2018–2019 ANNUAL REPORT

Marine Science Institute

UC SANTA BARBARA

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Mission Statement

The Marine Science Institute at the University of California, Santa Barbara, is committed to fostering innovative and significant research, to promoting effective stewardship, and to sharing exciting discoveries of the world's oceans.

From the Director

Overview

The Marine Science Institute (MSI) provides an intellectual and physical environment at UCSB that fosters world-renowned marine research. The institute brings together marine researchers from across the UCSB campus and supports multi-investigator collaborative projects and individual research efforts. The scientific membership at MSI consists of both ladder faculty and professional researchers. In 2018-2019 MSI membership included 25 ladder faculty and 32 professional researchers with 228 additional participants distributed across postdoctoral scholars, graduate students and undergraduates. Beyond research, MSI's Research Experience and Education Facility (REEF) educates UCSB students and the general public about MSI science.

MSI is housed in the marine science research building (MSRB) on the UCSB campus. The MSRB contains both MSI support services and research laboratories. Support services include the MSI administrative staff that support pre- and post- award activities, the MSI analytical facility that provides expertise in the chemical analysis of environmental samples from the marine environment, and the MSI information technology group support scientific computing. Research space is allocated to individual ladder faculty and professional researchers and to collaborative research groups. MSI professional researchers are also housed within departmental spaces, at Devereux and off campus lease space. MSI educational and outreach facilities are located at campus point.

The MSRB is also one of the few research buildings at UCSB plumbed into the campus seawater system. Researchers have access to over 1,600 ft^2 of seawater workroom space distributed across six seawater laboratories. An additional three walk-in environmental chambers provide access to temperature controlled conditions simulating environments from the tropics to the poles. Other common spaces provide access to common use scientific equipment including autoclaves, freeze dryers, centrifuges and refrigerator/freezer space. These common-use facilities serve the needs of individual research projects and collaborative efforts on an as needed basis.

MSI has a reputation of providing strong pre- and post- award administrative support to its investigators. In 2018/2019 MSI submitted 158 proposals and managed 331 projects. Post award activities include accounting, personnel management, procurement and travel. Beyond pre- and post-award activities MSI staff are also responsible for MSRB management and maintenance, management and maintenance of common use scientific equipment, laboratory safety compliance, seawater system maintenance, room scheduling, and they serve as the interface between the Channel Island Marine Sanctuary offices and campus facilities and management offices. The MSI administrative staff are recognized as highly innovative with a history of bringing new systems to campus (GUS, Cayuse, Coupa, IT works) that increase efficiencies quickly and at modest cost. MSI staff are often called upon to serve on campus committees seeking to improve campus-wide management systems.

The MSI analytical laboratory provides investigators with analytical services for environmental samples from the marine environment. The purpose of the facility is to provide investigators access to instrumentation and analyses that would be too costly or too inefficient for individual PIs to maintain. The laboratory also serves a strong educational function supporting research by graduate students and postdoctoral scholars and laboratory staff assist undergraduates conducting honors research and independent study projects. The laboratory routinely employs undergraduates to assist in sample preparation and in routine analyses providing vital real-world work experience. Moreover, laboratory

personnel guide investigators in the development of new analytical methods to catalyze new avenues of research and to support new extramural proposals. The laboratory supports many large research programs including the SBC and MCR LTERs, the SONGS project, the MBON program and the NASA EXPORTS project.

The MSI Information technology group maintains the computational and data storage infrastructure supporting both individual and group science. The IT group also supports the computational needs of the MSI administrative unit and supports the audio-visual equipment throughout the MSRB. Currently about 50 servers (both virtual and physical) are running in support of the unit. They provide file sharing, web and web application hosting, database hosting, network monitoring, and compute nodes. Shared data are stored in a departmental SAN (Storage Area Network) system hosting 60 TB of data along with another 30TB of backups. End user support covers over 350 individual clients.

MSI's Educational and Outreach Program brings our discoveries to K-12 students, the general public and to UCSB students. A recent goal has been to engage more UCSB undergraduates. These efforts have been wildly successful. The REEF now serves nearly 4,000 UCSB undergraduates in activities ranging from laboratory classes to research training and other activities spanning six campus administrative divisions. This newfound success at the campus level is complimented by a very successful outreach program to the general public and K-12 schools. This past year the REEF served a record high number of visitors reaching nearly 20,000 members of our community.

Like all organized research units MSI is led by the director who is advised by the business services officer and a deputy director. The MSI Advisory Committee, consisting of faculty and researchers from each of the participating campus departments and professional schools, serves an oversight role and reports on MSI needs and activities to the vice chancellor for research. Local governance is handled by the MSI resources committee that reviews requests for office and laboratory space with the MSRB and makes recommendation to the director. The MSI computing committee assesses the computer infrastructure necessary to support MSI research and makes policy and purchase recommendations to the director.

Executive Summary

Accomplishments:

MSI has had another highly successful year of scientific discovery with the institute PI's conducted nearly 331 research projects ranging from efforts to develop new policies for ocean management to developing new isotopic tools to understand ocean biogeochemistry. Here are some highlights, but remember this is only the tip of the iceberg relative to MSI's research activity.

Before diving into MSI research I'd like to acknowledge the service of MSI's Management Service Officer, Tim Schmidt. Tim Schmidt retired in June, 2019 after 28 years at UCSB with his last 14 years spent as MSI's MSO. MSI has grown considerably over the past 14 years and through it all Tim kept the organization running smoothly through both the easy and the tough times. Tim was a campus leader in administrative innovation putting in place efficient, cost effective, electronic purchasing and accounting systems at MSI long before campus moved in those directions. He created a culture of professionalism and teamwork at MSI that pervades the organization today. His career contributions to MSI and campus as a whole have been substantial. He will be greatly missed. All of us at MSI thank Tim for his many years of selfless service and wish him the best as he moves on to enjoy his life with his family in retirement.

Now onto a few research highlights. Assistant Professor Holly Moeller is examining how mixotrophic plankton that both photosynthesize and consume prey respond the changes in ocean conditions anticipated with climate change. Ecological theory predicts that these organisms will evolve to become more animal like, foregoing their ability to photosynthesize. Long-term (years) studies are underway to monitor how these organisms both evolve and adapt under stimulated future ocean conditions.

Associate Professor Nicholas Nidzieko is using autonomous ocean robots to investigate turbulent kinetic energy beneath breaking ocean waves. These processes help drive the transport of nutrients, sediments, plankton, larvae, and pollutants in the coastal ocean yet few measurements of these processes are available due to the difficulty working in this narrow and energetic environment. Nidzieko and his team are overcoming this challenge through the use of autonomous underwater vehicles equipped with microstructure probes and fast velocimeters and seek one of the most complete descriptions of the turbulent kinetic energy budget of the surface ocean.

Associate Professor Douglas McCauley continues to lead the Benioff Ocean Initiative (BOI). The BOI seeks to understand how science can both inform and solve problems affecting our oceans. This year the initiative launched a new large initiative focused on ocean plastics. This particular effort seeks to design and deploy a pilot intervention strategy that both physically captures plastic waste in rivers before it reaches the ocean, and catalyzes policy-based, infrastructural, and/or societal change to reduce plastic waste inputs rivers.

Most people familiar with MSI know that the institute is the intellectual home of two of the nation's long-term ecological research programs: The Santa Barbara Coastal (SBC) LTER, led by Researcher Dan Reed, that focuses on kelp forest dynamics and the Moorea Coral Reef (MCR) LTER, led by Professor Russel Schmitt, that studies the coral ecosystems of French Polynesia. These programs are designed to test ecological theory on timescales not approachable in short-term studies and

to evaluate how ecological communities respond to climate perturbations. These two studies bring together over 100 investigators from UCSB and elsewhere in a highly interdisciplinary effort to advance our understanding of these ecosystems. These programs periodically undergo leadership transitions and Researcher Bob Miller will be assuming the role of lead principle investigator of SBC and Professor Deron Berkepile will be taking the reins for MCR. We salute Dan Reed (SBC) and Russel Schmitt (MCR) who each served for many years as the original leaders for these two highly successful programs.

Researcher Bob Miller led a team of ecologists, oceanographers, engineers and geneticists in a successful renewal of the NASA/BOEM//NOAA-sponsored marine biodiversity observation network (MBON) project. This effort seeks to develop effective means of assessing marine biodiversity at all levels within an ecosystem from the smallest microbes to large whales. The research team is developing the technology needed to survey and quantify marine biological diversity in an efficient cost-effective manner. In the original first five years, this project involved development of image analysis systems, genetic tools and spatial models to assess both abundant and cryptic species in the Santa Barbara Channel. The renewed project will take what was learned in phase one and expand to the entire Southern California Bight.

Researcher Jenn Caselle is running four new projects that focus on the evaluation and assessment of the State of California's network of Marine Protected Areas. These projects involve collaborators across the state and together will form the basis for a management review of the MPA network in 2022. Caselle's teams will be using SCUBA surveys of kelp forests, Baited Remote Underwater Stereo-Video systems (BRUVs) to monitor deepwater rock reefs, intertidal rocky reef surveys and a citizen science project utilizing sport fishermen and hook and line surveys. Caselle and her lab are working closely with the California Department of Fish and Wildlife and the CA Ocean Protection Council to create the review process and to inform stakeholders, managers and policy makers about Marine Protected Areas.

Another young investigator, Researcher Adam Lambert, continues his work to investigate invasive species dynamics and restoration strategies in the Santa Clara River ecosystem. This project will restore between 150 and 170 acres of riparian habitat by removing 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. This is not only an example of solution science, but it illustrates the broad range of science conducted at MSI that extends from the ocean into freshwater ecosystems.

5-Year Plan

Looking to the future MSI has the following goals for the next 5 years which largely reflect our goals from last year.

Over the past few years MSI's has broadened its REEF programs to serve an increasing number of UCSB undergraduates that participate in its programs. We have partnered with six campus divisions ranging from Academic Affairs to Student Affairs and Administrative Services to engage undergraduates at multiple levels. These efforts have been highly successful with nearly 4,000 undergraduates now benefitting from our programs each year beyond the record number, 18,000, public visitors. This level of activity is coordinated by a single staff member with the assistance from undergraduate student docents. The REEF used to have a full time coordinator that was let

go for lack of funding. With this new level of activity we will be seeking mechanisms to restore the coordinator position.

A continuing goal is to capitalize on the untapped research potential of its investigators by creating a fund to catalyze new research endeavors that will provide seed money for turning new ideas into proposals. The goal is to fund collaborative groups to sponsor workshops, meetings with program managers and other activities that will position MSI researchers for success on new innovative projects.

MSI is also focused on support for our professional researchers who rely on grants for 100% of their salaries. Professional researchers account for over half of MSI's grant and research activity. MSI continues to work with OR on finding ways of support this group. Beyond support for all researcher there is a subset of professional researchers that merit special attention. Professional researchers at MSI lead the largest of our collaborative group projects including the SBC LTER, the MBON and the SONGS project. These group projects are often leveraged by other investigators to bring in significant research funding beyond the original project. Leading one of these project demands considerable time and effort which is often not covered by the project budget. A system that rewards Researchers for taking on these leadership roles will help ensure that MSI can continue to organize the teams necessary to compete for, manage and renew these large programs.

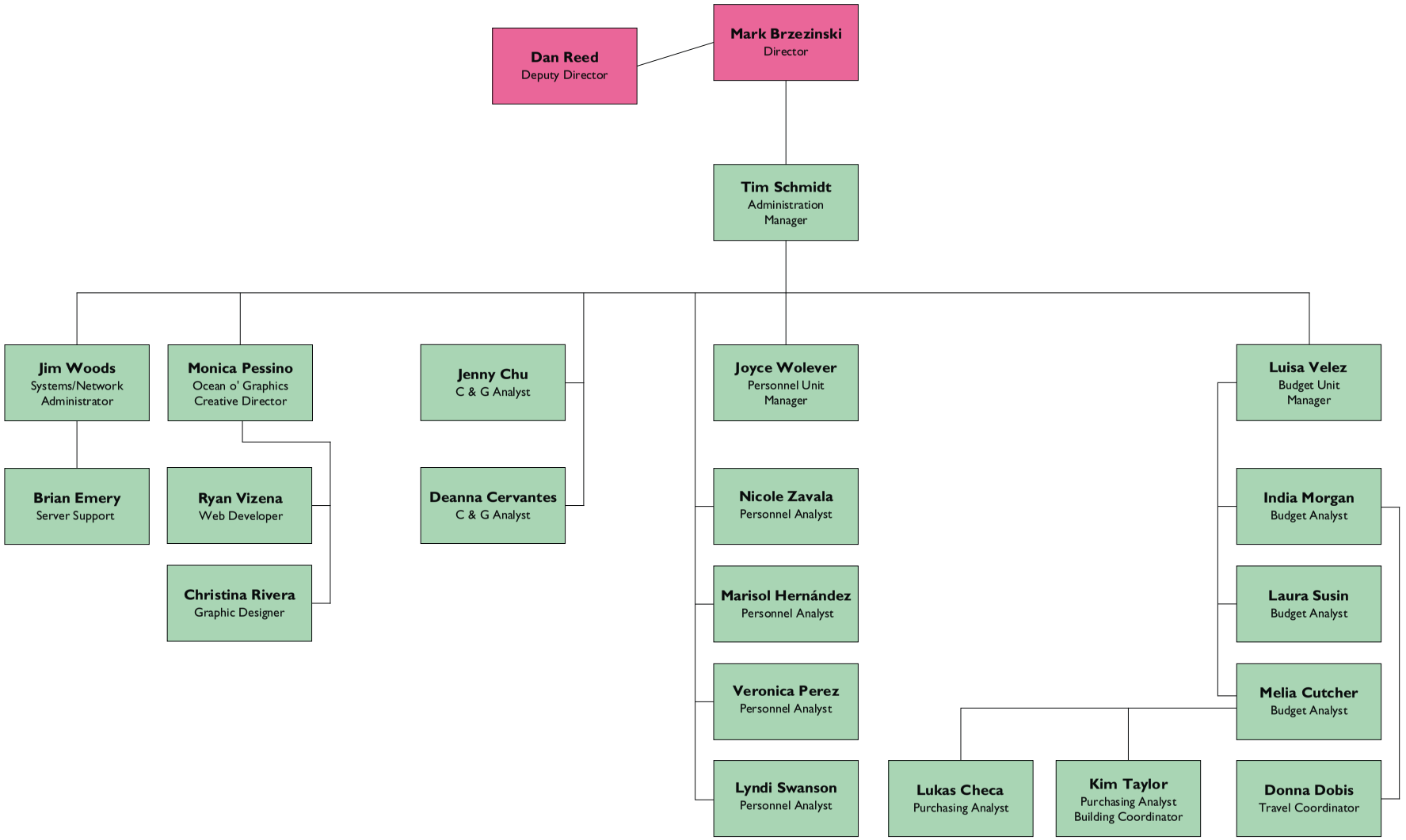
Future continued growth in marine research at UCSB will require that MSI to seek additional research space. MSI is fortunate to have access to research space in the MSRB which is strategically deployed in support of collaborative projects and individual projects for both ladder faculty and professional researchers. Much of MSI's membership is from departments that are also experiencing space limitations. MSI is now working with departments to explore creative solutions for new research space. Our approach is to develop partnerships that will produce synergies to allow new space to meet multiple needs across campus. Current efforts focus on replacement of the Old Marine Laboratory" at campus point which suffers from severe structural deficiencies offering the opportunity to construct a new expanded state-of-the-art facility.

For the past few years MSI has had the goal of working with the Office of Research to reorganize MSI's budget to simplify the Institute's fragmented and confusing funding profile. The goal was to eliminate funding sources gained through short-term deals to support the analytical facility, the education and outreach program and the administrative unit and to incorporate those costs into MSI's base budget. This goal proved unrealistic and we have worked with OR to again find short-term funding for the education and outreach program and the analytical laboratory staff.

Organizational Charts

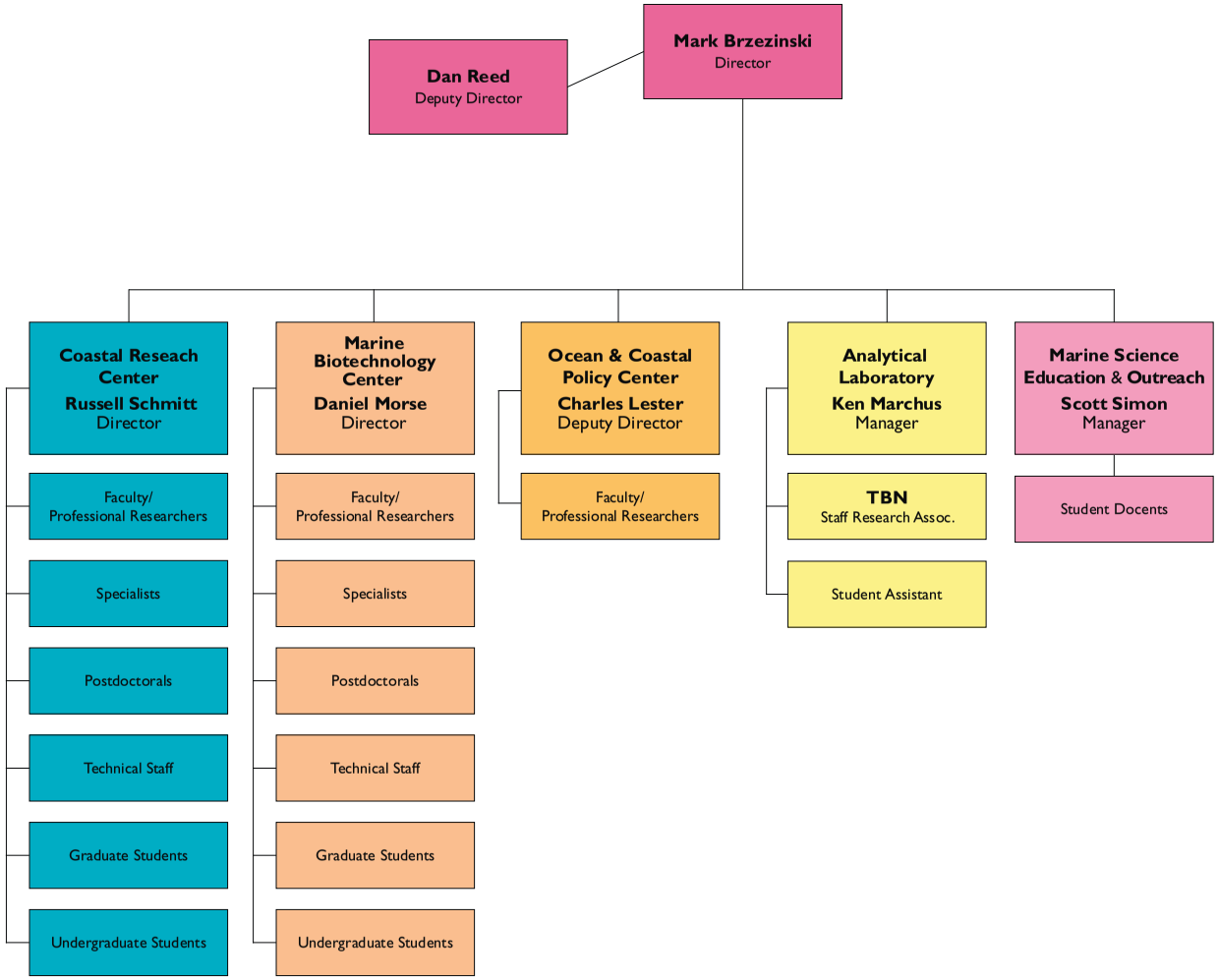
MARINE SCIENCE INSTITUTE

2018–2019 ORGANIZATIONAL CHART



MARINE SCIENCE INSTITUTE

2018–2019 ORGANIZATIONAL CHART



MSI Advisory Committee, Administrative, and Professional Technical Staff

Marine Science Institute
2018-2019

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
Erika Eliason, EEMB
Adam Lambert, MSI
Alyson Santoro, EEMB
Russell Schmitt, Commitee Chair, EEMB
David Siegel, Geography
Mark Torchin, MSI
Hillary Young, EEMB

Ex-Officio Members –

Mark Brzezinski, Director, MSI
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
Charles Lester, Director, Ocean Coastal Policy 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, Melia Cutcher

Budget Analyst, India Morgan

Budget Analyst, Laura Susin

Contracts & Grants Officer, Jenny Chu

Contracts & Grants Officer, Deanna Cervantes

Development Officer, Matt Fratus

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

Purchasing Analyst/Building Coordinator, Kimberly Taylor

Travel Coordinator, Donna Dobis

Statistical Summary

Research Support Summary
2018-2019

Federal Agencies

National Aeronautics and Space Administration (NASA)	$372,044	1.76%
National Aeronautics and Space Administration (Shared Serv)	$773,975	3.67%
National Fish and Wildlife Foundation	$184,280	0.87%
National Oceanic and Atmospheric Administration (NOAA)	$279,317	1.32%
National Science Foundation-NSF	$6,604,614	31.32%
USDA, Forest Service	$947,523	4.49%
USDI Bureau of Ocean Energy Management	$650,000	3.08%
Federal Totals	**$ 9,811,753**	**46.51%**

State

California State Lands Commission	$657,563	3.12%
California Wildlife Conservation Board	$2,793,858	13.25%
CSU San Diego State University	$99,850	0.47%
San Jose State University	$80,000	0.38%
UC Davis	$60,820	0.29%
UC Los Angeles	$126,000	0.60%
UC Mexus	$33,735	0.16%
UC San Diego	$923,384	4.38%
UC Santa Cruz	$750,367	3.56 %
UC Sea Grant College Program	$275,636	1.31%
State Totals	**$ 5,801,213**	**27.52%**

Private

American Genetic Association	$ 9,387	0.05%
Bermuda Institute of Ocean Sciences	$234,000	1.11%
Conservation International Foundation	$14,180	0.07%
Environmental Defense Fund	$50,000	0.24%
Exxon Mobil Upstream Research Company	$497,948	2.36%
Global Fishing Watch	$125,000	0.59%
Grantham Foundation for the Protection of the Environment (The)	$188,075	0.89%
Harvard University	$157,563	0.75%
James S. Mcdonnell Foundation (The)	$200,000	0.95%
John Wood Group PLC	$47,129	0.22%
Montana State University	$11,632	0.06%
National Geographic Society	$166,931	0.79%
Nature Conservancy (The)	$1,055,299	5.00%
Oak Ridge Associated Universities	$34,000	0.16%
Paul M. Angell Family Foundation	$68,000	0.32%
Pew Charitable Trusts	$336,854	1.60%
Rare. Inspiring Conservation	$100,000	0.47%
Schmidt Family Foundation (The)	$200,115	0.95%
Simons Foundation	$10,000	0.05%
Society for Conservation Biology	$117,171	0.56%
Systemiq	$140,000	0.66%
Texas A&M University	$113,433	0.54%
University of Georgia	$39,892	0.19%
University of Hawaii	$47,579	0.23%
University of Miami	$315,401	1.50%
University of Pittsburgh	$17,824	0.09%
University of Southern California	$20,000	0.09%
University of Tennessee	$71,629	0.34%
University of Wisconsin	$312,019	1.48%
Waitt Family Foundation	$600,000	2.85%
Walton Family Foundation, Inc.	$20,000	0.09%
Zegar Family Foundation	$152,461	0.72%
Private Totals	**$ 5,473,522**	**25.97%**
Total	**$ 21,086,488**	**100.00%**

Statistical Summary for the Marine Science Institute 2018-2019

	MSI
1. Academic personnel engaged in research	
Faculty	25
Professional Researchers (including Visiting)	22
Project Scientists	10
Specialists	41
Postdoctoral Scholars	37
Postgraduate Researchers	0
Academic Coordinators	3
TOTAL	**138**

2. Graduate Students	
Employed on contracts and grants	62
Employed on other sources of funds	0
Participating through assistantships	0
Participating through traineeships	0
Other (specify)	0
TOTAL	**62**

3. Undergraduate Students	
Employed on contracts and grants	129
Employed on other funds	0
Number of volunteers, & unpaid interns	0
TOTAL	**129**

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

5. Staff (Univ. & Non-Univ. Funds):	
Technical	154
Administrative/Clerical	18
TOTAL	**172**

6. Seminars, symposia, workshops sponsored	
7. Proposals submitted	158
8. Number of different awarding agencies dealt with*	91
9. Number of extramural awards administered	248
10. Dollar value of extramural awards administered during year**	$96,794,967.25
11. Number of Principal Investigators***	126
12. Dollar value of other project awards ****	$4,663,709.35
13. Number of other projects administered	83
14. Total base budget for the year (as of June 30, 2018)	$1,828,535.39
15. Dollar value of intramural support	$610,904.66
16. Total assigned square footage in ORU	38,807
17. Dollar value of awards for year (2018 Total)	$21,086,488

* 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 2015-2019

	2014-15	2015-16	2016-17	2017-18	2018-19
1. Academic personnel engaged in research					
a. Faculty	27	25	30	29	25
b. Researchers/ Project Scientists	32	40	36	32	32
c. Visiting Researchers					
d. Specialists/ Academic Coord/ Academic Admin.	40	42	49	44	44
e. Postdoctorals/ Postgraduates	28	36	37	46	37
Total	**127**	**143**	**152**	**151**	**138**
2. Staff (Univ. & Non-Univ. Funds)					
a. Technical	125	158	143	161	154
b. Administrative/Clerical	36	37	32	26	18
Total	**161**	**195**	**175**	**187**	**172**
3 Graduate students employed by MSI	51	63	67	59	62
4. Undergraduate students employed by MSI	122	153	127	187	129
5. Publications	1**	1**	1**	1**	N/A
6. Seminars, symposia, workshops, etc., sponsored by MSI					
7. Proposals submitted	161	156	192	171	158
8. Annual extramural awards	$18,017,630	$21,780,363	$17,781,660	$22,614,258	$21,086,488
9. Extramural awards administered	231	247	249	230	248
10. Other project awards	$2,574,097	$4,524,827	$6,423,928	$8,443,613	$4,663,709
11. Other projects administered	93	111	118	116	83
12. MSI base budget	$1,643,266	$2,327,940	$2,849,823	$2,858,472	$1,828,535
13. Intramural support	$87,525	$124,543	$194,037	$339,162	$610,905
14. Total Funds Administered	$90,505,464	$87,991,153	$82,475,035	$86,460,197	$96,794,967

** Only Departmental Publications

Funding Agencies 2018-2019

Alfred P. Sloan Foundation

AMEC (Great Britain)

American Genetic Association

Arizona State University

Bermuda Institute of Ocean Sciences

Burleson Consulting

Cal EPA Pesticide Regulation

California Artificial Reef Enhancement (CARE)

California Coastal Commission

California Department of Fish and Wildlife

California EPA Water Resources Control Board

California Ocean Protection Council

California Sea Urchin Commission

California State Lands Commission

California Wildlife Conservation Board

Coastal Fund (UCSB Assoc. Students)

Conservation International

David and Lucile Packard Foundation (The)

Duke University

Environmental Defense Fund

Eppley Foundation for Research, Inc. (The)

ExxonMobil Upstream Research Company

Global Fishing Watch

Grantham Foundation for the Protection of the Environment (The)

Great Lakes Fishery Commission

Harvard University

James S. Mcdonnell Foundation (The)

John Wood Group PLC

Marisla Foundation

Montana State University

National Academies Keck Futures Initiative

National Aeronautics and Space Administration (NASA)

National Fish and Wildlife Foundation

National Geographic Society

National Institutes of Health, NIH Dental and Research

National Institutes of Health, NIH General Medical Sciences

National Oceanic and Atmospheric Administration (NOAA)

National Park Foundation

National Science Foundation-NSF

Nature Conservancy, The

Next 10

NIH Center for Scientific Review

Oak Ridge Associated Universities

Oakland Zoo

Ocean Conservancy

Oceana Azul Foundation

Oceans 5

Oregon State University

Paul M. Angell Family Foundation

Pew Charitable Trusts

Phycological Society of America

Rare

Rockefeller Philanthropy Advisors

San Diego State University

San Francisco Zoo

San Jose State University

San Jose State University Foundation

Santa Barbara Foundation

Schmidt Family Foundation (The)

Simons Foundation

Simpson and Simpson Business and Personnel Services, Inc.

Society for Conservation Biology

Southern California Coastal Water Research Project (SCCWRP)

Systemiq

Texas A&M University

Tufts University

UC Agriculture and Natural Resources

UC Davis

UC Los Angeles

UC MEXUS

UC San Diego

UC Santa Cruz

UC Sea Grant College Program

University of Exeter

University of Georgia

University of Hawaii

University of Miami

University of Nevada

University of Pittsburgh

University of Southern California

University of Tennessee

University of Wisconsin

US Environmental Protection Agency

USDA Forest Service

USDI Bureau of Ocean Energy Management

USDI Fish and Wildlife Service

USDI Geological Survey

Ventura County

Waitt Family Foundation

Walton Family Foundation, Inc.

Zegar Family Foundation

Marine Science Institute Principal Investigators 2018–2019

Marine Science Institute Principal Investigators 2018–2019

Adam, Thomas	Assistant Researcher	Marine Science Institute
Ahn, Byung-Jun Kollbe	Assistant Researcher	Marine Science Institute
Alagona, Peter	Associate Professor	History/Environmental Studies
Bell, Thomas	Assistant Professor	Earth Science
Blanchette, Carol	Associate Researcher	Marine Science Institute
Bradley, Darcy	Assistantl 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
Burkepile, Deron	Associate Professor	Ecology, Evolution & Marine Biology
Cabin, Zachary	Graduate Student	Ecology, Evolution & Marine Biology
Cabral, Reniel	Postdoctoral Researcher	Marine Science Institute
Caldow, Chris	Research Associate	Marine Science Institute
Carlson, Craig	Professor	Ecology, Evolution & Marine Biology
Caselle, Jennifer	Researcher	Marine Science Institute
Caylor, Kelly	Professor	Earth Science
Clark, Jordan	Professor	Earth Science
Cooper, Scott	Emeritus Research Professor	Ecology, Evolution & Marine Biology
Costello, Christopher	Professor	Bren School of Envir. Sci. & Management
Couture, Jessica	Graduate Student	Bren School of Envir. Sci. & Management
Culver, Carrie	Research Scientist	Marine Science Institute
D'Antonio, Carla	Professor	Environmental Studies
DeMartini, Daniel	Assistant Researcher	Marine Science Institute
Deschenes, Olivier	Professor	Economics
Dore, Hugo	Postdoctoral Researcher	Ecology, Evolution, and Marine Biology
Dudley, Tom	Researcher	Marine Science Institute
Dugan, Jenifer	Associate Researcher	Marine Science Institute

Eliason, Erika	Assistant Professor	Ecology, Evolution, and Marine Biology
Emery, Brian	Computer Network Tech.	Marine Science Institute
Froehlich, Halley	Assistant Professor	NCEAS
Eurich, Jacob	Postdoctoral Researcher	Marine Science Institute
Fisher, Alexander	Postdoctoral Researcher	Geography
Foltz, Kathy	Associate Professor	Molecular, Cellular & Devel. Biology
Gaines, Steven	Dean, Bren School, Professor	Bren School of Envir. Sci. & Management
Geyer, Roland	Professor	Bren School of Envir. Sci. & Management
Halpern, Benjamin	Professor	Bren School of Envir. Sci. & Management
Haskell, William	Postdoctoral Researcher	Marine Science Institute
Herbst, David	Associate Researcher	Marine Science Institute
Hodges, Scott	Professor	Ecology, Evolution & Marine Biology
Hollarsmith, Jordan	Postdoctoral Researcher	Ecology, Evolution & Marine Biology
Hofmann, Gretchen	Professor	Ecology, Evolution & Marine Biology
Holbrook, Sally	Professor of Biology	Ecology, Evolution & Marine Biology
Iglesias-Rodriguez, Maria	Professor	Ecology, Evolution & Marine Biology
Ingeman, Kurt	Postdoctoral Researcher	Ecology, Evolution & Marine Biology
Israelachvili, Jacob	Professor	Chemical Engineering
Jack, Brooke Kelsey	Associate Professor	Bren School of Envir. Sci. & Management
Jerde, Chris	Assistant Researcher	Marine Science Institute
Kendall, Bruce	Professor	Bren School of Envir. Sci. & Management
Kennett, James	Emeritus Research Professor	Earth Sciences
Knapp, Roland	Researcher	Marine Science Institute
Kuczenski, Brandon	Associate Researcher	ISBER
Kuris, Armand	Professor of Biology	Ecology, Evolution & Marine Biology
Lafferty, Kevin	Research Biologist	Marine Science Institute
Lambert, Adam	Assistant Research Biologist	Marine Science Institute
Lea, David	Professor	Earth Sciences

Lenihan, Hunter	Professor	Bren School of Envir. Sci. & Management
Lerch, Sarah	Postdoctoral Researcher	Marine Science Institute
Lester, Charles	Researcher	Marine Science Institute
Libecap, Gary	Professor	Bren School of Envir. Sci & Management
Lisiecki, Lorraine	Associate Professor	Earth Sciences
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
Melack, John	Professor of Biology	Ecology, Evolution & Marine Biology
Meng, Kyle	Associate Professor	Bren School of Envir. Sci. & Management
Miller, Karly	Graduate Student	Ecology, Evolution & Marine Biology
Miller, Robert	Associate Researcher	Marine Science Institute
Moeller, Holly	Assistant Professor	Ecology, Evolution & Marine Biology
Morikawa, Megan	Postdoctoral Researcher	Marine Science Institute
Morse, Marisa	Graduate Student	Ecology, Evolution & Marine Biology
Muller, Erik	Associate Researcher	Marine Science Institute
Myers, Monique	Associate Researcher	Marine Science Institute
Nelson, Craig	Associate Specialist	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
Page, Henry Mark	Researcher	Marine Science Institute
Pak, Dorothy	Academic Coordinator	Marine Science Institute
Passow, Uta	Researcher	Marine Science Institute
Park, Isaac	Associate Project Scientist	Marine Science Institute
Peng, Xuefeng	Postdoctoral Researcher	Marine Science Institute
Pivovaroff, Alexandra	Assistant Project Scientist	Marine Science Institute
Plantinga, Andrew	Professor	Bren School of Envir. Sci. & Management
Pruitt, Jonathan	Assistant Professor	Ecology, Evolution & Marine Biology
Qin, Qianhui	Graduate Student	Earth Science
Rassweiler, Andrew	Assistant Researcher	Marine Science Institute
Raven, Morgan Reed	Assistant Professor	Earth Science
Reed, Daniel	Researcher	Marine Science Institute
Russak, Justin	Associate Specialist	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
Siegel, David	Professor	Geography
Simon, Scott	REEF Manager	Marine Science Institute
Siple, Margaret	Postdoctoral Researcher	Ecology, Evolution & Marine Biology
Sokolow, Susanne	Postdoctoral Researcher	Marine Science Institute
Stears, Keenan	Assistant Project Scientist	Ecology, Evolution & Marine Biology
Stier, Adrian	Assistant Professor	Ecology, Evolution & Marine Biology
Szuwalksi, Cody	Assistant Researcher	Marine Science Institute
Tao, Yun	Graduate Student	Ecology, Evolution & Marine Biology
Torcin, Mark	Researcher	Marine Science Institute
Torregrosa-Crespo, Javier	Postdoctoral Researcher	Marine Science Institute
Turner, Thomas	Associate Professor	Ecology, Evolution & Marine Biology
Valentine, David	Professor	Earth Sciences

Waite, J. Herbert	Professor	Molecular, Cellular & Devel. Biology
Warner, Robert	Emeritus Research Professor	Ecology, Evolution & Marine Biology
Washburn, Libe	Professor	Geography
Wear, Emma	Postdoctoral Researcher	Marine Science Institute
Wilbanks, Elizabeth	Assistant Professor	Ecology, Evolution & Marine Biology
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

Marine Science Institute
Postdoctoral Researcher, Graduate and Undergraduate students
2018–2019

Postdoctoral Researchers

Bradley, Darcy

Brown, Kevin C

Burgess, Matthew

Cabral, Reniel B

Caldwell, Iain R

Cannon, Johanna

Closset, Ivia

Cortes Cortes, Alicia

Demartini, Daniel

Direnzo, Graziella V

Donovan, Mary K

Eule- Nashoba, Amber

Eurich, Jacob G

Ezzat, Leila

Fisher, Alexander William

Free, Christopher

Goodheart, Jessica A

Ingeman, Kurt

James, Anna

Kamath, Ambika

Kellom, Matthew

Larios, Eugenio

Little, Alexander

Liu, Shuting

Mclaughlin, John Peter

Meyer-Gutbrod, Erin L

Oremus, Kimberly

Peng, Xuefeng

Pfab, Franz Ferdinand

Rehm, Evan

Siple, Margaret C

Smith, Thomas

Stephens, Brandon

Strader, Marie

Wilber, Mark Quentin

Wilson, Emily

Yorke, Christie E

Graduate Students

Arrington, Eleanor Catherine

Baetge, Nicholas Q

Bao, Ken Quan

Bennett, Michelle

Carberry, Luke

Cavanaugh, Katherine C

Collie, Samuel Brinton

Comstock, Jacqueline

Cook, Dana T

Couture, Jessica Leigh

Cox, Danielle Diane

Csik, Samantha

Doering, Grant N

Dressler, Terra

Ellis, Emily Ann

Esaian, Sevan

Fitch, Robert Lloyd

Forbes, Elizabeth Sullivan

Garcia, Alberto Gabriel

Hardesty Moore, Molly Ruth

Hensley, Nicholai Marcus

Huynh, Nicholas

Katz, Tatum Shaw

Killingsworth, Bradley Walter

Kozal, Logan Cheyenne

Ladd, Mark

Ladd, Tanika Marie

Laperriere, Sarah

Leach, Terence S

Liu, Na

Love, Connor

Love, Natalie LR

Lowman, Heili Eileen

Ma, Stephanie A

Maier, Jason Ari

Malakhoff, Katrina D

Maniscalco, Michael

Mcelroy, Mary Ellis

Michaud, Kristen M

Miller, Karly M

Molina, Nury Elizabeth

Morton, Dana Nicole

Munsterman, Katrina

Ohlwiler, Mercette C

Ovando, Daniel Andres

Picciani De Souza, Natasha

Qin, Qianhui

Rand, Devin Scott
Russell, Imani
Speare, Kelly E
Strauss, Charles Kent
Sugano, Cailan S
Swafford, Andrew
Tang, Joanna Jiaying
Tarn, Jonathan
Tyrrell, Brian Patrick
Urbisci, Laura Christine
Valois, Eric
Vander Zee, David Lee
Welch, Zoe
Zenteno, Jose

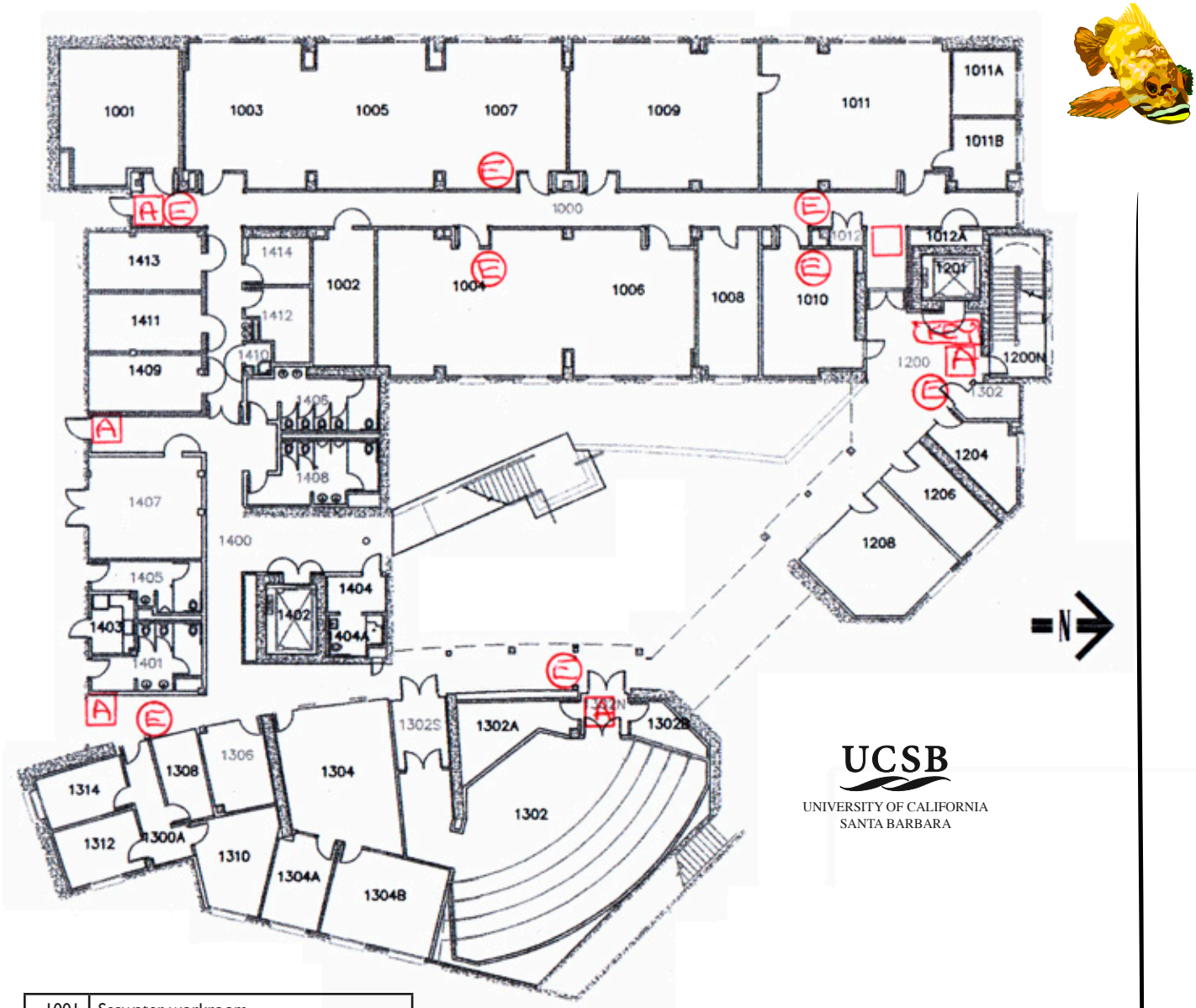
Undergraduate Students

Acosta-Hernandez, Alejandra
Ajina, Alia C
Amiri, Sarah- Marie
Anderson, Ellyse M
Aplin, Allison R
Bagla, Anshika
Barron, Marco Antonio
Begino, Emi Beth Suzane D
Begin-Roh, Margaret
Bell, Keegan Knox
Beltran, Nelson V
Bennett, Michelle
Boyle, Sarah
Breck, Justin L
Bryant Williams, Dominique
Campbell, Della C
Campbell, Sophia
Chan, Iris J
Chen, Wei Tung
Chi, Christian Park
Childs, Jeffrey R
Cochran, Courtney
Culpepper, Peter
Curry, Stephen C
Daniel, Tyler A
Davison, Calvin Ross
Davison, Carolyn
Della Colleta Vianna,Caio
Dezzani, Alecia
Ditzler, Hannah Louth
Dorji, Shey W`
Duncan, Nicholas
Eisaguirre, Jacob
Ellman, Samantha C
Emery, Kyle A
Ernster, Adam
Fang, Tiffany
Flood, Mason Andrew
Flores, Jose M
Fogg, Sandra A
Frank, Nora Joy
Fyfe, Caroline Ec
Gallagher, Jordan P
Garcia, Jonie C
Garcia, Kimverly Anne D
Gavigan, Jenna N
Gorman, Deyana L
Guerra, Mia J
Guerrero, Eric
Hammargren, Hali Compton
Hernandez, Marisol Y
Hornaic, Emma C
Hunt, Abigail D
Jack, Lauren B
Jones, Mathhew P
Kahler, Alexandra M
Kenny, Rachel Leah
Kordell, Tia Renee
Kovalsky, Sara D
Krebs, Karina S
Ladner, Ian M
Lai, Sally
Lamanna, Renee K
Le, Katherine
LeDonne, Tasi A
Lopez, Kalissa
Lowry, Megan C
Marley, Annaclaire Rose
Marrero, Eva D
Martinka, Arielle B
Mason, Margot
Mccamy, Colleen R
McComb, Sofie Hinderkien
McGill, Rebecca C
Mckinnon, Tara L
McPhail, Lindsay Grace
Methot, Nils
Miller, David Lauchlin
Moore, Samantha Marie
Morenao, Luiza D
Nguyen, Marie T
Nolan, Madeline
Ochoa, Jacob M
Oda, Kai C
Ogawa, Jacob G
Ortiz, Elizabeth
Packard, Ian J

Parcell, Theresa
Perez, Yanelyn T
Plouffe, Kyler A
Prewitt, James Scott
Primavera, Skylar Delahanty
Pullman, Avery M
Racine, Phoebe E
Ramirez Negron, Adriana I
Richards, Austin D
Rivard, Amanda G
Saccomanno, Vienna Rose
Schooler, Nicholas K
Sencan, Gokce
Shelby, Benjamin T
Sime, McKenzie J
Soglin, Tatiana
Sparks, Cristina Robin
Stead, Courtney K
Sweetnam, Marina A
Szychowski, Gina R
Tang, Irvin
Tapia Lewin, Sebastian
Thomas, Courtney Lynn
Topete, Alma Joanna
Torres, Ulysses
Tran, Thienkim Q
Tyrrell, Brian Patrick
Undurraga, Diego
Van De Wyngaerde, Kylie R
Vega, Jessica R
Vu, Kelly K
Wagner, Noah N
Walton, Miette P
Wei, Sophia
Wellington, Bethlehem M
Wetherley, Erin Blake
Williams, Jonathan Taylor
Williams, Morgan
Winslow, Erin M
Yeung, Kai-Kan J
Youlton, Michelle S
Zounes, Jade A

Space

Marine Science Research Building
Bldg. No. 520 – 1st floor
06/2019

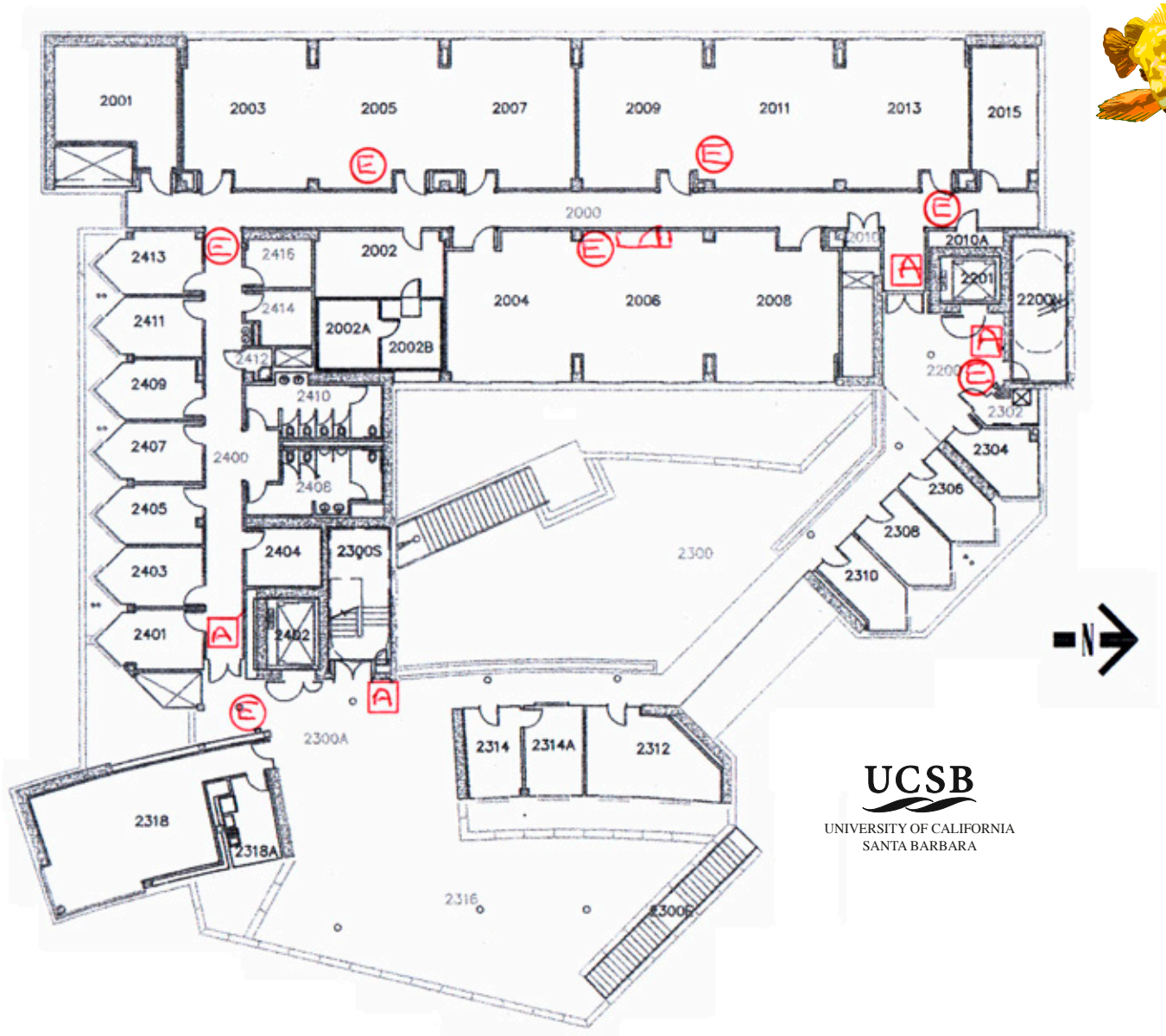


UCSB
UNIVERSITY OF CALIFORNIA
SANTA BARBARA

1001	Seawater workroom
1002	Common support laboratory
1003	Valentine laboratory
1004	Page/Dugan laboratory
1005	Valentine laboratory
1006	SONGS
1007	Siegel laboratory
1008	Hacker laboratory
1009	Analytical laboratory
1010	Hacker laboratory
1011	Analytical laboratory
1204	Graduate Student office space
1206	Graduate Student office space

1208	Graduate student office space
1302	Auditorium
1304	SFG
1304a	SFG
1304b	SFG
1308	Copier room
1310	Carrie Culver & Monique Myers
1312	Kyle Emery
1314	Alex Fisher
1409	Seawater workroom
1411	Seawater workroom
1413	Seawater workroom

Marine Science Research Building
Bldg. No. 520 – 2nd floor
06/2019



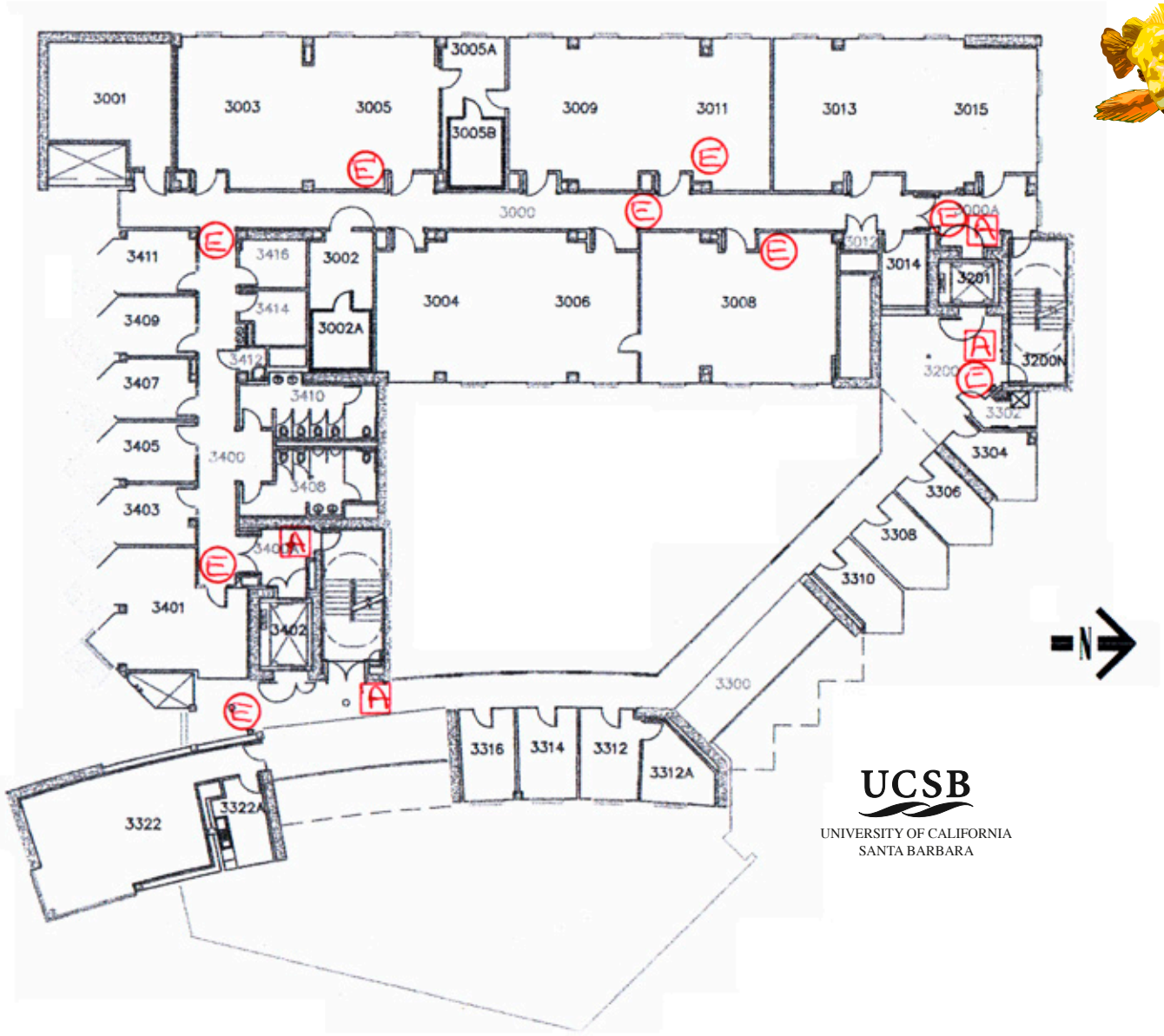
UCSB
UNIVERSITY OF CALIFORNIA
SANTA BARBARA

2001	Seawater workroom
2002	Common support laboratory
2002a	Environmental room
2002b	Environmental room
2003	Hofmann laboratory
2004	Miller laboratory
2005	Hofmann laboratory
2006	Miller laboratory
2007	Hofmann laboratory
2008	Shared laboratory
2009	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	Corey, Van Kirk, Hobson
2407	Mark Torchin
2409	Chamorro/McDonald/Sugano
2411	Gretchen Hofmann
2413	Bogon/Clare

Marine Science Research Building
Bldg. No. 520 – 3rd floor
06/2019

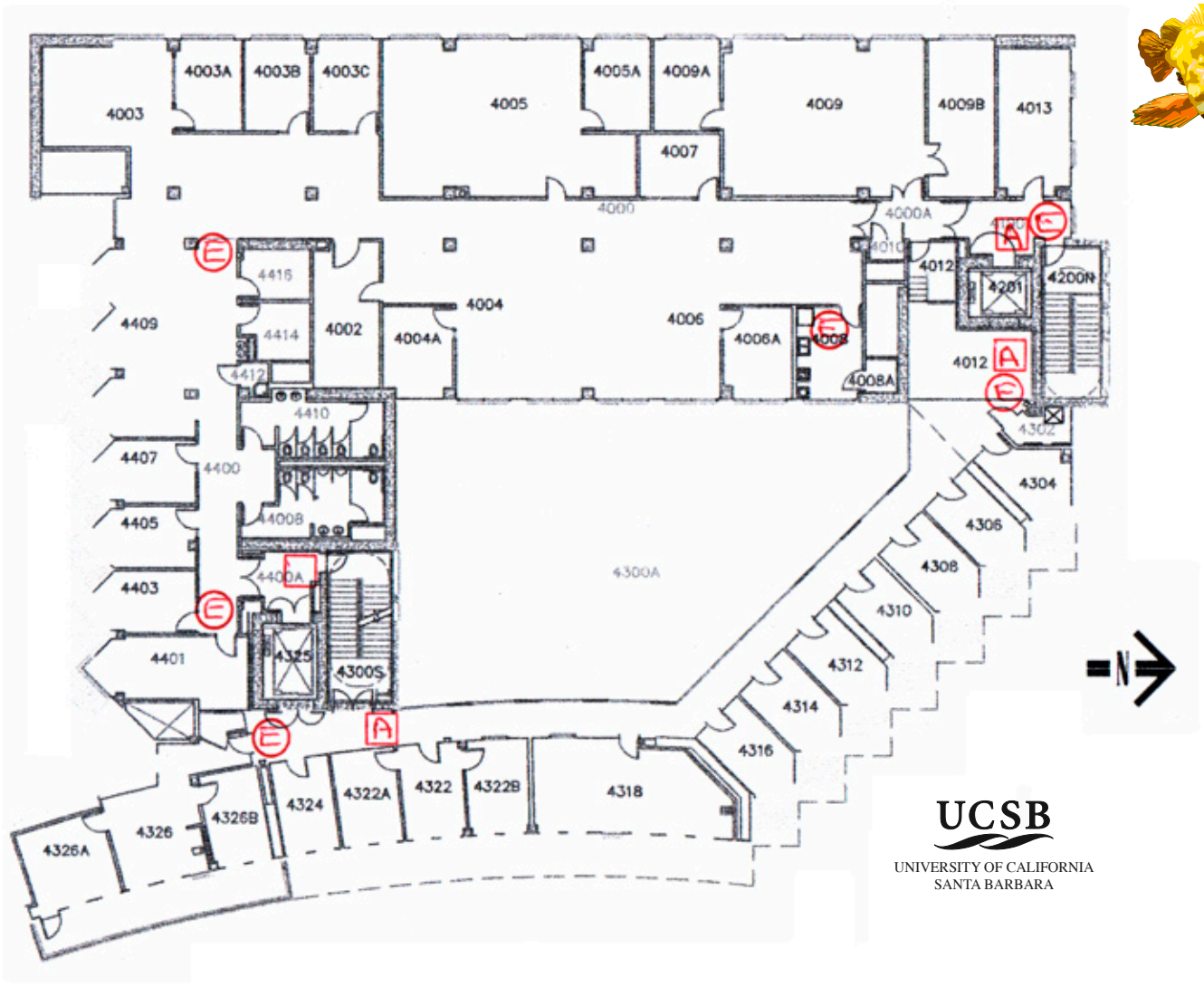


3001	Seawater workroom
3002	Common support laboratory
3003	Reed laboratory
3004	Holbrook laboratory
3005	Reed laboratory
3005a	Common support laboratory
3006	Schmitt laboratory
3008	Blanchette laboratory
3009	Warner laboratory
3011	Caselle laboratory
3013	Washburn laboratory
3014	Storage

3015	MacIntyre laboratory
3304	Charles Lester
3306	Christie Yorke
3308	Dan Reed
3310	Andrew Brooks
3312	Grad student office
3312a	Tom Adam
3314	Russell Schmitt
3316	Sally Holbrook
3322	Conference room
3401	Margaret O'Brien – Mary Gastil-Buhl

3403	Adam Lambert
3405	BON
3407	BON
3409	Chris Jerde
3411	Craig Nicholson

Marine Science Research Building
Bldg. No. 520 – 4th floor
06/2019



4002	Receiving
4003a	Ocean o' Graphics – Monica Pessino
4003b	NRS
4003c	NRS
4004a	File Room
4004c	Kimberly Taylor
4004d	Melia Cutcher
4005a	Nicole Zavala
4005a	Marisol Hernandez
4005b	Veronica Perez
4005c	Lyndi Swanson
4006a	India Morgan
4006a	Laura Susin
4006b	Melia Cutcher
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	Nick Nidzieko
4318	Conference Room
4322	SFG

4322a	Michaela Clemence
4322b	Robert Warner
4326b	Matt Fratus
4326	Development
4326a	MSI Director
4401	Tim Schmidt
4403	Joyce Wolever
4405	Luisa Velez
4407	
4409a	Jenny Chu
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

Other Projects and Activities

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

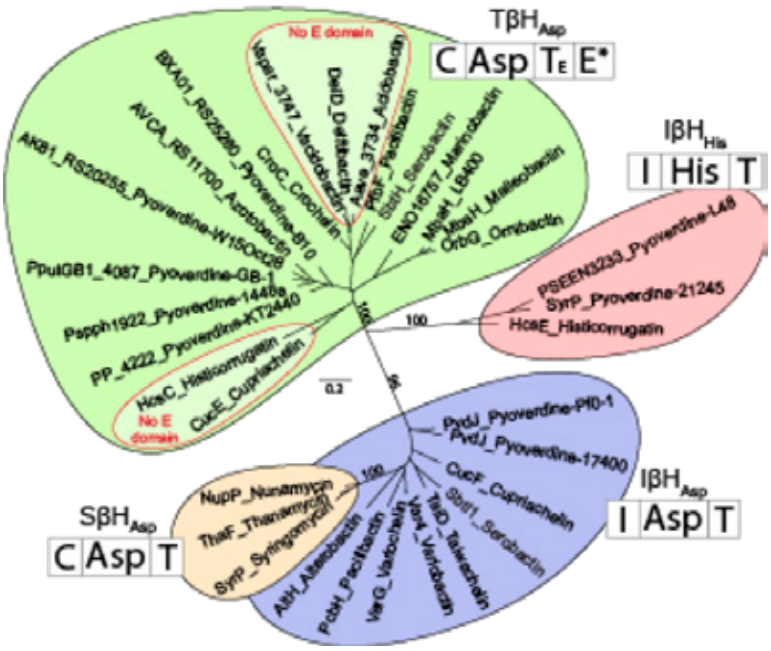
Marine Biotechnology Center

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 improve our understanding of the causes and impacts of global and local climate and environmental changes and develop improved preventative and responsive measures; 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 Marine Biotechnology Building is just one of the campus's many facilities housing this diverse research and teaching, led by faculty from numerous departments, the Marine Science Institute and the state-supported California NanoSystems Institute, the Materials Research Laboratory (an NSF-supported MRSEC), the Institute for Collaborative Biotechnologies and the new BioEngineering Program. A small sampling of the faculty leaders and research projects across the spectrum of these areas includes the following:

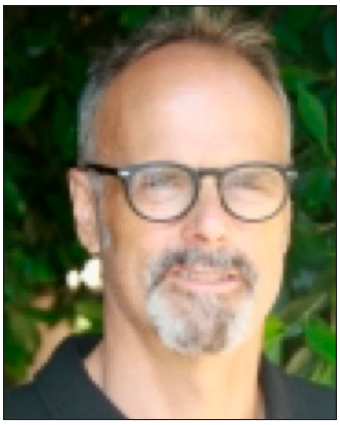
Alison Butler

Department of Chemistry and Biochemistry
(butler@chem.ucsb.edu)

Marine metallobiochemistry: Our lab works on new metalloenzymes and pathways that marine microorganisms use to sequester the transition metal ions required for growth. Nearly all bacteria require iron for growth, yet iron is present at vanishingly low concentrations in much of the world's oceans. Iron is thus an object of competition among microbes. Bacteria often secrete small molecules called siderophores to sequester iron(III) and promote microbial iron uptake. Through microbial genome screening we have been able to predict interesting siderophores, ranging from specific chirality of ligands (see Figure) and Fe(III)-siderophore complexes, which may confer a competitive advantage for iron uptake, to new chelating groups that coordinate Fe(III). In contrast to the paucity of iron in the ocean, vanadium is the second most abundant transition metal ion. Vanadium haloperoxidase enzymes are present in all classes of marine algae and as well as in many microbes. The halogenating activity confers a competitive advantage, such as limiting quorum sensing in potentially unwanted colonizing microbes.



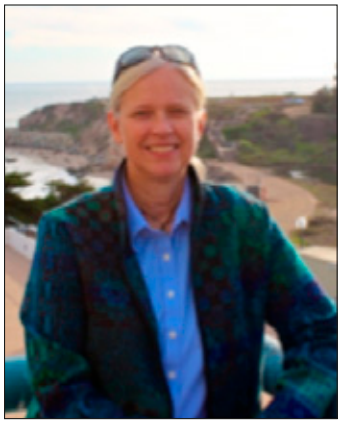
The figure shows the stereo-specificity of aspartic acid hydroxylation by the Fe(II)-2-ketoglutarate class of enzymes, in which the stand alone enzyme, TβHase, and the nonribosomal aspartic acid hydroxylase domain, IβHase, produce opposite stereo-isomers in formation of the Fe(III)-chelating group β-hydroxyaspartic acid.



Tony DeTomaso

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.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.



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.

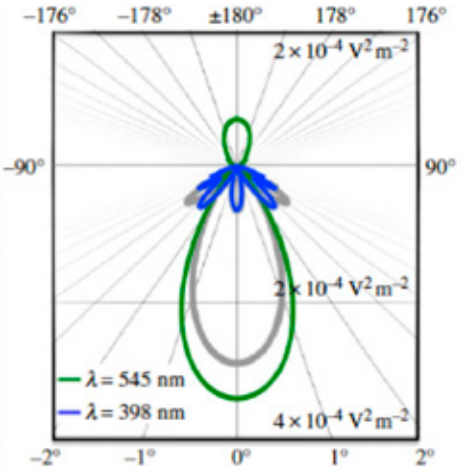
(Left) Sea urchins induced to spawn, shedding eggs (yellow) or sperm (white). (Right) Sea urchin fertilization, showing sperm on the egg surface.

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.

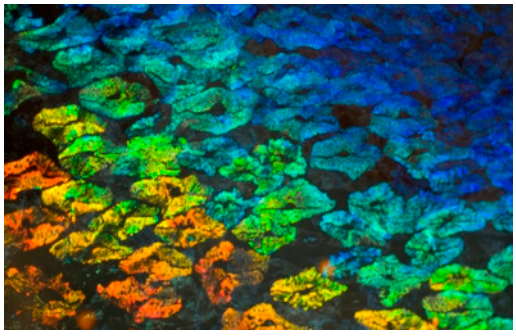


(Left) Giant clam, showing brilliantly reflective cells in the mantle tissue exposed to sunlight.
(Right) Quantitative simulation revealing that <10% of solar photons are reflected back to the observer; the majority are scattered deep into the tissue.

Dan Morse

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

Squids use a molecular machine to disappear: Squids and their cousins, the octopi and cuttlefish, fine-tune the colors and patterns of their skin for camouflage that's so effective that they seem to disappear. They also use this ability for underwater communication, signaling information ranging from aggression to courtship. We recently discovered the mechanism by which a unique molecular machine regulates the color of specialized skin cells, by a mechanism as remarkable as one that might have been invented by Doctor Who: Nerve cells from the brain release a neurotransmitter that activates a signal-transducing relay in the skin cells, culminating in the enzymatic addition of phosphates to "reflectin" proteins that fill the membrane-enclosed layers of an intracellular reflector. The reflectins are block copolymers, with repeated, evolutionarily conserved domains interspersed with positively charged linkers. Phosphorylation progressively neutralizes the linkers' positive charge, overcoming their electrostatic repulsion to progressively allow the spring-loaded condensation and secondary folding of the conserved segments to form amphiphilic, bifacially phase-segregated structures, with the emergence of hydrophobic faces that mediate hierarchical molecular assembly to form progressively larger and larger multimers. The reciprocal reduction in reflectin's particle number concentration drives osmotic dehydration of the membrane-enclosed layers of the intracellular reflector, shrinking the thickness and spacing of these layers while increasing their refractive index. This progressively changes the color of reflected light from red to blue, while increasing its intensity. This process is reversible, cyclable, calibrated 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 camouflage and communication. Translation of the underlying mechanism of this biomolecular machine 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 reflector assembled to progressively drive osmotic shrinking of the thickness and spacing of the reflecting layers, 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)

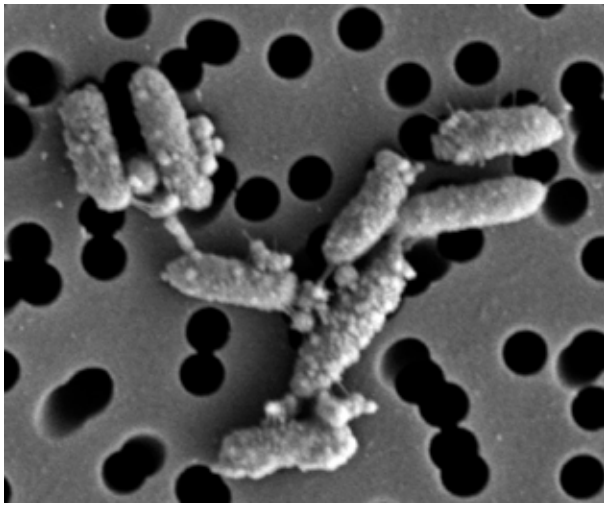
Evolution of genes for sensing and producing light: Evolution has produced amazingly diverse solutions for sensing and producing light, especially in marine environments. How did this diversity come about and can we harness and enhance these solutions for practical gain? Light sensing and vision are 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.

Alyson Santoro

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

The oceans contain some 1029 microorganisms. Yet, despite the ever-increasing abundance of DNA sequences from the sea, the specific metabolisms of most microorganisms living there are largely unknown. One reason for this is the difficulty of cultivating relevant microorganisms that can be used to interpret sequence datasets. I approach this problem in two ways: (1) cultivating as-yet uncultivated microorganisms for characterization, and (2) combining sequence data from uncultured organisms with field-based geochemical rate measurements. These two complimentary approaches allow hypotheses formed from field data to be tested using newly cultivated organisms in the laboratory, and vice-versa. Our research will lead to a better understanding of how physical environments in the ocean influence the gene content of marine microbes, how the metabolic pathways in the nitrogen cycle evolved, and how co-occurring microbes interact in the food web. In short, we want to answer the questions: *Why are microbes in the ocean so diverse? What are they doing there? How do they keep the oceans habitable for other creatures?*

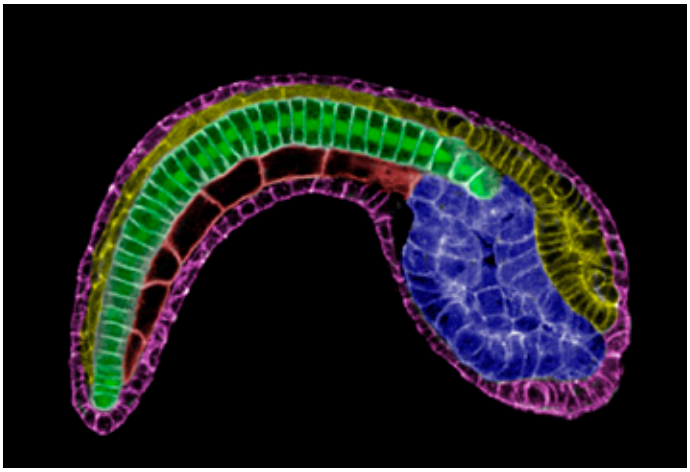


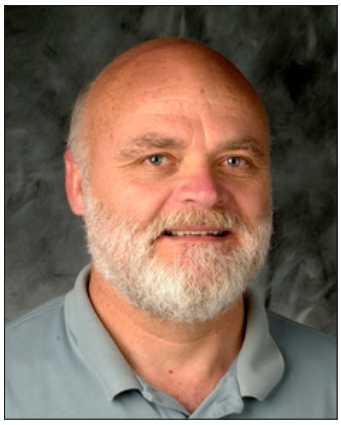
Electron micrograph of a novel marine archaea grown in the Santoro lab. Studying the metabolism of this organism will help us understand production of the greenhouse gas nitrous oxide (N_2O) in the ocean.

William Smith

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

Neurobiology of the tunicate *Ciona*. We investigate nervous system development and function using a unique marine invertebrate model: the tunicate *Ciona*. Tunicates occupy a special evolutionary position - they are chordates and the closest extant relatives of the vertebrates. While tunicates resemble vertebrates, particularly as larvae, they are much less complex. The *Ciona* larval central nervous system is of particular interest to us. It contains only 177 neurons, yet has an evolutionarily conserved structure to vertebrate CNSs, with homologs of the vertebrate forebrain, midbrain, hindbrain and spinal cord. Moreover, its development closely parallels that of vertebrates. In our work, we focus on neural tube closure (NTC). NTC is an embryonic morphogenetic process common to all chordates, and transforms the nascent CNS from a sheet to a closed tube. In a second area of research we study the function of the larval *Ciona* CNS, guided by the recently published synaptic connectome. In our research we use behavioral studies of normal and mutant *Ciona* larvae to investigate neural circuits underlying behavior.





Herbert Waite

Department of Molecular, Cellular and Developmental Biology
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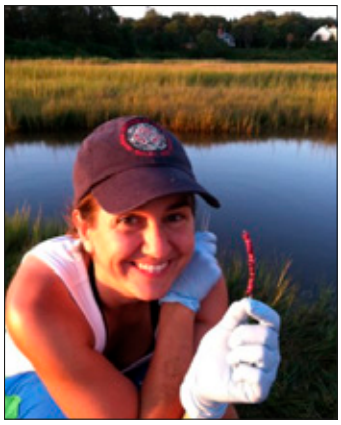
Opportunistic wet adhesion: Marine organisms and their extended structures are held together by molecular glues whose adhesive and cohesive properties are adapted to their function. Wet bioadhesion can be specific or opportunistically nonspecific. Mussel adhesion is of the latter type and depends on 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 in order to enhance the superior chemisorption of DOPA to a variety of surfaces. Reducing redox is maintained by a liquid-liquid phase separation of Dopa and thiol-rich proteins that remain insulated from seawater and provide H+/e- as needed to neutralize interfacial oxidants. 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
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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

The coast is a place of profound beauty, complex ecology, and immense social value. It is also a place where we struggle to contain the impacts of increasing human use, pollution, and development. And with the threat of global climate change, our desire to protect the coast now frames a more fundamental, existential question: how can we live sustainably, and equitably, in the face of unprecedented environmental change?

UC Santa Barbara's Ocean and Coastal Policy Center (OCPC) is tackling this question by addressing some of our most pressing coastal policy challenges: adapting to sea level rise, assuring universal shoreline access, and protecting the coast's unique ecology. Working at the intersection of coastal stewardship, governance, and justice, OCPC provides expert science and policy analysis to governments, NGOs, and citizens working for sustainability and equity along our coasts. The OCPC seeks to leverage the extensive expertise of the University's marine and coastal science faculty and programs, including the Bren School of Environmental Management and UCSB's Environmental Studies Program, one of the nation's first undergraduate programs in interdisciplinary environmental studies. With the recent appointment of Dr. Charles Lester as OCPC Director, the Center is focusing on major projects:

The California Coastal Leadership Project

California's leadership of successful coastal management is world-renowned. The Ocean and Coastal Policy Center is carrying this leadership forward through the integration of science, law and policy to inform current policy actions and governance, and promote the public's interest in a sustainable and just coastal future. OCPC will be examining the successes and failures of California's first 50 years of coastal management and identify critical management needs for the next 50 years. The project will culminate with a celebration of the 50th anniversary of California's coastal program in November 2022 and conclude with a strategy to protect the California Coast for future generations.

The Coastal Resilience Project

Coastlines face incredible challenges. Sea level rise threatens communities. Marine ecosystems are stressed by increased temperatures and plastic pollution. Housing costs in the coastal zone continue to rise while shoreline access remains unavailable for many. The Ocean and Coastal Policy Center will address these challenges by focusing on community governance and adaptation, and social and environmental justice, including developing new ideas and policies to address the resilience of coastal communities, including beaches, neighborhoods and critical infrastructure. OCPC is also sponsoring research on the Public Trust Doctrine, to identify policy and management measures that will protect the public trust values of beaches, and the rights of citizens to use and enjoy the shoreline.

About the Director

Dr. Charles Lester has been working for coastal protection for more than 25 years in the fields of law, policy and management. From 2011 to 2016 he served as the fourth executive director of the California Coastal Commission, and was the principal architect of California's first comprehensive sea level rise land use planning guidance. He is a leading expert on the California Coastal Act and integrated coastal management. Dr. Lester began his career as a professor at the University

of Colorado at Boulder, teaching environmental and public policy, and public lands governance. He has a Ph.D. in Jurisprudence and Social Policy, and a J.D., from UC Berkeley, where he studied environmental and administrative law. His doctoral thesis examined the U.S. federal offshore oil program. He also holds a BA in geochemistry from Columbia University in New York City. For more information please contact: Dr. Charles Lester, Director of the Ocean and Coastal Policy Center: charleslester@ucsb.edu or phone: 831-706-8280.

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 2018-2019, MSI Oceans-To-Classrooms (O2C) Education/Outreach Programs provided marine science education and awareness to over 23,000 people. This number is up significantly from our last report of 19,000, 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 13,000 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.

Awards Administered

Contracts/Grants Awarded 2018-2019

AMERICAN GENETIC ASSOCIATION

Cabin, Zachary A	5/1/2018-4/30/2019	$9,387
Evidence of positive selection on a homeotic mutant of Aquilegia coerulea		
	American Genetic Association Subtotal	**$9,387**

BERMUDA INSTITUTE OF OCEAN SCIENCES

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

CAL STATE LANDS COMMISSION

Valentine, David	9/1/2018-8/31/2021	$657,563
A Platform Holly Seep Acoustic Observatory		
	Cal State Lands Commission Subtotal	**$657,563**

CAL WILDLIFE CONSERVATION BOARD

Lambert, Adam	11/26/2018- 3/31/2022	$2,793,858
Arundo removal at the Sespe Cienega		
	Cal Wildlife Conservation Board Subtotal	**$2,793,858**

CONSERVATION INTERNATIONAL FOUNDATION

Gaines, Steven	12/03/2018- 6/30/2019	$14,180
Task 3: Spatial Planning for Protected Areas in Response to Climate Change (SPARC)		
	Conservation International Foundation Subtotal	**$14,180**

CSU SAN DIEGO STATE UNIVERSITY

Miller, Robert J	08/18/2015-2/28/2021	$99,850
Archaeological and Biological Assessment of Submerged Landforms in the Pacific Coast		
	CSU San Diego State University Subtotal	**$99,850**

ENVIRONMENTAL DEFENSE FUND

Gaines, Steven	9/28/2018- 8/30/2019	$50,000
Predicting and Planning for Regional Climate Change Impacts on Fisheries		
	Environmental Defense Fund Subtotal	**$50,000**

EXXON MOBIL UPSTREAM RESEARCH COMPANY

Love, Milton S — 9/15/2018- 2/28/2021 — $497,948
A comparative Field Study of Survey Methodologies with the Analyses of the Fish and Invertebrate Assemblages of A Santa Ynez Platform and Its Associated Pipeline

Exxon Mobil Upstream Research Company Subtotal **$497,948**

GLOBAL FISHING WATCH

Costello, Christopher J — 5/1/2018- 7/15/2019 — $125,000
Building the Global Tuna Watch System: Detecting Human Rights Violations in the Global Tuna Fleet

Global Fishing Watch Subtotal **$125,000**

HARVARD UNIVERSITY

McCauley, Douglas — 9/1/2018- 8/31/2019 — $157,563
CNH-L: Socio-ecological traps and interactive dynamics of reef fisheries and human health in Kiribati

Harvard University Subtotal **$157,563**

JAMES S. MCDONNELL FOUNDATION (THE)

Siple, Margaret — 3/1/2019- 2/28/2022 — $200,000
Putting value on biological complexity

James S. McDonnell Foundation (The) Subtotal **$200,000**

JOHN WOOD GROUP PLC

Herbst, David B — 9/1/2015- 12/31/2019 — $47,129
Leviathan Mine Stream Biomonitoring Fall 2018: research on progress of remediation activities and comparison of aquatic invertebrate communities with water chemistry

John Wood Group PLC Subtotal **$47,129**

MONTANA STATE UNIVERSITY

Dudley, Thomas L — 7/26/2018- 12/31/2019 — $11,632
Using an aggregation compound formulation to strategically focus Diorhabda carinulata (Desbrochers) on Tamarix spp.: Enhancing the impact of a defoliating herbivore and improving the operational efficiency of monitoring establishment and population expansion

Montana State University Subtotal **$11,632**

NASA MISCELLANEOUS CENTERS

Carlson, Craig A — 1/19/2018- 1/18/2021 — $372,044
Evaluating the Controls of Dissolved Organic Matter Accumulation, its Availability to Bacterioplankton, its Subsequent Diagenetic Alteration and Contribution to Export Flux

NASA Misc Centers Subtotal **$372,044**

NASA SHARED SERVICES CENTER

Miller, Robert J Demonstrating an Effective Marine BON in the Santa Barbara Channel- NASA	10/01/2014-09/30/2020	$773,975
	NASA Shared Services Center Subtotal	**$773,975**

NATIONAL GEOGRAPHIC SOCIETY

Costello, Christopher J Pristine Seas	07/01/2016- 11/30/2019	$166,931
	National Geographic Society Subtotal	**$166,931**

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Culver, Carolynn S Gathering essential fishery information for the brown box crab, Lopholithodes foraminatus, to assess the potential for a new California trap fishery	9/01/2018- 8/31/2020	$279,317
	National Oceanic and Atmospheric Administration Subtotal	**$279,317**

NATIONAL SCIENCE FOUNDATION

Briggs, Cheryl J LTREB : Collaborative Research: Long-term dynamics of amphibian populations following disease-driven declines: REU Supplement	05/01/2016-04/30/2021	$22,253
Burkepile, Deron CAREER: Fish-Derived nutrients in a coral reef ecosystem-impacts on benthic communities and importance for coral restoration	7/01/2015- 4/30/2021	$330,973
Hofmann, Gretchen E Mechanisms of physiological plasticity in early stage marine invertebrates in response to multiple stressors - epigenomic perspective in a global change context	3/15/2017- 2/29/2020	$22,701
Hofmann, Gretchen E RAPID: Collaborative Research: Studies of recovery from bleaching in Acropora hyacinthus: epigenetic shifts, impacts on reproductive biology and carry-over effects	6/15/2019- 5/31/2020	$123,319
Hofmann, Gretchen E REU Site: Ocean Global Change Biology	3/15/2017- 2/29/2020	$126,610
Mazer, Susan J Evolutionary adaptation to intensifying drought across a geographic gradient: a comprehensive test of Fisher's Fundamental Theorem	08/01/2017- 07/31/2021	$25,200
Miller, Robert J LTER: Environmental drivers and ecological consequences of kelp forest dynamics (SBV IV)	12/15/2018- 11/30/2024	$1,127,000
Moeller, Holly Testing the evolutionary responses of mixotrophs to future ocean conditions	5/15/2019- 4/30/2022	$536,087
Nidzieko, Nicholas Measuring the TKE budget and turbulent momentum flux beneath breaking waves using an autonomous underwater vehicle	8/01/2018- 9/30/2021	$674,144
Pak, Dorothy K Collaborative Research: The Holocene and Anthropocene as windows into the future of marine systems	9/01/2018-8/31/2020	$49,555
Schmitt, Russell J LTER: MCR III: Long-Term Dynamics of a Coral Reef Ecosystem	9/01/2016- 8/31/2022	$2,288,995
Stier, Adrian C.	6/01/2019- 5/31/2022	$651,134

COLLABORATIVE RESEARCH: Dynamic Marine Landscapes: Feedbacks and spatial patterns of corals and their associated fishes

Valentine, David L — 10/01/2018- 9/30/2021 — $442,502
Collaborative Research: Do benthic feedbacks couple sulfur, nitrogen and carbon biogeochemistry during transient deoxygenation?

Washburn, Libe — 3/15/2017- 2/28/2021 — $15,600
Collaborative Research: Resolving complex coastal flows via advances in high-frequency radar

Wittmann, Marion E — 07/01/2018- 06/30/2020 — $24,944
Developing a Strategic Plan for Santa Cruz Island Reserve

Young, Hillary S — 05/01/2019- 04/30/2022 — $126,950
SG: Collaborative Research: Effects of changing wildlife communities across climatic contexts on tick-borne disease in California

Young, Oran R — 11/01/2016-10/31/2019 — $16,647
Collaborative Research: Belmont Forum-Pan-Arctic Options, Holistic Integration for Arctic Coastal-Marine Sustainability

National Science Foundation Subtotal **$6,604,614**

NATIONAL FISH AND WILDLIFE FOUNDATION

D'Antonio, Carla M — 06/01/2018-06/30/2019 — $184,280
Evaluation and restoration of degraded chaparral within Piru Fire perimeter: Phase II

National Fish and Wildlife Foundation Subtotal **$184,280**

NATURE CONSERVANCY (THE)

Bradley, Darcy E — 5/23/2019- 6/30/2020 — $145,000
Task 31: Climate-Ready Fisheries Management Modeling

Caselle, Jennifer E — 9/11/2018- 6/30/2019 — $26,149
Task 29: Monitoring of California's MPA network to improve fisheries management using citizen science and novel technology

Caselle, Jennifer E — 5/09/2018- 6/30/2020 — $138,322
TASK 27:Kelp Workshop and Action Plan

Costello, Christopher J — 1/1/2018- 8/31/2019 — $141,757
TASK 22: Diversifying Fisheries Investment for the PNA: Evaluating the Potential Benefits of Implementing a CDQ Program in the Western and Central Pacific Ocean

Gaines, Steven — 5/01/2018- 6/30/2019 — $17,000
Task 25: Dangermond Preserve Bren Summer Interships and Group Project

Gaines, Steven — 5/01/2018- 6/30/2019 — $2,300
Task 26: Bren School Summer Internships and MESM Group Projects – Oakology

Geyer, Roland — 5/01/2019- 6/30/2020 — $108,618
Task 32: Scoping Ocean Plastics

Mcclintock, William J — 4/09/2018- 11/30/2018 — $38,405
Task 24: Developer support for Crab Gear Recovery Tool

W. McClintock — 4/26/2018- 6/30/2020 — $278,358
Task 23: Developer support for Abalone and Lobster Ocean Ruler Tools

W. McClintock — 2/20/2019- 11/15/2019 — $159,390
Task 30: CA Lost Crab Gear Recovery Program Tools

Nature Conservancy (The) Subtotal **$1,055,299**

OAK RIDGE ASSOCIATED UNIVERSITIES

Briggs, Cheryl	01/02/2019-01/01/2021	$34,000
Predicting behavioral influences on epidemic dynamics		
	Oak Ridge Associated Universities Subtotal	**$34,000**

PAUL M. ANGELL FAMILY FOUNDATION

McClintock, William	01/01/2019-12/31/2020	$68,000
Designing A Sustainable Seascape: Mapping Hawaii's New Marine Protected Areas with SeaSketch		
	Paul M. Angell Family Foundation Subtotal	**$68,000**

PEW CHARITABLE TRUSTS

Costello, Christopher	10/12/2018-03/31/2020	$250,020
The Future of Fisheries Subsidies: Evaluating the Economic and Biological Effects of Imposing Subsidy Bans in Global Fisheries		
Costello, Christopher	04/26/2019-08/25/2019	$65,714
Global Atlas of Fisheries Subsidies		
McCauley, Douglas	03/27/2019-11/26/2019	$21,120
Creating a biologically and socio-economically informed map of priority areas for the establishment of marine protected areas on the high seas		
	Pew Charitable Trusts Subtotal	**$336,854**

RARE

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

SAN JOSE STATE UNIVERSITY FOUNDATION

Caselle, Jennifer	06/01/2017-02/28/2020	$80,000
Statewide MPA Monitoring		
	San Jose State University Foundation Subtotal	**$80,000**

SIMONS FOUNDATION

Peng, Xuefeng	04/01/2018-03/31/2021	$10,000
Impact of Marine Fungi on Global Biogeochemical Cycling of C and N		
	Simons Foundation Subtotal	**$10,000**

SOCIETY FOR CONSERVATION BIOLOGY

Ingeman, Kurt	06/01/2018-05/31/2020	$117,171
Top-down restoration: a food web perspective on enhancing recovery of over-fished species and reducing the social costs of marine conservation		
	Society for Conservation Biology Subtotal	**$117,171**

SYSTEMIQ

Costello, Christopher	11/01/2018-07/15/2019	$140,000
Estimating the Ocean's True Potential for Feeding the Planet		
	Systemiq Subtotal	**$140,000**

TEXAS A&M UNIVERSITY

Passow, Uta	01/01/2018-06/30/2020	$113,433
Aggregation and Degradation of Dispersants and Oil by Microbial Exopolymers – ADDOMEx-2		
	Texas A&M University Subtotal	**$113,433**

THE GRANTHAM FOUNDATION FOR THE PROTECTION OF THE ENVIRONMENT

Gaines, Steven	03/01/2019-12/31/2019	$188,075
Seaweed Aquaculture: A climate mitigation strategy worth pursuing?		
The Grantham Foundation for the Protection of the Environment Subtotal		**$188,075**

THE SCHMIDT FAMILY FOUNDATION

McCauley, Douglas	02/15/2019-02/14/2021	$200,115
Environmental Solutions Graduate Fellows Program		
	The Schmidt Family Foundation Subtotal	**$200,115**

UC DAVIS

Young, Hillary	01/01/2018-12/31/2019	$60,820
Megafires and ecological networks		
	UC Davis Subtotal	**$60,820**

UC LOS ANGELES

Pruitt, Jonathan	05/01/2018-04/30/2019	$126,000
Consortium grant: Quantitative approaches to the study of keystone individuals		
	UC Los Angeles Subtotal	**$126,000**

UC MEXUS

Mazer, Susan	04/01/2019-03/31/2020	$33,735
Evolution in a heterogeneous environment: identifying the mechanisms that promote the maintenance of genetic variation and the adaptive capacity of wild populations		
	UC Mexus Subtotal	**$33,735**

UC SAN DIEGO

Brzezinski, Mark	06/01/2018-05/31/2019	$56,300
Southern California Regional Coastal Ocean Observing System: Harmful Algal Bloom (HAB)		
Dugan, Jenifer	05/24/2019-11/30/2021	$485,484
Evaluating the performance of California's MPA network through the lens of sandy beach and surf zone ecosystems		

Washburn, Libe Southern California Regional Coastal Ocean Observing System: Surface Current Mapping (HFR) and Quality Control (QC)	06/01/2018-05/31/2019	$381,600
	UC San Diego Subtotal	**$923,384**

UC SANTA CRUZ

Alagona, Peter Kevin Brown ISEECI Post Doc Fellowship	07/01/2016-06/30/2019	$900
Caselle, Jennifer Mechanisms of resistance and resilience to system-wide loss of keystone predator in an iconic intertidal community	03/01/2019-12/31/2019	$26,696
Caselle, Jennifer Monitoring and Evaluation of Kelp Forest Ecosystems in the MLPA Marine Protected Area Network	05/24/2019-11/30/2021	$682,942
Caselle, Jennifer Assessment of Rocky Intertidal habitats for the California Marine Protected Area Monitoring Program	05/24/2019-11/30/2021	$39,829
	UC Santa Cruz Subtotal	**$750,367**

UC SEA GRANT

Culver, Carolynn Aquatic Resources Research, Education & Outreach Program	02/01/2019-01/31/2020	$8,331
Myers, Monique Sea Grant Extension Program Funds	07/01/2018-01/31/2019	$6,324
Myers, Monique Sea Grant Citizen Science Vision	08/26/2018-01/31/2019	$5,350
Myers, Monique Sea Grant Extension Program Funds	02/01/2019-01/31/2020	$8,205
Stier, Adrian Benefits beyond biomass: Bio-physical feedbacks within Marine Protected Areas may promote ecosystem resilience in the face of global climate change	12/01/2018-11/30/2021	$247,426
	UC Sea Grant Subtotal	**$275,636**

UNIVERSITY OF GEORGIA

Passow, Uta ECOGIG-2: Ecosystem Impacts of Oil and Gas inputs to the Gulf	01/01/2015-12/31/2019	$39,892
	University of Georgia Subtotal	**$39,892**

UNIVERSITY OF HAWAII

Carlson, Craig Hawaii Ocean Time-series (HOT): 2018-2023	08/01/2018-07/31/2019	$47,579
	University of Hawaii Subtotal	**$47,579**

UNIVERSITY OF MIAMI

Carlson, Craig Collaborative Research: Global Ocean Repeat Hydrography, Carbon, and Tracer Measurements, 2015-2020	03/15/2015-02/28/2021	$315,401
	University of Miami Subtotal	**$315,401**

UNIVERSITY OF PITTSBURGH

Briggs, Cheryl	09/26/2016-09/25/2019	$17,824
Effects of Climate on Host-Pathogen Interactions in Chytridiomycosis		
	University of Pittsburgh Subtotal	**$17,824**

UNIVERSITY OF SOUTHERN CALIFORNIA

Nicholson, Craig	02/01/2018-01/31/2019	$20,000
Enhancing the Community Fault Model (CFM) to support SCEC science, community model development, and hazard assessment		
	University of Southern California Subtotal	**$20,000**

UNIVERSITY OF TENNESSEE

Briggs, Cheryl	08/15/2018-07/31/2020	$71,629
Transmission pathways and immunological factors that affect invasion potential of the recently discovered pathogen, Batrachochytrium salamandrivorans		
	University of Tennessee Subtotal	**$71,629**

UNIVERSITY OF WISCONSIN

O'Brien, Margaret	07/15/2016-06/30/2020	$102,664
Environmental Data Initiative		
Reed, Daniel	03/15/2019-03/14/2020	$209,355
Genome wide association studies for breeding Macrocystis pyrifera		
	University of Wisconsin Subtotal	**$312,019**

USDA FOREST SERVICE

D'Antonio, Carla	04/20/2016-04/19/2021	$81,524
Evaluating the status and trends of Southern California Forest Service lands through long-term monitoring		
D'Antonio, Carla	09/01/2018-08/31/2023	$418,000
Ecological Restoration Support for Post-fire Landscapes		
Dudley, Thomas	08/09/2018-07/31/2019	$28,000
Biological control implementation for giant reed (Arundo donax) and Cape-ivy (Delairea odorata) in southern California		
Eliason Parsons, Erika	07/03/2018-05/31/2023	$419,999
Monitoring stream habitat conditions on the LPNF: the effects of wildfire, floods, and drought on freshwater ecosystems		
	USDA Forest Service Subtotal	**$947,523**

USDI BUREAU OF OCEAN ENERGY MANAGEMENT

Miller, Robert	07/07/2015-06/30/2020	$650,000
A Demonstration Marine Biodiversity Network (BON) for Ecosystem Monitoring		
	USDI Bureau of Ocean Energy Management Subtotal	**$650,000**

WAITT FAMILY FOUNDATION

Costello, Chris	01/01/2019-12/31/2019	$600,000
Sustainable Fisheries Group: Sustainable Ocean Solutions through Rights-Based Management, Fisheries Certification, and Marine Protected Areas & Aquaculture Scope		
	Waitt Family Foundation Subtotal	**$600,000**

WALTON FAMILY FOUNDATION

Costello, Chris	11/01/2018-01/31/2019	$20,000
Walton Family Foundation Program Evaluation		
	Walton Family Foundation Subtotal	**$20,000**

ZEGAR FAMILY FOUNDATION

Burkepile, Deron	11/29/2017-12/31/2019	$152,461
Coral Reef 'Bright Spots': Helping Coral Reefs Survive Climate Change		
	Zegar Family Foundation Subtotal	**$152,461**

Total Contract and Grants Awarded FY 2018-19	**$21,086,488**

Research Summaries
(Contracts/Grants Administered)

Peter Alagona, Kevin C. Brown **07/01/2016 to 6/30/2019** **$154,653**
UC Santa Cruz A15-0023-S011

Kevin Brown ISEECI Post Doc Fellowship

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 Libe Washburn **04/01/2017 to 3/31/2020** **$475,969**
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, Marion Wittmann **8/1/2017 to 1/31/2020** **$24,990**
National Science Foundation 1722660

Developing a sustainable plan to advance research and education at the Valentine Eastern Sierra Reserve

The Valentine Eastern Sierra Reserve (VESR) comprises 2 of 39 field stations in the University of California Natural Reserve System, and is located at the base of the eastern escarpment of the Sierra Nevada mountains. VESR attracts researchers from throughout the US to study many wide-ranging issues, from aquatic ecosystem ecology to ecological responses to climate change, and is well known for its active outreach programs. Scientists at VESR regularly engage with local and regional resource managers in water quality, snowpack assessments, and threatened and endangered species conservation. By user-days and publications in peer-reviewed journals, the station is productive. However, use is mainly opportunistic and, with recently-improved facilities attracting heighted interest, heavier use is anticipated. To best serve the growing VESR constituency while perpetuating VESR as a resource, we propose to develop a long-term strategic plan for VESR research, education, outreach programs, and facilities. The strategic plan will articulate a scientific vision for research and educational use, and an evaluation of the programs, facility needs and resources necessary to support that vision. To develop an effective strategic plan, we will form a steering committee, engage extensively with key stakeholders through virtual and in-person workshops, and engage a professional strategic planner to facilitate the process. We will host a special strategic planning process module to identify regional coordination opportunities. The goal of the strategic plan is to enhance research and education activities at VESR as well as the regional coordination of research, education and outreach activities across the Sierra Nevada region through a network of regional agency, non-profit, academic and field station partners.

Cherie Briggs, Roland Knapp **8/15/2015 to 7/31/2019** **$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.

Darcy Bradley **4/1/2019 to 3/31/2020** **$145,000**
Nature Conservancy SB150143-Task31

Task 31: Climate-Ready Fisheries Management Modeling

Impacts of climate change are global, diverse, and accelerating, yet both our recognition and understanding of the full scope of this problem are still in their infancy. Addressing the numerous threats to California's ocean ecosystems, and ensuring that California fisheries can deliver positive outcomes for both the environment and people will require advancing fisheries management

toward a new "climate-ready fisheries" model. Climateready fisheries management can be achieved through improved information flows via new technology and partnerships, adaptive management and decision-making frameworks, accounting for climate dynamics in stock assessments, flexible permitting systems, dynamic spatial management, and improved capacity for evaluating and preparing for social-ecological impacts. Though examples of successful climate-ready fisheries approaches do exist, there is still uncertainty and miscommunication around how and why climate-ready fisheries management should be implemented. Relevant questions that remain unanswered include: What are the defining characteristics of climate-ready fisheries? What are the benefits of climate-ready fisheries management? How do we efficiently transition California's state-managed fisheries to a climate-readiness? What are the limitations and challenges associated with this transition? For the purpose of this project, the Sustainable Fisheries Group (SFG) at UC Santa Barbara will develop a model that seeks to identify and better understand the different types of management strategies that will best position California to develop effective climate-ready fisheries management policies. To do so, SFG will address two critical questions, with a focus on one (or more) specific fisheries that will be selected jointly by SFG and TNC:

How robust are potential management solutions to a range of climate change threats and scenarios (i.e. how can we design strategies that account for our uncertainty about future climate change impacts)?

For any given fishery and its associated suite of potential climate-ready management strategies (each with varying degrees of robustness to climate change), what is the expected outcome for the stock compared to business as usual, and subsequently, what is the benefit to a broad range of stakeholders?

Cheryl Briggs | **09/26/2016 to 09/25/2019** | **$52,610**
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 | **5/01/2016 to 4/30/2021** | **$218,198**
Roland Knapp
National Science Foundation | 1557190
REU supplement | $22,927

LTREB: Collaborative Research: Long-term Dynamics of Amphibian Populations Following Disease-driven Declines

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 **8/15/2018 to 7/31/2020** **$71,629**
University Of Tennessee 9500073623

Transmission pathways and immunological factors that affect invasion potential of the recently discovered pathogen, Batrachochytrium salamandrivorans

As part of the collaborative NSF EEID project, Co-PI Briggs is tasked with developing and parameterizing the Bsal load-based models, using Integral Projection Modeling (IBM) approaches to explore the importance of resistance and tolerance in the system (Objective 3). She will work with co-PI Peace on model development. She will mentor and train a graduate student researcher on modeling and data analysis. Briggs will coordinate with the other groups for yearly meetings and conference presentations of results, as well as manuscript preparation.

Cheryl Briggs, Yun Tao **1/2/2019 to 1/1/2021** **$34,000**
Kevin Lafferty
Oak Ridge Associated Universities SB190033

Predicting behavioral influences on epidemic dynamics

Most epidemic models (e.g. individual-based simulations, compartmental models) assume that hosts mix uniformly or do not move. However, host movement could easily change during the course of infection, either due to behavioral changes associated with infection, or actions related to control that cause individuals to move towards or away from the ones infected. In the proposed project, I will develop a dynamical disease model based on my Finite-volume Updates of Grid Use Estimates (FUGUE) model to test hypotheses about how behavioral feedback affects outbreak dynamics. New to this model will be a mechanistic description of movement, which I term Transient Epi-Behavior Lattice Equations (TREBLE). Next, I will use advanced statistical tools from the field of movement ecology to analyze human data and expand the model to incorporate empirical observations about movement and epidemics. I will then implement FUGUE and develop management counterpart model to TREBLE, termed Behaviorally Adaptive Spatial Strategies (BASS). I will apply these advances in understanding to model the movement response of healthcare personnel and explore more efficient context-dependent intervention strategies. These FUGUE, TREBLE, and BASS models are unified under a common conceptual and mathematical framework, naturally extending my previous work on population dynamics, movement ecology, and epidemiology. The models I propose here are the next step in moving toward a predictive capacity to contain real-world outbreaks, on real landscapes, with real behavioral responses.

Cheryl Briggs **7/1/2016 to 6/30/2019** **$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.

Andrew Brooks, Marion Wittmann **11/13/2017 to 9/30/2020** **$91,700**
California Wildlife Conservation Board WC-1709SF

Carpinteria Salt Marsh Infrastructure Improvement Project

Reserve (CSMR) comprises the central 120-acre portion of the 230-acre Carpinteria Salt Marsh. Representing one of the more pristine coastal salt marshes remaining in southern California, the Reserve includes intertidal estuarine wetlands, adjacent palustrine wetlands and sub-tidal deep water habitat. The Reserve provides critical habitat for a rich assemblage of native plants and animals including several species of special concern. The Reserve serves as a valuable nursery and feeding ground for many species of commercial and recreationally important finfish, and provides an important refuge and feeding ground for many species of migratory birds traversing the Pacific flyway.

Research within the Reserve includes both large research programs funded by state and federal agencies (NSF, NIH, USGS, US National Park Service, and the California Department of Fish and Wildlife) as well as numerous graduate student dissertation and thesis projects. The Reserve is used annually as an outdoor classroom by eight to ten university level courses representing eight university and community college campuses located throughout southern California. Examples of public use of the Reserve include docent led tours for local K-12 classes and visits by bird watching groups, painters and members of the California Native Plant Society.

The sole avenue of access into the Reserve for all users is the unpaved extension of Estero Road (Figure 4.A.2).As such, this roadway is a vital portion of the Reserve's infrastructure and supports the Reserve's missions of research, education and stewardship. Built in 1945 and extending southward from the Union Pacific Railroad tracks, the Estero Road extension effectively bisects the CSMR and creates two separate intertidal basins: Basin II and Basin III*(Figure 4.A.2). Unlike Basin III which maintains a natural connection to the Pacific Ocean, Basin II is isolated from natural tidal flows by the presence of several large, earthen berms constructed in the early 1970's for increased flood control. Movement of ocean water into Basin II occurs from Basin III via six large culverts that run under the Estero Road extension. These culverts are heavily degraded and have begun to collapse under the roadway. Additionally, the sub-tidal channels located on either side of the Estero Road extension have deepened significantly over time and the existing culverts no longer lie on the bottoms of these channels. Our primary aim is to replace the existing culverts running beneath the Estero Road extension with new 30" HDPE culverts and lower the elevation of these new culverts so that they lie at the same elevation as the channel beds.

Mark Brzezinski **2/15/2018 to 1/31/2020** **$778,865**
National Science Foundation 1756130

A second generation silicon isotope mass spectrometer

This is a proposal to develop a second generation silicon isotope mass spectrometer. It is an admittedly unusual proposal for NSF Chemical Oceanography, and that issue is addressed directly in the main text.

The proposed instrument will support research on marine Si isotope biogeochemistry. The field of marine Si isotope biogeochemistry is about 20 years old having been pioneered at UCSB in the early 1990s. The field has grown to where over 18 laboratories from 8 countries are now measuring Si isotopes in marine systems. Si isotopes are a powerful tool for understanding the marine silica cycle and the contribution of silicifiers to marine biogeochemistry. Variations in isotopes of Si in biogenic silica and in dissolved silicic acid are used to constrain net silica production rates in the modern ocean and variations in the Si isotopic composition of diatom frustules and of deep-sea sponge spicules are used to reconstruct the history of diatom productivity in surface waters and changes in deep water silicic acid content over geologic time. The reconstructions of diatom productivity in both the modern and past ocean using Si isotopes require knowledge of the isotopic composition of the silicic acid supplied to surface waters through mixing. That need has inspired efforts to understand controls on δ30Si(OH)4 distribution in deep waters through programs like international GEOTRACES. Recent modeling studies have been surprisingly successful at simulating Si isotope distributions in the global ocean pointing to significant progress in our understanding of the controls on Si isotope distributions and their relation to ocean circulation and biogeochemistry.

In 2000 the P.I. was funded by NSF Chemical Oceanography to alter a MAT 252 IRMS mass spectrometer and Kiel III inlet system to enable their use for the analysis of Si isotopes. The project was successful and the prototype instrument has supported Si isotope research for the past 16 years via 6 NSF research awards to the PI and it has supported research by five other investigators from outside UCSB. Operation of the instrument is now highly problematic with no publishable data generated during 2017 to date. It is time for replacement.

Intellectual merit: The original prototype was a one-off instrument. For the second generation system the P.I. is partnering with Nu Instruments, Ltd to create a commercially available instrument based on the Nu Carb and/or Eurovector HT-PyrOH I° inlet system(s) and Nu Perspective isotope ratio mass spectrometer. The two main goals for the new instrument are 1) to increase sample throughput by a factor of four and 2) to lower sample size by an order of magnitude. To meet these goals both acid and thermal decomposition of silicon fluorides to generate the analyte SiF4 gas will be explored. The second generation system should be faster, as or more precise, and much easier for the novice compared to the original prototype and compared to alternatives like MC-ICP-MS.

Broader Impacts: The current prototype is the only instrument actively making measurements of isotopes of Si in marine materials in the country and it is failing. Success will restore routine measurements of isotopes of Si from marine systems in the United States. By partnering with Nu Instruments a commercial instrument will be produced that will be available to all at relatively low cost compared to competing technologies like MC-ICP-MS contributing to national and international capacity building in this field. Finally, achieving higher sample throughput would both lower costs and facilitate our ability to make the proposed UCSB instrument available to others further accelerating progress in the field.

Mark Brzezinski **3/1/2018 to 2/28/2022** **$512,233**
National Science Foundation 1756442

Collaborative Research: Diatoms, Food Webs and Carbon Export- Leveraging NASA EXPORTS to Test the Role of Diatom Physiology in the Biological Carbon Pump

The research focuses on the fate of the carbon associated with a major group of phytoplankton, the diatoms. The major objective is to understand how diatom community composition and the prevailing nutrient conditions create taxonomic differences in metabolic state that combine to direct diatom taxa to different carbon export pathways. The focus is on diatoms, given their large contribution to global marine primary productivity and carbon export which translates into a significant contribution to the biogeochemical cycling of carbon (C), nitrogen (N), phosphorus (P), iron (Fe) and silicon (Si).

Mark Brzezinski **10/1/2017 to 9/30/2020** **$657,959**
National Science Foundation 1732139

US GEOTRACES Pacific Meridional Transect (GP- 15): Resolving Silicon Isotope Anomalies in the North Pacific

The silicon isotope proxy is increasingly being used to assess the role of diatoms and of silicic acid supply in driving modern day and past shifts in ocean productivity and their implications for climate. Application of the proxy requires knowledge of the Si isotopic composition of ventilating water masses. Uncertainty in those values translates directly into uncertainty in the level of productivity implied by the proxy. The growing δ30Si(OH)4 database implies that a first principle understanding of the controls on Si isotope distributions is attainable which would improve inferences in both modern- and paleo- reconstructions. Current data show systematic variations in the isotopic signature of major water masses that appear to be driven by interactions between biological Si isotope fractionation in surface waters, the biological pump and the MOC. The deep waters of the northeast Pacific are of interest for testing this concept as they contain the highest [Si(OH)4] and oldest waters at the 'end' of the MOC. Moreover, the northeast Pacific may be unique due to the presence of the North Pacific Silicic Acid Plume that originates in the Cascadia Basin. Current data imply that the plume constitutes the largest silicon isotope anomaly in the global ocean as the relationship between Si isotopes and Si concentration across the Plume are the opposite of model predictions challenging our current understanding of the mechanisms controlling Si isotope distributions. Outside the plume the section will sample several major water masses (North Pacific Intermediate Water, North Pacific Deep Water, and Antarctic Intermediate Water and Circumpolar Deep Water) allowing further tests of predictions of how Si isotopes vary along the MOC.

We will also work with GEOTRACES P.I.s measuring N isotopes in nitrate to investigate whether Si and N isotopes can predict the high silicic acid:nitrate drawdown ratios in the HNLC waters of the equatorial Pacific and the Subarctic Pacific that the section will sample. In addition, prior US GEOTRACES sections suggest that a comparison of Si and Zn isotopes may provide a new novel constraint on the mechanisms leading to the correlation between Si and Zn concentrations in the sea.

Mark Brzezinski **1/1/2015 to 12/31/2019** **$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 10/31/2018** **$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 12/31/2019** **$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 05/31/2019** | **$150,900**
UC San Diego | 20160735(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.

Mark Brzezinski, Scott Simon | **6/1/2018 to 10/31/2018** | **$5,000**
UC San Diego | 20151994

CIMEC Science into the Oceans- to Classrooms Outreach Program

The Oceans to Classrooms (O2C) program at MSI is run by REEF DIRECTOR/Staff Research Associate, Scott Simon, and employs undergraduate that serve as docents, mentors and role models to the students through our on-, and off-, campus efforts.

On-campus instruction is done at the Research Experience and Education Facility (the REEF) located adjacent to the beach at UCSB, while off-campus efforts are conducted through the Mobile REEF which are the foci of this increment of funding. In the O2C program students learn about the marine ecosystems off southern California and the environmental and socio-economic challenges that they face. Experiences include learning the natural history of key species that are of ecological and economic importance thorough hands-on experiences with live animals and student-designed experiments on climate impacts on ecosystems including responses to ocean acidification and warming. The current funding will be used integrate current CIMEC research into relevant learning experiences for students and their teachers.

Local teachers will be informed of CIMEC, its goals and current research during teacher professional development activities. Integration is straightforward as CIMEC's mission and research naturally aligns with existing approaches within O2C.

This increment of funding will focus on the Mobile REEF. The Mobile REEF brings the O2C also experience to classrooms who may not be able to visit the REEF on the UCSB campus. Additional, it may be used as a pre/post campus visit tool to frontload students, or extend learning back in the classroom, respectively. The equipment for students to conduct experiments and live animals are brought to classrooms. The Mobile REEF program will use the same CIMEC research themes and examples to convey the importance and societal relevance of CIMEC research to students and teachers.

Deron Burkepile | **7/1/2015 to 4/30/2020** | **$840,190**
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).

Deron Burkepile **11/29/2017 to 12/31/2018** **$299,658**
Zegar Family Foundation SB180089

Coral Reef 'Bright Spots': Helping Coral Reefs Survive Climate Change

Climate change and rising ocean temperatures are causing massive, worldwide coral bleaching events. The Great Barrier Reef may have lost over 50% of its corals in the past two summers to bleaching. Few corals may survive the next 100 years. Why is this a problem? Coral reefs are one of the world's most diverse and valuable ecosystems. They provide numerous ecosystem services and are crucial sources of income and protein to around a billion people on the planet. Yet, we are at risk of losing many reefs within the next two to three generations. Our work asks two critical questions: (1) Where in the world do corals bleach and die less or more than expected based on NOAA's predictive models? and (2) What factors predict these coral reef 'bright spots" and 'dark spots', respectively? Identifying the context for bright spots, places with less than expected bleaching, could help guide future conservation decisions by enabling managers to target reefs with lower probability of bleaching that could be protected from human encroachment. Identifying dark spots, places with more than expected bleaching, could lead to changes in stress mitigation strategies if the drivers of dark spots are amenable to local management, such as local nutrient pollution or sedimentation. These potential refuges from coral bleaching may ensure that coral reefs persist during our climate crisis as we begin to control our carbon emissions.

Zachary Cabin, Scott Hodges **5/1/2018 to 4/30/2019** **$9,387**
American Genetic Association SB180174

Evidence of positive selection on a homeotic mutant of Aquilegia coerulea

Naturally occurring homeotic mutants offer a rare chance to study how a radical morphological shift affects fitness. Aquilegia coerulea var. daileyae is a homeotic mutant where the petals, with long spurs and a nectar reward, have been changed into a second set of sepals. While, this change would appear to be deleterious due to the loss of the nectar reward, I have found that the mutant consistently has a fitness advantage in a polymorphic population and has reached fixation in two other populations. Previous work identified a candidate locus (AP3-3) and I have found that non-functional alleles are perfectly associated with the mutant phenotype. I have found elevated LD at these mutant alleles indicating strong natural selection. I propose to re-sequence individuals from the polymorphic and fixed populations (and nearby wild-type populations) to determine (a) how far the elevated LD extends around AP3-3 and (b) if other regions in the genome also experience similar selection. With this information, I will be able to demonstrate current ecological selective pressure with and molecular signatures of selection favoring a radical homeotic mutant.

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

Craig Carlson **8/1/2018 to 7/31/2019** **$47,579**
University of Hawaii MA 1392

Hawaii Ocean Time-series (HOT): 2018-2023

Since 1988, the Hawaii Ocean Time-series (HOT) program has provided information on time variability in biogeochemical and physical processes in one of Earth's largest ecosystems, the North Pacific Subtropical Gyre (NPSG). The program is built around interdisciplinary shipboard sampling and data collection at near monthly intervals (10 cruises/year) at the open ocean site Station ALOHA (22.75N, 158W). The multi-investigator program is based at the University of Hawaii (UH), with key long-term partners at Oregon State University (OSU), Montana State University (MSU), Scripps Institution of Oceanography (SIO), and more recently (since 2004) Woods Hole Oceanographic Institution (WHOI). Measurements conducted by HOT continue to transform our view of linkages between ocean biogeochemistry, plankton ecology, and physical processes in the NPSG. Foremost among the program objectives are to quantify time-varying (seasonal to decadal) changes in reservoirs and fluxes of carbon (C) and associated bioelements; and identify processes controlling air-sea C exchange, rates of C transformation through the planktonic food web, and fluxes of C into the ocean's interior. This subcontract will support regular program analyses of dissolved organic carbon and total dissolved nitrogen in seawater samples collected on near-monthly HOT cruises.

Craig Carlson **9/1/2015 to 8/31/2020** **$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 11/30/2019** | **$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** | **$921,480**
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** **$740,870**
University of Miami S15-49/ SPC-000185

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.

Craig Carlson **01/19/2018 to 01/18/2021** **$602,639**
NASA 80NSSC18K0437

Evaluating the Controls of Dissolved Organic Matter Accumulation, Its subsequent Diagenetic Alteration and Contribution to Export Flux

Food web dynamics play an important role in partitioning the pelagic net community production

(NCP) between particulate (POM) and dissolved organic matter (DOM). Approximately 50% of the DOM produced is rapidly consumed to meet bacterial carbon demand. However, biotic and abiotic transformation of organic matter can lead to the accumulation of carbon-rich DOM resistant to rapid microbial degradation in the surface ocean; a fraction of this persists long enough to be entrained during overturn such that it impacts the efficiency and magnitude of the biological carbon pump. The vertical redistribution of DOM results in the global ocean export of ~1.8 Pg C from the euphotic zone, or ~20% of the total export production. Thus, vertical export of DOM represents one of the five major flux pathways central to the EXPORT program. The contribution of DOM to export flux is most pronounced at high latitudes where convective mixing and submesoscale processes deliver dissolved and suspended materials to the depth, whereby the carbon is sequestered for decades to millennia. To resolve the contribution DOM to export it is critical to obtain high quality DOM data, assess the controls on its net production, chemically characterize the accumulated pool, and quantify export; it is critical to assess the microbial bioavailability at each ecosystem / carbon cycling (ECC) state observed by the EXPORTS field campaigns in the North Pacific and North Atlantic.

Jennifer Caselle **06/01/2017 to 06/30/2019** **$192,000**
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 **05/09/2018 to 6/30/2020** **$145,381**
Nature Conservancy SB150143-Task27

TASK 27:Kelp Workshop and Action Plan

Caselle will provide general assistance to The Nature Conservancy for conducting a Kelp Forest workshop and development of an Action Plan for California's kelp forests.

Specific tasks include:

Pre Meeting:

- Contact invited scientists to encourage attendance and answer questions about meeting content and logistics.
- Help draft and revise agenda.
- Draft a ~2 page problem statement in collaboration with TNC team (not only focused on kelp loss, but regional complexity)
- Draft a "Kelp Interventions Table", including table structure and addition of a few interventions, in collaboration with TNC team.
- Draft an "Action Plan" outline in collaboration with TNC team.

Meeting:

- Give an opening presentation that sets up 3 regional presentations
- Facilitate break out discussions as appropriate, serve as subject-matter expert and meeting co-host, take notes when possible.

Post Meeting:

- Assist when possible on 3 products (not the lead due to travel): 1) Problem Statement; 2) Interventions Table; 3) Plan for Action Plan

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Jennifer Caselle **09/11/2018 to 6/30/2019** **$26,149**
Nature Conservancy SB150143- Task 29

Task 29: Monitoring of California's MPA network to improve fisheries management using citizen science and novel technology

Dr. Caselle, together with one research technicians and volunteer assistants,will complete 6 charters aboard Commercial Passenger Fishing Vessels (CPFVs) in Santa Barbara, CA. I will add a new site to my current sampling design with the California Collaborative Fisheries Research Program (CCFRP), and integrate the taking of individual fish photographs into the CCFRP sampling protocol. Camera systems and photography protocol will be developed and tested by technicians, in coordination with and approved by Lyall Bellquist from The Nature Conservancy, to identify the most appropriate and seamless method for integration with the CCFRP protocol aboard Commercial Passenger Fishing Vessels (CPFVs). Potential camera systems include, but are not limited to, use of smartphones or GoPros during the fish tagging and measuring process. Each photo will be taken with the fish lying horizontally on the measuring board or fillet table, with a U.S. quarter at least two inches away from the fish. Species, tag number, location (site name and coordinates), and total length (mm) will be recorded for each fish photographed, with a unique identifier linking the data to each photograph. We will generate a library of fish images that will be stored on Caselle lab computers, and post-processed using Poseidon to build a database of geolocated individual fish lengths across multiple species.

Jennifer Caselle, Carol Blanchette **03/01/2019 to 12/31/2019** **$26,696**
UC Santa Cruz A18-0211-S001

Mechanisms of resistance and resilience to system-wide loss of keystone predator in an iconic intertidal community

UCSB researchers will support the NSF funded project 'Mechanisms of resistance and resilience to system-wide loss of keystone predator in an iconic intertidal community' awarded to Pete Raimondi at UC Santa Cruz. Staff researcher Avrey Parsons-Field will provide both field and lab support. Field work involves maintaining field experiments and conducting surveys at central and southern California rocky intertidal sites. All collected data will be entered into standardized forms and checked prior to submission to project leaders at UC Santa Cruz. Parsons-Field will also maintain the permits for access to Hollister Ranch and Vandenburg airforce base. UCSB undergraduate students will conduct larval sorting in the lab of Jenn Caselle under the supervision on Parson-Field. Sorting of larvae from barnacle plates and tuffies will be done form the following sites: WAD, SOB, PSN, LOM, ALEG, and COPT. Samples from the UCSC group will be sent to UCSB for processing. Data will be entered and check at UCSB. All recruitment supplies will be provided by UC Santa Cruz. Parsons-Field will maintain consistent protocols for sorting with collaborators at Oregon State University.

Jennifer Caselle, Carol Blanchette **5/24/2019 to 11/30/2021** **$39,829**
UC Santa Cruz A19-0773-S004

Assessment of Rocky Intertidal habitats for the California Marine Protected Area Monitoring Program

The California Legislature passed the Marine Life Protection Act (MLPA) in 1999, requiring the state to redesign its system of marine protected areas (MPAs) to function as a statewide network in order to protect the abundance, integrity, and diversity of marine life, habitats, and ecosystems. The MLPA requires monitoring of the state's MPAs to evaluate progress toward achieving the goals of the MLPA, and to facilitate adaptive management of the network of MPAs. The recently adopted MPA Monitoring Action Plan (Action Plan) also identifies the need for monitoring of specific habitats and human uses. CDFW and OPC are now designing and implementing statewide long-term monitoring to reflect current priorities and management needs. They have requested proposals to support California's Action Plan, specifically with respect to MPA monitoring. The state is seeking information about the effects of MPAs to date, and suggestions for long-term monitoring of eight key habitats. We will be part of a team of experts in MPA design, monitoring, and evaluation to help the state

identify and evaluate changes that have occurred in the rocky intertidal portions of California MPAs and to help design plans for the continued monitoring of California MPAs.

Staff researcher Avrey Parsons-Field will provide both field and lab support. Field work involves maintaining field experiments and conducting surveys at central and southern California rocky intertidal sites. All collected data will be entered into standardized forms and checked prior to submission to project leaders at UC Santa Cruz. Parsons-Field will also maintain the permits for access to Hollister Ranch and Vandenburg airforce base.

Jennifer Caselle — **2/1/2016 to 12/31/2018** — **$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 — **5/24/2019 to 11/30/2021** — **$682,942**
UC Santa Cruz — A19-0764-S006

Monitoring and Evaluation of Kelp Forest Ecosystems in the MLPA Marine Protected Area Network

Shallow rocky reefs and kelp forests are iconic coastal marine ecosystems, which support economically and culturally significant ecosystem services along the coastline of California and its offshore islands. Consequently, this ecosystem was targeted for protection in the MLPA Master Plan and prioritized in the Marine Protected Area Monitoring Action Plan (MPAMAP). To achieve the long-term monitoring and evaluation goals identified in the MPAMAP, we have organized a consortium of institutions distributed across the three MPAMAP regions of California, with interdisciplinary expertise in ecological and environmental monitoring and MPA evaluation. The consortium is uniquely qualified and geographically situated to design, conduct, analyze and present ecological and environmental monitoring results to directly address many of the management questions identified in the MPAMAP relevant to this ecosystem. We propose to collect historic MPA monitoring and environmental data sets, collect new ecological and environmental data over all three years of the project, simultaneously analyze these data yearly, and generate graphical and textual interpretations for presentation prior to and at the 2022 evaluation review. We will conduct this work in close consultation with CDFW,

OPC and OST personnel. The overarching goal is to inform the adaptive management of California's network of MPAs with focus on network review in 2022.

The specific objectives are:

1. Conduct kelp forest surveys at selected MPA and reference sites,
2. Collect oceanographic information at selected MPA sites,
3. Conduct statistical analyses on MPA performance guided by the MPAMAP and focused on key metrics and species for kelp forest ecosystems using both recent and historical data,
4. Conduct outreach activities in partnership with CDFW and OPC.
5. Document datasets and analysis code and submit to appropriate repositories.

Task 1. Conduct kelp forest monitoring data collection in the Santa Barbara channel and northern Channel islands portion South coast MLPA region in the Kelp & Shallow Rock Ecosystems (0-30 m)

— Using standardized methods, conduct kelp forest surveys using SCUBA at MPA and references sites throughout the Santa Barbara channel and norther Channel islands.

— Train new staff and volunteers in established kelp forest survey methodology

— Selection of sites is linked directly to sites selected by the California Department of Fish and Wildlife and detailed in the MPA Action Plan

— Work collaboratively with partner academic scientists to ensure that data are collected using the same established protocols and that the data are statistically compatible.

— Work collaboratively with partner academic scientists to ensure that QA/QC procedures are compatible and implemented similarly across institutions, Task 2. Conduct analyses and participate in outreach and reporting for the 2022 MPA network evaluation

— Conduct data synthesis for the consortium – merging PISCO datasets and where appropriate, ReefCheck CA datasets

— Locate, assemble and document existing historical datasets identified in the proposal (e.g. NPS KFM, CRANE, San Nicholas)

— Conduct statistical analyses on MPA performance guided by the MPAMAP and focused on key metrics and species for kelp forest ecosystems using both recent and historical data

— Participate with other PIs on report writing and dissemination of results

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Jennifer Caselle **06/10/2016 to 05/31/2019** **$209,794**
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 10/31/2018** — **$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 — **3/22/2016 to 12/31/2019** — **$525,000**
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.

Chris Costello — **10/17/2017 to 9/30/2018** — **$47,870**
Nature Conservancy — SB150143-Task17

TASK 17: Technical training in the Economics of Fisheries Management for Mexican 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 Mexico. SFG has created the curriculum and textbooks for the course that will be used in 2017, when two, week-long training sessions are offered to government officials in Mexico.

Chris Costello — **11/1/2018 to 1/31/2019** — **$20,000**
Walton Family Foundation. Inc — C2018-2793

Walton Family Foundation Program Evaluation

The Environmental Markets Solutions Lab (emLab) team will conduct research on the initiatives and outcomes of the Walton Family Foundation (WFF) environmental programs and analyze the role that environmental markets play across the group's environmental portfolio. As a final deliverable, we will develop a presentation in which we evaluate the successes and opportunities for growth across WFF's environmental programs, and suggest how principles of environmental market design could be leveraged to improve future WFF interventions. In order to successfully create this final deliverable, our team will collaborate closely with WFF staff, soliciting their feedback and suggestions, over email and the phone, as needed.

Chris Costello | **4/26/2019 to 8/25/2019** | **$65,714**
Pew Charitable Trusts | 32876

Global Atlas of Fisheries Subsidies

UCSB will compile historical data on fishing effort as identified by GFW's cutting-edge analysis of satellite transmissions from most of the large fishing vessels transiting the world's oceans. By linking this information with data on fisheries subsidies collected by Dr. Rashid Sumaila, UCSB can estimate the distribution of these subsidies among large fishing vessels. The following general approach will be taken to analyze the effects of subsidies for distant water fishing fleets:

1. GFW will be used to identify the vessels that make up the global distant water fishing fleet and the locations and magnitudes of their fishing effort in foreign EEZs.
2. For each country known to provide subsidies to large scale fisheries, the total amount of subsidies provided will be apportioned to distant water fishing vessels based on the proportion of the total landed value for each country that was generated in foreign EEZs. These distant water subsidies will be further apportioned across vessels based on capacity and the time spent fishing. Further research might even incorporate the likely catch compositions of these vessels and the status of the affected stocks.
3. The distribution of subsidies across distant water fishing fleets will be shown relative to the landed value generated by those fleets in a series of maps and other visualizations.

Chris Costello | **6/01/2018 to 5/31/2019** | **$25,000**
Rockefeller Philanthropy Advisors | SB180197

Planning Grant for Collaborative Research Initiatives in French Polynesia

For the purpose of this project, SFG will be conducting background research on: (1) high seas fishing activity taking place by foreign fleets around FP's EEZ, and (2) nearshore fisheries dynamics and other social, economic, and ecological factors that can inform island-specific marine spatial plans and data-limited fisheries management programs in coastal zones. Over the course of this project, we will focus on answering a few key questions related to each research area:

1. **Characterizing high seas fishing activity around the border of FP's EEZ:**
   How many foreign vessels fish the border of FP's EEZ?
   From which countries do these vessels come and where else do they fish?
   What times of year are different border regions most heavily exploited?
   What is the size and value of foreign vessels' catch?
2. **Developing island-specific marine spatial plans and data-limited fisheries management programs in coastal zones:**
   What tools and approaches will allow FP to sustainably manage parrotfish, unicorn fish, and other key grazers in lagoon and fore reef habitats to ensure long-term ecosystem resilience and productivity?
   How can we engage local fishing communities and government fisheries managers to identify candidate processes for managing these resources?
   What data streams are available to us for conducting analyses that will help us develop a collaborative, data-limited fisheries management program in FP?

SFG will synthesize the insights from these research activities in two background reports. In addition to serving as the final deliverables for this grant, these reports will support the FP government and inform its future decision-making at the nearshore and offshore scales. Furthermore, given the government's sincere interest in involving SFG in their fisheries management and marine spatial planning efforts in a meaningful way, we expect that these two background reports will inform the way SFG collaborates with the FP government in the future to develop on-the-ground initiatives that will ultimately improve the sustainability and profitability of the country's marine resources and ecosystems.

Christopher Costello **05/31/2018 to 10/31/2018** **$35,000**
Pew Charitable Trusts 31791

The Future of Fisheries Subsidies: Evaluating the Economic and Biological Effects of Imposing Subsidy Bans in Global Fisheries

Despite the fact that nearly 90% of global fish stocks are either fully exploited or overfished, governments around the world continue to provide billions of dollars in subsidies to support the fisheries sector. These subsidies are often targeted at reducing or completely offsetting operational costs, fuel costs, and the cost of building new vessels or bringing more sophisticated technologies onto existing vessels, and thus often incentivize fishermen to remove more fish from the water. These subsidies are known to contribute to illegal, unreported, and unregulated (IUU) fishing, as well as other unsustainable fishing practices. It is widely believed that any global effort to recover overfished stocks will require examining and addressing the role that subsidies play in driving overfishing.

Long-running World Trade Organization (WTO) negotiations on fisheries subsidies will culminate at the 2019 Ministerial Conference, where a new agreement on fisheries subsidies will be adopted. This agreement will deliver on Sustainable Development Goal 14.6, which, by 2020, calls for the prohibition and elimination of fisheries subsidies that contribute to IUU fishing, overcapacity, and overfishing, with special and differential treatment for developing and leastδdeveloped countries. At present, eight proposals with varying parameters on subsidy bans have been submitted for review at this WTO convening.

In this proposed project, the Sustainable Fisheries Group at UC Santa Barbara will develop a first-of-itskind modeling framework that empirically evaluates the way fleets, and therefore fish stocks, would respond to a variety of policies that ban or otherwise modify different forms of subsidies. Our model will capture the full range of proposals put forward to the WTO so that it serves as a comprehensive decision-making tool that can effectively inform Pew's campaign on fishing subsidies, as well as the upcoming WTO negotiations.

Christopher Costello **10/12/2018 to 3/31/2020** **$250,020**
Pew Charitable Trusts 32088

The Future of Fisheries Subsidies: Evaluating the Economic and Biological Effects of Imposing Subsidy Bans in Global Fisheries

Phase 2 - Model Construction and Policy Evaluation

During the second phase of this project, we will use the data collected during Phase 1 to build a modeling framework to evaluate and visualize (1) the way different fleets and individual vessels would respond to a variety of subsidy reforms (spanning the range of the eight proposals mentioned above) and (2) estimates of the way the resulting changes in fishing behavior could affect global fish stocks.

Christopher Costello **01/01/2018 to 12/31/2018** **$115,000**
Gary Libecap
Nature Conservancy SB150143-Task20

Catch Share Allocation Handbook

Catch share programs, such as individual transferable quotas (ITQs), are quickly becoming one of the most ubiquitous fishery management institutions, particularly in industrial-scale fisheries, which generate most of the food and profits that come from global marine fisheries. Among the many known effects that these programs can have on the economic and biological status of fisheries, they have almost unanimously been shown to increase the profitability of the fisheries in which they are implemented. Because they typically assign a type of property right as a secure area or share of the Total Allowable Catch (TAC) in a fishery, they appear to change time horizons for fishers and associated incentives to preserve the stock and the related ecosystem. Many of these programs are granted as temporary or not defined use rights, subject to reallocation by the granting government. Catch share programs are predominantly distributed via grandfathering, but other allocation methods

as auction and equal share rules are also possible. Reallocation could involve a change in the allocation mechanism. Recognizing the tremendous economic value produced by these programs, some governments are beginning to explore options for tapping into these benefits as (1) a source of government revenue, and/or (2) a funding source for fishery science and management. Whether and how governments choose to tap into these benefits can have significant implications for the incentives fishers face in a specific catch share program or their participation in a proposed system. If fishery profits are expropriated in reallocation and the security and time frame of the assigned use right called into question, then incentives for long-term investment in the fishery and the related stock and ecosystem could change. Under these circumstances the economic, ecological, and social benefits that these programs are designed to generate could be jeopardized.

In collaboration with The Nature Conservancy, the Sustainable Fisheries Group at the University of California, Santa Barbara will develop a user-friendly handbook on catch share allocation. This project will build on previous work we have conducted synthesizing relevant information on design, quota allocation, term and security of the quota, taxation in the industry in different types of catch share programs as ITQs, Individual Quotas (IQs), Individual Vessel Quotas (IVQs), and effects on biological, economic and social outcomes and will include additional modeling work to explore outcomes of various allocation methods. Users of the handbook can assess how quota might be allocated and/or reallocated and what theory and data indicate are the likely effects of different policies. No publicly available handbook of this kind currently exists, and as these systems expand, fishers and policy makers can benefit from a rigorous, neutral assessment of allocation options. In light of this information gap, we recognize the potential value of this product for NGOs, industry representatives, government officials, and scientists, all of whom play a key role in designing, implementing, and managing fisheries.

Christopher Costello **01/01/2018 to 12/21/2019** **$91,392**
Oceano Azul Foundation SB180127

Economic Valuation of Ecosystem Services in the Azores

Our proposed approach for this work includes the following three steps:

Valuation of ecosystem services: We will work with Oceano Azul to identify local partners and experts to support our economic evaluation, and a small research team from SFG will travel to the Azores at the onset of the project to begin developing relationships with key partners and identify the scope of ecosystem services to include in our analysis. After identifying the ecosystem services of interest, we will create a list of data needs, available data, and data gaps for the economic evaluation. We will work closely with local partners to collect and synthesize key data inputs, and leverage proven methodologies to evaluate ecosystem services with use values (such as fishing, tourism, and seabed mining) and non-use values (such as species preservation, biodiversity, and bequest value). After completing the analysis, we will present and ground-truth our results with partners, ideally in person, but remotely if necessary.

Assessment of existing and emerging markets: Once we have estimated the value of different ecosystem services, we will explore the opportunities for the value of these ecosystem services to be captured by existing and emerging environmental markets, or through new financing mechanisms that we will develop ourselves. While some ecosystem services will have a direct market value, others will have only non-market values for which revenue cannot be captured. For that class of services, we will assess the potential for the Azores to access newer markets, such as payments for ecosystem services programs or biodiversity markets, in order to capture the benefits of their conservation efforts.

Explore the conservation outcomes of future policy scenarios: While a more comprehensive understanding of the value of ecosystem services will be helpful, there may be particular policy interventions under consideration that could significantly affect ecosystem service provision. We will work with local partners to identify such policies under consideration, and will estimate the ecosystem values lost (or gained) from these interventions. Examples may include: MPAs, co-management regimes (including TURFs), and possible capacity building for sustainable new businesses (such

as blue biotech, renewable energy, and scientific tourism). Ultimately we will quantify the costs and benefits of each policy scenario to evaluate the tradeoffs between the interventions, and our results can be used to inform the way Azorean authorities manage and conserve the islands' marine resources and ecosystems moving forward.

Christopher Costello **01/01/2018 to 08/31/2019** **$300,686**
The Nature Conservancy SB150143-Task22

TASK 22: Diversifying Fisheries Investment for the PNA: Evaluating the Potential Benefits of Implementing a CDQ Program in the Western and Central Pacific Ocean

This project asks: What are the economic benefits of different Community Development Quota (CDQ) program structures, and how might this play out for the PNA? CDQ programs are designed to provide small coastal communities with a viable pathway to participate and invest in their own fisheries, achieve more sustainable and diversified economies, and generate social and economic benefits that can help alleviate poverty. The CDQ program implemented in Western Alaska in the early 1990's proved to be highly successful, providing a new source of revenue for the 65 participating Alaskan villages, and supporting the creation of more robust economies and social programs. In October 2017, members of The Nature Conservancy's Pacific Fisheries Program (TNC) traveled to Alaska with leaders of the Parties of the Nauru Agreement (PNA) to get a firsthand look at the way the Alaska CDQ program positively transformed participating communities. Given the similarities between Western Alaska and Pacific Island economies and communities, TNC and PNA CEO Ludwig Kumoru are interested in exploring the potential for a CDQ program to be implemented in the PNA to help local communities increase value capture from their fisheries. In the coming months, Kumoru and TNC will begin socializing this novel concept with the Heads of Fisheries of the eight PNA member countries.

Christopher Costello, Steven Gaines **12/31/2012 to 12/31/2019** **$3,861,324**
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** **$162,532**
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, Steven Gaines **05/01/18 to 7/15/2019** **$125,000**
Global Fishing Watch 39117633A

Building the Global Tuna Watch System: Detecting Human Rights Violations in the Global Tuna Fleet

Our partners at Global Fishing Watch (GFW) are using their revolutionary platform to shine a light on industrial fishing activity across the world's oceans. GFW is now launching an exciting new program called Global Tuna Watch for which they will be adding new functionality to their existing system in order to (1) visualize the global supply chain for tuna from fishing line to port, (2) detect illicit behavior within the tuna fleet, including illegal fishing, transshipment, and human rights violations; and (3) support adoption activities among States and regulators that foster greater transparency, sustainability, and social responsibility within the global tuna supply chain. Building this tool will require the development of key analytical and engineering products, data from multiple sources, and close engagement with human rights experts who can provide insights into vessel behaviors and help validate our work.

Working closely with GFW, the Sustainable Fisheries Group (SFG) will play a key role in creating this new tool by developing a predictive model that can be used to identify vessels that are likely committing human rights violations, focusing specifically on forced labor. The model SFG develops will be used to show trends of human rights violations within the tuna fishery, including where these violations are occurring, what sectors of the fleet are involved, and patterns over time. Ultimately, this information will increase transparency and awareness of this problem among the global community, and could be used by distributors and suppliers--including Walmart, the original funder of this project--to stop sourcing seafood from these vessels, and by governments and NGOs to anticipate, respond to, and prevent these activities.

Christopher Costello, Steven Gaines **07/01/16 to 07/01/2018** **$367,739**
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 **06/01/18 to 11/30/2019** **$216,328**
Steven Gaines
National Geographic Society SB180183

Mapping Global Conservation Priorities

The vision of the Pristine Seas project launched by National Geographic's explorer-in-residence Dr. Enric Sala, is to identify, survey, and help protect the last wild places in the ocean. The Sustainable Fisheries Group at University of California, Santa Barbara, will collaborate with Dr. Enric Sala and other academic and non-governmental organization partners to develop a global map that prioritizes future marine protected areas motivated by the most cost-effective means of meeting four conservation objectives: 1) biodiversity, 2) productivity, 3) ecosystem resilience, 4) climate mitigation.

This ambitious endeavor will synthesize existing global datasets on indicators of biodiversity, productivity, ecosystem resilience, and climate mitigation, and consider threats to each (e.g. fishing, climate change) to develop new cutting-edge analyses to identify spatially explicit global marine conservation priorities that achieve these objectives now and into the future. To understand the feasibility of implementing expanded marine conservation areas around the world, these analyses will consider the costs, and benefits of realizing various spatial configurations of protection.

This global analysis will inform the most important global marine targets for conservation and will be an essential input into the Convention on Biological Diversity's (CBD) Post-2020 Biodiversity Framework.

Christopher Costello **06/01/2018 to 11/30/2018** **$41,500**
Nature Conservancy SB150143- Task 28

TASK 28:: A Framework to Compare the Cost Effectiveness of Electronic Monitoring (EM) Systems and Human Observer Programs & Case Studies

Modeling framework - for comparing the cost-effectiveness of different levels of EM and HO coverage in different types of fisheries, at different scales, for different management goals, and accounting for biases and inaccuracies in each program.

ShinyApp - through which stakeholders can explore the relative costs of using HO coverage or EM to meet specific management goals for a range of coverage targets.

Final report - detailing the results of the French Polynesia and FSM analyses, e.g., the costs of each program type and the conditions under which each country would want to choose one program type over the other.

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 | **11/01/17 to 6/30/2018** | **$5,000**
Nature Conservancy | SB150143-Task18

Task 18: Mapping Global Aquaculture

UCSB and The Nature Conservancy both recognize the growing importance of aquaculture as a sustainable food production system that can have negative environmental consequences if improperly managed. Properly managing the aquaculture sector globally will require improved information on how and where aquaculture is growing around the world to assess social, economic, and environmental costs and benefits.

The purpose of this task agreement is to work towards development of a collaborative project between the Nature Conservancy and UCSB to globally map aquaculture facilities ("Mapping Global Aquaculture" project). Both parties recognize that a project of this ambition is a major undertaking under which resources need to be combined to be successful. It is envisioned that a collaborative project will involve staff from both UCSB and the Nature Conservancy to participate in the fundraising, project design and strategy and implementation for the project. Concurrently, UCSB and TNC will be pursuing funding from other independent sources to support the overall work.

Christopher Costello | **11/01/17 to 2/15/2019** | **$91,867**
Ocean Conservancy | SB180069

Driving Management Innovation in the Indonesian Deep-Slope Snapper Fishery

The Sustainable Fisheries Group at the University of California Santa Barbara (UCSB) will support a collaborative project with the Ocean Conservancy and the Nature Conservancy on modeling sustainable fisheries interventions in Indonesia. The joint project is focused on the deep-slope snapper-grouper fishery complex in Indonesia. The deep-slope snapper fishery in Indonesia's Timor Sea (Fishery Management Area 573) serves as a great beta-site for the development of new, replicable fisheries management tools. Through their deep, on-the-ground engagement in Indonesia, TNC has assembled the fundamental building blocks of this effort: an accurate taxonomy of the local snapper complex, biological information regarding the health of key species, and spatial information on fishing patterns. The joint project team will harness these critical datasets, as well as new field data on fisher decision-making and responses to price premiums. Our team will use an agent-based model to map pathways to MSC certification in the fishery by 2022, optimizing around the fishery objectives and key data sources identified in the MSC pre-assessment, scheduled to be completed in September 2017. UCSB will be primarily focused on supporting the development and validation of policy interventions on spatial effort controls and market interventions on price premiums to model for the snapper-grouper fishery, but they may also contribute more broadly to the project.

Carolynn Culver | **03/01/2017 to 1/31/2019** | **$83,518**
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.

Carolynn Culver **02/01/2019 to 1/31/2020** **$8,331**
UC Sea Grant College Program A/EA-19CC

Aquatic Resources Research, Education & Outreach Program

This award is in support of Dr. Culver's Sea Grant Extension program, a program 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 outreach program. Some funds are allocated toward support staff that will assist Culver with program activities, including assistance with field sampling, processing of samples in the laboratory and office support. General operating expenses are included for such things as supplies, telephone, transportation for sampling, and stipends for material review and program trainings.

Carolynn Culver, Henry Page **09/01/2018 to 8/31/2020** **$279,317**
National Oceanic and Atmospheric Administration (NOAA) NA18NMF4270219

Gathering essential fishery information for the brown box crab, Lopholithodes foraminatus, to assess the potential for a new California trap fishery

The goal of this project is to gather essential fisheries information needed to evaluate the feasibility of a sustainable fishery for the brown box crab, Lopholithodes foraminatus, in California. Our objectives are threefold and include: 1) generating basic life history information on growth; 2) assessing reproductive capacity; and 3) exploring the trophic position and role in ecosystem functioning. We will use a combination of field surveys and laboratory analyses to achieve our objectives. For our first objective, we will determine molting seasonality by molt staging a monthly sample of crabs from each region and calculating the proportion of pre- and postmolt animals. Growth rates will be investigated through analysis of gastric mill growth bands, size frequency distributions, and studies of molt increments and intervals. We also will determine size at maturity (physiological and functional) for each region through examination for mature gametes and readiness to mate as determined through presence of eggs for females and setae wear on gonopores for males. To access reproductive capacity (Objective 2), we propose to evaluate reproductive seasonality, fecundity, and brood duration and mortality. Reproductive seasonality will be determined through the analysis of reproductive status for the same samples used for evaluation of molting seasonality. Size-specific fecundity and brood duration and mortality will be assessed through laboratory studies on subsamples of gravid females. Lastly, we propose to investigate the trophic position of L. foraminatus through laboratory studies using a combination of stomach content analysis (SCA) and stable isotope analyses (SIA). Together these methods will provide information on recent (SCA) and cumulative (SIA) diets over time, something not previously evaluated for this species. This information will help identify the role box crabs play in deep water ecosystems.

We will work with commercial fishermen to obtain samples of box crabs throughout the year. We will rely on monthly samples from trappers that are interested in this fishery, including those that have submitted a request for an experimental fishing permit. We also will seek supplemental samples from trawl fishermen that may encounter box crabs while they are fishing. Obtaining samples from both gear types will ensure information on active and inactive stages. Crabs caught in traps represent the target of the fishery and include only active crabs – those that are attracted to bait and may enter traps. Trawls are able to sample inactive animals.

The information we gather on growth, maturation, reproduction and trophic level will be synthesized to summarize the life history of the box crab in California and potential implications for management. We will hold a workshop at the end of the project to share the results with fishermen, resource managers and others interested in the fishery and to discuss management options and future research needs.

Carla D'Antonio **04/20/2016 to 04/19/2021** **$256,027**
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 08/31/2020** **$808,712**
National Science Foundation 1557177
REU Supplement $13,450

Collaborative Research: Do Ecological Feedbacks Across Trophic Levels Affect Alternate Stable States and Restoration of Tropical Forests?

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.

Carla D'Antonio **09/01/2018 to 08/31/2023** **$418,000**
USDA Forest Service 18-CS-11050700-016

Ecological Restoration Support for Post-fire Landscapes

While fire is a natural disturbance across the wildlands in southern California, short interval fire and fire suppression tactics that remove vegetation and disturb soil can promote undesirable non-native species, particularly annual grasses. The characteristics of many non-native species (e.g. shallowly rooted, low live fuel moisture, high stem density, low structural diversity) reduce habitat quality for

native biota and increase the probability of erosion and fire ignitions. Ecological restoration of native shrubs along contingency lines, fuel breaks and degraded areas within the fire scar is an important goal of the post-fire restoration strategy for many fires across US Forest Service lands in southern California. To date, however, restoration of native chaparral has proven challenging and costly. In particular restoration from seed has been wholly unsuccessful. The purpose of this work is to develop and implement restoration techniques that minimize cost and maximize success within the Piru and Zaca Fire scars on the Los Padres National Forest. Together US Forest Service and UC Santa Barbara plan to undertake active restoration along degraded contingency lines and staging areas with a focus on selecting species that are competitive against non-native species and resilient to drought and moderate disturbance. In areas with vetted fuel breaks that are likely to undergo frequent disturbance, restoration will be focused on replanting native species with higher live fuel moisture than invasive annuals, and low stature to limit fire spread and intensity. Ideally these species would also have high resistance to occasional mowing. This strategy will help align the goals of ecological restoration with those of fuels and vegetation management.

Statement of Purpose

The purpose of this agreement is to document the cooperation between the parties to provide analytical and field support to restoration within the Zaca and Piru Fire scars on theLos Padres National Forest, in accordance with the following provisions and the hereby incorporated Operating and Financial Plan, attached as Exhibit A.

Statement of Mutual Benefit

The collaboration will benefit both parties. Maintaining the integrity of natural resources is a priority following wildfire on US Forest Service managed lands, therefore there is a desire to increase capacity to support native vegetation recovery through ecological restoration and the creation of resilient landscapes. The Forest Service is entering into an agreement with UC Santa Barbara to enhance its capacity to conduct seed collection, plant propagation, restoration design and implementation, and field monitoring. Principal benefits to the southern California National Forests will include: partnership to enhance stewardship of US Forest Service lands, plant propagation, capacity for restoration implementation, more robust study design and statistical analysis, authorship of reports and studies, implementation of presentations, and field trips; and a report detailing the best methods for ecological restoration in areas disturbed during fire. The US Forest Service, Pacific Southwest Region has a long history of fruitful collaboration with UC campuses, and previous cost share agreements that have resulted in the training of future US Forest Service employees, long-lasting partnerships that enhance stewardship of federal lands and the production of influential publications co-written by Forest Service and UC investigators, including students, and land managers. UC Santa Barbara is among the top-rated ecological research universities in the United States, and will be a high-quality partner in collaborative projects with the Forest Service in southern California. Student training and outreach is a hallmark of this cost share agreement and will provide much needed hands-on experience to paid and volunteer students and recent graduates. The US Forest Service, being a land management organization, is in a prime position to expose students to state and federal environmental sampling protocols, and guide students on the use of these programs to ensure the collection of defensible data suitable for environmental decision making. By executing a cost-share agreement between UC Santa Barbara and the US Forest Service, Regional Ecology Program, paid and volunteer students will gain highly transferable skills during their tenure working on the Los Padres and other national forests. These include experience in plant identification, plant propagation, restoration methodologies, project monitoring, and data collection, entry and summarization. To this end, the University of California, Santa Barbara will benefit from this partnership in multiple ways: 1) this agreement will provide financial support for graduate, recent graduates and/or undergraduate students; 2) scholars, paid and volunteer students supported by this agreement will develop technical skills and receive training and experience in ecological field investigation and restoration; 3) paid and volunteer students supported by the agreement and primary investigators will learn Forest Service methods and field protocols in inventory and monitoring of shrubland and grassland conditions; 4) UC Santa Barbara investigators, including students, will collaborate in the analysis, write-up and publication of results in peer-reviewed science journals, which will directly benefit

the investigators and further solidify the university's standing as a leader in ecological research. Through this process students, recent graduates and volunteers will position themselves for careers in field biology and become competitive for acceptance into graduate school; 5) UC Santa Barbara investigators and students will receive access to data that will form the basis for further ecological analyses, publications, and classroom curricula; 6) scholars and students will be exposed to Forest Service personnel and practices, which could provide access to future employment with the US Forest Service. 7) US Forest Service personnel will engage in classroom presentations and community outreach that highlight the partnership between UC Santa Barbara and US Forest Service. Results of the work carried out under this agreement will be presented at management and professional conferences and in seminars on campus.

Carla D'Antonio **06/01/2018 to 06/30/2019** **$184,280**
Natl Fish And Wildlife Foundation 0806.18.059767

Evaluation and restoration of degraded chaparral within Piru Fire perimeter: Phase II

Fire frequency is increasing across southern California shrublands while drought and invasive grasses continue to constrain chaparral recovery. Degradation of chaparral into alien grassland/ savanna is increasing at lower elevations and on south facing slopes. The prevalence of dry invasive grasses in such areas increases the likelihood of future fire while decreasing native plant diversity. This project evaluates methods to restore chaparral species into degraded sites within the Piru Fire perimeter. Restoration of chaparral species has been largely unsuccessful in California. Most projects are successful only at restoring sage scrub species such as Artemisia californica and Eriogonum fasciculatum where chaparral species have disappeared. Thus, more information is needed on how to get the slower growing, larger evergreen chaparral species to establish and persist in degraded sites. This project is designed to begin to fill the information gap on how to restore chaparral species. We propose two strategies for bringing more insight to this challenging problem. Strategy (1) employs large scale planting across a several acre area focusing on 8 species planted across a heterogenous landscape. Strategy (2) takes a more local trait-based approach, planting out specific assemblages designed to either withstand drought, or suppress invasive species or a combination that balances drought tolerance, resprouting ability and competitiveness while maximizing native species richness.

Thomas Dudley **07/01/2016 to 12/31/2018** **$98,169**
Adam Lambert
National Fish & Wildlife Foundation 0806-16-052206

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 **08/09/2018 to 07/31/2019** **$28,000**
Adam Lambert
USDA Forest Service 18-DG-11052021-227

Biological control implementation for giant reed (Arundo donax) and Cape-ivy (Delairea odorata) in southern California

The bicontrol programs for the riparian weed species giant reed/arundo and Cape-ivy are at a critical stage of refinement and implementation in California. The Cape-ivy fly has developed in cages northern CA, but timing of release and warm, dry conditions likely impeded survival at the one test

site in southern CA (Portman and Moran 2017). The imported arundo wasp has not yet established in northern CA (Bitume and Moran 2017) but an unintentionally introduced form of this wasp is present in southern counties (Dudley et al. 2008) and may be better suited for re-distribution in the State. The arundo armored scale was successfully transferred to plants in the field in northern CA, but the release techniques have not been tested in central and southern CA; a similar scale of uncertain identity was recently discovered in southern CA which also may offer potential for statewide re-distribution, if found to be taxonomically and ecologically similar to the imported insect.. In addition, a non-native arundo fly is sparsely present at some southern CA sites and causes significant impact; a form of this Arundo fly is the subject of pre-release overseas testing but has not yet been imported into North America.

Thus, both biocontrol programs need refining to ensure implementation success in infested coastal and inland watersheds from the Oregon border to San Diego, including taking advantage of the potential for augmentation biocontrol using specialist herbivores present in currently limited ranges. Prior experience with weed biocontrol agents shows that latitude, climate and moisture gradients influence establishment (e.g. Byrne et al. 2002, Bean et al. 2007; Reeves 2017), particularly if only one/two genotype/accessions of the agent are available, as is the case for arundo and Cape-ivy. The goal of this project is refine release methods and assess establishment and early impact of these agents in central-southern CA, in coordination with USDA cooperators in northern CA, and to evaluate the potential for re-distribution to regions where weed control is desired. The objectives are:

1. Conduct studies of specialist herbivores currently present, to determine taxonomic affinities, relationships with host plants and suitability for re-distribution to other parts of the State;
2. Release biocontrol agents into controlled field environments to assess establishment and developmental responses, , while measuring efficacy in relation to geographic and climatic factors;
3. Conduct open releases where appropriate to assess initial establishment and dispersa behaviorl;
4. Develop field monitoring protocol for subsequent (including post-project) evaluation of impact to target weeds, and changes in plant community composition.

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 **07/26/2018 to 12/31/2019** **$11,632**
Justin Russak
Montana State University G114-19-W5957

Using an aggregation compound formulation to strategically focus Diorhabda carinulata (Desbrochers) on Tamarix spp.: Enhancing the impact of a defoliating herbivore and improving the operational efficiency of monitoring establishment and population expansion.

Our goal is to optimize the deployment of male-produced aggregation pheromone of the tamarisk leaf beetle, Diorhabda carinulata (Dc), introduced for the biological control of Tamarix spp., to better develop, implement and assess the biocontrol program in western North America. The project directly addresses two of the Priorities for the 2014 FHP/FHTET Biological Control of

Invasive Plants program, specifically to: 1. Develop improved rearing, distribution and post-release monitoring techniques for a biological control agent; and 2. Develop and implement technologies for rapid quantitative assessment of biological control impacts. It also indirectly addresses the final FHTET Priority, 3. Integrated weed management with a biological control component that is part of a methods development approach to determine efficacy and is not considered an operational treatment. Elements of the project are directed at enhancing the effectiveness of Tamarix biocontrol programs in FS Regions 1, 2, 4 and 6 where Dc has been historically released, and to evaluating its dispersal and establishment in FS Regions 3 and 5, and portions of Region 4, where population expansion is occurring and federally listed wildlife populations are potentially at risk via defoliation of nesting habitat. The sub-project combines with the Montana State University research program into a unified theme of optimizing efficacy of biocontrol of Tamarix spp. by Dc and by monitoring its continued expansion and establishment. The core component of this is the strategic use of commercially formulated aggregation pheromone (in SPLAT™). The following objectives are centered on this technology.

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 **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 04/30/2019** **$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.

Thomas Dudley **10/01/2017 to 06/30/2019** **$124,972**
National Fish and Wildlife Foundation 0808.17.057447

Evaluation and Biological Control of IFire-promoting Invasive Riparian Plants in LPNF River Systems

Invasive plants in riparian systems, esp. non-native tamarisk (Tamarix spp.) and giant reed (Arundo donax), degrade habitat for biodiversity, and alter fire regimes by increasing ignition risks and subsequent fire severity and spread. We will assess the current status of these and other potentially fire-promoting weedy species in and adjacent to Angeles NF riparian systems, and develop management prescriptions based on a set of prioritization criteria. In particular, we will implement biological control measures for these and other weedy taxa for which agents have been approved by USDA-APHIS, and participate in development of biocontrol for other target weeds. Tamarisk biocontrol with D. carinulata will be implemented, and a monitoring program established to document its impact to invasive Tamarix and the responses of other plants and ecosystem elements to weed suppression.

Arundo biocontrol with the two candidate agents will be implemented if feasible. We will prepare brochures and online information, along with meeting with agency representatives and citizen organizations, to enhance understanding of the process of weed biocontrol and the relative costs and benefits of biocontrol implementation as an alternative to herbicide use. This will be done in the context of our CalEPA-sponsored Calif. Alliance for Tamarix Biocontrol program for extending weed suppression to tamarisk-infested systems across California.

Jenifer Dugan **4/1/2015 to 3/31/2020** **$1,027,987**
Robert Miller
J Carter Ohlmann
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 **5/24/2019 to 11/30/2021** **$485,484**
Robert Miller
Henry Page
UC San Diego C0302700

Evaluating the performance of California's MPA network through the lens of sandy beach and surf zone ecosystems

Sandy beaches and their surf zones make up a large proportion of the open coast of California and are significant components of many MPAs statewide. The rich and productive food webs of beaches, including invertebrates, fishes and birds, are closely linked to subsidies from rocky reefs and coastal waters. In MPA baseline studies, these subsidies were shown to strongly affect the diversity and abundance of prey resources available for surf zone fish and birds in recipient beach ecosystems. Thus, MPA protection can affect beaches and their surf zones in two ways: directly through harvest of fish, and indirectly through the influence of trophic cascades and other factors influencing the key donor ecosystems of kelp forests and rocky reefs. The strong connections of beaches to rocky habitats, especially kelp forests, are key ecological pathways through which direct and indirect effects of MPA protection can cascade, making sandy beaches and surf zones an important element of long-term monitoring and integrative analyses to assess the performance of MPAs and inform adaptive management of the State's MPA network.

Our project goals for using beach and surf zone ecosystems to address MPA performance and the evaluation questions and goals of the MLPA are two fold. We will assess indirect effects of MPAs by exploiting the bottom up effects of the ecological connectivity of sandy beaches with kelp forests and rocky reefs thru monitoring the abundance and composition of kelp subsidies and birds. We will assess direct effects of MPAs by surveying the abundance, biomass, size and diversity of surf zone fish, including harvested species. We will monitor: 1) abundance and diversity of birds that forage on sandy beaches and in adjacent surf zones, including shorebirds, seabirds and terrestrial birds 2) population size structure, abundance and diversity of ecologically and culturally important surf zone fishes that could directly respond to MPA protection: including surfperch species, atherinids, flatfish, sharks, and rays, 3) abundance and composition of kelp wrack subsidies cast onto beaches from

adjacent intertidal and subtidal ecosystems inside and outside MPAs, and 4) physical characteristics of sandy beaches and adjacent surf zones over time inside and outside MPAs. We will use new and existing datasets to conduct integrated analyses across sites and regions and donor and recipient ecosystems to evaluate MPA performance and inform adaptive management through the lens of sandy beach and surf zone ecosystems

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Jenifer Dugan **5/1/2018 to 4/30/19** **$5,000**
California Department of Fish and Wildlife P1775043

Polycyclic Aromatic Hydrocarbon (PAH) Exposures using Talitrids

Study Objectives:

Plan, coordinate and collect biotic samples of intertidal biota using clean techniques. Provide the live animal culturing expertise and training needed to conduct a bioassay experiment on the effects of petroleum hydrocarbons on intertidal talitrid amphipods.

Task to be accomplished include:

1) Collect samples of adult talitrid amphipods for use in tissue analysis from a to be determined beach location along the coast of California, These samples of intertidal biota will be collected using clean techniques for tissue analysis and transmitted for to a laboratory for analysis using appropriate COC and handling protocols.

2) Establish laboratory culturing and bioassay testing techniques and set up replicated culture vessels for talitrid amphipods for use in a laboratory bioassay experiment to be conducted at the Granite Canyon Research Facility in Monterey, CA.

3) Collect live samples of adult talitrid amphipods from an uncontaminated site using clean techniques that will be suitable for use in laboratory bioassay experiments.

Erika Eliason Parsons **9/1/2017 to 6/1/2019** **$145,730**
National Fish and Wildlife Foundation 0808.17.057446

Using environmental DNA to Map the presence of aquatic species of interest in watersheds within and near the Copper, Ranch and Sayre fire scars

Environmental DNA analysis is an inexpensive and highly effective tool for assessing the presence of aquatic species within watersheds. Sampling streams within and near the Copper, Ranch, and Sayre fire scars will further current knowledge of both native and invasive species distributions in relation to fire history. This knowledge will allow important questions concerning ecosystem responses to fires to be addressed and inform appropriate management actions to recover listed species and suppress invasive species.

Erika Eliason Parsons **5/9/2016 to 5/8/2021** **$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.

Erika Eliason Parsons **9/1/2017 to 9/1/2019** **$145,730**
National Fish and Wildlife Foundation 0808.17.057446

Using environmental DNA to Map the presence of aquatic species of interest in watersheds within and near the Copper, Ranch and Sayre fire scars

Environmental DNA analysis is an inexpensive and highly effective tool for assessing the presence of aquatic species within watersheds. Sampling streams within and near the Copper, Ranch, and Sayre fire scars will further current knowledge of both native and invasive species distributions in relation to fire history. This knowledge will allow important questions concerning ecosystem responses to fires to be addressed and inform appropriate management actions to recover listed species and suppress invasive species.

Steven Gaines **3/1/2019-12/31/2019** **$188,075**
Bradley Darcy
The Grantham Foundation for the Protection of the Environment SB190210

Seaweed Aquaculture: A climate mitigation strategy worth pursuing?

The proposed project seeks to add concrete insight to the role seaweed aquaculture could play in carbon offsetting, using approaches that have not been previously applied to this area of research (LCA and bioeconomic feasibility modeling). If we are able to find economic strategies worth pursuing to scale seaweed aquaculture in Phase 2, we would want to be a part of the process that turns our theoretical solution into a real-world application. We would host a workshop with industry, non-profit, and government representatives to work towards implementing proposed solutions in a location (either working with existing farms, or equipping farms with engineered solutions to maximize production and sequestration). We would then complete field testing to collect primary data to ground truth our modeling efforts. This envisioned next phase would be the first step in being able to scale the project globally.

Given the urgency of climate change related threats to our planet, the world is looking for creative ways to get to carbon neutrality. If our project is successful, we will create a platform for identifying novel solutions, which could help support new business ventures. To this end, we will work with the Grantham Foundation to identify the best pathways for dissemination of results and analytical tools that promote the successful implementation of innovative solutions and new business ventures.

Steven Gaines **8/1/2017-1/31/2020** **$12,860**
Karly Miller
National Science Foundation 1735886

Doctoral Dissertation Research: Assessing the effects of tourism development on small-scale fisheries

This research investigates the human-environment interactions of tourism development in rural coastal communities, specifically asking how tourism development affects small-scale fisheries. The goal of this proposal is to use qualitative research methods to investigate: (1) How the availability of alternative livelihoods changes fishing behavior, (2) How the presence of tourists changes the demand and local consumption of seafood, and (3) How these changes affect community and household socio-economic status, food security, and marine resource impact. Through interviews, participant-observation, and archival research this study will probe the directionality and causality of relationships

that emerged during previous fieldwork conducted by K.M. Miller. This proposal hypothesizes that tourism development leads to an increase in seafood demand and a decrease in fishing effort in the community, leading to possible intensification, and ultimate displacement of effort to neighboring communities and international markets. This will be accompanied by an average increase in socio-economic status and food security, but as inequality increases with development, it will also mean that some families experience decreasing nutrition and food security as seafood becomes more expensive to acquire.

Steven Gaines **1/1/2018-12/31/2018** **$31,594**
Conservation International Foundation SB180117-Task1

TASK 1: Guiding Sustainable Aquaculture: Developing Policy and Planning Guidance for Governments and Business

The Sustainable Fisheries Group at the University of California Santa Barbara (UCSB) will support a collaborative project with Conservation International (CI) and the Sustainable Fisheries Partnership (SFP) on developing governance guidelines on best practices in aquaculture policy and regulation for government agencies, production industries and supply chain businesses in Indonesia. Aquaculture has grown substantially in the last few decades and will continue to grow with rising seafood demand. Appropriate and effective governance of this sector has lagged behind this growth, often leading to a degraded environment and jeopardizing this sector's sustainability. Science-based, effective governance guidelines on how to best regulate and manage the aquaculture industry are needed urgently. This is especially true in Indonesia, the world's second largest aquaculture producer. Our joint team will review key scientific and technical guidance for zonal aquaculture management, analyze applicable legal and policy systems in Indonesia, and strengthen relationships between critical Indonesian government, communities and private sector partners. Our team will provide actionable guidance, enabling government and private sector partners to develop a responsible and sustainable aquaculture sector in Indonesia. UCSB efforts will be primarily focused on supporting the development and synthesis of scientific and technical guidance guidelines for two critical areas: 1) spatial planning of aquaculture and 2) interactions between marine aquaculture and wild fisheries, but they may also broadly contribute to the project. Specific responsibilities include: • Participate in virtual and, if possible, in-person meetings with CI, SFP, Indonesia government and/or other project participants to discuss project development, direction, and deliverables and advise on any guideline development. • Review and synthesize scientific and technical guidance for key issues related to aquaculture spatial planning and siting and interactions between marine fisheries and aquaculture sectors. • Co-develop a white paper with SFP that outlines best practices for aquaculture governance and actionable scientific guidance for the planning and implementation of aquaculture management, focused on leading content related to aquaculture spatial planning and siting and interactions between marine fisheries and aquaculture sectors. • Support the development of two summary documents with SFP for government and supply chain stakeholders on the key findings of the white paper. • Participate in key stakeholder meetings to review the findings and guidelines of the white paper and advise on a blueprint for pilot implementation phase of this project.

Steven Gaines **9/28/2018-8/30/2019** **$50,000**
Environmental Defense Fund SB190069

Predicting and Planning for Regional Climate Change Impacts on Fisheries

We are already beginning to witness countless ways in which climate change is reshaping marine ecosystems worldwide. As our oceans continue to warm in the decades to come, we expect that there will be significant changes in the productivity of global fisheries, as well as major shifts in species' current geographic ranges. Both of these climate change impacts will have serious implications for the stability and well-being of communities around the world that rely on the presence of healthy and stable fish stocks for their livelihoods and food supply. In a newly published study led by our research team from the Sustainable Fisheries Group (SFG) at UC Santa Barbara and collaborators from Environmental Defense Fund (EDF), we find that while changing climate conditions

do pose a serious threat to global fisheries, we could in fact have higher profits and yields in the future, relative to today, if fisheries are reformed to fix current inefficiencies, adapt to changes in fisheries productivity, and include new, effective transboundary institutions. Our results suggest that improving the management of global fisheries today could offset some of the future negative impacts of climate change. The model we created for the aforementioned study successfully produced broad insights about global patterns in fishery responses to climate change (e.g., changes in productivity and geographic range shifts). Our model outputs indicate that management reform has the potential to improve future outcomes for fisheries under changing climate conditions, but this analysis was done at a global scale and did not produce country-level results. EDF is now interested in expanding upon our previous work to gain insights at the level of individual countries that will help inform their strategy moving forward and determine the most impactful areas of focus in the countries where they are already engaged. More specifically, these country-level results would illuminate (1) how fisheries in EDF's 12 target geographies are likely to be affected by changes in productivity and range shifts due to climate change, and (2) the role that new or existing institutions could play in proactively addressing these expected changes to ensure the resilience of effected fisheries and the people whose lives depend on them. This project will consist of two phases: Phase 1 - Applying the Global Model to EDF Target Geographies in Phase 1, SFG will use our global model to take a first look at EDF's 12 target geographies (United States, Mexico, Peru, Chile, European Union, China, Myanmar, Japan, Indonesia, Philippines, Pacific Islands and Vietnam). Contingent on approval for use of the global spatial species dataset used in our global paper, we will project the climate change effects on fish stocks in individual EEZs and evaluate the validity of and our confidence in these country-level results. Phase 2 - Building a Framework for Robust Country-Level Analyses We expect the global model will not be able to produce robust country-level results for many of EDF's target geographies. Therefore, in Phase 2, based on what we learn from our Phase 1 results, we will develop a framework outlining what it will take (e.g., more data, alternative modeling approaches, new partnerships, etc.) to effectively model country-level climate change effects on fisheries in the 12 geographies of interest. Ultimately, the results produced by these country-specific models will produce information EDF needs to identify the technical or institutional solutions that are required to address the most pressing climate change challenges facing each country's fisheries.

Steven Gaines **5/1/2018-6/30/2019** **$17,000**
Kelly Caylor
Nature Conservancy SB150143-Task 25

Task 25: Dangermond Preserve Bren Summer Interships and Group Project

This research investigates the human-environment interactions of tourism development in rural coastal communities, specifically asking how tourism development affects small-scale fisheries. The goal of this proposal is to use qualitative research methods to investigate: (1) How the availability of alternative livelihoods changes fishing behavior, (2) How the presence of tourists changes the demand and local consumption of seafood, and (3) How these changes affect community and household socio-economic status, food security, and marine resource impact. Through interviews, participant-observation, and archival research this study will probe the directionality and causality of relationships that emerged during previous fieldwork conducted by K.M. Miller. This proposal hypothesizes that tourism development leads to an increase in seafood demand and a decrease in fishing effort in the community, leading to possible intensification, and ultimate displacement of effort to neighboring communities and international markets. This will be accompanied by an average increase in socio-economic status and food security, but as inequality increases with development, it will also mean that some families experience decreasing nutrition and food security as seafood becomes more expensive to acquire.

The Nature Conservancy's recent establishment of the Dangermond Preserve, a 25,000 acre protected area at Point Conception, presents a rare opportunity to engage historical information in designing effective protection, restoration, management. With many sacred Chumash sites and its unique location at Point Conception where the cold Pacific current meets the warmer waters from Baja California, the Preserve represents an area of exceptional natural and cultural value. Site surveys

show it is home to over 50 endangered and rare species, making it a hotspot for biodiversity. The land was previously known as the Cojo and Jalama Ranches, or collectively, the Bixby Ranch. Starting as a Spanish land grant, the property was ranched for over 100 years and is home to oak woodlands, coastal prairies, and eight miles of untouched coastline.

This Group Project represents an unparalleled opportunity to work with TNC to incorporate historical ecological information with leading conservation science during the creation of the Dangermond Preserve Management Plan. The use of historical information to study past ecosystem characteristics is a broad interdisciplinary field referred to as "historical ecology". Historical ecology is a critical component in identifying locally appropriate restoration targets. Similarly, historical ecology can help us design and manage more flexible, resilient future ecosystems. The study of historical landscapes can provide clues to how ecosystems were adapted to a highly variable climate regime, buffering the effects of environmental extremes. This research will inform planning uncertainties that TNC has regarding the creation of a management plan for the preserve.

The objective of this Group Project and student internship opportunity is to compile and synthesize historical data and information that can support TNC management and restoration planning for the Dangermond preserve. Thus, TNC is proposing a project to explore the historical ecology of the Point Conception region and the new Dangermond Preserve to determine what conservation goals are appropriate for the terrestrial or marine ecosystems. Bren students will engage in the conservation management planning process and other data and analytic approaches to inform management approaches that promote climate resilience. TNC has amassed a great deal of ecological data relevant to the property, but is lacking historical baseline information and guidance for how historical information can best inform management planning. Specifically, Bren students will:

- Analyze current ecosystem at the Dangermond Preserve and combine with historical knowledge and data-driven approaches to provide a frame of reference for assessing modern patterns and processes.
- Provide guidance for using historical information in management planning, monitoring and change detection (e.g. resampling of survey plots and photo points) in support of a climate resilient preserve.
- Provide to TNC a final report summarizing their findings at the end of the internship.

Steven Gaines **5/1/2018-6/30/2019** **$2,300**
Bruce Kendall
John Melack
Nature Conservancy SB150143-Task 26

Task 26: Bren School Summer Internships and MESM Group Projects - Oakology

This project's overall goal is to model species range shifts on the Channel Islands as average temperatures increase. Island managers can then use the information to identify and explore management and conservation techniques for various species. Oak woodland communities, comprised of Quercus tomentella and Lyonothamnus floribundus, are most at-risk on the islands. With a warming climate, researchers believe these communities will move upslope on north-facing slopes, following the relatively cool temperatures they rely on. In an island environment, viable habitat for plants adapted to cooler microclimates are very limited, and now shrinking as temperatures increase. Oak woodland communities are struggling on all of the islands except Santa Cruz Island, where they are thriving. This may be due to the presence of island scrub jays, which spread acorns across Santa Cruz Island. Our model would look at past and current distributions of Quercus tomentella, and project its likely future distribution as climate change drives range shifts. There is not sufficient data to do an analogous model for Lyonothamnus floribundus, but it follows parallel trends to Quercus tomentella.

Similar methods could be used to model expansion of invasives due to climate change. Understanding where invasives are likely to expand would provide island managers with more robust information about which native plant communities are most at risk of invasive competition and

therefore the highest priority in restoration efforts. Many invasive plants favor current climate change trends, whereas a multitude of native island plants are suffering due to the warmer and drier climate. We will model the spread of high profile invasives in a changing climate, and separately, where native plant alliances may shift with a changing climate—with that combination, we hope to determine which plant communities will be at the greatest risk of losing habitat from both a changing climate and competition with aggressive invasives.

The general approach will synthesize existing resources into a model to inform management strategy that meets the conservation goals and objectives identified by The Nature Conservancy and the managers of the other islands. This approach will include:

- A thorough review of current island management plans, GIS assessments, and relevant literature.
- Interviews with various island managers from the National Park Service, the Nature Conservancy, US Navy, Catalina Island Conservancy, and Mexico.
- Research of existing management programs for island endemics to determine feasibility for the Channel Islands.
- Use of extensive vegetation maps of the islands to model the potential distribution shifts of Quercus tomentella on the islands using available modeling programs like Maximum Entropy (Maxent) with bioclim climate variables.
- Analysis of conservation approaches such as translocations, biocontrol, and genome editing from other locations to assess feasibility of implementation for the California Islands.

Ultimately, the approach will focus on:

- Inputting existing climate information, species distributions, and remote sensing data into climate envelope models to develop a strategy for Quercus tomentella.
- Analyzing the ecological, economic, and infrastructure data to develop recommendations about prioritizing conservation resources to address oak woodland communities.

This group project will focus on Quercus tomentella as it is the rarest oak species in North America, and it is the dominant species in the oak woodland community on the islands. There is not enough data on Lyonothamnus floribundus to model its distribution changes with climate change, but it expected to behave similarly to Quercus tomentella.

Steven Gaines **12/3/2018-6/30/2019** **$14,180**
Conservation International Foundation SB190087-Task 3

Task 3: Spatial Planning for Protected Areas in Response to Climate Change (SPARC)

The student project assistant will provide general logistical support, perform technical analysis, and assist with the production of written and/or printed materials for the project. Activities will be performed under the supervision of Steve Gaines and will entail 10-15 hours/week of effort. Specific activities may include:

1. High-volume analysis of spatial data
2. Assist with data preparation and stewardship for ecological modeling under scenarios of climate change
3. Preparation of visuals for presentations and/or printed materials
4. 4Development and maintenance of project website
5. Logistical support for meetings and workshops.
6. Assistance with the preparation of publications where relevant

The relative workload among the above activities will vary depending on the most immediate needs of the project. Student project assistant will hold weekly meetings with supervisors to define and adjust the priorities for that week.

Roland Geyer **05/01/2019 to 06/30/2020** **$108,618**
Brandon Kuczenski
Nature Conservancy SB150143- Task32

Task 32: Scoping Ocean Plastics

Co-PIs Geyer and Kuczenski have substantial experience in performing material flow analyses of waste products, including metals, polymers, and waste oil. Co-PI Kuczenski will perform the major work of the project, and Co-PI Geyer will support the work with domain expertise in marine debris. Additional research, including literature review, data processing, and analysis, will be performed by highly motivated students enrolled in the Bren School MESM program as paid summer interns or part-time research assistants during the school year, jointly supervised by both Co-PIs.

David Herbst **1/1/2018 to 12/31/2018** **$52,270**
Burleson Consultng, Inc. SNA-001

Leviathan Mine Biomonitoring Support

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 (EPA) 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.

David Herbst **9/1/2015 to 12/31/2019** **$221,765**
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.

Scott Hodges **8/01/2015 to 7/31/2019** **$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 **3/15/2017 to 2/29/2020** **$379,077**
Alice Nguyen
National Science Foundation 1659835

REU Site: Ocean Global Change Biology

The proposed site REU will provide research experiences for students from under-represented groups with particular attention to recruitment of undergraduates from groups under-represented in STEM, at institutions ranging from community colleges to 4-year liberal arts colleges. Using an interdisciplinary research, the OGCB project will contribute to creating a generation of scientists with greater knowledge in global change biology. Given that communicating climate science is simultaneously becoming more important for the nation, and also more problematic in terms of clarity and communication style with public audiences, we have included an activity that will increase the communication skills of the OGCB participants. This project will include a science communication workshop facilitated by the PI. Finally, this program will provide the junior researchers with skills to connect their work in science to other groups affected by climate change, for example, local fisherman and shellfish growers. Thus, the proposed OGCB project provides hands-on experiences in addressing real-world problems.

Gretchen Hofmann **6/15/2019 to 5/31/2020** **$123,319**
National Science Foundation 1935305

RAPID: Collaborative Research: Studies of recovery from bleaching in Acropora hyacinthus: epigenetic shifts, impacts on reproductive biology and carry-over effects

Overview: The mass coral bleaching event currently occurring in French Polynesia offers an opportunity to test hypotheses regarding mechanisms of rapid response to large scale disturbances. Colonies of Acropora hyacinthus, a widespread major reef-building coral in the Indo-Pacific, showed variable bleaching severity and prevalence in the field (April 2019), and we propose to investigate potential epigenetic and genetic mechanisms involved in either resisting stress or recovering from bleaching. This project will leverage the Moorea Coral Reef (MCR) LTER, which will allow us to integrate high resolution oceanographic metrics and data on long-term community dynamics into our study on rapid adaptation of Acropora hyacinthus. We propose to track genetic and epigenetic signatures of a natural selection event (bleaching) in the field and test the impact of bleaching history on reproductive and carry-over effects in larval and juvenile corals. This work will investigate associations between selection on genetic variation and epigenetic variation as well as the potential role of DNA methylation in phenotypic change across a generation in association with coral bleaching. In this era of global change, mounting evidence is showing that rapid evolutionary processes are occurring at time scales relevant to ecological processes. Therefore, capitalizing on a system with rich long-term ecological data, such as that associated with the MCR LTER, is ideal to investigate mechanisms of rapid adaptation.

Intellectual Merit: This research will provide valuable resolution on how coral reefs recover from repeated, and variable, disturbance regimes. To date, there is limited data on reproductive biology of major reef-building corals in the MCR, therefore data generated through the proposed research will give valuable insight into potential mechanisms of resiliency of coral reef ecosystems. Further, there is a gap of knowledge on how allele frequency shifts are occurring across ecological time scales associated with the LTER, especially in response to strong selection events, and this proposed project would begin to address this gap. This also provides an opportunity to investigate interactions between allele frequency shifts and changes in epigenetic processes, which could drive rapid adaptation in the face of disturbances. Finally, by focusing on sites around the island with variable recovery dynamics, we can gain a broader picture of coral community resiliency in a relatively healthy ecosystem. Taken together, this proposed research in association with the MCR LTER could elucidate critical mechanisms of long-term response in coral populations that could be expanded globally.

Broader Impacts: Data from this project will be come of the first of its kind namely, linking changes on the DNA methylome to the response to bleaching in the field context. In addition, the insight gained as a result of this proposed work will likely contribute to the management of coral reefs, providing information about how the interaction of 3 processes - previous experience of the coral, genetics and epigenetics might intersect to influence resistance to and resilience from a bleaching event. Importantly, this work will fill an important knowledge gap about mechanisms by which bleaching events shape future coral populations. In addition to contributions to research, this collaborative project will support four early career researchers (junior faculty and graduate students), many of them

female or from underrepresented groups. Further, the proposed research has ample opportunities for undergraduate research projects and we intend to heavily involve undergraduates at Auburn University for data processing and analysis. We aim to involve 3 senior graduate students and >5 undergraduate students in various aspects of the proposed projects. In addition, if supported, this project would benefit early career researchers at an EPSCoR institution.

Gretchen Hofmann **1/1/2016 to 12/31/2020** **$2,450**
USDI Bureau of Ocean Energy Management (BOEM) SB150058

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** **$778,593**
National Science Foundation 1656262

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.

Sally Holbrook **9/15/2017 to 2/28/2022** **$1,600,000**
National Science Foundation 1714704

CNH-L: Multiscale dynamics of coral reef fisheries: feedbacks between fishing practices, livelihood strategies, and shifting dominance of coral and algae

Overview: Millions of coastal dwellers rely on coral reef fisheries for food, income, and their personal and cultural identities, yet reefs are under threat worldwide as corals are increasingly replaced by macroalgae.

Although overfishing of herbivorous fish has been identified as one of the key drivers behind coral to algae transitions, we have little understanding of the feedbacks and interrelations between fishing practices, coral reef livelihoods, and spatial patterns of coral and algal dominance. In this project we propose to bring cutting-edge techniques together in an integrated social, ecological, and modeling research program centered on the coral reef fishery of Moorea, French Polynesia. The research will

be groundbreaking in that it will employ newly available high resolution (<1m) satellite imagery to provide comprehensive spatio-temporal data on shifts between coral and algae in Moorea's lagoons, complemented by fisher-led, participatory data collection techniques where local reef fishers use GPS enabled smartphones to document where they fish and what they catch. Livelihoods, social networks, and fish flow analyses will help reveal the adaptive capacity and livelihood strategies of households and communities who face fluctuating fishing opportunities and provision of seafood. This social and ecological work will be combined in spatially explicit models and analyses that explore how ecological dynamics and fisher decision-making processes jointly drive spatial dynamics on coral reefs.

Intellectual Merit: Coral reefs in the lagoons of Moorea are comprised of a patchwork of coral and macroalgae whose shifting dominance has broad implications. Understanding the mechanisms causing reefs to transition from coral to algal dominance is one of the most pressing issues facing those who use or manage coral reef systems. The role of herbivores in preventing these transitions is commonly acknowledged, as is the importance of fishing on herbivores, but the factors that drive fishing effort and behavior are poorly understood. In particular, the broader adaptive capacity of these social-ecological systems is determined by factors such as available livelihood opportunities, unequal access to resources and command over ecological services, and the structure of networks through which information and resources are shared. In addition, both ecological and human dynamics in these systems are spatially structured and fluctuate through time. Understanding feedbacks between these components requires accounting for the spatial dynamics of ecological interactions and human behavior. By capitalizing on recent advances in satellite technology, inexpensive smartphones, and innovative ecological, social network, and modeling techniques this research program will reveal how fishing links the physical landscape with the landscape of social interactions, and reveal unique insights into the dynamic interrelations of the system.

Broader Impacts:

We will provide an exceptional integrative training environment for six graduate students, two postdoctoral researchers and numerous undergraduates who will gain experience in ecology, social science, and modeling. Graduate students and post-doctoral researchers will attend our fisher community workshops at the Te Pu Atitia Center on Moorea, and participate in the Moorea Coral Reef LTER All Investigator Meeting held annually at UC Santa Barbara. K-12 outreach activities will occur in both the U.S. and in Moorea; by partnering with teachers, we will develop multilingual curricula for California and Moorea elementary schools based on the new LTER Schoolyard series book "Kupe and the Corals".

Our project will improve local capacity for monitoring, data collection and fishery management. We will foster interaction between local Moorea institutions and between local institutions and others (e.g., the Territorial government, the international science community) by (1) skill building at the community level through training and collaborative science and learning and (2) fisher and community workshops on Moorea to enhance understanding and interest in coral reef co-management. Capacity building will be further enhanced via our long-term partnerships with local NGOs. The proposed research will also be of direct value to coral reef conservation and management practitioners, yielding insights into sustainably managing similar systems across the Pacific region and into the processes that determine the spatial dynamics of coral reefs worldwide.

Debora Iglesias-Rodriguez **1/1/2014 to 6/30/2019** **$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.

Kurt Ingeman **06/01/2018 to 05/31/2020** **$206,489**
Adrian Stier
Society for Conservation Biology SB180154

Top-down restoration: a food web perspective on enhancing recovery of over-fished species and reducing the social costs of marine conservation

Conservation "wins" can sometimes create new tradeoffs and threaten broader conservation goals. For example, predator protection has produced some notable successes, yet growing predator populations can suppress and delay the recovery of prey that are themselves conservation priorities. These stalled prey recoveries can have dramatic social, economic, and ecological consequences; therefore, integrating predator-prey interactions into conservation plans to facilitate rapid and direct, whole ecosystem recoveries represents a vital conservation challenge. Coordinated, multispecies management may improve conservation outcomes and increase economic opportunities by employing adaptive predator harvest (culling) to accelerate simultaneous recovery of predators and prey. Yet, not all predator removals are effective and even when predator populations are reduced, they do not always produce the desired outcome. As such, the contexts in which predator removal will enhance recovery outcomes and the optimal application of predator control remain poorly understood. I propose to address this critical knowledge gap and advance ecosystem-based management for restoration of marine food webs by: 1) determining the empirical generality of top-down regulation of marine recoveries, 2) identifying contexts where predator harvest is predicted to enhance multispecies recovery, and 3) evaluating the utility of predator harvest within a high-profile case study of delayed species recovery. Working in collaboration with NOAA, I will first synthesize predator-prey time series of recoveries at multiple spatial scales from NE Pacific to identify the signature of top-down regulation in a marine ecosystem. Building on the results of this synthesis, I will construct a strategic model generalizing the effects of species traits, ecological context, and management decisions on the utility of predator removal for accelerating mutual recovery. In collaboration with NOAA and TNC, I will then apply this model to spatially-explicit data on the interaction between lingcod (Ophiodon elongatus) and recovering rockfish species (Sebastes spp.) to evaluate the proposed selective lingcod harvest across large-scale environmental and ecological gradients, thereby building coalitions among organizations to support conservation science. My proposed research will simultaneously answer basic questions about the processes that drive variation in species recoveries and produce specific guidance for accelerating recoveries in a marine ecosystem, which I will integrate into existing and future management plans for conservation targets. This research will advance the leading edge of conservation science by integrating ecosystem-based principles into species recovery strategies. By applying community ecology theory to marine resource management, this research will allow practitioners to successfully manage the conservation tradeoffs inherent in restoring degraded marine food webs and will identify potential socio-ecological "win-win" scenarios

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Christopher Jerde **05/01/2017 to 09/30/2018** **$45,585**
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 04/30/2019** **$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 **04/15/2018 to 03/31/2019** **$10,815**
San Francisco Zoo SB180160

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 research group 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 sierrae). 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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During the next six months, I expect to analyze a total of 1,500 swabs for the zoo.

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.

Roland Knapp **6/1/2016 to 5/31/2019** **$142,733**
USDI Geological Survey G16AC00220

Understanding and Ameliorating Predation on Reintroduced Mountain Yellow-legged Frogs by Terrestrial Gartersnakes in the Sierra Nevada

Objective 1: Snake occurrence and abundance.— This work has two components:

A) We will calculate the probability that gartersnakes occur at lakes that are also frog habitat using new and existing observational survey data of snake and amphibian occurrence. We will determine which ecological and environmental factors affect that probability, such as the abundance of MYL frogs, Sierran treefrogs (Pseudacris sierrae), or lake elevation. We predict a positive relationship between both frog species and snake occurrence, and a negative relationship between elevation and snake occurrence.

B) We will monitor snake population size in frog-containing lakes using capture-mark-recapture methods.

This work is important because it can guide future selection of MYL frog reintroduction sites, by indicating habitats where frogs may thrive but snakes are unlikely to occur.

Objective 2: Gartersnake diet.— We will quantify the proportion of mountain gartersnake diet made up of MYL frogs versus other amphibians and other aquatic or terrestrial prey. We predict that MYL frogs form a majority of the mountain gartersnake diet.

This is important because it clarifies the extent to which mountain gartersnakes are dependent on MYL frogs as prey, or whether they have a broad diet. This will indicate how likely snakes are to survive in the absence of MYL frogs. It is also important for later snake relocation work; knowing which resources are required by snakes will help us choose which lakes translocated snakes are released into.

Objective 3: Snake translocations.— Concurrent with our ongoing MYL frog reintroduction work, we will remove snakes from lakes where frogs are released, and translocate snakes into frogless lakes. Snake recipient lakes will vary in their distance from source lakes and in the complexity of the intervening topography. All translocated snakes will be marked to enable us to measure how many return to frog-recipient sites. We predict that distance and topographical complexity will reduce the rate at which snakes return to frog-recipient sites; we also predict that snake removals will enhance survival of released frogs and persistence of the reintroduced frog population.

This work is important because it reduces one of the threats to reintroduced frog populations, and simultaneously indicates whether this is a viable management action to enhance frog reintroduction success.

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.

Armand Kuris **8/1/2014 to 1/31/2020** **$1,499,897**
Susanne Sokolow
David Lopez-Carr
National Science Foundation BCS-1414102

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

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

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

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

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

Adam Lambert **8/1/2015 to 7/31/2020** **$1,349,008**
Tom Dudley
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 **11/26/2018 to 3/31/2022** **$2,793,858**
Tom Dudley
Cal Wildlife Conservation Board WC-1744BC

Arundo removal at the Sespe Cienega

This project proposes removal of Arundo donax (giant reed) from 175 acres on an extremely important portion of the Santa Clara River in Fillmore, initiating the restoration of a native ecosystem at the site of a critical historic wetland (Sespe Cienega; Beller et al 2011). The primary objective of this project is to protect native riparian woodlands and dependent wildlife from decline and loss owing to dominance by this destructive invasive plant. This area of mature cottonwood-willow forest is part of a larger property in escrow by the California Wildlife Conservation Board (ownership to be transferred to California Department of Fish and Wildlife) for long-term protection and enhancement of regionally-threatened habitat and wildlife species, including multiple listed and candidate species. The woodland is severely impacted by direct competition and water depletion by Arundo, and faces risk of catastrophic loss from Arundo-fueled wildfire that could eliminate fire-intolerant native forest species, as well as be carried into adjacent agricultural lands and coastal sage scrub.

Arundo removal is the first phase of implementation that will re-create a fully functioning riparian ecosystem necessary for native species, while decreasing the risk of detrimental fires. Arundo removal will also allow native vegetation to recover and sequester excessive nutrients discharged from the fish hatchery, thereby improving water quality before it enters the main channel of the Santa Clara River. Arundo removal will also save significant water resources resulting in increased water availability for sensitive terrestrial and aquatic species, as preliminary data from a nearby site indicated Arundo uses approx. 3–4 times the amount of water for evapotranspiration (Dudley and Cole 2010, Giessow et al. 2011). These changes will be long lasting and will contribute to the resilience of the ecosystem along the Santa Clara River in the face of potential climate change and natural disturbances.

Hunter Lenihan **2/1/2016 to 12/31/2018** **$212,912**
Erik Muller
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.

Sarah Lester **1/1/2014 to 12/31/2018** **$500,000**
Christopher Costello
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 **4/1/2018 to 3/31/2021** **$231,625**
National Science Foundation 1760878

Collaborative Research: Bringing the Late Pleistocene into Focus: Better Estimates of Ages and Ocean Circulation Through Data-Model Comparison

Overview: Understanding the causes and rates of climate change in the past requires accurate age models; however, age estimates for many climate records from ocean sediment cores are based on stratigraphic alignment of benthic G18O (a proxy for global ice volume and deep ocean temperature), which produces age uncertainties of several thousand years. This project focuses on creating more accurate benthic G18O age models with smaller uncertainties for the last glacial cycle (0-150,000 yr ago), a time period which includes the Last Glacial Maximum, the previous interglacial, two rapid deglaciations, and large amplitude millennial-scale variability. Over this time period, a major source of uncertainty for G18O alignments is that the timing of benthic G18O change can differ by 4000 years between different parts of the ocean. These differences have been observed during the last deglaciation at a few core sites with very accurate radiocarbon (14C) age models, but overall little is known about how benthic G18O signal propagation may have varied throughout the last glacial cycle. Specifically, this research will characterize benthic G18O lags and improve alignment age models using a three-pronged approach that incorporates ocean circulation models, analysis of paleoclimate data (benthic G18O and 14C) from ~100 globally distributed cores, and statistical inference. The final products of the project will be (1) probabilistic stacks (averages) describing regional and global patterns of benthic G18O variability, (2) probabilistic algorithms for multiproxy core alignments and for generating Bayesian inferences of lags, (3) a database of age models for ~300 cores with benthic G18O data, and (4) estimates of ocean circulation changes based on comparing benthic G18O data with different ocean model scenarios.

Intellectual Merit: Paleoclimate studies rely on age models when identifying cause-and-effect (lead/lag) relationships, creating snapshots of the climate state at a specific point in time, or characterizing the magnitude of natural variability on different timescales. Such information is crucial for testing the effectiveness of climate models and improving confidence in their ability to simulate potential future climate changes. Compilations of marine sediment core data are also used to estimate past changes in global mean surface temperature and in deep ocean carbon storage. To maximize the spatial coverage of such datasets, they often include cores with indirect age estimates, such as benthic G18O alignment, that have large, poorly constrained uncertainties. This project will improve age and uncertainty estimates for benthic G18O alignments and allow for more informed selection of which data to include in compilations and overall better accuracy. Data-model comparison will also better constrain ocean circulation changes (e.g., mixing pathways and rates) and the surface climate signals which propagate to the deep ocean (e.g., distinguishing signals which originate from the North Atlantic versus Southern Ocean). These results may help describe the causal chain of events for past climate changes and identify isolated ocean reservoirs that may have sequestered carbon from the atmosphere during glaciations.

Broader Impacts: This project may benefit society by improving paleoclimate reconstructions used to validate the climate models that forecast future climate change. Its impact will be enhanced by incorporating results into community data compilation efforts. This research also bridges the gap between paleoclimate and the mathematical sciences and will provide interdisciplinary training to two graduate students. Research methods and findings will be incorporated into undergraduate and graduate classes through the development and dissemination of two course modules that include interactive computer lab activities. PI Lisiecki has a strong record of mentoring female and under-represented minority students; she also organizes bimonthly meetings for female Earth Science graduate students and post docs to discuss articles about overcoming the challenges faced by women in science and academia.

Milton Love **06/01/2017 to 10/31/2018** **$64,155**
Ann Bull
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 M16AC00025

Net Environmental Benefit Analysis of Pacific Platform Decommissioning Scenarios

All oil and gas platforms have a finite economic life span. When that life span is reached a process called decommissioning occurs during which the fate of that platform is decided. The Bureau of Offshore Management has a role to play in this process for platforms in federal waters. Off California, the State of California will also play a role in the decommissioning process. Based on California AB 2503, the Net Environmental Benefit (NEB) of each platform will be an important factor in the state's decision on what will be done with each structure. At this time, NEB remains undefined, particularly for California oil and gas platforms. This study is designed to explore what NEB is, how it can be measured, and to use the oil and gas platforms off California as a model for how this analysis would be done. Specifically, we will 1) estimate the productivity of fish and invertebrate communities and key fish species under different decommissioning scenarios on offshore California platforms, 2) compare platform productivity and community structure with that of the natural habitat that is replaced by each platform, 3) explore how these differences might change over time as decommissioning options alter the conditions for associated biological communities, and 4) model and predict positive and/or negative effects to the marine environment that could result from partial removal versus full removal of the structure.

Milton Love **8/20/2015 to 10/31/219** **$400,000**
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 12/31/2018** **$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 **09/15/2018 to 2/28/2021** **$497,948**
Mary Nishimoto
Ann Scarborough Bull
Exxon Mobil Upstream Research Company EM11487

A comparative Field Study of Survey Methodologies with the Analyses of the Fish and Invertebrate Assemblages of A Santa Ynez Platform and Its Associated Pipeline

Methodological Comparisons Invertebrate Surveys at A Santa Ynez Platform

This task will endeavor to answer the following questions:

Question 1. What invertebrates live on the 30 and 80-foot platform crossbeams?

Question 2. Do the assemblages vary between these two depths? Do they vary with platform side? Are assemblages inside the platform different from those on the outside?

Question 3. How do species richness and density estimates compare between two survey tools, scuba and ROV?

Methods:

- UCSB will conduct an invertebrate survey on the platform horizontal crossbeams with UCSB AAUS-certified scuba divers. Scuba divers will use a still camera with lights to document the invertebrate assemblage.
- UCSB will adhere to all ExxonMobil safety requirements.
- ExxonMobil Upstream Research Company (EMURC) will facilitate an invertebrate survey at the platform with a ROV. The ROV will collect footage of invertebrate assemblages with a video system.
- UCSB marine biologists will provide recommendations on ROV flight path, data collection strategy appropriate for an invertebrate survey at a vertical offshore infrastructure and provide real-time guidance to the ROV operator during the ROV survey duration. Surveys will attempt to capture the platform base and platform crossbeams.
- In both diver and light-weight ROV surveys, still images and footage from the outer margins of these structures (those facing away from the platform), the in margins (facing into the platform) and all sides of the platform are collected to determine if crossbeam orientation affects assemblages.
- In the laboratory, the still images from the scuba survey and the video imagery from the ROV survey will be analyzed and organisms greater than 5 cm in size will be identified to lowest taxon, their size estimated, and their density assessed to compare estimates of invertebrate species densities and diversity using the two methods.

Sally MacIntyre **1/15/2018 to 12/31/2019** **$100,000**
National Science Foundation 1737411

Circulation, Metabolism, and Greenhouse Gas Emissions from Arctic Lakes and Ponds

The goal of the proposed work is to analyze, synthesize, and publish results obtained from physical and biogeochemical data sets obtained from five arctic lakes of different sizes over four years during fall, winter, and spring. In short, we will quantify the lakes' physical limnology and under ice metabolism. Specifically, in the manuscripts we will quantify seasonal and interannual variability in thermal structure and hydrodynamics. Results will include assessing the pathway and retention of snowmelt water with its loading of dissolved organic carbon and greenhouse gases, the convective processes which induce circulation under the ice, the extent of penetrative convection in spring, and the internal wave dynamics and related extent of mixing at ice off. We will quantify production of greenhouse gases in winter. We will develop and test scaling laws which will enable results from our study sites to predict processes and fluxes in lakes of a range of sizes across the landscape. One set of scaling laws will enable prediction of lake-size dependent controls on under ice mixing, production of CO2, and formation of anoxia. Another set will predict the lake-size dependent controls on the fraction of climate forcing trace gases produced over the winter which are emitted at ice off. We will use observations from multiple thermistor arrays in one lake to validate commonly used one and three dimensional hydrodynamic models. This work is important as the parameters used for mixing coefficients in the models were primarily developed by laboratory experiments in the 1970s and 1980s and have not been tested with comprehensive field data. Additional manuscripts will validate new equations for turbulence in the upper water column based on meteorology and within lake thermal structure and used to compute gas transfer coefficients and the coefficient of eddy diffusivity.

These two coefficients are required for accurate computations of fluxes within lakes and ultimately across the air-water interface. Manuscripts on turbulence will be based on data from thaw ponds and glacially formed lakes. The planned manuscripts, with their goals of improved understanding of physical limnology under the ice and controls on winter respiration and gas evasion in the ice free period, will fill a major gap in limnological understanding of high latitude lakes and enable increased accuracy in modeling greenhouse gas emissions.

Susan Mazer **06/15/2016 – 05/31/2020** **$249,999**
Isaac Park
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 **4/1/2015 to 6/30/2019** **$76,963**
Cheryl Briggs
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 **4/1/2019 to 3/31/2020** **$33,735**
Eugenio Larios
UC Mexus FE 18-25

Evolution in a heterogeneous environment: identifying the mechanisms that promote the maintenance of genetic variation and the adaptive capacity of wild populations

The ability of wild populations to adapt to a rapidly changing environment depends on genetic variation of traits that are closely related to fitness. The size of a seed is one of the most important characteristics of plants, whereby relatively large seeds typically have a greater capacity to tolerate environmental stress and uncertainty. One of the most important goals of evolutionary biologists is to identify the mechanisms that maintain seed size variation at the phenotypic and genetic levels. In this study, we address five processes hypothesized to help maintain genetic variation in seed size in natural populations: environment-specific natural selection, genotype x environment interactions, maternal and grand-maternal effects on seed mass, historical environmental effects on seed-size selection, and correlational selection. With the aid of quantitative genetics and a set of manipulative experiments that will control water availability in the maternal and grand-maternal generations, we will determine whether seed size variation is maintained by spatiotemporal variation in water

availability and the process of natural selection. These results will illuminate how the dynamics of selection on fitness-related traits are mediated by the availability of limiting resources that fluctuate greatly in space and time.

Susan Mazer **08/1/2017 to 7/31/2021** **$804,009**
National Science Foundation 1655727

Evolutionary adaptation to intensifying drought across a geographic gradient: a comprehensive test of Fisher's Fundamental Theorem

Many studies of wild plant species have either detected plastic responses of phenological traits (e.g., flowering time) to experimentally induced or natural climatic variation, or have reported changes in the strength or direction of phenotypic selection in populations occupying different environments. Few studies, however, have measured the process of adaptive evolutionary change, in real time, in phenological, morphological, or physiological traits. The proposed research will integrate the study of geographic variation in fitness-related traits among populations of a widespread annual herb (Nemophila menziesii, Hydrophyllaceae) with measures of: phenotypic selection on traits that contribute to drought-escape and drought-tolerance; inter-generational change in additive genetic variance in fitness; and the response to selection in order to test predictions regarding adaptation to environmental conditions across an aridity gradient. We will use the powerful quantitative genetic Aster models to estimate additive genetic variance in individual lifetime fitness in pedigreed populations under field conditions as well as to estimate the strength and direction of selection on phenological, morphological, and physiological traits. Recent statistical innovations of the Aster model (including the incorporation of random effects) now allow the estimation of genetic variance in lifetime fitness. The intellectual merit of this project includes its application of the Aster model, enabling an empirical evaluation of the accuracy of Fisher's Fundamental Theorem of Natural Selection, which predicts that the rate of change in population mean fitness should equal the ratio of additive genetic variance in fitness to mean absolute fitness. This ratio represents a population's capacity to adapt to current conditions, or its "adaptive capacity". The broader impacts of this project include intensive undergraduate participation and outreach to members of Tribal communities near the targeted study sites.

Susan Mazer **08/1/2018 to 7/31/2022** **$225,844**
Katja Seltmann
National Science Foundation 1802181

Digitization TCN: Collaborative: Capturing California's Flowers: using digital images to investigate historical and geographic phenological change in a biodiversity hotspot

The digitization of herbarium specimens has advanced our ability to understand complex and changing biological systems. However, when digital records provide only taxon names, dates, and locations, the types of research questions that can be addressed with these records are limited. While basic data such as these can be used to detect changes in species distributions, herbarium specimens are rich in additional information regarding plant health, reproductive condition, and morphology that is generally not captured in digitization workflows. Flowering time, in particular, is a character that has cascading effects on multiple levels of biological organization from individuals to ecosystems. Here, 22 herbaria propose to capture the currently untapped research potential contained in California specimens through a massive imaging effort of the California flora. This endeavor will image, database, georeference, and score phenological traits on ~900,000 specimens at 22 collaborating institutions with significant California holdings. The target specimens include the oldest specimens (pre-1930) to establish a phenological baseline before the most recent onset of climate change, as well as the most diverse vascular plant families in California to understand the evolution of phenological shifts. The target taxa also include species currently monitored by the USA National Phenology Network (USA-NPN) and the California Phenology Project (CPP), making the data immediately applicable for current-day research. Data standards for scoring phenology on herbarium specimens are currently lacking. This project will collaborate with iDigBio and TDWG to create

community-wide data standards for phenological traits, integrate those traits into the Darwin Core, and develop the training tools necessary for phenological digitization to be included in all future digitization workflows.

Douglas McCauley **2/15/2019 to 2/14/2021** **$200,115**
The Schmidt Family Foundation G-1901-58099

Environmental Solutions Graduate Fellows Program

UC Santa Barbara envisions an opportunity to restore this funding and to replicate and expand upon this model of graduate research success by establishing the Environmental Solutions Graduate Fellowship program at UC Santa Barbara. This intervention is aimed to extend the impact of graduate research and, perhaps equally importantly, to send a strong and clear message to graduate students that the outputs of their research and their commitment to science are indeed more needed and more valued than ever before. Elements of the proposal further target translating the success of graduate students into success for next generation environmental scholars through graduate/undergraduate research partnerships.

Douglas McCauley **5/1/2018 to 5/31/2020** **$25,000**
Zegar Family Foundation SB180192

Santa Barbara Ocean Friendly Restaurant Project

In collaboration with the Benioff Ocean Initiative and the Surfrider Foundation, two graduate-level UCSB students will be employed for the summer of 2018 to lead the launch of an Ocean Friendly Restaurants (OFR) program in Santa Barbara. The OFR program helps restaurants minimize their impact on the ocean by adopting practices that reduce single-use plastic waste, maximize energy efficiency and conserve water. As part of their scope of work, the interns will:

- Implement the OFR communication strategy that was developed by students in the Bren School Communication Capstone during the spring of 2018
- Enroll new restaurants in the OFR program and maintain restaurant relationships through the registration process
- Plan and administer surveys to quantify restaurants' plastic waste reduction achieved through the OFR program
- Design and implement a public outreach campaign around OFR, including writing press releases, assisting to develop graphics on ocean plastics, and creating social media and website content
- Plan public events at OFRs, including a program launch event and events celebrating key program milestones (e.g. 25, 50, 75 restaurants enrolled)
- Assist with training and overseeing Surfrider OFR volunteers, including coordinating restaurant outreach and maintaining a shared database of restaurants
- Collaborate with local nonprofits, government bodies, and green business certification programs as needed

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Douglas McCauley **7/1/2017 to 6/30/2019** **$14,733**
Eppley Foundation For Research Inc. (The) SB180008

Climate change mediated effects on watersheds: conservation and management of the vulnerable common hippopotamus through spatial ecology research

Hippopotamuses have never been tracked electronically, and consequently no rigorous study of their spatial use has been conducted. We propose a novel approach to study hippopotamus spatial use, using GPS tracking collars. The use of GPS technology to understand habitat use by wildlife is not a new technique. However, this approach has never been successfully used on hippopotamuses.

We plan to conduct this research in Ruaha National Park. The Great Ruaha river and associated rivers are the main source of water for wildlife within this region. Rapid development of industrial rice plantations in the basin have transformed the Greater Ruaha River from a perennially flowing river to a river that now dries for multiple months (Mwakalila 2005, Kashaigili 2007). Thus, the Ruaha River provides an ideal study site to assess how changing hydrology influences the spatial ecology of the hippopotamus. Furthermore, current climate change predictions suggest a decrease in rainfall across the distribution range of the hippopotamus. Consequently, rivers that are inhabited by hippopotamus will experience severe reduction in hydrology. Therefore, we can apply the results obtained in Ruaha National Park to predict how climate change may affect hippopotamus population throughout Africa.

We plan to attach customized ankle collars to 10 hippopotamuses in Ruaha National Park, Tanzania. This proposed research has been approved by the UCSB Institutional Animal Care and Use Committee (IACUC). Collaring will span both the wet and the dry season in the Ruaha ecosystem over the course of one year to determine how reduced flow in degraded rivers affects attributes of hippopotamus spatial ecology. The main objective of this research is to obtain multi-seasonal information regarding hippopotamus spatial use.

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 **3/27/2019 to 11/26/2019** **$21,120**
Pew Charitable Trusts 32741

Creating a biologically and socio-economically informed map of priority areas for the establishment of marine protected areas on the high seas

This project aims to generate a biologically and socio-economically informed prioritization map for the establishment of marine protected areas (MPAs) in areas beyond national jurisdiction (ABNJ). The map will focus on strategically synthesizing insight from existing data and utilizing reserve design theory to execute the prioritization of high seas areas for protection. The spatial format of input data layers will be standardized, overlain, and transparently weighted to produce the MPA prioritization map. Results from this analysis will be submitted for publication in an open access, peer-reviewed journal. Researchers involved in the project will work with Pew Charitable Trusts to communicate the results of this exercise to decision makers presently considering establishing MPAs in ABNJ.

Douglas McCauley **9/1/2018 to 8/31/2019** **$157,563**
Harvard University 111269-5110907

CNH-L: Socio-ecological traps and interactive dynamics of reef fisheries and human health in Kiribati

For the NSF we are applying for the coupled natural and human systems grant. UCSB is responsible for the natural systems component. Harvard is responsible for the human systems component (human health). UCSC is responsible for assistance with how these two systems interact and the governance related questions. UCSB will be responsible for coordinating, conducting, and overseeing all

ecological fieldwork, data analysis, data management, and the preparation of peer reviewed publications arising from the natural systems research and collaborations. We will be entirely in charge of the natural system component of this project from start to finish. We will also assist UCSC with the Natural to Human and Human to Natural interactions. We will be obtaining fisheries stock estimates from the ecological data collection and plan to extract catch per unit effort data from this. Therefore, the two main natural data components within the project are overall reef heath and stock size. Additionally, Doug will be responsible for mentoring and training the postdoctoral researcher and all undergraduates that are integrated into this research plan. The teachings will focus on ecological theory and reef systems dynamics.

Will McClintock **01/01/2019 to 12/31/2020** **$68,000**
Paul M. Angell Family Foundation CON-F18-09

Designing A Sustainable Seascape: Mapping Hawaii's New Marine Protected Areas with SeaSketch

OVERVIEW: The successful design and designation of marine protected areas must be created in a process that is both participatory and science-based. This means that all stakeholders are given a voice in the decision making process, and that the best available data and information are brought to bear to enable ecosystembased management. For any project, this is a tall order. Planning bodies often have limited capacity to engage stakeholders in a meaningful way. In addition, they also often lack the technical expertise to interpret a full complement of relevant science, much less conveying data to stakeholders that can be readily understood. Expert facilitation and tools for science communication and collaboration are key to achieving a truly participatory process.

Will McClintock **02/09/2018 to 10/31/2018** **$30,687**
Nature Conservancy SB150143-TASK19

TASK 19:Technology for Fisheries Management

TNCs coastal fisheries program and the McClintock Lab seek to develop a collaboration to create and test comprehensive technological solutions to improve the collection, sharing and dissemination of information for use in improving marine conservation outcomes and fisheries management decision-making. Through development of SeaSketch and other web-based visualization and analytical tools, the McClintock lab has improved conservation of marine resources and worked effectively with a suite of collaborators, including TNC.

The McClintock Lab at UCSB will alter an algorithm to automatically measure abalone length for use by TNC in their support of CDFW management of the recreational abalone fishery, to explore expansion to the Lobster and finfish commercial fisheries. In addition, the McClintock Lab will provide a prototype application using ARkit to capture length data, to compare the two methods and inform future application development.

Will McClintock **02/20/2019 to 11/15/2019** **$159,390**
Nature Conservancy SB150143-TASK30

Task 30: CA Lost Crab Gear Recovery Program Tools

We propose building a new system from scratch, building on lessons learned using modern technology and a new user interface. It would be an opportunity to remove complex and redundant features and develop a system that can be more easily replicated and maintained. This new system would be paired with a native application for iOS and Android which would greatly simplify tasks for both recovery captains and port coordinators, while also opening up the possibility for crowdsourced data collection on lost gear. The project presents an opportunity to field a cross-platform mobile app with a simple feature set. With a well understood domain and an existing user-base, it's very likely to be a successful case study for this sort of technology.

Will McClintock **04/26/2018 to 06/30/2020** **$415,273**
Nature Conservancy SB150143-TASK23

Task 23: Developer support for Abalone and Lobster Ocean Ruler Tools

TNCs coastal fisheries program and the McClintock Lab seek to develop a collaboration to create and test comprehensive technological solutions to improve the collection, sharing and dissemination of information for use in improving marine conservation outcomes and fisheries management decision-making. Through development of SeaSketch and other web-based visualization and analytical tools, the McClintock lab has improved conservation of marine resources and worked effectively with a suite of collaborators, including TNC.

The McClintock Lab at UCSB will alter an algorithm to automatically measure abalone length for use by TNC in their support of CDFW management of the recreational abalone fishery, to improve usability, scalability, and to include additional abalone fisheries. In addition, the McClintock Lab will provide a new application to measure lobster length in support of the commercial lobster fishery. For both applications, they will work with Ocean o' Graphics at the Marine Science Institute at UCSB to develop app logos, giving the tools a clear visual identity.

Will McClintock **04/09/2018 to 11/30/2018** **$135,571**
Nature Conservancy SB150143-Task24

Task 24: Developer support for Crab Gear Recovery Tool

Crabgear Recovery Tool Web-based Software Development

Take over lead development role from Falk Schuetzenmeister of TNC:

- Travel to Half Moon Bay, CA for in-person meeting(s) with lead port coordinator and user Lisa Damrosch
- Continued electronic communication with Lisa Damrosch to identify uses, changes, and improvements to the tool
- Collect, organize and triage a continuously-evolving list of work on the tool (using GitHub)
- Coordinate decisions with TNC on work priority and cost
- Participate in weekly status meetings with TNC and other McClintock Lab/UCSB members

Completion of feature development tasks resulting in:

- Deployment of the repository code versions as of 3/31/18 to production
- A working, tested email submission workflow
- Generation of a 'yard report' or 'yard list' to be used when verifying recoveries in land storage
- Submission of reports from mobile devices via a simple mobile webpage (as an alternative to email). Full validity checks on uploaded content.
- Support selection of, and bulk operations on, multiple gear reports and recoveries
- Support advanced filters on the reports displayed on map, particularly date and reporter filters
- Persistence of the user's map selections between application reloads
- Auto-complete and suggestions for repeated field entry in forms (to support manual entry of multiple similar recoveries)
- Addition of a tab or section serving as a port coordinator 'knowledge base' containing documentation and reference materials
- Allow port coordinators to add/remove content from the knowledge base
- Support for logging calls to gear owners & call outcomes

- Correct rounding behavior during the conversion of decimal degrees
- Continuous improvement and updating of the back-end tools, libraries, and mechanisms to keep the app maintained, current, and using up-to-date systems.

Maintenance and oversight of a portion of web operations

- Ensure the service is available more-or-less continuously for testing and use
- Coordinate with TNC technical staff when Amazon AWS setups must be changed
- Delivery of all code to TNC via GitHub
- Participation in, and support of, port coordinator training
- Research potential major features or changes
- Consider re-implementing the client app in React instead of the currently-used, obsolete Angular 1 framework
- Other emergent issues

Robert Miller **7/7/2015 to 6/30/2020** **$1,400,000**
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** **$3,641,868**
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 **6/1/2016-6/30/2018** **$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 **8/15/2015 to 6/30/2019** **$659,971**
Mark Page
Jenifer Dugan
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.

Holly Moeller **09/01/2017 to 08/31/2020** **$9,827**
Phycological Society of America SB180016

Quantifying Niche Partitioning along an Acquired Phototrophy Gradient

Kleptoplastidic microeukaryotes transiently obtain photosynthetic abilities by retaining stolen chloroplasts from their algal prey. These organisms therefore provide insight into the endosymbiosis pathway that led to the permanent incorporation of plastids into diverse extant eukaryotic phytoplankton lineages. However, while much attention has been paid to the cell and molecular biology of these organisms (e.g., quantifying photophysiology, carbon budgets, and gene expression, and identifying horizontal gene transfer events), comparatively little is known about the ecology of these organisms, particularly how they partition their niche space and achieve ecological success in the context of a diverse planktonic community. This proposed research uses the Mesodinium genus, which contains sister species of ciliates ranging from entirely heterotrophic grazers to entirely phototrophic acquired phototrophs, as a model system to study niche partitioning as acquired phototrophs emerge from a heterotrophic background. Specifically, this work will use a combination of laboratory co-culture experiments and mathematical models to test for niche partitioning along axes of prey specialization and light availability, and then use these data to predict the evolutionary trajectories that led to the emergence of the modern eukaryotic phytoplankton. This work is synergistic with existing studies of Mesodinium physiology and ongoing efforts to sequence the genomes of several Mesodinium species, and also lays the foundation for future research testing other axes of niche partitioning.

Holly Moeller **5/15/2019 to 4/30/2022** **$536,087**
National Science Foundation 1851194

Testing the evolutionary responses of mixotrophs to future ocean conditions

Overview: The Earth has entered a time of rapid, unprecedented environmental change, including increases in global mean temperature of roughly 0.2 degrees Celsius per decade over the last 40 years with a projected further increase of up to 5 degrees by 2100. This warming is expected to continue to alter the function of biological systems because living organisms are constrained by their thermal environments. For example, intracellular enzymes function more rapidly at warmer temperatures, leading to increases in core metabolic reactions. This proposal tests the effects of temperature on marine microbial mixotrophs, organisms that combine two fundamental forms of metabolism--photosynthesis and phagotrophic heterotrophy--within one cell. Existing evidence suggests that mixotrophs should become more heterotrophic with rising temperatures because rates of aerobic respiration increase more rapidly than photosynthesis per degree of warming. However, as small cells with rapid generation times and large populations, mixotrophs are likely to experience evolutionary changes in response to altered environmental conditions. Here, we describe a plan to experimentally evolve members of a globally distributed mixotroph genus by exposing them to a gradient of temperatures. We will also manipulate the availability of light and food in a fully factorial design to impose selection pressures on phototrophy and heterotrophy, respectively. We will then use our experimental results to parameterize a global upper ocean biogeochemistry model in order to quantify the impact of mixotroph evolution on future nutrient and carbon cycling.

Intellectual Merit: Our proposed work unites two areas of growing interest: experimental evolution of marine microbes, and the study of mixotrophs. In recent years, mixotrophs have gained renewed attention as omnipresent members of marine ecosystems that may regulate nutrient recycling and carbon export. These organisms are also noteworthy for their dominance in oligotrophic waters, which are predicted to expand with increasing oceanic stratification. Thus, mixotrophs may mediate an important potential climate feedback loop: Increased rates of heterotrophy under warmer future ocean conditions could accelerate warming by reducing carbon uptake and export via the biological pump. This proposal combines empirical and theoretical approaches to assess the impacts mixotroph evolution will have on this climate feedback. The evolution experiment quantifies the extent to which adaptive changes to mixotroph physiology can ameliorate the effects of warming by focusing on changes to the biogeochemically relevant traits of: relative phototrophy, cell size, and cellular stoichiometry. The modeling work introduces mixotrophy for the first time into the COBALT upper ocean biogeochemistry model, allowing extension of laboratory results to the global scale. Collectively, our approach works toward a predictive understanding of how mixotrophs in future oceans will alter the planet's carbon cycle.

Broader Impacts: The proposed work has implications beyond biological oceanography to the fields of climate science, microbial ecology, and evolutionary biology. In addition, this research provides training opportunities for undergraduates (recruited through UCSB's California Alliance for Minority Participation and McNair Scholars programs to engage first-generation and underrepresented minority students), a doctoral student, and a postdoctoral investigator. This proposal also funds a continued collaboration between the Moeller Lab and the Santa Barbara Museum of Natural History's Sea Center, a non-profit educational center with ~100,000 visitors per year. Through this collaboration, we will (1) develop a "Meet the Plankton" science cart for permanent use by Sea Center interpreters; (2) develop, launch, and evaluate a Portal to the Planet program on "Climate Feedback Loops," to be shared with other regional zoos and aquariums; and (3) participate in the annual "Underwater Parks Day" open house. In addition, researchers supported by this project will engage in other outreach activities, including participation in the National Network of Ocean and Climate Change Interpreters regional climate science training for zoo and aquarium educators (Moeller) and public lectures such as the Santa Barbara Museum of Natural History's Science Pub Night (postdoctoral investigator).

Monique Myers | **10/01/2018 to 01/31/2019** | **$21,733**
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 annd field trips. Providing information to local communities about climate change adaptation of coastal ecosystems is a key goal.

Monique Myers | **08/26/2018 to 01/31/2019** | **$5,350**
UC Sea Grant | W18-85

Sea Grant Citizen Science Vision

The employee will implement edits to the citizen science visioning document. This includes: creating tables and diagrams, setting up initial layout and cover page for the report, creating reference section and appendices. He will complete the nationwide compilation of SG citizen science programs and potentially provide a summary document in addition to the citizen science visioning document appendix. The employee will participate in conference call(s) about document edits and SG Week sessions. He will correspond with visioning team members from other SG programs to ensure their input is included in creating documents and agendas. Also, he will create online surveys and summarize workshop evaluations and potentially provide a summary document detailing evaluation results. Under guidance of SG Specialists develop a high quality Powerpoint presentation of visioning workshop results for presentation at SG Week. Under guidance of SG Specialists develop a survey/ evaluation tool for the SG Week Citizen Science visioning session and meeting. As appropriate help with logistics and documents for the two SG Week CS sessions and Friday meeting.

Craig Nicholson | **2/1/2018 to 1/31/2019** | **$20,000**
Univeristy of Southern California | 18032

Enhancing the Community Fault Model (CFM) to support SCEC science, community model development, and hazard assessment

We propose a series of enhancements to the SCEC Community Fault Model (CFM) and Statewide Community Fault Model (SCFM) (Plesch et al., 2007, 2016; Nicholson et al., 2017) to support their use in new community modeling efforts (e.g., Community Rheologic Model, CRM), fault systems studies, earthquake simulators, and hazard assessment. The CFM is one of the most mature modeling efforts within SCEC, and has seen widespread use in many aspects of our science (e.g., UCERF3). Nevertheless, it remains critical that the CFM and SCFM continue to be updated, expanded, improved, assessed, and validated – so that they can effectively support a wide range of community modeling activities targeted by SCEC5. Thus, we propose to:

- Work with the new CXM Model manager to support their development and implementation of a database and web-based graphical interface that can be used to help access the CFM models and supporting information.
- Generate map trace representations and metadata tables for CFM5.2 and SCFM 3.0 faults, including area, Qfault ID, Qfault link, and Qfault/UCERF slip rate ranges. This includes fault map surface traces and map tiplines for buried or blind faults.
- Develop a complete collection of alternative fault representations and supporting metadata for CFM 5.2, and organize these into viable alternative models.
- Make a series of additions and improvements to SCFM fault representations, based on recommendations outlined at northern California workshop.
- Generate regular gridded representations of the SCFM as well as alternative faults for the CFM 5.2 (remeshed versions of preferred CFM 5.2 faults are already available on the CFM website).
- Coordinate activities with other community modeling projects in SCEC that will benefit from CFM

representations, including the Geologic Framework and the Community Rheologic Model TAG. This will involve targeted enhancements to the CFM for these groups, as well as greater user accessibility.

Based on feedback from the panel, we will focus on improving and expanding access to the current model, while continuing to develop CFM enhancements, and coordinating efforts with other groups in SCEC to facilitate and encourage greater use of this important SCEC resource. This proposal represents a collaborative effort between the lead development teams for the CFM at Harvard University (John Shaw & Andreas Plesch) and University of California-Santa Barbara (Craig Nicholson). The attached budget reflects only the UCSB portion of the project. UCSB will collaborate with Harvard on these project elements, including helping to coordinate CFM activities with various model user groups, and will take the lead on some of the recommended targeted improvements to the CFM database and—together with Andreas—will continue to maintain, update and populate the CFM metadata tables, and to register CFM entries to their corresponding Qfault ID equivalents. Both Harvard and UCSB CFM developers will coordinate their activities with the CXM leadership group and new community models manager.

Nicholas Nidzieko **08/01/2018 to 08/31/2020** **$9,827**
Alexander Fisher
National Science Foundation 1829952

Measuring the TKE budget and turbulent momentum flux beneath breaking waves using an autonomous underwater vehicle

Few studies have measured the turbulent kinetic energy and dissipation beneath breaking waves, because direct measurements of turbulent Reynolds stress and the full TKE budget in the oceanic surface boundary layer are rare owing to constraints associated with typical observational platforms. Consequently, the inclusion of surface wave effects in turbulence closure schemes relies heavily on numerical modeling results due to the limited availability of direct observations.

We propose to make detailed, comprehensive measurements of the turbulent Reynolds stress and terms in the turbulent kinetic energy budget of a wave-affected surface layer using an autonomous underwater vehicle equipped with microstructure probes and fast velocimeters. Our results will inform future modeling efforts through analysis of momentum and energy transfer within the framework of second moment closure schemes and ultimately improve our ability to predict the fate and transport of nutrients, sediments, plankton, larvae, and pollutants in the coastal ocean.

Roger Nisbet **6/1/2015 to 5/31/2019** **$799,723**
Erik Muller
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.

Margaret O'Brien **07/15/2016 to 06/30/2020** **$301,397**
Dan Reed
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 **06/01/2017 to 05/31/2019** **$19,955**
Emily Ellis
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 4/30/2019** **$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 **7/1/2018 to 6/30/2022** **$250,000**
National Science Foundation 1754770

Collaborative Research: Origin and Evolutionary Divergence of the Pancrustacean Brain

UCSB researchers in Oakley's lab will complete parts of Objective 1 and 2, as described in the proposal. As described in Objective 1, Oakley and a postdoctoral researcher will sequence transcriptomes from approximately 16 arthropod species, and conduct a phylotranscriptomic analysis of 33 species (adding public data). They will produce a time calibrated phylogenetic tree and analyze character evolution of traits measured by the other PIs. From objective 2, they will sequence replicate transcriptomes of brain regions (tissues supplied by other PIs). They will then analyze patterns of gene expression in from those transcriptomes. Each of these aims will lead to collaborative publications with the other PIs and students/postdocs in all the collaborating labs.

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.

Dan Ovando **08/01/2016 to 06/30/2019** **$76,569**
Christopher Costello
Steven Gaines
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 **7/1/2013 to 12/31/2018** **$800,000**
Jenny Dugan
Robert Miller
USDI, Bureau of Ocean Energy Management (BOEM) M13AC00007

Understanding the Role of Offshore Structures in Managing Potential Watersipora Invasions

The purpose of this award is to survey offshore oil and gas platforms in the Santa Barbara Channel/ Santa Maria Basin and San Pedro Basin, other artificial structures, and natural reefs for the non-indigenous species (NIS) Watersipora subtorquata, measure the reproductive seasonality of this

species and identify potential vectors for dispersal among platforms and between platforms and natural habitat, propose mitigation measure(s) that may be employed to manage Watersipora, and to incorporate this information into environmental reviews regarding managing the spread of Watersipora at ongoing operations, during decommissioning of oil and gas platforms, and at potential renewable energy facilities. The need for this information is to elucidate the role that offshore artificial structures may have in affecting biological communities. Information is needed for use by the State of California to consider for decommissioning options under the California legislation AB 2503 (the California Marine Resources Legacy Act). The Act requires California to consider reefing OCS oil and gas platforms, if their ecological value warrants, before decommissioning and potential removal. The information is also needed to comply with the duties of Federal agencies that are outlined in Section 2 of Executive Order 13112 (Invasive Species). BOEM will use study results for environmental reviews concerning ongoing operations and decommissioning alternatives of offshore oil and gas platforms and potential marine renewable energy facilities. The issue of platform decommissioning and decisions related to decommissioning and possible reefing will be decided on a platform by platform basis with each of the platforms judged on its own merits as far as ecological value is concerned. This study will also extend the application of existing methodology to develop results applicable specifically for Bureau of Safety and Environmental Enforcement (BSEE) management decisions so that BSEE can specify requirements to industry or other interested parties when decommissioning occurs. Using the results, the State of California can ensure proper evaluation under the California Rigs-to-Reefs Program law AB 2503 (the California Marine Resources Legacy Act), and BSEE can ensure that specified criteria can be properly evaluated during the decommissioning process pursuant to the federal regulations at 30 CFR 250.1730 . Thus, the overarching purpose of this research is to collect information on Watersipora for environmental reviews regarding managing the spread of Watersipora during decommissioning of oil and gas platforms for the State of California.

Dorothy Pak **9/1/2018 to 8/31/2020** **$49,555**
National Science Foundation 1832837

Collaborative Research: The Holocene and Anthropocene as windows into the future of marine systems

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

Paleoceanographic records provide a unique opportunity to understand how ecosystems have responded to rapid climate change in the past. Recent research along the California margin indicates strong ecosystem responses to climate change, including transitions between multiple ecosystems, and long recovery times from disturbance. This project will use sediment records from along the California margin to address two key questions:

1. How did the development of the modern oxygen minimum zone during the Holocene influence marineecosystems, including multiple stages of perturbation and recovery?
2. Can we identify the marine ecological impacts of the Anthropocene, against a background of decadalcentennial scale climate variability?

This work will utilize a suite of available sedimentary archives (over 20 piston, box and multi cores), with moderately high sedimentation rates and available geochemical records, to identify and interpret metazoan and protistan assemblages.

Uta Passow **1/1/2016 to 12/31/2019** **$308,420**
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. 3partitioning 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 **1/1/2018 to 12/31/2019** **$224,415**
Texas A&M University M1802078

Aggregation and Degradation of Dispersants and Oil by Microbial Exopolymers – ADDOMEx-2

An estimated 5-30% of the oil spilled during the Deepwater Horizon (DwH) accident settled on the sediments via marine oil snow (MOS). Microbially produced exopolymeric substances (EPS), which are an important component of MOS, are central in mediating sinking and degradation pathways of oil in the water. Our mesocosm and roller table experiments suggest that the presence of water accommodated fraction (WAF) of oil or chemically enhanced WAF made with dispersant (ie, CeWAF) triggers the microbial community to produce more EPS. However, Corexit disperses EPS, resulting in a decrease in the formation of oil-laden marine snow. Moreover Corexit increases the oil content in aggregates that do form. These opposing processes lead to complex consequences. Synthesis of the different processes and pathways of marine oil snow formation will be a primary goal of ADDOMEx-2. We will integrate mechanisms of EPS production and its fate in relation to oil and Corexit on the different scales, emphasizing sub-cellular (nm) to cellular (µm) to marine snow sized (mm to cm) scales. Our synthesis efforts will build a conceptual framework and contribute to ongoing modeling efforts: we will work with Burd, Daly and Passow. To support these synthesis efforts wrap up experiments on roller tanks and mesocosm experiments will be conducted. Specifically, the longer term signal of oil or oil and Corexit degradation in organic matter will be investigated. Another focus of our efforts will be on EPS to examine how it is serving as both a vehicle for sedimentation and a habitat for oil degradation, with the non-aromatic portion of the oil degrading much faster than the aromatic portion (WAF) that we studied. This will facilitate the synthesis of the possible mechanisms that may have led to MOS, MOSSFA, and sedimentation of the oil, after the DwH spill. Last but not least, we (Quigg, Passow, Santschi) will continue to work with the MOSSFA community to further understand and develop this concept, and deliver new information to a broad range of the community.

Uta Passow **10/1/2015 to 5/31/2020** **$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 12/31/2019** **$880,151**
University of Georgia RR100-047/5054876 (SUB00000594)

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 12/31/2018** | **$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 to 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

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Xuefeng Peng, David Valentine | **04/01/2018 to 03/31/2021** | **$256,000**
Simons Foundation | 547606

Impact of Marine Fungi on Global Biogeochemical Cycling of C and N

Fungi have been long overlooked as a player in the biogeochemical cycling of carbon and nitrogen in marine environments. Compared to their terrestrial counterparts, marine fungi are vastly understudied partly due to the bias of research interests, and partly because of their cell biology and feeding strategies. As osmotrophs, fungi feed by secreting extracellular enzymes into the environment to depolymerize food substrates before transporting the digested monomers and nutrients back into the cell for growth. As major decomposers of a wide range of complex carbon substrates such as cellulose, hemicellulose, and lignin, fungi produce carbon dioxide, volatile fatty acids, and under anoxia, potentially hydrogen. Recent evidence has suggested that fungi in marine sediments could be responsible for a significant portion of denitrification and nitrous oxide (N2O) production. Moreover, fungi's ability to degrade large particles in the water column, along with their spore-forming life cycles, provides them a special position in the microbial food web, which

remineralizes organic matter in the mixed layer and reduces particle export.

However, most of our knowledge describing marine fungi's ecological roles remains qualitative. Research on marine fungi in the past decade has focused on their diversity. Little is known about the marine fungi's activity and their quantitative contribution to geochemical cycles of carbon (C) and nitrogen (N). I propose to work in David Valentine and Michelle O'Malley's laboratories at UC Santa Barbara to determine the fungal activity in organic matter degradation and N2O production in coastal and estuarine sediments in Santa Barbara, coastal waters off Santa Barbara, and on a research cruise to the eastern tropical North Pacific oxygen minimum zone (Chief Scientist: Bess Ward). Next-generation sequencing will be used to link fungal abundance and diversity to their activities. Additional incubations will be performed to examine the influence of elevated nutrient input and temperature (individually) on the contribution of fungal biomass degradation and denitrification.

This project will contribute to elucidating the potentially significant role marine fungi play in the global biogeochemical cycling of C and N.

Andrew Plantinga **2/1/2018 to 8/31/2018** **$25,000**
Nature Conservancy SB150143-Task21

TASK 21: Economic Assessment of Land-Based Strategies to Mitigate Climate Change in California

The State of California has set ambitious targets for future reductions in greenhouse gas emissions. Part of the strategy for meeting these targets is land-based interventions such as fuels management to reduce wildfire severity and land conservation to promote carbon sequestration in biomass and soils. This project will provide an economic assessment of alternative interventions. The work will be done by the economics team (Professor Erik Nelson at Bowdoin College and Professor Andrew Plantinga at the University of California, Santa Barbara) in collaboration with researchers at The Natural Conservancy (TNC). The main objective is to monetize the costs associated with modifications in land use and land management strategies. We will also monetize the climate regulation and other ecosystem service and human health benefits associated with interventions when possible; otherwise, we will present these benefits in physical or qualitative terms. For the assessment of Merced County, the set of countywide interventions have been identified (step 1) and will include a) avoided conversion of natural lands to cropland and urban uses, and b) restoration of woodlands and riparian areas. We will also include changes in agricultural management and specific landowner case study examples of these interventions if feasible. A land use change model has already allocated the land use and land management changes these interventions are expected to create on the Merced landscape. That same model will also measure the expected impacts these interventions will have on the county's agricultural production, water quality, human wellbeing, and biodiversity (steps 2 and 3). The cost analysis (step 4) will focus on quantifying the costs, including opportunity costs, of the projected land use and land management changes: the value of foregone opportunities associated with the interventions in step 1. For example, the opportunity cost of avoided land conversion can be quantified using the market value of agricultural and urban lands. Or the costs can be quantified using agricultural and forestry enterprise budgets. The evaluation of natural areas restoration would account for direct costs associated with removal of non-native vegetation, planting of preferred species, etc., and any ongoing maintenance costs. Some benefits from the interventions will be relatively straightforward to monetize. For example, the value of additional carbon sequestered can be calculated with an estimate of at least the social cost of carbon. Further, there are now straightforward ways to estimate the monetary value of pollutants removed by trees. Other benefits are more difficult to value (e.g., biodiversity gains) and will be described in physical or qualitative terms. Since the costs and benefits of interventions will occur over time, we will use discounting to translate cost and benefit flows into present value measures.

Andrew Plantinga **2/1/2018 to 11/1/2018** **$40,221**
Next 10 SB180130

Economic Assessment of Land-Based Strategies to Mitigate Climate Change in California

The State of California has set ambitious targets for future reductions in greenhouse gas emissions. Part of the strategy for meeting these targets is land-based interventions such as fuels management to reduce wildfire severity and land conservation to promote carbon sequestration in biomass and soils. This project will provide an economic assessment of alternative interventions. The work will be done by the economics team (Professor Erik Nelson at Bowdoin College and Professor Andrew Plantinga at the University of California, Santa Barbara) in collaboration with researchers at The Natural Conservancy (TNC). The main objective is to monetize the costs associated with modifications in land use and land management strategies. We will also monetize the climate regulation and other ecosystem service and human health benefits associated with interventions when possible; otherwise, we will present these benefits in physical or qualitative terms.

For each scenario we evaluate the economic assessment will involve four steps: 1) identify the set of land-based interventions to be evaluated, 2) identify the land use and land management changes relative to a baseline, 3) use biophysical models to project changes in land-based carbon stocks and fluxes, habitat quality, and other outcomes relative to a baseline projection and under alternative climate regimes, 4) evaluate the costs and benefits of the interventions, and 5) summarize results for presentation and publication. More details on each of these steps are provided below.

For the statewide assessment, the economics team will participate in the identification of interventions (step 1). Interventions will span forest, agricultural, and rangeland systems. For example, one potential intervention in the forest sector is fuels management to reduce the severity and extent of wildfires. The LUCAS model will be used to generate the baseline and alternative projections of land use and land management patterns and the production of various land-based outputs (steps 2 and 3). In addition to enhanced carbon storage and sequestration, land-based outputs that could improve on the alternative landscapes relative to the baseline will include habitat quality, risk to natural disturbances, commodity production, and employment.

The cost analysis (step 4) will focus on quantifying the costs, including direct and opportunity costs, of the projected land use and land management changes. For example, the opportunity cost of avoided land conversion can be quantified using the market value of agricultural and urban lands. Or the costs can be quantified using agricultural and forestry enterprise budgets. Some benefits from the interventions will be relatively straightforward to monetize. For example, the value of additional carbon sequestered can be calculated with an estimate of at least the social cost of carbon. Further, there are now straightforward ways to estimate the monetary value of pollutants removed by trees. Other benefits are more difficult to value (e.g., biodiversity gains) and will be described in physical or qualitative terms. Since the costs and benefits of interventions will occur over time, we will use discounting to translate cost and benefit flows into present value measures.

A report on the economic analysis will be produced in time for inclusion in a larger report for the Global Climate Action Summit, September 12-14 (step 5). The economics team will also pursue publication of articles in scholarly journals in collaboration with TNC collaborators.

Tasks of Economics Team

Participate in relevant calls with TNC collaborators to align economic assessment with scenarios development and model runs. Inform intervention selection and definition. Work with broader team to define the integration of the simulation modeling and economic analysis.

Manage research analysts to conduct relevant research tasks.

Review literature and determine data availability for the development of the methodological approach for economic analysis in coordination with other team members. Provide written summary of the selected methodology.

Assemble data for costs of intervention implementation and selected economic benefits. Create database or spreadsheet, reference manager with citations, and library of reference materials. Clean data and organize to facilitate analysis.

Use model output for statewide scenarios to run economic models to assess implications of alternative GHG mitigation scenarios.

Summarize results of economic analysis for reporting and publication, write report on statewide results for Global Climate Action Summit, and contribute to jointly-authored publications.

Jonathan Pruitt **05/01/2018 – 04/30/2019** **$378,000**
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 5/31/2019** **$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.

Andrew Rassweiler **8/15/2014 to 8/30/2019** **$40,000**
Dan Reed
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 **12/1/2012 to 11/30/2019** **$6,246,158**
Sally Holbrook
John Melack
David Siegel
Robert Miller
National Science Foundation OCE-1232779
ROA & REU support $89,000

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 **12/15/2018 to 11/30/2024** **$1,127,000**
Gretchen Hofmann
Robert Miller
David Siegel
Adrian Stier
National Science Foundation 1831937

LTER: Environmental drivers and ecological consequences of kelp forest dynamics (SBV IV)

Intellectual Merit:

The ecological effects of climate change are expected to be large, and long-term studies aimed at foundation species that define a community offer great potential for understanding the consequences of such effects on entire ecosystems. Short-lived foundation species serve as excellent models for examining ecological responses to environmental variation and climate change because, unlike populations of longlived foundation species (e.g., trees, desert shrubs or corals), data collected

over multiple generations are readily obtained. Research at the SBC LTER exemplifies the value of long-term data for understanding short-lived species as it focuses on coastal ecosystems dominated by the giant kelp Macrocystis pyrifera, a large, short-lived seaweed that provides the foundation for extremely productive and diverse marine forests that are highly valued in coastal temperate regions worldwide. The dynamic nature of giant kelp forests, characterized by frequent disturbance and rapid regeneration every few years, coupled with their high productivity and diverse food webs, make them ideal systems for investigating a plethora of ecological patterns and processes that requires many decades to centuries to address in other ecosystems. Such features underlie the broader ecological significance of an LTER site such as SBC, whose research on population dynamics, community properties and ecosystem processes has spanned multiple cycles of disturbance and recovery since it was established in 2000.

Broader Impacts:

SBC LTER research provides the foundation for a diverse array of environmental education and outreach programs that include K-12 education and teacher professional development, undergraduate and graduate student training, and stakeholder engagement. Our K-12 schoolyard LTER program targets historically under-represented groups from underserved schools, while our undergraduate, graduate and postdoctoral training at UCSB (a Hispanic Serving Institution) emphasizes tiered mentorship in interdisciplinary research that enhances the educational experience of many students who historically have been underrepresented in the sciences. The proposed research has direct applications to the policy and management of several topical issues for coastal regions. SBC LTER scientists have a demonstrated history of sharing their research results with resource managers, decision makers, stakeholders, and the general public to address these issues.

Daniel Reed **3/15/2018 to 3/14/2020** **$423,458**
Robert Miller
University of Wisconsin 183405383

Genome wide association studies for breeding Macrocystis pyrifera

UCSB investigators Reed and Miller are collaborating with scientists from the University of Wisconsin, Milwaukee, the University of Southern California and the J. Craig Venter Institute on a proposal to the Advanced Research Projects Agency – Energy (ARPA-E) that aims to develop a state of the art genomics selection breeding program for the giant kelp Macrocystis pyrifera for potential use in offshore ocean farming of giant kelp for biofuel production. Reed and Miller will be responsible for the field component of this project, which includes: (1) collecting reproductive tissue from natural populations of giant kelp throughout southern California for purposes of establishing genetically distinct gametophyte strains used for selective breeding of sporophyte cultivars, (2) designing, installing and maintaining an ocean farm system at Catalina Island for growing selected sporophyte cultivars, (3) outplanting small sporophyte cultivars reared in the laboratory to the ocean farm and maintaining them throughout the 5-month growing season, and (4) measuring phenotypic traits of the farm raised sporophyte cultivars during and at the end of the growing period.

Cristina Sandoval **9/22/2015 to 6/30/2020** **$61,920**
Sue Swarbrick
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.

Alyson 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.

Alyson 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.

Alyson 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.

Alyson Santoro **10/01/2016 to 01/31/2020** **$370,840**
University of Exeter SB170187

Transporter Function and Kinetics in Uncultivated Marine Microbes

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.

Alyson Santoro **07/01/2016 to 03/31/2020** **$408,515**
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 **09/01/2016 to 08/31/2022** **$4,542,995**
Sally Holbrook
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	**9/1/2012 to 8/31/2018**	**$4,432,747**
Sally Holbrook		
National Science Foundation		OCE-1236905
Chem-OCE Supplement		$2,145
UNOLS Supplement		$125,213
LIDAR Supplement		$194,040
Thailand Travel Supplement		$41,215
Equipment Supplement		$200,000

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

Intellectual Merit: The Moorea Coral Reef (MCR) LTER is an interdisciplinary research and education program that was established in 2004, to explore the joint effects of climate and disturbance on the structure and function of coral reefs. Our study area is the reef complex that surrounds the island of Moorea in French Polynesia. Our initial focus (MCR I) was to advance understanding of major controls of processes that modulate ecosystem function, shape community structure and diversity, and determine abundance and dynamics of constituent populations. We build on this foundation by adapting a unifying conceptual framework (US LTER 2007) and developing a set of research themes to organize the MCR II research program and facilitate cross-site collaboration. Coral reef ecosystems appear especially vulnerable to changes in abiotic drivers associated with Global Climate Change (GCC). These arise from two mechanisms related to increasing concentrations of atmospheric 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.

Stephen Schroeter **7/1/2018 to 6/30/2019** **$5,044**
California Sea Urchin Commission SB180204

Studies of Sea Urchins Settlement in Southern and Northern California

The long-term monitoring of settlement of sea urchins and other marine invertebrates study is part of an ongoing long-term study that is unique along the west coast. Its value increases exponentially with time and is critically dependent on maintaining continuity and avoiding data gaps. The data has proven useful in assessing the changes in larval output of the both harvested (red sea urchins) and non- or minimally harvested (purple sea urchins) sea urchin species over a time period that encompasses a significant period of the commercial harvesting in California. These data are used in combination with similar data collected at sites in Santa Barbara and Mendocino counties.

Stephen Schroeter **1/1/2018 to 12/31/2019** **$5,749,211**
Daniel Reed
Mark Page
Simpson & Simpson SB180148

San Onofre Nuclear Generating Station Mitigation Project Monitoring Program, 2018-2019

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. To meet the goals specified in the permit under Condition D and to complete the tasks identified in the 2018-2019 work program, the contract program staff is aided by contract staff biologists who are responsible for collecting and assembling the monitoring data. The contract program staff is also assisted on occasion by independent consultants and subcontractors when expertise for specific tasks is needed or when additional field assistance is needed for monitoring tasks. The Commission's permanent staff also spends a portion of their time on this program, but except for direct travel reimbursements, their costs are paid by the Commission and are not included in the SONGS budget. The staff implements the Commission's technical oversight and independent monitoring program through a contract with the University of California, Santa Barbara. UCSB has an international reputation for excellence in ecology and marine biology and is well equipped to support extramural contracts and grants in these areas. The UCSB contract uses the existing Principal Scientists as project managers for both the wetland restoration and reef mitigation oversight and independent monitoring, with data collection done by the university contract staff biologists under their direction. The Principal Scientists are responsible for supervising the contract staff biologists, subcontractors and consultants, authorizing purchases, and interacting with UC administrative staff on issues pertaining to personnel, budget, and UC policies (e.g., boating and diving safety regulations) relevant to the project. Monitoring of these projects is being adaptively managed in order 2 to streamline effort and minimize costs without compromising the integrity of the data and their value in decision making with regards to the performance of the mitigation projects. Continuous interaction between the Principal Scientists and contract staff biologists is crucial to fulfilling the monitoring tasks for both the wetland restoration and mitigation reef. Before starting the five-year experimental reef monitoring program in 1999, staff conducted a cost comparison among UCSB, other universities, and private consultants and concluded that use of a qualified university would save SCE a substantial sum over use of private consultants. Based on 1995 real cost data from private consultants for work that included the same physical and biological variables used in the SONGS reef monitoring program, costs for private consultants were nearly three times higher than the cost of implementing the monitoring program through UCSB. The Commission concurred with staff at the start of the monitoring program and continues to find that implementing the field monitoring programs through a contract with UCSB is the most efficient, cost-effective, scientifically rigorous, and timely method of achieving the goals of the independent monitoring required by the SONGS permit.

Adrian Stier **12/01/2018 to 11/30/2021** **$247,426**
Nicholas Nidzieko
Thomas Bell
Gretchen Hofmann
UC Sea Grant College Program R/OPCOAH-02

Benefits beyond biomass: Bio-physical feedbacks within Marine Protected Areas may promote ecosystem resilience in the face of global climate change

Marine Protected Areas (MPAs) are a critical tool for conservation and management of economically, socially, and ecologically valuable species in California. The positive effects of MPAs on the

biodiversity and abundance of targeted (fished) species are well-described; however, the objective of this research is to consider whether MPAs can promote ecosystem resilience in the face of global climate change. Many commercially important species are at risk due to changing ocean conditions including acidification and hypoxia. This project will examine the potential for MPAs to serve as climate change refuges to economically important species via persistence of kelp forests that mediate the physical and chemical environment. By assessing these additional ecosystem services provided by MPAs, the outcomes of this research can help guide evaluation and adaptive management of California's MPAs by CDFW, and help California prepare for and reduce harmful impacts of climate change on ecosystems and the services they provide to California's residents and economy.

Adrian Stier **06/01/2019 to 05/31/2022** **$651,134**
National Science Foundation 1851510

COLLABORATIVE RESEARCH: Dynamic Marine Landscapes: Feedbacks and spatial patterns of corals and their associated fishes

Overview: Many nearshore marine ecosystems are defined by habitat-forming species (e.g., kelp, oysters, and coral) that provide shelter and food to other organisms. As a result, spatial variation in the amount, size and distribution of habitat-forming species plays a central role in determining patterns of density and diversity of associated fauna. While it is well-known that many occupants of biogenic habitat also affect the dynamics of the habitat itself (e.g., through consumption or fertilization), the role of bidirectional habitatoccupant interactions in driving the dynamics and spatial patterns of occupants and their habitat is poorly understood. The proposed research addresses these feedbacks in coral reef ecosystems. Specifically, we will study bidirectional interactions between corals in the genus Pocillopora (an important biogenic habitat) and the coral-associated fishes and invertebrates (CAFI) that depend on these corals for their persistence. The project uses field surveys, mesocosm and field experiments, and mathematical models to investigate the feedbacks in the coral-CAFI system by: (1) quantifying variation in the coral-CAFI spatial landscape; (2) testing the effects of habitat attributes (coral density, size, and proximity) on the settlement of CAFI and on the distribution of signals used by larvae to locate habitat; (3) testing the effects of habitat attributes on CAFI density (incorporating effects on settlement and post-settlement processes), on coral condition, growth, survival, and on the services that CAFI provide to the coral; and (4) extrapolating these shorter-term effects to understand long-term (e.g., multi-decadal) dynamics. This will be accomplished by building, parameterizing, evaluating, and applying a model that translates short-term experimental results into predictions of coral-CAFI dynamics on larger temporal and spatial scales. The model will be used to evaluate how coral ecosystems recover from disturbances, in light of the coral- CAFI feedbacks.

Intellectual Merit: The mechanisms that underlie the effects of habitat configuration on the density of its occupants remain poorly understood. The proposed research tackles this problem by proposing and testing a mechanism (which we term ?propagule redirection?) that has the potential to explain diverse empirical relationships between habitat amount, patch size, and proximity on occupant density. Furthermore, the feedbacks that arise from the effects of occupants on their habitat are largely absent from past studies of landscape dynamics. Because variation in habitat attributes drives variation in occupant densities, which in turn likely drive the dynamics and distribution of the habitat itself, such feedbacks are a critical, albeit currently missing, component of landscape ecology. Further study of this connection will offer novel understanding regarding the creation of spatial patterns in habitat and associated fauna, and illuminate consequences of habitat loss and fragmentation that many systems defined by habitat-forming species are currently experiencing.

Broader Impacts: This project will: (1) facilitate restoration effects; (2) enhance the scientific workforce; and (3) engage the public in scientific research and knowledge. For example, results of this project will provide insights about the restoration, conservation, and ecosystem-based management of coral reefs, a threatened and economically important ecosystem. Through continuing collaboration with the NOAA Ecosystem Science Program, scientific outputs will be connected with opportunities to improve marine conservation and policy. Further, by coordinating with the Moorea Coral Reef LTER program, the project will benefit (and benefit from) ongoing studies of that ecosystem. This award facilitates NSF?s Strategic Framework for Investment in Graduate Education by training several early

career researchers including one postdoc, two PhD students, and several undergraduates. Students will be fully engaged in the research and will present products of this project at several venues, including national conferences. To include personnel from diverse backgrounds, PIs will coordinate with recruitment programs at UCSB, UGA, and Tulane (e.g., UCSB's Bridge to Doctorate Program). Outreach to the public will be conducted in French Polynesia (e.g., via the Atitia Center) and at the PI's home institutions, and will include a range of activities, including science fairs, ocean awareness programs, and community engagement projects designed to link arts and science.

Cody Szuwalski **10/1/2017 to 9/30/2018** **$67,282**
UC San Diego 20174555

Eastern Bering Sea snow crab assessment and modeling

Two key duties will be performed for the duration of this grant: 1) performing work in support of the assessment and management of eastern Bering Sea snow crab, and 2) beginning the process of designing and coding a spatial projection framework to evaluate the future extent of the snow crab fishery under climate change scenarios. Support for assessment and management Each year, survey and catch data are used to provide assessments of the exploitable biomass of male snow crab in the eastern Bering Sea in order to set a total allowable catch. This process requires lengthy analyses of different model scenarios to ensure appropriate harvest levels. A key duty under this grant will be to begin the process of updating and documenting the assessment model to accommodate scenarios deemed necessary by the Crab Plan Team and the Science and Statistical Committee (SSC), which will be determined at the October 2017 meeting of the SSC. Spatial projection framework The productivity of the population of snow crab in the eastern Bering Sea has been suggested to be influenced by environmental variables such as the Pacific Decadal Oscillation. This population of snow crab supports a valuable fishery and has produced an average of ~27,000 tons a year over the last ten years. Large changes in the physical environment of the eastern Bering Sea are projected under all climate change scenarios examined by the International Panel on Climate Change (IPCC). Spatial assessment methods and the resolution of climate projections has recently improved dramatically. Our goal is to seize these improvements and begin to lay the groundwork for a spatial projection model that will accept spatial projections of environmental variables deemed important in snow crab population dynamics. The ultimate goal of this modeling framework is to evaluate harvest strategies under projections into the near future to understand how fishers and fisheries managers may adapt to the coming environmental changes. During the grant duration, input data will be cleaned, a roadmap for the coding process will be developed, and coding will begin. It is unlikely that the framework will be completed over the grant period.

Cody Szuwalski **9/01/2016 to 5/31/2019** **$500,000**
Christopher Costello
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.

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 – 08/31/2020** **$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 **9/1/2018 to 8/31/2021** **$657,563**
Cal State Lands Commission C2018030

A Platform Holly Seep Acoustic Observatory

Hydrocarbon seepage to the ocean from underlying petroleum deposits is a natural process known to occur worldwide, and is estimated to release more than 600,000 tonnes of oil to the ocean annually (National Research Council 2003). The Santa Barbara Channel hosts natural hydrocarbon seepage that dates back at-least 40,000 years (Valentine et al. 2010; Hill et al. 2006) and likely much further (Boles et al. 2004), with seeping petroleum used by the Native American tribes prior to Spanish settlement of the area. The seepage in this region is especially prevalent in the vicinity between Campus Point and Coal Oil Point, the so-called Coal Oil Point seeps. The seeps at Coal Oil Point have been described as the world's most spectacular (Hornafius, Quigley, and Luyendyk 1999), and are among the most voluminous – though most seeps remain unstudied. These seeps release oil and gas, with quantities once estimated at 100 barrels of oil and 1.7±0.3×105 m3 of gas, daily (Hornafius, Quigley, and Luyendyk 1999). The offshore oil platform, Holly, is located within the Coal Oil Point seep field, where it has been producing oil and gas since 1968. The hydrocarbon extraction from Platform Holly has been linked to a reduction in flux rate of gas (Boles 2015; Quigley et al. 1999), for at-least one location, evidence that has been used to formulate the hypothesis that industrial hydrocarbon production reduces seepage rates of oil and gas proximal to the production area. While available evidence suggests a linkage between gas seepage and hydrocarbon production, several uncertainties have hindered the general acceptance of this hypothesis. These uncertainties include: i) reservoir connectivity – that is, produced wells must intersect the reservoir or conduits that feed seepage; and ii) the exclusive use of gas flux to relate production to seepage – that is, changes in oil flux from the seeps has not been rigorously quantified despite being the measure of greatest relevance to local stakeholders. In May, 2015 the Refugio Pipeline Oil Spill forced a shut-in at Platform Holly, with abandonment planned imminently. Within the weeks following the shut-in exceptional quantities of oil were observed at the sea-surface and reported at the proximal beaches near Coal Oil Point. While largely anecdotal and subject to reporting bias, experienced observers noted increases in seep surface oil coverage, distance of slick travel, quantities of oil washing ashore, and

instances of bird oiling. The highly publicized effects of these oiling anomalies again brought to the fore the linkage between historical production and seepage. The shut-in at Platform Holly, combined with advances in broadband acoustic technology provide for a unique opportunity to assess the relationship between hydrocarbon production and natural seepage. Specifically, Platform Holly has been in production since the 1960's and with production remaining shut in since 2015, the reservoirs are expected to increase in pressure with time with potential impacts to rates of natural seepage. This situation creates a unique opportunity to survey the current baseline of hydrocarbon seepage, using broadband acoustic technology, and through the establishment of an observatory, to monitor the time series changes in seepage for extended duration and at high resolution of data collection. A collaborative team was assembled to conduct this research, including a seep expert from UCSB and an acoustician specializing in marine hydrocarbon seeps, from the University of New Hampshire. The team has worked together previously, including during the Deepwater Horizon event in the Gulf of Mexico, the 2013 Nautilus Live cruises, during the SEEPS 2015 expedition to the Gulf of Mexico, and for a US DOI funded precursor project. Collectively the PI's have published over 100 papers in the peer reviewed literature, many of which are relevant to the research proposed here. A select listing of relevant papers are included in the biographies of the two PI's (Exhibit A5). The research team provides complimentary expertise with Valentine providing local seep expertise in combination with gas and oil chemistry expertise, and Weber providing geophysical expertise in seep acoustics.

David Valentine **03/1/2018 – 2/28/2021** **$415,570**
National Science Foundation 1756947

Collaborative Research: Chemical and microbiological studies of water-soluble alkanes in the ocean

This award addresses the chemical and biological processes affecting watersoluble alkanes in the ocean, using natural seeps to study their fluxes, partitioning between ocean and atmosphere, and the bacterial response to their input.

Intellectual Merit: Hydrocarbons enter the Ocean through a combination of natural seepage, anthropogenic discharge and biological production, with profound impacts on Ocean biogeochemistry, ecology, and the atmosphere. Impacts can be viewed from two perspectives - where hydrocarbons in the marine setting can act as both an energy-rich food substrate and as a toxic substance - with impacts modulated by the activity of hydrocarbon-degrading bacteria. The transport, fate, and effects of marine hydrocarbons have been the subject of numerous studies, and the importance of petroleum hydrocarbons in the sea has been reiterated through an ongoing series of reports published by the National Academy of Sciences (i.e., Oil in the Sea). These efforts have led to significant advances toward understanding the behavior of liquid phase oil in the ocean, with a focus on the long chain alkanes and multicyclic compounds. However, the behavior of highly volatile hydrocarbons - a class that is abundant in petroleum reservoirs and many crude and refined products - is less studied and is poorly understood. Such hydrocarbons display distinct behaviors compared with traditional oil in that they will partition to seawater or the atmosphere depending on their molecular structure and the context by which they enter the ocean, a combination of characteristics unsuitable for traditional fate and transport models that govern our understanding of liquid oil. The current research proposal addresses this gap in knowledge and describes a plan to study volatile, water-soluble hydrocarbons in the context of natural seepage, focusing on key questions about their transport and fate, and the Ocean's microbial response. Two key questions include: 1) What factors control the partitioning of water-soluble alkanes between water and the atmosphere at natural seeps, and how does this affect their availability to microbes? 2) What genomic and metabolic factors enable the microbial response to the input of water-soluble alkanes and how does the microbial response vary with regional oceanographic and geologic factors such as proximity and flux of natural seepage? The hypotheses that result from these questions will be tested through a series of oceanographic and laboratory-based experiments designed around natural oil seeps in the Pacific and in the Gulf of Mexico. The results of these studies promise to inform our understanding of the transport, fate, and effects of water-soluble alkanes in the ocean.

Broader Impacts: The broader impacts of this research include both educational opportunities and broader societal relevance. Toward educational opportunities, the proposed research includes training of multiple undergraduate and graduate students. The requested research expedition would

be leveraged to provide the capstone experience driving a field studies course - a proven mechanism by which ~8 undergraduate and ~4 graduate students will directly engage in oceanographic research. An additional ~10 undergraduate students from a primarily undergraduate institution will gain hands on experience with atmospheric sampling and data analysis as part of their senior capstone course. The results of this research will inform policy and public debate, insomuch as they will provide a scientific foundation to understand the transport and fate of water-soluble alkanes in the ocean - an issue of direct societal relevance. Such basic scientific knowledge is especially prudent in the context of numerous scenarios that involve large scale discharge of water soluble alkanes to the ocean. Lastly, the PIs of this proposal are actively engaged in the public discussion about hydrocarbons and Ocean health - with industry, Government officials, policy makers and NGOs - a discussion which will be informed by this research.

David Valentine **10/1/2018 – 9/30/2021** **$442,502**
National Science Foundation 1830033

Collaborative Research: Do benthic feedbacks couple sulfur, nitrogen and carbon biogeochemistry during transient deoxygenation?

We will conduct and analyze the metagenomic and microbial community experiments including DNA sequencing. Second, we will conduct the nitrogen isotope biogeochemical studies and analyze the samples and resulting data. Third, the UCSB PI will serve as the Chief Scientist on the first of the two proposed cruises. Fourth, UCSB will conduct broader impact activities including the integration of research with a field studies course. Fifth, UCSB will analyze samples as needed for the project, including solid samples for stable isotopes and various at-sea chemical measurements. Sixth, UCSB will participate in annual project meetings, will generate manuscripts based on these studies and will present results at National meetings.

David Valentine **2/1/2018 to 1/31/2020** **$109,990**
Debora Iglesias-Rodriguez
Craig Carlson
National Science Foundation 1821916

RAPID: Biogeochemical effects of fire ash deposition to the coastal ocean, in response to the 2017 Southern California fires

This RAPID proposal describes a study to investigate the impact of fire ash deposition on coastal ocean biogeochemistry. This will be achieved through a combination of experimentation and environmental measurement, capitalizing on the ongoing occurrence of fires in Southern California and a previously-scheduled graduate student cruise on the R/V Sally Ride.

J. Herbert Waite **9/1/2013 to 8/31/2019** **$1,942,671**
Jacob Israelachvili
NIH Dental and NIH Research, National Institutes of Health 5R01DE018468-10

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.

Libe Washburn **6/1/2017 to 5/31/2019** **$1,112,200**
UC San Diego 20160735

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, Brian Emery **3/15/2017 to 2/29/2020** **$551,879**
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.

Marion Wittmann **11/13/2017 to 9/30/2020** **$1,380,000**
Cal Wildlife Conservation Board WC-1710SF

Sedgwick Reserve Infrastructure and Facilities Project: Phase 2

Sedgwick Reserve has all the attributes of a world-class field site for university research and teaching, except that its facilities are inadequate to support high levels of use, particularly longerterm use. The Sedgwick Reserve Infrastructure and Facilities Project (henceforth 'the Project") will create the infrastructure and facilities needed to serve the Reserve's current and projected needs and to turn it into a world-class natural reserve and field station. Phase 1 of the Project was supported by WCB Proposition 84 (henceforth WCB) funds. Developing the infrastructure needed for Phase 2 is the subject of this proposal. Phase 2 will further the Project by creating much-needed facilities for housing, office space, and camping and day-use support.

Marion Wittmann **7/01/2018 to 6/30/2020** **$24,944**
Lyndal Laughrin
National Science Foundation 1820785

Developing a Strategic Plan for Santa Cruz Island Reserve

Our goal is to develop a sustainable plan to advance long-term research and education goals at Santa Cruz Island Reserve (SCIR) over the next decade. This planning process will result in the creation of a strategic plan and will focus on: a) framing a scientific vision for research at SCIR over the next 5-10 years, b) appraising the facility needs necessary to support that vision, c) evaluating ongoing education and training programs, d) identifying the resources needed to support university-level classes and training, e) assessing public service and outreach programs, and f) developing a sustainable and effective model for connecting the scientific and educational resources of SCIR with a broad array of stakeholders. The UCSB Santa Cruz Island Reserve (SCIR) is the oldest research driven academically motivated field station in the California Islands network and is primed to enhance its leadership role in research, university-level teaching and public service in the region. An additional objective of our proposed planning process is to enhance the regional coordination of research, education and outreach activities across the California Channel Islands region as well as the Baja California Peninsula island chains through a network of regional agency, non-profit, academic and field station partners.

SCIR is uniquely well situated to serve as a hub for research and education in the California Islands region. Due to its location on Santa Cruz Island, the reserve has custom-built facilities, including laboratory space, high speed Internet and computing infrastructure, as well as classroom, meeting

and housing accommodations. SCIR has been a research field station of the University of California Natural Reserve System since 1966, and has been under the Directorship of Dr. Lyndal Laughrin since 1970. Use of SCIR is heavy and as a result, the facilities have experienced some significant deferred maintenance needs. Further, technological advances and new conservation initiatives amongst the Channel Islands suggest that SCIR facilities may benefit from upgrades to better serve today's researchers, students and public. Although research and education use at SCIR is expected to grow, optimal use of SCIR resources has yet to be carefully evaluated. What comprises the optimal uses of the Reserve across research, education, outreach, and natural resource stewardship? What research can best be supported now, and should be supported in the future? What resources are needed? This proposal seeks funding to help address these questions, specifically by supporting a deliberate planning process that will develop a strategic plan for the next decade, and identify infrastructure changes and research, educational, and outreach opportunities that will allow the SCIR to better serve users from California and around the nation and internationally.

Hillary Young | **5/1/2016 to 4/30/2020** | **$135,985**
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 | **01/01/2018 to 12/31/2019** | **$68,339**
UC Davis | A17-0676-S001

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 | **5/1/2019 to 4/30/2022** | **$126,950**
National Science Foundation | 1900502

SG: Collaborative Research: Effects of changing wildlife communities across climatic contexts on tick-borne disease in California

Identifying and understanding synergies between multiple aspects of global change has been identified as a research and conservation priority. This project aims to address this challenge by exploring the interactive effects of changing climatic context and faunal turnover on a critical ecosystem function – control of infectious disease. Specifically, this study will focus on effects of large wildlife loss (defaunation) and associated replacement with livestock, as this is one of the most prominent forms of faunal change in the Anthropocene. Understanding how such changes in large faunal communities may interact with changing climates to drive changes in risk of tick-borne disease is important and timely. This study will use a large-scale field exclosure experiment, replicated across a strong regional climate gradient that serves as a proxy for regional climate change predictions, to mechanistically examine the effects of large wildlife loss, and the addition of livestock, on tick abundance, prevalence of tick-borne disease, and disease risk, under a range of climatic conditions. This project will be conducted in California, which is experiencing both rapidly warming and drying climates and strong declines in large wildlife with concomitant increases in livestock.

While there has been extensive work on the role of climate change in altering parasitism and disease dynamics, much of this research has focused on the direct effects of temperature change on vector or pathogen growth, life history characteristics, and range size. However, changes to climatic conditions will also alter host composition, abundance and behavior, all factors which are likewise independently affected by other forms of anthropogenic disturbance (e.g. defaunation and land use change), which themselves are established drivers of changing landscape scale disease dynamics. It is thus critical to understand how changing climatic context will interact with faunal turnoverin order to move from simple descriptions of current disease dynamics to reliable forecasts of future risk for complex, vector-borne diseases in a rapidly changing world. By utilizing experimental manipulations of wildlife and livestock along strong climate gradients, this study will be able to examine the extent to which these

components of global change interact to affect disease dynamics. The large scale (1ha) and long-term (5 year) nature of these manipulations will enable this project to capture the host and vector dynamics most relevant to the transmission of ticks and pathogens.

This project will have a strong and diverse set of broader impacts. Results from this research will allow us to identify areas that are most likely to experience increases in disease in a changing climate, and identify how and where changes in large mammal abundance and composition are likely to exacerbate or mediate these differences, thus informing wildlife and livestock management and guiding public health efforts. From an educational perspective, this project will provide critical training for multiple graduate students and undergraduates, with a focus on underrepresented groups. Outreach to grade school children and teachers in training will also amplify the educational value of the project. All data from this project will be made available through open-access publications, and findings will be presented at national and international venues.

Hillary Young **7/1/2017 to 7/31/2018** **$9,238**
UC Davis A14-0034-S001

LTREB RENEWAL: COLLABORATIVE RESEARCH: Scaling up and scaling out at the Kenya Long-term Exclosure Experiment (KLEE)

After much thought and consideration, the PIs of this NSF REU grant (number: 1720003, title: LTREB RENEWAL: COLLABORATIVE RESEARCH: Scaling up and scaling out at the Kenya Long-term Exclosure Experiment (KLEE) are requesting changes to the project proposed in the original grant proposal. There are several important logistical considerations at play in this request: first, the severe drought currently afflicting the Laikipia region of Kenya (where the Mpala Research Centre, the home institution of the KLEE, is located) has recently resulted in some conflicts between pastoralists seeking water and pasture for their herds, and large-scale private landowners. Several of these conflicts have resulted in violence. Second, there is some speculation that these conflicts are exacerbated by the upcoming general elections to be held in early August of 2017.

Hillary Young, Kevin Lafferty **6/1/2015 to 5/31/2020** **$547,149**
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 8/31/2019** — **$235,562**
Tufts University — NS3819

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** **$49,018**
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.
