ANNUAL REPORT 2016-2017

UCSB

MARINE SCIENCE INSTITUTE | UC SANTA BARBARA

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DIRECTOR'S STATEMENT

Director's Statement

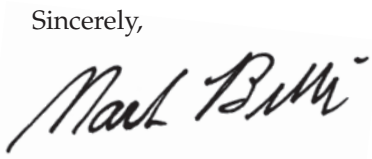
As we move towards MSI's 50th anniversary in 2019 the Marine Science Institute our scientists continue on a trajectory of engaging in cutting edge research and of solving pressing problems in ocean science. Our research portfolio continues to diversify with an ever growing set of funders representing 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,

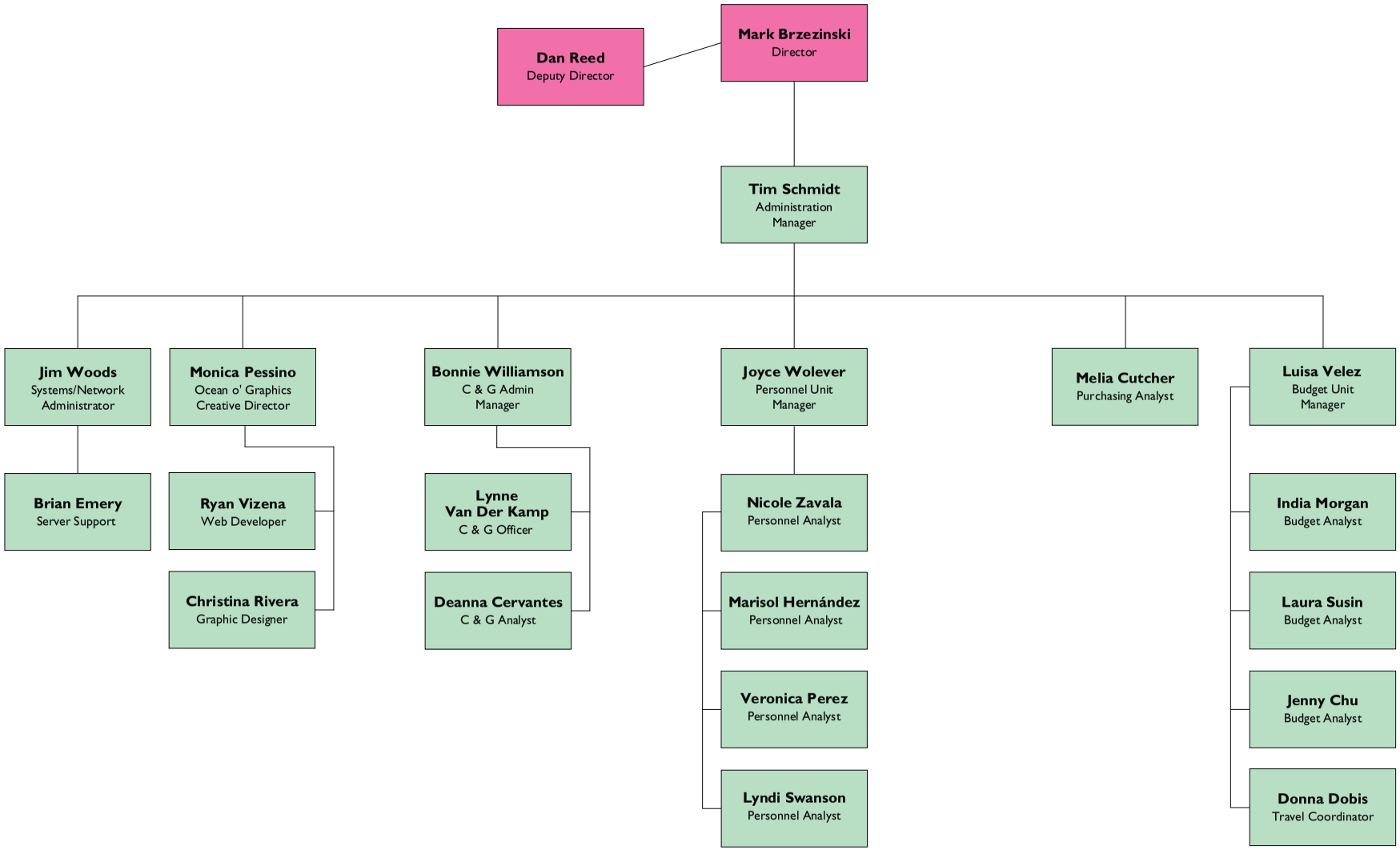


Mark Brzezinski, Director
Marine Science Institute

ORGANIZATIONAL CHARTS

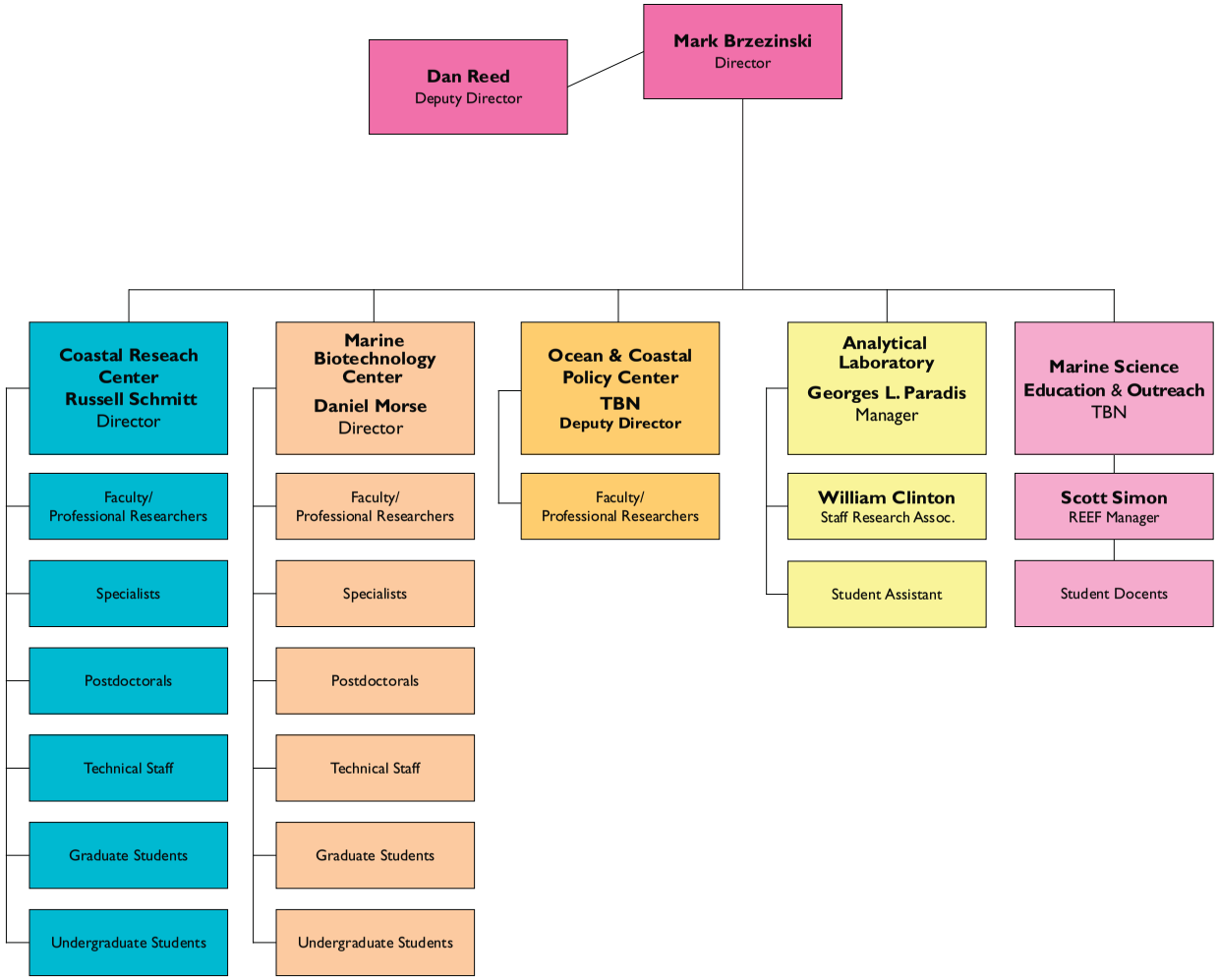
MARINE SCIENCE INSTITUTE

2016–2017 ORGANIZATIONAL CHART



MARINE SCIENCE INSTITUTE

2016–2017 ORGANIZATIONAL CHART



OTHER PROJECTS & ACTIVITIES

Seminars, Workshops, Conferences, and Meetings July 1, 2016-June 30, 2017

The Marine Science Institute continues to support various seminars, workshops, conferences and meetings. During the 2016-2017 fiscal year 35 events took place, in which a wide range of marine science topics were highlighted.

Dates	Coordinators	Topic
July 4, 2016	Grace Goldberg	Seasketch Workshop, Queensland
July 6, 2016	Douglas McCauley	Benioff Initiative
July 7, 2016	Douglas McCauley	Benioff Initiative
July 13, 2016	Douglas McCauley	Benioff Initiative
August 11, 2016	Douglas McCauley	Benioff Initiative
August 24, 2016	Douglas McCauley	Benioff Initiative
August 29, 2016	Robert Miller	MBON Ecological Forecasting Conf.
September 7, 2016	Tyler Clavelle	SFG Workshop
September 13, 2016	Ashley Stroud	MODassic Meeting
September 17, 2016	Douglas McCauley	Lonely Whale Foundation
September 30, 2016	Laura Lea Rubino	Tuna Project Meeting
October14, 2016	Shannon Harrer	SBC Grad Interns
October 20-21, 2016	Keith Seydel	MCR Meeting
November 1, 2016	Gretchen Hofmann	On Thin Ice Participants
November 7, 2016	Ruby Holder	Mellichamp Joint Group Meeting
November 14, 2016	Robert Miller	MBON Visit
November 18, 2016	Dan Reed	SBC LTER Affiliates
December 2, 2016	Dan Reed	SBC LTER Undergrads
December 11, 2016	Steve Gaines	Catholic University of Chile
January 23-25, 2017	Steve Gaines	Fish Forever Workshop
February 3, 2017	Shannon Harrer	SBC Workshop
February 10, 2017	Shannon Harrer	SBC Planning Workshop
February 16, 2017	Shannon Harrer	SBC Planning Workshop
February 24, 2017	Shannon Harrer	SBC Planning Workshop

* Non-UCSB personnel

March 1, 2017	Steve Gaines	Tuna Project Meeting
March 1, 2017	Tom Dudley	Santa Clara River Science Affiliates
March 9, 2017	Steve Gaines	UCSB-CI Planning Meeting
March 10, 2017	Shannon Harrer	SBC Workshop
March 17, 2017	Shannon Harrer	SBC Workshop
April 26, 2017	Michaela Clemence	Indonesia Snapper Meeting
April 18, 2017	Monique Myers	SBC CEVA Meeting
June 2, 2017	Shannon Harrer	SBC LTER Meeting
June 5, 2017	Ruby Holder	Mellichamp Group
June 8, 2017	Monique Myers	Kids in Nature Meeting
June 16, 2017	Dan Reed	SBC MBON Meeting

* Non-UCSB personnel

Coastal Research Center

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

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

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

The Center has four major objectives:

- To act as a center for production and integration of basic scientific information to more fully understand coastal and island ecosystems and their natural and exploited populations.
- To evaluate and predict effects of human activities on the marine environment, and to develop measures to ameliorate lost or degraded natural resources.
- To train students in basic research on marine environmental issues that may be applicable to decision-makers.
- To facilitate and promote interdisciplinary research initiatives.

Faculty/Professional Research Participants:

Russell J. Schmitt, Director and Professor of Biology

Alice Alldredge, Professor of Biological Oceanography

Giacomo Bernardi, Professor of Molecular Ecology (UCSC)

Andrew Brooks, Associate Project Scientist

Mark Brzezinski, Professor of Biology

Alison Butler, Professor of Chemistry

Bradley Cardinale, Assistant Professor of Biology

Craig Carlson, Associate Professor of Biology

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

Joseph H. Connell, Research Professor of Zoology

Jenifer E. Dugan, Associate Research Biologist

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

John M. Engle, Associate Research Biologist

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

Steven D. Gaines, Professor of Biology

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

Scott Hodges, Professor of Biology

Gretchen Hofmann, Associate Professor of Biology

Sally J. Holbrook, Professor of Biology

Evelyn Hu, Professor of Electrical and Computer Engineering

Ronald Iltis, Professor of Electrical and Computer Engineering

Robert Jacobs, Professor of Biology

Ryan Kastner, Assistant Professor of Electrical and Computer Engineering

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

David Lea, Professor of Geology

Hua Lee, Professor of Electrical and Computer Engineering

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

Hunter Lenihan, Associate Professor of Environmental Science

Milton Love, Research Biologist

Sally MacIntyre, Professor of Limnology and Oceanography

Stéphane Maritorena, Associate Researcher

John Melack, Professor of Biology

Daniel Morse, Professor of Biology

Erik Muller, Assistant Research Biologist

Roger M. Nisbet, Professor of Biology

Henry M. Page, Associate Research Biologist

Daniel C. Reed, Research Biologist

Stephen C. Schroeter, Research Biologist

Hannah Stewart, Postdoctoral Researcher (Un. Washington)

Allan Stewart-Oaten, Professor of Biology

David Valentine, Assistant Professor of Geological Sciences

Libe Washburn, Professor of Geography

Allison Whitmer, Assistant Dean (Georgetown University)

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

Leslie Wilson, Professor of Biology

Marine Biotechnology Center

UCSB is recognized internationally for its leadership in Marine Biotechnology. This exciting field uses the latest breakthroughs in modern DNA and genetic technologies, bioengineering, molecular and cell biology – all closely integrated with quantitative ecology and evolution; environmental physiology; geochemistry; ocean, climate, and conservation science; and materials and energy engineering. The aims of these highly collaborative, interdisciplinary investigations are to solve basic problems in marine resource biology; to improve the production of medical, chemical, food, and energy resources from the ocean; to develop new products and industries based on more efficient use and management of the ocean's resources, and to discover and develop new materials for future engineering needs, while training students for future careers in each of these vital areas. The state-of-the-art Marine Biotechnology Building is just one of the campus's many facilities housing this diverse research and teaching, led by faculty from numerous departments and the the state-supported California NanoSystems Institute, the Materials Research Laboratory (an NSF-supported MRSEC), and the new BioEngineering Program. A small sampling of the faculty leaders and research projects across the spectrum of these areas includes the following:

TONY DE TOMASO

Department of Molecular, Cellular and Developmental Biology
(anthony.detomaso@lifesci.ucsb.edu)

Discoveries in immunology, stem cell biology and regeneration in Botryllus: Our lab works at the intersection of immunology, stem cell biology and regeneration using the marine basal chordate, Botryllus schlosseri as a model. Unique biological features of Botryllus, including a natural transplantation reaction, parasitic stem cells, and a colonial life history that includes regeneration of all somatic and germline tissues on a weekly basis, allow novel approaches for studies in each of these fields. In turn, results from those studies have allowed us to explore new fields, including angiogenesis, mechanotransduction and aging. Botryllus has a wealth of biology ripe for experimentation, and our overall goal is to utilize these unique features and carry out innovative, interdisciplinary research.

KATHY FOLTZ

Department of Molecular, Cellular and Developmental Biology
(kathy.foltz@lifesci.ucsb.edu)

Decision networks controlling cell differentiation and development:

In biology, some cells make a once-in-a-lifetime decision to respond to a signal. A misfire results in cell death or disease. One example is immune cell activation – inappropriate activation leads to autoimmunity while failure to activate results in infection. My lab is interested in the evolution of these "decision networks" and also how they are tuned at a molecular level. Another example of a one-time-only response is the rapid activation of an egg to begin development at the time of fertilization. We use multiple marine invertebrate deuterostomes (primarily echinoderms and ascidians) as model systems to address this process, which is highly conserved across all multicellular species, including mammals. Some of our projects focus on specific proteins and signaling pathways, others are more discovery-based and address the question from a systems perspective. Recently, using high throughput, quantitative proteomics platforms, we built an information-rich network of thousands of proteins that undergo quantitative changes in phosphorylation state and exhibit dynamic interaction complexing in the first few minutes post fertilization. Using the exquisitely synchronous and biochemically tractable sea urchin fertilization system, this approach revealed excitable signaling systems that had not previously been implicated in egg activation. Predicted high-value candidate nodes are being investigated for novel roles in controlling the switch-like decision an egg makes at the time of fertilization. One goal is to understand the design principles that enable cells to carry out finely tuned, once-only responses.

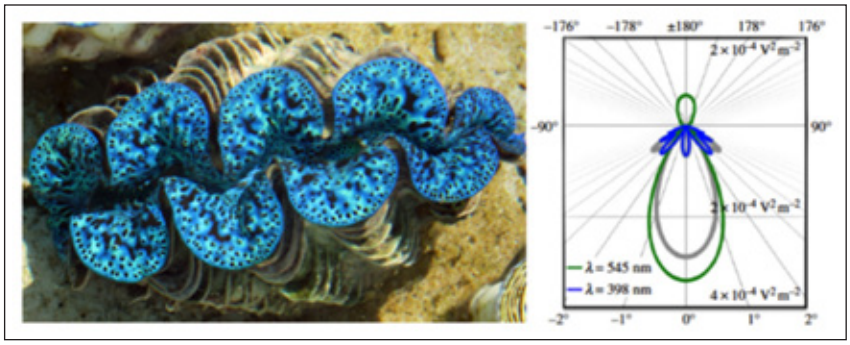
(*Left*) Sea urchins induced to spawn, shedding eggs (yellow) or sperm (white). (*Right*) Sea urchin fertilization, showing sperm on the egg surface

MIKE GORDON

Department of Chemical Engineering
(mjgordon@engr.ucsb.edu)

Optical device engineering inspired by marine biophotonics: My students and I are pursuing collaborative research aimed at translating new discoveries from marine biophotonics into useful optical device engineering. Our recent and ongoing collaborations have been focused on the mechanism by which squids dynamically and adaptively change their patterns of skin color for camouflage and communication, and the mechanism by which specialized cells in the giant clam direct solar photons deeper into the clam tissue to boost the efficiency of photosynthesis by the clam's endosymbiotic microalgae. We're collaborating with Dan Morse's group, that recently elucidated the molecular mechanism by which the reflectin proteins act as a molecular spring-loaded Coulombic sensor, controlling an osmotic motor that changes the refractive index contrast and lattice dimensions of a subcellular Bragg reflector to smartly tune the color and intensity of light reflected from specialized cells in squid skin (cf. below). Our teams are now working together to translate that discovery to make tunably reconfigurable new materials that can tune the color of light emitted from lasers and light-emitting diodes (LEDs). We're aiming first to develop reflectin-inspired synthetic block-copolymers capable of exhibiting the signal-dependent, cyclable reconfigurability discovered in the natural reflectins, and then incorporating these to drive the tunability of light emitted from solid-state devices.

Beyond these studies, my students and I are interested to collaborate with other teams pursuing any of the myriad remarkable biophotonic systems in marine organisms. Our aim is to help translate exciting new discoveries from the marine biological realm into practical optical engineering.



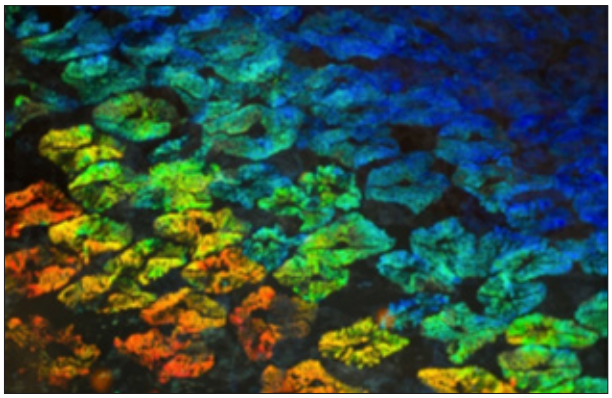
(*Left*) Giant clam, showing brilliantly reflective cells in the mantle tissue exposed to sunlight.
(*Right*) Quantitative simulation revealing that <10% of solar photons are reflected back to the observer; the majority are scattered deep into the tissue.

DAN MORSE

Department of Molecular, Cellular and Developmental Biology
(d_morse@lifesci.ucsb.edu)

Molecular spring-loaded Coulombic sensor governs the squid's biophotonics:

Squids exhibit a remarkable ability to adaptively change skin color for camouflage and communication. We recently discovered the mechanism by which the unique "reflectin" proteins act as a molecular spring-loaded Coulombic sensor, controlling an osmotic motor that changes the refractive index, thickness and spacing of intracellular Bragg reflectors to tune the color and intensity of light reflected from cells in the squid skin: These reflectin proteins - major constituents of the membrane-bound Bragg lamellae – are block copolymers with repeated canonical domains interspersed with cationic linkers. Adaptive changes in reflectance from the Bragg lamellae are initiated by a neurotransmitter-activated signal transduction cascade that culminates in catalytic phosphorylation of the reflectins' cationic linkers. The resulting charge-neutralization overcomes the linkers' Coulombic repulsion, progressively triggering the spring-loaded condensation and secondary folding of the canonical repeat segments to form amphiphilic, bifacially phase-segregated structures, with the emergence of hydrophobic faces that mediate hierarchical molecular assembly. This phase-segregation provides the potential entropic drive, stored in the protein like a stretched spring, while neutralization-tuned Coulombic repulsion of the cationic linkers provides the "stretch." Once released by charge-neutralization, the resulting condensation, folding and hierarchical assembly trigger Gibbs-Donnan dehydration, shrinking the thickness and spacing of the Bragg lamellae while increasing their refractive index. This progressively changes the color of light reflected from the Bragg lamellae from red to blue, while increasing its intensity. This process is reversible, cyclable and finely tunable, precisely regulating color across the visible spectrum without chromophores. Employing this tunability, the squid can produce any color in the individually innervated patches of reflective cells in the skin to produce intricate patterns of color for both communication and camouflage. Translation of the underlying mechanism of this biomolecular sensor to practical engineering is opening new approaches to smart, dynamically reconfigurable, nanostructured materials and tunable systems.



Activation with a droplet of the neurotransmitter, acetylcholine, induced a wave of color to ripple through the cells in squid skin from top to bottom. The individual cells sequentially reflected first red, then orange, yellow, green, and finally, blue, as proteins in the intracellular Bragg lamellae condensed to progressively drive osmotic shrinking of the thickness and spacing of the lamellae, thus changing color of the reflected light. (Each object shown is a single cell, ca. 10 micrometers long; the dark spot in the center of each cell is the location of the nucleus.)

TODD OAKLEY

Department of Ecology, Evolution and Marine Biology
(oakley@lifesci.ucsb.edu)

Evolution of genes for sensing and producing light:

Evolution has produced amazingly diverse solutions for sensing and producing light, especially in marine environments. How did this diversity come about and can we harness and enhance these solutions for practical gain? Light sensing and vision are well understood in a few model systems like flies and humans, yet we know far less about these processes in other organisms. Oakley's lab searches for light sensitivity by looking for the genes, especially in marine organisms, often leading to surprises. For example, jellyfish and comb jellies are very distant relatives of humans, yet they use very similar genes to sense light, some using this sensitivity to help decide when to fire their stinging cells. Additionally, Octopuses sense light directly with their skin using similar genes, and one squid senses light made by bacteria in its light-/producing/ organ, again using a similar gene. Oakley's lab also studies light production, or bioluminescence, mainly in a group of crustaceans called 'sea fireflies'. The lab discovers a diversity of new sea firefly species, each uses different patterns of light-pulses for courtship. The lab is working toward understanding the genetic basis for the diversification of these light pulses. While aiming to understand fundamental evolutionary questions, the answers to these questions could lead to better ways to engineer genetically encoded light detectors and light-producing molecules, for use in a variety of tools from biomarkers to reading or controlling neural circuits with light.

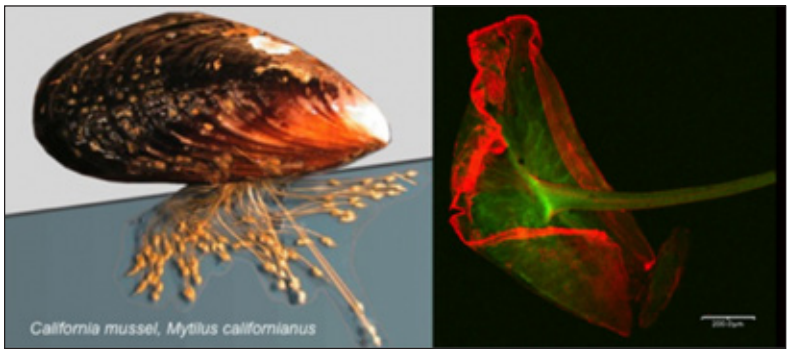
Marine copepod (ca. 2 mm length) emitting its species-specific nocturnal bioluminescence.

HERBERT WAITE

Department of Molecular, Cellular and Developmental Biology
(waite@lifesci.ucsb.edu)

Opportunistic wet adhesion:

Marine organisms and their extended structures are held together by molecular glues whose adhesive and cohesive properties are adapted to their function. Wet bioadhesion can be specific or opportunistically nonspecific. Mussel adhesion is of the latter type and depends on elaborately tuned redox chemistry. Mussel adhesive proteins contain up to 30 mol% of the catecholic amino acid DOPA (3, 4-dihydroxyphenylalanine), an exquisitely redox sensitive functionality. At or near the interface between the adhesive proteins and the substratum, mussels impose a highly reducing local environment (low pH and high thiol content) in order to exploit the superior chemisorption of DOPA to a variety of surfaces. Farther from the interface, however, mussel proteins are maintained in either Fe3+-rich or oxidizing local environments (high pH and catecholoxidase). The first leads to protein gelation stabilized by multifunctional DOPA- Fe3+-complexation, whereas the latter, to the covalent cross-links between DOPAquinone and reactive amino acids. By adjusting the redox of the local environment, mussels "tune" the optimal level of adhesion (DOPA) or cohesion (quinone and cross-linking) needed in each part of the holdfast. A deeper understanding of mussel adhesive chemistry and its regulation is likely to inspire improvements in adhesive technology especially in wet applications.



(Left) Mussel showing protein attachment fibers and terminal adhesive plaques; *(Right)* Microscopic view of the wet-adhesive plaque at the end of a fiber, stained to reveal different molecular components.

ELIZABETH WILBANKS

Department of Ecology, Evolution and Marine Biology
(elizabeth.wilbanks@lifesci.ucsb.edu)

Marine microbial ecology & biogeochemistry:

Research in the Wilbanks lab examines how the ecology of microorganisms influences evolution and drives nutrient cycling in marine environments. We work to discover and quantify microbial interactions in natural marine ecosystems over scales bridging single cells to ecosystems. Understanding ecosystems with this resolution will help us improve predictive models of ecosystem function and discover fundamental principles governing the dynamics of microbial communities.

Microbial metabolism has shaped our planet since early geological time, and is the engine powering global nutrient cycling. Key ecosystem processes are driven trophic exchanges between microbes, and often occur extremely rapidly and over nanometers – a scale that often makes them invisible to traditional approaches.

At present, we focus on the bacteria and archaea associated with marine particles, aggregates, and biofilms. Our experiments range from the field to the lab and integrate a diverse toolset including (meta)genomics, microscopy, microsensors, cultivation, and stable isotope geochemistry. Current study systems include the giant kelp microbiome, marine snow, and photosynthetic bacterial aggregates (the pink and green "berries") from salt marshes.

Current research themes in the lab are inspired by several overarching questions:

- How does the microscale structure of microbial food webs determine macro-scale ecosystem properties? Can we harness such information to improve predictive models?
- How do the spatial and temporal distributions of microorganisms alter their physiology, ecology, and evolution over different scales? At what scale can we capture ecologically relevant bacterial populations?
- Are theory and observations from "macrobial" ecology and evolution concordant with data from microbes? Within the same ecosystem? Across different systems?

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
Carol Blanchette, Resident Reserve Director
John M. Melack, Faculty Advisor

UCSB Natural Reserve System Administration
Patricia Holden, Director
Marion Wittmann, Associate Director
Deby Puro, MSO
Alexa Johnson, Administrator Assistant

Analytical Laboratory

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

MSI Education and Outreach

Throughout 2016-2017, MSI Oceans-To-Classrooms (O2C) Education/Outreach Programs provided marine science education and awareness to over 19,000 people (See Figure 1). This number is up over 3,000 from last year (16,258), reaching people within the Tri-Counties (SLO/SB/Ventura), as well as other communities from California and beyond. Exposure to this many people included visits to the Research Experience Education Facility (REEF) as well as community outreach events via the Mobile REEF Unit. This last year, K-12 education alone extended to over 12,000 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 over 2,000 university students. None of this would have been possible without the continued support and collaborations from groups both on- and off-campus. This includes the Office of Education Partnerships, The AS Coastal Fund, Santa Barbara Channel Islands National Marine Sanctuary (CINMS) and many more. One partnership of note is a unique opportunity with UC Santa Barbara alumnus, Dr. Robert Ballard, and his research vessel, the E/V Nautilus, which spent time in the SB Channel engaged in seafloor mapping and deep-sea exploration. UCSB has partnered with Dr. Ballard and his Ocean Exploration Trust (OET) to provide a Nautilus Live interaction to our programs.

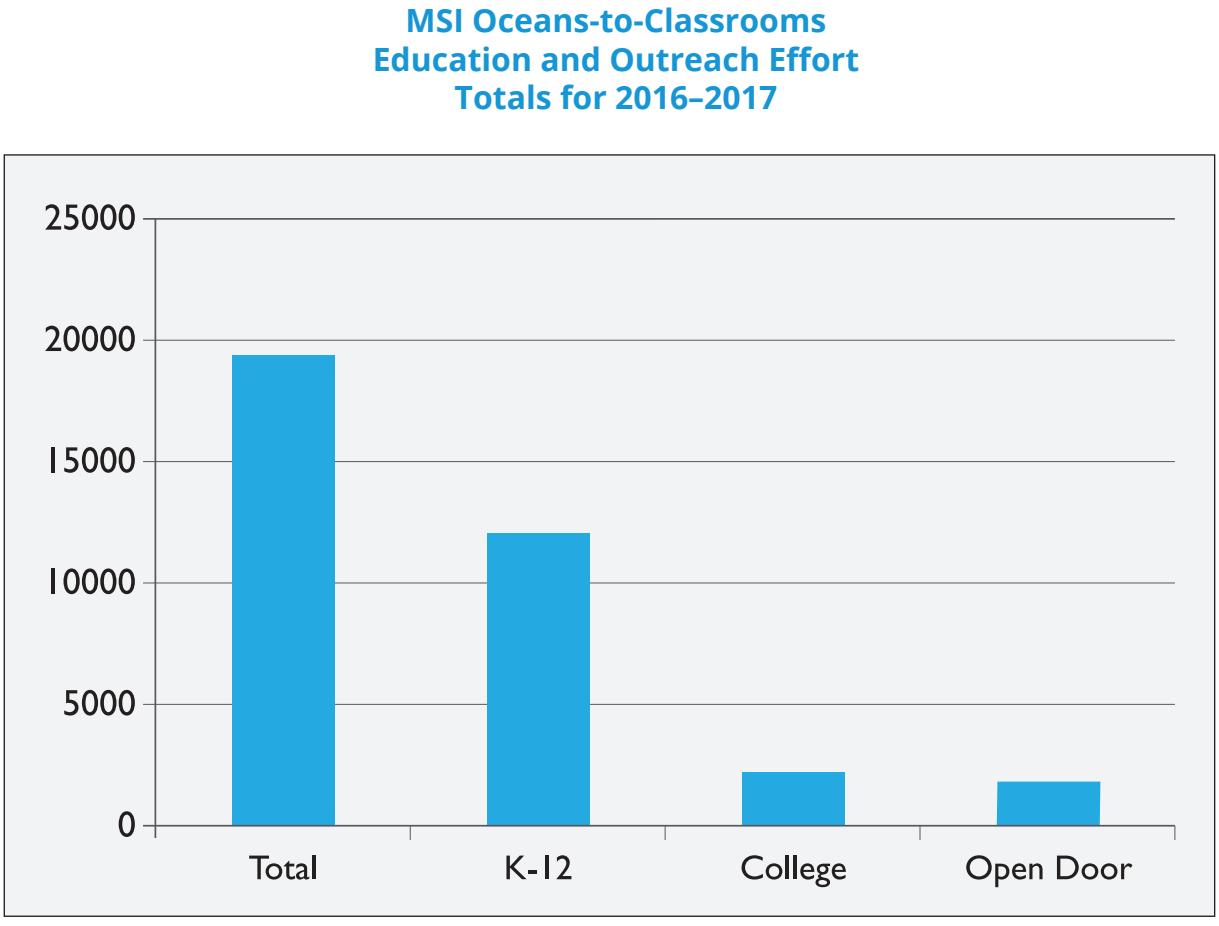


Figure 1. Graph of total number of participants served through MSI Ed/Outreach Oceans-To-Classrooms (O2C) Programming.

AWARDS ADMINISTERED

Awards Administered
2016-2017

ALFRED P. SLOAN FOUNDATION

A. Santoro Alfred P. Sloan Research Fellowship	09/15/2016-09/14/2019	$16,531
	ALFRED P. SLOAN Subtotal	**$16,531**

AMEC (GREAT BRITAIN)

D. Herbst Biomonitoring of Leviathan Creek Watershed for Fall 2015	9/1/2015-12/31/2017	$68,868
	AMEC (Great Britain) Subtotal	**$68,868**

ARIZONA STATE UNIVERSITY

U. Passow **Aggregation of Marine Picoplankton**	03/15/2017-02/29/2020	$69,626
	ARIZONA STATE UNIVERSITY Subtotal	**$69,626**

BERMUDA INSTITUTE OF OCEAN SCIENCES

C. Carlson **BIOS-SCOPE - A collaborative program for the study of microbial oceanography in the North Atlantic Subtropical Gyre**	11/1/2015-10/30/2020	$234,000
	Bermuda Institute of Ocean Sciences Subtotal	**$234,000**

CALIFORNIA COASTAL CONSERVANCY

C. Sandoval Education Center at Coal Point Reserve	6/30/2015-1/31/2017	$45,000
	California Coastal Conservancy Subtotal	**$45,000**

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

J. Dugan Refugio Oil Spill NRDA Shoreline Research	03/23/2017-10/31/2019	$7,500
R. Knapp Three Crucially Important Conservation Actions to Recovery R. sierra in the Northern Sierra	03/23/2017-10/31/2019	$195,000
	California Department of Fish and Wildlife Subtotal	**$202,500**

CALIFORNIA EPA PESTICIDE REGULATION

T. Dudley California Alliance for Tamarisk Biocontrol	09/01/2016-03/20/2019	$188,043
	California EPA Pesticide Regulation Subtotal	**$188,043**

CALIFORNIA EPA WATER CONTROL BOARD

T. Dudley	12/12/2016-03/31/2019	$200,000
Freshwater Mussel Assessment for Ventura/Los Angeles Region		
	California EPA Water Control Board Subtotal	**$200,000**

CALIFORNIA TROUT, INC.

D. Herbst	06/15/2017-05/30/2018	$25,200
Prioritizing Meadow Restoration for Kern River Rainbow Trout Recovery		
	California Trout, Inc. Subtotal	**$25,200**

CALIFORNIA OCEAN PROTECTION COUNCIL

J. Caselle	6/21/2016-07/31/2018	$79,161
Evaluation of Methods for Long Term Monitoring for the State of California		
	California Ocean Protection Council Subtotal	**$79,161**

CALIFORNIA SEA URCHIN COMMISSION

S. Schroeter	07/01/2016-06/30/2018	$10,000
Studies of Sea Urchin Settlement in Southern and Northern California 2017-18		
	California Sea Urchin Commission Subtotal	**$10,000**

DAVID AND LUCILE PACKARD FOUNDATION

C. Costello	01/01/2017-12/31/2017	$230,000
Analysis of Fisheries Management and Climate Change		
C. Szuwalski	09/01/2016-08/31/2018	$500,000
Capacity Building in China through Collaborative Marine Research		
	David and Lucile Packard Foundation Subtotal	**$730,000**

ENVIRONMENTAL PROTECTION AGENCY

R. Nisbet	06/01/2015-05/31/2018	$222,972
Dynamical Systems Models Based on Energy Budgets for Ecotoxicological Impact Assessment		
	Environmental Protection Agency Subtotal	**$222,972**

GREAT LAKES FISHERY COMMISSION

C. Jerde	01/01/2017-04/30/2018	$13,236
Uses and Limitations of Environmental DNA (eDNA) in Fisheries Management		
	Great Lakes Fishery Commission Subtotal	**$13,236**

MARISLA FOUNDATION

J. Caselle	03/22/2016-03/22/2019	$175,000
Coral Reef Resilience in a Rare, Undisturbed Ecosystem: UCSB and Palmyra Atoo		
	Marisla Doundation Subtotal	**$175,000**

NASA SHARED SERVICES CENTER

R. Miller	10/01/2014-09/30/2019	$729,336
Demonstrating an Effective Marine BON in the Santa Barbara Channel		
	Nasa Shared Services Center Subtotal	**$729,336**

NATIONAL ACADEMIES KECK FUTURES INITIATIVE

A. Santoro	05/15/2017-06/30/2019	$75,000
Small Wonder: Inside the World of Marine Microbes on the Smithsonian Ocean Portal		
	National Academies Keck Futures Initiative Subtotal	**$75,000**

NATIONAL GEOGRAPHIC SOCIETY

C. Costello	07/01/2016-07/01/2017	$100,404
Pristine Seas		$100,404
H. Young	10/20/2016-10/19/2017	$23,109
	National Geographic Society Subtotal	**$223,917**

NATIONAL SCIENCE FOUNDATION

C. Briggs	05/01/2016-04/30/2021	$14,400 $22,927
LTREB: Collaborative Research: Long-term Dynamics of Amphibian Populations following Disease-driven Declines		
D. Burkepile	07/01/2015-04/30/2020	$168,628 $162,845
CAREER: Fish-derived Nutrients in a Coral Reef Ecosystem: Impacts on Benthic Communities and Importance for Coral Restoration		
C. D'Antonio	09/15/2016-08/31/2019	$13,450 $780,612
Collaborative Research: Do Ecological Feedbacks Across Trophic Levels Affect Alternate States and Restoration of Tropical Forests?		
J. Dugan	04/01/2015-03/31/2019	$10,225
Linking Nearshore Kelp Forest Dynamics to Sandy Beach Ecosystem, REU Supplement		
G. Hofmann	03/15/2017-02/29/2020	$546,091
Mechanisms of Physiological Plasticity in Early Stage Marine Invertebrates: An Epigenetic Perspective with a Global Change		
G. Hofmann	03/15/2017-02/29/2020	$124,785
REU Site: Ocean Global Change Biology		
S. Mazer	06/15/2016-05/31/2019	$249,999
Phenological Sensitivity to Climate Across Space and Time: Harnessing the Diversity of Digital Herbarium Data to Generate and to Test Novel Predictions		
T. Oakley	06/01/2017-05/31/2018	$19,955
Dissertation Research: Correlated Diversification of a Sexual Male Trait and Associated Female Perception		
T. Oakley	09/01/2015-08/31/2018	$26,728
Collaborative Research: Evolutionary Origins of Chiton Shell-eyes: Integrating Structure, function, and Gene Expression within a Phylogenetic Context		

J. Pruitt Collaborative Research: The Effects of Keystone Individuals on Collective Behavior	01/01/2016-05/31/2018	$121,893
D. Reed LTER: Land/Ocean Interactions and the Dynamics of Kelp Forest Ecosystems	12/01/201-11/30/2018	$486,000 $494,000
A. Santoro Collaborative Research: New Approaches to New Production	07/01/2016-07/31/2018	$101,545
A. Santoro Collaborative Research: Gene Content, Gene Expression, and Physiology in Mesopelagic Ammonia-oxidizing Archaea	07/01/2016-03/31/2018	$10,313
D. Valentine Collaborative Research: Do Cyanobacteria Drive Marine Hydrocarbon Biogeochemistry?	09/01/2016-08/31/2019	$364,254
L. Washburn Collaborative Research: Resolving Complex Coastal Flows via Advances in High-frequency Radar	03/15/2017-02/29/2020	$536,279
H. Young Using Replicated Empirical Networks to Understand Drivers of Ecosystem Structure and Stability	06/01/2015-05/31/2018	$10,096
H. Young SG Collaborative Research: The Changing Role on Watering holes in Concentrating Parasites in a Changing Climate	05/01/2016-04/30/2019	$8,068
O. Young Collaborative Research: Belmont Forum-Pan-Arctic Options, Holistic Integration for Arctic Coastal-Marine Sustainability	11/01/2016-10/31/2019	$16,026
	National Science Foundation Subtotal	**$6,543,119**

NATIONAL FISH AND WILDLIFE FOUNDATION

C. D'Antonio Evaluation and Restoration of Degraded Chaparral with Piru Fire Periment	07/01/2016-06/30/2018	$195,668
	National Fish and Wildlife Foundation Subtotal	**$195,668**

NATURE CONSERVANCY (THE)

C. Costello Task Agreement #15: Identifying Best Practices in Global Pelagic ITQ Fisheries to Inform Peruvian Anchoveta Quota System	04/01/2017-11/30/2017	$15,000
C. Costello Task Agreement #14: Technical Training in the Economics of Fisheries Management for Peruvian Decision Makers	04/01/2017-11/30/2017	$23,000
C. Costello Task Agreement #8: Bio-Economic Modeling of Pacific Tuna Fisheries	01/01/2017-12/31/2017	$280,000
C. Costello Task Agreement #10: TNC-Bren Collaboration on Climate-ready Fisheries and Frameworks for more Effective Fisheries and Ocean Management	01/012017-12/31/2017	$81,541
C. Costello Task Agreement #1: University Internships, Postdoctoral Positions, and Student and Staff Researcher Projects	09/02/2015-09/01/2020	$68,652 $15,513

C. Costello Task Agreement #13: An Island Nation TURF System to Sustain Fisheries and Culture: Phase 1	03/15/2017-09/15/2017	$48,337
C. Costello Task Agreement #1: University Internships, Postdoctoral Positions, and Student and Staff Researcher Projects	09/01/2015-09/01/2020	$10,000 $12,272 $11,122
W. McClintock Task Agreement #9: Abalone Length Data Technology	01/01/2017-03/31/2017	$30,507
W. McClintock Task Agreement #11: eCatch Mobile Application Updates	01/01/2017-12/31/2017	$35,845
W. McClintock Task Agreement #12: Technology for Fisheries Management Abalone	03/01/2017-06/30/2017	$25,931
W. McClintock Task Agreement #12: Technology for Fisheries Management Abalone	03/01/2017-10/31/2017	$45,761
W. McClintock Task Agreement #16: Developer for Crab Gear Recon App	06/26/2017-12/31/2017	$36,485
	Nature Conservancy (The)	**$739,966**

NIH DENTAL AND NIH RESEARCH

H. Waite Translating Mussel Adhesion	09/01/2016-08/31/2017	$342,267
	NIH Dental and NIH Research Subtotal	**$342,267**

NIH GENERAL MEDICAL SCIENCES

C. Briggs EID Disease in Complex Communities: Multi-host, Multi-pathogen Interactions	07/01/2016-06/30/2018	$455,508
	NIH General Medical Sciences Subtotal	**$455,508**

OAKLAND ZOO

R. Knapp Disease Assays for Frog Captive-Rearing Program	04/15/2017-09/30/2018	$10,815
	Oakland Zoo Subtotal	**$10,815**

OCCIDENTAL COLLEGE

M. Love The Current and Potential Contribution of Manmade Reef Habitats to Fisheries Resources and Protected Species Recovery in Southern California	07/01/2016-06/30/2017	$12,741
	Occidental College Subtotal	**$12,741**

OCEAN CONSERVANCY

S. Gaines Reimagining Fishery Management: A Joint Project to Identify Breakthrough Approaches to Fisheries Management	07/01/2015-12/31/2017	$10,000
	Ocean Conservancy Subtotal	**$10,000**

OREGON STATE UNIVERSITY

C. Blanchette PISCO Science for an Informed Society	01/01/2015-03/31/2018	$70,606
	Oregon State University Subtotal	**$70,606**

RARE

C. Costello Fish Forever	01/01/2014-12/31/2018	$100,000
	Rare Subtotal	**$100,000**

SAN FRANCISCO ZOO

R. Knapp Disease Assays for Frog Captive-Rearing Program	03/01/2017-08/31/2018	$17,850
	San Francisco Zoo Subtotal	**$17,850**

RARE

S. Gaines Fish Forever	3/1/2016-12/31/2016	$50,000
	RARE Subtotal	**$50,000**

SANTA BARBARA FOUNDATION

M. Wittmann IA Pilot Project to Demonstrate Best Water Management Practices for Sustainable Agriculture, Wildlife Conservation, and Regional Fire Security at UCSB's Sedgwick Reserve	12/02/2016-12/01/2017	$16,000
	Santa Barbara Foundation Subtotal	**$16,000**

SANTA BARBARA, COUNTY OF

C. Sandoval Coal Oil Point Reserve Education & Conservation Center	11/01/2016-02/15/2018	$23,000
	Santa Barbara County Subtotal	**$23,000**

SIMONS FOUNDATION

A. Santoro Growth Efficiency in the Mesopelagic at Station ALOHA	07/01/2016-03/30/2018	$408,515
D. Valentine The Refugio Oil Spill as a Microbial Laboratory	07/01/2015-03/31/2017	$588,041
	Simons Foundation Subtotal	**$996,556**

SIMONS FOUNDATION

D. Valentine, D. Iglesias-Rodriguez, R. Miller MARINe Rocky Intertidal Survey Program	7/1/2015-3/31/2017	$588,041
	Simons Foundation Subtotal	**$588,041**

SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT (SCCWRP)

R. Miller	06/01/2016-06/30/2018	$42,010
Develop Techniques to Batch-identify Ichthyoplankton Larvae		$2,547
Southern California Coastal Water Research Project Subtotal		**$44,557**

TEXAS A&M UNIVERSITY

U. Passow	01/01/2015-12/31/2017	$162,988
Role of Microbial Exopolymers in Aggregation and Degradation of Oil and Dispersants		
Texas A&M University Subtotal		**$162,988**

TUFTS UNIVERSITY

O. Young	12/01/2015-08/31/2018	$220,067
Collaborative Research: Holistic Integration for Arctic Coastal-Marine Sustainability (HIACMS)		
Tufts University Subtotal		**$220,067**

UC AGRICULTURE AND NATURAL RESOURCES

T. Dudley	07/01/2016-06/30/2018	$41,872
Deception and Implication of Polyphagous Shot Hole Borer in Riparian Ecosystems and Adjacent Agricultural Systems		
A. Lambert	07/01/2016-12/31/2017	$8,877
Deception and Implication of Polyphagous Shot Hole Borer in Riparian Ecosystems and Adjacent Agricultural Systems		
UC Agriculture and Natural Resources Subtotal		**$50,749**

UC DAVIS

H. Young	01/01/2017-12/31/2017	$7,519
Megafires and Ecological Networks		
UC Davis Subtotal		**$7,519**

UC LOS ANGELES

J. Pruitt	08/01/2016-04/30/2017	$126,000
Consortium Grant: Quantitative Approaches to the Study of Keystone Individuals		
UC Los Angeles Subtotal		**$126,000**

UC SAN DIEGO

M. Brzezinski	06/01/2016-05/31/2017	$47,300
Southern California Regional Coastal Ocean Observing System: Harmful Algal Bloom		
L. Washburn	06/01/2016-05/31/2017	$386,600
Southern California Regional Coastal Ocean Observing System: Surface Current Mapping, and Quality Control		
UC San Diego Subtotal		**$434,100**

UC SANTA CRUZ

P. Alagona	07/01/2016-06/30/2017	$61,983
Kevin Brown ISEECI Postdoctoral Fellowship		$32,879
J. Caselle	06/10/2016-05/31/2017	$65,520
Collecting Data: Assessing Ecosystem Conditions and Trends: Subtidal		
M. Love	10/01/2016-09/30/2017	$51,200
Quantifying Avoidance and Attraction of Demersals Fishes to Mobil Visual Survey Platforms		
S. Mazer	01/01/2017-12/31/2017	$12,866
Using UC Reserves to detect and forecast climate impacts		
	UC Santa Cruz Subtotal	**$224,448**

UC SEA GRANT

J. Caselle	02/01/2017-01/31/2018	$111,103
Species Distribution Models for Management of Fisheries and MPAs: Innovative Approaches to Cost-Effective Data Collection in California		
C. Culver	03/01/2017-01/31/2018	$8,000
Sea Grant Extension Allocation Funds		
H. Lenihan	2/1/2017-01/31/2018	$106,432
Impact of Neonicotinoid Pesticides on Estuaries and Coastal Streams		$44,844
M. Myers	12/01/2016-01/31/2017	$2,788
		$2,960
Sea Grant Extension Program Funds		$4.934
D. Ovando	08/01/2016-06/30/2018	$76,569
A Bayesian Framework for Utilizing Fishery Independent Marine Protected Area Monitoring Data in Stock Assessments		
	UC Sea Grant Subtotal	**$357,630**

UNIVERSITY OF EXETER

A. Santoro	10/01/2016-01/31/2020	$370,840
Transporter Function and Kinetics in Uncultivated Marine Microbes		
	University of Exeter Subtotal	**$370,840**

UNIVERSITY OF GEORGIA

U. Passow	1/1/2016-12/31/2017	$101,793
Oil-Marine Snow-Mineral Aggregate Interactions and Sedimentation during the BP Oil Spill		
U. Passow	1/1/2015-12/31/2017	$212,450
ECOGIG-2: Ecosystem Impacts of Oil and Gas inputs to the Gulf		
	University of Georgia Subtotal	**$314,243**

UNIVERSITY OF HAWAII

C. Carlson	1/1/2015-7/31/2017	$51,089
Analyses of dissolved organic carbon and total nitrogen for the Hawaii Ocean Time-series (HOT) program		
	University of Hawaii Subtotal	**$51,089**

UNIVERSITY OF MIAMI

C. Carlson	3/15/2015-2/28/2021	$147,074
Collaborative Research: Global Ocean Repeat Hydrography, Carbon, and Tracer Measurements, 2015-2020		
	University of Miami Subtotal	**$147,074**

UNIVERSITY OF PITTSBURGH

C. Briggs	09/26/2016-09/25/2017	$17,251
Effects of Climate on Host-Pathogen Interactions in Chytridiomycosis		
	University of Pittsburgh Subtotal	**$17,251**

UNIVERSITY OF SOUTHERN CALIFORNIA, SOUTHERN CALIFORNIA EARTHQUAKE CENTER

D. Valentine	4/1/2016-06/30/2018	$118,568
Using a targeted metagenomic approach to examine adaptive protein diversification by microorganisms and their viruses in subseafloor sediments		
	University of Southern California Subtotal	**$118,568**

UNIVERSITY OF WISCONSIN

M. O'Brien	07/15/2016-06/30/2017	$98,223
Environmental Data Initiative		
	University of Wisconsin Subtotal	**$98,223**

US DEPARTMENT OF AGRICULTURE, FOREST SERVICE

S. Cooper	5/9/2016-5/08/2021	$45,000
Evaluating the status of South Central and Southern California Steelhead populations and stream habitat conditions on the LPNF through data acquisition and analysis		$100,000
C. D'Antonio	4/20/2016-4/19/2021	$60,000
Evaluating the status and trends of southern California Forest Service lands through long-term monitoring		$37,003
	US Department of Agriculture, Forest Service Subtotal	**$242,003**

USDI BUREAU OF OCEAN ENERGY MANAGEMENT

M. Love	09/20/2016-09/30/2019	$455,000
Net Environmental Benefit Analysis of Pacific Platform Decommissioning Scenarios		
	USDI – Bureau of Ocean Energy Management Subtotal	**$455,000**

USDI BUREAU OF SAFETY AND ENVIRONMENTAL ENFORCEMENT

D. Valentine	08/29/2016-12/31/2017	$499,949
The Effect of Hydrocarbon Production on Offshore Natural Seep Rates in the Coal Oil Point Area, Santa Barbara, CA		
	USDI – Bureau of Safety and Environmental Enforcement Subtotal	**$499,949**

USDI FISH & WILDLIFE SERVICE

R. Knapp	09/22/2015-07/31/2020	$44,000
Treatment and prevention of infection by Bd in two species of mountain yellow-legged frogs		
	USDI Fish & Wildlife Service Subtotal	**$44,000**

USDI GEOLOGICAL SURVEY

M. Brzezinski	9/1/2016-03/31/2018	$28,000
Wave energy in kelp forests		
R. Knapp	02/07/2017-12/31/2017	$21,473
Understanding and Ameliorating Predation on Reintroduced Mountain Yellow-legged Frogs by Terrestrial Garter snakes in the Sierra Nevada		
D. Wilson	5/1/2016-12/31/2017	$33,076
Synthesis of Mendocino Ridge regional Geologic Framework, Tectonic and Magmatic Processes and Margin Evolution in Support of US Extended Continental Shelf Assessments		
	USDI Geological Survey Subtotal	**$82,549**

USDI NATIONAL PARK SERVICE

R. Knapp	6/10/2015-06/10-2020	$105,000
Restoring rare frogs in Yosemite National Park		$96,658
R. Knapp	09/30/2016-09/30/2021	$70,500
Critical Restoration Efforts to Recover Endangered Mountain Yellow-Legged Frogs in Sequoia and Kings Canyon National Parks		
	USDI – National Park Service Subtotal	**$272,158**

WAITT FAMILY FOUNDATION

C. Costello, S. Gaines	12/31/2016-12/31/2017	$500,000
Sustainable Fisheries Group: Sustainable Ocean Solutions through Rights-Based Management, Fisheries Certification, and Marine Protected Areas & Aquaculture Scope		
	Waitt Family Foundation Subtotal	**$500,000**

TOTAL 2016-2014 AWARDS	**$17,781,660**

Research Summaries
(Contracts/Grants Administered)
July 2016 – June 2017

Peter Alagona, Kevin C. Brown **07/01/2016 to June 30, 2018** **$94,862**
UC Santa Cruz A15-0023-S011

Using UC Reserves to Detect and Forecast Climate Impacts

This postdoctoral research project investigates the changing relationship between land use, ecology, and climate change on the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa) during the nineteenth and twentieth centuries. It asks, for example, how the introduction of ungulates to the islands, the human uses of wood products, the islands' gradual incorporation into the national park system, and changes in climate have combined to reshape the islands' landscapes. Ultimately, this work seeks to build a clear understanding of the mechanisms, tempo, and variations in environmental change across the Channel Islands during this period, providing a novel and nuanced portrait of the archipelago. This work can contribute not only to ongoing ecological and archeological research on the islands as well as management planning the National Park Service, but also to understandings of the political economy of southern California, the twentieth century development of ecology and range management sciences, and the broader history and historiography of island environments. The specific products of this research will be three manuscripts suitable for submission to peer reviewed journals.

To produce this history, the project will utilize archival collections from around California and elsewhere, including at the Natural History Museum of Los Angeles, the Museum of Vertebrate Zoology at UC Berkeley, the Santa Barbara, Natural History Museum, and the National Archives in College Park, Maryland. Along with examining the textual records traditionally used by historians, this project will examine historical maps, photographs, climate data, and specimen collections. By examining the records of the Santa Cruz Island Reserve (UC Santa Barbara), meanwhile, this project will also help develop a methodological model for using the archival materials of, and writing about, sites within the UC Natural Reserve System.

Carol Blanchette, Jennifer Caselle, **1/01/2015 to 3/31/2018** **$546,982**
Steven Gaines, Robert Warner, Libe Washburn
Oregon State University F08866A-C

PISCO Science for an Informed Society, 2016

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 protec¬ed areas), and effects of changing climate. Established in 1999, PISCO is a consortium of scientists located at Oregon State University, Stanford University's Hopkins Marine Station, University of California Santa Cruz, and University of California Santa Barbara. Over the years, PISCO has refined and expanded its research program to add expertise and engage collaborators in specific projects. We will capitalize on the trusted relationships that we have built with colleagues in boundary organizations, state and federal agencies, and other academic centers to develop collaborations and partnerships that advance visions of (1) sustaining interdisciplinary, ecosystem science efforts that inform management and policy and (2) combining different but complementary organizational perspectives and approaches to address environmental problems in unique and innovative ways. This renewal request is organized in two major sections: Request for 2015 activities (this document): We aim to continue developing PISCO's ecosystem time series that provide

uniquely valuable perspectives on climate change, sustainable ocean resources, and ecosystem-based management. Our objectives are: 1. Time series advance new understanding about coastal marine ecosystems of the CCLME and inform multiple conservation actions. PISCO ecosystem time series has multiple applications for conservation science and policy, and has been important for leveraging new awards. Due to regional differences in development of time series and leveraging opportunities for co-funding, not all time series activities span this entire temporal or geographic range. But, when combined coast-wide, they provide comprehensive insights into how the CCLME functions. In 2015, we will continue some time series efforts in the intertidal and subtidal, contribute to the development of genomic-based survey methods, and develop products that employ our long-term datasets to gain new insight into ecosystem dynamics and communicate our findings. 2. Apply insights from PISCO time series to key questions for MPA management, nearshore fisheries, and climate change policy. We will apply PISCO ecosystem approaches to key questions relevant for (a) adaptive management of marine protected areas, (b) nearshore fisheries, and (c) climate change. Cornerstones of our MPA and fisheries work will be select exploratory projects that we develop and initiate in 2015 with partners in academia, management, and policy to evaluate feasibility of longer-term and more formal academic-agency partnerships. Besides research and analysis, our climate change work will consist of continued engagement with policy advising processes, product development, and convening scientific exchanges with other research groups about ecosystem impacts along the West Coast. In 2015, we will also meet periodically with DLPF's West Coast team to ensure that our activities are coordinated with DLPF and partner activities. These activities will determine the path and projects that we pursue in the remainder of this 5-year phase of PISCO.

Carol Blanchette, Jennifer Caselle Libe Washburn — **04/01/2017 to 12/31/2017** — **$178,532**
Oregon State University — F0975A-C

PISCO Science for an Informed Society, 2017

Activities supported by these funds include:

- Intertidal recruitment research in Southern California.
- Contributions via personnel time to intertidal community and biodiversity surveys with UCSC.
- Sea star wasting recovery data collections as part of field team trips to intertidal sites.
- Analysis of existing subtidal data (community structure and recruitment) to address questions of Objective 1 and 2, including the developing of products that communicate the results.
- Leadership engagement in management and policy processes as part of Objective 2 research.
- Fish and urchin recruitment in Southern California.
- Participation in Principal Investigator meetings, conference calls, and other collaborative consortium activities that support proposed Objectives 1 and 2.

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

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

Characterization of Rocky Intertidal, Kelp Forest and Deep Rocky and Sandy Ecosystems at San Clemente Island Our approach to characterizing the baseline conditions of rocky intertidal ecosystems within SCI exclusion and reference sites will be closely linked to the rocky intertidal baseline monitoring approaches used to provide baseline characterization for the California MPA network: South Coast Study Region (Blanchette and Raimondi co-PIs), Central Coast Study Region (Raimondi and Blanchette, co-PIs) and the North-Central Coast Study Region (Raimondi, PI). This

tight integration of leadership, personnel, protocols and datasets with sampling programs in other California regions will ensure consistency in methods and data facilitating synthesis and analysis across study regions. Our program will be closely coordinated with the two major existing west coast regional monitoring programs for intertidal ecosystems (where Raimondi and Blanchette are also PI's). The first is MARINe (Multi Agency Rocky Intertidal Network, http://www.marine.gov/), which evolved from the monitoring program initiated by the Channel Islands National Park in the early 1980's (Davis 1985; Richards and Davis 1988). The MARINe monitoring was explicitly directed at detecting temporal changes in the intertidal communities (Raimondi et al 2005). The second is PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans, http://www.piscoweb.org/), which has supported the Coastal Biodiversity Survey program (described in detail below). These biodiversity surveys have been conducted at 130 sites from central Alaska to southern Baja, California, Mexico (Blanchette et al. 2008). While the unified MARINe protocols have proven to be extraordinarily powerful for detecting changes in communities (Minchinton and Raimondi 2005) and particularly in separating anthropogenic from natural dynamics (Raimondi et al 1999), they were not designed to estimate biodiversity. Moreover, we found that geomorphology was tremendously important in determining communities and dynamics of communities. To address these concerns we designed a spatially explicit biodiversity monitoring program. This program has been variously called the SWAT or comprehensive surveys, but herein we will use the term biodiversity surveys. These surveys have been conducted at almost all of the MARINe sites and several non – MARINe sites. Our baseline characterization and monitoring plan will be based on the successful elements from both the MARINe and biodiversity survey programs and aimed at the assessment and understanding of ecological conditions in rocky intertidal ecosystems in this region at or near the time of MPA implementation. Our protocols will be generally aligned with those used in other study regions, and identical to those being used across the south coast study region. Based on our experiences with both the MARINe and PISCO programs, as well as leading the baseline monitoring efforts in both the central and north central regions, we propose to use two separate survey types to characterize rocky intertidal ecosystems of SCI. Both types of surveys will be done in each of the first two years to establish baseline conditions. These sites will include sites previous sampled in 2009 (Boy Scout Camp and Eel Point). Other specific locations will be determined as part of our coordinated planning meeting, which is intended to produce a joint sampling plan for all projects.

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

MARINe Rocky Intertidal Survey Program

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

Cherie Briggs, Roland Knapp **8/15/2015 to 7/31/2018** **$306,075**
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.

Cheryl Briggs **09/26/2016 to 09/25/2017** **$17,251**
University of Pittsburgh 0051433-1

Effects of Climate on Host-Pathogen Interactions in Chytridiomycosis

Work will be conducted to incorporate the empirical findings from the field survey and laboratory experimental portions of the project into an individual-level model that can be sued to predict the impact of climatic conditions on the susceptibility, tolerance, infectivity, and performance (e.g. survival, maturation) of individuals of the target amphibian species. Will work with modelling postdoctoral researchers to develop, implement, and analyze the individual-level models, and prepare publications based on the results.

Development of community-level models will be produced to investigate how climate and amphibian community composition may interact to determine the potential for chytridiomycosis outbreaks at specific DoD sites, under both current and future climate scenarios. The community-level models will be used to predict the impacts of specific management strategies to mitigate the effects of chytridiomycosis on threatened amphibian species.

Cheryl Briggs, Roland Knapp **5/01/2016 to 4/30/2021** **$136,052**
National Science Foundation 1557190

LTREB: Collaborative Research: Long-term Dynamics of Amphibian Populations Following Disease-driven Declines REU supplement $22,927

The research builds on data from a long-term study of the population dynamics of mountain yellow-legged frongs (Rana sierra and Rana muscosa) in the California Sierra Nevada mountains, and the impacts of the amphibian chytrid fungus, Batrachochytrium dendrobatidis (=Bd), as it has invaded and spread through frog populations in hundreds of high elevation lakes. In most cases, invasion of Bd results in epizootics of the disease chtrydiomycosis, rapid frog population declines, and local extinctions, but in some cases long-term persistence of frog populations occurs with Bd in an enzootic state. The proposed research will investigate the patterns of change in both the frog and the fungus as Bd swept across the Sierra Nevada, and the implications of these changes for Bd virulence and frog resistance/tolerance to infection. This will be accomplished through a combination of Bd cultures and frog mucosal samples from field populations, and laboratory experimentation on Bd virulence and frog susceptibility.

Cheryl Briggs **7/1/2015 to 09/30/2017** **$17,100**
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 hammondii,* 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.

Cheryl Briggs **9/1/2013 to 6/30/2018** **$1,664,693**
NIH General Medical Sciences 1R01GM109499

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

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

Mark Brzezinski **12/1/2012 to 11/30/2017** **$349,538**
National Science Foundation OCE-1233028

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

We propose to measure silicon isotope distributions along the US GEOTRACES section from Peru to Tahiti scheduled for the Fall of 2013. The silicon isotope proxy is increasingly being used to assess the role of diatoms and silicic acid in past shifts in ocean productivity and their implications for climate. It is becoming clear that successful application of the silicon isotope proxy for diatom productivity requires a mechanistic understanding of how the silicon isotopic composition of ventilating waters masses varies in time and space. Model results suggest control through the fractionation of isotopes of Si during silica production and during silica dissolution coupled to the movement of Si by biological pump and the meridional overturning circulation. Empirical support for model predictions is equivocal. The very few full ocean depth profiles of δ30Si(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 δ30Si(OH)4and [Si(OH)4] in deep waters are the opposite of what current models predict. The spatial resolution of the present data set is inadequate to resolve conflicting hypotheses regarding the mechanisms driving large-scale δ30Si(OH)4 distributions in this region, but we hypothesize that the North Pacific Silicic Acid Plume plays a critical role. We propose to test model predictions regarding δ30Si(OH)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 δ30Si(OH)4data set that a comprehensive test will require spatially resolved δ30Si(OH)4data from multiple oceans basins. International GEOTRACES sections completed or planned by Canada, Great Britain, France, Germany, Sweden and India include δ30Si(OH)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 [Si(OH)4] of each sample using colorimetric methods, data entry and data management.

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

UC Santa Barbara Marine Laboratory SCUBA Compressor Improvement

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

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

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

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

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

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

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

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

Arctic, and bottom waters of the Canada and Makarov Basins. Two full-depth profiles of the isotopic composition of diatoms will test for the effects of fractionation of Si isotopes during silica dissolution.

Mark Brzezinski **9/1/2015 to 3/31/2018** **$124,263**
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.

Mark Brzezinski **9/1/2013 to 8/31/2018** **$484,536**
National Science Foundation OCE-1334387

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

Diatoms, unicellular, eukaryotic photoautotrophs, are one of the most ecologically successful and functionally diverse organisms in the ocean. Despite accounting for <1% of Earth's biomass, diatoms are estimated to contribute ~20% of total global primary productivity. In addition to being a key component of the global carbon cycle, diatoms are also tightly connected to silicon (Si) biogeochemistry because of their obligate requirement of Si for cell wall formation and growth. It is estimated that diatoms process over 240 Teramoles of biogenic silica each year and that each molecule of silicon is cycled through a diatom 39 times before being exported to the deep ocean. This proposal seeks to understand Si regulation of diatom productivity in the sea at the molecular level through a unique combination of state of the art tracer methods and assessments of silicon transporter expression and diversity. Success will provide new insights into the physiological basis of Si limitation in the sea and the molecular mechanisms involved.

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, δ15NDB and δ30SiBSi, respectively, are important paleoceanographic tools used to investigate the role of the Southern Ocean biological pump in regulating atmospheric CO2 concentrations. Existing calibrations, including culture experiments, surface sediment data and downcore reconstructions, all suggest that nutrient utilization is the primary driver of δ15NDB and δ30SiBSi 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 δ30SiBSi. 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.

Mark Brzezinski **06/01/2017 to 05/312/2018** **$94,600**
UC San Diego 94339A

Southern California Regional Coastal Ocean Observing System: Harmful Algal Bloom

UCSB will carry out a set of observations at Stearns's Wharf 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 Stearns's wharf providing a continuous data record of temperature, salinity, and chlorophyll fluorescence. Stearns'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.

Deron Burkepile **5/1/2015 to 4/30/2020** **$509,217**
National Science Foundation OCE-1547952

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

Overview: Dramatic changes in ecosystem function often follow changes to top-down and bottom-up forcing. Importantly, alterations of both top-down and bottom-up processes may be mediated through changing the abundance of consumers. That is, in addition to altering primary producer abundance through consumption, consumers may be a significant source of limiting nutrients via their excretion. Despite the important role of both consumers and nutrients in influencing community dynamics on coral reefs, the role of bottom-up forcing by fish excretion has generally been ignored as a mechanism for altering benthic community structure.

Objectives: The goal of this proposal is to quantify how nutrients from fish excretion impact coral reef community structure and how this effect varies across environmental context. Specifically, I outline research to focus on three general sets of objectives that we will ask on reefs in the Florida Keys, USA: 1. Assess how fish-derived nutrients influence benthic community structure and coral growth and health both across and within reefs and how this influence varies with abiotic context. 2. Test how the physiology and growth of individual corals and algae respond to the different nutrient sources in fish excretion vs. anthropogenic nutrient loading. 3. Examine how fish-derived nutrients impact coral restoration and how to design restoration programs to take advantage of important of fish-derived nutrients for coral growth. I will address these questions with: (1) a field monitoring program (Objective 1), (2) mechanistic nutrient enrichment experiments (Objective 2), and (3) coral restoration experiments (Objective 3).

Craig Carlson **1/1/2015 to 7/31/2018** **$231,855**
University of Hawaii MA1126

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

Since 1988, the Hawaii Ocean Time-series (HOT) program has provided information on time variability in biogeochemical and physical processes in one of Earth's largest ecosystems, the North Pacific Subtropical Gyre (NPSG). The program is built around interdisciplinary shipboard sampling

and data collection at near monthly intervals (10 cruises/year) at the open ocean site Station ALOHA (22.75N, 158W). The multi-investigator program is based at the University of Hawaii (UH), with key long-term partners at Oregon State University (OSU), Montana State University (MSU), Scripps Institution of Oceanography (S10), and more recently (since 2004) Woods Hole Oceanographic Institution (WHOI). Measurements conducted by HOT continue to transform our view of linkages between ocean biogeochemistry, plankton ecology, and physical processes in the NPSG. Foremost among the program objectives are to quantify time-varying (seasonal to decadal) changes in reservoirs and fluxes of carbon (C) and associated bioelements; and identify processes controlling air-sea C exchange, rates of C transformation through the planktonic food web, and fluxes of C into the ocean's interior. This subcontract will support regular program analyses of dissolved organic carbon and total dissolved nitrogen in seawater samples collected on near monthly HOT cruises. In addition, the subcontract includes funds for analyses of several years of samples previously collected by HOT to establish a new analytical baseline for these inventories of carbon and nitrogen. University of California Santa Barbara

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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 Diagnetic 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 10/31/2020** **$453,480**
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 **1/1/2015 to 2/28/2021** **$425,469**
University of Miami S15-49

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

Summary: DOM is one of the largest of the bioreactive pools of carbon in the ocean (680-700 Pg C; Williams and Druffel, 1987; Hansell and Carlson, 1998, Hansell et al., 2009), second only to TCO2. The size of the reservoir (comparable to that of atmospheric CO2), as well as its role as a sink for autotrophically fixed carbon, as a substrate to heterotrophic microbes (Carlson, 2002; Carlson and Hansell 2014), and as a sink/source of carbon involved in climate variations over long time scales (Sexton et al. 2011), highlights the importance of DOM in the ocean carbon and nitrogen cycles. DOC exports 1.9 PgC yr-1 out of the epipelagic zone, contributing ~20% to the biological pump via meridional overturning circulation (Hansell et al. 2002; Carlson et al., 2010). Mechanisms that control DOM accumulation, allowing it to persist and be transported to the regions of overturn, are still poorly understood. Small perturbations in the production or sink terms of the oceanic DOC pool

could strongly impact the balance between oceanic and atmospheric CO2. In this global ocean repeat hydrography, carbon and tracer program D. Hansell (University of Miami) and C. Carlson of UCSB will be responsible for at sea sampling and analyses of dissolved organic carbon (DOC) and nitrogen (DON) measurements. The proposed program includes 14 legs over 11 cruises conducted in various ocean basins from 2015 – 2020. The tentative break down of Carlson's cruise coverage is as follows:

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

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

Jennifer Caselle **06/01/2017 to 06/30/2018** **$112,000**
San Jose State University Foundation 22-1509-5619

Statewide MPA Monitoring

This project will conduct collaborative fisheries monitoring data collection in the Santa Barbara channel and northern Channel Islands portion of the South coast MLPA region in the Kelp & Shallow Rock Ecosystems (0-30m) and Mid-depth Rock Ecosystems (30-100m). The team will also participate in Program Development.

Jennifer Caselle **2/1/2016 to 1/31/2018** **$220,887**
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.

Jennifer Caselle **06/10/2016 to 05/31/2018** **$131,040**
UC Santa Cruz A16-0555-S001

Collecting Data: Assessing Ecosystem Conditions and Trends: Subtidal

The goal of this project is two-fold, and will aid the State in meeting the goals mandated by the Marine Life Protection Act (MLPA): 1). Use existing scientific tools and information, including models, to create siting recommendations for the Statewide Marine Protected Area (MPA) Monitoring Program, including specifying which MPAs and associated reference sites will need to be monitored statewide to assess network performance at meeting MLPA goals, and 2) collect data annually for two years in the sites identified by the recommendations in the North Central Coast, Central Coast, and South Coast MLPA regions within two priority ecosystem features.

The capacity and expertise to conduct this work do no currently exist in the state service. By leveraging existing partnerships and capacity of academic partners, this project will lower costs and ensure a scientifically robust product that meets or exceeds the scientific standards established by the state in order to effectively evaluate the performance of the MPA network. The expert knowledge of the Principal Investigator (PI), Dr. Peter Raimondi at University of California, Santa Cruz, is necessary to select the most appropriate sub-recipients to partner and provide the scientific expertise and support to the sub-recipients in order to achieve these standards. Effective partnerships between the PI and potential sub-recipients that carry out this type of work are inherently dynamic due to funding cycles, personnel changes, and other factors that affect institutional operations. Due to this, it is critical to allow the PI to identify the most effective and efficient sub-recipients to partner with immediately prior to field operations to ensure all deliverables of the contract are met or exceeded.

Jennifer Caselle **06/21/2017 to 07/31/2018** **$79,161**
California Ocean Protection Council C0750600

Evaluation of Methods for Long Term Monitoring for the State of California

The overarching goal of the project is to conduct a methodological comparison of existing data collected in and out of MPAs throughout the state in shallow (<20m) and mid-depth (30-100m) rocky ecosystems to inform long-term statewide monitoring. For shallow depths, we will focus on comparing results from the two primary scuba programs (PISCO and CA Reefcheck). For midwater depths we will gather existing data from drop cameras, hook and line surveys, and shallow ROV surveys. Nearshore SCUBA time series are long enough to allow an evaluation of suitability of the data streams for long-term MPA evaluation. Mid-depth data sets will focus on benefits and limitation of various tools used in these habitats. The results of the project will inform the MPA Action Plan which guide long-term monitoring to evaluate the performance of the MPA Network at meeting the goals of the Marine Life Management Act.

Jennifer Caselle **2/10/2016 to 4/30/2017** **$65,000**
Nature Conservancy 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.

Jennifer Caselle **3/30/2016 to 03/22/2019** **$350,000**
Marisla Foundation 1-16-058/1

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 3/31/2017** **$9,654**
Australian Museum, Lizard Island Research Station SB14014

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

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

Scott Cooper **05/09/2016 to 05/08/2021** **$268,500**
USDA Forest Service 16-CS-11050700-007

Evaluating the Status of South Central and Southern California Steelhead Populations and Stream Habitat Conditions on the LPNF through Data Acquisition and Analysis

There are many resource management issues facing the United States Forest Service (USFS) in

southern California. These include fire and fuels management, climate change vulnerability and adaptation, and ecological restoration. The 2015-2020 USFS Strategic Plan highlights the importance of fostering resilient, adaptive ecosystems and this effort includes adopting management activities aimed at reducing the effects of wildfire, climate change, and non-native species on natural resources, as well as restoring watersheds for the protection of water resources and the aquatic biota. Despite the USFS's commitment to long-term conservation of its lands, there is a need for on-the-ground monitoring and data collection to generate knowledge regarding the state and trajectories of aquatic resources to USFS lands in southern California. In a joint effort to better serve vital applied ecological science needs, the Los Padres National Forest (LPNF) and the University of California, Santa Barbara (UCSB) will enter into a Cooperative Agreement to enhance capacity, and provide analytical and field monitoring support to the LPNF through hands-on training of graduate and undergraduate students.

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

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

The SCSR of the Marine Life Protection Act is unique from other regions in several aspects. First, southern California marine ecosystems are among the best studied anywhere in the state (and, arguably, the West Coast). Second, the South coast study region is the third region in the MLPA process (after the central and north-central regions) and also follows the successful implementation of a network of MPAs in the northern Channel Islands in 2003 and now part of the MLPA network. More than other MLPA regions, a large body of both ecosystem monitoring data and a wealth of contextual data exist (e.g. oceanographic and water quality data, remotely sensed data, habitat maps). However, many of these datasets have yet to be analyzed outside of the context for which they were originally created and even monitoring data from similar habitats have yet to combined into synthetic measures of ecosystem health. Here we have the opportunity to create the partnerships and data products that will be required in order to step up from single location or single habitat analyses and for the first time, move towards cross ecosystem syntheses to support measures of ecosystem health and MPA performance. We have developed a collaborative group that has committed to the goals of synthesis among our various individual projects. The key innovation of our proposed approach is the collaborative nature of the program, which should carry forward in the design, databases and analyses for a more comprehensive and integrated long-term monitoring program. The collaborative and integrated characterizations of separate ecosystem features will also facilitate outreach efforts that transcend individual features and, by including collaborations with the fishing (consumptive) and recreational (consumptive and non-consumptive) sectors, strengthen collaborations of future monitoring programs.

Chris Costello and Gary Libecap 07/01/2016 to 12/31/2017 **$280,000**
Nature Conservancy SB150143

Task 8: Bio-Economic Modeling of Pacific Tuna Fisheries

In collaboration with The Nature Conservancy, the Sustainable Fisheries Group (SFG) at the University of California, Santa Barbara, will conduct a bio-economic evaluation of alternative scenarios for the institutional structure of the tuna fisheries in the Western and Central Pacific Ocean. The primary goal of the Tuna Project is to ensure that the management of Pacific tuna fisheries – which are among the most valuable to commercial fisheries in the world – chart a path towards sustainable and economically sound management of tuna catch and bycatch, supporting both the long-term viability of the fisheries and fisher livelihoods. Modeling scenarios will be selected during the project.

Christopher Costello, Steven Gaines **1/1/2016 to 12/31/2016** **$187,270**
OCEANA, Inc 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 **01/01/2017 to 12/31/2017** **$81,541**
Nature Conservancy SB150143

Task 10: TNC-Bren Collaboration on Climate-ready Fisheries and Frameworks for More Effective Fisheries and Ocean Management

UCSB will conduct literature reviews, outreach, and independent research on three tasks of mutual interest to The Nature Conservancy (TNC) and the Bren School of Environmental Science and Management (Bren).

Task 1: Support TNC-Bren collaboration on climate-ready fisheries.
Task 2: Support the further development and implementation of FishPath
Task 3: Track emerging issues and opportunities for TNC-Bren collaboration

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Christopher Costello **01/01/2017 to 12/31/2017** **$230,000**
David and Lucile Packard Foundation 2016-65300

Analysis of Fisheries Management and Climate Change

The Sustainable Fisheries Group (SFG) at UCSB proposes a research project to assess the impacts of climate change on fisheries dynamics. The main objective is to identify management approaches for which climate change will impose disproportionate losses and to distinguish situations in which adaptation strategies may be critical. It is known that climate change will impact global fisheries primarily in two ways: demographic changes to individual species (e.g., changes in pelagic larval dispersal, metabolism etc.) and shifts in the range and distribution of species. These biological changes are becoming increasingly well understood, but how managers and practitioners should plan and adapt for these changes is far less clear, and is the focus of our proposed work.Evaluation of the case for economic reform of Chinese fisheries: the University will evaluate the economic case for reform by quantifying the lost revenues and food production implications of overexploited fisheries and the potential upside of recovery. The detail and extent to which these economic projections can be derived will depend on the availability of data on fishing effort and fishing costs.

Christopher Costello, Steven Gaines **12/31/2012 to 12/31/2017** **$2,761,324**
Waitt Family Foundation SB130076

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

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

Christopher Costello **09/01/2015 to 09/01/2020** **$127,532**
Nature Conservancy SB150143

Task 1: University Internships, Postdoctoral Positions, and Student and Staff Research Projects

Across the globe, climate change is adversely affecting our oceans, our fisheries, our food system stability, and our coastal communities' economic resilience. Climate-driven changes in the ocean are exacerbating existing stressors, including overfishing, pollution, and habitat degradation. Given the importance of California's seafood economy and the interplay between temperature-dependent upwelling and ecosystems productivity, the California Current large marine ecosystem (LME) and fishery-dependent communities are particularly vulnerable to the impacts of a changing climate. Increased ocean temperatures, ocean acidification, changes in sea level and currents, as well as increased storm and drought intensity are all likely to significantly impact California's ocean ecosystem, the population dynamics of marine species (including species of importance to fisheries), and coastal communities.

Despite these known threats, the specific biological, social and economic risks associated with accelerating climate change are rarely factored into fisheries resource management, business, or investment decisions. There are many recent efforts to document climate change impacts to fisheries and the social vulnerability of coastal communities. For example, the National Marine Fisheries Service (NMFS) has recently launched an effort, using an expert panel approach, to assess the climate vulnerability of fish species in the California Current LME that are managed by the federal agency for the Atlantic coast, as well as nationwide assessments of social vulnerability of coastal fishing communities. In California, the California Ocean Sciences Trust and the California Department of Fish and Wildlife are considering the utility of ecological risk assessment approaches to evaluate the sustainability of California's fisheries in the face of fishing pressure, climate change, and other stressors.

This information should be brought together in a risk assessment framework to evaluate the climate-related risks to fisheries productivity and fisheries-dependent assets and communities that could inform management or business decisions to ensure that California's fisheries are "climate ready". With a framework for risk analysis, we can better identify strategies and opportunities for risk reduction, preparedness and protection at every level in both the public and private sectors.

Christopher Costello **06/13/2016 to 07/31/2017** **$250,000**
Packard Foundation 2016-64364

Benefits of Fisheries Sustainability in Indonesia: Collaborative Modeling to Inform Strategic Institutional and Policy Reform in Indonesia

The Sustainable Fisheries Group (SFG) at UCSB is currently working with the Packard Foundation on a planning grant to build a long-term collaboration and conduct preliminary analyses of the potential benefits of fishery reform in Indonesia. The project leverages our state-of-the-art bio-economic model developed by Costello and colleagues (Proceedings of the National Academy of Sciences, March 2016) that evaluates fisheries benefits and recovery potential from institutional and policy reforms at a global level. Underpinning this model is the most comprehensive global database of fishery status, fishery-specific growth parameters, and fishery economic data ever compiled. While informative at a global scale to help motivate the case for fishery reform, the model uses data sources that are unlikely to deliver accurate results for individual fisheries. This is true in Indonesia, where the data we currently have provide an incomplete picture, particularly for nearshore fisheries.

To fill this gap, we propose to work with key partners to design and develop a parallel series of complementary customized models that leverage more detailed data sets and model real policy measure to more accurately predict the potential benefits of fisheries reform in Indonesia. We are currently pursuing a multi-phased approach to develop and deliver these fisheries reform predictions with the goal that they can motivate policy changes through collaborative efforts with our partners.

Christopher Costello, Steven Gaines **07/01/16 to 07/01/2018** **$200,808**
National Geographic Society SB170043

Pristine Seas

The vision of the Pristine Seas project launched by the National Geographic Society is to identify, survey, and help protect the last wild places in the ocean. The Sustainable Fisheries Group at University of California, Santa Barbara, is continuing to collaborate with Dr. Enric Sala of the Pristine Seas project and Dr. Rashid Sumaila of the University of British Columbia to analyze the economic impacts of closing different regions of the high seas to fishing.

In the next phase of our partnership with Pristine Seas and UBC, SFG will use stock assessment and Global Fishing Watch data to build a bioeconomic model evaluating the costs and benefits of closing high seas areas to fishing within each of the world's Regional Fishery Management Organizations (RFMOs). The model will help SFG identify areas specific to each RFMO where closures would come at a low cost to fisheries and generate conservation benefits.

Christopher Costello **10/13/2015 to 7/31/2016** **$50,000**
David and Lucille Packard Foundation 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.

Christopher Costello, Hunter Lenihan **03/15/2017 to 09/15/2017** **$48,337**
Nature Conservancy SB150143-Task 13

TASK 13: An Island Nation TURF System to Sustain Fisheries and Culture: Phase 1

The work proposed here is a novel integration of economics, ecology, traditional knowledge, and cross-cultural communication that will advance marine fisheries conservation and management in French Polynesia. It will also provide a strategy for tackling complex, large-scale sustainable fisheries challenges around the globe, and will advance The Nature Conservancy's current tuna fisheries reform efforts across the Pacific.

Christopher Costello **04/01/2017 to 11/30/2017** **$36,650**
Nature Conservancy SB150143

Task 14: Technical Training in the Economics of Fisheries Management for Peruvian Decision Makers.

In collaboration with The Nature Conservancy, the Sustainable Fisheries Group (SFG) has developed a technical training workshop on the Economics of Fisheries Management for government officials in Peru. SFG has created the curriculum and textbooks for the course, which will be used in 2017 when the training session is offered to government officials in Lima. As a one week extension to this workshop, the following activities will be added –

- 5 lab sessions of three hours each where the students apply the theoretical concepts learned in class.
- 5 training sessions of two hours each to teach Peruvian government officials how to conduct policy analysis using bioeconomic tools for anchoveta.

Christopher Costello **01/01/2014 to 12/31/2018** **$400,000**
RARE SB150042

Fish Forever (Subaward from Waitt Foundation)

TURF-Reserves combine spatial property rights with marine reserves where fishing is off-limits. Fishermen are given built-in incentives to defend reserves because reserves replenish fisheries and the rights-based system ensures that good management is in the self-interest of local communities. We will achieve scale through a multipronged approach that includes "top down" national level adoption and "bottom up" demand-building, where fishermen in neighboring communities seek out the benefits they see in the pilot and mass prototype sites. Fish Forever brings together three experienced organizations that are uniquely positioned to achieve lasting, scalable conservation solutions across multiple communities and countries.

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

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

This project concerns the bioeconomics of fishery management under uncertainty, a topic that Professor Costello has focused on for his past 11 years at UCSB. Costello's primary role will be to develop and implement analytical and statistical models to address the research proposal's key themes. Specifically, Costello will play a leading role in developing and implementing models of salmon fishery management strategies that explicitly cope with environmental variability, tradeoffs between ecosystem sustainability and economic performance of salmon fisheries management, and how capital investment in salmon fisheries is influenced by environmental stochasticity. What follows is a brief description of Costello's role in each of these themes: Theme 1: Salmon Management with Environmental Variability. The key research question here concerns how management decisions can influence the ecological and economic consequences of a variable environment. Alaska's salmon fisheries are notoriously

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

Christopher Costello **04/01/17 to 11/302017** **$15,000**
Nature Conservancy SB150143

Task 15: Identifying Best Practices in Global Pelagic ITQ Fisheries to Inform Peruvian Anchoveta Quota System

In collaboration with The Nature Conservancy, the Sustainable Fisheries Group (SFG) at the University of California, Santa Barbara will conduct an in-depth literature review on global individual transferable quotas (ITQs) for pelagic fisheries. Through this literature review, SFG will identify best practices relate to the management of species similar to anchoveta. The findings of this research will be delivered to relevant stakeholders to inform the revision of the quota system for the Peruvian Anchoveta Fishery, which globally produces the largest volume of fish from a single fishery stock.

Carolynn Culver **03/01/2017 to 1/31/2018** **$76,545**
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.

Carla D'Antonio **04/20/2016 to 04/19/2021** **$204,503**
USDA Forest Service 16-CS-11050700

Evaluating the Status and Trends of Southern California Forest Service Lands Through Long-term Monitoring

The U.S. Forest Service manages nearly 4 million acres of land in southern and coastal central California. There are many resource management issues facing the U.S. Forest Service lands in southern California, including fire and fuels management, climate change vulnerability and adaptation and ecological restoration. The 2015-2020 U.S. Forest Service Strategic Plan highlights the importance of fostering resilient, adaptive ecosystems and this effort includes adopting management activities aimed at reducing the effects of wildfire, climate change and non-native species. Despite the U.S. Forest Service's commitment to long-term conservation of its lands, there is a strong need for on-the-ground monitoring and data collection to generate knowledge regarding the condition and trajectories of U.S. Forest Service lands in southern California. Working collaboratively with the University of California, Santa Barbara the U.S. Forest Service seeks to meet these needs, while providing valuable field training and experience to undergraduate and recent UCSB graduates. In a joint effort to better serve applied ecological science needs and prepare students for careers in applied sciences, the U.S. Forest Service and UC Santa Barbara will enter into a cooperative agreement to enhance the province's capacity to provide analytical and field monitoring support to the National Forests in southern California.

Carla D'Antonio **09/15/2016 to 08/31/2019** **$780,612**
National Science Foundation 1557177

Collaborative Research: Do Ecological Feedbacks Across Trophic Levels Affect Alternate Stable States and Restoration of Tropical Forests? **REU Supplement $13,450**

Objectives: (1) Advance an understanding of alternative stable state theory as it applies to terrestrial ecosystems and restoration; (2) Evaluate how ecosystem condition is affected by priority effects, multiple feedbacks and the presence/loss of key species; (3) Determine whether all feedbacks must be addressed simultaneously, or whether manipulation of individual state variables can drive change. Methods: The proposed research evaluates potential feedbacks constraining recovery of degraded Hawaiian mesic forest ecosystems focusing on avian seed dispersers, overstory and understory plant litter, and mycorrhizal fungi. It proposes intensive sampling of sites to understand relationships between birds, litter, and mycorrhizae and natural forest regeneration. It then tests interactions between these factors using a manipulative field experiment, greenhouse feedback experiments, and individual-based models to evaluate whether all factors must be addressed simultaneously for natural ecosystem recovery to proceed, or whether a subset of factors can be prioritized to achieve the same goal.

Thomas Dudley, Adam Lambert **07/01/2016 to 12/31/2017** **$98,169**
National Fish & Wildlife Foundation 0806-17-055660

Assessment and Management of Invasive Riparian Plants in LPNF Rivers Systems

The National Fish and Wildlife Foundation (NFWF) in cooperation with its federal partner, the Los Padres National Forest (LPNF), is pleased to announce the Zaca and Piru Fires Restoration Grant Program for the recovery of lands and watersheds degraded from the influences of these two wildfire events. The grant program will be coordinated closely among LPNF and NFWF program staff.

The goals of this competitive grant program are to (1) provide support for projects in the LPNF that address the factors facing the health and function of ecosystems affected by the Zaca and Piru Fires, (2) promote ecological resilience to future wildfire events, (3) improve the LPNF's capacity to identify and address resource management issues, and (4) provide sustainable and lasting ecological benefits.

Thomas Dudley **09/01/2016 to 03/30/2019** **$188,043**
Cal EPA Pesticide Regulation 16-PML-G001

California Alliance for Tamarisk Control

This alliance is intended to build a regulatory, managerial and scientific framework for the implementation of Tamarix biocontrol in California, with particular emphasis on the southern and central California regions. The arrival of Diorhabda carinulata into California via the Colorado River opens the door to regional re-distribution into tamarisk-infested systems where control is desired by agricultural and conservation groups as an alternative to chemical and mechanical treatments, and where wildlife protection agencies can verify that implementation will be beneficial. We will prepare and distribute informational materials and presentation to facilitate implementation to ensure a program that is coherent and meets with regional approval.

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

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

UCSB will provide via the post-doctoral associate identified in this grant the coordination 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. Postdoc 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 subcontract to UCSB, and he will provide supervision along with D'Antonio for the postdoctoral researcher.

Thomas Dudley **9/12/2015 to 5/21/2020** **$129,944**
USDI Fish and Wildlife Service 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 collects seeds and cuttings of native plants and assist with replanting of areas where Arundo has been removed.

Thomas Dudley, Randall Long **2/1/2016 to 7/31/2016** **$1,499**
UC MEXUS 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).

Thomas Dudley **07/01/2016 to 06/30/2018** **$41,872**
UC Agriculture and Natural Resources SA16-3315-02

Detection and Implication of Polyphagous Shot Hole Borer in Riparian Ecosystems and Adjacent Agricultural Systems

The Polyphagous Shot Hole Borer (PSHB), Euwallacea sp. (Scolytinae: Curculionidae), is a tny (ca. 2mm), recently established ambrosia beetle presumed to be from Asia and known to attack, and spread a damaging Fusarium fungus to several dozen species of both economic and native trees in southern California. PSHB was detected in 2015 in Santa Paula and Fillmore where it threatens avocados and numerous ornamental trees. Elsewhere PSHB is known to attack riparian trees such as sycamore, willows, maples, and box elder, cottonwoods, alders, live oaks, etc., many of which are foundational species for sustaining biodiversity (esp. listed species such as least Bell's vireo, willow flycatcher and yellow-billed cuckoo) and for conserving water and other ecosystem functions. In the Santa Clara River (SCR), millions of dollars are spent on riparian restoration, removing invasive taxa such as giant reed (Arundo donax) and replacing them with native woodlands. It is unknown if PSHB is currently present in riparian systems of Ventura County or whether these systems are at-risk for future attack. In addition to the threat posed to riparian trees, beetles may be harbored in these systems and later attack nearby economic trees.

We will establish and monitor a network of detection traps in riparian systems, and at the interface between riparian and adjacent agricultural areas, for the SCR and other key riparian systems in Ventura County to provide early detection of new PSHB infestations.

Thomas Dudley **12/12/2016 to 03/31/2019** **$200,000**
Cal EPA Water Control Board 16-023-140

Freshwater Mussel Assessment for Ventura/Los Angeles Region

Unionid mussels are known to be sensitive to ammonia so this taxonomic group, with many locally and globally endangered species, warrant special attention with respect to USEPA's recommendations for water quality criteria to protect aquatic life from acute and chronic exposure to ammonia in freshwater ecosystems.

The specific objectives of the project will –

- Evaluate existing literature and archival material to better establish historical distributions, environmental conditions and taxonomic composition of native unionids in order to guide field studies and interpret results.
- Carry out field surveys (snorkel/visual observations, benthic sampling, etc. as needed) for the target species.
- Collect water samples from field sites in order to characterize current water quality status for ammonia and other nutrients, and analyze the presence of DNA from the target species.

Thomas Dudley **04/01/2016 to 04/02/2018** **$168,183**
National Fish and Wildlife Foundation 0806.17.055495

Using Environmental DNA to Map the Distributions of Aquatic Species in Areas within and near the Zaca, Piru, and Jesusita Fire Scars

We plan to use environmental DNA to determine presence of selected species of management interest in streams affected by the Zaca, Piru, and Jesusita fires. To achieve this, water samples will be taken from intermittent and perennial streams within these wildfire scar areas as well from nearby reference streams. DNA will be obtained using vacuum filtration and phenol-chloroform extraction. The presence of target species' DNA will be evaluated using quantitative Polymerase Chain Reaction with species-specific primers. Results will be sued to map the distribution of target species and will be compared to data on the history, intensity and areal extent of wildfire in surrounding areas.

Jenifer Dugan, Robert Miller **4/1/2015 to 3/31/2019** **$1,017,762**
National Science Foundation OCE-1458845

Linking Nearshore Kelp Forest Dynamics to Sandy Beach Ecosystems

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

Jenifer Dugan **2/1/2014 to 1/31/2017** **$12,601**
Pepperdine University SB150118
A New Method for Monitoring Urban Beach Ecosystems

Task 1: Develop a list of indicators suitable for use in volunteer-based beach monitoring Task 2: Develop methods and field test protocols for volunteer-based beach monitoring of selected indicators Participate in meetings of the project team during 2014 to identify and select indicators and to develop non-invasive methods and protocols for monitoring selected indicators. Participate in field testing of monitoring protocol for selected indicators: work with the project team to assess beaches using the new protocols in 2014, with comparisons and discussion of reliability for quality control. Contribute to production of overall project deliverables: List of indicator species/taxa for southern California beaches Set of field protocols suitable for use by volunteers in monitoring beaches Task 3: Develop draft field guides, protocols and materials for use by volunteers in monitoring Work with project team and a graduate student (sea grant trainee) to develop and produce materials to be incorporated in a field guide and protocol manual for beaches With project team, evaluate and test field guide and protocol manual Participate in revising and refining draft field guide and protocol manual based on feedback from field testing Contribute to production of overall project deliverables: A draft field guide and protocol manual for use by volunteers in monitoring beaches.

Jenifer Dugan **5/1/2009 to 12/31/2017** **$37,500**
California Coastal Commission SB090092

Evaluating Status and Trends in California's Sandy Beach Ecosystem

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

Jenifer Dugan **2/1/2014 to 3/31/2017** **$45,000**
UC Sea Grant College Program R/MPA-38D

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

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

state agencies (Humboldt Bay Harbor Recreation and Conservation District, Mendocino Fish and Game Commission, California Department Fish and Wildlife), and commercial fishers (California Commercial Beach Fishermen's Association) to help with sandy beach and surf zone monitoring; and 4) interpret the important ecological links among sandy beach species for use in evaluating the effectiveness of northern California's MPAs in conserving the structure and function of sandy beach ecosystems.

Jenifer Dugan **06/05/2017 to 12/31/2017** **$7,500**
California Department of Fish & Wildlife 6600 PCA 57350

Refugio Oil Spill NRDA Shoreline Research

Plan, coordinate and conduct field surveys and collect biotic samples of sandy beach shorelines that provide data and information for the Refugio Oil Spill NRDA.

Jenifer Dugan **7/15/2013 to 12/31/16** **$50,000**
USDI National Park Service P13AC00900

Wave-Exposed Sandy Beach Invertebrate Staining and Mark-Recapture

The primary objectives for the proposed study are to: Objective 1: NPS and UCSB to conduct reconnaissance surveys of beaches near Santa Barbara to identify the locations most likely to yield invertebrates and the species of invertebrates available from these areas for use in the project. The field reconnaissance surveys will be conducted by both NPS PM and UCSB PI or their appointed representatives, likely with a small net like a 8 or 10 inch aquarium net and/or corers and mesh bags, unless NPS travel restrictions prevent NPS participation. This objective should occur during June, July or August 2013, unless NPS travel restrictions delay the travel into FY2014. Objective 2: UCSB to perform stain trials on a variety of California sandy beach crustaceans to eliminate species that do not take up and retain the stain well and those with high mortality resulting from stain exposure; stain trials will attempt to include one (1) to three (3) species each of isopods, amphipods, mysid shrimp, and mole crabs [20 individuals per species, 20 minute stain exposure to 50 mg L-1 neutral red, stain retention and mortality evaluated against controls after 72 to 96 hours]. Objective 3: NPS and UCSB to rank the available invertebrate species as to suitability for further research based on the reconnaissance and stain trials. Ranking with include stain & mortality suitability (%), order of magnitude abundance (10x), distance-cost to location (km), simplicity to locate and sample, and ease to identify. Objective 4: UCSB to develop a stain procedure in the laboratory that can later be tested for field mark-recapture studies of top ranked sandy beach invertebrate(s) based on staining methods of Drolet and Barbeau 2006. Objective 5: UCSB to determine the speed and variation in burrowing time for top ranked invertebrate released onto wet native beach sand under varying submergence conditions in a laboratory setting. Objective 6: Conduct field mark-recapture population estimates that determine how wide ranging in distance, time and invertebrate density (as indexed by CPUE) the staining can be effectively used for mark-recapture of the top ranked invertebrate. Objective 6 may require pilot studies close to the laboratory facility to test and refine field methods. Objective 7: Make and provide rate of dispersal, population estimate and CPUE calculations and regression for top ranked invertebrate(s). Objective 8: Compare the efficiency of size based sorting techniques for live invertebrates at beach sampling location vs. a controlled setting, specifically speed and accuracy of sorting adults from recruits in beach population samples. Objective 8 to be conducted during a time period when some recruits are present in the population. UCSB will conduct the sampling and counting; NPS will consult on sampling design and assist as requested on statistical analysis and short report. The controlled location could be a laboratory, motel room, vehicle or tent where invertebrates could be held and sorted carefully, and by dissecting microscope if necessary. Cold temperatures and anesthetics will be utilized to slow the animals for counting in preference to killing the organisms for counting. Objective 9: Compare the efficiency of determining reproductive status in samples of live invertebrates at the beach sampling location vs. a controlled setting, specifically the speed and accuracy of determining reproductive status of the top ranked invertebrate adults in sandy beach population samples. Objective 9 to be conducted during a time when > 5% of adult females are

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

Steven Gaines **3/1/2016 to 12/31/2016** **$50,000**
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.

Steven Gaines **7/1/2015 to 12/31/2017** **$268,750**
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

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

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

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

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

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

Aquatic Invertebrate Research for Experimental Watersheds in the Kings River System

Samples of benthic invertebrates will be collected from the lower regions of the streams draining the experimental headwater catchments in June of 2013, using a standard D-frame collection net (30 cm wide, 250 µm mesh). This is the spring following the summer (2012) that thinning treatments will be

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

David Herbst **06/15/2017 to 05/30/2018** **$25,200**
California Trout, Inc SB170147

Prioritizing Meadow Restoration for Kern River Rainbow Trout Recovery

Assessment of stream macroinvertebrate biological integrity in various meadow streams, and before/after restoration actions. Field sampling invertebrates, laboratory sorting, identification and counting of preserved samples, data compilation, analysis of pattern and relationships to other measures of meadow and riparian structure and function, testing of hypotheses related to expected results, preparation of sub-report within framework of project.

David Herbst **9/1/2015 to 8/31/2018** **$174,636**
AMEC (Great Britain) C013105571

Biomonitoring of Leviathan Creek Watershed for Fall 2015

Scope of Work. Tasks are partitioned by season of collection (September 2015 in this case), with completion of each subtask at the listed task deliverable date: Task 1: September 2015 Leviathan Creek field sampling for biomonitoring of stream condition, consisting of 5 replicate samples collected at each of 7 Leviathan Creek monitoring stations (35 total samples). Field protocols will be as detailed in previous biomonitoring reports, taking each replicate as 3 combined riffle areas of 1 square foot collected each for each sample, using a 250 micron mesh D-frame net, processed in the field to remove organic debris, gravel and sand (elutriated from buckets, serial washed and sorted in trays). Sample preservation in ethanol in 500 mL containers. Work to be performed by David Herbst and Bruce Medhurst of the University of California, Sierra Nevada Aquatic Research Laboratory (SNARL) during week of September 21, 2015. Deliverable: sample collections log sheet of dates and sites. Due Date: September 30, 2015. Task 2: September 2015 Leviathan Creek Aquatic Invertebrate Sample Processing, Identifications and Enumerations: David Herbst and Bruce Medhurst of SNARL

will perform laboratory work for macroinvertebrate processing, sorting, identifications and counts from 5 replicate samples collected at each of 7 Leviathan Creek monitoring stations (35 total). These data will support preparation of annual reporting updates as conforms with previously prepared reports by the Contractor. SubTask 2.1: Sample processing September 2015 samples. Sample processing will include sample homogenization, subsampling, removal of invertebrates from stream debris, and preliminary sorting into taxonomic groups. Quality control includes checks on sample processing (splits, count minimum), condition of specimens, removal efficiency, and sample coding for each of the collections from the Leviathan Creek watershed. · Deliverables: Processing log sheets. · Due date: no later than June 30, 2016. (anticipated March 31, 2016) SubTask 2.2: September 2015 Bioassessment Data Benthic macroinvertebrate (BMI) identifications from sorted samples will be made to the lowest taxonomic level consistent with previous Leviathan data (usually genus or species), including small midges and mites requiring use of slide mounts and 400X compound microscope. All sample identifications will incorporate quality control for taxonomy and counts through confirmations both by the primary lab taxonomist (Herbst) and cross-checks by staff of the Sierra Nevada Aquatic Research Laboratory (Medhurst). The Contractor will compile data in Excel spreadsheet format for Leviathan stream BMI counts and taxonomic identities consistent with existing biomonitoring data from Leviathan Creek watershed, and submit to AMEC, AR, US EPA and US ACE contacts.

David Herbst **4/18/2016 to 12/31/2016** **$296,511**
Roy F. Weston, Inc 0087111

Bio Assessment Study Support for Leviathan Mine Superfund Site, CA

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

Scott Hodges **8/01/2015 to 7/31/2018** **$463,579**
National Science Foundation 1456317

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

All plants build their bodies via the repetitive production of a small number of fundamental building blocks, one of which is the lateral determinate organ. While many aspects of lateral organ development appear to be highly conserved, there exists enormous morphological variation both within the plant body and among flowering plant taxa. In order to understand the basis for this variation, we need to address a series of questions: How does the interplay of cell division and expansion sculpt organ shape? How is complex shape generated from a developmental perspective and what genes control these processes? How do novel organ shapes first evolve? What types of developmental and genetic changes are associated with morphological variation between taxa? The dramatic development of the Aquilegia nectar spur, a complex three dimensional structure that is both recently evolved and highly variable between species, provides a rich context to investigate all of these fundamental questions. The specific aims of the current proposal are: 1) Elucidate major players in spur development from genetic, hormonal and biomechanic perspectives. 2) Use high-resolution genetic mapping approaches to identify additional genes controlling the initiation, length and shape of the petal spur. 3) Use evolutionary genomic and functional approaches to identify selective sweeps associated with nectar spur development. The initial analysis of the development and evolution of the Aquilegia petal spur demonstrates that it can serve as a powerful model for investigating the control and evolution of complex organ shape. In this case, an early phase of localized, oriented cell

divisions create the prepatterned spur cup, which is then followed by a period of highly anisotopic cell elongation that gives rise to the final length and shape of the spur. Among the closely related and interfertile species of Aquilegia, variation in spur length and shape is generated by changing several developmental parameters: length is primarily controlled by cell anisotropy, which is in turn controlled by the duration of cell elongation; curvature is generated by varying cell elongation between the distal vs. proximal compartments of the spur; and circumference is controlled both by changes in cell anisotropy and cell number in the radial orientation. Thus, if the development and evolution of Aquilegia spurs can be understood, we will gain insight into all of these fundamental aspects of lateral organ development, which can provide new perspectives on the evolution of lateral organs more broadly across the angiosperms. The proposed Aims seek to integrate multiple lines of study drawn from the fields of developmental genetics, evolutionary genomics/genetics, and biophysics. Specifically, we will seek to understand the fundamental genetic control of petal spur development, explore the roles of hormonal signaling and biomechanical strain in controlling spur development, and use QTL-based approaches to identify the genes involved in the diversification of spur shape. Broader Impacts: This proposal brings together a range of techniques drawn from development, molecular genetics, evolutionary genomics and biophysics, creating a unique training opportunity for postdoctoral, graduate and undergraduate students. PI Kramer is working with Science Club for Girls (http://scienceclubforgirls.org/) to develop a research experience that would be based on performing VIGS and characterizing resultant phenotypes. These projects would involve morphological studies, RNA preparation, and qRT-PCR analyses. All students will, at the very least, prepare their own first author manuscripts for the Journal of Emerging Investigators (JEI; http://emerginginvestigators.org/). PI Hodges will employ groups of 6-8 undergraduates for phenotyping of F2 individuals using a range of microscopy and imaging analysis techniques. Students will be encouraged to identify additional phenotypes segregating in the F2 population and create their own mapping project for this trait. Upon completion of the project, they will be mentored through writing the work up for publication, whether in a primary scientific journal or JEI. Special efforts will be made to recruit female and underrepresented minority students to this research program.

Gretchen Hofmann **10/1/2013 to 9/30/2018** **$510,394**
National Science Foundation 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/pCO2 dynamics that most marine organisms experience in their respective habitats are relatively unknown. This is a significant data gap as the resilience of organisms is closely related to the physical conditions to which they are adapted. Thus, data regarding the 'OA seascape" would greatly facilitate organismal research; laboratory experiments could be performed in an environmental context and investigators would have a better baseline from which to project pH dynamic changes in the future that are driven by anthropogenic ocean acidification. The central focus of the current proposal is to better frame the study of the response of Antarctic marine organisms to OA conditions by measuring the annual pH dynamics in Antarctic coastal waters and performing organismal experiments that are parameterized using these field observations. The project has two main activities: (1) we will deploy autonomous pH sensors called SeaFETs in four sites in McMurdo Sound and at a nearshore Palmer site (the Palmer LTER Station A) in order to continuously record pH time series data; the sensors can be programmed to record all year and can be deployed on the benthos, below the sea ice and will not be interfered with by changes in sea ice coverage; (2) using these field observations of annual variation in pH dynamics, we will perform lab experiments using environmentally relevant pHs and pCO2 to study the resilience and tolerance of a key marine invertebrate, the Antarctic pteropod Limacina helicina antarctica. In these lab experiments, we will also examine the interaction of ocean warming and ocean acidification, two potentially interacting anthropogenic stressors that could drive ocean change in the future. For the pteropod exposure studies and temperature x CO2 combinations, we will measure the

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

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

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

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

Gretchen Hofmann **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).

Gretchen Hofmann **03/15/2017 to 02/29/2020** **$546,091**
National Science Foundation 1655262

Mechanisms of Physiological Plasticity in Early Stage Marine Invertebrates – An Epigenetic Perspective with a Global Change Focus

The conceptual framework of the proposed research is grounded in the "genome to phenome" concept as we plan to investigate mechanisms that contribute to rapid shifts in organismal physiological capacities in response to environmental change – mechanisms that would alter physiological capacities on ecological rather than evolutionary time scales. Our model system is the purple sea urchin, both adults and early life history stages, and we will focus on two processes that could account for changes in physiological plasticity: (1) intra-generational effects where the genome of the developing embryo or larvae is altered to affect the phenotype, and (2) transgenerational plasticity or context dependent inheritance (aka maternal effects). Our goal is to use an epigenetic perspective to explore the physiological plasticity we have observed in the early life history stages of the purple urchin in response to variation in abiotic factors such as pH, temperature and hypoxia.

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 REU Supplement $5,500

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 (CO2), ocean acidity and ocean warming are predicted to change dramatically by the end of the 21st century. Specifically, increased dissolved CO2 concentrations in the global ocean are predicted to reduce the pH of surface ocean waters from 8.1 now to ~7.8 by the year 2100 (IPCC 2007). Additionally, the average surface seawater temperatures are predicted to increase by anywhere from +1ºC to +6ºC by the year 2100. In manipulative laboratory experiments, I propose to raise cultures of larval sea urchins under varying CO2 and temperature conditions that reflect future ocean change conditions. In order to characterize the metabolic status of the larvae and the costs associated with development under varying pCO2 and temperature conditions, the following physiological processes will be measured: (1) respiration rate, (2) lipid content, (3) calcification rates, (4) total protein content, (5) tolerance of acute thermal stress and (6) morphometric analysis of the larval endoskeleton. Additionally, gene expression profiling will be performed using an oligonucleotide DNA microarray and 'next-generation' RNA sequencing (Illumina mRNA-seq) to explore transcriptome dynamics in response to a changing conditions. This transcriptomic approach will provide mechanistic understanding into how the larvae respond to environmental change in a multiple stressor scenario.

Sally Holbrook, Deron Burkepile, Russell J. Schmitt **3/1/2016 to 2/28/2018** **$199,988**
National Science Foundation OCE-1325652

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.

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

Debora Iglesias-Rodriguez, **1/1/2014 to 12/31/2017** **$494,091**
Mark Brzezinski, Craig Carlson, Uta Passow, David Valentine
National Science Foundation OCE-1337400

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.

Christopher Jerde **05/01/2017 to 09/30/2017** **14,279**
University of Nevada UNR-17-70

Wonders of the Mekong in Cambodia Project

The Wonders of the Mekong in Cambodia activity seeks to stimulate and inform a discussion about how to achieve the optimum balance of meeting current needs without diminishing future potential – in other words, how to make development more sustainable. The activity will conduct applied field research and develop communications products designed to increase the public's and government's valuation and conservation of the vital ecosystem services that the Mekong River, its watershed and biodiversity provide for the sustainable development of Southeast Asia and resilience to climate change. The results of multidisciplinary analyses will be used to produce a multimedia package of regional and international publications that encourage appreciation of the Mekong as a global asset, and that facilitate government, civil society, and private sector entities across the region to advocate for and pursue sustainable development options in the face of a changing climate. The activity will build a constituency for sustainable development options.

Christopher Jerde **01/01/2017 to 04/30/2018** **$13,236**
Great Lakes Fishery Commission WEL-77011

Uses and Limitations of Environmental DNA (eDNA) in Fisheries Management

Great Lakes fishery managers require an objective understanding of potential uses and limitations of eDNA surveillance, and tradeoff's of employing eDNA over more traditional survey methods.

To meet needs of managers. We are proposing to develop a project that summarizes potential uses and limitations of environmental DNA in fishery management. The products developed during this project will also transparently acknowledge areas of scientific controversy, and compile resources to help manages make informed decisions about eDNA monitoring in their jurisdictions.

Roland Knapp **09/22/2015 to 07/31/2020** **$289,549**
USDI Fish and Wildlife Service F15AC00500

Treatment and Prevention of Infection by Bd in Two Species of Mountain Yellow-Legged Frogs

There are approximately 22 *R. sierra* and *R. muscosa* populations in the Sierra Nevada that remain Bd-naïve. Thirteen of these occur within Sequoia and Kings Canyon National Parks (SEKI) and the remainder occur on the adjacent Sierra, Sequoia, and Inyo National Forests. These populations comprise the largest remaining populations of both species, with population sizes commonly exceeding 1000 adults. As such, these populations are critically important for their role as donor populations for current and future frog conservation efforts. Unfortunately, based on current rates of Bd spread, all are expected to become Bd-positive and suffer serious declines or extirpations within the next 10 years. The severity of these declines can be mitigated using anti-BD treatments applied at the beginning of an epizootic, treatments that increase frog survival by allowing time for treated frogs to develop effective immune responses that subsequently render them much less susceptible to Bd. To allow effective treatments to be conducted, intensive monitoring (2+ site visits per summer) is necessary to detect Bd outbreaks at an early stage and quickly implement a treatment effort.

Roland Knapp **09/30/2016 to 09/30/2021** **$70,500**
USDI National Park Service P16AC01701

Critical Restoration Efforts to Recover Endangered Mountain Yellow-Legged Frogs in Sequoia and Kings Canyon National Parks

This project is anticipated to be conducted in two phases, subject to the availability of additional funds. Funding in this task agreement is for the initial phase of the project, in which investigators from UCSB and NPS staff will collaborate to accomplish the following specific objectives.

This project is targeted at mitigating the effects of Bd on MYLF population persistence in SEKI, with a primary goal of using visual and CMR surveys and translocations to help stabilize dwindling populations or re-establish extirpated populations in up to two watersheds. The following is a detailed description of each project component including: methods; and an indication of respective UCSB and NPS roles in the project execution, project schedule, and planned products (reports and datasets).

1) Conduct visual surveys (Crump and Scott 1994) of one moderate size population persisting with disease in one small pond with simple habitat to determine how many adult frogs (at least 40 mm in snout-vent length) can be safely collected for direct translocations to a nearby waterbody.

2) Conduct CMR surveys and disease monitoring at one small population that is struggling to survive with disease in a basin of complex habitat (several lakes, ponds, and streams).

Roland Knapp **6/10/2015 to 6/20/2020** **$290,745**
USDI National Park Service P15AC01412

Restoring Rare Frogs in Yosemite National Park

The goal of this study is to expand the distribution of the endangered Sierra Nevada yellow-legged frog (*Rana sierrae*) in Yosemite National Park. This will be accomplished using translocations of adult frogs collected from populations that are persisting despite ongoing infection with the frog-killing chytrid fungus *Batrachochytrium dendrobatidis* (Bd). Translocations will be conducted as carefully-monitored experiments to allow as much as possible to be learned from implementation of the conservation measures, and will include the following elements: (1) use of mark-recapture methods to describe

the population sizes and trends of several naturally-occurring *R. sierrae* populations that may serve as sources of frogs for future translocations, (2) use of mark-recapture methods to describe the population sizes and trends of several frog populations that were established during previous translocations conducted between 2006 and 2014, (3) conduct several supplemental and new translocations to continue the effort to reestablish frog populations at several sites from with they were previously extirpated, and (4) conduct amphibian visual encounter surveys at additional sites to assess the status of particularly important populations. New potential source populations include those at Mono Pass, Unicorn Pond, and Gallison Basin. If these and other source populations are large enough to allow collection of adults, translocations and/or mark-recapture monitoring will be conducted at Skelton Lake, Miller Lake, Soldier Lake, Upper Mattie Lake, two South Lyell Lakes, Dog Lake, Ardeth Lake, Miwok Lake, Budd Lake, Gallison Basin, and Roosevelt Lake. To the extent possible, mark-recapture monitoring will be conducted using a robust design to allow the accurate estimation of frog population sizes.

Roland Knapp **04/15/2017 to 09/30/2018** **$10,815**
Oakland Zoo SB170145

Disease Assays for Frog Captive-Rearing Program – Oakland Zoo

The Oakland Zoo participates in a broad range of public outreach and public service programs, including supporting the recovery of endangered amphibians in California by rearing animals in captivity. For the past five years, my laboratory at the Sierra Nevada Aquatic Research Laboratory has been assisting the zoo in their efforts related to recovery of the endangered mountain yellow-legged frog (Rana muscosa, Rana sierra). During this time, we have collected early life stage animals for captive rearing and reintroduced captive-reared animals back into the wild.

One of the major threats to the mountain yellow-legged frog is the amphibian chytrid fungus (Batrachochytrium dendrobatidis; Bd). This novel pathogen has been spread worldwide by global commerce and has caused the decline or extinction of hundreds of amphibian species. Given the high susceptibility of mountain yellow-legged frogs to this pathogen, as part of the captive-rearing protocol animals are frequently screened for the presence of Bd. Because the Bd assay requires highly specialized and expensive equipment that the zoo does not have access to, the zoo has requested the assistance of my laboratory in analyzing these samples.

Samples will be analyzed at the microbial laboratory at the Sierra Nevada Aquatic Research Laboratory (SNARL) using established protocols. This entails extraction of DNA from skin swabs, and the use of real-time quantitative PCR to estimate Bd concentration. Samples will be analyzed within one week of receipt at SNARL. Sample results will be provided to the zoo in digital form, without any interpretation or analyses.

Roland Knapp **03/01/2017 to 08/31/2018** **$17,850**
San Francisco Zoo SB170112

Disease Assays for Frog Captive-Rearing Program- San Francisco Zoo

The San Francisco Zoo participates in a broad range of public outreach and public service programs, including supporting the recovery of endangered amphibians in California by rearing animals in captivity. For the past five years, my laboratory at the Sierra Nevada Aquatic Research Laboratory has been assisting the zoo in their efforts related to recovery of the endangered mountain yellow-legged frog (*Rana muscosa, Rana sierra*). During this time, we have collected early life stage animals for captive rearing and reintroduced captive-reared animals back into the wild.

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Roland Knapp **03/23/2017 to 10/31/2019** **$195,000**
Cal Department of Fish & Wildlife P1620105

Three Crucially Important Conservation Actions to Recovery R. sierra in the Northern Sierra

During the 2016 Traditional Section 6 grant cycle CDFW successfully sponsored a grant to continue a research project undertaken by a UC Santa Barbara research to inform recovery of Federally Endangered Sierra Nevada yellow-legged frogs. Actions will be undertaken to reestablish three *Rana sierra* populations in the portion of the Desolation Wilderness managed by the Lake Tahoe Basin Management Unit. This work will continue efforts conducted during 2013-16, that included translocations of adults and egg masses from the Rivendell source population (Eldorado National Forest) to Lake Lucille and/or Jabu Lake in 2013 and 2014, collection of eggs and/or metamorphs from the Rivendell source population in 2013 and 2014 for captive rearing at the San Francisco Zoo, and reintroduction of captive-reared adults to Lake Lucille and/or Tamarack Lack in 2014, 2015, and 2016. Insufficient time has elapsed to determine the outcome of these efforts. During the current project (11/1/2016 – 10/31/2019), we will continue efforts to establish self-sustaining R. sierra populations at Jabu Lake, Lake Lucille, and Tamarack Lake. This will be accomplished via translocations, and reintroductions of captive-reared frogs. All populations will be intensively monitored using capture-mark-recapture (CMR) methods. On completion, this project will provide key insights into the feasibility of restoring R. sierra to this portion of the Desolation Wilderness, allow comparisons of the success of frog translocation versus captive rearing/reintroduction, and make recommendations regarding recovery methods that should be considered in future *R. sierra* recovery efforts both in the Desolation Wilderness and across the species' native range.

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

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

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

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

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

Objectives: Six reintroductions of MYL frogs are proposed within SEKI and YOSE using methods that will allow the detailed quantification of temporal patterns of Bd infection intensity, survival rates, and fates of individual frogs. By combining information from this study with that collected during a previous reintroduction study (Knapp et al. 2011) we will also be able to evaluate the role of habitat conditions on the outcome of reintroductions. Collectively, this information will allow us to assess the importance of disease, stochasticity, and habitat in influencing the success of reintroductions. The results will be used to develop a reintroduction protocol to guide future reintroduction efforts conducted throughout the range of the MYL frog. Methods Site selection: During a five-year period starting in 1997, my research group surveyed all aquatic habitats in SEKI and YOSE for amphibians,

fish, and habitat attributes (Knapp et al. 2003, Knapp 2005). Since this initial survey, I have conducted repeated resurveys of all MYL frog populations in both parks to describe the distribution and spread of Bd, and its impact on these populations (Rachowicz et al. 2006, Vredenburg et al. 2010, Knapp et al. 2011). The resulting data set provides a detailed view of the status and trend of MYL frog populations at an unprecedented spatial scale. For the proposed reintroduction research, we used this data set to identify six MYL frog source populations (three in SEKI and three in YOSE) that experienced Bd-caused population die-offs during the past 5-15 years but that have at least partially recovered despite ongoing chytridiomycosis. All six populations are large enough (≥200 adult frogs) to allow the removal of small numbers of adult frogs for reintroductions without negatively affecting their viability. Results from previous reintroductions in YOSE indicate that removal of approximately 20% of the adult frogs from the source population resulted in a large pulse of recruitment in subsequent years that compensated for the removals (Knapp et al. 2011). The six proposed reintroduction sites are paired with the six source sites (i.e., each pair contains one source and one reintroduction site), and sites in each pair are located within 10 km of each other. Until recently, each of the proposed reintroduction sites contained a robust MYL frog population, but all six of these populations were extirpated following the arrival of Bd. The reintroduction sites are all lakes predicted to be of very high habitat suitability (Knapp et al. 2003).

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

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

Roland Knapp **9/22/2015 to 7/31/2020** **$194,000**
USDI Fish & Wildlife Service 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 **4/1/2012 to 3/31/2017** **$453,487**
National Science Foundation OCE-1155663

Group-Specific Diatom Silica Production in a Coastal Upwelling System

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

Armand Kuris, Ryan Hechinger, Kevin Lafferty **8/1/2011 to 7/31/2017** **$2,149,227**
National Science Foundation P13AC01131

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

This project focuses on how ecological complexity influences infectious disease dynamics and how

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

Armand Kuris, Sara Weinstein **06/01/2016 to 05/31/2018** **$19,550**
National Science Foundation 1601362

Dissertation Research: Understanding Effects on Climate Change on Parasitism in Small Mammals

The rapid rates of global climate change are increasingly accepted as a major driver of the recent Holocene to Anthropocene biotic transition. In addition to its effects on free-living biodiversity, global climate change is now established as a major driver of changes in patterns of parasitism and disease. Given that 19% of human mortality, particularly in the developing world is due to infectious disease and parasitism, this will have enormous implications for human health and well being. Yet, we are sorely lacking in our fundamental understanding as to how climate change is likely to alter basic patterns of parasite distribution, diversity, and transmission dynamics, much less the mechanisms that drive these changes. Closing these gaps will be essential for any public health or policy efforts to mitigate the deleterious effects of climate change on infectious disease. This dissertation to date has focused on the impacts of a range of other major types of anthropogenic disturbance (urbanization, defaunation, invasive species) on wildlife disease transmission, but has not yet been able to examine the effects of climate change. The work proposed here will allow the addition of research on this critical type of human disturbance: climate-mediated impacts on disease patterns. Specifically, using host parasite data from 850 small mammals collected along 2700m elevation gradient on Mount Kenya, this project will first describe the role of parasite life history and host demography in determining parasite richness and intensity. Using elevation gradients as a natural laboratory for studying climate change, cumulatively these results should represent strong progress towards developing a predictive frame work for understanding how climate change will impact parasite communities and their hosts.

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

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

Ecological damage caused by human activity can directly influence infectious diseases and human health. Yet, public health campaigns rarely turn to ecological solutions to mitigate infectious disease risk, instead favoring traditional approaches such as vaccine development or drug treatment. Here, we propose an experimental investigation of a novel disease control strategy for schistosomiasis, one of the most prevalent parasitic diseases in the world. The proposed strategy will mitigate the ecological damage caused by dam building on a river in sub-Saharan Africa, and thereby reduce the transmission of this disease that emerged and spread to epidemic levels following dam completion. We propose the novel integration of bio-economics, aquaculture, social science, ecology, and epidemiology to develop and test an unprecedented, ecology-based solution. More than 700 million people are at risk of schistosomiasis worldwide, mostly children in poor, rural villages, and Africa contains 97% of the world's infected population. Schistosomes are waterborne parasites that require aquatic snails as obligate intermediate hosts. There is convincing evidence that dam construction has increased habitat for, and decreased native predators of, medically important snail

hosts in the Senegal River, contributing to the emergence of human schistosomiasis. *Macrobrachium vollenhovenii* is a large, edible, native crustacean that has suffered dramatic declines in the Senegal River ecosystem. Causes and consequences of the decline have not been previously recognized or studied. Our preliminary research reveals that prawns probably declined due to dam construction: prawns are currently in low abundance below the dam and nearly extirpated above the dam. Prawns are predators of snails. Therefore, we propose to test environmental re-introduction of the native prawn, *M. vollenhovenii*, using village-based aquaculture, as a socially and economically sustainable control strategy for schistosomiasis. Our proposed research will test two hypotheses: (1) that we can mitigate the ecological disruption of aquatic food webs to greatly reduce disease transmission, and (2) that this mitigation will be sustainable in the long-term, given fusion of mitigation with an aquaculture enterprise.

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

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

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Adam Lambert, Tom Dudley **8/1/2015 to 7/31/2020** **$1,349,008**
Ventura County 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

Adam Lambert **7/1/2014 to 12/31/2017** **$34,909**
UC Agriculture and Natural Resources SA14-2254-06

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

This project will examine the biology and interactions with weeds of a new invasive insect pest (*Bagrada hilaris*) of cole crops in Ventura County and provide information for reducing its economic impact on agriculture in the region. Specifically, the project will determine the extent to which invasive mustards in riparian areas, which are alternative hosts for *B. hilaris*, support bug populations and facilitate the spread of this pest into cropping systems. Bug populations will be monitored on weeds adjacent to agricultural fields to evaluate life history characteristics, such as phenology, growth, and reproduction, and population dynamics over the growing season. Cole crops commonly grown in Ventura County will also be evaluated in an agricultural plot to determine

their susceptibility to *B. hilaris*. The project will be conducted at the Hansen Agricultural Center and field sites in Ventura County, and in our lab at UC Santa Barbara, but will have implications for management of this insect across its introduced range. This research project will directly address the Endemic and Invasive Pests and Diseases and Sustainable Food Systems initiatives of ANR, as well as the Hansen goal of assuring the economic viability of agriculture to sustain agriculture's contribution to a healthy Ventura County.

Ashley Larsen, Steven Gaines **09/28/2014 to 09/27/2016** **$17,000**
Environmental Protection Agency FP-91762601-0

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

The goals of my research are to identify the causal drivers of pesticide use and to understand whether and to what extent climate change will influence the quantity and location of pesticide use. (1) Does landscape simplification drive insecticide use in the Midwestern US? (2) What explains year-to-year variation in insecticide and pesticide use in the US? (3) How will climate change modify the amount of pesticides being used and which states may expect the largest increases or decreases in pesticide use and which pesticides classes on which crops are expected to increase or decrease the most?

Hunter Lenihan, Erik Muller **2/1/2016 to 1/31/2018** **$212,912**
UC Sea Grant College Program R/HCME-24

Impact of Neonicotinoid Pesticides on Estuaries and Coastal Streams

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

The specific objectives are:

1. To determine the temporal [wet and dry season] patterns of imidacloprid and five related neonicotinoid insecticides as well as several major metabolites in stormwater feeding coastal streams and estuaries in agricultural and urban areas.
2. To test the hypothesis that streams receiving runoff from urban land uses and agricultural (nursery) land uses have different concentrations or loading rates of imidacloprid.
3. To test the hypothesis that samples from creek and estuaries in Santa Barbara will exhibit toxicity when neonicotinoid-sensitive test species and assays are used.
4. To produce pilot-scale data on transport mechanisms of neonicotinoids to urban streams.
5. To test the hypothesis that two species of aquatic organisms [*Chironomus riparius* and *Leptocheirus plumulosus*] develop lethal and/or sublethal responses when exposed to field-relevant concentrations of neonicotinoid insecticides in modified routine controlled laboratory sub-chronic [10 day] and chronic [28 day life cycle] bioassays.
6. To predict the individual and population level impacts from field-relevant concentrations of imidacloprid, using Dynamic Energy Budget (DEB) models.

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

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

Exploitation of renewable marine resources provides for many of the world's human needs, and this dependence is unlikely to change in the future. Exploited fish stocks are especially important in providing sources of protein as well as employment to millions of people world-wide. Without appropriate management that is based on high quality science and adequate enforcement, sustainable

fishing is difficult to maintain (Hutchings and Myers 1994). Most managed stocks rely on single-species stock assessments to provide the necessary information to support sustainable harvest. Dynamic stock assessment models range from simple biomass dynamics models to complex age and sex-structured models (Pope and Shepherd 1985; R. Methot 1989; Hilborn 1990; R. D. Methot 1990). Modern integrated stock assessment models are capable of utilizing a wide range of data types from traditional fisheries monitoring (e.g. catches, surveys, composition) in addition to environmental data. In a statistical framework, population level processes (i.e. recruitment, mortality) are used to govern the estimation of dynamics (i.e. changes in abundance through time), which in turn are then used to compare the model predications to the data. However, single-species models stop short of understanding broader ecosystem concepts, because they do not adequately incorporate energy transfer through food-webs and species interactions. Ecosystem models on the other hand can generate critical information that so far has limited the power of single species stock assessments. To meet the needs of more comprehensive management and assure sustainable fishing, integrated ecosystem models are being developed to address broader ecosystem level processes, such as the total fish biomass that can be produced for a given level of primary production. We use single-species models to manage quotas for individual stocks. These models rely heavily on estimates of population "scale", another term for population abundance used by stock managers. Population scale is a critical metric because it used to estimate the virgin stock biomass, against which sustainable removals through fishing, as stipulated in annual quotas, are calculated. As such, sustainable fishing is heavily reliant on good estimates of population scale that was present prior to the initiation of the fishery. Of course, actual scale measures are not possible, so are backed out of the available stock biomass data generated from catches through time. For apex predators, such as tunas, sharks, and swordfish, estimates of virgin stock biomass are difficult to generate because their population scale is heavily dependent on the state of the ecosystem, specifically in terms of prey availability (i.e., biomass in low trophic levels) and thus primary Laura Urbisci NMFS Fellowship Application: Project Proposal production, as well as environmental features, especially temperature, which helps determine their spatial distribution. My project is designed to utilize information from ecosystem models, specifically potential secondary production of apex predators and environmental conditions, to generate more robust estimates of population scale for use in single species stock assessment. This project will therefore make a very important contribution to ecosystem-based fishery management. Sharks and other chondrichthyan species are apex predators that we fish heavily in many fisheries worldwide. However, as apex predators sharks appear to be highly susceptible to overfishing due primarily to their low reproductive rate (i.e. slow growth, late maturity and low fecundity)(Holden 1974; Holden 1977). In low production species, only a relatively small portion of the population can be removed annually if the catches and populations are to remain sustainable. Populations of sharks are therefore difficult to manage in single-species stock assessments because the estimate of virgin biomass, "population scale", is so critical in estimating sustainable catches. Apex predators are also of major importance in ecosystem-based fishery theory because of their role in controlling the abundance of prey species that are also fished or are utilized by other species as prey. Thus overfishing of apex predators can lead to the destabilization of food web dynamics (Friedlander and DeMartini 2002).Destabilization of food web dynamics may alter the relationship between the apex predator and the trophic system through poorly understood ecosystem feedback mechanisms. As such, developing a more sustainable approach to managing apex predators is of major concern to fishery managers at NMFS and elsewhere. Shortfin mako sharks (*Isurus oxyrinchus*) are a highly migratory apex predators that are widely distributed in tropical and subtropical waters and are commercially fished across the globe (Compagno 2001). Despite their importance to both fisheries and trophic dynamics, considerable uncertainty remains in their stock status, productivity and resilience to heavy fishing and natural disturbance, as well as the influence of ecosystem changes (biological and environment) on their population dynamics and regulatory mechanisms. The focus of my research will be on integrating alternative estimates of population scale size from ecosystem models into single-species models to improve the reliability and reduce uncertainty of the current stock assessment models. The objectives of my proposed study are to compare results of two different theoretical approaches to modeling shortfin mako population dynamics. In the first approach, I will create a traditional fisheries single-species dynamic model. In the second approach, I will develop an alternative ecosystem model that includes non-traditional data and ecological process allowing

for understanding of alternative and higher level population regulation mechanisms. I plan on comparing both the model performance and key drivers of population dynamics from the two approaches. I intend to focus on the strengths and shortcoming of both methods as well as how to use our ecosystem level understanding to improve shortcomings in the single-species approach (i.e. calculating population scale size)

Hunter Lenihan **03/20/2016 to 12/31/2017** **$40,000**
Nature Conservancy SB150143

Task Agreement #6: Survey and Assessment of California Rock Crab

Task 1: Develop necessary relationships, secure necessary permits, communicate with the regulatory agency, perform necessary fishermen trainings and develop written documentation of process and scientific research plan.

Task 2: Conduct field research program and manage the day to day logistics of fishermen-led data collection and ensure all QA/QC concerns are mitigated. Perform port side monitoring of catch and record size data, effort and other pertinent information at locations along the California coastline.

Task 3: Preparation of manuscript comparing the current research survey to similar data collected in 2008.

Task 4: Use FishPath software to evaluate cost-effective and context appropriate management strategies.

Sarah Lester, Christopher Costello **1/1/2014 to 12/31/2018** **$400,000**
Rare SB150042

Fish Forever (Waitt Foundation)

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

1. Providing scientific guidance on site assessment and selection, including assisting with the application of a Rapid Site Assessment tool.
2. Providing technical support in the development of global and regional monitoring and evaluation plans and baseline assessments, including data collection protocols and guidance on the development of a data management platform.
3. Performing data analysis and modeling to inform implementation decisions such as TURF-reserve design and adaptive fisheries management, including the use and development of new data-limited fisheries assessment methods; assistance with setting harvest controls; tracking and evaluating progress towards our stated goals for the program; and providing technical expertise on barrier removal strategies.
4. Writing scientific papers, to be submitted to peer-reviewed journals, based on research related to Fish Forever, when appropriate.
5. Participating in the Fish Forever Science and Design team, including attending regular meetings.
6. Assisting with the development of Fish Forever curriculum on technical/scientific topics, including attending Fish Forever Training Team meetings.
7. Participating in the development of strategic plans for Fish Forever.

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

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

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

Milton Love and Ann Bull **06/01/2017 to 04/25/2018** **$64,155**
Exxon Mobil Upstream Research Company EM11103

Worldwide Oil and Gas Platform Decommissioning: A Review of Practices and Reefing Options

We propose to review existing information and write a report for general readership that will inform managers, decision-makers, and the general public about global and regional oil and gas platform decommissioning and reefing.

Milton Love and Robert Miller **09/20/2016 to 09/30/2019** **$455,000**
USDI Bureau of Ocean Energy Management (BOEM) M15AC00014

Synthesis of Pacific Platform Research

The ecology and assemblages of platforms off California continue to be a subject of interest and about 30-yrs. of scientific research. Since 1985, federal and state agencies have invested over $25 M to conduct research on fishes, mega-invertebrates, and corals that may exist around the platforms and on natural reefs of southern California. Research has also examined contaminant load, oceanography, trophic links, and larval transport, to name a few subjects. A brief survey of the peer-reviewed literature has found about 25 peer-reviewed articles (17 as a result of MMS funding) and at least an equal number of agency reports. The purpose of this study is to publish a special, peer-reviewed issue of a journal that includes review articles and new data analyses that synthesize the scientific research focused at oil and gas platforms off California. The single resource will provide the basis for evaluating potential environmental effects of platform structures on regional marine ecology and consequences to their eventual removal.

Milton Love | **06/01/2016 to 05/31/2018** | **$150,000**
California Artificial Reef Enhancement | SB160136

Fish Surveys Around California Oil and Gas Platforms Preparatory to the Decommissioning Process

California has a rigs-to-reef procedure in place and a major factor in any decision regarding platform reefing is Ecological Net Benefit (ENB). One of the components of this metric is an analysis of the fish communities around the platform to be decommissioned. Because our last fish surveys were in 2011, it could be argued that this data is out of date and new surveys would be required to address the ENB question.

Milton Love | **07/01/2016 to 06/30/2018** | **$25,836**
Occidental College | G650-SUB1

The Current and Potential Contribution of Manmade Reef Habitats to Fisheries Resources and Protected Species Recovery in Southern California

Project will focus on providing taxonomic expertise and development of recommendations for manmade reef placement and design.

Milton Love | **10/01/2016 to 09/30/2017** | **$51,200**
UC Santa Cruz | A16-0309-S004

Quantifying Avoidance and Attraction of Demersals Fishes to Mobil Visual Survey Platforms

University of California, Santa Crus researchers and staff will work with NMFS/SWFSC scientists to conduct cooperative research to broaden the scientific basis for aspects of marine studies that will ultimately yield results intended to add to the scientific basis to guide resource managers in developing policies to recover ESA listed anadromous fish stocks and conserve West Coast groundfish. This research will span the full spectrum of topics ranging from basic research to improve the theoretical basis of fishery science to those with a clear policy application in fisheries management. Activities will include both field and laboratory experiments and investigations, modeling and computational studies, and will involve both marine and freshwater habitats and species. While most research will be biological in nature, the spectrum of topics will include physical, chemical, geological and economic aspects of marine freshwater environments as well.

Sally MacIntyre | **8/1/2012 to 7/31/2017** | **$943,094**
National Science Foundation | 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 CO2, labile organic matter, and nutrients so important for a lake's productivity in spring and summer. We propose time series studies to 1) quantify physical controls on under ice thermal structure and circulation, mixing of snow melt waters, mixing during spring and fall, 2) to quantify respiration rates in arctic lakes of differing morphology and on different geological substrates, and 3) to illustrate the linkages and feedbacks between these physical and biogeochemical processes. Measurements will include temperature and conductivity, meteorology, sediment temperatures, ice thickness, snow cover, and respiration with newly developed oxygen and pCO2sensors. Winter limnological studies are rare, and rarer still in the Arctic with its harsh environment. The proposed research, with its goals of better understanding physical limnology under the ice and controls on winter respiration and spring time gas evasion will fill a major gap in limnological understanding of high latitude lakes.

Susan Mazer, Isaac Park **06/15/2016 – 05/31/2019** **$249,999**
National Science Foundation 1556768

Phenological Sensitivity to Climate Across Space and Time: Harnessing the Diversity of Digital Herbarium Data to Generate and to Test Novel Predictions

This study will use historical herbarium samples and citizen-collected data to assess the magnitude and direction of changes that occur in the timing of flowering onset in response to interannual variation in climate across an unprecedented number of taxa representing the continental United States. This study is designed to detect differences (if present) in the magnitude of phenological responsiveness to climate changes across functional groups, phyla, or regional floras, and to provide risk assessments of "floral deserts" (in which the diversity of flowering species is reduced below historical norms) that may develop in response to changes in climate. To accomplish this, we will produce a species-level models of flowering phenology across thousands of plant taxa and determine the potential for inferring the phenological responses to climate change of previously unstudied taxa based on the responses of closely related species. Thus, this work will both improve predictions of frost-related reproductive damage, and predict changes to bloom synchrony among co-occurring taxa under projected climate conditions.

Susan Mazer, Cheryl Briggs **4/1/2015 to 12/31/2018** **$63,477**
UC Santa Cruz 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.

Susan Mazer **10/15/2011 to 9/30/2016** **$325,292**
University of Minnesota D002520602

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

The goal of this project is to collect seeds from multiple populations of each of 30-40 wild species of plants native to or introduced to California; these seeds will then be archived in the National Germplasm Resources Lab in Fort Collins, Colorado. In the future, these seeds will be distributed to evolutionary biologists so that they can compare them to seeds obtained from the same populations in order to assess the degree and kind of evolutionary change that has occurred due to environmental change. Dr. Susan Mazer will direct all field components of this project that will be based in California and coordinate UCSB's research activities with collaborators in Minnesota and New York. The other collaborators (Dr. Julie Etterson [University of Minnesota-Duluth] and Dr. Steve Franks [Fordham University, New York]) will direct the field components to be performed in parallel in the Midwest and in New England. In addition, the activities of all collaborators will be integrated by a Project

Director who will be based in Duluth. Susan Mazer's responsibilities include a variety of tasks that will require 1.5-2.0 months of activity per year, including: Recruitment of Assistant Specialist, who will perform many of the day-to-day activities of this project; assisting with species selection and the choice of collection locations in California; coordinating with the Project Director at UMN-Duluth and the Assistant Specialist at UCSB to plan the annual collecting route and collection sites; designing the most efficient collection schedule for the selected taxa; soliciting, writing, editing, and disseminating contributions to Project Baseline eNewsletter that reports each region's progress in the collection of seeds and provides communication among teachers, park staff, reserve docents, and citizen scientists about educational programs involving seed collection, seed preservation, and phenology; supervising the Assistant Specialist's adherence to Project Baseline protocols and data management plant; collation and organization of environmental data to be transmitted to the Project Director; designing and participating in training workshops to introduce the public, graduate students, and other scientists to the principles and methods of Project Baseline.

Douglas McCauley **1/1/2016 to 12/31/2016** **$3,000**
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.

Douglas McCauley **7/1/2015 to 04/30/2018** **$40,000**
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.

Douglas McCauley **9/15/2015 to 9/14/2019** **$50,000**
Alfred P. Sloan Foundation FR-2015-65479

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 macro-ecosystems 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.

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

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

The purpose of this proposal is to catalyze a new international collaboration between researchers in the departments of Ecology, Evolution, and Marine Biology and Electrical and Computer Engineering at University of California Santa Barbara (UCSB) and the laboratory of Dr. Benezeth Mutayoba at Sokoine University in Tanzania. The aim of this partnership will be to creatively adapt existing very high resolution satellite technologies to study patterns of self-organization (i.e. the process by which global patterns emerge from individual interactions in multi-member systems; Camazine et al. 2001) in large-bodied vertebrates at large spatial scales. Despite rapid advancements in the accuracy of publically available satellite-based imaging technologies (i.e. ≤50 cm resolution quality; Fig. 1), biologists have been slow to utilize this tool for directly observing and studying patterns in animal ecology and behavior. With our proposed collaborators in Tanzania, we will undertake this task through a focused study of self-organization in wildebeest (*Connochaetes taurinus*) aggregations in the Greater Serengeti Ecosystem (GSE) in northern Tanzania. We propose in the first year of this international partnership to 1) illustrate the utility of this tool for asking new spatially and conceptually ambitious questions about self-organization in large vertebrates; 2) to develop novel, efficient, and accurate tools for the computer- assisted extraction of data on the geometry of large animal aggregations directly from satellite imagery; and 3) to generate a demonstration paper which characterizes the architecture of wildebeest herds and compares patterns of self-organization in these large-bodied vertebrates to patterns observed in better studied smaller-bodied animal aggregations (Parrish et al. 2002; Couzin and Krause 2003). With these outputs in hand, our ultimate purpose is to generate a body of preliminary data that can be used to launch a more advanced exploration of the mechanisms that shape herd self-organization in our wildebeest model system, and more broadly, the general principles that control the geometry of animate aggregation. This effort would take form as a full submission to the NSF Division of Integrative Organismal Systems (IOS). To begin working towards these goals we propose herein to organize a first, multi-investigator, multi-student planning visit to Tanzania in Nov 2014. During this planning visit all five researchers in the collaboration will split time between conceptual development and data analysis at Sokoine and preliminary data collection in the GSE. The IOS pre-proposal and our group's first publication on wildebeest herd architecture will be largely written on site during this visit.

Will McClintock **06/26/2017 to 12/31/2017** **$36,485**
Nature Conservancy SB150143-16

Task 16: Developer Support for Crab Gear Recon App

Continue to assist primary software developer Falk Schuetzenmeister in software development tasks.

Will McClintock **01/01/2017 to 12/31/2017** **$66,532**
Nature Conservancy SB150143-11

Task 11: eCatch Mobile Application Updates

Software development work on the eCatch Mobile and Server applications. Distribute eCatch to beta testers via TesFlight App for both groundfish and crab fishery testing. Provide user support in the form of written materials and remote communication to TNC staff and external beta testers. Coordinate receipt and prioritization of software issues that arise, and feature requests, with development team and TNC staff.

Will McClintock **03/01/2017 to 10/31/2017** **$71,692**
Nature Conservancy SB150143-12

Task 12: Technology for Fisheries Management Abalone

Deploy the length recognition algorithm and build a simple demo application that would enable users to upload a photo and receive immediate feedback. While these measurements would not be stored and it is not a full realization of the user-facing workflow, this work would be used to develop the full mobile web application. The image analysis system could be demonstrated either with new photos or provided images.

William McClintock **12/18/2015 to 07/31/2016** **$9,948**
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.

Robert Miller **7/7/2015 to 6/30/2020** **$750,000**
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.

Robert Miller **10/1/2014 to 9/30/2019** **$2,867,893**
NASA NNX14AR62A

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

Although we spend millions annually monitoring marine resources, these efforts are uncoordinated and have major information gaps. We propose to develop a scalable and transferable demonstration Biodiversity Observation Network (BON) in the test bed of the Santa Barbara Channel (SBC), one of the most monitored areas of the world. This BON will network existing monitoring efforts and fill the major remaining information gaps. Our focus on SBC allows us to effectively cover the complete spectrum of biodiversity from ecosystems to microbes within a reasonable scope of funding. This is due to the profusion of existing biological monitoring and research programs by our partners including government agencies, universities and NGOs. Yet there are significant gaps in our knowledge of even this relatively well-studied area, such as microbial diversity. We propose to use a

pincer strategy to attack these issues, using optical and acoustic imagery to approach diversity from ecosystem scales downwards and genetics to assess diversity from genes and microbes upwards. Expanded use of imagery will be facilitated using cutting-edge machine learning image analysis techniques developed by the UCSB Center for BioImage Informatics. The Scripps Institution of Oceanography's Whale Acoustics Lab will develop signal-processing algorithms to identify marine mammals from noise passively collected in SBC. Metabarcoding and eDNA analyses will benefit from state-of-the-art molecular biology labs at the NOAA Southwest Fisheries Science Center and UCSB. Our overall objective is to provide a complete picture of biodiversity in SBC using a transferable system that integrates and augments existing monitoring programs including the NSF-funded SBC LTER program and the Channel Islands National Park. Products created by SBC BON will include geographically-integrated time-series metrics of biodiversity and ecosystem health, a transferable BON data management system, a sampling cost-benefit optimization framework that can be used to design a BON anywhere, and dissemination of products and results to a wide range of end users from scientists to schoolchildren. Partners: Channel Islands National Marine Sanctuary, Channel Islands National Park, USGS San Nicolas Island Monitoring, SCCOOS, Plumes and Blooms, Southern California Coastal Water Research Project, Santa Barbara Coastal Long-Term Ecological Research Program, Gray Whales Count, San Onofre Nuclear Generating Station Mitigation Monitoring Program, BOEM, NASA

Robert Miller **6/1/2016 to 6/30/2018** **$81,266**
Southern California Coastal Water Research Project 10234

Develop Techniques to Batch-Identify Ichthyoplankton Larvae

Develop methods to batch-identify ichthyoplankton larvae using modern genetic methods.

Robert Miller, Mark Page, Jenifer Dugan **8/15/2015 to 6/30/2019** **$560,121**
San Diego State University 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.

Monique Myers **02/01/2017 to 01/31/2018** **$10,682**
UC Sea Grant A/EA-15MM

Sea Grant Extension Program Funds

The Sea Grant Extension Program provides a diverse array of research and extension activities. Activities include workshop and outdoor education program planning and implementation and field and laboratory research and field trips. Providing information to local communities about climate change adaptation of coastal ecosystems is a key goal.

Monique Myers, Jenifer Dugan, Mark Page, John Melack **9/1/2013 to 5/31/2017** **$178,721**
NOAA 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.

Craig Nicholson **3/1/2016 to 07/31/2017** **$48,933**
US Geological Survey 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].

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

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

I propose to continue conducting detailed studies of active faults along major fault zones in southern

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

Roger Nisbet, Erik Muller **6/1/2015 to 5/31/2018** **$799,723**
Environmental Protection Agency 83579701

Dynamical Systems Models Based on Energy Budgets for Ecotoxicological Impact Assessment

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

Mary Nishimoto **8/14/2014 to 11/30/2017** **$600,000**
USDI, Bureau of Ocean Energy Management (BOEM) M14AC00027

Potential Impacts of Submarine Power Cables on Crab Harvest

The Bureau of Ocean Energy Management (BOEM) requires information concerning the level of impacts from seafloor power cables on marine fisheries. West coast fishermen have expressed concern over the potential effects of renewable energy power cables on their ability to harvest target species of rock and Dungeness crabs (OCN 2008; PFMC 2010). Fishermen are concerned that electromagnetic fields (EMF) associated with renewable energy power cables will present an electrified fence on

the seafloor that their resource will not cross. If true, their ability to catch crab species near power cables could be negatively impacted, as well as potentially affecting crab home range. This study is designed to test the fear of crab fishermen that their target species will not traverse power cables, even in response to baited traps. Combined with the assistance of professional fishermen, submarine transmission cables that electrify communities and offshore oil platforms in the Pacific Region provide an opportunity to test the harvest of crab species across power cables. The information will be applicable to consideration of offshore renewable energy projects.

Margaret O'Brien, Dan Reed **07/15/2016 to 06/30/2018** **$198,733**
University of Wisconsin 692K182

Environmental Data Initiative

Organize available documentation on best practices for formats, metadata, and processing approaches for specific data types based on input from the communities vested in their production and use, in the context of a data type's life cycle. Specific tasks include developing templates for data life cycle description and data curation processes, and archiving resulting process documentation; facilitating working groups to define life cycles and processes for specific data types associated with the EDI; collaborating with other project personnel on issues of code management; gathering input from EDI research groups (LTER, MSGB, LTREB, OBFS) for handling thematically similar data; contributing data quality rules that provide feedback to data submitters on their adherence to best practice recommendations.

Todd Oakley, Emily Ellis **06/01/2017 to 05/31/2018** **$19,955**
National Science Foundation 1702011

Dissertation Research: Correlated Diversification of a Sexual Male Trait and Associated Female Perception

Whether the influence of sexual selection can be detected at deep, macroevolutionary time scales has recently been called into question due to the abundance of ambiguous empirical studies. Population-level studies show a clear link of how sexual selection can lead to rapid species accumulation, as well as phenotypic diversification of male sexual signals and associated female preferences. A missing link in the literature is a study that tests specific population genetic theories in a macroevolutionary context, and one that correlates phenotypic differentiation in male signals and female perception. If population genetic theory holds at macroevolutionary time scales, I expect to find a close association between diversification of the male sexual trait (emission spectra) and female perceptual spectra. Next, I propose to investigate these signal-receiver dynamics to implicate a driver of phenotypic diversity in signals and receiver physiology. Divergence in female perception across species is potentially an overlooked driver of signal and species diversity. As female perception largely underlies preference, it is essential that we understand how raw perception diversifies. Bioluminiscent, courtship signaling ostracods offer a unique arena to understand how closely associated sexual signals are to their intended receivers and to their signaling environment.

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

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

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

Todd Oakley, Daniel Speiser **1/15/2014 to 3/31/2018** **$350,0003**
National Science Foundation DEB-1354831

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

Overview: To establish how many times, when, where, and how 'shell' eyes evolved in chitons (Mollusca: Polyplacophora), the following proposal will reconstruct a data rich phylogeny of Chitonina using fossil calibrations, preliminary 16S/COI data, new transcriptomes, and new sequences of conserved gDNA. Chitons are the target for study because most species have photosensory organs (known as aesthetes) yet ancestrally lack image-forming eyes. Nevertheless, at least one lineage within Chitonina contains species that have hundreds of eyes embedded in their dorsal shell plates. These 'shell' eyes provide spatial vision and are the only eyes known to focus light using lenses made of aragonite. Chitons are an excellent system in which to study the origins of eyes because eyes evolved recently in this group, behavioral and molecular experiments are tractable, and certain extant taxa may act as morphological intermediates that link species with and without eyes. Using dense molecular and taxonomic sampling, combined with divergence time estimates of nodes using fossil and molecular clock calibrations, the following proposal will test the prediction that the eyes of chitons originated within the last 56 mya. The proposal seeks three years of funding to: (1) Produce an unparalleled dataset for resolving relationships within Chitonina by adding to existing 16S/COI data for 126 estimated species: a) transcriptome data for 17 species of chitons (9 already completed) and b) gDNA Target Enrichment (gTE)regions from 126 species across Chitonina; (2) Combine 16S/COI, transcriptomes, and gDNA sequences from gTE to achieve dense taxon sampling and produce a robust phylogeny of Chitonina; (3) Estimate divergence times for Chitonina using fossil and biogeographic records; (4) Analyze transcriptome data to find the ancestral source(s) of genes employed by chiton eyes; (5) Implement existing tools and new analysis scripts in Galaxy, an open source bioinformatics platform.

Intellectual Merit: Establishing a data rich phylogeny for Chitonina (the group of chitons that includes species with 'shell' eyes) will be important to systematists, evolutionists, paleontologists, and other scientists who are using a phylogenetically-informed approach to study non-model organisms. Co-PI Oakley will develop new scripts for bioinformatics and implement existing tools for estimates of divergence time in Galaxy (an open source bioinformatic platform). PI Eernisse and Co-PI Oakley will also develop methods for using transcriptome data to design probes for the multi-gene sampling of genomic DNA through gTE. Additionally, Co-PI Speiser will refine methods for assigning specific identities to the gene fragments produced by assembly programs, a necessary step in the study of the origin of complex traits. Current annotation methods depend on BLAST similarity scores, which do not necessarily correspond to phylogenetic relatedness. Instead, Co-PI Speiser will develop a tree-based framework for annotating transcriptomes that is more specific, informative, flexible and objective than current methods.

Broader Impacts: Research on the 'shell' eyes of chitons will benefit society by advancing the field of biomaterials. To learn more about how mollusks build precisely shaped structures through biomineralization, Co-PI Speiser and Senior Collaborator Brooker are using transcriptome data to identify genes in chitons that are associated with the development of their aragonite lenses. Studying the origins of chiton eyes will help counter popular misconceptions about evolution by demonstrating how complex traits evolve through stepwise processes. Therefore, all of the PIs will continue to engage the public by submitting articles to popular publications such as Scientific American, contributing to biodiversity websites like iNaturalist, and collaborating with science blogs such as EarthSky, Wired, and Discover Magazine. To help develop a diverse, globally competitive STEM workforce, PI Eernisse will train three undergraduate students from CSUF (at 15-20 hours per week for 2.5 years) who will curate voucher specimens and use cutting-edge molecular techniques to sequence conserved segments of gDNA from chitons. These students will present their work at the Society for the Study of Evolution and will co-author publications. With 33% of its students self-identifying as Hispanic, CSUF has been a noted Hispanic-Serving Institution since 2004; CSUF ranks No. 1 in California and fourth in the nation among top colleges and universities awarding bachelor's degrees to Hispanics.

Todd Oakley **9/1/2015 to 8/31/2018** **$162,969**
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 aetsthetes 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.

Todd Oakley **9/1/2013 to 08/31/2016** **$424,787**
University of Michigan 3002735491

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

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

Ryoko Oono **7/1/2015 to 12/31/2017** **$16,400**
UC MEXUS SB160015

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 engelmanii (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).

Dan Ovando, Christopher Costello and Steven Gaines **08/01/2016 to 06/30/2018** **$76,569**
UC Sea Grant College Program E/PD-15

A Bayesian Framework for Utilizing Fishery Independent Marine Protected Area Monitoring Data in Stock Assessments

The proposed study will develop innovative methods for using fishery independent length frequencies and densities inside and outside of marine protected areas (MPAs) to inform fisheries assessment and management. The methods resulting from the proposed project will bolster existing assessment methods, and help open the door for science-based assessment and management in places lacking traditional streams of fishery dependent data.

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

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

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

Mark Page, Jenny Dugan, Robert Miller | **7/1/2013 to 5/31/2018** | **$800,000**

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.

Uta Passow | **1/1/2016 to 12/31/2017** | **$202,682**

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.

Uta Passow, Mark Brzezinski, Craig Carlson | **10/1/2010 to 9/30/2016** | **$971,524**

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 µatm. Upwelling systems are responsible for a significant fraction of global carbon export making them prime targets for investigations on how ocean acidification is already affecting the biological pump today. It is the goal of this proposal to investigate the potential effects of ocean acidification on the strength of the biological pump under the transient increases in CO2 experienced due to upwelling. Increases in CO2 are expected to alter the path and processing of carbon through marine food webs thereby strengthening the biological pump. Increases in inorganic carbon without proportional increases in nutrients result in carbon overconsumption by phytoplankton. How carbon overconsumption affects the strength of the biological pump will depend on the fate of the extra carbon that is either incorporated into phytoplankton cells forming particulate organic matter (POM), or is excreted as dissolved organic matter (DOM). POM and DOM follow very different paths through the pelagic ecosystem. POM is exported primarily through gravitational sinking. DOM can either form exopolymer particles that facilitate aggregation accelerating sedimentation rates of POM, or, in its dissolved form DOM export occurs when DOM that has accumulated in surface waters is carried to depth by physical processes. There is evidence that carbon overproduction leads to more carbon rich POM and to a rise in exopolymer formation, increasing particle aggregation and export. Carbon overconsumption may additionally enhance the production of low quality (high C: N) exudates that resist microbial degradation allowing a greater fraction of DOM produced under high CO2 to accumulate in surface waters and eventually be transported to depth. Thus, ocean acidification may enhance the export of both POM and DOM strengthening the biological pump and accelerating the rate at which increases in atmospheric CO2 are transferred to the deep ocean. Results from mesocosm experiments demonstrate that the mechanisms controlling the partitioning of fixed carbon between the particulate and dissolved phases, and the processing of those materials, are obscured when both processes operate simultaneously under natural or semi-natural conditions. Here, POM and DOM production and the heterotrophic processing of these materials will be separated experimentally across a range of CO2 concentrations by conducting basic laboratory culture experiments. In this way the mechanisms whereby elevated CO2 alters the flow of carbon along these paths can be elucidated and better understood for use in mechanistic forecasting models.

Uta Passow | **10/1/2015 to 9/30/2018** | **$663,945**

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, pCO2 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 pCO2, 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 atmosphericpCO2 is altering all the environmental conditions important for phytoplankton growth, including increases in temperature and pCO2 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 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.

Uta Passow **1/1/2015 to 12/31/2017** **$710,151**
University of Georgia RR100-047/5054876

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

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

Collaborations with microbiological colleagues in ECOGIG will look at the fate of such marine snow and the role of microbes for marine snow formation. Collaborations with Bill Lehr (NOAA) should provide input to ADIOS 3 or similar models, developed for rapid response planning. We will prepare and submit the data to GRIDCC and write scientific publications in collaboration with our colleagues.

Uta Passow | **1/1/2015 to 12/31/2017** | **$483,825**
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.

Uta Passow | **03/15/2017 – 02/29/2020** | **$69,626**
Arizona State University | 17-170

Aggregation of Marine Picoplankton

This project will investigate the aggregation behavior of picoplankton under different environmental conditions between January 2017 and December 2019. The experiments will be conducted at Arizona State University. I will advise in designing these experiments, and contribute to their interpretation. Regular determination of TEP (transparent exopolymer particles) and CSP (coomassie stainable particles) dynamics will be an important component of this study, because TEP and CSP are central for coagulation processes. Preparation of the calibration solutions for TEP and CSP are non-trivial and require an ultra-sensitive balance. My laboratory will generate the calibration solutions needed for TEP and CSP measurements during these experiments.

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

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

Organisms are constantly responding to change. The abiotic environment fluctuates, physiological processes are noisy, and other individuals behave unpredictably. The dynamic changes in conditions over time contain information that can be sensed, remembered, processed, and acted upon. We define the dynamic response strategy of a genotype as the dynamical system they use to produce a response given a time series of sensed inputs. This project will develop theoretical approaches based on optimal control theory and population genetics to understand biological scenarios involving sensed environmental input and a dynamic response. Specific focus will be given to determining how the reliability of sensory input and the tempo of environmental variation relate to the optimal strategies for gathering, processing, and responding to information. The focus is on cellular dynamic response systems including simple gene regula¬tion, regulation of interacting genes in a network,

cellular sensory mechanisms, and competitive foraging. For each biological system, the mechanistic details of the dynamic response will be mod¬eled and population genetic techniques will be used to determine the evolutionary outcomes. The optimal control solutions define an upper bound to fitness and can be compared to the biologically constrained evolved strategies. This comparison will show how well biological systems can approximate the optimal solutions, explain the general principles behind the evolution of dynamic response strategies, and address whether the optimal solutions are evolutionarily achievable. This project has the potential to be transformative because our methods apply equally well to single cell responses, developmental responses, physiological responses, and behavioral responses.

Jonathan Pruitt **10/1/2015 to 06/30/2017** **$24,767**
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 evolutionarily 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.

Jonathan Pruitt **05/01/2017 – 04/30/2018** **$252,000**
University of California, Los Angeles 20164989A

Consortium Grant: Quantitative Approaches to the Study of Keystone Individuals

The Pruitt laboratory will contribute to the proposed research by performing aspects of all aims. The lab will take a lead role in the field work, experimental manipulations of colony composition, colony development experiments, and the filming of collective behavior. The lab will be responsible for deploying colonies in the field and then monitoring their behavior and success. These experiments will be vital for obtaining parameter estimates for our mean field model and agent-based simulations. Pruitt will establish experimental colonies both in the laboratory and in the field, execute the entirety of the experiments, and provide all of the videos to the Pinter-Wollman laboratory for network analysis. Likewise, Pruitt will establish all of the experimental colonies and perform the removal experiments in the wild.

Jonathan Pruitt **1/1/2016 to 5/31/2018** **$321,582**
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.

Langdon Quetin, Robin Ross **4/1/2011 to 9/30/2016** **$445,002**
National Science Foundation 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 zooplankon > 2 mm. Net and bioacoustic data are complimentary, and should be integrated. Net data yield samples for community composition, population demography and experiments, and serve for target identification of sound scatterers. Bioacoustic data yield data on smaller scales relevant to the ecology of the different sound scatterers and their predators, both biomass and aggregation characteristics. In addition, in situ rates of secondary production (growth, spawning and egg production) were measured experimentally for the key species Antarctic krill in order to estimate secondary production. This zooplankton data set combined with the coherent multi-disciplinary data sets collected by the Palmer LTER is uniquely suited for studies of spatio-temporal variability and mechanisms underlying that variability, partially due to the fact that the time period spans three full cycles of recruitment in Antarctic krill and variability in primary production. Focus areas for the data synthesis proposed include: (1) A Principal Components Analysis and Canonical Correlation Analysis (PCA-CCA) approach, as recently used to document zooplankton abundance and distribution patterns, will be used for analysis of the time-series 1993-2008 of zooplankton and the biological-biological and biological-physical linkages. Three workshops will be convened with colleagues with complimentary hydrographic, sea ice and phytoplankton data to test hypotheses and produce manuscripts. (2) After full restoration, the bioacoustic data will be analyzed for patterns and/or trends in biomass and aggregation characteristics, and relationships to environmental factors and ecosystem function. With the British Antarctic Survey (BAS), zooplankton (Antarctic krill and other sound scatterers) biomass and aggregation characteristics within the Palmer LTER study region will be compared to the South Georgia region. These data will be archived in a format easily used by future investigators as a consensus on such variables as target strength emerges. (3) Secondary production experimental data will be modeled as a function of environmental variables such as food quantity and quality and individual size and sexual maturity, then integrated with acoustic biomass data to estimate secondary production rates and production:biomass ratios (turnover) and their spatio-temporal variability throughout the study region. In addition funds will bring to fruition separate collaborative efforts on somatic growth and life cycle timing for salps in this region (P. Kremer), and the use of Antarctic krill length frequency data to explore linkages among populations around the continent (BAS). Included are resources for multiple data base activities: completion of sample analysis and data submittal for the 0708 field season, interactions with the Palmer LTER information manager, and submittal to the LTER data directory of completed derived products as described above.

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

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

Channel Islands National Park (CHIS) initiated kelp forest (KF) monitoring in 1982 to better understand the long-term dynamics of these important ecosystems. Monitoring data have been collected continuously for 31 years with a total of 33 sites currently being sampled annually. The purpose of the KF monitoring program is to understand the natural variation within these communities and collect baseline data for comparing resources inside and outside of marine protected areas, and to better understand the dynamic nature of these communities so that it can be properly conserved for current and future generations. In 1994, a detailed review of the CHIS KF monitoring program was conducted by a scientific panel (Schroeter and Dixon 1994). Several adjustments were made to the monitoring protocols following the 1994 review. With the

establishment of new marine protected areas in 2003, KF monitoring at CHIS was extended to several new locations resulting in a greatly expanded monitoring effort. This resulted in an increase in monitoring from 16 original sites in 1982 to 33 sites in 2005 in order to monitor and assess the new marine protected areas. As a result of these changes an in-depth review of monitoring protocols and sampling design is needed to identify recommendations for prioritizing monitoring efforts, streamlining protocols, and evaluate the monitoring effectiveness for marine protected area evaluation. In addition, an updated synthesis and interpretation of the long-term KF monitoring dataset is needed to support the protocol review and to share KF monitoring results with scientists, resource managers and the interested public. KF monitoring data are currently available on the web at http://pyrifera.marinemap.org. CHIS staff and others have authored a data paper for Ecology (Kushner et al. In Press) that summarizes the KF methodology and data set. These KF data resources will be updated as part of this project.

Andrew Rassweiler and Dan Reed **8/15/2014 to 7/30/2018** **$40,000**
USDI National Park Service P14AC01661

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

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

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

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

Sargassum horneri is a fast growing brown alga native to shallow reefs of Japan and Korea. It has spread aggressively in southern California since first being discovered in 2003 and poses a major threat to the sustainability of native marine ecosystems in this region. While numerous groups collect data on *S. horneri* as part of their routine monitoring, the ecology and impact of this invader in southern California are poorly known. Of particular note is the manner in which the spread of *S. 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

$6,246,158
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.

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

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

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

A new tool that has been developed to help control algal invasions is an underwater suction device, called the "Super Sucker" (Conklin et al., unpublished data). The device was used on coral reefs in Oahu, Hawaii to reduce densities of the invasive red alga *Gracilaria salicornia* below a threshold level such that herbivores could maintain low densities of the invader. A similar device intended to aid control of southern California marine invasions was recently constructed through a partnership between Los Angeles Waterkeeper, Santa Barbara Channelkeeper, and NOAA's National Marine Fisheries Service. It has been used in trial runs to transport material from the ocean floor up to a platform on the surface with the aid of divers feeding material into the suction hose. However, the effectiveness of this device in controlling marine invasive species requires further investigation.

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

Dan Reed, Mark Page, Robert Miller, Craig Carlson, John Melack | **2/1/2016 to 1/31/2017** | **$199,500**
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 Ninos 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 **9/1/2012 to 8/31/2016** **$264,575**
National Science Foundation OCE-1233283

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

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

Bight. Our research will be greatly facilitated by our recent developments of: (1) highly polymorphic microsatellite markers for characterizing the population genetics of giant kelp, and (2) a novel method for estimating effective population size for all discrete patches of giant kelp in the Southern California Bight using Landsat satellite imagery.

Daniel Reed, Andrew Rassweiler and Kevin Lafferty **9/22/2011 to 3/31/2018** **$449,927**
USDI Bureau of Ocean Energy Management (BOEM) M11AC00012

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

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

Daniel Reed, Stephen Schroeter Mark Page **1/1/2016 to 12/31/2017** **$5,362,124**
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.

Cristina Sandoval, Sue Swarbrick **9/22/2015 to 6/30/2020** **$61,920**
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 6/30/2018** **$505,000**
California Wildlife Conservation Board WC-145BC

Coal Oil Point Reserve Infrastructure and Facilities Project

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

Cristina Sandoval, Sue Swarbrick **6/30/2015 to 12/31/2017** **$345,000**
California Coastal Conservancy 14-094

Education Center at Coal Oil Point Reserve

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

Cristina Sandoval, Sue Swarbrick **10/23/2015 to 6/30/2017** **$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.)

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

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

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.

Cristina Sandoval and Sue Swarbrick **11/01/2016 to 02/15/2018** **$23,000**
Santa Barbara County SB170105

Coal Oil Point Reserve Education & Conservation Center

Education and conservation centers are important facilities that engage communities in the effort to sustain natural areas by providing venues and programs to enrich our connection to nature. The centers become hubs for education, research, and outreach activities and broaden our experiences of the natural world. The goal of the Education & Conservation Center is to support conservation, restoration, environmental education, and research programs for all ages by providing a venue for classes, tours, volunteerism and science. COPR is a protected natural area with important coastal wetland resources. The key to protecting these coastal resources in areas that are impacted by oil and gas development lies in conservation, restoration, education and research. The Center will also support Reserve staff members who lead these activities and are stewards of the natural resources.

Alison Santoro **9/15/2016 to 9/14/2019** **$16,531**
Alfred P. Sloan Foundation FG-2016-7129

Alfred P. Sloan Research Fellowship

The mesopelagic ocean is one of the most poorly described biomes on Earth, yet has a global impact on global marine elemental factors. This project will investigate controls on the phylogenetic, genetic, and functional biodiversity of three abundant microbial groups involved in carbon and nitrogen remineralization thoughout the mesopelagic that have diverse, often distinct, but in some cases overlapping metabolic capabilities. The PI will explore the hypothesis that gradients in subsurface dissolved oxygen and trace metals together control the biodiversity of these three taxa across basin scales. It is hypothesized that these taxa control the distribution of mealloenzymes necessary for the remineralization of carbon and nitrogen. Phylogenetic diversity will be determined through high-resolution mapping of taxa using 16S rRNA gene amplicons and of select phylogenetically informative protein coding genes. Genetic diversity will be assessed using long read metagenomics, assembly, and binning methods designed to efficiently recover entire genomes of individual taxa both within and between lineages. Functional diversity will be assessed using global and targeted metaproteomics, stable isotope probing, and isotope tracer incubations to determine process rates and substrate affinities. Integration of phylogenetic, genetic, and functional diversity will be accomplished by correlating community-level rates with trace metal concentrations and the presence of specific taxa and metalloenzymes, and by using stable isotope probing techniques to determine the phylogenetic distribution of complex functional traits (carbon fixation) among abundant microbial lineages. Novel technological capabilities will be tested and deployed, including quantitative metaproteomics to elucidate the biogeography and stoichiometry of metalloenzymes across a Pacific Ocean transect, long read metagenomics sequencing, and a new autonomous underwater vehicle capable of high-resolution 'omic sampling named Clio.

Alison Santoro **07/01/2016 to 03/31/2018** **$10,313**
National Science Foundation 1739144

Collaborative Research: Gene Content, Gene Expression, and Physiology in Mesopelagic Ammonia-Oxidizing Archaea

The goal of this project is to use comparative genomics and transcriptomics of a model ammonia-oxidizing archaea (AOA) grown under a range of energy availability and nitrosative stress conditions to identify genes that can be used to diagnose the physiological state of natural populations in the ocean. These experiments will facilitate a thorough reinterpretation of existing metagenomic and metatranscriptomic datasets, as well as provide a better contextual understanding in future studies.

Alison Santoro **07/01/2016 to 07/31/2018** **$101,545**
National Science Foundation 1740538

Collaborative Research: New Approaches to New Production

Our project goal is investigating primary production and nitrogen (N) dynamics at the SPOT station, specifically an analysis of new production at this site. The new production conceptual model has been a powerful organizing principle in biological oceanography since its inception and provides a means to constrain the amount of primary production which may be exported or "sequestered" from the system. Despite qualifications to the definitions of new and regenerated forms of N as originally articulated, the concept has, for the most part, been narrowly applied with respect to the model compounds assessed, namely nitrate as the primary form of new N and ammonium as the predominant recycled form. Evidence continues to accumulate that in certain ecosystems, these definitions warrant expansion. N2 fixation, for instance, can be at times a substantial source of new N; similarly, forms of dissolved organic N (e.g., urea) may contribute significantly to recycled production, but the specific organisms taking part in these transformations are still uncertain. Nitrification in the upper water column may also compromise the strict definitions of new and recycled N. With the recent advent of molecular techniques, scientists can probe more deeply into new and regenerated production, and directly identify major agents of these processes.

Alison Santoro **05/15/2017 to 06/30/2019** **$75,000**
National Academies Keck Futures Initiative NAKFI DBS17

Small Wonder: Inside World of Marine Microbes on the Smithsonian Ocean Portal

The ocean's living biomass is ninety percent microbes by weight, yet they are invisible to the naked eye. Microbes are found from shallow to deep waters, from the poles to the tropics. In this project, science communication experts from the Smithsonian National Museum of Natural History will work with marine microbe researchers and digital media practitioners to produce fun, easy to understand and informative marine microbe content for the Ocean Portal website (https:ocean.si.edu). Anticipated products from the grant include a short video, a digital interactive, and instructions for microbe-focused "tangible interactives" that viewers can create themselves.

Alison Santoro **10/01/2016 to 01/31/2020** **$370,840**
Simons Foundation 345889

Growth Efficiency in the Mesopelagic at Station ALOHA

The gap between our ability to generate sequence information from the ocean and our ability to interpret it continues to grow. Fording this gap requires novel approaches and collaboration among ecologists, molecular cell biologists, and engineers. We propose to employ a high-throughput screening approach to understand the functional characteristics of one group of proteins – membrane transporters- that determine which chemical compounds are being used and consumed by microbes in the ocean. Transport proteins will be reconstituted in both model systems and model lipid bilayers (giant unilamellar vesicles, GUVs). Using a novel microfluidic platform as a tool, we will identify the substrate(s) transported through each protein, determine their relative affinities, and ultimately calculate quantitative kinetic parameters such as half-saturation constants and saturated uptake rates.

Russell Schmitt, Sally Holbrook **09/01/2016 to 08/31/2022** **$1,127,000**
National Science Foundation 1637396

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

Coral reefs have enormous ecological, economic and cultural value, but are threatened by natural disturbances and human activities including those causing global-scale changes. Worldwide, corals increasingly are being replaced by macroalgae or non-coral invertebrates. The reefs of Moorea, French Polynesia, provide an ideal model system to understand factors that mediate ecological resilience and to develop the capacity to forecast the composition and function of reefs in a future ocean of warmer water and a lower pH. The overarching goal of the Moorea Coral Reef (MCR) LTRE, established in 2004, is to gain a predictive understanding of the dynamics and functionality of oceanic coral reef ecosystems. MCR science achieves this goal through long-term observations, experiments and modeling. Changes in community structure revealed by the time series are used to generate hypotheses, which are tested using process-oriented studies including long term experiments. Empirical studies are synthesized process-oriented studies including long term experiments. Empirical studies are synthesized and modeled to gain novel insight into the responses of coral reefs of Moorea to changing environmental conditions, to search for ecological generality, and to advance ecological theory.

Russell Schmitt, Sally Holbrook **9/1/2012 to 8/31/2018** **$4,432,747**
National Science Foundation OCE-1236905

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

Chem-OCE Supplement	$2,145
UNOLS Supplement	$125,213
LIDAR Supplement	$194,040
Thailand Travel Supplement	$41,215
Equipment Supplement	$200,000

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 CO2: 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 **7/1/2006 to 6/30/2018** **$113,978**
California Sea Urchin Commission SB070019

Studies of Sea Urchins Settlement in Southern and Northern California

The patterns of settlement of red (*Strongylocentrotus franciscanus*) and purple (*S. purpuratus*) sea urchins may have important impacts on the commercial fishery and provide an important fishery-independent measure of stock health. The investigators have monitored weekly to bi-weekly sea urchin settlement at multiple sites in southern and northern California since February 1990. Studies to date have identified spatial and temporal patterns in sea urchin settlement (including the effects of periodic *El Niños* and *La Niñas*) and have identified some of the likely mechanisms responsible for

these patterns. They have added value to their work by volunteering their time and collaborating with University researchers and private industry. In particular, work done in collaboration with Jan Svejkovsky of Ocean Imaging has given important insights into the effects of large-scale oceanographic forcing on sea urchin settlement patterns, while collaborative work on population genetics with Dr. Ron Burton has shed light on the structure of parental source populations during a heavy settlement event. Perhaps most importantly, their long-term and geographically extensive record of sea urchin settlement continues to provide the only integrated, fishery independent index of the condition of the breeding stock, since larval supply and settlement are a function of the effective breeding population. The value of this inexpensive tool for monitoring the health of the sea urchin resource in California increases each year the study is continued.

Scott Simon, Michele Johnson **8/1/2015 to 7/31/2017** **$99,968**
NOAA 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.

Cody Szuwalski, Christopher Costello **09/01/2016 to 8/31/2018** **$500,000**
Packard Foundation 2016-64741

Capacity Building in China Through Collaborative Marine Research

The Sustainable Fisheries Group (SFG) at UCSB seeks a partnership with the Packard Foundation on a project grant to engage Chinese researchers in collaborative research aimed at understanding the status and evaluating the management of Chinese marine resources. The planned research collaborations will increase our Chinese partner's capacity to employ more quantitative methods by exposing them to cutting edge management tools and analytical methods. The Chinese government is enthusiastic about involving international experts in the process of exploring potential management strategies for their ocean resources, but sensitivities exist, particularly with regard to sharing data. SFG proposes the following approach to respect our collaborators' need for privacy while offering meaningful guidance in ocean management.

SFG will design a user-friendly tool to quantitatively assess the impacts of alternative changes in fishery management with an emphasis on flexibility so that it can be applied to many species. This tool will be able to consider the influence of climate change and trophic interactions in the process of evaluating potential management interventions from both ecological and economic perspectives. We will provide training in the use of the tool and the concepts behind it to researchers at multiple institutes and universities in China so they can use it in their own research. Currently, four projects are planned using this tool, and more projects will emerge as SFG continues to build relationships with Chinese scientists and fisheries researchers.

The planned projects are aimed at deepening the sophistication of China's ocean management and increasing the visibility of the potential benefits of management reforms. To further our goal of building capacity in China and raising the profile of the results of our collaborations, we will host up to 4 visiting scholars over the grant period, targeting individuals for their potential to influence future management decisions and to spread technological innovations more broadly within the Chinese academic and management communities. SFG will collaborate with these researchers and others to produce peerreviewed publications in English-speaking journals related to the management of species fished by the Chinese fleets

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Thomas Turner **8/1/2011 to 12/31/2017** **$1,452,662**
NIH General Medical Sciences 5R01 GM098614-04

Evolutionary Behavioral Genomics of Drosophila Courtship

Genome-wide association studies hold the promise of comprehensive and systematic identification of the genetic basis of natural trait variation. By quantifying how genetic polymorphisms induce large, small, precise, general, or conditional effects on traits, we can unlock a vast reservoir of natural variation that will help us understand how biological systems function and evolve. However, good statistical power to identify variants with low population frequencies or modest effects requires sample sizes that are generally prohibitive. Here, we develop a new approach, "Evolve and Resequence" (E&R), that overcomes this barrier using the genetic model system Drosophila. We have re-purposed experimental evolution of *D. melanogaster*, which has been used for over 100 years to address fundamental questions in population genetics, and adapted it for use in genome-wide mapping. Together with high-throughput behavioral quantification and various statistical approaches, our technique will be used to build models of behavior based on genotype. The predictive power of these models will tell us a great deal about the nature of genetic information and the molecular systems that translate this information into behavioral output. The long-term goal of this research is to characterize the genetic and environmental influences that result in variation in courtship behavior, for both males and females, in multiple Drosophila species. This work begins with characterization of male courtship song production: during courtship, a Drosophila male extends a single wing and "twangs" this wing repeatedly to produce a wing vibration song consisting of a series of pulses. These traits are among the best characterized of Drosophila behaviors, both in *D. melanogaster* and across the genus, and they are currently the focus of intensive efforts in neurobiology and molecular genetics. As such, these traits serve as a model system for studying the genetic basis of behavior in animals. Specifically, this proposal aims to 1) locate and characterize the genetic variants affecting courtship song in *D. melanogaster*, 2) do the same for the closely related *D. simulans*, to compare and contrast results from multiple species, and 3) begin molecular genetic investigation of the genes and gene systems discovered in aims 1 and 2.

David Valentine **10/1/2013 to 9/30/2018** **$341,714**
National Science Foundation OCE-1333162

Collaborative Research: Oxygenation of Hydrocarbons in the Ocean

Overview: More than 400,000 tons of petroleum hydrocarbons are released annually into the ocean, with human activities and natural seepage contributing comparable amounts. Once in marine environments, hydrocarbons are subject to physical, chemical and biological processes, collectively referred to as weathering, that are well established to remove select hydrocarbons from the ocean. However, little attention has been given, mainly due to analytical limitations, to the ubiquitous residues left by oil's weathering. Recent studies from oil spills point to the importance of hydrocarbon oxygenation, the incorporation of oxygen into hydrocarbons, as an important process in forming major constituents of recalcitrant tar. Furthermore, other oxyhydrocarbons could dissolve into ocean water, and several studies suggest that oxygenated hydrocarbon compounds can be toxic. This proposal seeks to lay a scientific foundation for understanding which processes control the formation of oxygenated hydrocarbons, the rates of these processes, the identity of the major products, the rates at which they are formed and destroyed, and for distinguishing photochemical oxygenation from biological oxygenation. The primary hypotheses driving this study are that (i) hydrocarbon oxygenation in the ocean is controlled by a balance between photooxidation and biodegradation, with each process leading to distinct suites of products and (ii) oxygenation produces both terminal recalcitrant products, which dominate the mass of tar in the environment, and lesser amounts of dissolved organic carbon. The approach involves a series of field and laboratory studies that include using hydrocarbon seeps as natural laboratories and oil spills (Deepwater Horizon oil spill 2010, and Cosco Busan spill 2007) as individual experiments. Laboratory experiments will isolate photochemical and biological oxygenation, whereas field studies will assess changes and patterns of oxygenation in natural slicks at the sea surface and biodegraded oils from underlying natural seeps. To identify specific oxidation processes and recalcitrant products, labile and recalcitrant

oxygenation products will be identified using ultra-high resolution mass spectrometry (FT-ICR-MS) and comprehensive two-dimensional gas chromatography (GCGC), and changes in the stable oxygen isotopic composition characteristic of biological and photooxidation will be determined. These are novel approaches not previously applied to oxygenation of hydrocarbons.

Intellectual Merit: The results from these experiments will contribute to a better understanding of the petroleum oxygenation processes and the environmental fate of understudied oxygenation products. Thereby, characteristic changes in bulk, molecular, and isotopic composition of weathered petroleum seep and spill samples collected by the PIs will be linked to photooxidation and biodegradation processes. Overall, this study promises to reveal the composition, source, and fate of oxygenated hydrocarbons that result from petroleum released in marine systems by natural seepage or anthropogenic discharge.

Broader Impact: This study provides for several undergraduates and two postdoctoral scholars to be trained in innovative analytical and experimental techniques. The proposed oceanographic expedition in the Gulf of Mexico will double as a course offered at UCSB that will bring undergraduates to sea and provide a rich and integrated research and learning experience; undergraduate students from the University of Mary Washington will also be incorporated into the laboratory and oceanographic phases. Furthermore, the results of this effort will help regulatory agencies to define new analytical methods and target compounds for oil spill research. The involved PIs have built a strong relationship with federal and industry oil spill scientists in order to communicate and apply these results. Last, the iconic 2010 Deepwater Horizon spill has drawn attention to a wider audience of marine scientists studying cycling of organic matter in the ocean, beyond traditional oil spill research. The proposed study will add to their efforts to understand the fate and impacts of hydrocarbons released into the ocean.

David Valentine **09/01/2016 – 08/31/2019** **$364,254**
National Science Foundation 1635562

Collaborative Research: Do Cyanobacteria Drive Marine Hydrocarbon Biogeochemistry?

More than 400,000 tons of petroleum hydrocarbons are released annually into the ocean, with human activities and natural seepage contributing comparable amounts. This quantity is dwarfed, according to recent work, by the production of 308,000,000 – 771,000,000 tons of hydrocarbons by cyanobacteria. While the ubiquity of hydrocarbons in the oceans has long-been attributed to phytoplankton source, no study has considered the latent biogeochemical cycling of such biogenic hydrocarbons or the effects of this cycle.

This proposal seeks to lay a scientific foundation for understanding the distribution, partitioning, and cycling of biogenic hydrocarbons in the ocean. The hypotheses driving this proposal focus on the abundance and molecular diversity of biogenic hydrocarbons in relation to the cyanobacterial population; the extent to which volatilization to the atmosphere acts as a sink for biogenic hydrocarbons; and the rate at which hydrocarbons are produced by cyanobacteria and consumed by hydrocarbon-degrading bacteria.

David Valentine **08/29/2016 – 08/31/2019** **$499,949**
USDI Bureau of Safety and Environmental Enforcement E16AC00002

The Effect of Hydrocarbon Production on Offshore Natural Seep Rates in the Coal Oil Point Area, Santa Barbara, California

This proposal describes a research project led by the UCSB and conducted with sub equal contribution from the University of New Hampshire. The primary research goal of this project is to quantify the capitalizing on two conditions: shut in versus resumption of hydrocarbon production. This goal will be achieved by using geophysical methods to survey and monitor the flux of oil and gas at a hydrocarbon seep located at close proximity to Platform Holly, in the Coal Oil Point seep area. The platform is currently shut in, providing an opportunity to quantify oil and gas flux in the absence of hydrocarbon production; the return to production will provide an opportunity to test the

hypothesis that production reduces the rates of natural seepage. The results from this study should inform the public, the local County and State governments, the media, and academia about natural seepage by assessing the potential for oil and gas production to reduce environmental release of petroleum. The results from this study should further inform as to the role of gas-driven transport in the migration of heavy Monterey oil through overlying strata and waters, and may further help BSEE and the U.S. Coast Guard anticipate/explain anomalous occurrences of oil in the water and on the beaches such as happened in July 2015, two months after the platforms were shut-in.

Hillary Young **6/1/2014 to 5/30/2016** **$107,954**
Morris Animal Foundation D14ZO-308

Effects of Land-Use on Tick-Burden and Tick-Borne Diseases in Wild Dogs (*Lycaon pictus*)

Study Design: This project will take place in northern Kenya, where we have extensive preliminary data and a well-instrumented field team, and where there is a mosaic of different land-use types in close proximity. The first part of the project will examine variation in questing tick abundance and infection prevalence in ticks in known wild dog habitats with differing human use. We will conduct stratified random sampling of habitats by land-use type for tick abundance and infection prevalence, allowing us to assess landscape level risk across habitats. We will screen ticks and dogs for a suite of tick-borne pathogens that preliminary data show are present in wild dogs in this region. The second part of this project will estimate tick burdens and prevalence of tick-borne pathogens in wild dogs, and examine the effects of land-use and livestock density on these response metrics. We will use existing blood and tick samples, supplemented with additional tick collections from new dogs captured during this period (~15 animals) for these analyses. We will screen blood samples from the dogs and engorged ticks taken off the dogs for both tick transmitted pathogens as well as other pathogens for comparison. We will then analyze the relationships between individual habitat usage and both tick burden and pathogen prevalence.

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 than20,000 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.

David Valentine, Blair Paul **04/01/2016 – 06/30/2018** **$206,370**
University of Southern California 72781708

Using a Targeted Metagenomic Approach to Examine Adaptive Protein Diversification by Microorganisms and their Viruses in Subseafloor Sediments

Parasitic organisms depend upon evasive genetic strategies towards defense, including adaptive protein diversification. Although this phenomenon has not been widely examined in subsurface ecosystems, my recent assessment of subseafloor and subterranean archaeal genomes revealed a prodigious driver of protein evolution. Here, I propose to expand upon this discovery, leveraging the C-DEBI collaborative network, to examine the role of targeted protein diversification in shaping host-parasite interactions in subseafloor ecosystems. Importantly, I propose to investigate this mechanism in the following three stages.

1. Directly probe methane seep sediments sampled from the Santa Monica Basin, using a novel screening diversifiers.
2. Conduct metagenomics sequencing and bioinformatics analysis for samples prioritized in the previous step.
3. In collaboration with current C-DEBI researchers, apply newly developed bioinformatics tools to screen for latent hypervariable proteins in existing subseafloor metagenomes. This research will directly address C-DEBI phase II research themes 2 and 3 by investigating a targeted mechanism thought to drive protein evolution in subsurface microorganisms and their viruses. The collective efforts of this proposal will lead to a broad collaboration for the identification and annotation of proteins that have evolved through adaptive diversification in subseafloor microorganisms.

David Valentine **1/1/2011 to 9/30/2016** **$924,127**
National Science Foundation OCE-1046144

Dimensions: The Role of Viruses in Structuring Biodiversity in Methanotrophioc 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.

David Valentine **3/21/2013 to 3/31/2017** **$335,419**
California Institute of Technology 65Q-1094175

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

Personnel at UCSB will work closely with the collaborating scientists on the following topical areas: 1) Contribute experimental expertise to develop techniques to measure low abundance sulfur-containing compounds from whole cells, as well as metabolic intermediates using novel inductively coupled plasma mass spectrometry (ICP-MS) techniques. 2) Contribute to the development of experimental methods to link phylogenetic identity to metabolic activity of sulfur cycling microbes using fluorescence in situ hybridization coupled to mass spectrometry (FISH-nanoSIMS) 3) Conduct

collaborative experiments to track the flow of isotope labeled sulfur through extracellular metabolite pools as well as within intracellular pools. 4) Conduct aerobic and anaerobic pulse chase time course experiments using seafloor incubation chamber at Coal Oil Point. 5) Contribute to the development of new methods for using molecules containing more than one rare isotope species to track multiple sources and sinks of methane in cultures of microbes 6) Contribute to a synthesis paper on tracking activity and interactions of sulfur cycling microbes at the cellular level. 7) Contribute toward in-situ incubations involving for sulfur isotope tracking and metaproteomics.

Herb Waite **6/1/2015 to 5/31/2017** **$76,731**
National Science Foundation 1508717

EAGER: Collaborative Research: Mimicking Mussel Adhesion with Periodically Sequenced Polypeptides

Marine mussels use the catecholic amino acid 3,4 dihydroxyphenylalanine (Dopa) in mussel foot proteins to mediate robust wet adhesion in the turbulent intertidal zone. The objective of this EAGER proposal is to quantitatively explore the role of high fidelity sequence periodicity in a Dopa-rich polypeptide on the dynamics of coating and adhesion. Moreover, we propose a non-biological synthetic protocol for the synthesis of a high molecular weight periodic sequence with a low polydispersity, allowing us to synthesize bulk-scale inexpensive polymer. Our approach is based on the application of a transport-limited polycondensation reaction to define both the periodicity and the polydispersity. Subsequently, we propose to quantify the coating dynamics and work of adhesion as a function of the sequence parameters. We can use our synthetic protocols to precisely control the role of Dopa /proline frequency and the spatial distribution of peptides. Our team has established expertise in both the synthetic methods and the characterization tools, but the proposed work aims at EAGER funding because the vision of marrying polymer-scale synthetic tools and biomimetic adhesion is untested and involves a radically different approach.

Intellectual Merit: The proposed work blends the PIs' experience in interfacial science and marine biology to understand the fundamental behavior of non-toxic biomimetic adhesives. Our proposed macromolecular system is unique in its ability to precisely define the presentation of Dopa. Moreover, the SFA is well suited to quantitatively define the dynamic roles of hydroxyproline in coating and Dopa in adhesion and cohesion. The narrative describes our rationale for the initial periodically sequenced Dopa-rich polypeptides, and we describe our plan to rapidly iterate between the materials characterization and new sequences that allow us to validate our hypotheses on the balance between coating and binding in wet-adhesion.

Broader Impacts: The proposed work is in line with an NSF-defined priority to emphasize discoveries in bioadhesion, which has the potential to have "far reaching effects" in a number of technologies. Moreover, the ability to generate a significant quantity of a non-toxic biomimetic adhesive has excellent potential for STEM education, where simple demonstrations can be developed to engage students in fundamental science questions as well as the engineering of materials. Additionally, CCNY is a Minority Serving Institution, and the proposed interdisciplinary work is ideal for engaging students at the high-school, undergraduate and graduate levels. The PI has developed a 'community' of science teachers at Harlem area schools, where area teachers can work together with high school students in the research lab during the summer and school year. Taken together, the proposed work can both broaden participation in the local STEM community as well as lead to a significant impact in the adhesion and interfacial science community.

J. Herbert Waite **9/1/2013 to 8/31/2018** **$1,942,671**
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.

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

An Integrative Investigation of Population Connectivity Using a Coral Reef Fish

Work on this grant assigned to UCSB consists of two parts:

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

Libe Washburn, Mark Brzezinski **6/1/2010 to 5/31/2017** **$1,582,297**
UC San Diego NA11NOS0120029

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

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

Libe Washburn **6/1/2016 to 5/31/2018** **$730,600**
UC San Diego NA16NOS0120022

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.

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 r2);
- Constructing useful visualizations of results for operators.

Libe Washburn and Brian Emery **03/15/2017 to 02/29/2020** **$536,279**
National Science Foundation 1658475

Collaborative Research: Resolving Complex Coastal Flows via Advances in High-Frequency Radar

Coastal oceanography aims to understand and quantify complex coastal flows that transport momentum, heat, salt, nutrients, and other waterborne materials such as plankton and sediment along and across continental shelves. The rapid evolution of these flows over a wide range of spatial scales makes them challenging to observe. Oceanographic HF radar is an important approach for observing these flows through persistent measurement of surface currents over large areas of the coastal ocean. While HF radar is capable of resolving scales of surface currents essential for understanding the dynamics of larger scale transport processes, the present state of HF radar techniques constrains the accuracy and resolution of surface current observations in regions of higher complexity, thus limiting understanding of the full range of dynamics present. The overarching goal of this proposal is to advance knowledge of complex coastal dynamics by improving surface current observations from oceanographic radars. These improvements will increase the value of HF radar observations for basic research of the coastal ocean and for operational applications directly benefiting society.

Syee Weldeab **5/1/2015 to 6/30/2017** **$55,237**
National Science Foundation 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.

Syee Weldeab, David Lea **7/1/2013 to 12/31/2016** **$366,804**
National Science Foundation OCE-1260696

Data Synthesis and Evaluation of the Salinity Influence on Mg/Ca Paleothermometry in the Low Latitudes

Intellectual Merit: Foraminiferal Mg has become an important tool that paleoceanographers use to deduce past ocean temperatures. It is one of three methods that can be used in the low latitudes, and it has proven especially powerful in deducing changes in the tropical warm pools over time scales of hundreds to tens of millions of years. The co-occurrence of Mg and oxygen isotopes in foraminifera links these two important proxies in time and space, extending their usefulness. Recently three papers based on core-top data have argued that salinity is an overlooked and dominant influence on foraminiferal Mg. If correct, this inference would require recalibration of Mg paleothermometry as well as reinterpretation of existing and future paleoceanographic records, because salinity has varied sufficiently in the past, in concert with ice volume and hydrological shifts, to significantly shift the magnitude and timing of reconstructed temperature changes. The large magnitude of the hypothesized salinity influence from these three studies, however, is in conflict with a much smaller influence in published foraminifera culturing data, and therefore is not well established within the paleoceanographic literature. The goal of this proposal is to test the magnitude of the salinity influence using a three-pronged strategy: 1) a targeted analysis of sediment trap and core-top samples from three key regions with large salinity gradients – Arabian Sea, Bay of Bengal and NW Africa; 2) a synthesis of available core-top, plankton tow and sediment trap Mg/Ca data from the low latitudes, harmonized for differences in species morphotype, size fraction and sample preparation; and 3) an evaluation of the potential contribution of secondary diagenetic (i.e., post-depositional) Mg to foraminifera in high salinity regions. These three research products will then be used to systematically evaluate the magnitude of the salinity influence relative to temperature and other known influences – such as seasonality and seafloor dissolution – on foraminiferal Mg, by elucidating individual mechanisms and through the use of multivariate techniques to assess their influence. The culminating component of the proposal is a community workshop to be held in the second year, with the goal of developing a community paper that can guide the Mg paleotemperature community forward on this challenging problem. The workshop will also facilitate data and knowledge sharing. Although this proposal addresses an established, widely used climate proxy, if successful it will be as transformative for the paleoceanographic community as the development of a completely novel proxy.

Broader Impacts: The proposed project broadens the participation of underrepresented groups by providing an opportunity for a young black faculty member at UCSB to pursue his first NSF-funded project. It integrates research and education … by promoting teaching, training, and learning by 1) pairing a senior and junior PI, with ample opportunity for sharing of experience and mentorship; and 2) by giving a post-doctoral scholar a central role in the project, which will enable him/her to broaden their skills by combining analytical work with database integration, analysis and interpretation. Furthermore, the proposed project will enhance … research networks, and partnerships by including a community workshop that will enable the paleoceanographic community to use the Mg/Ca proxy more effectively. The results of the project will be disseminated broadly to enhance scientific and technological understanding through publication in leading journals, development of a searchable online sediment trap and core-top Mg/Ca database, and archiving of data at NOAA's National Climatic Data Center. The potential benefits of the proposed activity to society at large include increased confidence in low latitude temperature reconstructions for the past; such reconstructions are an integral part of model assessments of past climate sensitivity.

Douglas Wilson **05/01/2016 – 12/31/2017** **$65,558**
US Geological Survey G16AC00094

Sythesis of Mendocino Ridge Regional Geologic Framework, Tectonic and Magmatic Processes and Margin Evolution in Support of Extended Continental Shelf Assessments

The objective is to document the 30 million year history and evolution of the Mendocino system (ie the part of Mendocino history of direct relevance to ECS issues of US margin prolongation and continuity), through integrated interpretation of newly collected multibeam data with marine magnetics, seismics, and kinematic modeling, and to draft results into a manuscript for peer-reviewed publication. This scientific synthesis paper will focus on the geological, geophysical, morphologic and tectonic evidence for Mendocino transform and fracture zone system history and its broad eastern Pacific context, suitable for use as a basis for geologic background for the US ECS Project's Pacific West Coast regional submission.

Marion Wittmann and Chris Jerde **12/02/2016 to 12/01/2017** **$16,000**
Santa Barbara Foundation SB170079

A Pilot Project to Demonstrate Best Water Management Practices for Sustainable Agriculture, Wildlife Conservation, and Regional Fire Security at UCSB's Sedgwick Reserve

This project will reconfigure the well water system at the Sedgwick Natural Reserve in order to concurrently 1) decrease water demand by improving water storage for enhanced agricultural irrigation and emergency firefighting purposes and 2) maintain habitat for water-dependent wildlife on the Reserve, including the California state threatened species: the Tri-Colored Blackbird and the Western Pond Turtle. Project results will be communicated online and distributed in hard-copy through a brief document intended to recommend on-farm water management practices and demonstrate the benefits gained through water conservation for agriculture, environmental sustainability and improved emergency firefighting support.

Hillary Young **5/1/2016 to 4/30/2019** **$127,567**
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 exclosure 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.

Hillary Young | **01/01/2017 to 12/31/2017** | **$7,519**
UC Davis | 201700177-01

Megafires and Ecological Networks

The funded postdoctoral student at UCSB will be supervised by Hillary Young and will work closely with both PI's at other institutions. The postdoctoral research will focus research efforts on developing foodweb and network models based on field data, and modeling stability, resilience and network properties in these networks.

The student will compare predictions from various model types and across burned and unburned sites and then synthesize findings regarding the effects of catastrophic megafire on these network responses.

Hillary Young | **10/20/2016 to 10/192017** | **$23,109**
National Geographic Society | 9829-15

Interacting Effects of Climate Change and Defaunation on Tick-borne Disease in East Africa

There is increasing consensus that both climate change and wildlife declines can have strong impacts on infectious disease risk with significant downstream effects on human health and well being. This project aims to understand how these two aspects of global change may interact to determine prevalence of tick-borne disease in East Africa in the future. Given that biotic interactions are well established to mediate or exacerbate the effects of climate change on many other ecosystem properties, it is important to consider these interactions in the context of disease impacts. We thus propose to utilize existing large-scale and long-term manipulations ("exclosures") of large mammal communities along a strong climate gradient in East Africa, in order to understand the interactive effects of large wildlife and climatic conditions on tick-borne disease prevalence. To understand the extent to which the addition of livestock in real-world landscapes may mediate the effects of the loss of large wildlife, we will also partner the experimental manipulations with additional surveys in the

surrounding landscapes where livestock replaces large wildlife. Cumulatively, this research will both inform our understanding of the extent to which biotic interactions mediate climate effects on disease transmission, and provide practical guidance on public health impacts of wildlife loss with and without livestock replacement.

Hillary Young, Kevin Lafferty **6/1/2015 to 5/31/2018** **$539,239**
National Science Foundation 1457371

Using Replicated Empirical Networks to Understand Drivers of Ecosystem Structure and Stability

Despite a long history of inquiry, we still lack a clear understanding of the drivers of community structure and the ways this structure affects ecosystem stability. In this project, we will examine how ecosystem size and productivity structure ecological networks. To do this, we will assemble and compare high-resolution interaction networks replicated across a series of 23 islets in the central Pacific (Palmyra Atoll) that vary independently in size and productivity. Our preliminary data suggest that these basic environmental properties drive strong variation in community structure across these islets. Next, we will predict how this variation in community structure should affect network stability, measured using multiple metrics of network stability. We will then test if models can predict system responses to a perturbation by comparing expected persistence to observed changes in empirical networks before and after system-wide rat *(Rattus rattus)* eradication. Finally, we will use path analyses to evaluate the relative importance of ecosystem size, productivity, and network structure, in predicting system stability. All together, these efforts will help identify not only how environmental characteristics structure communities but also the extent to which they drive system-level responses to perturbation.

Intellectual Merit: Ecological complexity makes it difficult to identify general patterns in nature, such as community stability. To understand what drives stability, one could measure changes in systems over time across environmental gradients. Another approach has been to consider how system structure (e.g., their complexity) affects community stability. However, it is unlikely that structure and environmental gradients are independent, because environmental factors might alter system structure as well as their stability. Here, we address how system size and productivity affect structure, how system size and productivity affect stability, and the extent that size and productivity drive stability through their effects on system structure Although these topics seem simple, they remain largely unanswered and it thus remains challenging to predict how removing a single species will affect an ecosystem due to the potential for indirect effects to cascade through complex ecological networks. This can be investigated in mesocosms and with dynamical and structural models, but there are few such studies from replicated natural systems, and none that measure more than a few interacting species. Likewise, although several studies assess and model food-web stability, there are no systematic empirical tests of these findings in natural settings. Systematic comparisons are also difficult because current published networks comprise different ecosystems collected by different authors with different methods, making it unclear whether the variation seen among networks is due to ecology or disparate methodologies. The methods we propose thus represent many conceptual advances. We will create the best-replicated, high-resolution ecological networks to date; these will range across relevant ecological gradients, but be within the same system and location; and they will be subject to an experimental perturbation so we can test model predictions and measure the extent to which productivity, system size, and system structure affect stability.

Broader Impacts: This project will train multiple graduate students, undergraduates, and a postdoctoral researcher, with a focus on underrepresented groups. Furthermore, through partnerships with the UCSB KIN program, we will also reach grade school children, and train elementary school teachers in ecology and invasive species. Because invasions and removals are important challenges for resource managers, we will also position our general results in an applied context. Specifically, our in-depth biological characterization will allow better management and restoration of an isolated and important National Wildlife Refuge. This work should also produce broad management insight on the importance of environmental characteristics on species removals and invasions, greatly improving our capacity to predict and prioritize conservation actions. We will also publish open-access publications and make presentations at national and international meetings on our research

results and data. By making our data freely available, we will also create opportunities for other researchers to repeat our analyses as well as ask novel questions.

Oran Young, Ben Halpern | **12/1/2015 to 8/31/2018** | **$235,562**
Tufts University | 101180-00001

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

Oran Young | **11/01/2016 to 10/31/2019** | **$16,026**
National Science Foundation | 1660916

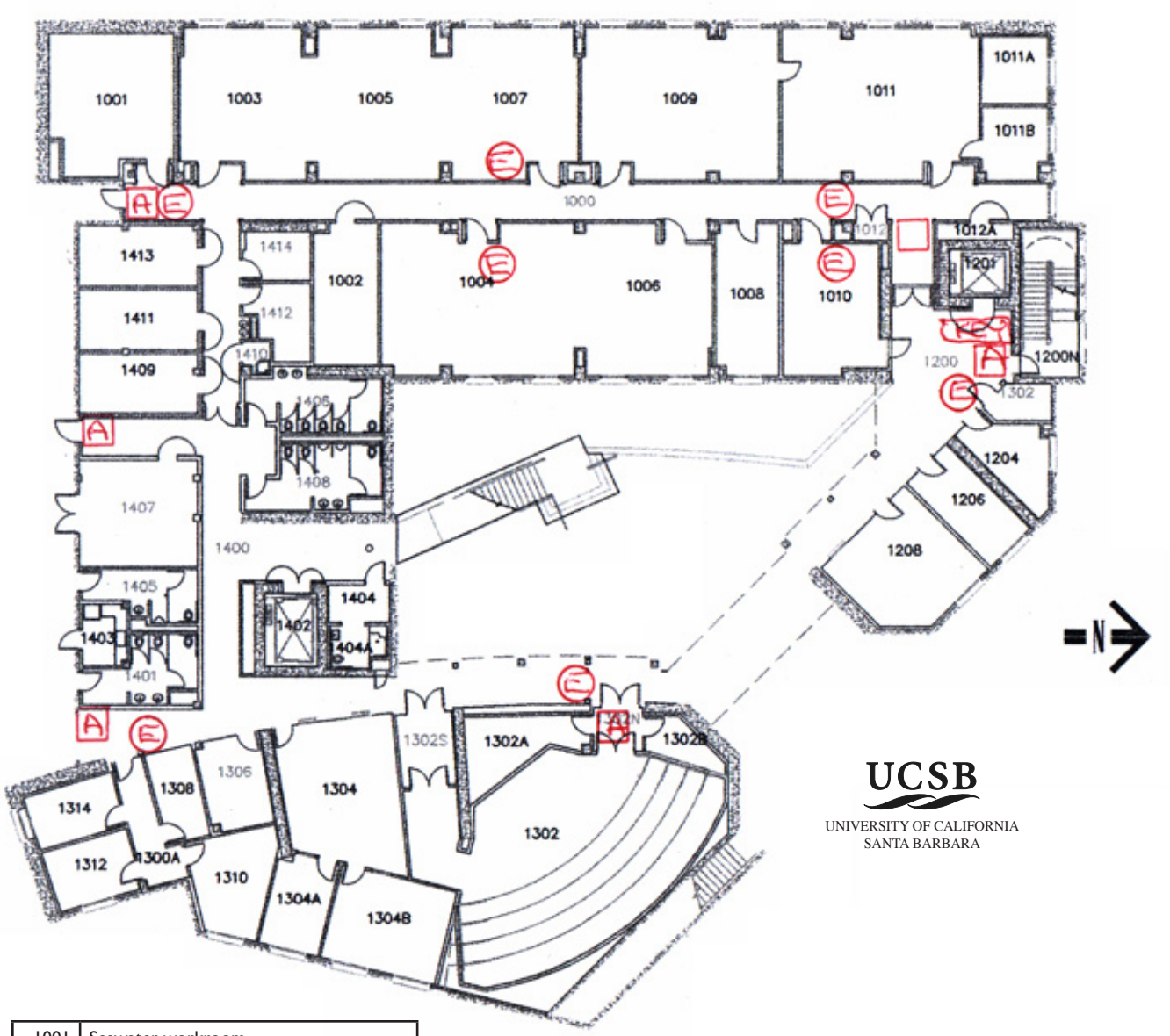
Collaborative Research: Belmont Forum: Pan-Arctic Options – Holistic Integration for Arctic Coastal-Marine Sustainability

The Arctic Ocean is experiencing an environmental state-change with expanding human activities ranging from commercial shipping and energy development to ship-based tourism. Accordingly, with involvement of indigenous peoples, Arctic and non-Arctic states have begun to develop national and international management regimes to address emerging issues, impacts and resources in the Arctic Ocean. In every case, there will be challenges to implement agreements in the face of political and financial constraints. "Pan-Arctic Options – Holistic Integration for Arctic Coastal-Marine Sustainability" is designed in an international, interdisciplinary and inclusive manner, involving cost-effective collaboration with currently funded projects to contribute to informed decision making by

policy makers from government to industry. The core team includes natural and social scientists from Canada, China, France, Norway, Russia, and the United States who will integrate document collections, geospatial data and stakeholder perspectives. This integrated decision-support tool will involve users in the co-design and co-production of options for both policy and built elements that are needed together for sustainable infrastructure development in the Arctic Ocean. A unique observational contribution from Pan-Arctic Options will be the analysis of Automatic Identification System (AIS) data of ship traffic across the Arctic Ocean collected from polar-orbiting satellites from 2009 forward. Results will be disseminated via journals (e.g. Science, Nature) and books as well as less-conventional methods involving facilitated dialogues in annual venues (e.g. Arctic Frontiers, Arctic Circle) and in the 2016 Arctic Expedition Summit involving the National Geographic Society and Google Ocean program Management of this holistic project will be in the hands of a Steering Committee and an international Advisory Board involving global thought leaders and organizations contributing to Arctic Ocean sustainability on a pan-Arctic scale.

SPACE

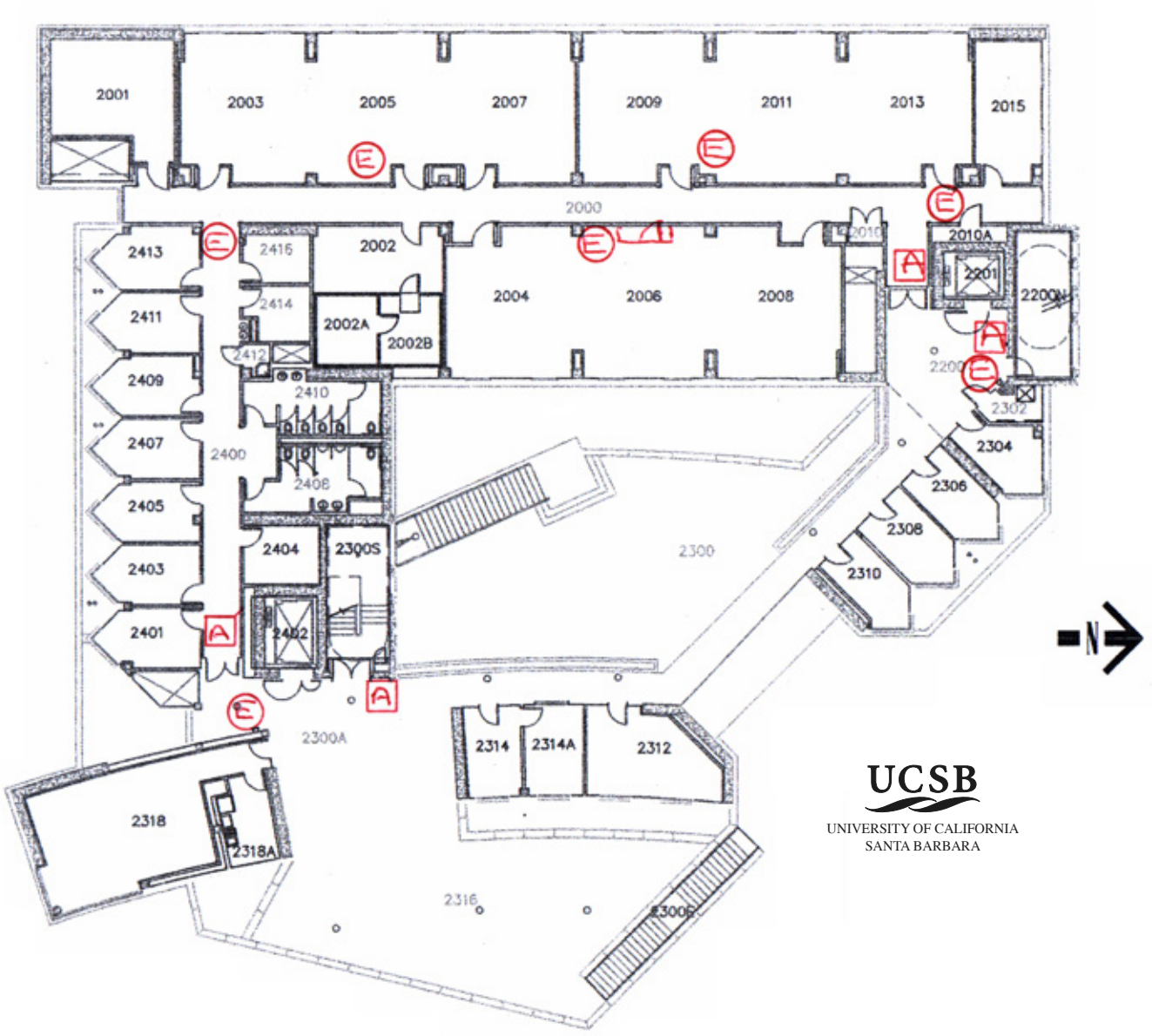
Marine Science Research Building
Bldg. No. 520 - 1st floor
06/2016



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

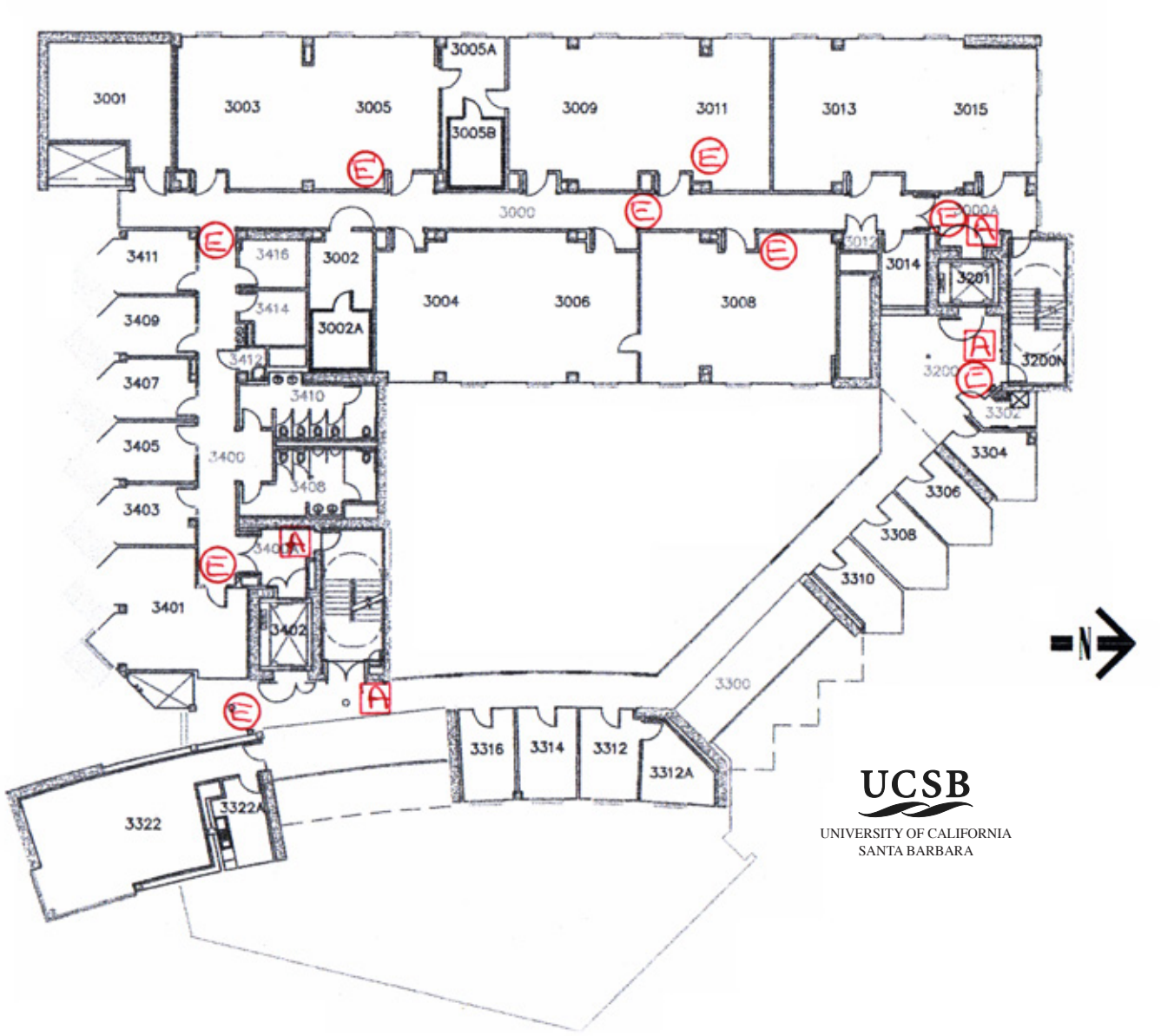


2001	Seawater workroom
2002	Common support laboratory
2002a	Environmental room
2002b	Environmental room
2003	Hofmann laboratory
2004	Miller laboratory
2005	Hofmann laboratory
2006	Miller laboratory
2007	Hofmann laboratory
2008	Shared laboratory
2009	Burkepile laboratory
2011	Burkepile laboratory
2013	Burkepile 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	Visiting Scholar
2407	Mark Torchin
2409	Wong/Kotal
2411	Gretchen Hofmann
2413	Chamorro/Leach

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 – Castorani
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	Chris Jerde
3411	Cody Szuwalski

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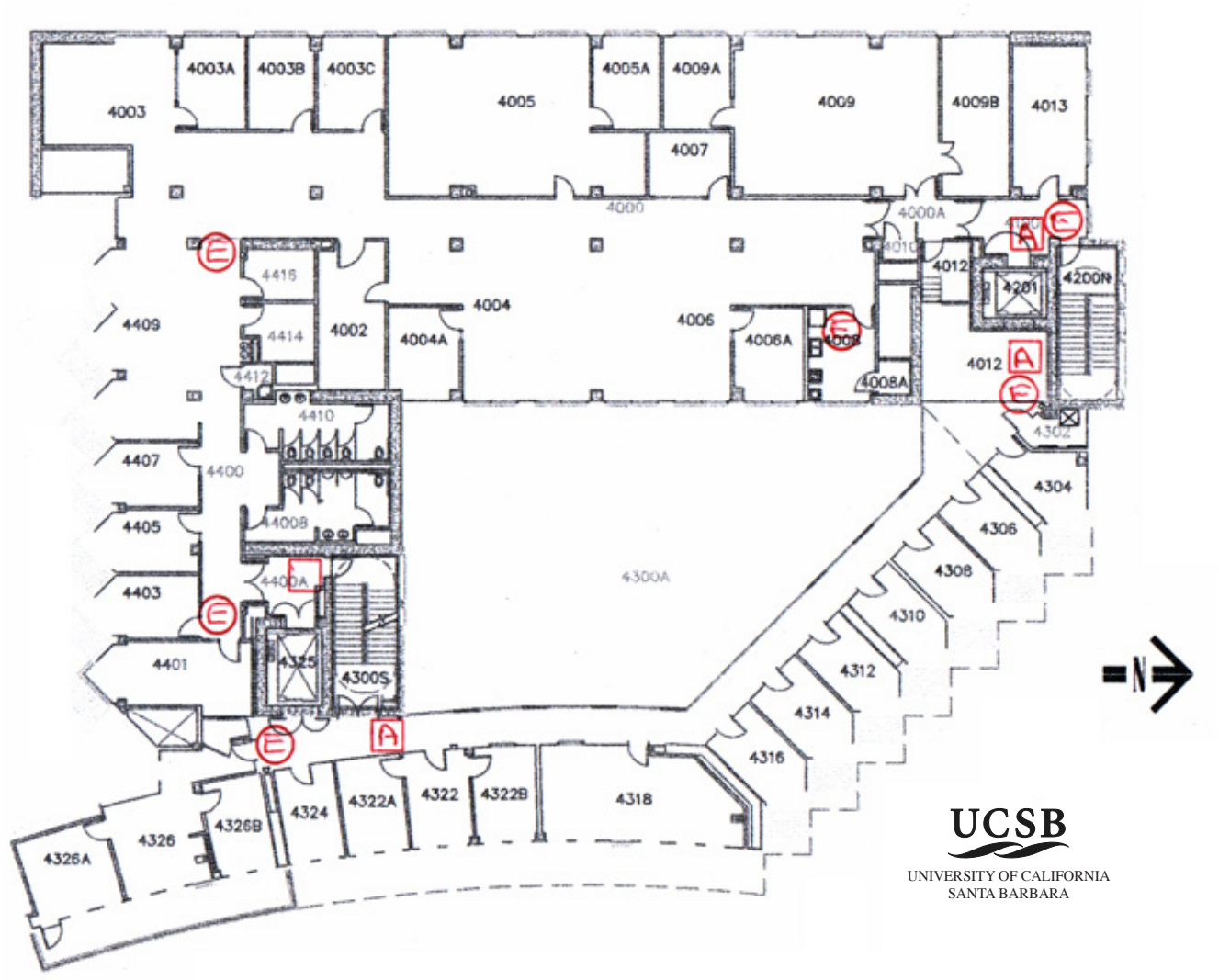
Bldg. No. 520 - 4th floor
06/2016



4002	Receiving
4003a	Ocean o'Graphics – Monica Pessino
4003b	NRS
4003c	NRS
4004a	File Room
4004c	
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	Matt Fratus
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	Jenn Caselle
319-b	Jenn Caselle
319-c	Jenn Caselle
319-d	Herb Waite
319-e	Herb Waite
325-a	John Richards
325-b	Craig Nicholson
325-c	Craig Nicholson
325-d	Scott Simon
325-e	Scott Simon
334-a	Scott Simon
334-b	REEF
334-c	REEF

STATISTICAL SUMMARY

Research Support Summary
2016-2017

	Awards	Percentage of Total
Federal Agencies		
National Aeronautics and Space Administration (NASA)	$729,336	4.12%
National Fish and Wildlife Service	$195,668	1.11%
National Science Foundation-NSF	$6,543,119	37.0%
National Institutes of Health (NIH) Dental	$342,267	1.94%
National Institutes of Health (NIH) General Medical	$455,508	2.58%
USDA, Forest Service	$242,003	1.37%
USDI Bureau of Ocean Energy Management	$455,000	2.57%
USDI Bureau of Safety and Environmental Enforcement	$499,949	2.83%
USDI Fish and Wildlife Service	$44,000	0.25%
USDI Geological Survey	$82,549	0.47%
USDI National Park Service	$272,158	1.54%
US Environmental Protection Agency	$222,972	1.26%
Federal Totals	**$10,084,529**	**57.04%**
State		
California Coastal Conservancy	$45,000	0.25%
California Department of Fish and Wildlife	$202,500	1.15%
Cal EPA Pesticide Regulation	$188,043	1.06%
Cal EPA Water Control Board	$200,000	1.13%
Santa Barbara County	$23,000	0.13%
Southern California Coastal Water Research Project	$44,557	0.25%
UC Agriculture and Natural Resources	$50,749	0.29%
UC Davis	$7,519	0.04%
UC Los Angeles	$126,000	0.71%
UC San Diego	$434,100	2.45%
UC Santa Cruz	$224,448	1.27%
UC Sea Grant College Program	$357,630	2.02%
State Totals	**$1,903,546**	**10.750%**

Private

Alfred P. Sloan Foundation	$ 16,531	0.09%
Amec (Great Britain)	$ 68,868	0.39%
Arizona State University	$69,626	0.39%
Bermuda Institute of Ocean Sciences	$234,000	1.32%
California Ocean Protection Council	$79,161	0.45%
California Sea Urchin Commission	$10,000	0.06%
California Trout, Inc.	$25,200	0.14%
David and Lucile Packard Foundation (The)	$730,000	4.13%
Great Lakes Fishery Commission	$13,236	0.07%
Marisla Foundation	$175,000	0.99%
National Academies Keck Futures	$75,000	0.42%
National Geographic Society	$223,917	1.27%
Nature Conservancy (The)	$739,966	4.18%
Oakland Zoo	$10,815	0.06%
Occidental College	$12,741	0.07%
Ocean Conservancy	$10,000	0.06%
Oregon State University	$70,606	0.40%
Rare. Inspiring Conservation	$100,000	0.57%
San Francisco Zoo	$17,850	0.10%
Santa Barbara Foundation	$16,000	0.09%
Simons Foundation	$996,556	5.64%
Texas A&M University	$162,988	0.92%
Tufts University	$220,067	1.24%
University of Exeter	$370,840	2.10%
University of Georgia	$314,243	1.78%
University of Hawaii	$51,089	0.29%
University of Miami	$147,074	0.83%
University of Pittsburgh	$17,251	0.10%
University of Southern California	$118,568	0.67%
University of Wisconsin	$98,223	0.56%
Waitt Family Foundation	$500,000	2.83%
Private Totals	**$5,695,416**	**32.21%**
Total	**$21,780,363**	**100.00%**

Statistical Summary for the Marine Science Institute 2016-2017

	MSI	NRS	TOTAL
1. Academic personnel on payroll			
Faculty	28	2	30
Professional Researchers (including Visiting)	27	0	27
Project Scientists	9	0	9
Specialists	47	1	48
Postdoctoral Scholars	37	0	37
Postgraduate Researchers	0	0	0
Academic Coordinators	1	0	1
TOTAL	149	3	152

2. Graduate Students on payroll			
Employed on contracts and grants	64	0	64
Employed on other sources of funds	0	0	0
Participating through assistantships	0	0	0
Participating through traineeships	0	0	0
Other- students at other campuses	3	0	3
TOTAL	**67**	**0**	**67**

3. Undergraduate Students on payroll			
Employed on contracts and grants	117	10	127
Employed on other funds	0	0	0
Number of volunteers, & unpaid interns	0	0	0
TOTAL	117	10	127

4. Participation from outside UCSB: (optional)			
Academics (without Salary Academic Visitors)	0	0	0
Other (specify)	1	0	0
TOTAL	1	0	0

5. Staff (Univ. & Non-Univ. Funds):			
Technical	115	28	143
Administrative/Clerical	17	15	32
TOTAL	**132**	**43**	**175**

6. Seminars, symposia, workshops sponsored			0
7. Proposals submitted	192	-	192
8. Number of different awarding agencies dealt with*	124	-	124
9. Number of extramural awards administered	249	-	249
10. Dollar value of extramural awards administered during year**	$82,475,035	-	$82,475,035
11. Number of Principal Investigators***	115	-	115
12. Dollar value of other project awards ****	$3,325,781	$3,098,146	$6,423,928
13. Number of other projects administered	78	40	118
14. Total base budget for the year (as of June 30, 2017)	$1,981,138	$868,685	$2,849,823
15. Dollar value of intramural support	$140,830	$53,206	$194,037
16. Total assigned square footage in ORU	38,807	-	38,807
17. Dollar value of awards for year (2017 Total)	$17,781,660	-	$17,781,660

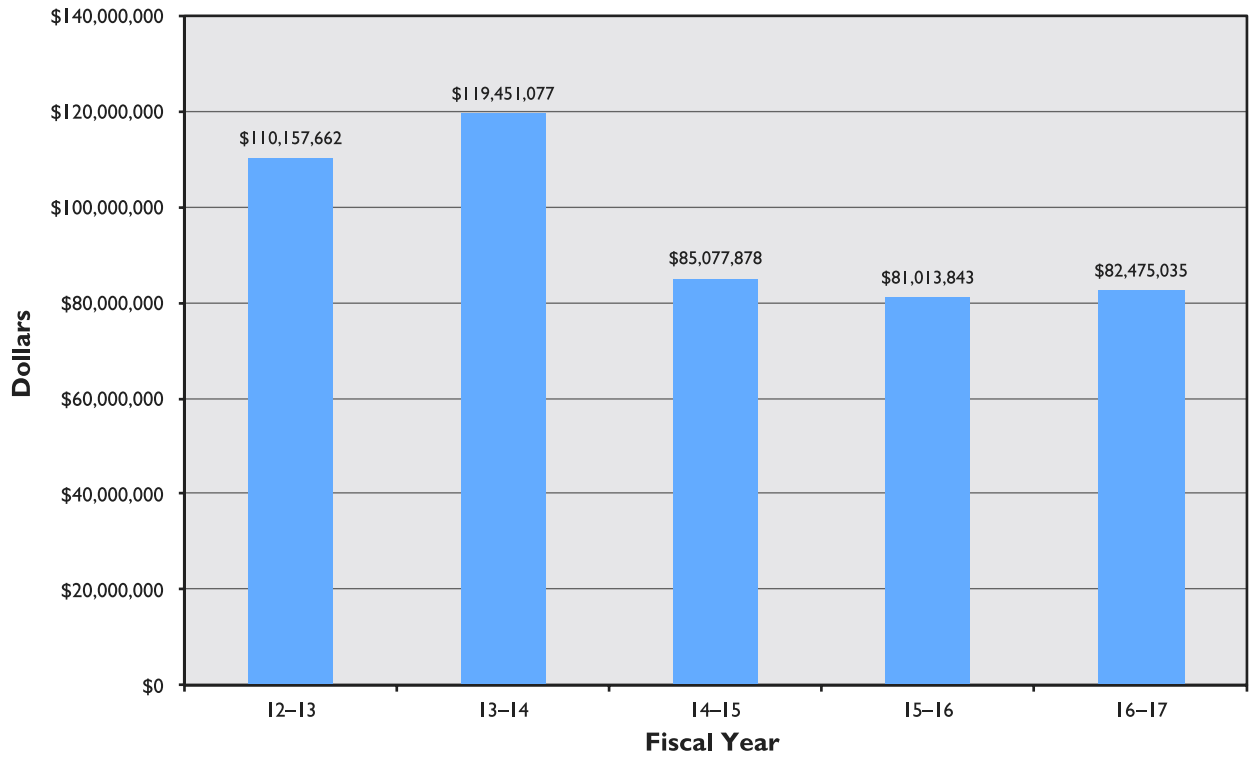
* Count each agency only once (include agencies to which proposals have been submitted).
** If the award was open during the year, even if for only one month, please include in total.
*** Number of PIs, Co-PIs and Proposed PIs (count each person only once.)
**** Other projects - such as donation, presidential awards, fellowships, anything that isn't core budget, extramural, or intramural.

Five-Year Statistical Summary 2012-2017

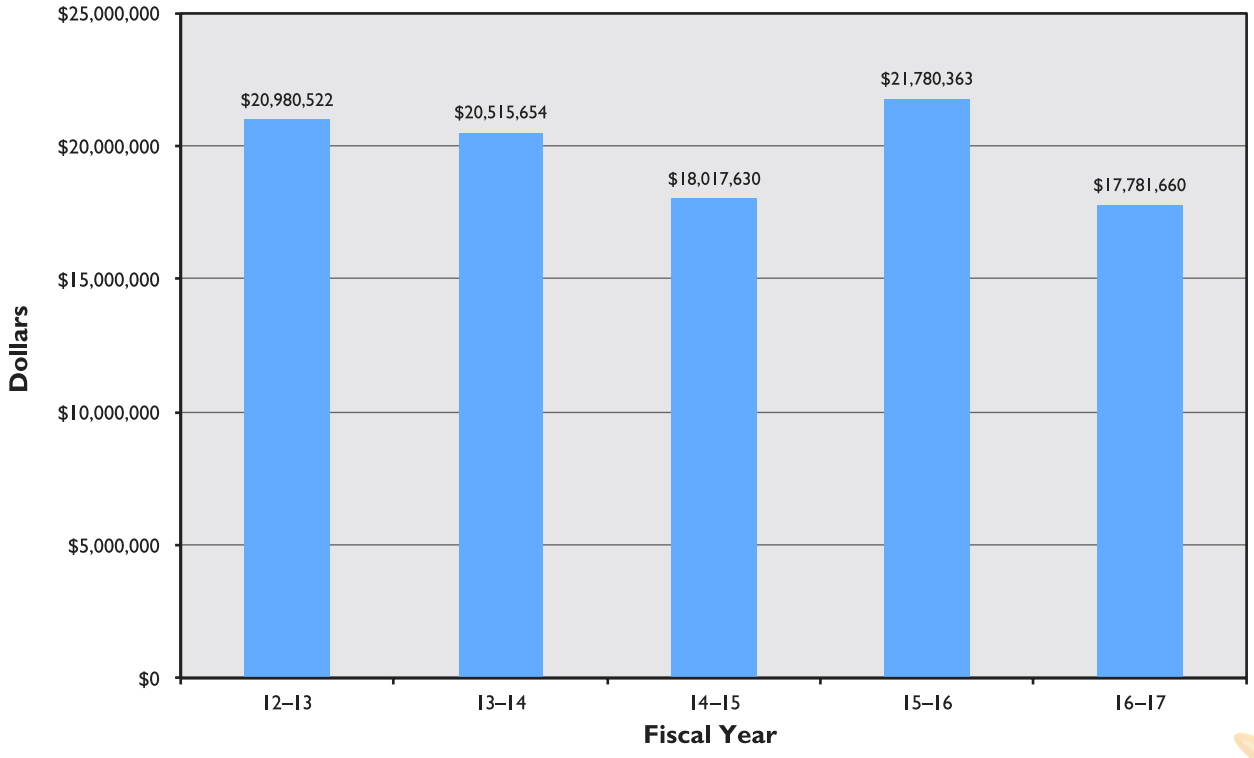
	2012-13	2013-14	2014-15	2015-16	2016-17
1. Academic personnel engaged in research					
a. Faculty	19	18	27	25	30
b. Researchers/ Project Scientists	58	58	32	40	36
c. Visiting Researchers					
d. Specialists/ Academic Coord/ Academic Admin.	46	40	40	42	49
e. Postdoctorals/ Postgraduates	37	36	28	36	37
Total	**160**	**148**	**127**	**143**	**152**
2. Staff (Univ. & Non-Univ. Funds)					
a. Technical	175	167	125	158	143
b. Administrative/Clerical	58	46	36	37	32
Total	**233**	**213**	**161**	**195**	**175**
3 Graduate students employed by MSI	54	47	51	63	67
4. Undergraduate students employed by MSI	146	140	122	153	127
5. Publications	1**	1**	1**	1**	1**
6. Seminars, symposia, workshops, etc., sponsored by MSI					
7. Proposals submitted	142	159	161	156	192
8. Annual extramural awards	$20,980,522	$20,515,654	$18,017,630	$21,780,363	$17,781,660
9. Extramural awards administered	247	262	231	247	249
10. Other project awards	$4,042,529	$3,953,513	$2,574,097	$4,524,827	$6,423,928
11. Other projects administered	80	34	93	111	118
12. MSI base budget	$919,082	$1,406,831	$1,643,266	$2,327,940	$2,849,823
13. Intramural support	$726,518	$88,978	$87,525	$124,543	$194,037
14. Total Funds Administered	**$117,642,277**	**$126,564,018**	**$90,505,464**	**$87,991,153**	**$82,475,035**

**Only Departmental Publications

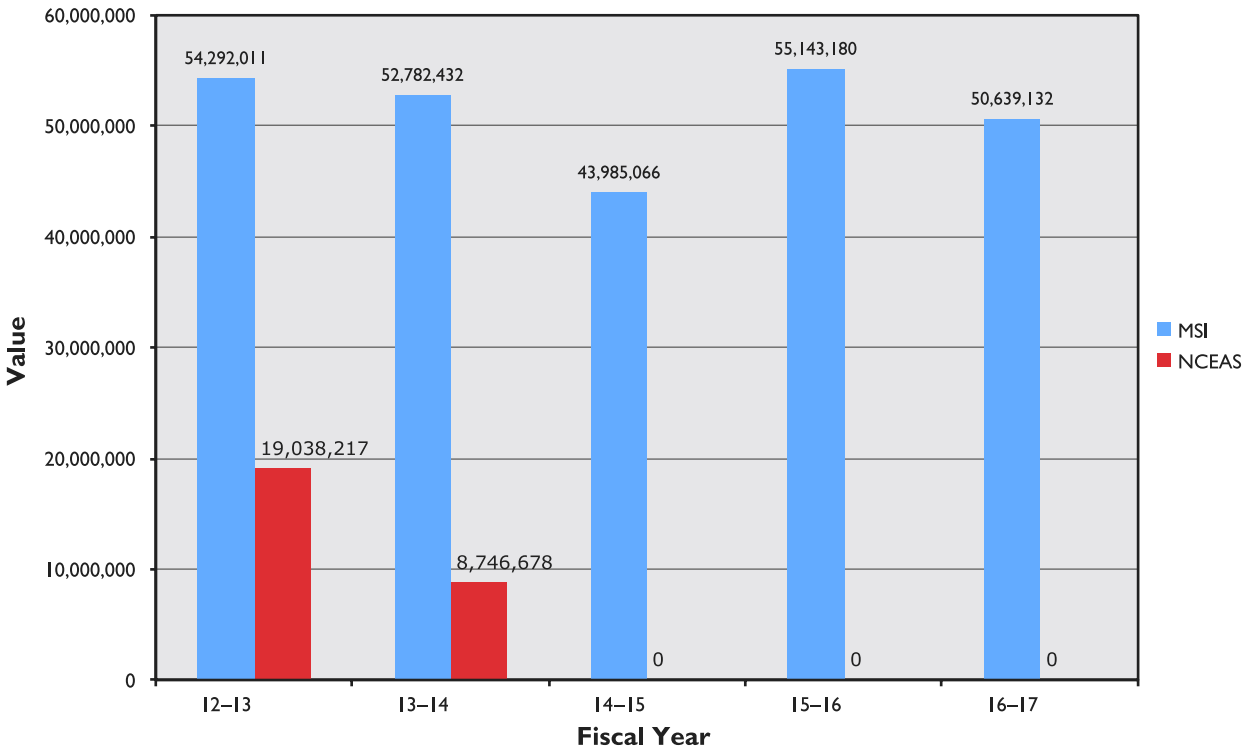
Marine Science Institute – Total Value of Awards Administered



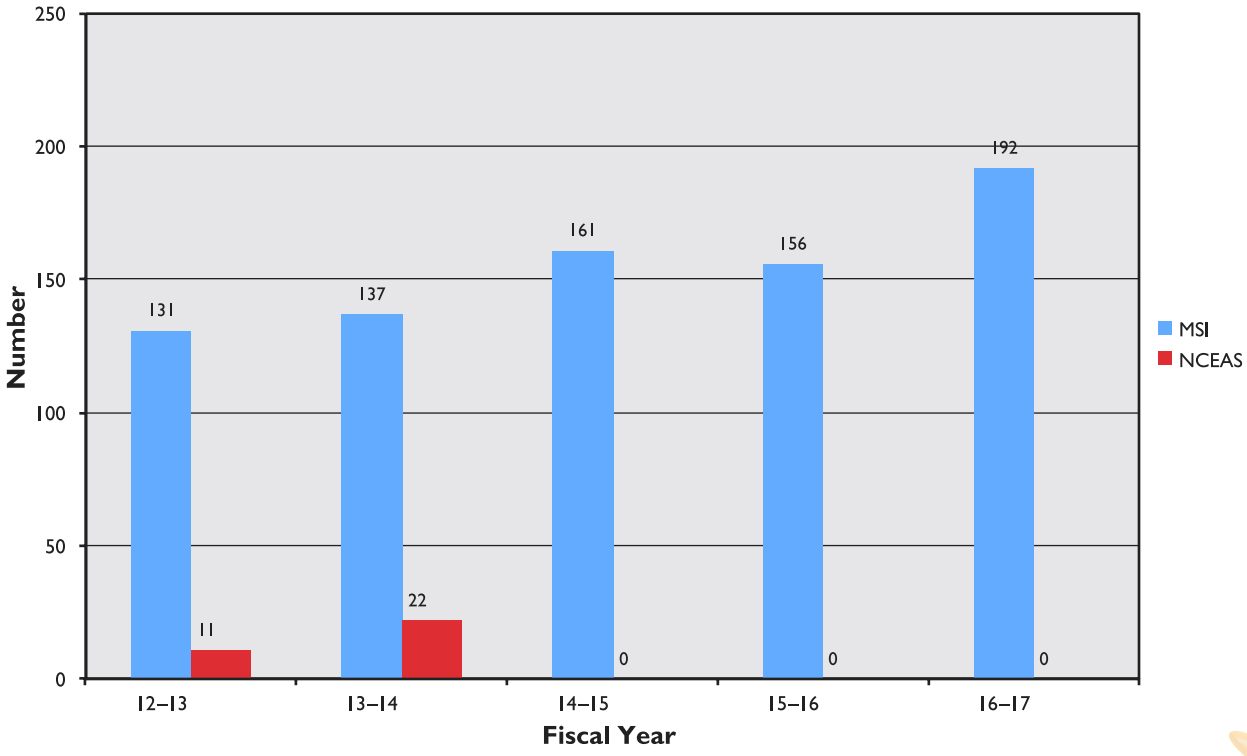
Marine Science Institute – Value of Extramural Awards Received Annually



Value of Proposals Submitted Annually by MSI & NCEAS



Number of Proposals Submitted Annually by MSI & NCEAS



Funding Agencies 2016-2017

Alfred P. Sloan Foundation

AMEC (Great Britain)

An Uncommon Legacy Foundation

Arizona State University

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, Pajaro

Cal EPA Pesticide Regulation

California Institute of Technology (CalTech)

California Ocean Protection Council

California Ocean Science Trust (CALOST)

Cal Poly University, San Luis Obispo

California Sea Urchin Commission

California Trout, Inc.

California Wildlife Conservation Board

Coastal Fund (UCSB Assoc. Students)

COM National Marine Fisheries

County of Santa Barbara

David and Lucile Packard Foundation (The)

Department of Defense and Engineering

Desert Botanical Garden

Duke University

Eppley Foundation for Research, Inc. (The)

ExxonMobil Upstream Research Company

Foundation for Food and Agriculture Research

Great Lakes Fishery Commission

Marine Fisheries Service

Marisla Foundation

National Academies Keck Futures Initiative

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

NIH Center for Scientific Review

National Science Foundation-NSF

Nature Conservancy, The

North Pacific Research Board

Oakland Zoo

Occidental College

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 Zoo

San Jose State University

Santa Barbara Foundation

Simons Foundation

Simpson and Simpson Business and Personnel Services, Inc.

Society for Conservation Biology

Southern California Coastal Water Research Project (SCCWRP)

Texas A&M University

The Belmont Forum Secretariat

Tufts University

UC Agriculture and Natural Resources

UC Berkeley

UC Davis

UC Los Angeles

UC Merced

UC MEXUS

UC Riverside

UC San Diego

UC Santa Cruz

UC Sea Grant College Program

University of Arizona

University of Exeter

University of Georgia

University of Hawaii

University of Miami

University of Michigan

University of Minnesota

University of Nevada

University of Pittsburgh

University of Rhode Island

University of Southern California

University of Tennessee

University of Washington

University of Wisconsin

USDA Forest Service

USDA National Institute for Food and Agriculture

US Dept of Commerce, National Oceanic and Atmospheric Administration

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

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
2016-2017

Chancellor	Henry T. Yang
Executive Vice Chancellor	David Marshall
Vice Chancellor For Research	Joe Incandela
Director	Mark A. Brzezinski
Deputy Director	Dan Reed

Advisory Committee

Francesco Bullo, ME
Deron Burkepile, EEMB
Jenny Dugan, MSI
Kathy Foltz, MCDB
Ben Halpern, Bren
Sally Holbrook, EEMB
Debora Iglesias-Rodriguez, EEMB
Bob Miller, MSI
David Siegel, Geography
David Valentine, Committee Chair, Earth Science
Hillary Young, EEMB

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

Graphic Designer, Christina Rivera

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

Travel Coordinator, Donna Dobis

MARINE SCIENCE INSTITUTE PRINCIPAL INVESTIGATORS 2016-2017

Marine Science Institute
Principal Investigators
2016-2017

Adam, Thomas	Assistant Researcher	Marine Science Institute
Ahn, Byung-Jun Kollbe	Assistant Researcher	Marine Science Institute
Alagona, Peter	Associate Professor	History/Environmental Studies
Blanchette, Carol	Associate Researcher	Marine Science Institute
Briggs, Cheryl	Professor	Ecology, Evolution & Marine Biology
Brooks, Andy	Project Scientist	Marine Science Institute
Brown, Kevin	Postdoctoral Researcher	Marine Science Institute
Brzezinski, Mark	Professor	Ecology, Evolution & Marine Biology
Bull, Ann	Visiting Researcher	Marine Science Institute
Burgess, Matthew	Postdoctoral Researcher	Marine Science Institute
Burkepile, Deron	Associate Professor	Ecology, Evolution & Marine Biology
Cabral, Reniel	Postdoctoral Researcher	Marine Science Institute
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
Dudley, Tom	Associate Researcher	Marine Science Institute
Dugan, Jenifer	Associate Researcher	Marine Science Institute
Eliason, Erika	Assistant Professor	Ecology, Evolution, and Marine Biology

Ellis, Emily	Graduate Student	Ecology, Evolution & Marine Biology
Emery, Brian	Computer Network Tech.	Marine Science Institute
Gaines, Steven	Dean, Bren School, Professor	Bren School of Envir. Sci. & Management
Fieldstone-Burgess, Alexa	Graduate Student	Environmental Studies
Florsheim, Joan	Researcher	Earth Research Institute
Foltz, Kathleen	Associate Professor	Molecular, Cellular, and Developmental Biology
Forbes, Elizabeth	Graduate Student	Ecology, Evolution & Marine Biology
Francis, Simone	Associate Specialist	Marine Science Institute
Halpern, Benjamin	Professor	Bren School of Envir. Sci. & Management
Halpin, Patricia	Assistant Researcher	Marine Science Institute
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
Hopkins, Skylar	Postdoctoral Researcher	NCEAS
Iglesias-Rodriguez, Maria	Professor	Ecology, Evolution & Marine Biology
Israelachvili, Jacob	Professor	Chemical Engineering
Jerde, Chris	Assistant Researcher	Marine Science Institute
Kapsenberg, Lydia	Graduate Student Researcher	Ecology, Evolution & Marine Biology
Kennett, James	Emeritus Research Professor	Earth Sciences
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
Lea, David	Professor	Earth Sciences
Lenihan, Hunter	Professor	Bren School of Envir. Sci. & Management
Lester, Sarah	Associate Project Scientist	Marine Science Institute
Libecap, Gary	Professor	Bren School of Envir. Sci & Management
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
MacIntyre, Sally	Professor	Ecology, Evolution & Marine Biology
Mazer, Susan	Professor	Ecology, Evolution & Marine Biology
McCauley, Douglas	Assistant Professor	Ecology, Evolution & Marine Biology
McClintock, William	Project Scientist	Marine Science Institute
Means, Jay	Professor	Bren School of Envir. Sci. & Management
Melack, John	Professor of Biology	Ecology, Evolution & Marine Biology
Miller, Karly	Graduate Student	Ecoloby, Evolution & Marine Biology
Miller, Robert	Associate Researcher	Marine Science Institute
Millet, Nicole	Postdoctoral Researcher	Marine Science Institute
Moeller, Holly	Assistant Professor	Ecology, Evolution & Marine Biology
Morse, Marisa	Graduate Student	Ecology, Evolution & Marine Biology
Muller, Erik	Associate Researcher	Marine Science Institute
Mychajliw, Akexis	Postdoctoral Researcher	Marine Science Institute
Myers, Monique	Associate Researcher	Marine Science Institute
Nguyen, Alice	Academic Coordinator	Ecology, Evolution & Marine Biology

Nicholson, Craig	Researcher	Marine Science Institute
Nidzieko, Nicholas	Assistant Professor	Geography
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
Ovando, Daniel	Graduate Student Researcher	Bren School of Envir. Sci. & Management
Page, Henry Mark	Researcher	Marine Science Institute
Passow, Uta	Researcher	Marine Science Institute
Paul, Blair	Postdoctoral Researcher	Earth Science
Peng, Xuefeng	Postdoctoral Researcher	Earth Science
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
Roberts, Dar	Professor	Geography
Ross, Robin	Emeritus Researcher	Marine Science Institute
Sandoval, Cristina	Reserve Director	Marine Science Institute
Santoro, Alyson	Assistant Professor	Ecology, Evolution & Marine Biology
Schmitt, Russell	Professor	Ecology, Evolution & Marine Biology
Schroeter, Stephen	Researcher	Marine Science Institute
Seltmann, Katja	Associate Researcher	Earth Research Institute

Shahandeh, Michael	Graduate Student	Ecology, Evolution & Marine Biology
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
Stears, Keenan	Assistant Project Scientist	Ecology, Evolution & Marine Biology
Stier, Adrian	Assistant Professor	Ecology, Evolution & Marine Biology
Swafford, Andrew	Graduate Student	Ecology, Evolution & Marine Biology
Swarbrick, Susan	Associate Director, NRS	Marine Science Institute
Szuwalksi, Cody	Assistant Researcher	Marine Science Institute
Tarn, Jonathan	Graduate Student	Ecology, Evolution & Marine Biology
Titcomb, Georgia	Graduate Student	Ecology, Evolution & Marine Biology
Torcin, Mark	Researcher	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
Weinstein, Sara	Graduate Student	Ecology, Evolution & Marine Biology
Weldaeb, Syee	Associate Professor	Earth Sciences
Wilson, Douglas	Research Geologist	Earth Sciences
Wittmann, Marion	Executive Director	Natural Reserve System
Young, Hillary	Assistant Professor	Ecology, Evolution & Marine Biology
Young, Oran	Emeritus Research Professor	Bren School of Envir. Sci. & Management