



2013 ANNUAL REPORT

CENTER FOR  
OCEAN  
SOLUTIONS



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The Center for Ocean Solutions works to solve the major problems facing the ocean and prepares leaders to take on these challenges.

# Letter from the Directors

Guided by our 2012–2016 Strategic Plan, the Center for Ocean Solutions has made significant progress in support of our mission to solve the major problems facing the ocean and to prepare leaders to take on these challenges. Our work remains focused in three areas—climate change, land-sea interactions and ecosystem health. Leadership development and education, as well as strategic communications, are critical underpinnings of all our work.

This report outlines our work and progress in detail. Here we highlight a few notable examples of how our work over the last several years is showing impact and draw attention to some of this year’s exciting accomplishments.

The Center began its work on ocean acidification in 2010 by invitation of the federal Ocean Research and Resources Advisory Panel and its Ocean Acidification Task Force. The Task Force’s final report adopted the Center’s novel analysis of how local, state and federal agencies and policy makers could take proactive steps under existing laws to both address ocean acidification and increase the resiliency of coastal ecosystems in the face of acidifying conditions. Over the last three years, the Center has worked with ocean acidification, water quality and science communication experts to generate high-impact interdisciplinary articles, reports and policy briefs that have catalyzed new use-inspired research programs for individual states like the State of Washington and new policy discussions in the halls of Congress. In short, our work has reframed the public discussion of ocean acidification in local contexts by identifying readily available policy levers to address local conditions.

Recognized as a “science to policy” leader in the field of climate change and coastal communities, the Center forged an interdisciplinary author team and delivered the Coastal Issues chapter of the *Southwest Regional Report for the 2013 National Climate Assessment*. Through this chapter and the outreach we are conducting, the Center is helping to reshape the conversation at the state and regional level from inquiries about climate change impacts to how the state and local decision makers can effectively apply scientific knowledge to guide preparation and coastal adaptation. Our cutting-edge public survey work with Stanford Woods Institute for the Environment experts and professor Jon Krosnick culminated this year with a first-of-its-kind public opinion survey producing nationwide and California results of public preferences on adaptation policy choices and funding options. The timing of this work couldn’t be better, as lawmakers and coastal managers are now actively shaping adaptation policy at all levels of government and are hungry for credible recent data on public preferences.

Our connections with the Monterey Bay Aquarium are deepening, particularly through regional work on climate change. The Aquarium has long been an international leader among its peers in focusing on the intersection of the ocean and climate change. Through the Center for Ocean Solutions, the Aquarium’s education staff joined forces with experts from Stanford, the Monterey Bay Aquarium Research Institute (MBARI), the National Oceanic and Atmospheric Administration (NOAA)

Our work is conceived and undertaken with a laser-like focus on scientific credibility, salience, relevance and timeliness while capitalizing on the unique strengths of our collaboration’s researchers and experts.

We know that solutions-oriented work often takes time to produce outcomes, so we season our enthusiasm for producing positive outcomes for the global ocean with a healthy dose of perseverance.

and other local institutions to co-develop and convene a training workshop within the Monterey Bay region on climate change communication. State agencies whose staff participated in this training workshop are now requesting similar workshops for other regions of the state.

In the area of ecosystem health, the team conceived and orchestrated an International Symposium on Dynamic Marine Conservation in collaboration with the Stanford Law School's Environmental and Natural Resources Law & Policy Program. The symposium strengthened the Center's ties with the international ocean academic, practitioner and governance community with two special journal issues in development. Our Center working group that is building the science case for Dynamic Ocean Management recently received funding from NASA to link satellite telemetry and remotely sensed oceanographic conditions using habitat models for protected species as a means to reduce bycatch while protecting fishing opportunities.

We are also deepening our collaborations with MBARI and the NOAA Northwest Fisheries Science Center and forging new collaborations with the University of British Columbia, Northwest Indian College, Washington State Department of Health, Taylor Shellfish Farms and Lummi Nation's Natural Resources Department through a project to pilot water-quality monitoring for the early detection of harmful algae and pathogens impacting shellfish aquaculture areas in Puget Sound. Through the use of MBARI's Environmental Sample Processor technology, our goal is to provide near real-time data to public health officials and shellfish growers on the presence of harmful algae and pathogens in the water to help improve the safety of seafood. In Puget Sound, our collaboration deployed four Environmental Sample Processors at two different shellfish aquaculture locations. Processors were activated on June 20, 2013, in Lummi Bay and on July 16, 2013, in Samish Bay, with live data streaming to the NOAA website. Demonstration projects like this one are critical to ensuring that the technology and analytic methods our staff are co-developing with MBARI and NOAA researchers are truly use-inspired and designed to address field conditions cost-effectively.

In support of our goal to advance leadership skills for up-and-coming and established decision makers, the Fisheries Leadership and Sustainability Forum hosted a workshop in January 2013 with the Mid-Atlantic Fishery Management Council to explore strategies for managing squid stocks in the Mid-Atlantic region. In March 2013, the Fisheries Forum convened a workshop for the New England Fishery Management Council on the topic of risk policy. In support of this work, the Fisheries Forum produced an updated report, *Risk Policy and Managing for Uncertainty across Regional Fishery Management Councils*. This leadership and training program is now recognized as a "go to" resource for fisheries managers nationally.

For the 2012–2013 academic year, the theme for our Monterey Area Research Institutions' Network for Education (MARINE) program was "Leadership and Networking." The year consisted of three seminars, two trainings, two intensive short courses and campus specific networking events, with increased participation from all seven campuses. As seen in this year's metrics, we're making more of an impact in almost all areas. Although we conducted fewer workshops, we reached more MARINE students through increased awareness of our programs.

In terms of broadening the geographic reach of our leadership development for graduate students, we hosted four Pacific Island Nation graduate students as participants in our 2013 Ocean Leadership course. The advisors of these Pacific basin graduate students report that the course was personally and professionally transformative for these emerging leaders.

In these introductory pages, we've focused on just a few of the Center's projects that are already producing tangible impacts. Our work is conceived and undertaken with a laser-like focus on scientific credibility, salience, relevance and timeliness while capitalizing on the unique strengths of our collaboration's researchers and experts. We know that this kind of solutions-oriented work often takes time to produce outcomes, so we season our enthusiasm for producing positive outcomes for the global ocean with a healthy dose of perseverance.

As we recognized the Center's fifth anniversary this year, we reflected on what we've learned collectively as an organization and will use that learning to help guide us as we work to secure a strong future for the Center for Ocean Solutions by putting strategies, people and funding in place for long-term success.

We thank our collaborators and the broader ocean and coastal research and policy community for your support and involvement in this important work.



*Meg Caldwell*

Meg Caldwell  
Executive Director



*Larry B. Crowder*

Larry Crowder  
Science Director



Bluefin tuna.

## Management Committee

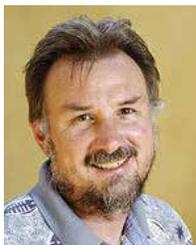
Over the past year, the Center's Management Committee continued to provide guidance in support of our work to link ocean science with policy. One of our Management Committee members, Mike Sutton, stepped down to take up his new role with the National Audubon Society as vice president of the Pacific Flyway. We wish him every success and thank him for his invaluable contributions to the Center. Pending a re-organization of the Aquarium's program, Julie Packard asked Chris Harrold, director of the Aquarium's conservation research program, to serve on the Committee. Upon his retirement in the spring, we thanked Chris for his tremendous contribution to the Center since its inception and welcomed Margaret Spring to the Management Committee as the Aquarium's new vice president of conservation and science.



**Robert Dunbar** is the William M. Keck Professor of Earth Sciences at Stanford University and the Victoria P. and Roger W. Sant Director of the Earth Systems Program. Professor Dunbar was the founding director of the Interdisciplinary Graduate Program in Environment and Resources and the 2009 recipient of the Richard W. Lyman Award. He is also the first J. Frederick and Elisabeth B. Weintz University Fellow in Undergraduate Education and a Senior Fellow of the Stanford Woods Institute for the Environment. He serves on the Board of Trustees of the U.S. Consortium for Ocean Leadership.



**Jeff Koseff** is the Perry L. McCarty Director of the Stanford Woods Institute for the Environment, the William Alden Campbell and Martha Campbell Professor of Civil and Environmental Engineering, and the Michael Forman University Fellow in Undergraduate Education, all at Stanford University. Professor Koseff's research falls in the emerging interdisciplinary domain of environmental fluid mechanics and focuses on the interaction between physical and biological systems in natural aquatic environments. Long-term research projects include understanding the transport of mass and energy in estuarine systems such as San Francisco Bay, and understanding how the coral reef systems of the Red Sea and Hawaii and the kelp forest systems of California function.



**Stephen Monismith** is Chair of Stanford University's Department of Civil and Environmental Engineering, and the Obayashi Professor in the School of Engineering. Since 1996, he has been Director of the Environmental Fluid Mechanics Laboratory at Stanford. He was a resident fellow at Robinson House (Stanford's environment theme house) and was a 1989 recipient of the Presidential Young Investigator award. Prior to coming to Stanford, he spent three years in Perth, Australia, as a research fellow at the University of Western Australia. A Bay Area native, Professor Monismith received his B.S., M.S., and Ph.D. from the University of California at Berkeley.

**Stephen Palumbi** is the Director of Stanford University's Hopkins Marine Station. He is the Harold A. Miller Professor in Marine Sciences, Professor of Biology, and a Senior Fellow at the Stanford Woods Institute for the Environment. Professor Palumbi's published books include *Death and Life of the Monterey Bay*, *The Future is Wild*, *The Evolution Explosion*, and *Marine Reserves: An Ecosystem Tool for Marine Management and Conservation*. He has also contributed to films to enhance science communication including the BBC/Animal Planet TV series *The Future is Wild*, *Urban Shark Hunting*, *Resilience on the Reef*, and *The Secret Life of Whales*. Professor Palumbi moved his laboratory from Harvard University in August 2002 to Stanford University's Hopkins Marine Station. He received his B.A. in biology from Johns Hopkins University and his Ph.D. in marine ecology from the University of Washington.



**Chris Scholin** is the President and CEO of the Monterey Bay Aquarium Research Institute (MBARI). Previously, Dr. Scholin served as Chair of MBARI's Research Division from mid-2005 to early 2009. He also serves on an External Advisory Committee for the University of Miami's Oceans and Human Health Center as well as on the Board of Trustees of the Monterey Bay Aquarium. A Missouri native, he received a B.A. in biology from the University of California, Santa Barbara, a M.A. in molecular biology and immunology from Duke University, and a Ph.D. from the Massachusetts Institute of Technology - Woods Hole Oceanographic Institution (MIT/WHOI) Joint Program in Biological Oceanography.



**Margaret Spring** is the Vice President of Conservation and Science at the Monterey Bay Aquarium. Prior to joining the Aquarium in April 2013, Margaret served first as Chief of Staff, and then Principal Deputy Under Secretary of the National Oceanic and Atmospheric Administration (NOAA), where she worked closely with the NOAA Administrator, NOAA senior leadership and the Department of Commerce to develop and drive strategic priorities with a particular focus on external constituents, interagency initiatives, and administration priorities. From 2007 to 2009, Margaret was Director of The Nature Conservancy's California Coastal and Marine Program. Before moving to the Conservancy, Margaret served as Senior Counsel, then General Counsel, to the U.S. Senate Committee on Commerce, Science, and Transportation, where she focused on crafting legislation and ensuring oversight on topics including fisheries conservation and management, coastal zone management, marine sanctuaries, coastal and atmospheric science, climate change, weather, satellite systems, mapping and other federal ocean and atmospheric programs. A graduate of Duke University School of Law and Dartmouth College, Margaret was an environmental attorney at Sidley & Austin in Washington, D.C. from 1992 to 1999.



# Solving our Ocean Challenges

The Center for Ocean Solutions seeks solutions to the major problems facing the ocean by concentrating on three focal areas that we identified as critical to solving the key challenges. These focal areas include: Climate Change, Land-Sea Interactions and Ecosystem Health. Each is inextricably linked to the other, and our work in one area informs and advances our work in other areas.

**Ocean acidification increasingly affects vulnerable coastal animals.**



## Climate Change

The Center is working with both research and decision-making communities to advance our collective understanding of how climate change affects the dynamics in ocean and coastal systems. We also work to communicate and translate these changes and help coastal communities adapt effectively for long-term sustainability. Climate change is an integrative challenge that will directly inform our strategies and approaches within the Ecosystem Health and Land-Sea Interactions focal areas. During the year, we made important strides in support of our objectives.

### Ocean Acidification

In November 2012, Washington State Governor Christine Gregoire announced the recommendations of a Blue Ribbon Panel on ocean acidification, a threat to the state's shellfish industry. The announcement capped a year of work by Meg Caldwell and early career fellow Ryan Kelly. Kelly advised the Governor's Blue Ribbon Panel and, under Caldwell's guidance, co-authored with Jenny Grote Stoutenburg a report, *Washington State's Legal and Policy Options for Combating Ocean Acidification in State Waters*, requested by the Panel to aid in their deliberations. The report is available on the websites of the Center for Ocean Solutions and the Washington State Department of Ecology. Kelly also presented the Center's work on ocean acidification at the Institute for Sustainable Development and International Relations (ISDIR) in Paris and at the Coral Reef Foundation in Australia. The Center recently learned from a Knauss Fellow working for the U.S. Senate Commerce Committee's Ocean Subcommittee that our ocean acidification reports for both Washington and California are among the first and most heavily used resources for legislative staff seeking reference materials and information about what can be done to address ocean acidification.

In the spring of 2013, the *Harvard Environmental Law Review* published the legal article, "Ten Ways States can Combat Ocean Acidification (and Why They Should)," authored by Kelly and Caldwell. This article is a first of its kind, providing the legal foundation for practical measures states can take based on locally relevant scientific data and analysis.

### Kelp Forest Array

The Center continues to engage in primary research to understand climate impacts in the nearshore environment. The underwater power and communication node known as the Kelp Forest Array has now been live for a year, yielding twelve months of high-resolution temperature, salinity, velocity and oxygen data. This ongoing dataset is available to the scientific community and will be particularly useful to those using the Array for intensive short-term experiments as it establishes monthly and yearly variability, which would otherwise not be captured. Center early career fellow Jamie Dunckley has been working closely with MBARI scientists on the shallow-water Free Ocean CO<sub>2</sub> Enrichment (swFOCE) system, and this year, the cable for the Array and FOCE system moved to its permanent location in the Hopkins Marine Station pump house.



**Washington State's Blue Ribbon Panel on Ocean Acidification tapped the Center for expertise, resulting in a report and toolbox that helped inform their recommendations.**

The Center's legal article on "Ten Ways States can Combat Ocean Acidification (and Why They Should)" is a first of its kind, providing the legal foundation for practical measures states can take based on locally relevant scientific data and analysis.

The Center continues to engage in primary research to understand climate impacts in the nearshore environment.

The Array streams live data through the Center's website and alerts interested users when certain conditions change. For example, when the Array detects low oxygen levels, it sends an email to scientists, including Paul Leary, a graduate student in the Hopkins Marine Station lab of Fiorenza Micheli, who is studying the response of kelp forest fishes at a community level to low oxygen events. The alerts can also signal ocean managers interested in low oxygen or upwelling events, or divers curious about water visibility.

To augment the Array's current capabilities, Dunckley is working with Stanford researchers to choose additional instrumentation and hardware, including a video camera, an additional CTD (conductivity, temperature and density) and a pH sensor to round out our baseline monitoring capacity.

In addition to facilitating long-term datasets, the Center hosted two intensive experiments conducted by Ryan Walter, a graduate student of Stephen Monismith, that set out to capture the fine-scale mixing in and around a kelp forest. Without the Array, these experiments would not have been possible due to limits of autonomous instrument data storage and battery power. These and other experiments are part of an automated ocean observing system coupled with Hopkins Marine Station's Marine Life Observatory that connects traditional observations initially used for research with longer-term applications to managing oceans as the climate changes.

With many of the Kelp Forest Array's technical hurdles surmounted, the Center has initiated talks with monitoring agencies interested in integrating the Array into existing systems to help fill their data needs for adapting to climate change impacts.



CHARLENE BOARTS

## Ecosystem Migration

In September, Ocean Solutions affiliated researcher Elliott Hazen, working with the Center’s science director Larry Crowder through the Center’s Climate Change and Pelagic Predators Working Group, published new research in the journal *Nature Climate Change* revealing that ecosystems in the North Pacific could migrate as much as 1,000 kilometers north as the ocean warms, forcing many Pacific pelagic species to alter their feeding and migration habits. The article received extensive media coverage in the U.S., including the *Washington Post*, as well as internationally.

## Climate Change Adaptation

The Center conducts research in natural and social sciences, and engages with decision-makers and resource managers to help coastal communities prepare for the projected impacts of climate change.



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### National Climate Adaptation Surveys:

Another milestone in our climate change work involved national surveys of the public. The Center for Ocean Solutions collaborated with the Stanford Woods Institute for the Environment senior fellow Jon Krosnick and Department of Communications visiting scholar Bo Maclnnis to develop surveys aimed at improving how we engage the public and decision-makers on climate change adaptation. These surveys focused on the public’s views of climate adaptation strategies and included two oversamples in California and New York.

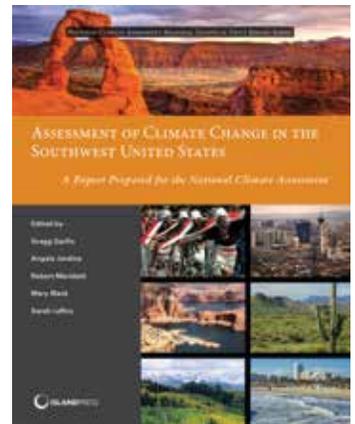
Professor Jon Krosnick unveiled the preliminary findings of the National Climate Adaptation Survey at the National Press Club.

Professor Krosnick unveiled the preliminary survey findings at the National Press Club in Washington, D.C. in late March. Extensive media coverage resulted in stories carried in the press worldwide.

Adina Abeles and Erin Prahler briefed Congressional staff on the survey results during Capitol Hill Ocean Week in June 2013. In addition to presenting the national results, Meg Caldwell and Adina Abeles briefed California agencies, decision makers and coastal adaptation training professionals on the responses from the California oversample.

**Sea Level Rise:** As more states and coastal communities are tackling sea level rise, coastal erosion and other local climate change impacts, Ocean Solutions brings the latest science to adaptation planning. In May, the California Assembly Select Committee on Sea Level Rise and the California Economy invited executive director Meg Caldwell to share the Center’s work on “Preparing for the Effects of Global Warming: The American Public’s Perspective on Sea Level Rise.”

In the spring, Island Press released to national audiences the *Assessment of Climate Change in the Southwest United States*, a 500-page technical advisory report for the National Climate Assessment. Caldwell and research analyst Eric Hartge served as coordinating lead authors of the Coastal Issues chapter.



Center staff contributed to the *Assessment of Climate Change in the Southwest United States* released by Island Press in the spring.

Sea level rise and other climate change impacts threaten coastal communities.



GARY GRIGGS

**Incorporating Natural Capital into Climate Adaptation Planning (INCCAP):** In collaboration with the Natural Capital Project, the Center completed analysis with the Greater Monterey County on its Integrated Regional Water Management Plan using the InVEST coastal vulnerability model to assess the vulnerability of the Monterey Bay area coastline and assist in prioritizing adaptation strategies. We also contributed recommendations for the plan’s climate change chapter to accurately reflect the importance of ecosystem services and highlight selection of “multi-benefit” strategies in project prioritization. The INCCAP team finalized similar work with Santa Cruz County in the fall.

The INCCAP project team also demonstrated the use of the InVEST hydrology models (i.e., water yield, nutrient retention and sediment retention) to help The Nature Conservancy scope adaptation work in the Monterey Bay region.

Finally, we extended our pilot work with the California Coastal Commission to incorporate principles of ecosystem services into coastal development permit decision-making and local coastal planning in two ways. First, we hosted several key Commission staff for the Annual InVEST Training and co-developed a strategy to complement and help achieve the objectives of their new NOAA grant to better incorporate beach ecosystem services into staff analyses and to work directly with local jurisdictions on incorporating ecosystem services approaches into their local coastal programs. Second, the INCCAP project team collaborated with several local jurisdictions—Marin, Sonoma, Monterey and Santa Cruz Counties—to add capacity to their grant proposals to develop and adopt updated plans that conserve and protect coastal resources from future climate related impacts. The three collaborative grant proposals from local jurisdictions were funded. The InVEST analysis tool developed by the Natural Capital Project will be utilized to inform these projects. The Greater Monterey and Santa Cruz Counties invited the INCCAP team to collaborate in their joint local coastal program grant proposal based on our engagement described above. Marin County also requested our participation in their grant proposal based on their Planning Director’s experience participating in the climate change adaptation training the Center co-developed and hosted with NOAA in 2010.

**Monterey Bay Area Climate Change Adaptation:** After the climate change adaptation training the Center co-developed and hosted with NOAA in 2010, the Monterey Bay National Marine Sanctuary approached the Center to see if we could deliver something in the Monterey Bay Area that would facilitate coastal adaptation planning to climate change. The Center realized this was a unique opportunity to move beyond a one-time training and use the Monterey Bay to pilot coastal adaptation approaches that could have widespread application.

On October 25, 2012 the Center for Ocean Solutions, the West Coast Governors Alliance on Ocean Health Climate Change Action Coordination Team, the City of Monterey, Monterey Bay National Marine Sanctuary, AMBAG Energy Watch and the Central Coast Wetlands Group hosted the workshop, “Progress Towards Preparing for the Future: Climate Change and the Monterey Bay Shoreline.” During this workshop, participants learned about progress made by scientists and practitioners in preparing the Monterey Bay shoreline community for the impacts of climate change since the first regional workshop in December 2011. The workshop was coordinated with Monterey County’s Coastal Storms Conference in an attempt to bring together the hazard mitigation planning community with the coastal adaptation community. Adina Abeles designed the agenda for these shared goals and moderated the day.

**Connections between Coastal Adaptation Planning and Hazard Mitigation Planning Workshop:**

On August 1, 2013, Monterey County held a kick-off of its multi-jurisdictional hazard mitigation plan update and invited Adina Abeles to be the keynote speaker. Updated hazard mitigation planning for the County will now incorporate climate change *projections* into planning. Local groups and jurisdictions working together on submitting proposals to fund coastal adaptation work reflect evidence of additional impacts from these regional discussions.

**Climate Change Communication Workshops:** Adina Abeles worked with the NOAA Coastal Services Center to deliver the training, *Climate Communication: Applying Communication Research to be Effective*, at the National Adaptation Forum in April 2013. Targeting interested climate change adaptation professionals, the forum piloted our new approaches to climate change communication training prior to delivering these trainings to coastal communities.

**Monterey Bay Area Climate Change Communication Training:** The Center’s Adina Abeles and Nora Deans worked with the Monterey Bay Aquarium’s vice president of programs Cynthia Vernon, MBARI’s senior education and research specialist George Matsumoto and NOAA Coastal Services Center’s climate adaptation trainer Gwen Shaughnessey to develop a day-long session for interested local government staff, natural resource managers and other leaders in the Monterey Bay area planning and management community to discuss strategies for engaging the public on climate change issues. This training, held in late August, built upon the training developed for the National Adaptation Forum and included the experience and knowledge from the Aquarium’s work in climate change communication.



ADINA ABELES

Two dozen resource managers and planners participated in the Monterey Bay Area Climate Change Communication Workshop.

The Center for Ocean Solutions brings the latest science to adaptation planning.

The workshop also built upon previous research, trainings, partnerships and our relationships: the Center's core partners (Stanford, MBA, MBARI) and NOAA Coastal Services Center (CSC), our years of work in Monterey Bay to increase and advance coastal practitioner dialogue around preparing for climate change impacts to our coastal ecosystems, years of working with NOAA CSC and other organizations in delivering climate change communication trainings, and our recent research on climate change communication and public perceptions of adaptation policy.

The 24 participants from local, state and federal government, NGOs and academics all reported that the workshop increased their ability to engage in dialogue on climate change adaptation.

**Successful Adaptation in the Coastal Context:** Adina Abeles worked with Stanford Woods Institute's social science research fellow Susanne Moser and collaborators from Oregon State University, University of Washington's Climate Impacts Group and the Institute for Sustainable Communities to conduct work on understanding what it means to be successful in climate change adaptation in the coastal context. NOAA Sea Grant and the Gordon and Betty Moore Foundation funded this work. Stanford Professor Pam Matson served as the principal investigator.

To ground the findings in science, yet make them applicable in the field, the project team hosted a series of five workshops with scientists and practitioners. An expert meeting in the fall of 2012, and three practitioner workshops in the winter and spring explored the question, "How will we know if we are successfully adapting to climate change?" The capstone meeting on July 23, 2013, brought together coastal practitioners from Washington, Oregon and California as well as several experts from Stanford University, University of Colorado, and researchers in the NGO and private sectors to synthesize findings to date, focus on successful adaptation outcomes and ways to measure progress and effectiveness over time.

During the Coral Reef Management class in Palau, Center staff facilitated meetings between students and Palau's president, other politicians and agencies.



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### **Climate Change and Coral Reefs Coral Reef Management in Palau:**

In July 2013, Meg Caldwell, Rob Dunbar, Stephen Monismith and early career fellow Meredith Bennett went to Palau to teach a group of 14 Stanford and Palauan students about threats to coral reefs and management opportunities for

their conservation. Caldwell and Bennett discussed legal frameworks for coral reef management generally and analyzed the historical and legal infrastructure of Palau in order to illustrate the challenges that a small developing island state faces in balancing development with conservation and to emphasize the unique conservation efforts Palau has undertaken that have made it a leader in coral reef conservation. Over the course of the three-week class, Caldwell facilitated meetings between the students and Palau's president, attorney general, the assistant attorney general working with Palau's environmental permitting agency, a former state governor and a member of one of Palau's politically powerful women's groups.



DAN BARSHIS

Prior to arriving in Palau, early career fellow Meredith Bennett helped translate the momentum of the Scientific Consensus Statement on Climate Change and Coral Reefs into next steps by analyzing Palau's laws and regulations for their adequacy in protecting the nation's coral reef ecosystems. This analysis identified areas where Palau has made significant strides in coral reef conservation that could potentially be replicated by other small island developing states as well as critical gaps where it is possible for Palau to improve its legal framework. Caldwell and Bennett met with environmental enforcement officers, government attorneys, NGOs and local businesses to get an on-the-ground perspective of Palau's conservation achievements and remaining obstacles. At the invitation of the attorney serving Palau's environmental permitting agency, the Center provided input on how to improve many of Palau's environmental regulations, which the assistant attorney general is currently updating. Many of the people with whom Caldwell and Bennett met mentioned that no one had undertaken such an in-depth analysis of Palau's laws before, so the analysis serves as a tool for conservation efforts in the future.

**Palau has made significant strides in coral reef conservation that could potentially be replicated by other small island developing states.**

## Land-Sea Interactions

In our Land-Sea Interactions focus, we work to demonstrate the viability and affordability of new technology and analytical methods for rapid detection of coastal pathogens and water quality, and impacts of coastal hypoxia in California waters. Due to the complexity of this topic, our work in this area is still emerging.

During the year, we continued to work on the deployment of Environmental Sample Processors, and over the next year we will greatly expand this collaborative to include other institutions and organizations. We also initiated an environmental DNA sampling project to enable rapid identification of marine species in a given locale and hosted a three-day meeting of scientists and managers to share the research results of the Coastal Hypoxia Working Group.

**Early career fellow Kevan Yamahara with an Environmental Sampling Processor (ESP) capable of autonomously monitoring water quality in near-real time.**



MBARI

**Rapid Detection of Marine Pathogens:**

This year, Ocean Solutions partnered with NOAA Northwest Fisheries Science Center, University of British Columbia, Northwest Indian College, Washington State Department of Health, Taylor Shellfish Farms and Lummi Nation’s Natural Resources Department in a collaborative project to pilot a water-quality

monitoring program for the early detection of harmful algae and pathogens impacting shellfish aquaculture areas in Puget Sound. The main goal of this project is to provide near real-time data to decision-makers (public health officials and shellfish growers) on the presence of harmful algae and pathogens in the water column to help improve the safety of seafood.

Another goal of this project is to assess the locations and number of Environmental Sample Processors (ESPs) needed to provide an early warning system. Over the long term, this collaboration seeks to develop a water-quality monitoring program utilizing ESP technology to predict when harmful algae and/or pathogens are present in shellfish. This would enable the shellfish industry to harvest their product when it is safe and to minimize potential consumer and economic risks.

In collaboration with the Southern California Coastal Water Research Project (SCCWRP), the Rapid Marine Pathogens Project secured funding through MBARI from the California Proposition 84 Clean Beaches Initiative to further the development of the next generation of ESP technology for water-quality monitoring. Continuing on the success of the Center’s Rapid Marine Pathogens work, the grant aims to develop an automated, field-portable instrument for tracking sources of microbial pollution that impact the beneficial uses of water bodies. This will allow beach managers to more quickly identify and remediate pollution sources impacting recreational waters.

**Environmental DNA:** With start-up funding from the Center and a subsequent Packard Foundation grant headed by Larry Crowder, early career science fellows Ryan Kelly, Kevan Yamahara and Jesse Port initiated an environmental DNA (eDNA) sampling project that could enable rapid and accurate identification of marine species in a given locale, a significant advance over the manual methods of environmental sampling that have historically dominated marine ecology and related fields. The ocean is a soup of its resident species’ genetic material, in the forms of metabolic waste, shed skin cells and damaged tissue. The team is working on a method of estimating the relative abundance of each of the species present—and potentially the number of individuals of each species present—merely from the DNA in a sampled liter of seawater.

With the goal of validating eDNA sampling methods, the Center team tested a one-liter sample from the Aquarium’s 4.5-million-liter Open Sea Exhibit. From this, the eDNA team was able to detect not only most of the bony fishes present but

The main goal of this project is to provide near real-time data about the presence of harmful algae and pathogens in the water to help improve the safety of seafood.



JESSE PORT

**The eDNA team completed their first phase of eDNA field sampling in the Marine Life Observatory at Hopkins Marine Station in Monterey Bay.**

even to reconstruct the probable contents of the commercial feed on which the tuna, mahi-mahi and others subsist. This kind of sensitivity is only possible due to recent advances in DNA sequencing technology and computing power. Until now these tools have largely been brought to bear on problems of microbial diversity; here the Center focuses on animal species with better understood ecological roles, more direct economic and social value, and greater vulnerability to human impacts.

We have also developed a bioinformatics pipeline to process large sequencing datasets, run quality control parameters and assigned taxonomy. We are collaborating with Philip Thomsen at the University of Copenhagen, who pioneered the use of eDNA in freshwater systems, to standardize the eDNA analysis framework.

Most recently, our eDNA team completed their first phase of eDNA field sampling in the Marine Life Observatory at Hopkins Marine Station in Monterey Bay. With assistance from colleagues at Hopkins and MBARI, we took visual taxonomic surveys in kelp forest, seagrass, deep reef and open-water habitats, collecting parallel water samples for eDNA analysis. The goal is to determine whether the eDNA results match the visual data, and to understand how oceanographic conditions may influence the distribution of eDNA.

Linking oceanography to eDNA abundance will be a critical step towards making eDNA a practical tool for conservation and environmental monitoring. Along these lines, the eDNA project has been selected by the American Geophysical Union (AGU) to serve as a prototype for their Thriving Earth Exchange program. This new program links communities seeking scientific expertise with scientists—such as AGU members—willing to provide that expertise. AGU has connected the Center with oceanographers at NOAA who have proposed a method to estimate the source of sampled seawater from which we will sample eDNA. Stanford professor Ali Boehm (Civil and Environmental Engineering) and science director Larry Crowder were recently awarded an ‘Environmental Ventures Projects’ (EVP) award from Stanford Woods Institute for the Environment to continue refining laboratory approaches and clarifying how we can most reliably produce and interpret eDNA data.

**Water Quality:** In the fall of 2012, Ocean Solutions participated in a large study with the Orange County Sanitation District (OCSD) to monitor the water quality associated with the repair and diversion of the OCSD offshore outfall pipe. A large consortium of researchers participated in the study, which provided information on the movement of the plume and the ecosystem response to the diversion event.

**Coastal Hypoxia Working Group:** In September, the working group on Consequences of Coastal Hypoxia in the California Current Large Marine Ecosystem led by Larry Crowder and Fio Micheli hosted a three-day meeting at Stanford’s Hopkins Marine Station to share its findings with fellow researchers and managers and further develop a consensus on the results of its work. Research results were shared during a special session chaired by Larry Crowder on “Drivers and Ecological Effects of Hypoxia in Coastal Upwelling Systems” at the Coastal & Estuarine Research Federation 2013 meeting in the fall.



RANDY WILDER / MONTEREY BAY AQUARIUM

**The Center team tested water from the Aquarium’s 4.5-million-liter Open Sea Exhibit to validate eDNA sampling methods.**

Linking oceanography to environmental DNA abundance will be a critical step towards making eDNA a practical tool for conservation and environmental monitoring.

## Ecosystem Health

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Our focus in Ecosystem Health centers on improving the governance and sustainability of marine resources, creating practical ways to reduce cumulative impacts and providing marine managers with expert guidance. Our work here revolves around a set of interwoven issues vital to the long-term sustainability of ocean resources: ecosystem-based ocean planning, social-ecological systems, ocean governance, cumulative impacts and marine ecosystem thresholds and indicators. Because ecosystem health depends upon the relationship between the human, biological, physical and social aspects of the ecology of the ecosystem, we focus on improving the nature of those relationships.

Over the past year, Ocean Solutions provided guidance on how to monitor the impacts of human activities and quantify the cumulative impact of many activities, how to conduct ecosystem-based ocean planning and management that effectively limits impacts to ecosystems while maintaining sustainable resource use, and how to create governance systems that create buy-in and offer incentives for stewardship behavior consistent with the achievement of social, economic and ecological goals. Science director Larry Crowder coauthored a major international synthesis on ocean health, *The Ocean Health Index*, which was published in *Nature* in late 2012. This year we produced guidance on how to measure cumulative impacts and are

The health of marine ecosystems depends upon the relationship between the human, biological, physical and social aspects of the ecology of the ocean.



ground-truthing cumulative impact scores so that policy and management systems can begin to reflect the reality that most areas of the ocean are impacted by multiple human activities. Similarly, we documented thresholds in coral reefs linked to fishing pressure and are now investigating thresholds in other marine systems to ensure that policy and management take into account that natural systems often do not respond to human impact in a linear fashion, but rather can undergo abrupt transitions.

### **Ecosystem-based Ocean Planning**

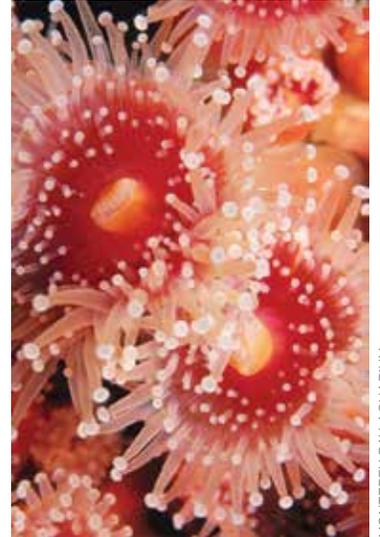
**Ecological Principles:** More than 400 copies of the reference guide, *Incorporating Ecological Principles into California Ocean and Coastal Management*, have been distributed via customized presentations, trainings and meetings with marine professionals in governmental, non-governmental and partner organizations. A December webinar based on the report drew about 20 professionals from a variety of international, national and state-based NGOs.

Further interest in the report led to meetings with the California Department of Fish and Wildlife, California's State Lands Commission, California Coastal Commission, California Ocean Protection Council, California Ocean Science Trust, State Water Resources Control Board, California Department of Fish and Wildlife Spiny Lobster Fishery Management Plan Advisory Committee, and 21 members of the Humboldt Bay Initiative (including representatives from industry, state and local agencies, and tribal groups).

The Center also organized a panel on the Guide at the Public Interest Law Conference in Eugene, Oregon, titled, "Real World Applications of Ecosystem-Based Management to Ocean and Coastal Challenges." Center staff also met with the National Ocean Policy Ecosystem-Based Management working group in Washington, D.C., to share lessons learned during the development of the Guide and to help create ecosystem-based management trainings for federal agencies. NOAA's international team is already using the Guide in its trainings for coastal and ocean managers around the Pacific.

**Eco-principles Connect:** In direct response to agency requests for assistance in linking specific facts of individual decisions to the Guide's contents and relevant scientific data, the Center is collaborating with the California Ocean Science Trust and San Francisco Estuary Institute to build a web-based interface that connects managers to scientific and geospatial information in the marine environment through the lens of the four key ecological principles detailed in the *Ecological Principles Guide*. The ultimate aim of the "Eco-Principles Connect" portal is to help managers become more efficient when integrating ecosystem-based management into their daily decisions. Specifically, the Center is co-developing a prototype of the web-based interface with the California Coastal Commission that connects agency staff to data sources in the marine and coastal environment, including sources housed in California's Marine Geoportal, and explains how these data are linked to specific ecological principles and existing agency mandates.

**International Applications:** At the invitation of New Zealand's National Institute of Water and Atmospheric Research (NIWA), former early career science fellow Melissa Foley took the lessons learned from our work in California on ecosystem-based marine planning to New Zealand to inform management decisions on land and the territorial sea (0 to 12 nautical miles) by the Auckland Regional Council. Council



MONTEREY BAY AQUARIUM

The Ecological Principles Connect portal will be designed to help managers become more efficient when integrating ecosystem-based management into their daily decisions.

scientists are currently working to determine where the ecological principles can be used given their existing legal mandates.

**Ocean and Coastal Law and Policy:** By invitation, the Center’s early career law and policy fellow Ashley Erickson, executive director Meg Caldwell and research assistant Zach Koehn submitted a new chapter on ocean planning for the second edition of the American Bar Association’s book *Ocean and Coastal Law and Policy*. The chapter is entitled “Smart Ocean Planning: Drivers, Enabling Conditions, and Global Examples.” The book is geared to U.S. practitioners of all disciplines working within ocean and coastal legal frameworks.



JONATHAN BLAIR / MONTEREY BAY AQUARIUM

**Monitoring Nearshore Ecosystem Health:**

In California, the state-wide network of marine protected areas (MPAs) is designed to “protect ecosystem structure, function and integrity.” To assess whether these goals are being met, several institutions, including California Ocean Science Trust and the MPA Monitoring Enterprise, are identifying indicators for monitoring ecosystem health, and developing a wide range

of tools to communicate the results of these assessments. Rebecca Martone and former early career science fellow Melissa Foley have been providing guidance and feedback on these indicators and monitoring approaches in nearshore ecosystems.

**Social Data in Ecosystem-based Management:** The Center finalized publications from a yearlong interdisciplinary effort to assess the use of social data in ecosystem-based ocean planning, led by the Center’s science director Larry Crowder and early career social science fellow Jack Kittinger. The first review, “Progress and Promise in Spatial Human Dimensions Research for Ecosystem-based Ocean Planning,” was published in *Marine Policy* in the spring. The second review assessed the use of social data in ocean planning practice, drawing on a global review of planning initiatives and survey of ocean and coastal planning practitioners. This paper, “Current Practice and Future Prospects for Social Data in Coastal and Ocean Planning,” is in revision for *Conservation Biology*.

Drawing upon these two reviews, the Center coalesced findings and insights from an expert workshop to develop the policy framework paper, “Putting People into Ecosystem-based Ocean Planning,” submitted for publication in *Frontiers in Ecology and Environment*. The paper shows how more systematic engagement of social data—together with ecological information—may help to improve planning and management outcomes.

**Dynamic Marine Management Working Group:** Dynamic ocean management relies on the development of continually adaptive management measures based on the dynamics of ocean features, how species of interest interact with these features and how people use ocean resources. We have the tools and techniques to both model species environment relationships in near real time and to inform fishers of changes in management boundaries, ultimately resulting in a holistic approach that maximizes human well-being and environmental sustainability.

A Center for Ocean Solutions-supported working group led by Larry Crowder is examining the potential conflict between fisheries and protected areas by using satellite and remotely sensed oceanographic data with state-of-the-art oceanographic modeling techniques to detect how they respond to environmental variables. This approach aims to help fishermen optimize their effort while achieving conservation goals. An initial paper from this working group, “Cumulative Human Impacts on Marine Predators,” was published in 2013 in *Nature Communications*.

Unlike traditional fisheries management strategies, dynamic ocean management supports a process that integrates new information as it becomes available. We plan to implement an interactive, web-based tool that uses dynamic ocean management for the California Drift Gillnet fishery and provides a framework in data-poor (fisheries data only) and data-rich (fisheries, observer, tracking data) fisheries for further dynamic ocean management implementation.

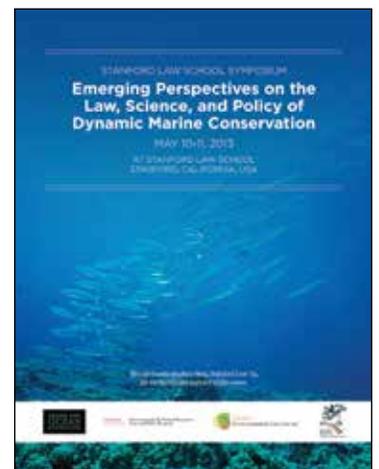
**International Symposium on Dynamic Marine Conservation:** Working closely with the Stanford Law School, the Center conceived, oversaw development and co-hosted a two-day International Symposium on Dynamic Marine Conservation in May, which drew more than 200 participants from around the world. Through the symposium, the Center strengthened ties with the international ocean academic, practitioner and governance communities. Two resulting special journal issues will include articles written by interdisciplinary author teams. The articles are designed to directly inform current marine conservation management questions on high seas governance, as well as Arctic and Antarctic governance.

### Cumulative Impacts

The Center’s work in cumulative impacts looks at the total harm to human health and the marine environment that results from a combination of stressors over space and time. Characterizing and quantifying cumulative impacts on the ocean from multiple human activities, such as fishing and land-based pollution, as well as natural processes, such as climate change, remains an enormous challenge.

**Ground-Truthing Impacts in California Waters:** Melissa Foley and early career science fellow Megan Mach are running a pilot project in central and southern California to ground-truth the cumulative impacts model for California state waters developed by Ben Halpern (U.C. Santa Barbara) and colleagues. The analysis uses existing ecosystem condition data for soft sediment, kelp forests and rocky intertidal habitats to determine if the cumulative impact scores generated in the model are correlated with ecosystem condition. If validated, the cumulative impact model would provide a way to assess stressors, and identify and prioritize stressors that could be reduced. Ben Halpern and Center for Ocean Solutions visiting fellow Rod Fujita published a paper that explains the underlying assumptions of cumulative impacts analysis and provides guidance on how to interpret results, as well as on further research to

Dynamic ocean management in fisheries integrates new information as it becomes available, based on the dynamics of ocean features, how species of interest interact with these features and how people use ocean resources



The Center and Stanford Law School co-hosted a two-day International Symposium on Dynamic Marine Conservation in May that drew hundreds from all over the world.

improve this kind of analysis. The results of these studies, together with our analyses of the legal requirements for cumulative impact assessments and the use of models in decision-making, will inform agency staff who are eager to improve cumulative impact analysis for coastal and ocean decision-making through the use of scientifically validated and legally sound approaches.

**Cumulative Impacts in New Zealand and Beyond:** While a visiting scientist with the National Institute for Water and Atmospheric Research (NIWA), Melissa Foley co-lead workshops for Regional Council and Ministry staff to determine how cumulative impacts and risk of ecosystem degradation are assessed in New Zealand. She also surveyed this group of practitioners on the specifics of cumulative impact assessment methods. The survey experience and calls from California agency staff interested in improving their own cumulative impact assessment spurred Melissa Foley and early career fellows Meredith Bennett, Ashley Erickson, Megan Mach, Erin Prahler and ecosystem health program lead Rebecca Martone to develop a work plan to deepen our understanding of the law, science and practice of cumulative impact assessments. We are revising the survey distributed to New Zealand practitioners for distribution in California, British Columbia, Canada and Queensland, Australia so we can compare practices across several jurisdictions.

**Best Practices:** Concurrently with the survey work, Meg Caldwell and the Center's early career law and policy fellows are leading a review of the legal requirements for cumulative impact assessment under the National Environmental Policy Act, the California Environmental Quality Act, and other California programs. This review will culminate in an article and possibly a guidance document that will identify not only the current legal requirements for cumulative impact assessment under these programs, but also best practices for practitioners conducting cumulative impact assessments. Simultaneously, early career science fellow Megan Mach and Ecosystem Health program lead Rebecca Martone are collaborating with scientific staff at World Wildlife Fund Canada to review the state of the science regarding cumulative impact assessment methods and to identify scientific best practices.

### **Aquatic Invasive Species**

Early career fellow Erin Prahler collaborated with the California Ocean Science Trust to identify and recommend policy approaches to prevent and manage introductions of invasive species in California through key pathways, including aquaculture, live seafood, aquarium and aquascape, live bait, recreational boating and commercial fishing. The resulting scientific findings and policy recommendations were presented to the Ocean Protection Council in July 2013. The California Department of Fish and Wildlife will use the policy recommendations to inform the update of the California Aquatic Invasive Species Management Plan.

### **California Fisheries Preliminary Policy Assessment**

At the request of the Resources Legacy Fund Foundation, the Center recently initiated a preliminary assessment of the ecological and economic performance of fisheries managed by California under the Marine Life Management Act to determine if and where management improvements are warranted. This study could contribute to a long-term strategy in state fisheries that transforms fisheries practices and management in ways that make them more effective in delivering long-term ecological, economic and social benefits.



RANDY WILDER/  
MONTEREY BAY AQUARIUM

## Social-ecological Systems

**Social-ecological Resilience in Small-Scale Fisheries Working Group:** This group led by Larry Crowder and Jack Kittinger published their first paper, “Emerging frontiers in social-ecological systems research for sustainability of small-scale fisheries,” as an invited contribution to *Current Opinion in Environmental Sustainability*. This publication translates new findings from social-ecological systems thinking for application in small-scale fisheries management. Building on this, the working group is assessing social-ecological linkages in an in-depth case study examining fisheries in Monterey Bay. Supported by several externally funded interns, this project seeks to uncover social and ecological dynamics in these fisheries and policy approaches that strengthen local fisheries sustainability and economies. Together with Hopkins Marine Station graduate student Elena Finkbeiner, the Center will host an interactive session entitled “Challenges and Opportunities in Transitioning Small-Scale Fisheries to Sustainability,” accepted for next year’s American Association for the Advancement of Science meeting in Chicago in February 2014. Jack Kittinger and Larry Crowder will moderate this session.

**Social-Ecological System Analysis of Small-Scale Fisheries in Monterey Bay:** In November, the Social-Ecological Resilience in Small-Scale Fisheries working group launched a project on small-scale fisheries in Monterey Bay. Led by Larry Crowder, Jack Kittinger, and Stacy Aguilera from the Abess Center of Ecosystem Science and Policy, the interdisciplinary team includes a number of social scientists, ecologists and fishery experts from around the Monterey Bay Area, including Carrie Pomeroy and Mark Carr from the University of California Santa Cruz and Rick Starr from Moss Landing Marine Laboratories. This project examines the long-term social-ecological dynamics of small-scale fisheries in this productive central California region with the overarching goal to gain insights that can be applied to the sustainable management of small-scale fisheries.

Working with fishing communities in coral reefs around the world, early career fellows are exploring processes designed to empower local resource users to manage, access and benefit from ecosystem services that will help alleviate poverty.



MIKE MARKOVINA, MARINE PHOTO BANK

Ecosystem services capture the benefits people gain from nature, and convey the likely impact of ecosystem change on human well-being.

Our interdisciplinary approach explores which sectors of small-scale fisheries in Monterey Bay are associated with different social and ecological outcomes, focusing on the salmon and albacore troll, groundfish trap and line, squid and “wetfish” (sardines, anchovies) round haul, crab trap and spot prawn trap fisheries. We aim to understand what has happened over time in all spheres of the five fisheries, characterizing changes and identifying drivers in the community, market, climate, governance systems and technological development in the Bay.

**Ecosystem Services:** New early career social science fellow Christina Hicks brings a holistic understanding of marine ecosystem services to the Center as she explores the barriers to effective uptake of ecosystem services approaches in marine management and proposes a means to overcome those barriers. Ecosystem services capture the benefits people gain from nature, and convey the likely impact of ecosystem change on human well-being. This project integrates social theory into ecosystem service science to broaden the way ecosystem services are conceptualized, measured and incorporated into decision-making processes. By achieving these aims, ecosystem services will be better equipped to inform policy choices in a diversity of settings, and anticipate unexpected or undesirable responses to policy as well as create equitable and enduring solutions to many environmental challenges.

Engaging with a global network of social scientists, anthropologists, and ecosystem service analysts and practitioners, Christina Hicks and Jack Kittinger are examining: 1) what motivates people to value ecosystem services; and, 2) what enables people to benefit from ecosystem services? Their work involves empirical data collection from 28 fishing communities in coral reefs across four countries. The next steps involve further collaborative fieldwork to determine the extent to which ecosystem services contribute to people’s well being; and a multidisciplinary workshop to determine how ecosystem services should be conceptualized and measured. The fieldwork component represents a multidisciplinary and multi-institutional effort to identify levers by which benefits from ecosystem services can be enhanced, as well as trade-offs that need to be considered in the flow of ecosystem services to human well-being. This work is designed to empower local resource users to manage, access and benefit from ecosystem services that will help alleviate poverty through enhancing benefits to the poor.

### Ocean Tipping Points

The Center is a collaborator on the four-year, \$3 million Ocean Tipping Points project that seeks to embed the science of tipping points in ocean management, with major funding from the Gordon and Betty Moore Foundation. Core partners include the University of California Santa Barbara (UCSB) and the National Center for Ecological Analysis and Synthesis (NCEAS), the National Ocean and Atmospheric Administration’s (NOAA) Northwest Fisheries Science Center and the Environmental Defense Fund (EDF).

The Center’s work on Ocean Tipping Points synthesizes and builds upon our growing scientific understanding of ecological and socio-economic tipping points in marine systems. Ocean Solutions is also leading efforts to work with practitioners to develop and test useful approaches for integrating that information into ecosystem management.



BRANDON PUCKETT, MARINE PHOTOBANK

In January, Center staff and fellows met with their collaborators and presented the Center's work on cumulative impacts, wrote the Expert Management Advisory Group's Terms of Reference, conducted a broad-scale literature review on indicators and thresholds in resource management, and developed a team strategy for project communication. Visiting fellow Rod Fujita completed an analysis of Caribbean coral reef ecosystem thresholds that will also be the subject of a manuscript for publication.



UCSB DIGITAL COMMONS

To co-develop approaches for management, Ocean Solutions convened a virtual introductory meeting of nine management experts in July, with an in-person meeting scheduled for September. The Center and NCEAS also lined up a multidisciplinary Science Working Group to develop an overarching conceptual framework for the project.

**Communication:** Ocean Solutions spearheaded the launch of a new project website ([oceantippingpoints.org](http://oceantippingpoints.org)) in late June, targeted toward marine managers and scientists as well as interested stakeholders. In late July, the project was invited to send a memo to NOAA Administrator Kathryn Sullivan and other NOAA leadership announcing the website launch. This was followed by an invited one-hour presentation in Washington, D.C., by collaborator Phil Levin, which was well received by high-ranking NOAA staff.

**Management Review:** The project team studied the attributes of 51 resource management systems linked to success or failure in avoiding or recovering from ecosystem thresholds. The results provide empirical support for management system design principles, such as appropriate scaling, the use of monitoring data and the use of the best available science.

Early career fellows Ashley Erickson, Ryan Kelly, and Jack Kittinger—along with research analyst Lindley Mease—collaborated with Rod Fujita and intern Willow Batista of the Environmental Defense Fund to review the social-ecological systems and associated management regimes for each case study, relating those factors to management success defined by ecological outcomes. They then used these findings to develop recommendations for managers seeking to ameliorate or prevent deleterious biophysical tipping points in the marine environment. Their paper entitled “Embracing Thresholds for Better Environmental Management” was accepted for publication in the *Philosophical Transactions of the Royal Society B* in 2013.

Ocean Tipping Points researchers selected two case study regions for applying research and analysis to real-world management scenarios.



PHIL LEVIN

**Law/Policy Review:** Ashley Erickson and Ryan Kelly began a review of select federal ocean management laws to identify the existing legal, regulatory and policy vehicles that can enable management-uptake of threshold-relevant science, with plans for completion in winter 2014.

**Literature Review:** Melissa Foley, research intern Michael Fox and Rebecca Martone led a literature review to identify challenges that currently limit our ability to apply tipping point science to management. Understanding the challenges helps to highlight where additional research, engagement and governance reforms can increase the uptake and application of the best available science by decision-makers. The team submitted the manuscript for publication in August to *Journal of Applied Ecology*.

**Case Study Regions:** In January 2013, the Ocean Tipping Points researchers selected two case study regions for applying research and analysis to real-world management scenarios: the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) and the Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site in Haida Gwaii, BC. Both exhibit important past or potential tipping points, good data availability, strong likelihood to engage in marine spatial planning and important policy opportunities with potential to serve as examples in the region or beyond.



MONTEREY BAY AQUARIUM

# Leadership Development and Education

## Fisheries Leadership & Sustainability Forum

Through this collaboration with the Stanford Woods Institute, the Nicholas Institute at Duke University and the Environmental Defense Fund, and under the leadership of executive director John Henderschedt, the Fisheries Forum convened two semiannual forums in support of the eight U.S. regional fishery management councils and their management partners.



FISHERIES LEADERSHIP AND SUSTAINABILITY FORUM

The discussion-oriented, policy-lab style forum in September 2012 explored the challenges and opportunities of complying with National Standard 1 and achieving optimum yield.

### National Standard 1 and Optimum

**Yield:** In September 2012, the Fisheries Forum convened its 9th Forum on the topic of National Standard 1 and Optimum Yield, hosted by Stanford University in Monterey, California. This discussion-oriented, policy-lab style Forum explored the challenges and opportunities of complying with National Standard 1 and achieving optimum yield, and also provided participants the opportunity to discuss ideas pertaining to the Advanced Notice of Proposed Rulemaking for revisions to the National Standard 1 Guidelines undertaken by NOAA Fisheries.

**Habitat Considerations:** The Fisheries Forum 10th Forum was held in Annapolis, MD in June 2013. The Forum explored the integration of habitat science and considerations into the decision-making process and built on habitat discussions convened at the third *Managing Our Nations Fisheries Conference* in Washington, D.C. in May 2013. The Fisheries Forum, in partnership with NOAA Fisheries and the eight regional fishery management councils, contributed to the development and execution of this national workshop to explore the progress and continuing challenges with managing the Nation's federal fishery resources.

**Managing Squid Stocks:** In January 2013, the Fisheries Forum supported the Mid-Atlantic Fishery Management Council in executing a workshop to explore strategies for managing squid stocks in the Mid-Atlantic region. Workshop participants included members of the commercial squid fishery, processing sector, scientists, council members and council staff.

**Risk Policy:** In March 2013, the Fisheries Forum and the New England Fishery Management Council convened a workshop on the topic of risk policy. Approximately 80 members of the New England Council, council staff, science and statistical committee advisory bodies, NOAA Northeast Regional Office and Science Center staff, as well as managers and scientists from other council regions participated in the workshop. In support of this work, the Fisheries Forum produced an updated report, "Risk policy and managing for uncertainty across Regional Fishery Management Councils."

Graduate students from seven MARINE campuses participated in three seminars, two trainings, two two-week intensive courses and campus-specific networking events.

### **Monterey Area Research Institutions' Network for Education (MARINE)**

The MARINE theme for the 2012-2013 academic year was leadership development. An increased number of graduate students from the seven MARINE campuses participated in three seminars, two trainings, two two-week intensive courses and campus specific networking events.

**Seminars:** MARINE seminars introduce students to leaders in ocean science and conservation and hear how their experience as a scientist led to change on the water. Between 70 and 120 students regularly attend these seminars. The initial seminar, "Linking Knowledge to Action: What's Killing Sea Otters?" was given by Dr. Pat Conrad, co-director, One Health Center at the University of CA Global Health Institute, U.C. Davis, and professor, Dept. of Pathology, Microbiology, and Immunology.

Dr. Nancy Knowlton, Sant Chair for Marine Science, Smithsonian Institution presented the second seminar, "Beyond the Obituaries: Success Stories in Marine Conservation."

The third seminar coincided with the Oceans Colloquium. Dr. Robert Richmond, professor, U. of Hawaii, president of the International Society for Reef Studies spoke about "Linking Knowledge to Action: Coral Reef Projects in Pacific Islands."



ERIC JOHNSON

**Trainings/Workshops:** MARINE sponsored a workshop, “Networking with Confidence” by Elin Kelsey prior to the Western Society of Naturalists meeting in November 2012. Twenty-eight students learned techniques on how to introduce themselves, approach a mentor or new colleague with a request and other communication techniques useful for networking.

MARINE director of education and training Adina Abeles led a media communication training, “You, Your Research and the Media,” at California State University, Monterey Bay (CSUMB) in November 2013, in partnership with Dr. James Lindholm, MARINE’s CSUMB faculty liaison. The training, attended by fourteen students, included local journalists from print, television and radio.

**Ocean Policy Course:** Held August 11-23, 2013, in Monterey and on Stanford’s main campus, this course introduced twenty-two graduate students in the natural and social sciences to ocean policy and governance and how science influences public policy decisions at the international, national and state levels. Students learned about pressing challenges to ocean health, and together with leaders in ocean science and policy, examined how science and scientists can work with the policy-making process to address these challenges. Students also learned how to communicate with ocean policy makers and journalists through hands-on practical exercises.



CENTER FOR OCEAN SOLUTIONS

**During the Ocean Policy Course, students learned how to communicate with ocean policy makers and journalists through hands-on practical exercises.**

**Campus Networking Events:** MARINE supported campus networking events to provide a space and opportunity for ocean-focused students with an interest in meeting other like-minded students at their own campuses to get together.

Oceans Colloquium Hopkins Marine Station, April 2013: The Stanford Coastal Society and MARINE hosted the 4th interdisciplinary Oceans Colloquium, which brought together students and post-docs to present ongoing ocean-related research and to share ideas about future collaborations. Following a keynote by Robert Richmond, students who attended the MARINE Ocean Leadership Practicum presented their recommendations for improving coral reef health.

**General Education Support:** In the fall of 2012, Stanford University’s Peter Vitousek invited Ashley Erickson, Erin Prahler, and Meg Caldwell to teach an ocean and coastal law and policy module for his Stanford Earth Systems Wrigley Field Program in Waimea, Hawai’i. Over the course of three days, the Center provided a legal primer on federal and state coastal zone management with a focus on coastal land use on the Big Island of Hawai’i. The module culminated in a what students deemed the highlight of the three days: a role-play exercise where students took on the role of planning staff and presented their research on a coastal development application in a mock Hawai’i Land Use Commission hearing.

**Ocean Conservation Leadership Practicum:** MARINE worked closely with Dr. Jeff Langholz from the Monterey Institute for International Studies to design and develop an Ocean Conservation Leadership Practicum, based on research regarding the most important skills to learn in graduate school according to successful ocean conservation leaders (Langholz & Abeles, *Marine Policy*, *in press*). The course set out to equip participants with the critical skills needed to lead disruptive change for ocean conservation with three primary themes: innovation, collaboration and communication. To ground their training in real ocean challenges, the twenty students, including four from Pacific Islands, worked in groups to design a strategy to lead a major breakthrough in coral reef conservation and management, inspired by the release of the Coral Reef Consensus Statement in July 2012.

Six weeks after the course, students participated in a “refresh” to reflect on the skills they gained and make commitments to furthering skill development.

In Spring 2013, Ashley Erickson served as a teaching assistant in a course cross-listed in the Schools of Civil and Environmental Engineering, Earth Systems, and Law called California Coast: Science, Policy & Law. This interdisciplinary course integrates the legal, science and policy dimensions of characterizing and managing our coastal resources in California.

The Ocean Conservation Leadership Practicum equipped participants with critical skills to lead disruptive change for ocean conservation with three primary themes: innovation, collaboration and communication.



## Organizational Development

To help us fulfill our mission, we had several positive organizational developments during the past year.

As we continue to fill critical positions, we were pleased to introduce Rebecca Martone in March 2013 as our new ecosystem health program lead. Rebecca is an internationally recognized researcher in nearshore ecosystem ecology and brings extensive experience conducting and managing large-scale, interdisciplinary team research, an extensive regional and international network of colleagues, a rapidly expanding publication record, and experience integrating social-ecological research into real-world ecosystem-based decision making. In her first few months with the Center, Rebecca applied her leadership and project management skills to work with staff members across the Center to integrate natural and social science with policy and management to inform solutions supporting healthy and resilient coastal and marine ecosystems. We are still in the process of securing leads for climate change and land-sea interactions but feel inspired by the candidates we have met with to date.

In January, Nora Deans joined us as communications manager. The Center has not had an internal staff communications lead for several years so we are thrilled to be the recipient of Nora's experience, including her work with the Monterey Bay Aquarium and the North Pacific Research Board in Alaska. Nora is chartered with raising the visibility of the Center, its research, faculty and experts through the development and implementation of a holistic and strategic communications program. In her first six months, Nora has laid a solid foundation for communications moving forward and re-energized networks with our collaborators in Stanford and in the Monterey Bay marine science community. She also championed the creation of our first early career fellowship in science communications.

In August, we welcomed Dr. Laura Good to the Center as the new MARINE program coordinator. In this role, Laura coordinates the collaborative and inter-institutional professional development activities in ocean leadership for graduate students across seven Monterey Bay Area academic campuses. Prior to joining the Center, Laura most recently worked as a educational research assistant for Oregon Sea Grant at Hatfield Marine Science Center in Newport. There, Laura helped design marine science exhibits and developed remote camera technologies to study how people learn in museum environments as part of their five-year \$2.2 million NSF-funded cyberlab project.

This year, the Center welcomed seven early career fellows. In January, Meredith Bennett joined as an early career law and policy fellow, and Jamie Dunckley and Megan Mach became early career science fellows, and Jesse Port joined as a science and policy early career fellow. Also in January, Elodie Le Cornu joined the Center as a research analyst. In May, Christina Hicks became an interdisciplinary social science early career fellow, and Sarah Mooney joined us as an early career law and policy fellow in August 2013, when Liz Hambleton became our first early career science communication fellow.

As we recognized the Center's fifth anniversary this year, we reflected on what we've learned collectively as an organization and will use that to help guide our work to secure a strong future for the Center for Ocean Solutions.



DON J.D., FLICKR CREATIVE COMMONS

We were proud to send three early career fellows off on the next step in their careers as they continue to share their expertise with us as affiliated researchers. Ryan Kelly is now an assistant professor in the School of Marine and Environmental Affairs at the University of Washington, C. Brock Woodson became an assistant professor at the University of Georgia College of Engineering, and Melissa Foley is a research fellow at the U.S. Geological Survey Pacific Coastal and Marine Science Center.

During the spring quarter, we had the honor of working with Dr. Jane Lubchenco as a visiting fellow while she was in residence at Stanford University's Haas Center for Public Service as the Mimi and Peter E. Haas Distinguished Visitor for spring 2013.

We closed this year with a big push toward the Center's fifth anniversary, which was celebrated at Stanford University on October 4, 2013, with a roundtable discussion featuring distinguished leaders in the field, including Julie Packard, and a special dinner with Jane Lubchenco as keynote speaker.

# Appendices

## Appendix A: External Partners

We define external partners as individuals and organizations working with COS to co-create projects or outputs, in both informal and formal ways. Over the last year, our engagement with external partners has deepened, and the number of external partners has grown, including a significant increase in the number of partners based internationally. (New partners for FY2013 are indicated by \*)

### Local, state, regional, federal, and international governments and agencies

#### Local

City of Pacific Grove  
 City of Santa Cruz  
 Marin County\*  
 Monterey County  
 Santa Cruz County  
 San Francisco Bay Conservation and Development Commission  
 Sonoma County\*

#### State

California Coastal Commission  
 California Energy Commission Public Interest Energy Research Program  
 California MPA Monitoring Enterprise  
 California Ocean Protection Council  
 California Ocean Science Trust  
 State of Hawai'i, Department of Land and Natural Resources  
 Washington State Department of Ecology  
 Washington State Department of Health\*

#### Regional

Association of Monterey Bay Area Governments\*  
 Integrated Regional Water Management Program  
 Lummi Nation's Natural Resources Department\*  
 US Regional Fishery Management Councils

#### Federal

Council on Environmental Quality  
 Gulf of the Farallones National Marine Sanctuary  
 Monterey Bay National Marine Sanctuary  
 NOAA Coastal Services Center  
 NOAA Coral Reef Conservation Program  
 NOAA Coral Reef Ecosystem Division  
 NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary  
 NOAA Headquarters  
 NOAA International Program  
 NOAA National Marine Fisheries Service  
 NOAA Northwest Fisheries Science Center\*  
 NOAA Southwest Fisheries Science Center  
 Ocean Research and Resource Advisory Panel  
 San Francisco Bay National Estuarine Research Reserve  
 South Slough National Estuarine Research Reserve  
 Tijuana River National Estuarine Research Reserve  
 United States Geological Survey

#### International

Department of Fisheries and Oceans, Canada\*  
 Parks Canada\*  
 Republic of Kiribati  
 Republic of Palau

#### NGOs

American Geophysical Union\*  
 California Current Acidification Network  
 Census of Marine Life  
 Center for the Future of the Oceans  
 Central Coast Wetlands Group  
 COMPASS  
 Comunidad y Biodiversidad  
 Conservation International  
 Consortium for Ocean Leadership  
 EBM Tools Network  
 Environmental Defense Fund  
 European Project on Ocean Acidification (EPOCA)  
 Humboldt Bay Initiative\*  
 ICLEI Local Governments for Sustainability  
 Institute for Sustainable Communities  
 International Coral Reef Society\*  
 IUCN (International Union for the Conservation of Nature)  
 Kua/Āina Ulu 'Auamo (KUA) [formerly Hawai'i Community Stewardship Network]\*  
 Leopold Leadership Program  
 Marine Protected Area Monitoring Enterprise\*  
 Meridian Institute  
 The National Audubon Society  
 National Council of Environmental Legislators  
 The Nature Conservancy - California  
 Natural Resources Defense Council  
 Ocean Conservancy  
 Resources Legacy Fund  
 San Francisco Estuary Institute\*  
 Santa Monica Bay Restoration Commission\*  
 Stockholm Resilience Center  
 West Coast EBM Network\*  
 World Wildlife Fund US\*  
 WWF Canada\*

### Research and Academic Institutions

American Bar Association  
 ARC Centre for Excellence – Coral Reef Studies  
 Boston University  
 California Sea Grant  
 California State University, Monterey Bay  
 Cawthron Institute  
 Central and Northern California Ocean Observing System  
 Dartmouth College\*  
 Duke University, Nicholas Institute for Environmental Policy Solutions  
 James Cook University  
 McGill University\*  
 Monterey Institute for International Studies  
 Moss Landing Marine Laboratories  
 National Center for Ecological Analysis and Synthesis  
 Natural Capital Project  
 Naval Postgraduate School  
 Northern Arizona University\*  
 Northwest Indian College\*  
 Oregon State University  
 Pacific Marine Analysis and Research Association  
 Palau International Coral Reef Center  
 Pontificia Universidad Catolica de Chile  
 Rutgers University  
 Sacramento State Center for Collaborative Policy  
 Simon Fraser University\*  
 Southern California Coastal Ocean Observing System  
 Southern California Coastal Water Research Project  
 Too Big To Ignore, International Collaborative on Small-scale Fisheries  
 University of Arizona  
 University of British Columbia  
 University of California, Los Angeles  
 University of California, San Diego  
 University of California, Santa Barbara  
 University of California, Santa Cruz  
 University of Copenhagen\*  
 University of Hawai'i  
 University of Iowa  
 University of Miami  
 University of Queensland  
 University of Southern California Sea Grant  
 University of Texas, Austin  
 University of Washington  
 Woods Hole Oceanographic Institution

### Foundations

Harold K. Castle Foundation\*  
 Gordon and Betty Moore Foundation  
 Okeanos Foundation  
 David and Lucile Packard Foundation  
 Resources Legacy Fund  
 Resources Legacy Foundation Fund\*

### For-Profit Organizations

Blue Earth Consultants, LLC  
 OuterShores Expeditions\*  
 Phillip Williams & Associates/ESA  
 Susanne Moser Research & Consulting  
 Resources Law Group\*  
 Taylor Shellfish Farms\*

### International Partners (drawn from all categories)

ARC Centre for Excellence – Coral Reef Studies  
 Cawthron Institute  
 Comunidad y Biodiversidad  
 Department of Fisheries and Oceans, Canada\*  
 European Project on Ocean Acidification (EPOCA)  
 IBA (International Bar Association) – Maritime Law Division  
 International Coral Reef Society\*  
 IUCN (International Union for the Conservation of Nature)  
 James Cook University  
 Lummi Nation's Natural Resources Department\*  
 McGill University\*  
 Republic of Kiribati  
 Republic of Palau  
 OuterShores Expeditions\*  
 Palau International Coral Reef Center  
 Parks Canada\*  
 Pontificia Universidad Catolica de Chile  
 Simon Fraser University\*  
 Stockholm Resilience Center  
 University of Copenhagen\*  
 University of Queensland  
 WWF Canada\*

## Appendix B: Publications

Listed alphabetically by first Center for Ocean Solutions author (Center authors in bold)

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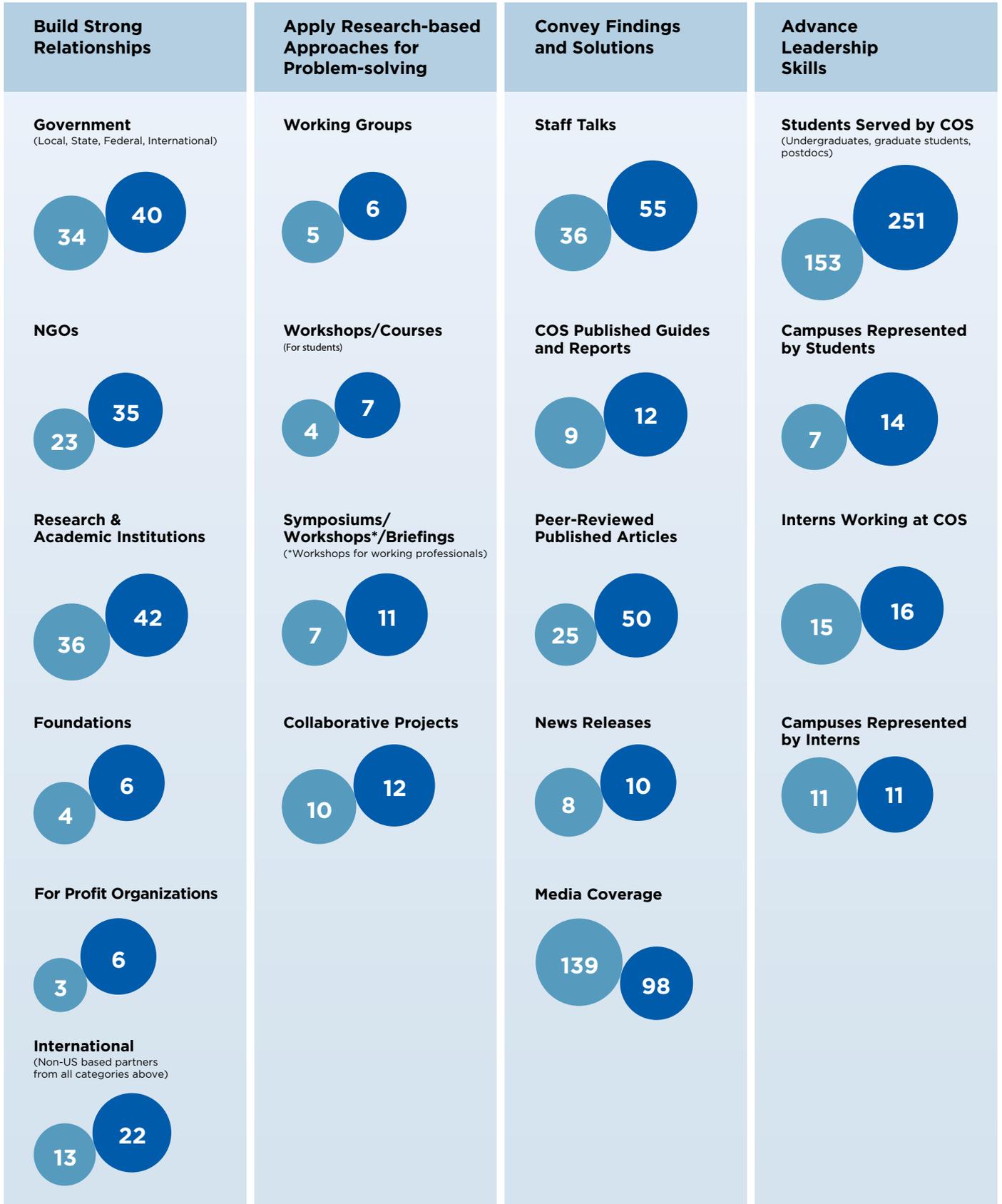
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## FY2012/FY2013 Metrics

● 2012 ● 2013



Note: Circle sizes represent year-over-year increases or decreases in each category. Numbers represent the number of interactions or events within that category.



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