BOEMRE OCEAN SCIENCE

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JANUARY/FEBRUARY/MARCH 2011

THE SCIENCE & TECHNOLOGY JOURNAL OF THE
BUREAU OF OCEAN ENERGY MANAGEMENT,
REGULATION AND ENFORCEMENT

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BOEMRE OCEAN SCIENCE is published quarterly by the Bureau of Ocean Energy Management, Regulation and Enforcement to communicate recent ocean science and technological information and issues of interest related to offshore energy recovery and ocean stewardship.

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ON THE COVER

Top left: An ochre sea star *(Pisaster ochraceus)* on a California beach.

Top right: Atlantic puffins *(Fratercula arctica)* at the Maine Coastal Island National Wildlife Refuge. *Photo courtesy of U.S. Fish & Wildlife Service Northeast Region.*

Bottom: Rachel Potter, University of Alaska Fairbanks, after installing an HF radar receive antenna at Barrow, Alaska, 2010. *Photo courtesy of Hank Statscewich, University of Alaska Fairbanks.*

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Michael R. Bromwich,
Director

Director's Note

Since I arrived at the Bureau of Ocean Energy Management, Regulation and Enforcement last summer, one of the guiding principles of our reform agenda for offshore energy development has been to renew and enhance our commitment to making decisions based on the best available science. Our management of offshore resources must be based on the best available scientific information, and we must be relentless in our search for additional scientific information available on which to base those decisions.

This issue of *BOEMRE Ocean Science* provides a glimpse of some of the very important research being conducted by our scientists and funded by our Environmental Studies Program. The results of these studies are used to inform our decisions as we implement broad safety and environmental reforms within the agency.

Significant scientific work has been conducted by and through this agency for decades, but we have concluded from both internal and external reviews that our scientific community has not always had a strong enough voice within the organization. We are changing that in various important ways—in not only our words but—more important—in our actions.

Michael R. Bromwich, Director

About This Issue

This issue highlights some of our cooperative efforts with State and Federal agencies, universities, nongovernmental organizations, and other partners. We are a Federal collaborator in the Coastal and Marine Spatial Planning effort, a planning process for future sustainable uses of the oceans, coasts, and Great Lakes that integrates science with existing laws and agency authorities.

We also partner with other scientists to fund and conduct studies, from biologists monitoring the Pacific Coast's coastal habitats to Native Alaskan hunters contributing traditional knowledge to our environmental studies in the Arctic. The Department of the Interior honors several such partnerships each year.

Several of our studies are "firsts," such as compiling a history of the south Louisiana oil and gas industry, and using gliders for long-term collection of oceanographic data in the Arctic.

We encourage fresh perspectives; for example, one of our geologists offers a new view on the quickly-increasing problem of wetlands loss and coastal erosion in south Louisiana.

The BOEMRE's studies are—and have always been—vital to understanding our marine and coastal habitats to ensure their protection.

Editor's Note: On June 18, 2010, Secretary of the Interior Ken Salazar signed a Secretarial Order formally changing the name of the Minerals Management Service to the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). This journal uses the acronym BOEMRE to refer to the bureau.

Update:
National Ocean Policy and Coastal Marine Spatial Planning

The first National Policy for the Stewardship of the Ocean, Coasts, and Great Lakes (National Policy) in the U.S. was established on July 19, 2010, when President Obama signed Executive Order 13547. The Executive Order also created the National Ocean Council (NOC) and released the "Final Recommendations of the Interagency Ocean Policy Task Force."

The Final Recommendations lay out nine National Priorities for the NOC to pursue.

One of the nine National Priorities is coastal marine spatial planning (CMSP): "Implement comprehensive, integrated, ecosystem-based coastal and marine spatial planning and management in the United States."

Based on sound science, CMSP is an adaptive, integrated, ecosystem-based, spatial planning process. To ensure more responsible and sustainable use of our ocean, coastal, and Great Lakes areas, this planning approach identifies areas that are most suitable for various types of activities. It also analyzes current uses and anticipates future uses.

CMSP is a regionally-based approach to planning and managing uses and activities. Geographically, the scope includes Federal and State waters, inland bays, and coastal and Great Lakes estuaries.

Based on currently-existing "large marine ecosystems," CMSP will be implemented in nine proposed planning regions: Alaska, Caribbean, Great Lakes, Gulf of Mexico, Mid-Atlantic, Northeast, Pacific Islands, South Atlantic, and West Coast.

Each region will have a regional planning body consisting of Federal, State, and tribal representatives to develop goals, objectives, and its own regional CMSP plan.

Regional planning bodies will ensure frequent, regular stakeholder engagement throughout all phases of the process (such as development, adoption, implementation, evaluation, and adaptive management).

Each regional planning body is required to consult with scientists, technical experts, and people with traditional knowledge or expertise. They will also work with existing science and technical entities, such as ocean observation organizations, and other groups with relevant physical, biological, ecological, and social science expertise.

CMSP is intended to provide a better framework for the application of existing laws and agency authorities; it is not intended to supersede them.

Implementation of CMSP is taking place in three phases. Phase 1 begins the process; during the first 12 months, the NOC will hold a national workshop, create a strategic action plan, and form regional planning bodies. During Phase 2 (9–24 months), regional work plans will be developed and data guidance will be issued. During Phase 3 (18 months–5 years), regional planning bodies will develop CMS Plans, for approval by the NOC and implemented at the regional scale.

Pond Island Lighthouse at the Maine Coastal Islands National Wildlife Refuge. *Photo courtesy of U.S. Fish & Wildlife Service Northeast Region.*

Currently in Phase 1, the Department of the Interior and BOEMRE are helping the NOC prepare for the national workshop and simulation exercise. The workshop will engage Federal, State, tribal, and regional stakeholders to build support and share the principles and objectives of the policy initiative. Within one year, similar workshops and simulation exercises will be held in each of the nine regions.

Our role (like that of other Federal agencies) with CMSP is primarily advisory. Federal agencies will advise and assist regional planning bodies in their planning efforts and will share scientific data and other resources where possible.

BOEMRE and CMSP

Our BOEMRE CMSP coordination team members, drawn from various BOEMRE divisions and regions, exchange information about the CMSP initiative at regional and national levels.

With other Federal partners, including the National Oceanic and Atmospheric Administration, Department of Energy, and U.S. Coast Guard, we assist existing regional ocean councils (such as the North East Regional Ocean Council and the Mid-Atlantic Regional Council on the Ocean) in their CMSP initiatives.

- **Science and data needs:** In December 2010, a workshop on this topic, organized by the U.S. Geological Survey and BOEMRE and held in San Francisco, was attended by other Federal agencies, scientists, and stakeholders. The workshop report will provide guidance to the West Coast Regional Ocean Council.
- **Studies that provide information and data:** BOEMRE is funding a study that identifies space-use conflicts (on the

Outer Continental Shelf) among renewable energy development and current and potential other uses, and ways to mitigate those conflicts.

- **Interagency Working Group on Ocean Social Sciences:** Assisting regional planning bodies in using social science to develop and implement coastal and marine spatial plans.

The BOEMRE is pursuing CMSP initiatives and will be particularly active in areas such as the Alaska, Gulf of Mexico, Mid-Atlantic, North Atlantic, and West Coast regions where we actively manage offshore resources.

FOR MORE INFORMATION

CEQ's National Ocean Policy Task Force web page, with links to "Final Recommendations of the Interagency Ocean Policy Task Force" and Executive Order
www.whitehouse.gov/administration/eop/ceq/initiatives/oceans

"Final Recommendations of the Interagency Ocean Policy Task Force" (3,725 KB pdf)
www.whitehouse.gov/files/documents/OPTF_FinalRecs.pdf

Tillamook Rock in the distance, off the north Oregon coast.
Photo courtesy of National Weather Service, Portland, Oregon.

Collaborative Projects Receive Conservation Awards

The Partners in Conservation Award is the Department of the Interior's highest award presented to private citizens and organizational partners.

Each year, the Secretary of the Interior honors Department employees and their partners for achievements in collaborative resource conservation. The Partners in Conservation Awards honor partnerships that promote conservation of our landscapes, preserve natural and cultural resources, bring innovative approaches to resource management, and engage diverse entities in accomplishing the Department's mission.

In March 2010, four BOEMRE-sponsored partnerships received Partners in Conservation Awards. The following month, the *Deepwater Horizon* incident occurred in the Gulf of Mexico, and took precedence over announcing the award recipients. We recognize those award recipients here.

History of the South Louisiana Offshore Oil and Gas Industry

Understanding Louisiana's relationship with offshore energy development must begin in the bayous, lakes, and marshes of south Louisiana in the late 1920's. Until 2002, that relationship had never been chronicled.

To document this story and share it with the public, in 2002 BOEMRE (then MMS) entered into a cooperative agreement with Louisiana State University—which partnered with the University of Arizona and the University of Houston—to compile the history of southern Louisiana's offshore oil and gas industry. Capturing the stories of inventiveness, hard work, tenacity, and entrepreneurship from the men and women of the industry's early days, the study shows the industry's influence in shaping Louisiana's culture, economy, geography, and society.

Funded by BOEMRE's Environmental Studies Program, the Offshore Oil and Gas History Project begins with the late 1920's origins of the oil and gas industry and draws from oral histories, documentary research and interviews, and economic analysis. Photographs, artifacts, and personal accounts of the industry's development were offered, and information was gathered from former industry engineers, managers, workers, and community and political leaders.

The project has two phases. The first phase, the origins of the industry up to 1970, describes the social and environmental history of the 1800's, and focuses on pioneers and the early years, the first and second World Wars, and the 1970's Oil Embargo. The second phase, the period since 1970, focuses on development farther offshore. The six volumes of the completed first phase are available online.

The full history and its collection of stories and photographs give a collective voice to the people behind southern Louisiana's rich history and complex relationship with oil and gas development. It also forms the basis for understanding the evolution of the industry and how that industry is intertwined with local communities.

FOR MORE INFORMATION

Project website, University of Arizona, with links to each completed study
http://gulfoil.bara.arizona.edu/Introduction.htm

Shell platform Number 7, offshore Cameron, Louisiana, in 1955. Photo courtesy of Jake Giroir.

Aerial Oil Thickness Mapping System Leads to More Development

Shortly before it was used during the *Deepwater Horizon* oil spill, the collaboration that led to the development of remote sensing and mapping technology for oil-spill response received a Department of the Interior's Partners in Conservation Award.

The initial development of a portable, aerial, oil thickness mapping sensor was funded by BOEMRE (then MMS) in 2005. Funding continued in 2007 and 2009, from MMS and the California Department of Fish and Game's Office of Spill Prevention and Response (OSPR).

The full system, manufactured by Ocean Imaging (OI), had been successfully completed in November 2008, in time to respond to an offshore platform spill one month later in the Santa Barbara Channel. The aerial mapping system imagery assisted response vessels by identifying where the greatest amount of oil could most effectively be removed. In 2009, the technology was used again during a San Francisco Bay tanker spill.

In May 2010, OI was called on to use its remote sensing and mapping efforts technology to collect valuable data for the *Deepwater Horizon* spill response. During the spill, OI's spill mapping team flew daily missions in the Gulf, mapping the location and thickness of the oil. Near-real-time maps helped guide oil recovery vessels and also provided information for the development of oil spill trajectory forecast models.

Remote sensing and mapping efforts also documented the effectiveness of the surface and subsurface dispersants; determined the location and thickness of oil accumulation and the oil's weathering state; and mapped boundaries of the spill, including oil that reached the shoreline.

In an extension of this project, similar spill response technology is being tested, validated, and developed for use in the extreme conditions and high altitudes of the Arctic. In July 2010, BOEMRE, along with staff from OSPR and OI, conducted a successful full-scale demonstration exercise of the spill response system in Cook Inlet. Initiated by a request from the Alaska Regional Response Team, the exercise drew 60 attendees, including the U.S. Coast Guard and local print and television news.

FOR MORE INFORMATION

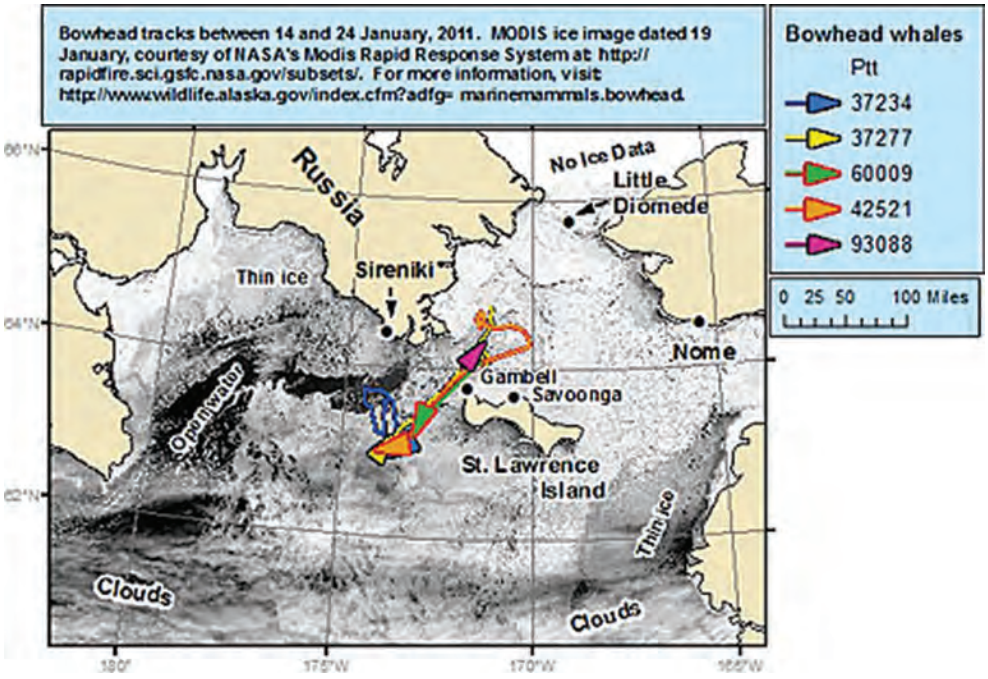
Project description, TA&R
www.boemre.gov/tarprojects/658.htm

Using Satellite-Based Synthetic Aperture Radar Imagery to Assess Hurricane Damage to Offshore Infrastructure

In the Gulf of Mexico, hurricane damage to energy infrastructure must be quickly assessed so that affected areas can be properly managed and the appropriate resources mobilized. Typically, searches for missing rigs and damage assessments cannot happen until days after a hurricane has passed due to safety risks and helicopter availability. For this reason, BOEMRE (then MMS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey, and the National Geospatial Intelligence Agency partnered to fund a project using synthetic aperture radar (SAR) imagery to assess post-hurricane damage.

Because SAR penetrates cloud cover and provides higher spatial resolution satellite measurements regardless of light conditions, it is more suitable for monitoring and assessing hazards.

Before 2009, NOAA initiated a project to research, develop, and implement oceanographic products derived from SAR data. From this research, NOAA's Office of Research and Applications designed a method to rapidly identify changes in platform stability or location compared with recorded locations compiled in NOAA and BOEMRE databases. The method is also useful for identifying oil spills in the Gulf after major storm events. In 2009, after NOAA's briefings, interest increased in using SAR data to assess infrastructure damage and mitigate environmental damage and harm to life and property.



Bowhead tracking map, January 2011. *Image courtesy of Alaska Department of Fish and Game.*

Using SAR imagery, NOAA has demonstrated the ability to provide data to BOEMRE and other emergency responders as early as 1–3 hours after a satellite overpass. Thus BOEMRE and other emergency responders can quickly target and prioritize problem areas where resources can be immediately mobilized. Responders can use the resulting data and analysis to mitigate risks to life, property, and the environment after hurricanes pass through the Gulf and make the best use of Federal and State vessels and surveillance aircrafts.

Bowhead Whale Tracking Project

Collaborators with the Bowhead Whale Tracking Project received a Partners in Conservation Award for outstanding conservation accomplishments and were also honored in the category of "Partnerships that Demonstrate Best Practices."

The Bowhead Whale Tracking Project studies endangered bowhead whales' movements and habitat use. Funded primarily by BOEMRE, the unique partnership includes the Alaska Department of Fish and Game (ADF&G), the Alaska Eskimo Whaling Commission, the North Slope Borough Department of Wildlife Management, the Canadian Department of Fisheries and Oceans, Greenland Institute of Natural Resources, and Tuktoyaktuk and Aklavik Hunters and Trappers Committees in Canada.

Initiated in 2004, when BOEMRE (then MMS) funded ADF&G meetings to determine the study's potential, the project got fully underway in 2005 to begin tagging bowhead whales with satellite-tracked tags. In May 2006, the first bowhead whale was tagged in Barrow, Alaska. Tagging has continued near Barrow and Kaktovik, Alaska, and Tuktoyaktuk, Northwest Territories, Canada; 44 whales were tagged through 2009.

One of the most unique aspects of the project is the engagement of Alaska Native hunters, who have done almost all of the tagging and share their traditional knowledge and expertise in tracking, whale behavior, and the region. Including these stakeholders in the research, and sharing results with them underscores how important this information is to all parties.

Data on whale movements and diving behavior, sea ice coverage, bathymetry, and other ocean conditions have been analyzed by ADF&G scientists. Each week, summarized data and movement maps are updated and shared with the scientific community and public through email and on an ADF&G website. The availability of this information benefits many groups, agencies, and scientists.

The project has deepened understanding of bowhead biology and the whales' relationship with their environment. With this knowledge, we can better estimate and mitigate the effects of energy-related activities in the Chukchi and Beaufort Seas.

FOR MORE INFORMATION

Satellite Tracking of Western Arctic Bowhead Whales, Alaska Department of Fish & Game Division of Wildlife Conservation
http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.bowhead

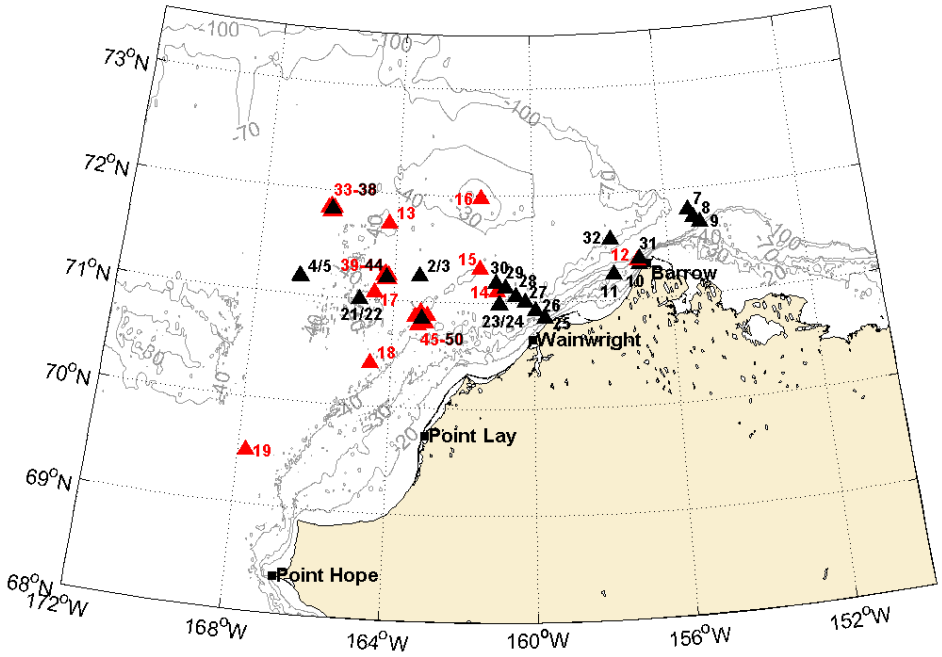
"Alaska Native Hunters and Whalers Actively Engage in Satellite Tracking Studies," *MMS Ocean Science, Vol. 6, Issue 2* (1,112 KB pdf)
http://www.gomr.boemre.gov/homepg/regulate/environ/ocean_science/mms_ocean_09_apr_may_jun.pdf

Charting Currents in the Chukchi Sea

Current, sound scientific information about the often forbidding Arctic environment and its ecosystems is a prerequisite for responsible decisionmaking. In light of recently-let oil and gas leases in Alaska's Chukchi Sea, validating and improving a Chukchi ocean circulation model is vital.

Understanding the hydography of the northeastern Chukchi Sea and the relationships of surface and subsurface currents is crucial for risk analyses, contingency plans, and spill trajectories. But available ocean circulation and oil-spill trajectory models don't capture the nearshore surface current circulation fields or finer scale circulation patterns in the Chukchi Sea.

To map the ocean circulation on the Chukchi Shelf adjacent to oil and gas lease areas, in 2009 BOEMRE (then MMS) and industry partners began a 3-year study with the University of Alaska Fairbanks, School of Fisheries and Ocean Sciences (UAF). Researchers have collected data using three technologies: high-frequency (HF) radars onshore, a mooring array, and Webb Slocum gliders offshore.



Mooring locations in the Chukchi Sea. *Image courtesy of Hank Statscewich, University of Alaska Fairbanks.*

HF radar systems collect hourly, real-time surface current data over broad areas of the coastal ocean. Each system includes two antennae. One transmits a signal out over the surface of the ocean; the other receives the signal that is bounced back by the waves and transmits it to scientists in real-time.

HF radar systems have also been used in the Beaufort Sea shelf, Prince William Sound, and Cook Inlet, as elements of oceanographic data gathering efforts, such as the SALMON Project, conducted by UAF and funded by BOEMRE and other partners.

The information they provide can help predict oil spill trajectories, evaluate circulation models, and, in case of a spill, provide responders with real-time data on spill evolution. The information will also be useful for search-and-rescue operations.

Native Alaskan communities also use HF radar information to examine changing conditions during subsistence hunting activities, gauging the best conditions for launching their boats.

An HF radar system was installed in each of three locations: Barrow, Wainwright, and Point Lay. From mid-September through mid-November 2009, and mid-July until freeze-up (November) 2010, the systems provided hourly surface current measurements in near real-time that were posted online. The data were collected from the top 6.5 ft (2 m) of the water column over an area extending up to 124 mi (170 km) offshore.

Analysis of the data identified an intermittent, strong coastal current about 19 mi (30 km) wide with speeds greater than 1.6 ft/s (50 cm/s). On time scales of less than one day, eddies about 19–25 mi (30–40 km) in diameter were typically located near the head of Barrow Canyon and southeast of Hanna Shoal.

In July 2011, all three systems will be operational again and the live data feed over the World Wide Web will resume.

A 6-mooring array was deployed in Barrow Canyon. The moorings measure currents, temperature, and salinity in the water column, along with wave characteristics and ice thickness. The moorings will be retrieved in August 2011 after operating for one year.

Gliders are being used to collect hydrographic data and measure changes in water stratification. Gliders are low-power, high-endurance automated underwater vehicles propelled by small buoyancy changes, similar to a fish's swim bladder, generating forward motion by gliding on wings attached to the body. The gliders have 2-way, real-time satellite communication capabilities to allow rapid changes to the programmed mission, status monitoring, and display of data in real time.

Deployed off Wainwright and Point Lay in the summer and early fall of 2010, two Webb Slocum gliders performed two month-long missions, collecting data continuously.

These were the first successful long-term glider missions in the rough Arctic waters. According to Peter Winsor, UAF physical oceanographer and principal investigator on the project, using gliders even in known waters can be risky. Gliders can disappear, become caught, or lose their way.

The risk is even greater in unknown, treacherous waters. Though the devices are equipped with several mechanisms to indicate a problem or malfunction, even if a glider does signal distress or jettison its ballast to reach the surface, the rough ocean makes accessing and retrieving it difficult. Researchers were extremely anxious as they waited for each glider to return and were finally relieved that not a single glider was lost.

More than 3,500 vertical profiles of pressure, temperature and conductivity (salinity), and estimated depth-average currents were collected by the gliders, covering about 497 mi (800 km).

The continuous sampling and the resolution of the glider data provide a new, unique view of the Chukchi Sea.

Using HF radar and gliders together can produce a real-time hydrocarbon mapping system. Also, by steering the gliders to areas that are also under the HF radar mask, researchers were able to get a detailed 3-D spatial and temporal view of the ocean.

The gliders are a proven, effective technology for observing remote areas and collecting valuable high-resolution data in the Arctic. Both gliders will be deployed again this year, and data will be streamed live onto a Google map interface.

Eugene Bodfish, Olgoonik Oilfield Services; Peter Winsor, University of Alaska Fairbanks; and Andrew Mullen, undergraduate intern from Notre Dame University, prepare to launch a glider from C/V *Tukpuk* off Wainwright, Alaska, 2010. *Photo courtesy of Hank Statscewich, University of Alaska Fairbanks.*

FOR MORE INFORMATION

Current real-time maps, Chukchi Sea Surface Currents website
www.ims.uaf.edu/hfradar/

University of Alaska Fairbanks, The SALMON Project
www.ims.uaf.edu/salmon/

Alaska OCS Region Environmental Studies Program
http://alaska.boemre.gov/ess/index.htm

Protecting this unique Arctic world demands a foundation of solid, up-to-date science. The BOEMRE is proud to continue sponsoring environmental studies in the Alaska OCS Region, working with university researchers, Alaska Native communities, industry, and State and Federal agencies.

The completed autonomous power module ("the hut"), Barrow, Alaska. *Photo courtesy of Hank Statscewich, University of Alaska Fairbanks.*

Problem: How do you power an HF radar system in the most remote Arctic areas, where electricity sources are either nonexistent or scarce and unreliable?

Solution: Create a portable, autonomous power source! Oceanographers at the UAF, funded by the Department of Homeland Security, designed and developed a remote, autonomous power module that uses renewable and biodiesel energy.

The module contains subsystems for power generation, satellite communications, and performance monitoring. It is also equipped to collect meteorological and oceanographic data. The subsystems are powered by a battery bank charged primarily by wind and solar energy, and secondarily by a biodiesel generator.

Though a module weighs about 6,000 pounds, it breaks down into components of less than 200 pounds each, so that two people can deploy, service, or relocate it. Local residents can also use the module for tasks like charging cell phones.

Because of its portability and autonomy, a module can be set up anywhere, an especially valuable feature in a very remote area. The first module was successfully field tested near Barrow, Alaska in 2010; another is being built this year.

BOEMRE Geologist:
Bryan Stephens

Bryan Stevens walking the marshes of Louisiana.

The BOEMRE relies on our employees' expertise and dedication. In each issue of *BOEMRE Ocean Science*, we talk with a specialist or scientist about their work. In this issue, Geologist Bryan Stephens, a native New Orleanian, describes his background, his motivations, and his work in the Gulf of Mexico OCS Region.

"I believe that it is important for citizens and policy-makers to have a better understanding of the dynamic landscape on which we live."

Like many south Louisiana residents, Bryan has a large network of extended family and friends that, for generations, has shared in the rich culture, traditions, and natural resources that characterize life on the Gulf Coast.

"I received my first geology lesson on the Gulf of Mexico from my father when I was eight years old. In 1970 he took me on a fishing trip to the oil and gas platforms in East Bay, off the mouth of the Mississippi River. It was an adventure in our small boat, dodging freighters in the river and following a crew boat into the Gulf of Mexico, where platforms dotted the horizon. We caught lots of fish, mostly croakers. At one point I asked him, 'How do they know where to put the platforms?' He explained that oil companies used something called 'seismic surveys' to locate the oil fields."

Louisiana's coastal erosion crisis has long been a concern to Bryan and his family. "We used to go on camping trips to the Last Island Barrier Chain off the coast of Terrebonne Parish. We fished for trout and redfish by day and gigged flounders by night. It was a paradise with miles of wild beaches and mangroves. Over a 20-year period, we've watched most of it disappear. The changes that we saw from year to year were alarming. We thought, at the time, that the State should have a sense of urgency to do something to solve this problem. However, we had no understanding of the processes at work."

At the University of New Orleans, Bryan earned a B.S. degree in Geology, then an M.S. in Geology from the University of Kansas. He went to work for one of the major oil companies in New Orleans, exploring for oil and gas among the same fields he had fished as a boy. In the 1990's, rather than join the exodus of oil and gas jobs leaving New Orleans for Houston, Texas, Bryan left a successful career in the petroleum industry and signed on with BOEMRE (then MMS).

As a BOEMRE Geologist, Bryan's primary responsibilities include geological and geophysical evaluations required to ensure the American public receives fair market value for the tracts awarded in offshore lease sales. He also participates in regional geological investigations that are useful for assessing petroleum resources, and that may also be helpful to coastal scientists.

"After grad school, I returned to Louisiana and went right back to hunting and fishing in the marshes. I continued to be deeply concerned about the loss of wetlands. I volunteered with a campaign to dedicate a portion of State mineral revenues to wetland projects and also helped place Christmas trees in the marsh to control erosion. I started going on field trips held by some of the leading coastal scientists to learn more about their studies and restoration projects."

"During my subsurface mapping projects, I began to recognize similarities between deep structural patterns and the arrangement of Gulf Coast barrier islands. Through assignments across the Gulf Coast and offshore Gulf of Mexico, and a good deal of geologic tourism, I have come to believe that the landscape of south Louisiana has been shaped by deep structural processes to a greater degree than is generally recognized. I hope that coastal scientists will more fully explore the implications of these ideas to the ongoing coastal restoration and protection efforts."

Bryan received the Best Paper Award at the Gulf Coast Association of Geological Societies' 2010 Convention for his 2009 publication: "Basement Controls on Subsurface Geologic Patterns and Coastal Geomorphology across the Northern Gulf of Mexico: Implications for Subsidence Studies and Coastal Restoration," marking the latest chapter in what has been a 40-year journey of geological understanding.

Subsidence in Southeast Louisiana:

A Deep Perspective

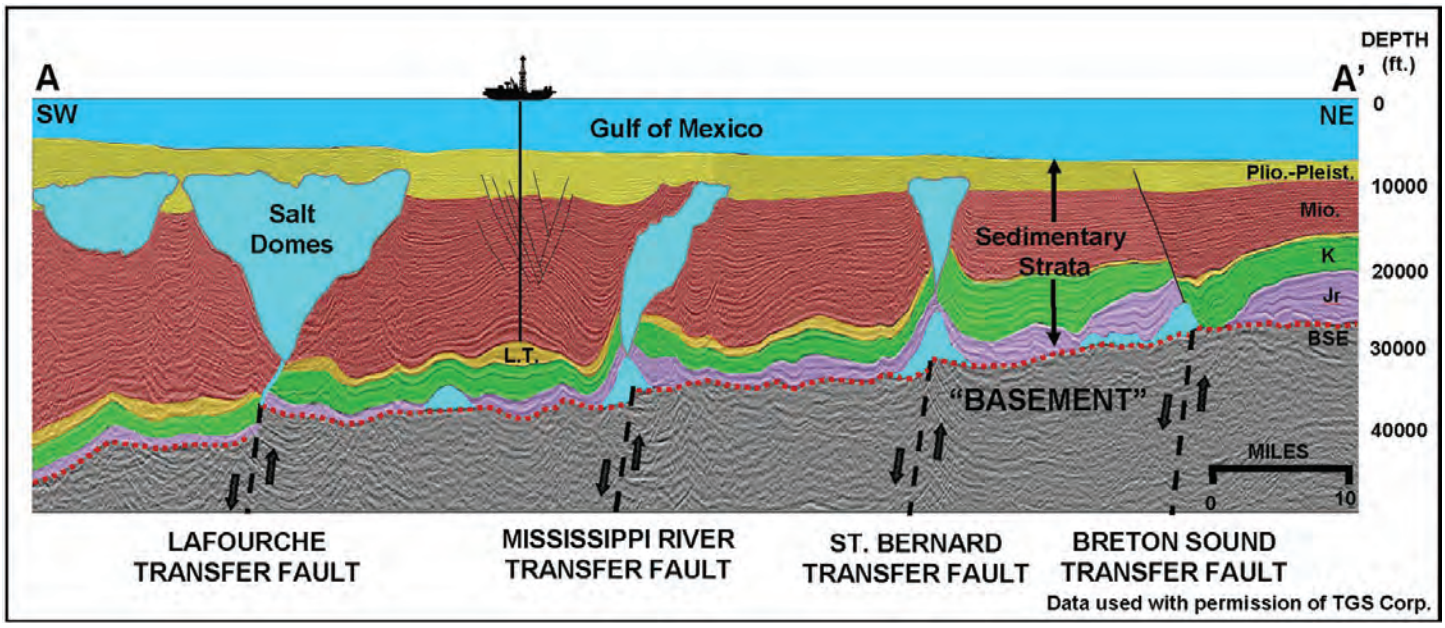


Figure 1: Seismic profile showing basement fault zones, salt domes, and sedimentary strata, offshore Louisiana.

Coastal erosion and wetland loss are topics of preeminent importance and concern in southeast Louisiana. Coastal scientists have been raising alarms for decades, and the recent destruction associated with Hurricanes Katrina and Rita have heightened awareness of the coast's increasing vulnerability.

As momentum builds for massive coastal restoration and flood protection projects, BOEMRE Geologist Bryan Stephens has offered a deeper perspective on some of the subsurface geologic processes that are contributing to the problem and could be of use to scientists and engineers searching for solutions. "The shape of the coast, the locations of coastal lakes and bays, the distribution of coastal barriers and the areas of greatest wetland loss all appear to be related to the deep subsurface structure," says Stephens.

Sea level is rising globally and is forecast to continue to do so because of climate change. However, the land is also sinking through a process known as subsidence, which is particularly acute in south Louisiana.

Subsidence can have many natural and anthropogenic causes. Stephens suggests that deep structural processes operating miles beneath the surface are having a profound effect on coastal environments and subsidence patterns. His research is the subject of "Basement Controls on Subsurface Geologic Patterns and Coastal Geomorphology across the Northern Gulf of Mexico: Implications for Subsidence Studies and Coastal Restoration," published by the Gulf Coast Association of Geological Societies (2009, Vol.59:729–751).

To understand subsidence, we must look back over 250 million years to the early formation of the Gulf of Mexico Basin. The area beneath the Gulf was once a land mass, part of the supercontinent Pangea. During the Triassic Period, Pangea separated into the smaller continents of North America, South America, and Africa, forming the North Atlantic Ocean and the Gulf of Mexico. At the time, the northern Gulf probably resembled modern East Africa, characterized by great rift valleys and salt basins.

Over millions of years, the rift valleys beneath the Gulf Coast were buried under miles of sediments. The salt deposits were squeezed upward to form the salt domes now associated with oil and gas reserves.

Stephens believes that there is an orderly arrangement of deep faults associated with both the early breakup of Pangea and the subsequent mobilization of the deep salt layers, and that both correlate with the patterns of subsidence in southeast Louisiana. Figures 1–3 illustrate that correlation.

The "basement" of the Gulf—the surface of the land before the Gulf was formed—is now buried beneath 5–10 miles (8–16 km) of younger sediments in southeast Louisiana.

Figure 1, an offshore seismic profile, shows the basement surface (dashed red line) stepping downward from northeast to southwest across the underlying faults. The thickening of the overlying sedimentary layers from right to left is a record of the ongoing vertical movements across these deep crustal boundaries. Also shown are some of the salt domes that are rising to the surface, causing the strata in their wake to sag and collapse.

Stephens has proposed that the basement faults form a series of parallel fault zones that extend onshore beneath southeast Louisiana. **Figure 2** shows the fault zones (dashed red lines). The light blue areas are salt domes and tabular salt bodies that have been squeezed up into the shallow sedimentary cover. The solid red lines are faults that formed in conjunction with the migration of salt from depth. The yellow areas are "minibasins," depressions that form in response to withdrawal of the underlying salt layers and are characterized by greater overall subsidence.

Figure 3 is a 3-D schematic model for southeast Louisiana and adjacent waters. It shows that although subsidence is highly variable, the patterns of subsidence are regular and predictable, and can be explained, in part, by the arrangement of the deep basement-related and salt-related faults.

The causes, rates, and patterns of coastal subsidence are matters of some disagreement among coastal scientists. Although some are attuned to the deep subsurface controls, there is not yet widespread recognition of the implications for coastal restoration and protection. Stephens' recent publication is not directed at policymakers, but rather at researchers in other agencies working on Louisiana's coastal restoration efforts.

Stephens sees potential for cooperation between petroleum geologists working in industry and coastal scientists to better understand the geologic dimensions of Louisiana's subsidence problem and how best to cope with them. Stephens points out that the oil and gas industry can contribute a great deal of data and expertise to the cause of coastal conservation. "I believe that petroleum geologists, as individuals, are very conservation-minded, and, perhaps more than any other discipline, understand the natural processes that built coastal Louisiana."

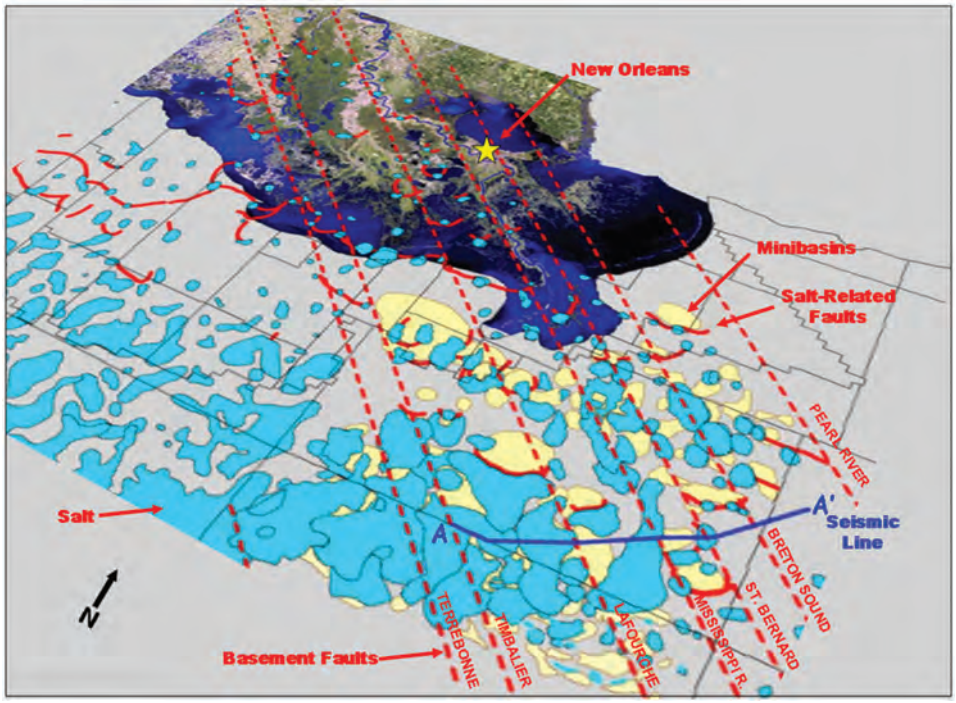


Figure 2: Perspective view of southeast Louisiana showing the trend of deep basement fault zones (red dashed lines) seen in offshore surveys and interpreted to extend beneath the coast.

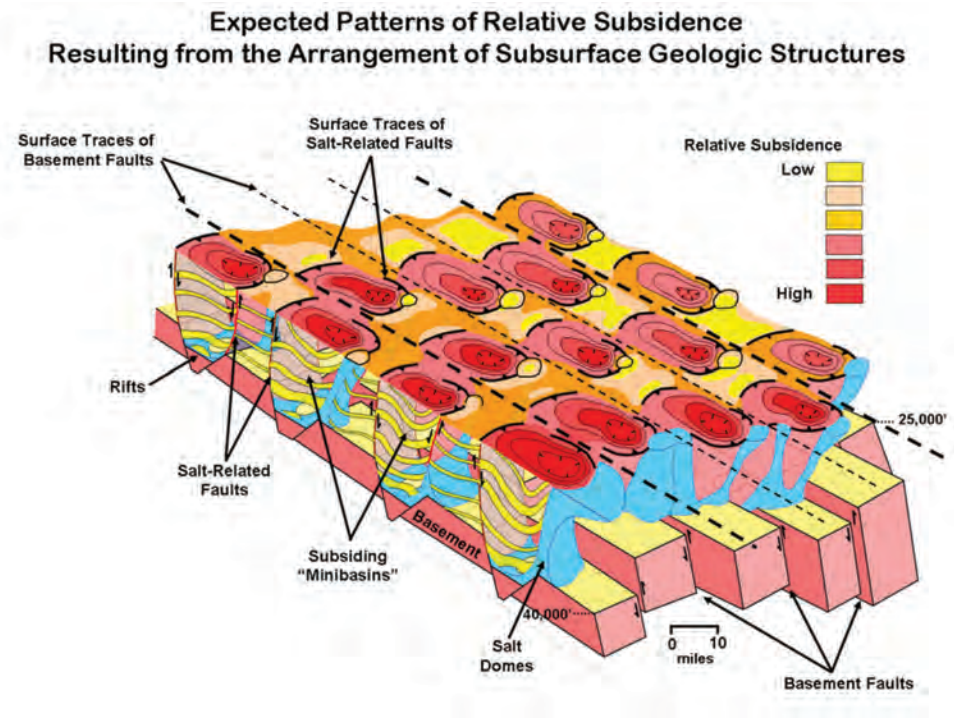


Figure 3: Schematic model of expected subsidence patterns that results from the arrangement of subsurface geologic structures beneath southeast Louisiana and adjacent waters.

FOR MORE INFORMATION

Narrated, animated slideshow of Bryan's presentation
www.gomr.boemre.gov/homepg/whatsnew/speeches/2010/100614_Stephens_NOGS_AUDIO.ppt

MARINe:
Monitoring Our Rocky Coastal Intertidal Communities

Straddling the ocean and land, our coastal habitats vary from region to region, from west to east and north to south, but all are sensitive to effects from human and natural causes.

For years, the rocky intertidal communities along the Pacific Coast have been closely monitored and studied.

In fact, this year BOEMRE is celebrating 20 years of continuous monitoring of the rocky intertidal coastal habitat on the Pacific Coast. This program began at sites in Santa Barbara County, California, in 1991.

In 1997, the Multi-Agency Rocky Intertidal Network (MARINe) was formed, with nine partners and 55 monitoring sites. Now MARINe has more than 30 members from private organizations, universities, and local, State, and Federal agencies. The number of sites has grown to more than 120, ranging from Alaska to Mexico, with several now on the Atlantic Coast.

The largest long-term monitoring effort of its kind, MARINe is funded by contributions from sponsors, partners, and members committed to the health of these unique coastal habitats. Members share research responsibilities, jointly publish in peer-reviewed journals, and share information with the public.

Team recording owl limpet *(Lottia gigantea)* counts at Old Stairs site Ventura County, California, fall 2010. *All images courtesy of Dave Pereksta, University of California Santa Cruz.*

To better carry out its long-term monitoring program, MARINe developed standardized monitoring protocols for these special habitats: The MARINe Monitoring Protocol Handbook used by survey teams.

Monitoring is carried out by more than a dozen teams. Using MARINe's standardized protocols, teams collect data that are placed in a shared database. Collecting data under a consistent protocol across a large area provides a unique opportunity to discover regional patterns and trends.

The teams use two survey approaches: Core Surveys and Biodiversity Surveys. Core Surveys track key assemblages of marine algae and invertebrates, and are usually conducted biannually. Using a fixed plot design, even a small rate of change can be detected. Biodiversity Surveys, conducted every few years, gather information about intertidal community structure and biodiversity,

A MARINe invertebrate survey underway.

mapping the distribution of algae and invertebrate communities at the sites.

Sharing the survey data benefits all interested parties and simplifies the analysis of large spatial and temporal patterns. Core survey data are stored on a shared database managed by the University of California (UC) Santa Cruz and UC Santa Barbara. Biodiversity survey data are placed in a separate database managed by UC Santa Cruz for the Partnership for Interdisciplinary Study of Coastal Oceans.

MARINe monitoring and research show that many of the coastal rocky shores are under stress, especially those near urban settings. Research also shows that some of the intertidal populations have changed significantly over the past several decades. These changes correlate with increased public use of shores, increased fishing pressure, poaching, and pollution.

The commitment of MARINe's members ensures that this diverse partnership is successful in gathering and sharing information that helps many groups protect our coastal habitats.

California mussels *(Mytilus californianus)*, barnacles, and sea lettuce (*Ulva* sp.).

Several protective actions have resulted from MARINe's work:

- The decline of the black abalone *(Haliotis cracherodii)* population has been well documented by MARINe data; data collected by the Channel Islands National Park in the 1980's, mainland data collected by MMS (now BOEMRE), and the University of California Santa Cruz data collected since the early 1990's. These data helped the State of California support closure of the black abalone fishery in Southern California in 1993 and the National Oceanic and Atmospheric Administration (NOAA) list the black abalone as a Federally endangered species in 2006.
- The State of California is using MARINe data to evaluate impacts to the shoreline from nonpoint discharges and to set up Marine Protected Areas across the State.
- The Mussel Watch program (sponsored by NOAA) has 13 new sites thanks to MARINe. Mussels are collected to help monitor water quality through the identification of heavy metals, hydrocarbons, and pathogens in mussel tissues. The Southern California Coastal Water Research Project, a long-time MARINe partner, provides for tissue analysis of mussels collected at MARINe sites.

FOR MORE INFORMATION

MARINe
www.marine.gov/About.html

BOEMRE Pacific OCS Region, Environmental Information
www.boemre.gov/omm/pacific/enviro/enviro.htm

A withered black abalone *(Haliotis cracherodii)*.

Go-Kits Outfit Biologists for Quick Response and More

To distinguish oil spill effects from natural changes in shoreline habitats, many types of data are necessary.

Biologists along the Pacific Coast are well armed with a tool that was initially developed for rapid response data collection in the hours *before* oil reached the shore. These Go-Kits—preassembled backpacks—make it easier to collect vital information about habitat structure and to document oiling.

While they are still used for pre-spill, Go-Kits have proven extremely valuable for post-spill data collection and also for tracking effects.

The kits were successfully used in the *Cosco Busan* spill (San Fransciso Bay, 2007) and the *Dubai Star* spill (San Francisco-Oakland, 2009).

The Go-Kits make it possible to conduct quick, systematic, and scientific assessment of shoreline habitats: rocky intertidal, sandy beach, and coastal wetlands.

In addition to equipment, the kits include specific protocols and step-by-step instructions for collecting photos, tissue samples, and species counts for each shoreline habitat type. The protocols standardize data collection so it can be compared before and after a spill, temporally and spatially, and also with un-oiled areas.

Go-Kit data are especially valuable because it ties back into MARINe's (Multi-Agency Rocky Intertidal Network's) long-term monitoring datasets, contributing sound scientific information that can be used to compare sites over time to determine damage and recovery.

BOEMRE; the California Department of Fish and Game, Office of Spill Prevention and Response; and the National Oceanic and Atmospheric Administration's Assessment and Restoration Office worked with the University of California (UC) Los Angeles and UC Santa Cruz to develop oil spill Go-Kits.

Go-Kits give biologists a significant advantage by facilitating the collection of current, relevant, scientifically rigorous data, a keystone for informed decisionmaking.

FOR MORE INFORMATION

"Pre-spill Assessments of Coastal Habitat Resources: Volume I: Development of Protocols, assessment kits" (SSEP 2006-06).
www.dfg.ca.gov/ospr/science/ssep.aspx

Multi-Agency Rocky Intertidal Network (MARINe)
www.marine.gov/Collaborations/SpillResponse.html

BOEMRE Pacific OCS Region
www.boemre.gov/omm/pacific/index.htm

Go-Kits in action at the *Cosco Busan* tanker spill, San Francisco Bay, November 2007. *Photo courtesy of Christy Bell, University of California Santa Cruz.*

Closeup of a tidepool, with anemones, urchins, algae. *Photo courtesy of Dave Pereksta, University of California Santa Cruz.*

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BOEMRE: A steward of the ocean environment

MARINe Annual Workshop Held in January

Members of the Multi-Agency Rocky Intertidal Network (MARINe)—including BOEMRE—convened for their annual taxonomic workshop, held January 28–29, 2011, at the University of California (UC) Santa Barbara.

Dr. Mark Denny, marine biologist from the Hopkins Marine Station at Stanford University, delivered the keynote address, "Worst Case Scenarios: Predicting Ecological Extremes."

The monitoring teams evaluated new field protocols at a pre-workshop science meeting and provided recommendations to the Science Panel.

Among the topics covered during the workshop were black abalone studies, ocean acidification, and biological impacts of climate change. Attendees discussed what additional climate change parameters MARINe should monitor, shared research updates, and held a special lab session on low intertidal species.

Oil-spill-related subjects were certainly not neglected. Involvement in oil spill data collection was discussed, and members shared reflections on the *Deepwater Horizon* and *Dubai Star* spills. Dr. Pete Raimondi of UC Santa Cruz presented a special address, "How MARINe and Go-Kit Data Informed Assessment of the *Cosco Busan* Spill."

Groups represented at the workshop included:

Agencies, tribal governments, private organizations: BOEMRE, California Coastal Commission, California Ocean Science Trust, California Office of Spill Prevention and Response, Monterey Bay Aquarium Research Institute, National Park Service, NOAA, Partnership for Interdisciplinary Study of Coastal Oceans, Quinault Indian Nation, Santa Barbara Natural History Museum, State Water Resources Control Board, Tenera Environmental, Inc., Tierra Data, U.S. Navy, Ventura County.

Universities: UC Santa Barbara, UC Santa Cruz, UC Los Angeles, UC Berkeley, California State University (CSU) Fullerton, CSU Long Beach, Stanford University.