology to discover new carbon cycle transformations. DOM biogeochemistry, and its interactions with microbial processes and bacterioplankton phylogenetic diversity, have been studied more intensively and for a longer period (> two decades), than at any other ocean site. At BATS and elsewhere theories have emerged to explain patterns of DOM oxidation. Rapidly expanding genomic data have shown that planktonic ecosystems are intensely competitive, and that that generalist DOM oxidizers (heterotrophic bacterioplankton) don't fair well in this competition. Theory supported by sparse examples explains patterns in DOM distributions as a consequence of the costs and benefits of specialized metabolism for the harvesting of DOM resources by oxidative cells. DOM may accumulate not because it is intrinsically resistant to biological uptake and oxidation, but because the "economics" of oxidizing the compound vary depending on the depth, season, and the availability of growth factors. Consequently, DOM quantity as well as its source, distribution and compositional nature are intricately related to the bacterioplankton communities that stratify along gradients of energy and nutrient availability.

These theories are being tested on a technically challenging scientific frontier that merges advances in measuring DOM chemistry and genome analysis with cell biology and field campaigns. The aim of BIOS-SCOPE is to expand knowledge about the BATS ecosystem and gather the new forms of data that are needed to test these ideas. For this purpose we have assembled a cross-disciplinary team including a microbial oceanographer (Carlson- UCSB), a chemist (Kujawinski- WHOI), microbiologist (Giovannoni- OSU), zooplankton ecologists (Maas and Blanco-Bercial- BIOS) and bioinformatician (Temperton- Exeter University) with the expertise and technical acuity that are needed to study complex interactions between food web processes, microbes and DOM quantity and quality in the oligotrophic ocean.

**Craig Carlson**  
University of Miami

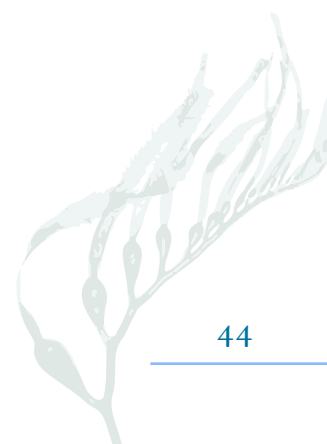
1/1/2015 to 2/28/2021

\$429,467  
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 TCO<sub>2</sub>. The size of the reservoir (comparable to that of atmospheric CO<sub>2</sub>), 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<sup>-1</sup> 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<sub>2</sub>. 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.

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<b>Jennifer Caselle</b>	<b>2/1/2016 to 1/31/2017</b>	<b>\$109,784</b>
UC Sea Grant		R/HCME-25A

**Species Distribution Models for Management of Fisheries and MPAs: Innovative Approaches to Cost-Effective Data Collection**

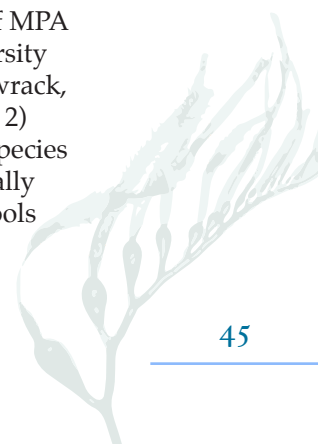
Project summary - As marine resource managers continue to adopt ecosystem-based approaches, there is a growing need to acquire reliable spatial information on species distributions (Fielding and Bell 1997, Manel et al. 1999, Costello et al. 2010). A landscape (seascape) approach that (i) identifies habitat and environmental features with which species associate, (ii) quantifies the numerical relationships of species with those habitats, and (iii) identifies the geographic distribution of habitats across a species range, is central to advancing our understanding of how and why marine populations are distributed throughout their environment and, as a result, can better inform a variety of management applications (Sala et al. 2002, Friedlander et al. 2006, Robinson et al. 2011). California has invested heavily in monitoring of coastal waters and as the baseline period of MPA monitoring comes to a close, future investment in long-term monitoring will require cost-effective, statistically robust methods. Here we propose to develop and apply advanced species distribution models (SDMs) while simultaneously testing new monitoring methods for coastal waters in southern California. Using state-of-the-art methods in spatial analysis, we will create highly resolved maps of geomorphic, biotic, geographic and oceanographic variables. The maps will be coupled with in situ survey data of ecologically and commercially important marine organisms using statistical models such as generalized linear models (GLMs) and generalized additive models (GAMs), which allow for typically nonlinear relationships between species and habitat and have, therefore, become widely used in modeling the distribution and abundance of species (Guisan and Zimmermann 2000). In situ survey data will be collected using established methods in conjunction with new methods. Newly designed stereo drop camera surveys will be explicitly compared to SCUBA surveys to evaluate the level of correspondence between the two methods as well as cost effectiveness and the potential for citizen science application.

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<b>Jennifer Caselle</b>	<b>4/1/2014 to 12/31/2015</b>	<b>\$10,930</b>
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.

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Jennifer Caselle  
UC Santa Cruz

6/24/2014 to 4/30/2016

\$85,281  
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  
Nature Conservancy

2/10/2016 to 4/30/2017

\$65,000  
SB150143-Task 5

### Task Agreement #5: Scientific and Strategic Support of TNC Oceans Initiatives

Task 1: Support TNC-North America's Oceans Program with:

1. Support the development of strategic guidance for TNC North America's Oceans program by participating on the advisory committee as an ocean content expert
2. Develop scaled guidance for North America Oceans and Coasts that will serve as the foundation for upcoming strategic retreat
3. Serve as liaison among the Global Conservation by Design team, North America Oceans, and CA Chapter.
4. Support the Director in mapping opportunity to augment funding for existing efforts and next steps.

Task 2: Support TNC-California's Oceans Program with:

1. Provide expertise in southern CA marine ecology and insights based on long experience in PISCO to help design and implement the marine portion of the TNC California's Islands Rediscovery Project.
2. Provide strategic analysis in support of TNC California's fisheries science enterprise, specifically in the prioritization and focus of fishery engagements.
3. Support a planned situational analysis of Collaborative Fisheries Research in California and the ongoing efforts to develop cost-effective underwater visual tools.

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

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<b>Jennifer Caselle, Robert Warner</b> The Coral Reef Alliance (CORAL)	<b>9/24/2012 to 12/31/2015</b>	<b>\$269,968</b> SB130041
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**Understanding Coral Reef Resilience to Advance Science and Conservation**

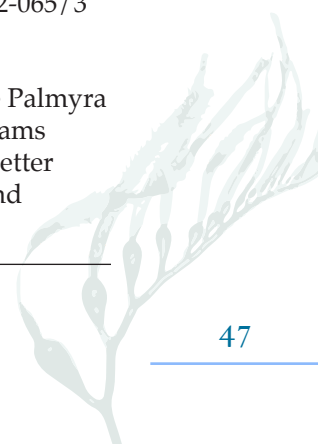
By developing a novel reef resilience model—based on synthesis of existing data and targeted new observations, and informed by a systematic analysis of management and conservation needs—scientists will have a critical new understanding of coral reef ecology and resource managers will be poised to apply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

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





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

\$9,654  
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.

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**Chris Costello, Steven Gaines** 9/1/2014 to 9/1/2015  
The Nature Conservancy

\$101,500  
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.

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**Christopher Costello, Steven Gaines** 1/1/2016 to 12/31/2016  
OCEANA, Inc

\$187,270  
SB160127

### **Forecasting the Impacts of Marine Conservation Intervention**

The Need:

The benefits of conservation interventions are uncertain and often occur well into the future. Such delayed benefits can reduce stakeholder support for interventions and create a longer monitoring and evaluation cycle, making it more challenging to improve outcomes through better intervention designs. Both of these challenges could be met with reliable forecasts of the environmental, economic and social benefits that are destined to occur. Currently, nearly all environmental interventions are evaluated solely by monitoring outcomes. Yet, simply monitoring changes in target outcomes (e.g., fish biomass or coral health) has many limitations. Most importantly, feedback is slow, and monitored changes alone lack a credible benchmark (i.e., a "counterfactual") to determine if the outcomes actually resulted from the target intervention or if the outcomes are higher or lower than should be expected.

In contrast, effective empirically grounded forecasts could help optimize the design of interventions, set expectations with key participants and influencers, and provide a model-based counterfactual. Although such reliable forecasts have been developed for some policy actions (e.g., anti-smoking campaigns), they are largely absent from conservation interventions, especially in the sea.

The Solution:

We propose to address this pressing need by identifying and modeling the causality between interventions and outcomes in fisheries reforms. As a first step, we will develop new forecasting tools to predict the impacts of a range of fisheries reforms, use the tools to examine the expected impacts of different policy and social/behavioral interventions, and then apply the tools to key Bloomberg initiatives. This work will set the stage for possible follow-on work that convenes an elite interdisciplinary working group to use these forecasting models as a foundation for a more general technical framework to allow practitioners, funders and government officials to estimate the impact of their planned interventions, and ultimately, to make informed choices on tradeoffs among costs and potential outcomes of alternative conservation investments.

**Christopher Costello**  
Nature Conservancy

5/1/2015 to 9/1/2015

**\$27,500**  
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

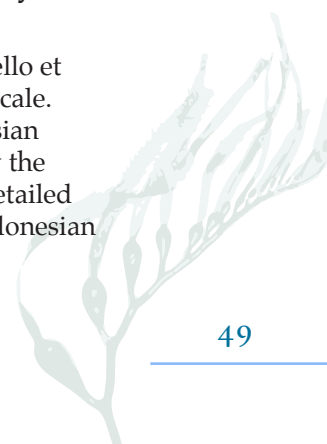
**Christopher Costello**  
David and Lucille Packard Foundation

10/13/2015 to 7/31/2016

**\$50,000**  
2015-63215

#### **Benefits of Fisheries Sustainability in Indonesia: Understanding and Customizing an Analytical Framework**

We propose to customize a global model that estimates the benefits of fisheries reform (Costello et al. in review) to Indonesia in order to more accurately estimate the potential benefits at this scale. Here we propose a planning phase during which we will develop partnerships with Indonesian institutions and assemble a project team, determine data needs and data availability, identify the most promising opportunities for data collection and model customization, and develop a detailed collaborative work plan for the full multi-phased initiative. Fostering collaborations with Indonesian



fisheries institutions and key researchers will be integral to this project, as the robustness of our results will depend largely on the quality and quantity of data that are brought to bear. This planning phase will allow us to establish these key partnerships and develop a thorough plan for assessing the benefits and opportunities for improving the management of Indonesian fisheries.

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**Christopher Costello, Steven Gaines**  
Nature Conservancy

10/1/2015 to 5/31/2016

\$49,029  
SB15013-Task 4

#### **TASK 4: Making the Case for Fisheries Reform in the East China Sea**

Scope of work: In the process of fulfilling the original scope of work for this project (i.e., determining the status of the major fisheries in the East China Sea [ECS] and identifying the conservation and economics impacts of recovering these fisheries), it became clear that a single species approach was not appropriate for the analysis. This is primarily because simultaneously recovering all of the 'overfished' species would result in a flood of predators that would change the ecosystem dynamics in a manner that violates the assumptions made in data-poor single-species assessment techniques. To address this, we developed an ecosystem model for the ECS in which to test alternative management strategies. This extension to the contract will allow us to continue work on this model as well as exchanges and finalization of the joint manuscript with the ECS researchers we are working with. We will also conduct thorough robustness checks of the model results to different assumptions we have made (because of the data-limited nature of the ECS). Together with the TNC China team we will contribute to organizing a workshop in China (March 2016) to address key areas of interest to sustainable fisheries management. We will present the results of our ecosystem model at the meeting in March. The meeting is expected to bring together around 30 representatives from academia, research institutes, government and partner NGOs working in China and will include other sessions being organized by TNC on reefs, restoration and the proposed revisions to the China fisheries law being led among other topics. Lastly, we will write up the results of this modeling as a scientific manuscript to be submitted to a peer-reviewed journal, including several Chinese professors as co-authors. We hope to use the meeting and the results of the collaboration as a launching point for future projects, and to engage with interested foundations in efforts to build capacity on fisheries management in China.

Specific tasks include:

- A Monte Carlo analysis for poorly known model parameters
- A comparison with other often used ecosystem modeling frameworks (EcoPath and EcoSim)
- A comparison with a size-spectrum model in a better known system
- Drafting, circulating, and submitting the scientific paper
- Assisting in the planning for the March meeting
- Presenting results at the March meeting
- Identifying specific projects for future collaboration with Dr. Li and Dr. Zhou

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**Christopher Costello**  
University of Washington

9/1/2011 to 8/31/2016

\$125,705  
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 fishermen's 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.

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

**Sea Grant Extension Program Funds**

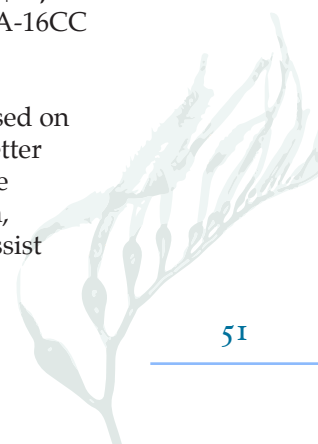
This award is in support of Dr. Culver's Sea Grant Extension program. This program is focused on discovering and transferring science-based knowledge to help California and its residents better balance the competing needs of using and conserving coastal and marine resources for future generations. Funds 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.

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<b>Carolynn Culver</b>	<b>2/1/2016 to 1/31/2017</b>	<b>\$10,250</b>
UC Sea Grant College Program		A/EA-16CC

**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.

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<b>Carla D'Antonio</b>	<b>9/1/2010 to 8/31/2015</b>	<b>\$587,453</b>
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.

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<b>Dan Dawson, Trish Holden</b>	<b>7/15/2015 to 6/30/2016</b>	<b>\$99,403</b>
National Science Foundation		1522430

### **FSML: Establishing a Modern Molecular Diagnostics Facility to Support Microbiology Research in the Sierra Nevada Ecoregion**

Overview: The Sierra Nevada Aquatic Research Laboratory (SNARL) is a unit in the University of California Natural Reserve System, and is located at the base of the eastern escarpment of the Sierra Nevada Mountains. Researchers from throughout the US are regular users of SNARL, and their studies range widely among the life and physical sciences but with a particular focus on aquatic ecology of lakes and streams. By commonly-used metrics (user-days, publications in peer-reviewed journals) the station is heavily used and productive. We propose to add a molecular diagnostics facility to the existing microbiology laboratory at SNARL. This will include a real-time quantitative PCR (qPCR) system, large-capacity autoclave, biological safety cabinet, high-throughput tissue homogenizer, and microcentrifuge. The proposed molecular diagnostics facility will be housed in the main laboratory building that was completely renovated and modernized in 2010-2011. The need for the proposed facility derived from a careful consideration of current and anticipated future research directions, an analysis of potential SNARL improvements and the projects they would benefit, and thorough consultation with SNARL users and the UCSB management team. This new facility will dramatically expand the research capabilities at SNARL, including of the existing microbiology laboratory that is currently used primarily for bacterial culturing.

Daniel Dawson, Susan Swarbrick  
Department of Cal Ra Fish and Game

7/6/2012 to 6/30/2016

\$1,412,000  
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.

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Thomas Dudley  
USDI Fish and Wildlife Service

11/29/2010 to 11/29/2015

\$476,000  
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  
Desert Botanical Garden

3/1/2015 to 2/28/2018

\$157,568  
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."

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Thomas Dudley  
USDI Fish and Wildlife Service

9/12/2015 to 5/21/2020

\$129,944  
F15AC00687

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

Since the start of the riparian restoration portion of this project, we have initiated work on 29 acres (Taylor property – 10 acres; Underwood property – 15 acres; Fillmore United School District Farm property – 4 acres). Additionally, Trustee Council funding has facilitated the acquisition of \$2 Million in funding from the Department of Water Resources (Proposition 84) for restoration on a total of 150 acres of riparian habitat. A portion of year five Trustee Council funds will be deferred (as was done in year four) to support future restoration work that may be necessary on the three properties named above. Year five restoration activities will consist of the following elements:

- Implementation of the Proposition 84 project. We will begin large-scale implementation of riparian restoration supported by funds received from the Department of Water Resources for Arundo removal, revegetation and monitoring on additional properties including Hedrick Property, Hedrick Ranch Nature Area, and Fillmore United School District Farm Property. The funding provided by the Santa Clara River Trustee Council is being used as match (cost share) for the Proposition 84 project.
- Restoration on TNC's Taylor property. We will continue removal and retreatment of Arundo resprouts and other invasive plants in the 10-acre project area. The bulk of the work will continue to focus on revegetation in areas where natural colonization is low. We will continue biological monitoring to track passive restoration and wildlife recovery by assessing establishment and regrowth of native vegetation, and habitat use by wildlife. We will also continue to evaluate the restoration treatment plots (mulch removal, passive plant recovery, active revegetation techniques, etc.) to provide information that will improve regional restoration efforts in the future. Planting of native vegetation will occur as necessary after passive revegetation is assessed in the spring and summer of 2014.
- Restoration on Underwood Farms property. We will continue Arundo removal in a fifteen acre riparian area on the Underwood Farms property, with a focus of connecting restored areas with the adjacent Taylor property. The majority of the work will involve 2 hand removals using cut and daub methods and will be conducted in February 2015 and between 15 September 2015 and 31 January 2016.
- Restoration on Fillmore United School District Farm property. We will continue working with Fillmore United School district staff and students to remove Arundo in a 13 acre riparian area along the south bank of the Santa Clara River. Under the direction of UCSB staff, students will also collect seeds and cuttings of native plants and assist with replanting of areas where Arundo has been removed.



Thomas Dudley, Randall Long  
UC MEXUS

2/1/2016 to 7/31/2016

\$1,499  
SB160105

### Surveys of Insect Communities in the Colorado River Delta

The primary goal of environmental restoration projects is to recover the proper functioning of basic ecosystem processes, such as wildlife habitat and enabling a normal water and nutrient cycle. An international restoration program was recently established in the Colorado River Delta south of the US-Mexico border in association with an agreement established by the International Boundary and Water Commission (IBWC). This agreement, known as Minute 319, is a provision to the 1944 water treaty between the United States and Mexico, and is intended to facilitate cooperative measures between the two countries regarding the Colorado River and continuing its ability to service the needs of both countries (IBWC 2012). In accordance with the Minute 319 measure a "pulse" flow of water would be supplied to the Lower Colorado River in an attempt to reconnect the river to the Sea of Cortez through what had historically been the Colorado River Delta. To fulfill this one time pulse flow a substantial allocation of water (190 million cubic meters) was released in March 2014 to mimic a natural flood event. The measure also indicated the importance of international projects involving joint cooperation to monitor the response of various restoration and unmanaged sites to the pulse flow (Glenn et al. 2013).

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Tom Dudley  
UC MEXUS

7/1/2014 to 9/30/2015

\$1,496  
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.

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<b>Jenifer Dugan, Robert Miller</b> National Science Foundation	<b>4/1/2015 to 3/31/2019</b>	<b>\$997,312</b> OCE-1458845
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### **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.

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<b>Jenifer Dugan</b> Pepperdine University	<b>2/1/2014 to 1/31/2017</b>	<b>\$12,601</b> SB150118
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### **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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<b>Jenifer Dugan</b> California Coastal Commission	<b>5/1/2009 to 12/31/2016</b>	<b>\$37,500</b> SB090092
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### **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.

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<b>Jenifer Dugan</b>	<b>2/1/2014 to 1/31/2017</b>	<b>\$45,000</b>
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**

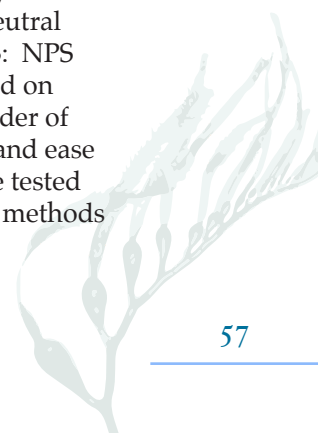
Northern California’s coast has many long and pocket beaches located within the boundaries of the region’s newly established MPAs. These ecosystem elements have regionally important ecological, cultural, recreational and commercial facets and are important indicators of coastal ecosystem health. The 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.

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<b>Jenifer Dugan</b>	<b>7/15/2013 to 7/28/2016</b>	<b>\$50,000</b>
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 will 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>.

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<b>Steve Gaines</b>	<b>11/1/2013 to 2/28/2016</b>	<b>\$228,125</b>
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 through 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.

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<b>Steven Gaines</b>	<b>3/1/2016 to 12/31/2016</b>	<b>\$50,000</b>
Rare		SB160106

**Fish Forever**

Subgrant funds are provided to support for the Sustainable Fisheries Group (SFG) to continue to play a supporting technical role in Fish Forever, particularly in facilitating the implementation of the AFAM toolkit at the partnership’s field sites. During the grant period, SFG will work closely with regional Rare staff and community leaders in the Philippines, Indonesia, Brazil and Mozambique, with the knowledge that regions are at various stages of resource management structuring and implementation.

In Indonesia and Brazil, SFG staff will be following up on workshops with direct technical support to assist Rare staff in validating data that has been collected to date, visualizing that data, and analyzing it using the AFAM toolkit. In Mozambique, the newest region identified for expansion of the Fish Forever approach, site selection has yet to take place; SFG staff will be supporting Rare staff in completing this process. In each country where Fish Forever works, the goal is to work alongside Rare co-leads to pilot the AFAM process at a minimum of one site during the grant period. Finally, SFG will publish a collaborative scientific paper with staff from EDF, Rare, and other implementation partners.

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<b>Steven Gaines</b>	<b>2/1/2014 to 1/31/2016</b>	<b>\$8,227 Core, \$89,894 Trainee</b>
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.

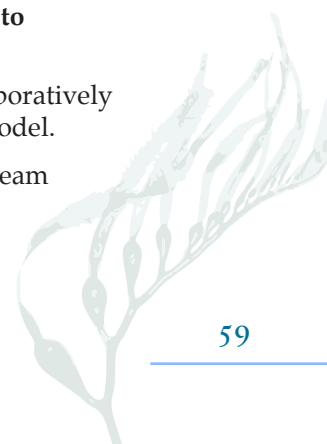
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<b>Steven Gaines</b>	<b>7/1/2015 to 12/31/2016</b>	<b>\$268,750</b>
Ocean Conservancy		SB150168

**Reimagining Fishery Management: A Joint Project to Identify Breakthrough Approaches to Fisheries Management**

During the grant period, SFG, under the direction of Project PI Steve Gaines, will work collaboratively with other members of the Project Team to develop the human-ecosystem coupled fishery model.

The UCSB-SFG team will include one full-time post-doctoral researcher and two additional team members providing part-time research and project management support.



UCSB-SFG will be responsible for providing fisheries modeling expertise and data support leading to the development of the human-ecosystem coupled model, including participation in the following activities:

- Model development
  - o Furnish fisheries data, including leading renewal of data access agreements as necessary
  - o Support literature reviews and data collection
- Policy simulation
  - o In partnership with Oxford University, develop a tightly coupled scope of work for hypothesis development and testing through a variety of analytic approaches
  - o Identify and develop innovative hypotheses for testing around faster, cheaper, simpler fisheries management strategies or indicators.
  - o Furnish details on expected outcomes, testing parameters, etc. to Project team
  - o Test innovative hypotheses (using a variety of analytical approaches including first-principles, conventional bio-economic modeling)
- Model verification and validation
  - o Support validation and verification of model results through comparison with alternative analyses and first principles. For example, if machine learning within the ABM produces a novel policy recommendation, we would explore its mechanistic basis (i.e., why it works) in order to make a convincing case for putting this policy into practice.
- On-going
  - o Documentation of SFG-led processes and outcomes, including comparative analyses
  - o Co-author scholarly articles and other papers as agreed to by team
  - o Participate in team calls, in-person meetings, and workshops as requested with the Project Team
  - o Review project plans and documents to provide comment and recommendations
  - o Provide other project support functions as needed

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<b>Steven Gaines, Cody Szuwalski</b>	<b>7/1/2015 to 6/30/2016</b>	<b>\$65,818</b>
UC San Diego		20154928

**Fixing Retrospective Biases in Stock Assessment and Implication for Management Targets**

The status of exploited marine stocks is assessed using mathematical models to determine current biomass relative to target levels. These models sometimes produce biased estimates of biomass for the most recent years called ‘retrospective biases’; and allowable catches based on biased biomass estimates can result in under- or over-fished stocks. Retrospective biases occur when a biological process (e.g. growth) changes over time, but the process is not allowed to vary within the stock assessment. Allowing a biological process to vary over time within an assessment model is one way to eliminate retrospective biases, but it is unclear how ‘fixing’ retrospective biases in this manner can influence the calculation of management targets. Our goal is to perform a simulation study in which we create and ‘fix’ retrospective biases by allowing different biological processes to vary in the assessment and then observe how the calculated management targets change. We hope to understand the magnitude of biases created in management targets by ‘fixing’ retrospective biases and suggest practices that can minimize these biases.

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<b>Patricia Halpin</b>	<b>1/1/2015 to 7/31/2016</b>	<b>\$30,389</b>
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.

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**Stephanie Hampton**  
National Science Foundation

9/15/2011 to 8/31/2015

\$348,737  
DEB-1136637

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

Anthropogenic global change is 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 by 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.

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**David Herbst, Scott Cooper**  
USDA Forest Service

9/24/2012 to 12/31/2016

\$185,000  
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  $\mu$ m 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 m<sup>2</sup>). 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.

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**David Herbst**  
AMEC (Great Britain)

9/1/2015 to 6/30/2016

\$56,268  
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.

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

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<b>Scott Hodges</b> Larimer County Department of Natural Resources	<b>5/1/2014 to 1/31/2016</b>	<b>\$2,000</b> SB150154
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#### **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.

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**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 anisotropic 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.

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**Scott Hodges, Nathan Derieg**  
National Science Foundation

6/1/2013 to 5/31/2016

\$19,890  
DEB-1311390

**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.

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**Gretchen Hofmann**  
National Science Foundation

10/1/2013 to 9/30/2017

\$510,394  
PLR-1246202

**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/pCO<sub>2</sub> 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

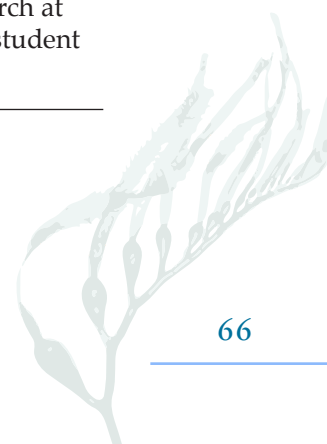
adapted. Thus, data regarding the ‘OA seascape’ would greatly facilitate organismal research; laboratory experiments could be performed in an environmental context and investigators would have a better baseline from which to project pH dynamic changes in the future that are driven by anthropogenic ocean 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 pCO<sub>2</sub> 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 CO<sub>2</sub> 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.

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<b>Gretchen Hofmann</b>	<b>2/1/2015 to 1/31/2017</b>	<b>\$24,999</b>
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** 1/1/2016 to 12/31/2016 \$2,450  
USDI Bureau of Ocean Energy Management SB160120

**Maintenance, Calibration, and Deployment of a Seafet 97 pH meter**

This Statement of Work is for the 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 a 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 collaborative 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. Hofmann 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 this sensor is on Channel Islands and so we are also proposing to work with the Channel Islands National Park Service (CINP).

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**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.

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**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<sub>2</sub>), ocean acidity and ocean warming are predicted to change dramatically by the end of the 21st century. Specifically, increased dissolved CO<sub>2</sub> 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 +1°C to +6°C by the year 2100. In manipulative laboratory experiments, I propose to raise cultures of larval sea urchins under varying CO<sub>2</sub> 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 pCO<sub>2</sub> 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.

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<b>Gretchen Hofmann</b>	<b>2/1/2012 to 1/31/2016</b>	<b>\$12,090</b>
National Science Foundation		OISE-1219542

**International: The Energetic Cost of an Acidic, Warm Environment: Changes in Lipid Consumption of *Pocillopora 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 CO<sub>2</sub> 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-Shiang 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 CO<sub>2</sub> 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.

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<b>Sally Holbrook, Deron Burkepile, Russell J. Schmitt</b>	<b>1/2/2015 to 2/28/2017</b>	<b>\$199,988</b>
National Science Foundation		1619697

**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.

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**Sally Holbrook, Andrew Rassweiler**  
National Science Foundation

10/1/2013 to 9/30/2016

\$247,089  
OCE-1325652

### **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.

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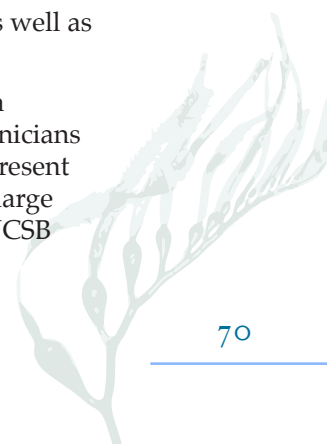
<b>Debora Iglesias-Rodriguez,</b>	<b>1/1/2014 to 12/31/2016</b>	<b>\$494,091</b>
<b>Mark Brzezinski, Craig Carlson, Uta Passow, David Valentine</b>		
National Science Foundation		SB150154

**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.

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<b>Lydia Kapsenberg</b> <b>Gretchen Hofmann</b> University of Washington	6/1/2011 to 8/31/2015	\$19,987  SB110188
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#### **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<sub>2</sub> 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<sub>2</sub>-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.



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

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.

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**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 which 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, Ardeh 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.

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**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 ( $\geq 200$  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 transmitters, 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, weighed, 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.

**Roland Knapp**  
USDI Fish & Wildlife Service

9/22/2015 to 7/31/2020

\$140,000  
F15AC00500

**Preventing Extirpation of Frog Population Following Arrival of the Frog-killing Fungus  
*Batrachochytrium dendrobatidis***

During the summers of 2016, 2017, and 2018, personnel from the University of California-Santa Barbara Sierra Nevada Aquatic Research Laboratory (SNARL) will visit approximately two-thirds (14-16) of the 22 Bd-naïve frog populations (Table 1), primarily those not in close proximity to SEKI's current fish removal efforts. All sites will be visited 1-2 times per summer to assess their disease status. The remaining approximately one-third (6-8) of the sites will be visited by personnel from SEKI. During each visit, swabs will be collected from 10-20 frogs in each population (~1000 swabs total per year). Swabs will be analyzed within two weeks of collection using standard qPCR methods. Results from swabs will be used to plan subsequent site visits. If an outbreak is identified, a treatment will be implemented, led by personnel from SNARL, and assisted by personnel from SEKI. In addition, if conditions in certain populations warrant it, some early life stages (eggs, tadpoles, and/or juveniles) may be collected and transported to a zoo for captive rearing. These frogs would be raised to adulthood, infected with Bd to immunize them, cleared of infection, and then reintroduced into the population from which they were collected.

**Jeffrey Krause**  
National Science Foundation

4/1/2012 to 3/31/2017

\$453,487  
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  $^{32}\text{Si}$  with measures of silicon deposition rates by individual cells using the fluorescent probe 2-(4-pyridyl)-5-((4-(2-dimethylaminoethyl-aminocarbonyl)-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.

**Armand Kuris, Ryan Hechinger,  
Kevin Lafferty**  
National Science Foundation

8/1/2011 to 7/31/2016

\$2,149,227  
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.

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

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

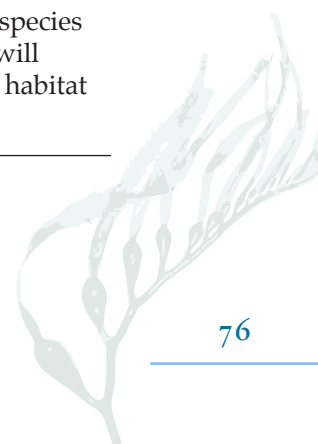
Ecological damage caused by human activity can directly influence infectious diseases and human health. Yet, public health campaigns rarely turn to ecological solutions to mitigate infectious disease risk, instead favoring traditional approaches such as vaccine development or drug treatment. Here, we 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.

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<b>Adam Lambert</b>	<b>9/30/2014 to 6/30/2020</b>	<b>\$1,962,430</b>
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  
Ventura County

8/1/2015 to 7/31/2020

\$1,349,008  
SB150163

### **Santa Clara River Upstream of Balcom Canyon Wash Habitat Restoration Project**

The Watershed Protection District (WPD) is contracting with UC Santa Barbara (UCSB) to perform habitat restoration work, monitoring, and related environmental research to support restoration efforts for the Santa Clara River Upstream of Balcom Canyon Wash Habitat Restoration Project, located near Fillmore, Ventura County. The Project involves conducting habitat restoration within 15.5 acres of riparian habitat on Underwood and Kenter Canyon Farm Properties, known as the project area. Project elements include retreatment of giant reed (*Arundo donax*) resprouts and other non-native plant species throughout the project area, revegetation with native riparian species, site maintenance (including irrigation if needed), and biological monitoring of vegetative cover and wildlife as required by regulatory permitting and to facilitate compliance with permit conditions. WPD completed initial giant reed removal for the entire site in February 2015, and will continue treating resprouts until June 30, 2015. The work period for this Scope of Work begins on July 1, 2015, and all site work is to be completed by June 30, 2020 with the final annual report submitted by July 15, 2020

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Adam Lambert  
UC Agriculture and Natural Resources

7/1/2014 to 6/30/2016

\$26,032  
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.

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Ashley Larsen, Steven Gaines  
Environmental Protection Agency

9/28/2014 to 9/27/2015

\$17,000  
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  
USDI National Park Service

8/1/2013 to 8/30/2015

\$13,581  
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.

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Hunter Lenihan, Erik Muller  
UC Sea Grant College Program

2/1/2016 to 1/31/2017

\$106,480  
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.

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Hunter Lenihan, Laura Urbisci  
UC Sea Grant College Program

6/1/2014 to 5/31/2017

\$96,249  
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)

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<b>Sarah Lester, Christopher Costello</b> Rare	<b>1/1/2014 to 12/31/2018</b>	<b>\$100,000</b> SB150042
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**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.

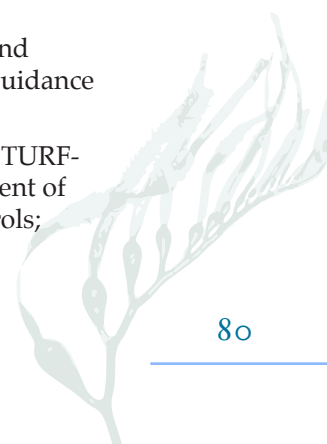
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<b>Sarah Lester, Christopher Costello</b> Rare	<b>8/1/2014 to 9/30/2015</b>	<b>\$250,000</b> SB150028
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**UCSB Fish Forever Support in Brazil and Philippines**

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.

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<b>Lorraine Lisiecki</b> National Science Foundation	<b>9/1/2011 to 8/31/2016</b>	<b>\$303,207</b> OIA-1125181
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**CDI-Type II: Collaborative Research – 4 Dimensional Visualization of Past Ocean Circulation from Paleooceanographic 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.

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<b>Milton Love</b> USDI Bureau of Ocean Energy Management (BOEM)	<b>9/22/2011 to 4/29/2016</b>	<b>\$1,232,660</b> M12AC00004
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**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.

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Sally MacIntyre  
National Science Foundation

8/1/2012 to 7/31/2017

\$943,094  
ARC-12045267

### **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<sub>2</sub>, 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 pCO<sub>2</sub>sensors. 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  
UC Santa Cruz

4/1/2015 to 12/31/2018

\$50,611  
A15-0023-S001

### 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.

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Susan Mazer  
USDI National Park Service

8/30/2010 to 8/29/2015

\$430,436  
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.

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Susan Mazer  
University of Minnesota

10/15/2011 to 9/30/2016

\$317,917  
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 plan; 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.

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<b>Douglas McCauley</b>	<b>1/1/2016 to 12/31/2016</b>	<b>\$3,000</b>
Phoenix Zoo		SB160097

**Promoting Hippopotamus Conservation and Management Through Research on the Ecology of Hippopotamus Habitat Use**

The common hippopotamus is declining across sub-Saharan Africa. In this project we propose to initiate a pilot effort using GPS ankle collars to track hippopotamus for the first time over long time periods to determine on how far the hippopotamus ranges, what habitats this species requires, and how their habitat requirements vary according to the health of the aquatic ecosystems upon which they depend. This information will vitally support improved hippopotamus conservation efforts.

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<b>Douglas McCauley</b>	<b>7/1/2015 to 6/30/2017</b>	<b>\$40,000</b>
Safari Club International		SB150167

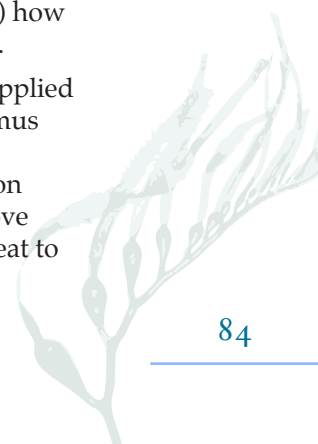
**Promoting Sustainable Hippopotamus Management Through Research on the Ecology of Hippopotamus Habitat Use**

The common hippopotamus (*Hippopotamus amphibius*) is one of the most iconic species of African wildlife and is a valuable resource in both sport hunting and ecotourism operations across Africa. The hippopotamus is also becoming increasingly well known for the important role it plays in both aquatic and riparian ecosystems (Mosepele et al. 2009, Kanga et al. 2013). In the last several decades concern has been raised about declines in hippopotamus populations that have been caused by anthropogenic development of watershed and landscapes and by escalating conflict between hippopotamus and local communities.

The hippopotamus has never been tracked electronically. It is perhaps the last of Africa’s charismatic megafauna for which we have no understanding of its spatial ecology. Consequently, managers seeking to sustainably manage this important resource have no rigorous data to rely upon to adapt current management protocols into tools that are more effective. Put simply, we cannot begin developing scientifically sound management plans for the hippopotamus until we have a basic quantitative understanding of how much space this species uses and what habitats it depends upon the most.

We propose to generate data on the spatial ecology of the hippopotamus that will directly meet this need. Specifically, we will determine: 1) what the home range size is of the common hippopotamus, 2) what habitat features it prefers and which features appear deleterious to its ecology, and 3) how changes to watershed and hydrology shape both hippopotamus home range and habitat use.

In preliminary methodological trials we have established that GPS tags can be successfully applied externally to hippopotamus in a safe fashion and can yield direct information on hippopotamus habitat use. This proposal includes a match of \$21,500 to cover the purchase of all of the GPS tags to be employed in this research. This data will be combined with remotely-sensed data on habitat distribution and advanced movement modelling tools to generate answers to the above three questions. This work will be carried out in the Ruaha ecosystem of Tanzania where threat to



hippopotamus habitats is high and the species carries multiple important values to users. Results from this research will be applied directly to informing the development of new management tools that will help to ensure a sustainable future for this important species.

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<b>Douglas McCauley</b> National Geographic Society	7/15/2014 to 7/14/2015	\$24,350 9538-14
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**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?, and 3) 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.

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<b>Douglas McCauley</b> Alfred P. Sloan Foundation	9/15/2015 to 9/14/2017	\$50,000 FR-2015-65479
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**Sloan Research Fellowship: Marine Community Assembly and Function in a Rapidly Changing World**

Using Sloan Fellowship funds my research group will focus on two spatially ambitious projects that consider how the effects we are having on marine wildlife will influence the ecology of marine macroecosystems and how these impacts scale up to influence human health. First, through both field-based (centered in central/south Pacific) and review-based (global scale) research I am working to evaluate the efficacy of newly established "mega-marine protected areas (MPAs)" for protecting a broad suite of more mobile marine vertebrates. Second, I will be moving forward with an investigation of the utility of Automated Identification System (AIS) big data to monitor vessel activity in the global oceans. Use of this AIS data will allow provide an improved view of legal and illegal fishing in both protected in non-protected zones.

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<b>Douglas McCauley</b> National Science Foundation	10/1/2014 to 9/30/2016	\$74,640 IIA-1427740
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**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.  $\leq 50$  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.

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<b>Will McClintock</b>	<b>11/1/2014 to 12/31/2015</b>	<b>\$286,515</b>
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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<b>William McClintock</b>	<b>9/2/2015 to 6/30/2016</b>	<b>\$296,146</b>
Nature Conservancy		SB150143-Task 2

**Task 2 - Software Development of eCatch Server and Mobile Application**

This Task Agreement is designed to cover work on the Project for the period from September 2, 2015 through June 30, 2016 and outlines collaborative research for the Development of the eCatch Server Application ("eCatch Project"). This Task Agreement describes the agreement between the University and the Conservancy to re-write and enhance the existing eCatch application. eCatch is a tool developed by the Conservancy 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, the Conservancy 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 this partnership is to develop a more accurate, effective and readily adopted mobile application that will better solve these problems than the existing application for iPad. Through the development



work to re-write the application to be used on iPhone mobile devices and improve the accuracy of the location manager, we were able to identify specific limitations of the current server application. We will now re-write and add functionality to the server application, as well as continue improving the iOS mobile application. Additional development will include a notification system, a map viewer for the mobile application, new user authentication on the server side and greater on-boarding capability within the mobile application.

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<b>William McClintock</b>	<b>12/18/2015 to 12/31/2015</b>	<b>\$9,543</b>
World Wildlife Fund		SB160080

#### **Assistance with WWF-Canada's Cumulative Impact Model in Seasketch**

Cumulative effects mapping is a rapidly developing field. In 2010, while this research area was still in its infancy, WWF-Canada worked alongside the UBC Fisheries Centre and the Pacific Marine Analysis Association to map the cumulative effects of human activities in Canada's Pacific marine waters. Despite the limitations associated with modelling exercises, cumulative impact mapping can provide useful information for marine and coastal planning and conservation efforts. For example, the study found that fishing, land-based activities, and marine transportation accounted for the majority of total cumulative impacts in the region.

In the last few years, WWF-Canada has updated the analysis of potential cumulative effects in Canada's Pacific marine waters using new, updated spatial datasets and methodological improvements over the previous analysis. Including a new index for land-based effects on marine ecosystems, and a modified treatment of vulnerability scores, the results showed an increase in potential cumulative effects for the region. For cumulative effects assessments to be useful to planners and managers, the data needs to be up-to-date and accessible with transparent procedures on how the data was obtained. With the peer-reviewed publication of the updated coast-wide cumulative effects assessment, WWF-Canada wanted to provide the opportunity to view the spatial data results more widely via a web-based tool. This tool would help ongoing conservation initiatives by raising awareness of the concept of cumulative effects and the impacts current and future threats are placing on Canada's Pacific ecosystems amongst a wide audience, while providing an important information support tool for those engaged in marine and coastal planning processes. The SeaSketch tool's ease-of-use, and its existing application by Marine Planning Partnership for the North Pacific Coast (MaPP), made SeaSketch an ideal choice for this project. In December, 2015, the University of California at Santa Barbara completed an agreement with WWF-Canada to create an online portal to present the public with WWF-Canada's studies on cumulative effects in Canada's Pacific. The purpose of this contract is to develop interactive analytical tools for the recently completed online portal in SeaSketch.

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<b>Robert Miller</b>	<b>7/7/2015 to 6/30/2020</b>	<b>\$250,000</b>
USDI Bureau of Ocean Energy Management (BOEM)		M15AC00006

#### **A Demonstration Marine Biodiversity Network (BON) for Ecosystem Monitoring**

Abstract: Time series data on marine biodiversity is collected at great expense, with the expectation that it will improve our capacity for science-based decision-making aimed at protecting natural ecosystems and sustaining the services that they provide. Unfortunately, most monitoring efforts in marine systems target specific sites, habitats or key groups of species, and are not linked, rendering them inadequate to address regional and global shifts in biodiversity and ecosystem services that result from climate change, pollution, fishing, and other regional- to global-scale impacts. Existing but under-utilized technologies have the potential to dramatically expand our ability to assess species change at all scales. Coordination of available tools, development of new techniques and infrastructure, and integration of these components into a cohesive program will significantly advance our knowledge and understanding of the patterns and drivers of change in marine biodiversity. This project will address these challenges in the Southern California region, with particular focus on the Santa Barbara Channel, and has two broad goals: (1) tie existing monitoring efforts together into a coordinated network and (2) fill the gaps in existing programs with new methods for marine biodiversity monitoring. 2.



Background/Relevance: Current knowledge about biodiversity in United States waters is limited in spatial and temporal scale and taxonomic scope. This compromises the ability of BOEM to understand, predict, manage and mitigate potential impacts of proposed marine energy projects, both conventional and renewable. To perform timely environmental reviews, data from ongoing projects and activities can be integrated and augmented to reduce the uncertainty in the range of outcomes and intensity of environmental consequences. NASA's Carbon Cycle & Ecosystems (CC&E) Focus Area aims to detect and predict changes in Earth's ecosystems and biogeochemical cycles. Resolution of uncertainties is needed because of the profound implications for future climate, food production, biodiversity, sustainable resource management, and the maintenance of a healthy, productive environment. Under the auspices of the National Oceanographic Partnership Program ((10 U.S.C. 7902 et seq.) which allows for inter-agency partnership on funding projects, DOI/BOEM has agreed to partner with NASA and NOAA to support selected projects which will increase understanding of marine biodiversity and facilitate cooperative conservation. Biological diversity, or biodiversity, is defined as the variety of life, encompassing variation at all levels of complexity -genetic, species, ecosystems, and biomes -and including functional diversity and diversity across ecosystems. A growing body of research demonstrates that: (1) the maintenance of marine biodiversity (including coastal biodiversity) is critical to sustained ecosystem and human health and resilience in a globally changing environment; and (2) the condition of marine biodiversity offers a proxy for the status of ocean and coastal ecosystem health and ability to provide ecosystem services. Thus, managing our marine resources in a way that conserves existing marine biodiversity would help address other ocean management objectives. For example, it would provide information to enhance biosecurity against threats such as invasive species and infectious agents, enable predictive modeling, better inform decision making, and allow for adaptive monitoring and Ecosystem-Based Management.

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Robert Miller, Mark Page  
National Science Foundation

7/1/2013 to 6/30/2016

\$58,354  
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.

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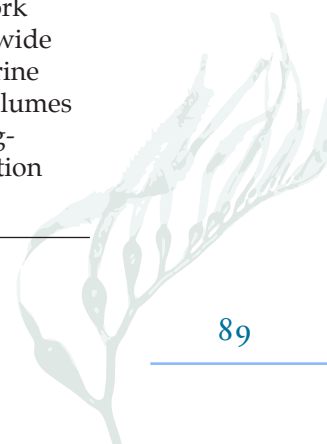
**Robert Miller**  
NASA

**10/1/2014 to 9/30/2019**

**\$1,411,551**  
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.



Robert Miller, Mark Page  
San Diego State University

8/18/2015 to 8/31/2016

\$76,836  
SA0000474

### **Archaeological and Biological Assessment of Submerged Landforms in the Pacific Coast**

1) Identify the relationships of coastal landforms to shoreline biological productivity and biodiversity, including the delivery and deposition of trophic and habitat forming subsidies, such as hydrocarbons and drift marine macrophytes.

Hydrocarbons and kelp subsidies are buoyant and therefore collect in shallow subtidal and intertidal environments where they may provide both energy and habitat to biological communities. Key among these are surf zone fishes, and juvenile as well as adult fishes are known to use drift algal subsidies as habitat. The influence of seep subsidies on these communities, however, and the interaction of hydrocarbons with drift algae are unknown. We will evaluate the connection of seep subsidies with drift algae and surf zone fishes through sampling drift algae, hydrocarbon abundance, and fish community structure across sites varying in proximity to hydrocarbon seeps.

2) Evaluate the influence of landforms and coastal processes on the structure of coastal food webs using field observations and food web analysis. In particular, information is needed on dietary responses and condition of surf zone fish to beach productivity / landforms.

3) Quantify the trophic subsidy provided by relict hydrocarbon seeps to benthic and shoreline communities. Explore the spatial extent of this subsidy and its effects on community composition, abundance and food web structure in shoreline communities.

Hydrocarbon seeps are reported as “hotspots” of productivity in the form of sulfate-reducing bacteria that support a higher abundance and more diverse community of benthic organisms than found at sites distant from these features. Although known to enhance local productivity, less explored is the extent to which relict hydrocarbon features subsidize the food webs of adjacent shoreline habitats. This task will be executed using stable isotope analysis, taking advantage of the unique isotopic signature of hydrocarbons compared to primary producers. Shallow subtidal hydrocarbon seeps will be explored and sampled by divers.

4) Rank coastal habitats and land form features by productivity: Using synthesis of information from observational studies and other published and unpublished sources to provide productivity information for the development of simple models linking coastal productivity and land forms with Chumash foraging and trade economies.

We will synthesize information from observational studies and other published and unpublished sources to provide productivity information for coastal sites in the Channel Islands. Biological surveys will be conducted to measure abundance of organisms at a range of Channel Islands and appropriate comparative sites, with particular focus on species known to be important resources to indigenous Chumash e.g. Pismo clams, Purple Olive Snail, and bean clams (and fish?). Data will be normalized to mean abundances across sites to generate a productivity index for predictive spatial archaeological models.

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Monique Myers  
California Coastal Commission

6/1/2014 to 4/30/2016

\$28,000  
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.

### **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.

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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.

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**Craig Nelson, Roland Knapp**

**9/1/2012 to 3/31/2016**

**\$56,000**

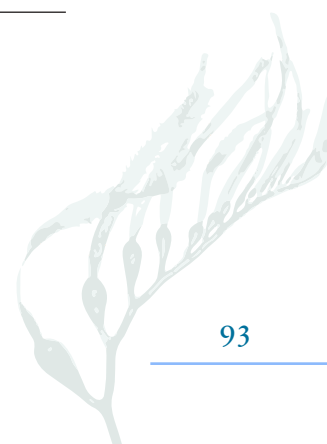
Sierra Business Council

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).

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Craig Nicholson  
US Geological Survey

3/1/2016 to 2/28/2017

\$48,933  
G16AP00100

### **An Integrated Onshore-Offshore Re-evaluation of 3D Fault and Fold Geometry, Coastal Uplift and Seismic Hazard in the Santa Barbara-Ventura Area**

Recently, several investigators have proposed that very large, damaging earthquakes with magnitudes of M7.7 to M8.1 may have occurred in the western Transverse Ranges based on repeated Holocene uplift of coastal marine terraces [Rockwell, 2011; Rockwell et al., 2014]. The principal locus of fault slip for these inferred events is believed to be the Pitas Point-Ventura fault [Hubbard et al., 2014], part of the larger, primarily offshore North Channel-Pitas Point-Red Mountain fault system [Kamerling et al., 2003; Fisher et al., 2005; Sorlien et al., 2014]. Owing to the increased seismic and tsunami hazard associated with such events, and the high degree of fault complexity likely needed to generate such potential large earthquakes, the Southern California Earthquake Center (SCEC) designated the Santa Barbara-Ventura region as a Special Fault Study Area for focused, integrated, multi-disciplinary research [Dolan et al., 2012].

There are, however, fundamental inconsistencies with this proposed model, not the least of which are: the appropriateness of the 2D fault-related fold model used to infer 3D fault geometry, the implied Holocene slip for the blind Pitas Point-Ventura fault, and the lack of expected widespread tsunami deposits. A viable alternative interpretation is that coastal uplift at Pitas Point is being driven instead by slip on the S-dipping, listric Padre Juan fault. Different fault models and alternative representations have also been proposed for the active N-dipping fault system. These models all need to be tested and evaluated with seismicity, subsurface structure mapping, geodetic strain data, or fault slip rates to see which fault set best fits the observations and patterns of surface deformation. These models, and their hazard implications, also need to be updated to incorporate alternative interpretations that properly account for the observed complex 3D fault and fold geometry and their possible fault interactions. This specifically includes active S-dipping thrust faults (like the Padre Juan fault) also involved in driving the near-surface folding and coastal uplift. I propose to test and re-evaluate these existing fault models for the Santa Barbara-Ventura area, including their related fold geometry and expected patterns of coastal uplift and fault slip. High-resolution marine seismic reflection data will be used to estimate rates of offshore fault slip and fold development, and compared with the fault slip expected from the observed coastal uplift and fault model geometry [e.g., Ryan et al., 2015].

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Craig Nicholson  
University of Southern California

2/1/2012 to 1/31/2017

\$190,000  
Y81716

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

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.

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<b>Mary Nishimoto</b>	<b>8/14/2014 to 8/31/2017</b>	<b>\$600,000</b>
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.

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<b>Margaret O'Brien, Daniel Reed</b>	<b>4/1/2015 to 3/31/2016</b>	<b>\$17,158</b>
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)

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

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

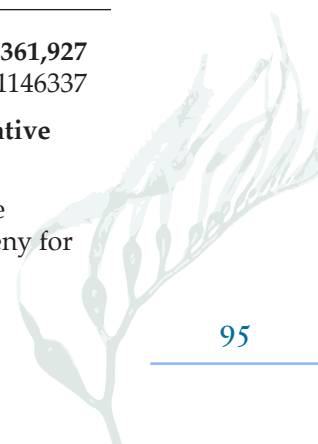
Statement of Work: UCSB. Oakley will serve as Co-PI and two graduate students (Ellis and Hensley) will be involved. UCSB researchers will help plan and execute 5 field collection trips to collect and preserve 45 species of cypridinid ostracods. Hensley will also assist PI-Gerrish with collecting video 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.

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<b>Todd Oakley</b>	<b>6/1/2012 to 5/31/2016</b>	<b>\$361,927</b>
National Science Foundation		DEB-1146337

**Collaborative Research: Eye Evolution in Sarsielloidea (Crustacea:Ostracoda): An Integrative Approach Based on Phylogenetics, 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.

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Todd Oakley, Daniel Speiser  
National Science Foundation

1/15/2014 to 3/31/2017

\$350,000  
DEB-1354831

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

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.

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

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

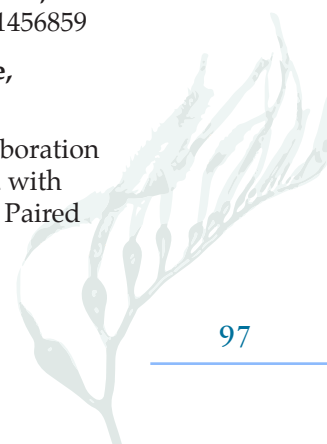
While a spectacular variety of life is perhaps the most defining feature of our planet, loss of this biological diversity is one of the most pronounced forms of environmental change in the modern era. Researchers have made great strides in understand how changes in biodiversity impact essential biological 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.

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<b>Todd Oakley</b>	<b>9/1/2015 to 8/31/2018</b>	<b>\$136,241</b>
National Science Foundation		1456859

**Collaborative Research: Evolutionary Origins of Chiton Shell-Eyes: Integrating Structure, Function, and Gene Expression Within a Phylogenetic Context**

Co-PI Oakley and Graduate Student Ramirez are responsible for the following work, in collaboration with U South Carolina. First we will collect and preserve individuals from 4 chiton species, 2 with eyes 2 without eyes. Using 3 individuals from each species, we will isolate RNA for Illumina Paired





End sequencing of aesthate tissue that we will dissect. Next, we will perform de novo assembly of all Paired End fragments into a reference transcriptome for each species. Using data from each individual, we will map all reads using BowTie to each species' respective reference transcriptome. We will compare overall rates of expression in aesthetes with and without eyes to identify differentially expressed genes to uncover candidates genes for eye function. We will publish these results in scientific journals and present our progress at SICB conferences.

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<b>Todd Oakley</b> University of Michigan	<b>9/1/2013 to 8/31/2016</b>	<b>\$424,787</b> 3002735491
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**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.

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<b>Ryoko Oono</b> UC MEXUS	<b>7/1/2015 to 12/31/2016</b>	<b>\$16,400</b> SB160015
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**Foliar Fungal Endophyte Assemblage and Diversity Compared Across Multiple Host Phylogenetic Scales - A Study on Pine Hosts of California and Mexico**

Host specialization of any particular fungal species or the evolutionary and ecological factors contributing to community assemblages have been shrouded in mystery and speculative at best (Arnold, 2007). Host specificity is challenging to assess without a thorough sampling of diverse host species and geographic locations, but necessary to understand the evolution and ecology of symbiotic organisms like endophytic fungi. Patterns of specificity also depends on the host taxonomic and spatial scales (Cavender-Bares et al., 2006). Hence, we propose to explore the community assemblage patterns and host specificity of foliar fungal endophytes associated within a host group that is taxonomically well-defined and relatively geographically narrow, the *Pinus* genus found in southwest USA and Mexico.

Our main Research Question surrounding our long-term goal to understand evolution of fungal endophytes is: How are community structures and host specificity of fungal endophytes related to the evolutionary history of the host species?

To this end, we propose investigating this question at three host phylogenetic scales:

1. All common conifer species
2. All major *Pinus* species (*Ponderosae*, *Australes*, *Strobi*, *Contortae*)
3. All *Ponderosae* species

Conifer trees tend to have high infection frequencies for FFE species, most likely due to their long-lived evergreen foliage and dominance in certain ecosystems. FFE community studies have a long history with conifers, beginning with Carroll's study on the redwoods (Carroll & Carroll, 1978), Ganley & Newcombe's study on the western white pine (Ganley et al., 2004), and more recently, Carrell & Frank's work with *Pinus flexilis* and *Picea engelmannii* (Carrell & Frank, 2014). Furthermore, one of the most well-studied FFE species, *Lophodermium* spp., are dominant among pine hosts and is becoming a model endophyte species to explore population genetic and ecological questions (Salas-Lizana et al., 2012, Oono et al., 2014).

Ryoko Oono  
UC MEXUS

10/1/2014 to 9/30/2015

\$24,491  
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 Needles 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.

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Mark Page, Dan Reed,  
National Science Foundation

1/1/2014 to 12/31/2015

\$4,715,399  
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.

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**Mark Page, Jenny Dugan,** 7/1/2013 to 5/31/2018 \$738,710  
**Robert Miller**  
USDI, Bureau of Ocean Energy Management (BOEM) 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.

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**Uta Passow** 1/1/2016 to 3/31/2016 \$25,223  
University of Georgia RR100-663/S001058

### **Oil-Marine Snow-Mineral Aggregate Interactions and Sedimentation during the BP Oil Spill**

Samples collected in years 1 and 2 along a N-S transect beginning at the river (west of the Mississippi mouth) will be analyzed. Specifically I will determine aggregation potential, potential vertical flux, and partitioning of PAH in triplicate on samples from the 3 trap stations at two depths (150 m, 250 m) each (6 samples in triplicate each in year 1 & 2).

1. *aggregation potential*: Aggregate abundance and total aggregate volume as a function of time (dependent on particle characteristics) will be measured using rolling tanks.
2. *potential vertical flux*: The characteristics of the aggregates that form (size, composition, carbon content, sinking velocity) and the determination of the fraction of material that aggregated in each sample will be determined and will allow us to estimate the potential for material to sediment.

3. *partitioning of PAH*: The fractionation between sinking and suspended matter will determine the fraction of PAH that is in the water column, but will eventually accumulate at the seafloor.

This experimental data with fresh samples will provide mechanistic understanding for in situ measurements provided by others.

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<b>Uta Passow, Mark Brzezinski, Craig Carlson</b>	<b>10/1/2010 to 9/30/2016</b>	<b>\$971,524</b>
National Science Foundation		OCE-1041038

**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  $\mu$ atm. 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.

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<b>Uta Passow</b>	<b>10/1/2015 to 9/30/2018</b>	<b>\$663,945</b>
National Science Foundation		1538602

**Collaborative Research: Effects of Multiple Stressors on Marine Phytoplankton**

Summary Overview: The objective of the proposed work is to investigate the acclimatization response of phytoplankton to different, simultaneous environmental stressors. Each phytoplankton





species has the capability to acclimatize to changes in temperature, light, pCO<sub>2</sub> and nutrient availability – at least within a finite range. However, the response of phytoplankton to multiple simultaneous stressors is frequently complex, because of interactive effects in the physiological response. To date, no datasets exist for even a single species that could fully test the assumptions and implications of existing models of phytoplankton acclimation to multiple environmental stressors. We propose to combine modeling analysis with laboratory experiments to investigate the combined influences of changes in pCO<sub>2</sub>, temperature, light, and nitrate availability on phytoplankton growth using cultures of an open ocean and coastal diatom strain (*Thalassiosira pseudonana* CCMP1014, CCMP1335) and an open ocean cyanobacteria species (*Synechococcus* sp.).

**Intellectual Merit:** Increasing atmospheric CO<sub>2</sub> is altering all the environmental conditions important for phytoplankton growth, including increases in temperature and pCO<sub>2</sub> in the surface ocean, and changes in the availability of nutrients and light due to the stronger vertical temperature gradient. As the competitive success of a phytoplankton species is determined by the balance between grazing pressure and its growth conditions, changes in phytoplankton composition and productivity are expected. Such shifts in phytoplankton community and production have important implications, because phytoplankton play a key role in marine systems, determining for example fisheries yield, and carbon sequestration by the ocean. However, the capacity of phytoplankton to acclimatize to simultaneous changes in several environmental parameters is largely unexplored and predictive models lack data on interactive effects of multiple stressors on phytoplankton. Our planned multifactorial experiments on the response of specific phytoplankton species to four primary environmental parameters, will address this knowledge gap and provide a framework to model phytoplankton response.

**Broader Impacts:** The planned experiments represent ideal case studies on the complex and interactive effects of the environmental conditions on organisms. We plan to use these for teaching on three different levels. (1) Undergraduate and graduate students working in our lab or attending our lectures will profit from the proposed work directly by participating in or hearing about the research. (2) High school students will benefit from the training of a teacher and the development of a teaching unit, which will be readily available for use by teachers. (3) The comic story developed by A. Warner on the topic will attract a larger and more diverse audience, communicating basic biological principals in a simple manner. In a world that is getting more and more multifaceted, the understanding of the complexity of biological interactions is important for future voters and residents alike.

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**Uta Passow**  
University of Georgia

1/1/2015 to 12/31/2016

\$497,701  
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.

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<b>Uta Passow</b>	<b>9/1/2011 to 12/31/2015</b>	<b>\$822,745</b>
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.

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<b>Uta Passow</b>	<b>1/1/2015 to 12/31/2016</b>	<b>\$320,837</b>
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.

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<b>Jonathan Pruitt</b>	<b>10/1/2015 to 9/30/2016</b>	<b>\$24,767</b>
US-Israel Binational Science Foundation		2013086

### **Stress, Development, and Behavioral Problems**

Animal personalities can be defined as consistent between-individual differences in several behavioral traits across different contexts (Dall et al. 2004; Carere & Maestripieri 2013). Animal personality is of evolutionary significance because of its potential to explain seemingly maladaptive behavior, and because it can provide a general mechanism for maintaining the behavioral variation within populations (e.g., Pruitt & Riechert 2012). For instance, being aggressive or active could be helpful in some contexts (e.g., towards prey or when a predator is absent) but maladaptive in other contexts (e.g., towards potential mates or in the vicinity of a predator) (Sih et al. 2004; Johnson & Sih 2005). Thus, seemingly maladaptive behavior in one context may merely represent a byproduct of positive selection on behavior in another ecological context. We perceive animal personalities as a framework to address various questions in behavior, ecology, evolution, and developmental biology. The most important aspect of studying animal personality in different contexts is: (1) properly addressing the interindividual variation in the population instead of only the population mean. Indeed, recent studies emphasize the importance of taking the intra-specific phenotypic variation into account in addition to the mean (e.g., Benedetti-Cecchi 2003); (2) considering traits as facets in a broader trait suite, which either have been concomitantly evolved (e.g., via correlated selection) or that are induced by the same underlying physiological mechanisms. This multi-trait approach is favorable over classical (i.e., single trait) approaches because it provides a more comprehensive understanding of animals' evolution and behavior.

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<b>Jonathan Pruitt</b>	<b>1/1/2016 to 5/31/2018</b>	<b>\$81,346</b>
National Science Foundation		1626668

### **Collaborative Research: The Effects of Keystone Individuals on Collective Behavior**

Overview: Collective behavior emerges from self-organized interactions among group members. Despite the traditional model that all group members follow similar rules, in many systems certain individuals, referred to here as keystone individuals, may have a greater impact on collective behaviors than others. However, only little is known about how keystone individuals influence collective behavior or about the consequences of their presence on the collective success of the group. We propose to study the causative mechanisms by which keystone individuals affect collective behavior, the effects of keystones on the development of collective behaviors, and the ecological and evolutionary consequences of the presence of keystone individuals in a group. We will use a model system that allows for detailed experimental manipulations that will serve as a basis for generating broad theory on keystone individuals: the social spider *Stegodyphus dumicola*, which forms multi-female societies. Specifically, we will: (1) Test whether keystone individuals produce tradeoffs among group-level processes such as prey capture and pathogen transmission, and how these tradeoffs change group performance in different environments; (2) Probe the temporal dynamics of the effects of keystone individuals on the development of collective foraging and web building behaviors of groups in the field; (3) Elucidate the behavioral mechanisms (affiliative vs. agonistic interactions) that underlie the catalytic effects that keystone individuals have on the behavior of their fellow group members, and the collective behavior of the group; and (4) Design and parameterize a series of simple and versatile agent-based models that will uncover the general mechanisms by which keystones influence collective behavior. We will address these questions by combining lab and field experiments and analyses using sophisticated image analysis technology and social network analysis with computational modeling.

**Intellectual Merit:** By examining how keystone individuals influence the formation and function of collective behavior, we will advance our understanding of how complex systems operate and the role of animal personalities in their success. The ease with which our study system, social spiders, can be manipulated and studied at both the individual and the group levels, will allow the testing of rigorous hypotheses about the emergence of collective behavior that cannot be examined experimentally in other complex systems, such as the brain. Furthermore, our work will move forward the study of keystone individuals, which currently includes mostly anecdotal and correlative work and lacks fundamental theory, by conducting large scale experimental manipulations, employing state of the art data analysis, and developing a general conceptual model. The collaboration we propose will bring together two young and energetic PIs with expertise in studying the effects of individual variation on collective behavior, both in the lab and the field, in a wide array of social species, using a broad range of analytical techniques.

**Broader Impacts:** Both labs will continue their strong track record of mentoring students, K-12 education, and general public outreach activities. The proposed work will generate numerous undergraduate and graduate research projects. Both PIs are committed to the education of K-12 students through established and successful outreach programs and will continue to translate their work into appropriate lesson plans on collective behavior. Public outreach activities geared towards adult science education will continue in the form of public lectures and one-on-one conversations at local communities, both near the home institutions and the field sites of the PIs. The PIs and graduate students will continue to engage in outreach with local game park managers in southwest Africa, thus enhancing the public's understanding of invertebrate ecology. Finally, both PIs will disseminate their findings through scientific publications and by engaging with the public through various media outlets.

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**Langdon Quetin, Robin Ross**  
National Science Foundation

4/1/2011 to 9/30/2016

\$445,002  
ANT-1010688

**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 zooplankton > 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.

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**Andrew Rassweiler**  
UC Santa Cruz

**8/30/2013 to 12/31/2016**

**\$34,000**  
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://pyriferamap.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  
USDI National Park Service

8/15/2014 to 7/30/2016

\$40,000  
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.

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Dan Reed, Sally Holbrook,  
Carolynn Culver  
UC Sea Grant

2/1/2014 to 1/31/2017

\$172,360

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. horneri* is 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  
National Science Foundation

12/1/2012 to 11/30/2018

\$4,049,364  
ROA & REU support \$89,000  
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.

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Dan Reed  
COM National Marine Fisheries

8/1/2014 to 7/31/2016

\$50,000  
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.

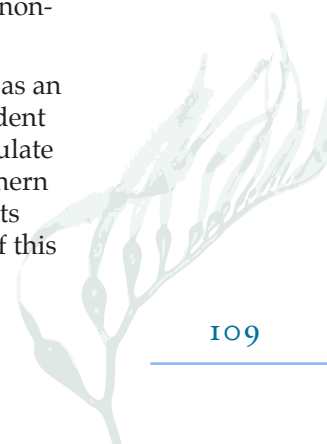
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<b>Dan Reed, Mark Page, Robert Miller, Craig Carlson, John Melack</b>	<b>2/1/2016 to 1/31/2017</b>	<b>\$199,500</b>
National Science Foundation		1623590

**RAPID: Tracing the Origin and Fate of Particulate Organic Matter in Nearshore Marine Sediments**

Overview: The unprecedented drought currently in its fourth year in California, coupled with the ongoing conditions of anomalously low ocean productivity and the prospect of one the strongest El Niños on record provide an unparalleled opportunity for researchers at the Santa Barbara Coastal LTER (SBC) to test specific hypotheses pertaining to the origin, distribution, processing and bioavailability of terrestrial organic matter in coastal marine sediments and their potential for serving as a reservoir of nitrogen storage to fuel nearshore primary production during periods when nitrate concentrations are low. RAPID funds will be used to: (1) measure bulk properties and biomarker tracers of particulate organic matter (POM) in stream water and in coastal marine sediments at SBC sites differing in exposure to terrestrial runoff prior to and following large storm events, and (2) determine the bioavailability of dissolved organic matter (DOM) released from POM in marine sediments following large runoff events. The proposed work will complement and inform SBC’s ongoing research investigating the availability and utilization of recycled forms of nitrogen in supporting the primary production of nearshore macrophytes and phytoplankton during non-upwelling periods when nitrate concentrations are consistently low.

Intellectual Merit: Material exchange between ecosystems is being increasingly recognized as an important determinant of many ecological patterns and processes. Nowhere is this more evident than in the highly productive coastal zone, which receives large amounts of terrestrial particulate organic (POM) matter through stream and river discharge. In semi-arid regions such as southern California, the delivery of terrestrial POM to the nearshore is largely restricted to storm events that are intensified during El Nino years of above average rainfall. The processing and fate of this



material is poorly known, yet there is growing evidence that it could contribute significantly to nearshore productivity. Our proposed research will help to fill a critical knowledge gap pertaining to the origin, distribution, processing of terrestrial POM and its potential to serve as a reservoir of nitrogen storage for nearshore primary production during periods of the year when marine sources of dissolved inorganic nitrogen are low.

**Broader Impacts:** Research on this award will be done in close collaboration with the Santa Barbara Coastal Long Term Ecological Research program (SBC). As such it will augment SBC's strong contribution to student training and mentoring in interdisciplinary research at the undergraduate, graduate, and post- doctoral levels. Specifically, two SBC graduate students and one post-doctoral researcher and numerous (~ 10) undergraduates will directly participate in the proposed research. Outcomes will be incorporated into SBC's ongoing Schoolyard LTER program, which is organized around a theme of kelp forest ecology and land-ocean exchanges and aimed at long-term connections with underserved, low-achieving schools that include year-round on and off campus activities. We have developed formal partnerships with local cities and Santa Barbara County to develop vulnerability assessments of the regions coastal ecosystems and we will incorporate the findings from this study into those assessments.

**Daniel Reed**  
National Science Foundation

9/1/2012 to 8/31/2016

\$264,575  
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.

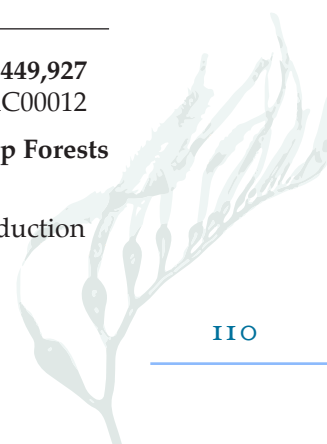
**Daniel Reed**  
USDI Bureau of Ocean Energy Management (BOEM)

9/22/2011 to 3/31/2017

\$449,927  
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.

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<b>Daniel Reed, Stephen Schroeter</b>	<b>1/1/2016 to 12/31/2017</b>	<b>\$5,362,124</b>
<b>Mark Page</b>		
Simpson & Simpson		SB160079

**San Onofre Nuclear Generating Station Mitigation Project Monitoring Program, 2016-17**

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.

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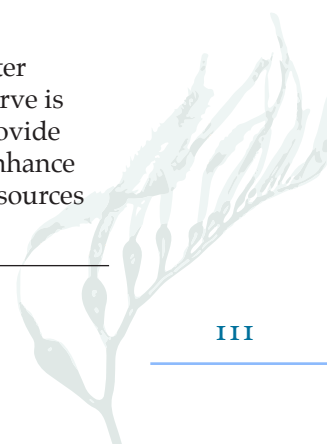
<b>Cristina Sandoval, Sue Swarbrick</b>	<b>9/22/2015 to 6/30/2020</b>	<b>\$61,920</b>
USDI Fish and Wildlife Service		F15AP00672

**Exhibits for the Coal Oil Point Reserve Nature Center**

The UCSB Coal Oil Point Reserve (COPR) will renovate a 5,390 square foot building adjacent to the Reserve on the former Devereux School property that will serve as a Nature Center (the Center) as well as a the new headquarters for COPR’s ongoing education, scientific research, and environmental stewardship programs.

Our vision for this Center is to maximize the Reserve’s potential for research and teaching and for the public to learn about and engage in natural history, conservation, and restoration. The Reserve already serves over 6,000 people of all ages each year, but has lacked an appropriate space to support outreach activities. The Nature Center will provide a place to train tour guides and the docents supporting the Reserve’s Snowy Plover Management Program, and provide interpretive and interactive displays for visitors. Having facilities for lectures and discovery will expand opportunities for the Reserve staff and volunteers to implement education programs and facilitate research. When the building is completed, we expect to 30% more research projects, which is typical of other reserves with a field station. We also expect to increase the visitation for education by 50%.

The displays located in the large meeting room will be a central attraction of the Nature Center that will convey information about the COPR ecosystem and special status species. The Reserve is home to several threatened and endangered species. The Reserve’s educational programs provide opportunities to view these species in their natural habitat. The displays in the Center will enhance a visitor’s experience at the Reserve by providing an introduction to the Reserve’s natural resources prior to a tour or other programmed activity.





**Cristina Sandoval, Sue 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.

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**Cristina Sandoval, Sue 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.

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**Cristina Sandoval, Sue Swarbrick** 10/23/2015 to 10/22/2016 \$25,000  
Santa Barbara Foundation SB160063

### **Coal Oil Point Natural Reserve Nature Center**

Nature centers are important facilities that engage communities in efforts to sustain natural areas by providing opportunities and programs to enrich our connection to nature. The centers become hubs for education, research and outreach activities and broaden our experiences and knowledge of the natural world. The Coal Oil Point Reserve (COPR) requests \$25,000 to assist in the creation of a new Nature Center adjacent to the Reserve. The Center will provide information about the Devereux watershed and the Reserve's natural resources available to academic users and public visitors, including information about research at the Reserve, which is typically not available to the general public. The Nature Center project will renovate a 5,390 sq. ft. university-owned building. The renovations will bring the structure into compliance with the current CA building codes, upgrade utility systems, add public restrooms, and repurpose interior rooms to provide spaces for lectures, classes, researchers, events and educational displays. The Center will include a large meeting room, a classroom, a wet lab, a library, a conference room, a work room, offices, a kitchen and space for informational displays about the Reserve's natural resources and research. We have completed the schematic designs for the renovation and envision completing the construction project in 2 phases so that we can initiate phase 1 before we reach our total funding goals. When phase 1 is completed, the building can be occupied and will meet the Reserve's basic needs. The elements of the project in



phase 2 are key to making the facility a fully functioning Nature Center. We have secured the funding to complete phase 1. The SB Foundation grant will be the bridge into phase 2; we can leverage the SB Foundation grant to fuel the final push to fully fund the project (although we can proceed with the SBF funded project even if no further funds were raised.)

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**Russell Schmitt, Sally Holbrook**  
National Science Foundation

9/1/2012 to 8/31/2016

\$4,732,736  
OCE-1236905

**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<sub>2</sub>: 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.

**Stephen Schroeter**  
California Sea Urchin Commission

7/1/2006 to 6/30/2016

\$103,978  
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 Svejksky 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.

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**Scott Simon, Mark Brzezinski**  
UC San Diego

2/1/2015 to 6/30/2016

\$7,976  
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.

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**Scott Simon, Michele Johnson**  
NOAA

8/1/2015 to 7/31/2016

\$59,968  
NA15NOS4290030

### **Oceans-to-Classrooms Watershed Education and Training Program**

Summary of work: This Oceans-to-Classrooms Watershed Education and Training Project consists of two main activities: 1) a five-day, 40-hour professional development workshop for teachers from the Santa Barbara Unified School District, and 2) three meaningful watershed educational experiences

for the students of these teachers during the school year. This project will train and support 22 6th grade teachers and their 700 students in watershed and coastal marine science and ocean acidification, and spend \$150 per student from the total project cost.

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<b>Thomas Turner</b> NIH General Medical Sciences	<b>8/1/2011 to 5/31/2017</b>	<b>\$1,151,408</b> 5R01 GM098614-04
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### **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.

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<b>David Valentine</b> National Science Foundation	<b>10/1/2013 to 9/30/2016</b>	<b>\$341,714</b> OCE-1333162
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### **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.

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<b>David Valentine</b>	<b>7/1/2013 to 1/1/2016</b>	<b>\$400,000</b>
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, Debora Iglesias-Rodriguez, Robert Miller** 7/1/2015 to 3/31/2017 \$588,041  
Simons Foundation 385324

### **The Refugio Oil Spill as a Microbial Laboratory**

The oil spill at Refugio provides a unique opportunity to understand how the marine ecosystem responds to acute disturbance. The disturbance in this case was the discharge of 101,000 gallons of heavy crude oil from the rupture of Line 901, more than 20,000 gallons of which flowed overland before spilling onto the beach and into the coastal ocean. Once in the ocean the heavy oil was physically and chemically transformed in unexpected ways— including rapid submergence of some oil to the sea floor— while some oil was transported more than 100 miles at the sea surface, and other oil was rapidly entrained in sand, sediment and ‘tumble-tar’. This massive disturbance to the ecosystem was captured beginning with the first days of the spill because of the accessibility of the site to UCSB scientists, with Refugio located just ten miles from the UCSB campus. Proposal personnel mounted an immediate scientific response and were sampling at the spill site within 6 hours of the initial discharge, and sampling offshore by the following morning. The sampling campaign initiated on day zero has been continued and the observations from these efforts feed the scientific questions that underpin this proposal. The Goal of this research is to use the Refugio event as a laboratory to understand how marine ecosystems respond to disturbance, with a focus on the microbial populations. The heavy oil discharged at Refugio inundated marine microbes – phytoplankton bacteria – archaea and viruses. We seek to understand how the inundation impacted the microbes in the context of ecosystem disturbance, but also how the microbial survivors adapted to the oil and subsequently affected the behavior and fate of the oil. To maximize the impact of this research program, we have chosen to focus this proposal on three specific themes that capitalize on the unique aspects of this event, on the expertise of UCSB’s marine scientists, and on the proximity to the site. Each theme considers microbial populations with different ecological roles.

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**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**

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 16S rRNA 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.

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**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 Methanotrophic Marine Ecosystems**

This project 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.

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<b>David Valentine</b>	<b>3/21/2013 to 3/31/2016</b>	<b>\$335,419</b>
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.

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<b>David Valentine</b>	<b>6/1/2012 to 5/31/2016</b>	<b>\$388,632</b>
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.

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<b>Herb Waite</b> National Science Foundation	<b>6/1/2015 to 5/31/2017</b>	<b>\$76,731</b> 1508717
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**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.

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<b>Herb Waite, Kollbe Ahn</b> Korean Institute of Industrial Technology	<b>3/1/2015 to 12/31/2015</b>	<b>\$31,236</b> SB150164
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**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 catechol 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.

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<b>J. Herbert Waite</b>	<b>9/1/2013 to 8/31/2016</b>	<b>\$496,954</b>
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.

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<b>Herbert Waite, Kolbe Ahn</b>	<b>7/31/2013 to 1/29/2016</b>	<b>\$577,836</b>
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/cm<sup>2</sup>) underwater comparable to dry-tack strength (2.5 N/cm<sup>2</sup>) 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.

Robert Warner  
Boston University

3/1/2013 to 2/28/2017

\$29,317  
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).

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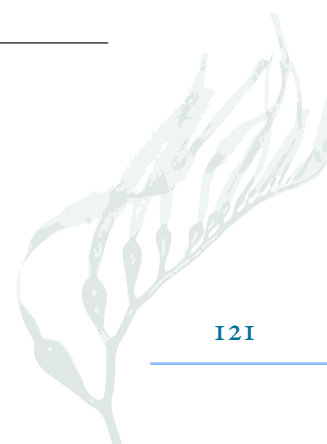
Libe Washburn, Mark Brzezinski  
UC San Diego

6/1/2010 to 5/31/2016

\$1,582,297  
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.





**Southern California Regional Coastal Ocean Observing System: Surface Current Mapping (HFR) and Quality Control (QC)**

**Task Title: HF Radar Operations**

Washburn's research group will operate a network of HF radar systems designed to measure ocean surface currents and developed with funding from NOAA/IOOS. 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 for the UCSB component of the SCCOOS HF radar system.

The systems are operated by Washburn's research group at UCSB in collaboration with Ian Robbins and other HF radar technicians at the California Polytechnic State University, San Luis Obispo (CalPoly). Washburn's group will also collaborate with Dean Wendt and Ryan Walter of CalPoly in the operation of the radars. The systems are deployed from Nicholas Canyon in the south to Ragged Point in the north.

**HF Radar Operations total: \$300,800**

**Task Title: HF Radar Quality Control**

Brian Emery and Libe Washburn will continue development of software tools for monitoring the quality of IOOS HF radar data. Emery will be the principal programmer on the project and he will consult with Washburn and other members of Washburn's research group during the project. The software tools will generate operational, real-time comparisons of time-series from overlapping HF radar sites in NOAA/IOOS Surface Current Mapping Network. These include comparisons along the baseline between two sites (baseline comparisons), and what we define as pseudo-radial comparisons: the use of two or more sites to generate radials to compare with measured radials from another site. Automated real-time comparisons will provide the metrics HF radar operators need to efficiently and objectively monitor the quality and consistency of HF radar radial data. We intend these metrics for use by regional associations, program managers and NOAA officials to assess network health and function.

An important objective is to develop a framework for objectively monitoring IOOS HF radar data quality. The proposed framework will also enable the assessment and validation of elliptical surface current components produced with multi-static software.

We will continue developing a MATLAB toolbox for:

- (1) Automatically comparing baseline radial currents;
- (2) Automatically comparing radials for a given site with radials components derived from other sites. We call this procedure pseudo-radial comparisons.

Development of the toolbox for automated calculation and visualization includes:

- Determining sites with where over-water baselines and pseudo radials can be computed;
- Determining the optimal comparison areas such as over a range of bearings or along portions of baselines;
- Establishing time series of useful metrics (e.g., root-mean-square (RMS) differences, and  $r^2$ );
- Constructing useful visualizations of results for operators.

**HF Radar Quality Control total: \$86,000**



**Libe Washburn**  
National Science Foundation

9/15/2010 to 8/31/2016

\$698,120  
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.

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**Syee Weldeab**  
National Science Foundation

5/1/2015 to 6/30/2016

\$55,237  
1546298

### **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.

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**Syee Weldeab, David Lea**  
National Science Foundation

7/1/2013 to 12/31/2016

\$366,804  
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.

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<b>Allison Whitmer</b>	<b>10/1/2008 to 9/30/2015</b>	<b>\$2,379,943</b>
Colorado State University		G-3062-76

**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.

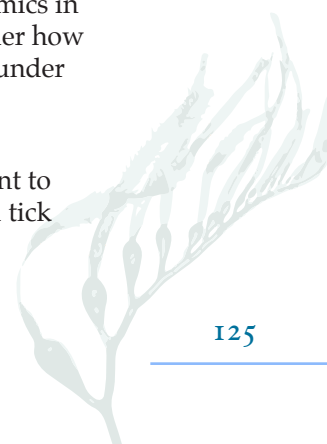
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<b>Hillary Young</b>	<b>5/1/2016 to 4/30/2019</b>	<b>\$119,499</b>
National Science Foundation		1556786

**SG Collaborative Research: The Changing Role in Watering Holes in Concentrating Parasites in a Changing Climate**

**Overview:** Watering holes (WHs) are iconic for their role in aggregating animals in dryland ecosystems, and any form of animal aggregations should tend to increase disease transmission risk. In addition, WHs may change microclimatic effects so as to favor parasite development and survival, contributing to heterogeneity in disease risk across a landscape. This study will examine the effect of WHs on parasite concentration and, ultimately, on landscape scale disease dynamics in a well-studied East African savanna ecosystem. The proposed research will especially consider how climate change modifies these dynamics of aggregation and habitat suitability for parasites, under different climate change scenarios for East Africa.

This project will use a complementary combination of observational study, experimental manipulation, and individual based models. Specifically, this study will (1) examine the extent to which WHs increase risk of three regionally important parasite groups (helminths, ticks, and tick



borne pathogens) using an observational study of 26 WH and control sites set across an established climatic gradient. (2) It will experimentally test these effects using an experimental drain and fill design at five pairs of watering pans. (3) It will experimentally examine the relative importance of host aggregation versus microclimatic factors as drivers of parasitism near WHs, via an established and replicated enclosure experiment along a climatic gradient. (4) It will then examine the landscape scale consequences of WHs on disease for multiple pathogens using individual based models that scale up from a single host species to a multiple host community. Collectively these efforts will identify the extent to which WHs affect parasite transmission risk for various parasites, and the extent to which they are likely to change under changing climatic and anthropogenic conditions, such as defaunation or increased water extraction.

**Intellectual Merit:** In terms of Intellectual Merit, this research will add crucial insights to the overlooked role of essential resources as sources of within- and between-species transmission of disease, while also incorporating effects of climate change on rainfall. An extensive and growing body of literature has examined the role of climate change on parasitism and disease dynamics. Yet, most of this work has focused on direct effects, mostly of temperature change, on parasite growth, life history and range shifts. Empirical research on WH effects on parasitism is essential given the importance of WHs to wildlife, livestock, and humans in dryland ecosystems globally, and the economic and health importance of wildlife borne diseases in these ecosystems. Given the rapid changes in water regimes and wildlife communities that are already occurring in many dryland ecosystems, it is critical to understand the ecology of infectious disease in relation to WHs.

**Broader Impacts:** In terms of Broader Impacts, this project, through partnerships with the UCSB KIN program, will reach a large number of underserved grade school children in California, while simultaneously training future school teachers in concepts of ecology and ecosystem services. Likewise, through partnership with Daraja Academy this project will be able to spread similar lessons in sustainability and environmental science to high achieving Kenyan girls that come from impoverished families near to the study sites. The combination of internships and classroom teaching will give these girls tangible skills and experiences in science in their final year of school. This project will supplement training for a graduate student researcher, provide training for a young scientist with a B.S. or B.A. looking for research experience prior to grad school, and support extensive undergraduate research, with a priority given to underrepresented groups for all cases. Given the potential importance of climate change on infectious disease dynamics, results will also have applied value for public health in dryland ecosystems. Specifically the research and models may help in creating clear predictions for likely consequences of water draw-down and wildlife loss on disease in changing climatic conditions. Finally, the research team will publish open-access publications, post all raw data and models in long-standing repositories, and present results at national and international meetings.

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**Hillary Young, Kevin Lafferty**  
National Science Foundation

6/1/2015 to 5/31/2018

\$529,143  
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.

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<b>Hillary Young</b>	<b>6/1/2014 to 5/30/2016</b>	<b>\$107,954</b>
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.

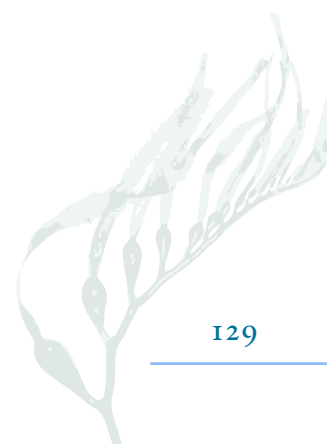


**Collaborative Research: Holistic Integration for Arctic Coastal-Marine Sustainability (HIACMS)**

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](http://www.arcus.org/search)) and ACCESS (Arctic Climate Change, Economy and Society: [www.access-eu.org](http://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](http://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.iaaos-equipex.upmc.fr](http://www.iaaos-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.

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# SPACE



# Marine Science Research Building Bldg. No. 520 - 1st floor 06/2016

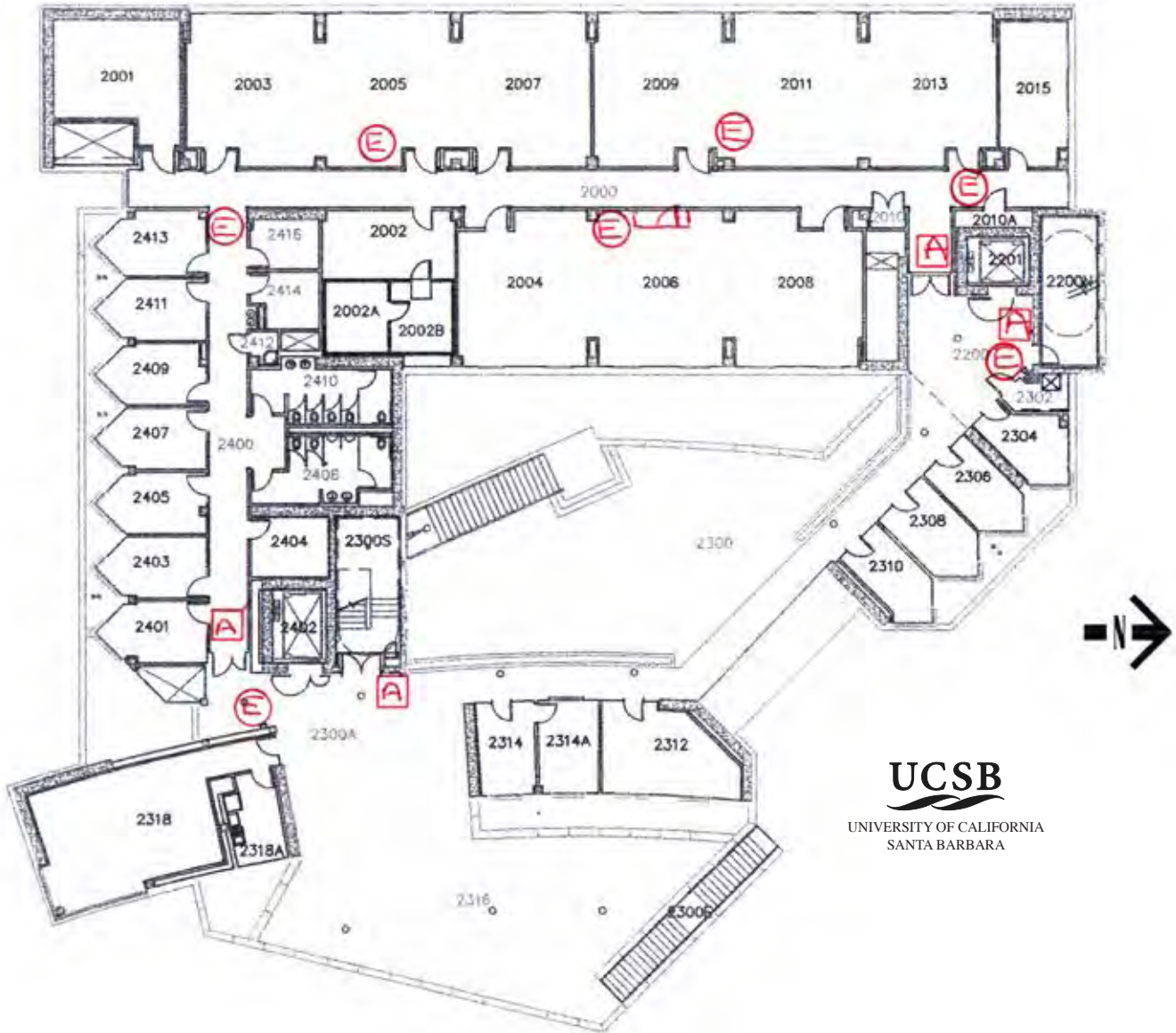


**UCSB**  
UNIVERSITY OF CALIFORNIA  
SANTA BARBARA

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 06/2016



**UCSB**  
UNIVERSITY OF CALIFORNIA  
SANTA BARBARA

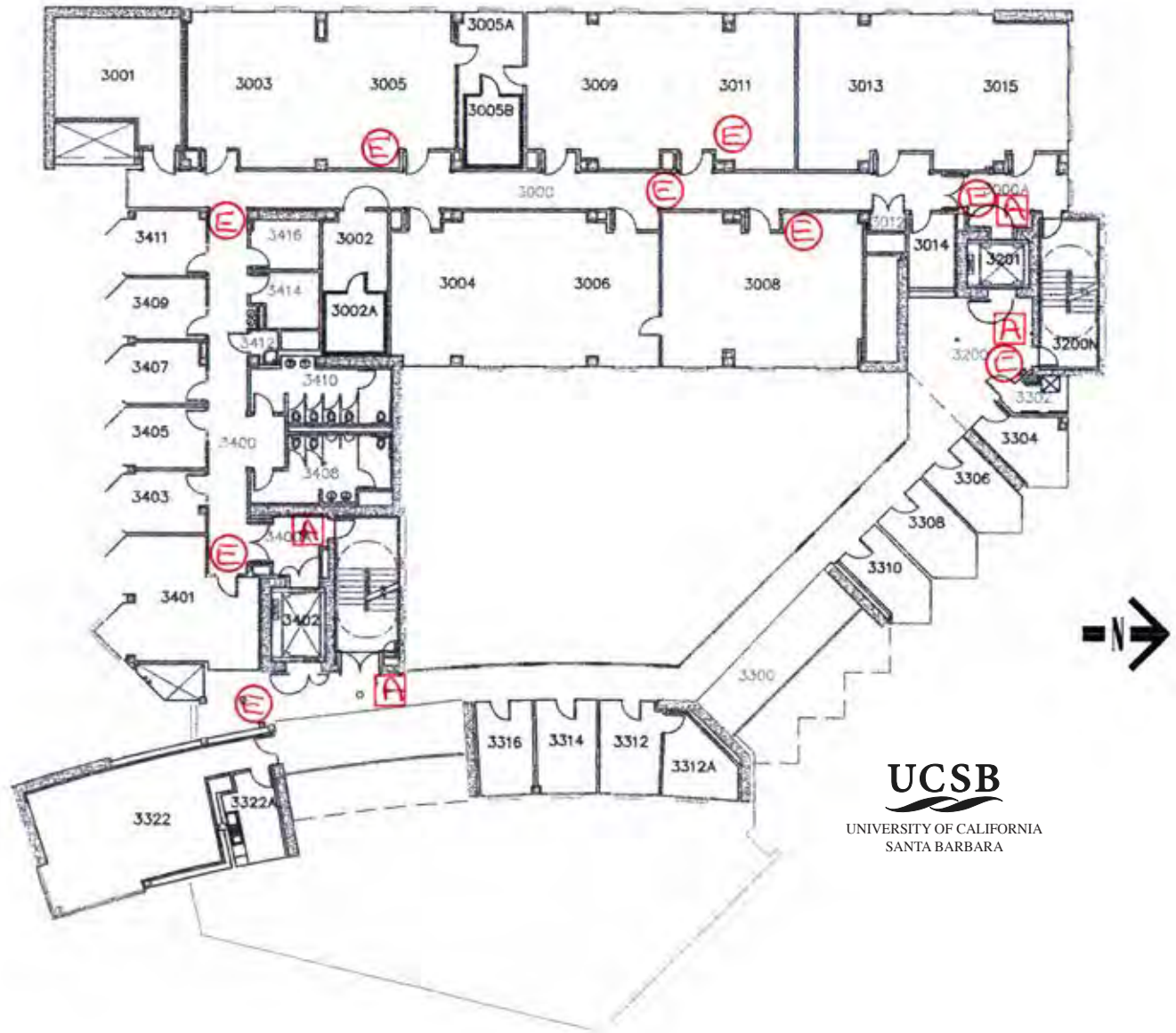
2001	Seawater workroom
2002	Common support laboratory
2002a	Environmental room
2002b	Environmental room
2003	Hofmann laboratory
2004	Miller laboratory
2005	Hofmann laboratory
2006	Miller laboratory
2007	Hofmann laboratory
2008	Shared laboratory
2009	Burkpile laboratory
2011	Burkpile laboratory

2013	Burkpile laboratory
2015	SONGS project
2304	Postdoc office
2306	Erika Eliason
2308	Kevin Lafferty
2310	Bob Miller
2312	Benioff Ocean Initiative
2314	Benioff Ocean Initiative
2314a	Benioff Ocean Initiative
2318	Conference room
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 06/2016

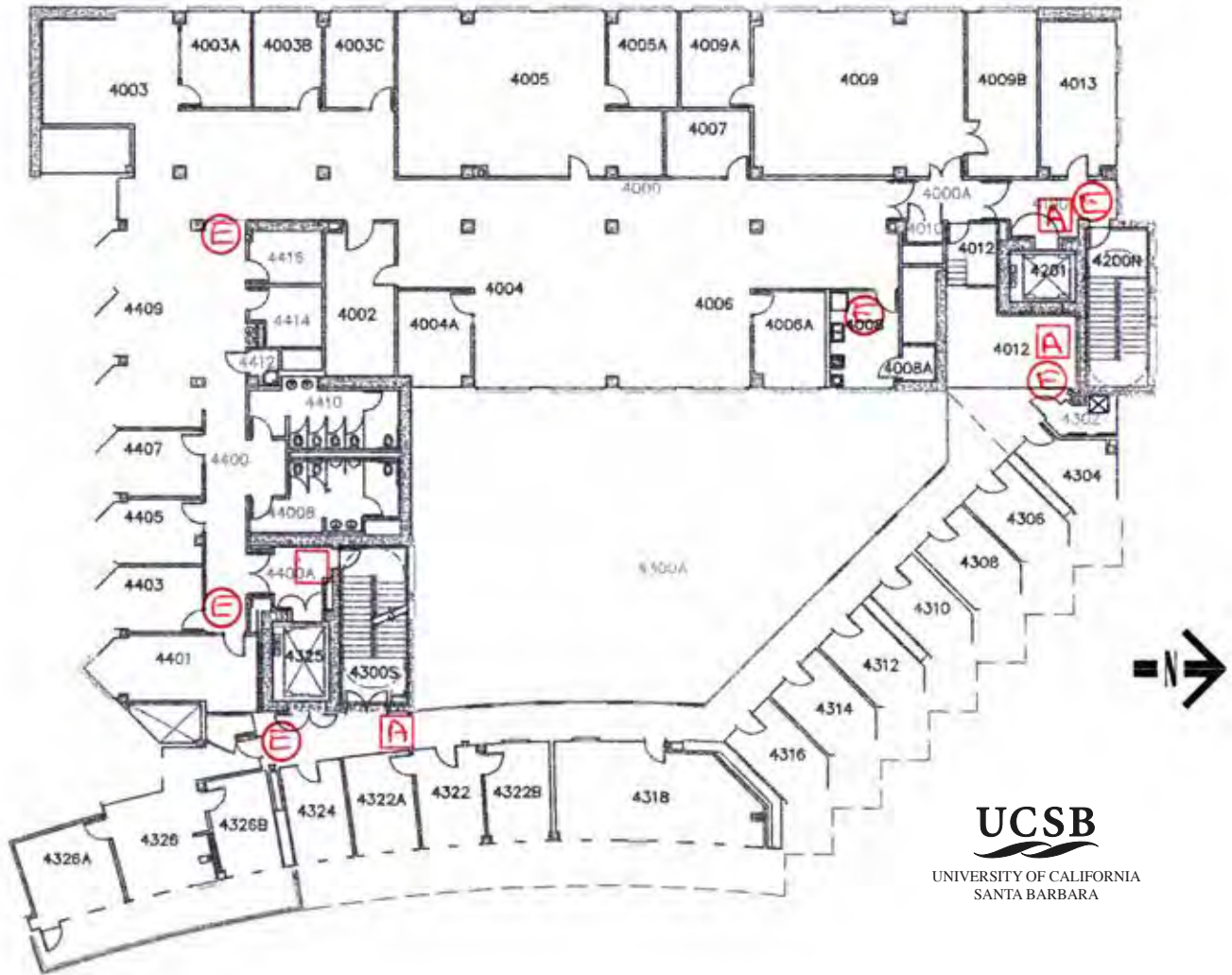


3001	Seawater workroom
3002	Common support laboratory
3003	Reed laboratory
3004	Holbrook laboratory
3005	Reed laboratory
3005a	Common support laboratory
3006	Schmitt laboratory
3008	Blanchette laboratory
3009	Warner laboratory
3011	Caselle laboratory
3013	Washburn laboratory

3014	Storage
3015	MacIntyre laboratory
3304	Postdoc office
3306	Postdoc office – Rassweiler
3308	Dan Reed
3310	Andrew Brooks
3312	Postdoc office
3312a	Postdoc office
3314	Russell Schmitt
3316	Sally Holbrook
3322	Conference room

3401	Margaret O'Brien – Mary Gastil-Buhl
3403	Kolbe Ahn
3405	BON
3407	BON
3409	Ross-Quetin
3411	Researcher office

# Marine Science Research Building Bldg. No. 520 - 4th floor 06/2016



**UCSB**  
UNIVERSITY OF CALIFORNIA  
SANTA BARBARA

4002	Receiving
4003a	Ocean o'Graphics – Monica Pessino
4003b	NRS
4003c	NRS
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	Lennon Thomas

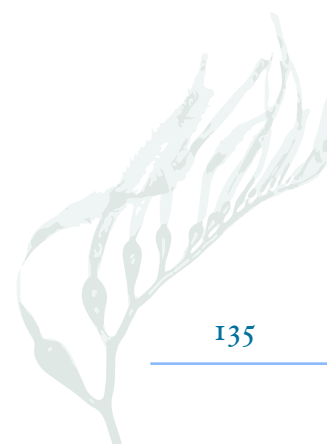
4322a	Michaela Clemence
4322b	Robert Warner
4326b	Kiya Gornik
4326	Development
4326a	MSI Director
4401	Tim Schmidt
4403	Joyce Wolever
4405	Luisa Velez
4407	Bonnie Williamson
4409a	Lynne Van Der Kamp
4409b	Deanna Cervantes
4409C	Donna Dobis

# 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



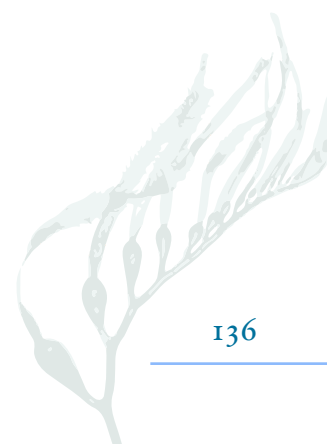
# STATISTICAL SUMMARY





# Research Support Summary 2015-2016

	Awards	Percentage of Total
<b>Federal Agencies</b>		
National Aeronautics and Space Administration (NASA)	\$687,733	3.16%
National Science Foundation-NSF	\$5,572,386	25.58%
National Institutes of Health (NIH)	\$838,371	3.85%
USDA, Forest Service	\$196,000	0.90%
USDC National Oceanic and Atmospheric Administration (NOAA)	\$99,968	0.46%
USDI Bureau of Ocean Energy Management	\$774,557	3.56%
USDI Fish and Wildlife Service	\$341,864	1.57%
USDI Geological Survey	\$233,328	1.07%
USDI National Park Service	\$89,087	0.41%
US Environmental Protection Agency	\$576,751	2.65%
<b>Federal Totals</b>	<b>\$9,410,045</b>	<b>43.21%</b>
<b>State</b>		
California Coastal Conservancy	\$300,000	1.38%
California State University, Chico	\$50,759	0.23%
CSU San Diego State University	\$76,836	0.35%
Southern California Coastal Water Research Project	\$36,669	0.17%
UC Agriculture and Natural Resources	\$12,866	0.06%
UC MEXUS	\$34,999	0.16%
UC San Diego	\$462,579	2.12%
UC Santa Cruz	\$80,369	0.37%
UC Sea Grant College Program	\$271,886	1.25%
Ventura County	\$1,349,008	6.19%
<b>State Totals</b>	<b>\$2,675,971</b>	<b>12.29%</b>



## Private

Amec (Great Britain)	\$56,268	0.26%
Bermuda Institute of Ocean Sciences	\$219,480	1.01%
California Artificial Reef Enhancement (CARE)	\$150,000	0.69%
California Institute of Technology – Cal Tech	\$119,897	0.55%
Conservation International Foundation	\$28,125	0.13%
David and Lucile Packard Foundation (The)	\$300,000	1.38%
Marisla Foundation	\$175,000	0.80%
Nature Conservancy (The)	\$499,148	2.29%
OCEANA, Inc.	\$187,270	0.86%
Oregon State University	\$238,188	1.09%
Pepperdine University	\$5,126	0.02%
Phoenix Zoo	\$3,000	0.01%
Rare. Inspiring Conservation	\$50,000	0.23%
Roy F. Weston, Inc.	\$99,036	0.45%
Safari Club International	\$40,000	0.18%
Santa Barbara Foundation	\$25,000	0.11%
Simons Foundation	\$588,041	2.70%
Simpson And Simpson Business And Personnel Services, Inc.	\$5,362,124	24.62%
Texas A&M University	\$161,106	0.74%
U.S.-Israel Binat'l Science Foundation (BSF) (Intl)	\$24,767	0.11%
University of Georgia	\$320,339	1.47%
University of Hawaii	\$137,718	0.63%
University of Miami	\$152,046	0.70%
University of Minnesota	\$7,375	0.03%
University of Southern California	\$125,802	0.58%
Waitt Family Foundation	\$600,000	2.75%
World Wildlife Fund, Canada	\$19,491	0.09%

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<b>Private Totals</b>	<b>\$9,694,347</b>	<b>44.50%</b>
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<b>Total</b>	<b>\$21,780,363</b>	<b>100.00%</b>
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# Statistical Summary for the Marine Science Institute 2015-2016

	MSI	NRS	TOTAL
<b>1. Academic personnel on payroll</b>			
a. Faculty	24	1	25
b. Professional Researchers (including Visiting)	29	0	29
c. Project Scientists	11	0	11
d. Specialists	41	1	42
e. Postdoctoral Scholars	35	0	35
f. Postgraduate Researchers	0	0	0
g. Academic Coordinators	1	0	1
<b>TOTAL</b>	<b>141</b>	<b>2</b>	<b>143</b>

<b>2. Graduate Students on payroll</b>			
a. Employed on contracts and grants	63	0	63
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
<b>TOTAL</b>	<b>63</b>	<b>0</b>	<b>63</b>

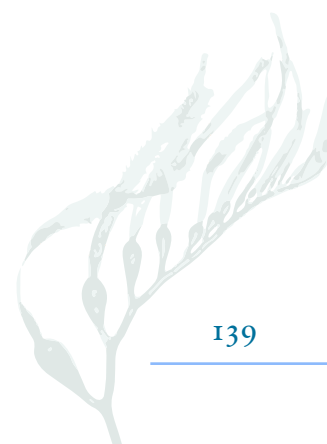
<b>3. Undergraduate Students on payroll</b>			
a. Employed on contracts and grants	142	11	153
b. Employed on other funds	0	0	0
c. Number of volunteers, & unpaid interns	0	0	0
<b>TOTAL</b>	<b>142</b>	<b>11</b>	<b>153</b>

<b>4. Participation from outside UCSB: (optional)</b>			
a. Academics (without Salary Academic Visitors)	0	0	0
b. Other (specify)	0	0	0
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>0</b>

<b>5. Staff (Univ. &amp; Non-Univ. Funds):</b>			
a. Technical	133	25	158
b. Administrative/ Clerical	20	17	37
<b>TOTAL</b>	<b>153</b>	<b>42</b>	<b>195</b>

6. Seminars, symposia, workshops sponsored	-	-	0
7. Proposals submitted	156	-	156
8. Number of different awarding agencies dealt with*	124	-	124
9. Number of extramural awards administered	247	-	247
10. Dollar value of extramural awards administered during year**	\$81,013,843	-	\$81,013,843
11. Number of Principal Investigators***	115	-	115
12. Dollar value of other project awards ****	\$1,454,691	\$3,070,136	\$4,524,827
13. Number of other projects administered	77	34	111
14. Total base budget for the year (as of June 30, 2010)	\$1,534,648	\$793,292	\$2,327,940
15. Dollar value of intramural support	\$114,852	\$9,691	\$124,543
16. Total assigned square footage in ORU	38,807	-	38,807
17. Dollar value of awards for year (2010 Total)	\$21,780,363	-	\$21,780,363

* 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.



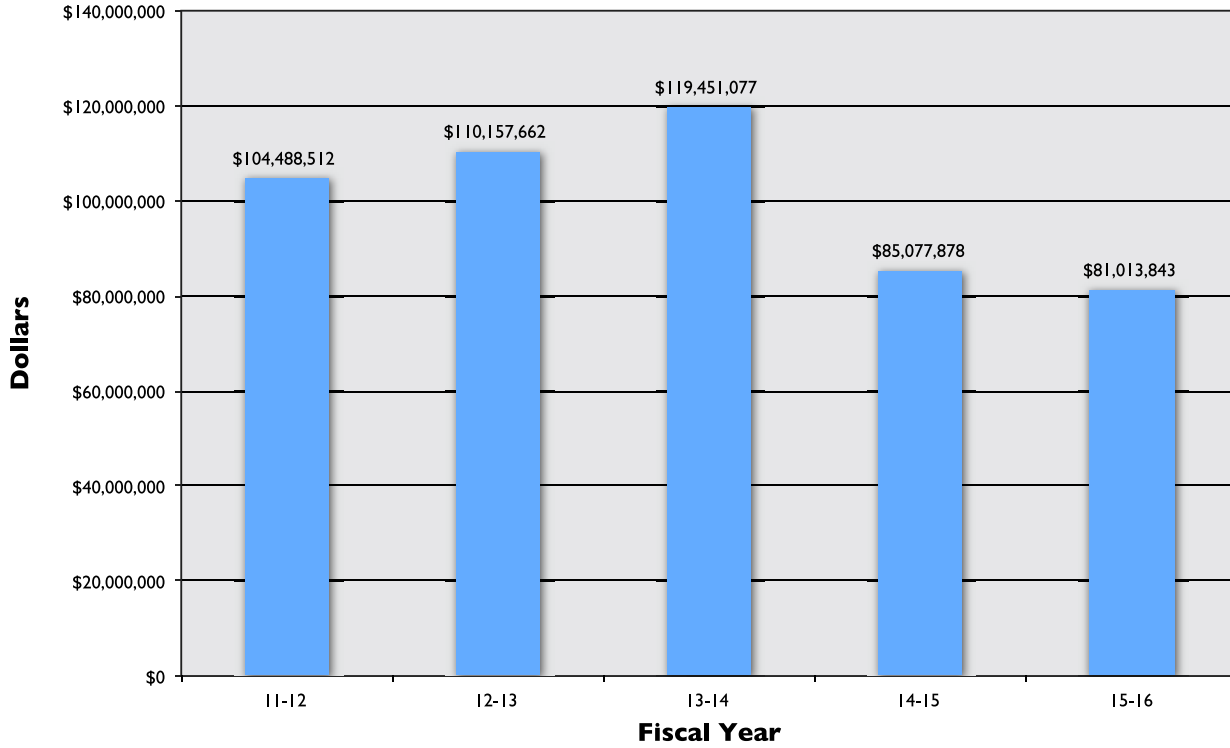
## Five-Year Statistical Summary 2011-2016

	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
1. Academic personnel engaged in research					
a. Faculty	25	19	18	27	25
b. Researchers/ Project Scientists	47	58	58	32	40
c. Visiting Researchers					
d. Specialists/ Academic Coord/ Academic Admin.	48	46	40	40	42
e. Postdoctorals/ Postgraduates	47	37	36	28	36
<b>Total</b>	<b>167</b>	<b>160</b>	<b>148</b>	<b>127</b>	<b>143</b>
2. Staff (Univ. & Non-Univ. Funds)					
a. Technical	167	175	167	125	158
b. Administrative/Clerical	58	58	46	36	37
<b>Total</b>	<b>225</b>	<b>233</b>	<b>213</b>	<b>161</b>	<b>195</b>
3 Graduate students employed by MSI	45	54	47	51	63
4. Undergraduate students employed by MSI	147	146	140	122	153
5. Publications	1**	1**	1**	1**	1**
6. Seminars, symposia, workshops, etc., sponsored by MSI					
7. Proposals submitted	187	142	159	161	156
8. Annual extramural awards	\$22,747,308	\$20,980,522	\$20,515,654	\$18,017,630	\$21,780,363
9. Extramural awards administered	251	247	262	231	247
10. Other project awards	\$4,479,085	\$4,042,529	\$3,953,513	\$2,574,097	\$4,524,827
11. Other projects administered	99	80	34	93	111
12. MSI base budget	\$1,085,010	\$919,082	\$1,406,831	\$1,643,266	\$2,327,940
13. Intramural support	\$623,925	\$726,518	\$88,978	\$87,525	\$124,543
<b>14. Total Funds Administered</b>	<b>\$112,733,656</b>	<b>\$117,642,277</b>	<b>\$126,564,018</b>	<b>\$90,505,464</b>	<b>\$87,991,153</b>

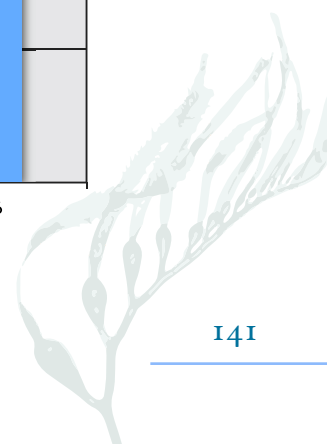
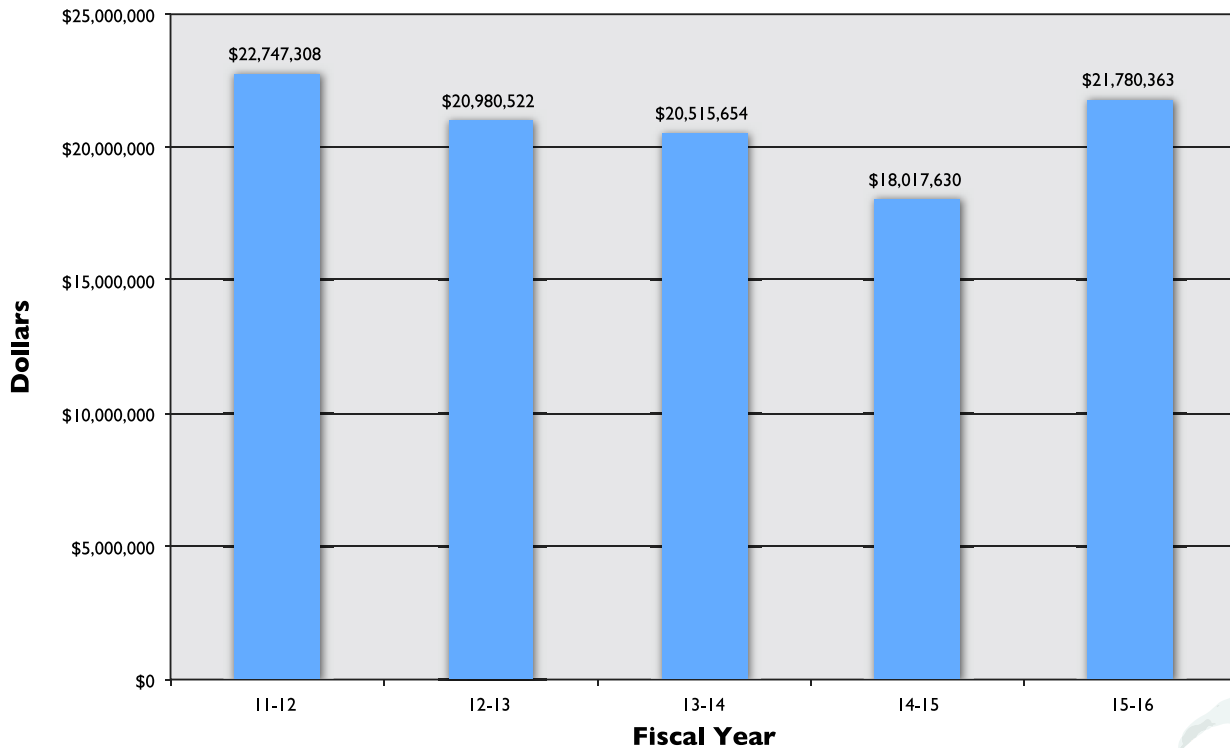
\*\*Only Departmental Publications



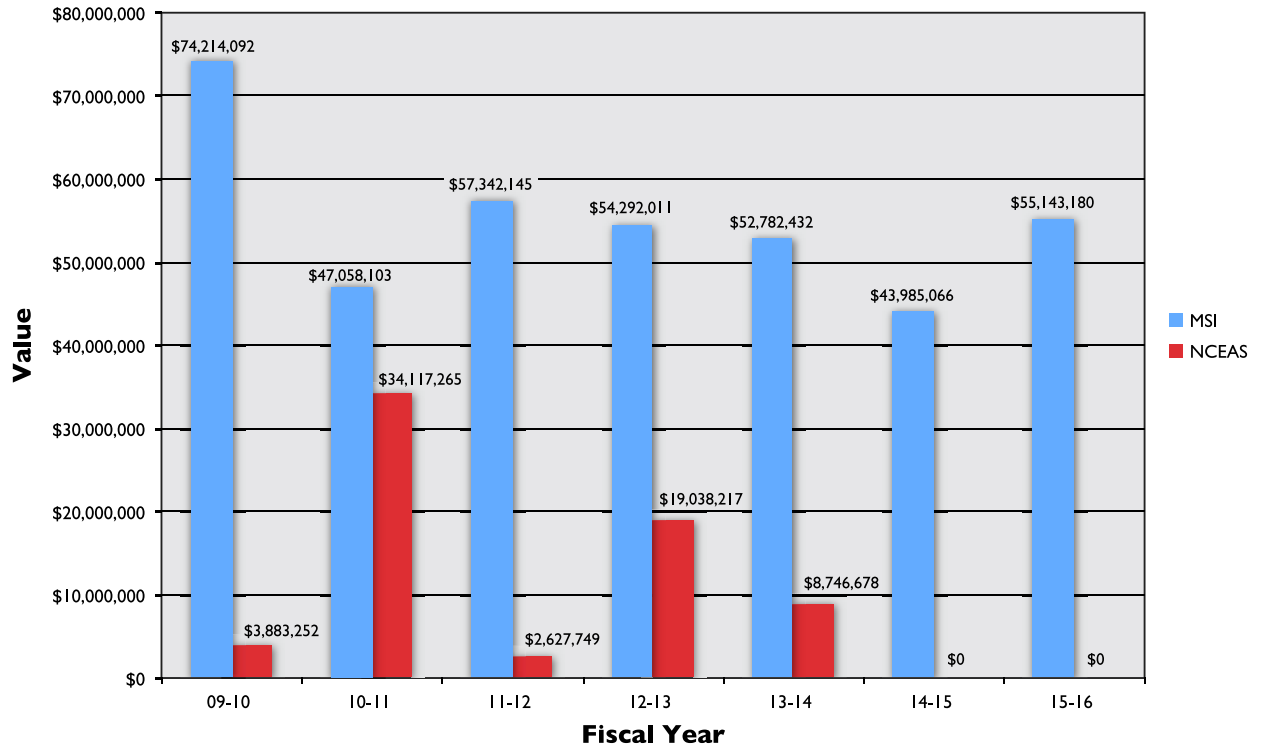
## Marine Science Institute - Total Value of Awards Administered



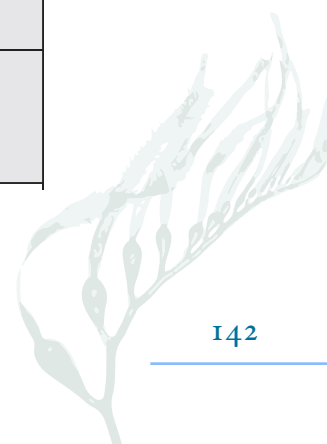
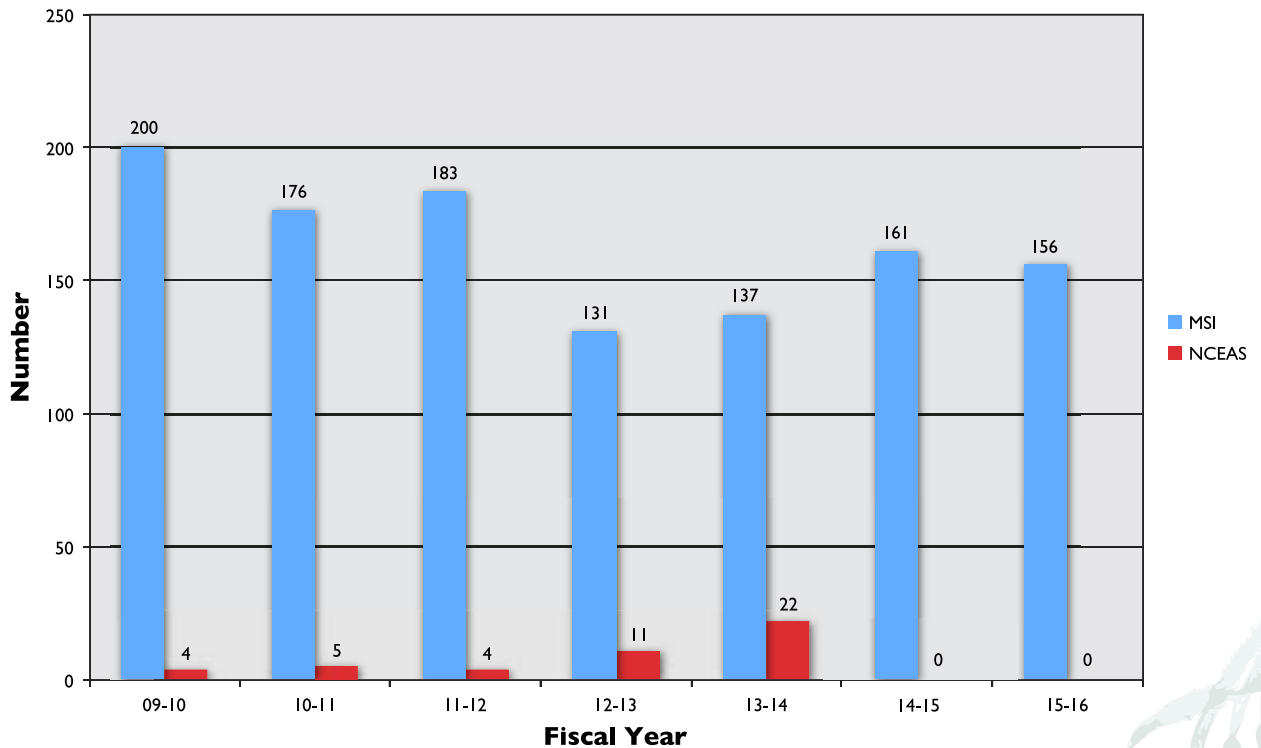
## Marine Science Institute - Value of Extramural Awards Received Annually



## Value of Proposals Submitted Annually by MSI & NCEAS



## Number of Proposals Submitted Annually by MSI & NCEAS



## Funding Agencies 2015-2016

Alfred P. Sloan Foundation  
AMEC (Great Britain)  
American Vineyard Foundation  
Arthritis Foundation  
Australian Museum  
Bermuda Institute of Ocean Sciences  
Boston University  
California Artificial Reef Enhancement (CARE)  
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)  
Cal Poly University, San Luis Obispo  
California Sea Urchin Commission  
California State University, Chico  
California Wildlife Conservation Board  
Coastal Fund (UCSB Assoc. Students)  
Collaborative Fisheries Program  
Colorado State University  
Conservation International Foundation  
Consortium for Ocean Leadership  
Coral Reef Alliance, The (CORAL)  
County of Santa Barbara  
CSU San Diego State University  
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  
Google Foundation  
Gordon and Betty Moore Foundation  
Gulf of Mexico Research Initiative  
International Initiative for Impact Evaluation  
King Abdullah University of Science  
and Technology  
Korean Institute of Industrial Technology  
Larimer County Dept of Natural Resources  
Louisiana State University  
Marisla Foundation  
Mohamed Bin Zayed Species  
Conservation Fund  
Morris Animal Foundation  
National Aeronautics and Space  
Administration (NASA)  
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  
Nova Southeastern University  
Oceana, Inc.  
Ocean Conservancy  
Oregon State University  
Pepperdine University  
Phoenix Zoo  
Rare  
Roy F. Weston, Inc.  
Safari Club International

San Diego State University

San Francisco State University Foundation, Inc.

Santa Barbara Foundation

Scripps Clinic and Research Foundation  
(Incl Scripps Research Institute)

Sierra Business Council

Simons Foundation

Simpson and Simpson Business and Personnel  
Services, Inc.

Society for Conservation Biology

Southern California Coastal Water Research Project  
(SCCWRP)

Swiss Federal Inst of Technology-Db a Eth  
(Switzerland)

Texas A&M University

The Belmont Forum Secretariat

The Coral Reef Alliance (CORAL)

Tufts University

Tulane University

UC Agriculture and Natural Resources

UC Los Angeles

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

University of Wisconsin

US Army, Army Research (AROD)

USDA Forest Service

USDA National Institute for Food  
and Agriculture

US Dept of Commerce,  
National Marine Fisheries Service

US Dept of Commerce, National Oceanic  
and Atmospheric Administration

US DoD Navy

USDI Bureau of Ocean Energy Management

USDI Bureau of Safety and Environmental  
Enforcement

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 Office of Naval Research (ONR)

US Environmental Protection Agency

U.S.-Israel Binational Science Foundation

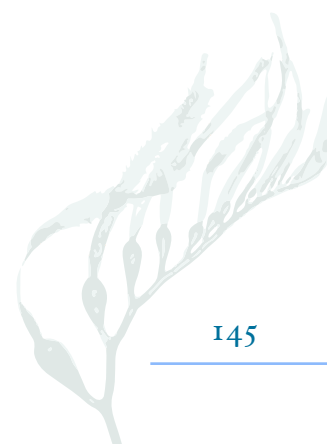
Ventura County

Waitt Family Foundation

World Wildlife Fund, Canada



**MSI Advisory Committee,  
Administrative,  
Professional  
& Technical Staff**





# Marine Science Institute 2015-2016

CHANCELLOR

HENRY T. YANG

EXECUTIVE VICE CHANCELLOR

DAVID MARSHALL

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DIRECTOR

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DAN REED

## Advisory Committee

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**Kathy Foltz**, MCDB  
**Ben Halpern**, Bren  
**Sally Holbrook**, EEMB  
**Debora Iglesias-Rodriguez**, EEMB  
**David Lea**, Earth Science  
**Hunter Lenihan**, Bren  
**Bob Miller**, MSI  
**David Valentine**, Committee Chair, Earth Science

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

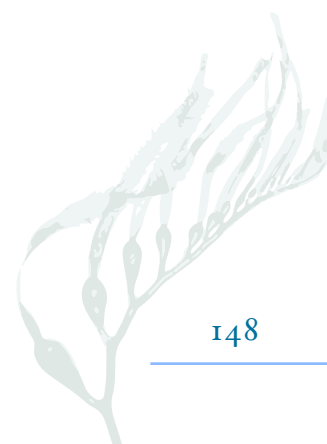
# Marine Science Institute

## 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, 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  
2015-2016**



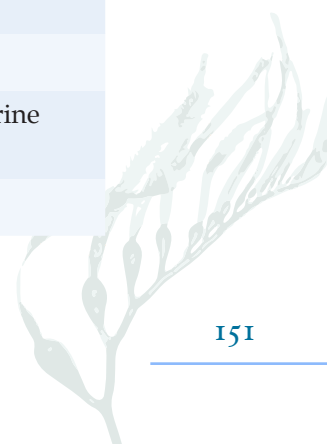
## Marine Science Institute Principal Investigators 2015-2016

Adam, Thomas	Assistant Researcher	Marine Science Institute
Ahn, Byung-Jun Kollbe	Assistant Researcher	Marine Science Institute
Allredge, Alice	Emeritus Research Professor	Ecology, Evolution & Marine Biology
Ballerini, Evangeline	Postdoctoral Researcher	Marine Science Institute
Berkman, Paul	Researcher	Marine Science Institute
Bitter, Mark	Undergraduate Researcher	Marine Science Institute
Blanchette, Carol	Associate Researcher	Marine Science Institute
Briggs, Cheryl	Professor	Ecology, Evolution & Marine Biology
Brzezinski, Mark	Professor	Ecology, Evolution & Marine Biology
Buntaine, Mark	Assistant Professor	Bren School of Envir. Sci. & Management
Burkpile, Deron	Associate Professor	Ecology, Evolution & Marine Biology
Carlson, Craig	Professor	Ecology, Evolution & Marine Biology
Caselle, Jennifer	Researcher	Marine Science Institute
Castorani, Max (Chris)	Postdoctoral Researcher	Marine Science Institute
Chang-Spada, Grace	Associate Researcher	Marine Science Institute
Churchill, Celia	Postdoctoral Researcher	Marine Science Institute
Cooper, Scott	Emeritus Research Professor	Ecology, Evolution & Marine Biology
Costello, Christopher	Professor	Bren School of Envir. Sci. & Management
Culver, Carrie	Associate Researcher	Marine Science Institute
D'Antonio, Carla	Professor	Environmental Studies
Davis, Frank	Professor	Bren School of Envir. Sci. & Management
Dawson, Daniel	Reserve Manager	Natural Reserve System
Derieg, Nathan	Graduate Student Researcher	Ecology, Evolution & Marine Biology

Dudley, Tom	Associate Researcher	Marine Science Institute
Dugan, Jenifer	Associate Researcher	Marine Science Institute
Emery, Nate	Graduate Student Researcher	Ecology, Evolution & Marine Biology
Gaines, Steven	Dean, Bren School, Professor	Bren School of Envir. Sci. & Management
Going, Barbara	Postdoctoral Researcher	Marine Science Institute
Halpern, Benjamin	Professor	Bren School of Envir. Sci. & Management
Halpin, Patricia	Assistant Researcher	Marine Science Institute
Hampton, Stephanie	Academic Coordinator	Nat'l Ctr for Ecol. Analysis & Synthesis
Hechinger, Ryan	Assistant Researcher	Marine Science Institute
Herbst, David	Associate Researcher	Marine Science Institute
Hespanha, Joao	Professor	Electrical & Computer Engineering
Hodges, Scott	Professor	Ecology, Evolution & Marine Biology
Hofmann, Gretchen	Professor	Ecology, Evolution & Marine Biology
Holbrook, Sally	Professor of Biology	Ecology, Evolution & Marine Biology
Holden, Patricia	Professor	Natural Reserve System
Iglesias-Rodriguez, Maria	Professor	Ecology, Evolution & Marine Biology
Johnson, Michele	Academic Coordinator	Marine Science Institute
Israelachvili, Jacob	Professor	Chemical Engineering
Kapsenberg, Lydia	Graduate Student Researcher	Ecology, Evolution & Marine Biology
Kennett, James	Emeritus Research Professor	Earth Sciences
Koweek, David	Postdoctoral Researcher	Marine Science Institute
Knapp, Roland	Researcher	Marine Science Institute
Krause, Jeffrey	Assistant Researcher	Marine Science Institute
Kuris, Armand	Professor of Biology	Ecology, Evolution & Marine Biology
Lafferty, Kevin	Research Biologist	Marine Science Institute



Lambert, Adam	Assistant Research Biologist	Marine Science Institute
Larsen, Ashley	Graduate Student Researcher	Bren School of Envir. Sci. & Management
Laughrin, Lyndal	Reserve Manager Emeritus	Natural Reserve System
Lea, David	Professor	Earth Sciences
Lenihan, Hunter	Professor	Bren School of Envir. Sci. & Management
Lester, Sarah	Associate Project Scientist	Marine Science Institute
Lisiecki, Lorraine	Associate Professor	Earth Sciences
Long, Randall	Graduate Student Researcher	Ecology, Evolution & Marine Biology
Lopez-Carr, David	Professor	Geography
Love, Milton	Researcher Emeritus	Marine Science Institute
Luong, Justin	Undergraduate Researcher	Marine Science Institute
MacIntyre, Sally	Professor	Ecology, Evolution & Marine Biology
Matson, Paul	Postdoctoral Researcher	Marine Science Institute
Mazer, Susan	Professor	Ecology, Evolution & Marine Biology
McCauley, Douglas	Assistant Professor	Ecology, Evolution & Marine Biology
McClintock, William	Project Scientist	Marine Science Institute
McLaughin, John	Graduate Student Researcher	Marine Science Institute
Melack, John	Professor of Biology	Ecology, Evolution & Marine Biology
Miller, Robert	Associate Researcher	Marine Science Institute
Moeller, Holly	Assistant Professor	Ecology, Evolution & Marine Biology
Muller, Erik	Associate Researcher	Marine Science Institute
Myers, Monique	Associate Researcher	Marine Science Institute
Nelson, Craig	Assistant Researcher	Marine Science Institute
Nicholson, Craig	Researcher	Marine Science Institute
Nisbet, Roger	Professor of Biology	Ecology, Evolution & Marine Biology
Nishimoto, Mary	Assistant Researcher	Marine Science Institute



Oakley, Todd	Professor	Ecology, Evolution & Marine Biology
O'Brien, Margaret	Specialist	Marine Science Institute
Ohlmann, J. Carter	Researcher	Marine Science Institute
Oono, Ryoko	Assistant Professor	Ecology, Evolution & Marine Biology
Orr, Devyn	Undergraduate Student	Marine Science Institute
Osherenko, Gail	Project Scientist Emeritus	Marine Science Institute
Ostman, Bjorn	Postdoctoral Researcher	Marine Science Institute
Ovando, Daniel	Graduate Student Researcher	Bren School of Envir. Sci. & Management
Page, Henry Mark	Researcher	Marine Science Institute
Passow, Uta	Researcher	Marine Science Institute
Proulx, Steven	Associate Professor	Ecology, Evolution & Marine Biology
Pruitt, Jonathan	Assistant Professor	Ecology, Evolution & Marine Biology
Quetin, Langdon	Emeritus Researcher	Marine Science Institute
Rassweiler, Andrew	Associate Project Scientist	Marine Science Institute
Reed, Daniel	Researcher	Marine Science Institute
Rice, William	Professor of Biology	Ecology, Evolution & Marine Biology
Richards, John	Marine Resource Specialist	Marine Science Institute
Ross, Robin	Emeritus Researcher	Marine Science Institute
Sandoval, Cristina	Reserve Director	Marine Science Institute
Santoro, Alyson	Assistant Professor	Ecology, Evolution & Marine Biology
Santschi, Christen	Graduate Student Researcher	Marine Science Institute
Schmitt, Russell	Professor	Ecology, Evolution & Marine Biology
Schroeter, Stephen	Researcher	Marine Science Institute
Siegel, David	Professor	Geography
Simon, Scott	REEF Manager	Marine Science Institute
Sokolow, Susanne	Postdoctoral Researcher	Marine Science Institute
Speiser, Daniel	Assistant Researcher	Marine Science Institute

Swarbrick, Susan	Associate Director, NRS	Marine Science Institute
Szuwalksi, Cody	Assistant Researcher	Marine Science Institute
Tarjan, Lily	Postdoctoral Researcher	Marine Science Institute
Toothman, Mary	Staff Research Associate	Marine Science Institute
Turner, Thomas	Associate Professor	Ecology, Evolution & Marine Biology
Urbisci, Laura	Graduate Student Researcher	Bren School of Envir. Sci. & Management
Valentine, David	Professor	Earth Sciences
Waite, J. Herbert	Professor	Molecular, Cellular & Devel. Biology
Warner, Robert	Emeritus Research Professor	Ecology, Evolution & Marine Biology
Washburn, Libe	Professor	Geography
Wear, Emma	Graduate Student Researcher	Marine Science Institute
Weldaeb, Syee	Associate Professor	Earth Sciences
Wenner, Adrian	Professor Emeritus	College of Creative Studies
Whitmer, Allison	Academic Coordinator	Marine Science Institute
Wilson, Douglas	Research Geologist	Earth Sciences
Wilson, Emily	Undergraduate Researcher	Marine Science Institute
Young, Hillary	Assistant Professor	Ecology, Evolution & Marine Biology
Young, Oran	Emeritus Research Professor	Bren School of Envir. Sci. & Management

