MBARI

Monterey Bay Aquarium Research Institute

2011 STRATEGIC PLAN

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Mission statement

The mission of MBARI is to achieve and maintain a position as a world center for advanced research and education in ocean science and technology, and to do so through the development of better instruments, systems, and methods for scientific research in the deep waters of the ocean. MBARI emphasizes the peer relationship between engineers and scientists as a basic principle of its operation. All of the activities of MBARI must be characterized by excellence, innovation, and vision.

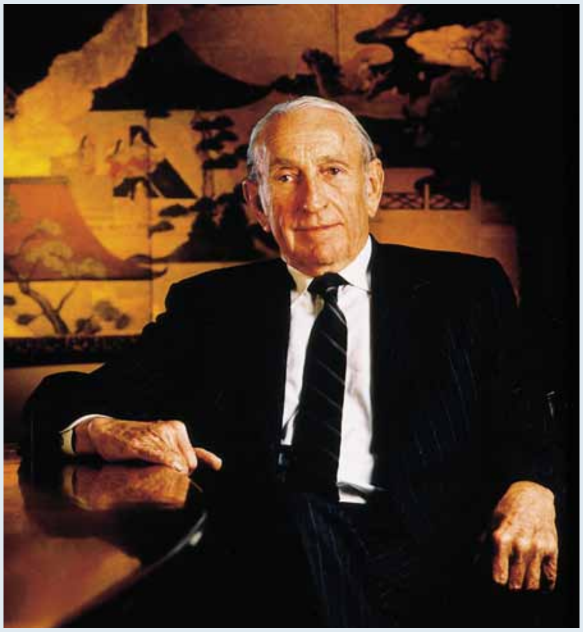
— David Packard
MBARI Founder

Definitions

Goals: Points that mark the ultimate state that we want MBARI to reach.

Objectives: Near-term achievements that mark MBARI progress toward our goals.

Strategies: Approaches that MBARI will adopt to reach our objectives.



David Packard

David Packard's vision

David Packard established MBARI to address the lack of technology for exploring, experimenting in, and understanding the ocean. He recognized that improved technology for observation of the ocean would offer great opportunity for scientific advances. To promote the development of instrumentation and equipment, Packard insisted that scientists and engineers work together in close collaboration. Packard also thought researchers would have a greater chance of success if they were freed from the burden of applying for external grants, so he funded the institute through the David and Lucile Packard Foundation. His vision of dynamic collaborations between science and engineering remains one of MBARI's distinguishing features and the Packard Foundation continues to supply over 75 percent of the institute's annual budget, as well as funds for new facilities.

MBARI's vision and values

David Packard founded the Monterey Bay Aquarium Research Institute (MBARI) as an alternative to the traditional academic oceanographic research institution. He challenged us to develop and apply new methods, instruments, and analytical systems to address fundamental problems in ocean science and to identify new directions where innovative technologies will accelerate progress. Achieving this requires a peer relationship among scientists and engineers, ready access to the sea, and effective communication with the broader oceanographic community. MBARI strives for the highest standards of excellence, reflected by the quality of our scientific results and the creativity of our methods and engineering developments. We aim to share technology, data, and knowledge with the external oceanographic community, educators, and the general public. Through enhanced scientific understanding of the functioning of marine ecosystems, MBARI contributes to the David and Lucile Packard Foundation's long-term goal to restore the health and productivity of the ocean on which all life depends.

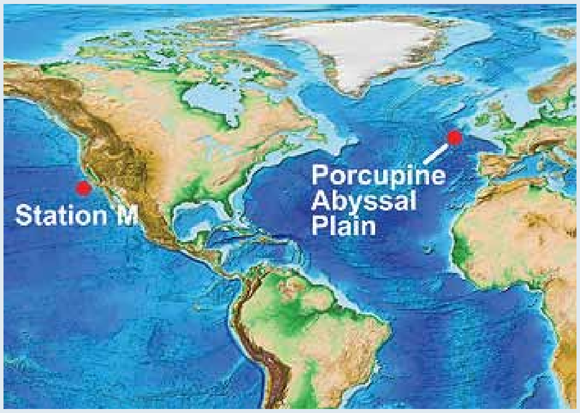
Institutional drivers and goals

The ocean comprises greater than 90 percent of Earth's biosphere and gives life to the rest of our planet. Yet the future of the ocean is greatly threatened. Well-recognized changes in oceanic processes are under way in response to both human activities and natural phenomena. Such alterations may very well lead to large ecosystem shifts that have not been experienced in recorded history; accordingly, our ability to forecast a realistic view of the "future ocean" is limited. The complexity of ocean processes and inadequate technology impede progress in ocean observation, experimentation, exploration, and conservation. Consequently, MBARI's focus is multidisciplinary in nature, encouraging the formation of teams that integrate research, engineering, and marine operations. This approach requires careful selection of problems that we are uniquely poised to address. We must accept the risk inherent in technological developments that other institutions will likely avoid.

Because MBARI's approach involves considerable risk of failure, it is unlikely to obtain full funding through traditional government-sponsored programs. Accepting such risks requires flexibility in the deployment of MBARI's ships and other assets. Institutional flexibility also encourages scientific and technological exploration and provides the capacity to pursue new opportunities in the face of unanticipated discoveries.

MBARI's strategic plan is a living document, updated periodically to reflect changing priorities in a rapidly changing world and the progress we make in meeting our objectives. This iteration builds directly from that which has guided us since 2006. Research themes have been refined to reflect our focus on documenting the state of the ocean and life within it in the face of global change. From that perspective, **our overarching goals** are to:

- Develop or adapt innovative technologies that allow researchers to identify and resolve important questions and advance our understanding of the ocean.



This map shows the locations of the long-term, deep-sea study sites at Station M and the Porcupine Abyssal Plain. Base map courtesy of NOAA (ETOPO1 Global Relief Model).

Assessing the impacts of climate change

Global climate change could alter oceanic food webs in many ways. Climate-driven changes in upwelling, ocean mixing, oxygen minimum zones, and nutrient cycling are likely to affect the year-to-year variation in ocean ecosystem processes. These changes will potentially impact marine life and the fundamental underpinnings of fisheries from shallow to deep-sea habitats. MBARI's technical achievements and knowledge are transforming climate change research with novel methods and technologies such as the Free Ocean CO_2 Enrichment system, the Benthic Rover, in situ respirometers, and Lagrangian sediment traps. These instruments and long-term studies demonstrate that deep-sea communities are coupled to surface production. For example, the amount of food reaching the deep sea varied dramatically over time at two deep-sea sites—one at Station M, off California, and a second on the Porcupine Abyssal Plain, southwest of Ireland. Dramatic year-to-year changes in fish and invertebrate abundance were observed and linked to changes in both the quantity and type of food reaching the seafloor. Climate-driven changes in upwelling, mixing, and other ocean processes are likely to alter the amount of food reaching the deep sea.

The ROV inserts a laser Raman spectrometer probe into the seafloor to take in situ measurements of this methane-rich area covered in bacterial mats.

Improved techniques for in situ studies

The enormous size of the gas hydrate reservoir in the marine environment has generated concern over potential gas releases and the stability of hydrate deposits in the face of climate change. A team of MBARI researchers and engineers developed equipment and methods to conduct some of the first experiments on gas hydrate formation and carbon dioxide sequestration in the deep ocean. The group also adapted laser Raman technology for precise in situ analyses of the physical and chemical properties of seafloor hydrates. More recent experiments with MBARI's laser Raman system showed pore-water methane signals nearly 30 times higher than those obtained by traditional methods from recovered sediment cores. MBARI's creative adaptation and use of laser Raman spectroscopy in the deep ocean continues to improve our understanding of ocean geochemistry.

- Utilize those developments to explore and understand how natural ocean systems operate and how they respond to natural and anthropogenic change.
- Transfer the knowledge gained, solutions devised, and the technology developed to communities outside of MBARI—researchers, educators, policy makers, resource managers, industry, and the general public.

Research themes: 2011-2020

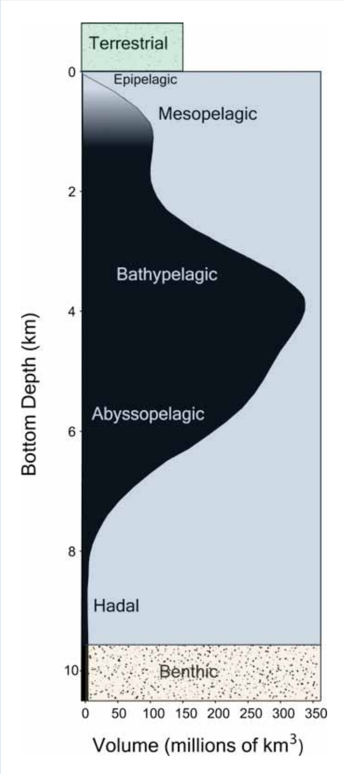
MBARI's distinction in the oceanographic community lies in its capacity to develop new technologies and quickly field them for testing and scientific applications. Within this broad framework, our principal focus over the next five to ten years will be to address issues of global and societal relevance by emphasizing the following interrelated research themes:

- **Exploration and discovery** builds on MBARI's long-term efforts to explore and understand the geology, chemistry, and biology of the world ocean, with a focus on Monterey Bay.
- **Ocean visualization** focuses on the development and use of MBARI's imaging technologies to create detailed representations of the seafloor and overlying water column, and the ecosystems within these domains.
- **Ecosystem dynamics** research aims to comprehensively study productivity and transfer of matter and life between the ocean surface and the deep sea.
- **Ocean biogeochemistry** exploits the use of MBARI sensor technologies, both by MBARI and by colleagues worldwide, for developing a predictive understanding of global-scale processes, including climate change.

Exploration and discovery

Exploration inevitably leads to discovery. During the past two decades, MBARI has emerged as a leader among the world's oceanographic institutions in the discovery of organisms that are new to science and in the characterization of poorly known oceanic processes. Discoveries that range from the structure and function of oceanic communities to documenting rapid changes in the shape of the seafloor have greatly increased public awareness of how little we know about our planet and how these unseen deep-sea systems are connected to our lives on land. For these reasons, continued development of tools and techniques for exploring the deep ocean remains one of MBARI's enduring research and development themes.

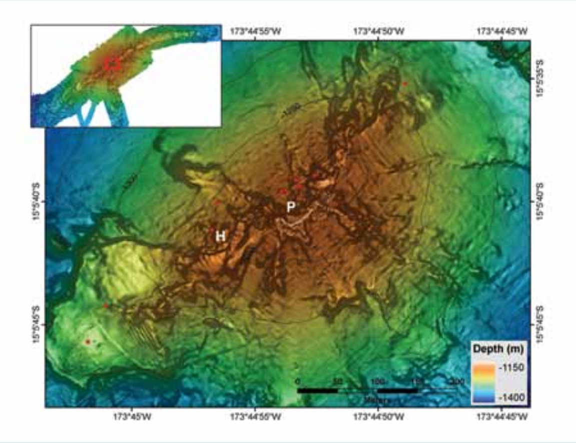
MBARI is uniquely positioned to explore the deep-sea realm and its connections with the ocean surface. Easy access to Monterey Bay's deep submarine canyon provides a natural laboratory for scientific research and engineering innovation. Developing and expanding our access to this undersea laboratory has been a primary theme since MBARI's founding. Platforms and sensors for observing the deep ocean and for conducting interactively controlled in situ experiments are hallmarks of MBARI's achievements. The continued use, development, and creative integration of these assets permit MBARI research teams to transcend many of the limitations faced by other scientists and engineers who endeavor to study marine environments.



Volume of habitat in the ocean at different depths and on the seafloor (benthic seafloor includes one kilometer above the seafloor), with a comparison to terrestrial habitat (including one kilometer of air above the surface).

The deep sea is Earth's largest habitat

The relative volumes of terrestrial and oceanic living space in the above graphic reveal the overwhelming prevalence of ocean habitats. MBARI's Ocean Access Plan targets the ocean realm from the surface to depths of 4,000 meters, the average depth of the world ocean—which includes most of the habitats likely to be affected by climate change. This target depth range for MBARI vehicles and instruments allows for research access to the depths of Monterey Canyon and Monterey Deep-Sea Fan, as well as most of the world ocean, from the sunlit epipelagic zone, through the mesopelagic and bathypelagic zones.



High-resolution bathymetry of the summit of West Mata Volcano, mapped by the AUV *D. Allan B.* deployed from a UNOLS vessel at the site of the erupting undersea volcano.

Developing tools for visualizing ocean change

Recent advances in the instrumentation and use of MBARI's autonomous underwater vehicles (AUVs) have brought the ability to "see" ocean chemistry, geology, and biology to a new level. Water samplers on the upper-water-column AUV extend its ability to characterize the biological, chemical, and physical aspects of the ocean, by collecting water samples and bringing them back to the laboratory. The *D. Allan B.*, our mapping AUV, acoustically images the seafloor and subseafloor with the ability to record features less than one meter in size. The benthic imaging AUV is designed to collect high-resolution images of large sections of the seafloor and its animal communities; in the future it will be used in the midwater as well. The detailed color images allow for more accurate identification and records of animals and seafloor features. Consequently, changes detected over time can be better quantified and documented compared to present-day methods.

Ocean visualization

Documenting oceanic change and understanding its consequences requires quantitative assessments of time-varying properties. Visualizing the ocean's interior, its inhabitants, and its bottom topography is a long-standing challenge that limits our ability to carry out such assessments. To enable future scientific breakthroughs in all areas of ocean science, more efficient technologies for acquiring, managing, and processing quantitative, multi-scale spatial images of the water column and seafloor are needed.

MBARI's development of scientific remotely operated vehicles (ROVs) was our initial step in ocean visualization. These efforts expanded to include image-synthesis and database-management tools. Autonomous underwater vehicles (AUVs) provide the next generation of visualization systems. The mapping AUV produces images of the seafloor and subseafloor. The water-column AUV, equipped with a suite of advanced instruments, presents the means to assess water-column chemistry and biology. The benthic-imaging AUV visualizes large sections of the seafloor and associated animal communities, and will be adapted for work in the midwater.

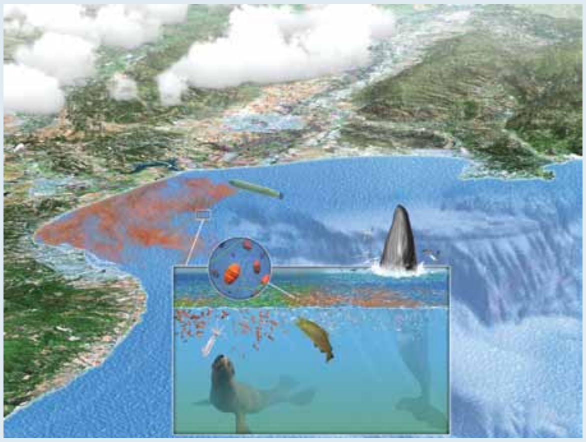
These technologies have greatly increased our capacity to image the ocean at new spatial scales, but they primarily obtain two- and three-dimensional views from planned tracks. Realizing four-dimensional visualizations—repeated spatial renderings over time—remains a key objective. This can be achieved by integrating AUV and ROV operations with fixed sensor systems strategically placed in particular locations. Efforts to extend mission length, add novel sensors, integrate data types, and improve data management will enhance our capacity to characterize environmental change while stimulating new discoveries. Further development of real-time, onboard analysis of data will enable observing systems that can detect and respond autonomously to document rapidly changing features.

Ecosystem dynamics

Oceanic life ultimately depends on a myriad of interactions among tiny organisms whose diversity and abundance are driven by processes that vary on multiple spatial and temporal scales. Complex interactions result in patchy distributions of biological communities and ephemeral population dynamics. These fluctuations alter food webs and rates of nutrient cycling in ways that propagate from the ocean's surface to the deep seafloor. The interplay of dynamic physical, chemical, and biological processes drives the transfer of matter and energy on a global scale, affecting Earth's climate as well as human health and prosperity.

Natural and anthropogenic perturbations alter these processes from the microscopic level to an ecosystem-wide scale, and can occur in minutes or over decades or longer. Microorganisms at the base of the food web play a key role in integrating these scales, translating short-lived events to more easily recognized patterns and cycles of productivity observable at the ecosystem level. Gaining a more detailed understanding of how microorganisms respond to highly ephemeral, spatially varying processes is therefore central to attaining a predictive understanding of the longer term and larger scale consequences of environmental change.

What we know about marine ecosystems comes mostly from repeated, discrete observations. This traditional approach often misses factors that give rise to a particular observation and the consequences that follow immediately thereafter. Undersea events are rarely captured due to present-day short-



Many of the red-tide blooms that occur in Monterey Bay propagate from the northeast region of the bay.

Understanding the critical phenomena in ecosystem dynamics

The life cycles of marine microorganisms create ephemeral features such as algal blooms that continually evolve and interact with the environment. These "booms" and "busts" reflect the interplay between physics, chemistry, and biology, and represent the core of the oceanic food web. Some blooms can be harmful to humans and wildlife and can bring negative economic consequences. Traditional oceanographic studies of the microbial ocean have required persistent use of ships with only sporadic sample collection. A more precise understanding of phenomena has eluded us because of technical difficulties tracking water masses and the rapidly changing life they carry. The Controlled, Agile, and Novel Observing Network (CANON) Initiative aims to create new ways to remotely assess oceanic conditions and collect samples of microorganisms for in situ and laboratory analysis.

The Decision Support System allowed researchers to select which data and which assets they wanted to view at any given point during the monthlong CANON/BIOSPACE experiment. The team could alter the courses of the vessels, AUVs, gliders, and other instruments in response to conditions detected in the bay.

Deciding when and where to sample

One challenge to imaging the ocean in four dimensions is determining where to deploy AUVs and other mobile assets and when to collect samples needed to resolve key ecological questions. For the 2010 CANON BIOSPACE experiment, engineers from MBARI and the University of Southern California developed a Decision Support System that captured data from various sources such as AUVs, satellites, moorings, and high-frequency radar, and presented this information online in real time. This system allowed researchers around the country to keep track of research activity during the CANON experiment and respond as conditions in the bay changed, rapidly redirecting the course of the marine assets and changing the sampling program as needed.

comings associated with integrating comprehensive physical, chemical, and biological assessments. Yet, to establish cause-and-effect relationships, finer resolution measurements are needed. This demands the development of fixed and mobile platforms equipped with new sensing and sampling technologies that will enable us to follow ecosystem processes over both space and time, and to track material exchange between surface waters and the deep sea. By operating such systems within an existing observatory framework, in concert with predictive models, we aim to develop and test hypotheses relating to ecosystem structure and function without necessarily requiring a human presence at sea.

Ocean biogeochemistry

Variations in ocean acidity, oxygen, temperature, density, nutrient transport, and trace metals can have major influences on ecosystem structure and function. These factors are all projected to change across the world ocean as a result of climatic alterations, but such alterations will not impact marine ecosystems uniformly. Increasing temperature and density stratification may limit upward nutrient transport and phytoplankton growth at low latitudes, while enhancing production of biomass at high latitudes by extending the growing season. Pelagic photosynthetic organisms such as microalgae turn inorganic carbon into organic material that feeds the food web and leads to production of carbon-rich particles that sink into the deep sea. This process, known as the biological pump, reduces atmospheric carbon dioxide and thereby influences the Earth's heat balance. Should that process decline, less carbon dioxide will be removed from the atmosphere and the climate will likely become warmer.

Increased biomass accumulation at high latitudes would have the opposite effect. In any case, alterations to the biological pump could have a profound impact on biological communities and global climate.

A network of globally distributed instruments is required to understand these processes and their consequences. Satellites provide high-frequency global coverage and their primary biogeochemical sensors provide ocean color data, which is available only during cloud-free periods. Ocean color instruments sense to tens of meters in depth and cannot resolve vertical structure or chemical processes. Consequently, we need to develop a new suite of in-water biogeochemical sensors, platforms, and related infrastructure (data systems, models, and calibration capabilities) that can be scaled to very large numbers and affordably distributed throughout the world's ocean basins. Such systems would have to operate for extended periods to detect and quantify shifts in ocean ecosystem processes.

MBARI is in a unique position to tackle the challenges of developing sensors that can be integrated into globally distributed, biogeochemical sensor networks. Ready access to the sea creates opportunities to engineer robust sensor systems that can operate in harsh environments. Once in place, this technology and know-how can be exported to institutions and agencies capable of deploying and operating the global sensor array. Such a network would be the focal point for future research on long-term change and process-oriented studies of biogeochemical dynamics.

An Apex float fitted with an In Situ Ultraviolet Spectrophotometer is prepared for deployment.

Extending the impact of the Argo network

An array of autonomous sensors deployed throughout the world ocean has the potential to provide insight on the ocean's biogeochemistry and the impacts of carbon flux into the ocean on a global scale. An MBARI team developed the In Situ Ultraviolet Spectrophotometer (ISUS) nitrate sensors and is deploying them on Apex floats, which are part of the worldwide Argo array. The MBARI group will add sensors to monitor ocean pH and chlorophyll fluorescence to the floats, as additional floats are assembled for the array. The operation of these physical, biological, and biogeochemical sensors on a global scale will provide an unprecedented view of major fluxes of nutrients essential for sustaining Earth's habitability.

The new long-range AUV, *Tethys*, expands the types of observations and experiments possible with autonomous platforms.

Tethys, the long-range autonomous underwater vehicle

Years of experience with AUV and glider operations have exposed a need for a vehicle with the range of a glider but the sensing capabilities of an AUV. MBARI is developing a long-range AUV to fill a niche between existing propeller-driven AUVs (that carry many sensors but have short endurance) and gliders (with few sensors and long endurance). The *Tethys* design provides the capacity for adaptive sampling with in situ sensors and water samplers to support chemical and biological process experiments covering ranges of 1,000 kilometers or more. This new class of vehicles includes highly energy-efficient, propeller-driven AUVs capable of drifting or operating at speeds up to one meter per second. *Tethys* will carry an impressive suite of sensors 10 times farther than our existing AUVs and extend our reach out into the California Current system.

MBARI's institutional objectives and strategies

Objective 1: Foster technological innovation

The research themes articulated above extend the institute's potential to address fundamental questions about ocean structure and function. Technological innovation and engineering developments are central to accelerating progress in this endeavor. Engineering at MBARI takes advantage of the close working relationship we have among the researchers, engineers, and operations staff to derive requirements for, and to evaluate the effectiveness of, systems, instruments, and methods developed at the institute. MBARI development teams aim to quickly converge on designs to support near-term needs and to establish the feasibility of particular approaches. These steps enable more innovative solutions that fulfill longer term research objectives. Supporting several fundamental research programs in engineering ensures that MBARI is engaged in cutting-edge technological developments to continuously spur and refresh ocean science research. The close working relationships in interdisciplinary teams ensure problem solving and subsequent advocacy for emerging technologies, resulting in wider acceptance and use. Innovation and focus will require looking beyond the 10-year timeframe to conceive a technology vision 20 to 40 years ahead.

Strategy 1.1: Develop a technology roadmap to identify emerging technologies that could have a major impact on future ocean research.

Strategy 1.2: Encourage the formation of interdisciplinary science and engineering teams to address high-priority research themes at the interface of multiple disciplines.

Strategy 1.3: Support feasibility studies by providing access to resources for scoping new ideas or directions, particularly for potentially transformational or disruptive technologies.

Strategy 1.4: Maintain the long-range perspective that technology developments require. Balance that commitment with annual reviews so that resources are appropriately distributed to the most promising projects.

Objective 2: Increase institutional flexibility

MBARI is a small institution which limits the scope and number of projects we can undertake. Long-term investments in projects and infrastructure can limit flexibility, but our size also keeps the institute nimble and able to mobilize resources to respond to new opportunities or unforeseen events.

Strategy 2.1: Distribute resources through the annual project review process to enhance flexibility of project teams and maximize opportunities to respond to new ideas.

Strategy 2.2: Hire, train, and cross-train staff strategically to support new research directions and emerging technologies.

Strategy 2.3: Adapt for contingencies; allow for redirection of resources in response to unprecedented events or unexpected opportunities.

Strategy 2.4: Refine the Ocean Access Plan to ensure institutional requirements are met for efficient, flexible access to vessels, vehicles, and platforms for research and for rapid testing of prototype systems.

Launching the upper-water-column AUV from a NOAA ship in the Gulf of Mexico.

Redirecting assets to the Gulf of Mexico oil spill

MBARI's unique capabilities and knowledge poised the institution to respond to requests from federal agencies in the wake of the 2010 Deepwater Horizon oil spill. We sent our AUV with "gulper" water samplers to the Gulf of Mexico. This AUV can measure physical and chemical characteristics of seawater, such as temperature, salinity, oxygen, chlorophyll, and concentrations of small particles (or oil droplets). Using artificial intelligence software, the AUV was able to collect water samples when optical and chemical measurements indicated a hydrocarbon plume-like feature below 1,000 meters depth. MBARI's AUV and gulper system provided a surveillance and sample collection capability complementary to other tools deployed to understand the fate of the subsurface plume of oil and dispersant. Coordinating this response in collaboration with government and academic institutions was important for providing much-needed fundamental information on the spill and its impacts, and also served as a valuable learning experience for understanding how to respond to such incidents in the future.

A Center for Ocean Solutions early career fellow investigates using MBARI's Environmental Sample Processor for water quality tests mandated by state and federal law.

Collaborating across disciplines

The integration of science and technology with economic, social, and political expertise can help effect practical solutions to ocean issues. Three institutions—Stanford University, the Monterey Bay Aquarium, and MBARI—have joined forces to create the Center for Ocean Solutions. This alliance combines Stanford's expertise in marine biology, engineering, economics, law, and policy, with the aquarium's success at public education, and MBARI's leadership in technology development and oceanographic research. The group's collaborative projects will provide information for decision-makers from government, business, and the nonprofit sectors, by translating the results of marine science and policy research into plans and action.

Objective 3: Enhance collaborations

MBARI must focus strategically on timely problems best suited to our core mission of integrating ocean science, engineering, and marine operations. However, limited resources and infrastructure constrain progress in several areas. Some thematic elements exceed MBARI's capacity to allocate resources to any single research group, and other elements may require capabilities that MBARI cannot practically procure. We can overcome many of these limitations by developing interdisciplinary teams of MBARI researchers and by seeking external grants and collaborating with external groups such as those at Woods Hole Oceanographic Institution, the University of Washington, Lawrence Livermore National Laboratory, the Schmidt Ocean Institute, and the University of California, San Diego. In these ways we can bring in technical expertise to complement MBARI capabilities and gain access to key assets that MBARI does not own.

Strategy 3.1: Collaborate on external grants to build relationships with groups from academia, industry, and national laboratories.

Strategy 3.2: Take advantage of non-MBARI vessels and platforms to utilize MBARI technology outside of our normal range of operations.

Strategy 3.3: Widen access for our collaborators and for other Packard Foundation grantees to use MBARI technology.

Strategy 3.4: Enhance technology transfer opportunities by working with appropriate commercial companies that have established manufacturing and marketing capabilities.

Objective 4: Expand our reach

External organizations significantly extend MBARI's outreach efforts. The Monterey Bay Aquarium, with nearly two million visitors a year and a broad Internet audience, exposes the public to MBARI research and exploration through its website, programs, and creative exhibits. Similarly, the Center for Ocean Solutions, a consortium involving MBARI and the aquarium and led by Stanford University, creates a new capability for informing government agencies and policy makers of fundamental discoveries and developments that can help to shape resource management decisions. The Central and Northern California Ocean Observing System (CeNCOOS), hosted at MBARI, is a consortium of over 40 regional institutions that provides a central source for shared oceanographic data through the greater Integrated Ocean Observing System (IOOS) network. These institutional collaborations provide opportunities for programs that stimulate new directions in ocean science, governance, technology development, and education.

MBARI also bears a direct responsibility for getting information and technology derived from our research and development activities out to the greater oceanographic community, policy makers, and the public. Scientific and engineering journal articles, technical reports, conference presentations, congressional testimony, and international, industrial, and government collaborations are all effective methods of disseminating our work. Further, we must share our knowledge in ways that engage public interest in the current state of the world ocean and that stimulate the public's imagination about the future of oceanography, scientific discovery, and the importance of ocean conservation. To that end, we will continue to make our data, information, and images available

Visitors to the Monterey Bay Aquarium experience the thrill of deep-sea exploration in the *Mission to the Deep* exhibit about MBARI.

Reaching the public

MBARI's educational mission builds on our strengths in science and technology to advance knowledge and understanding of the ocean. We especially value our strategic alliance with our sister institution, the Monterey Bay Aquarium, with its creative exhibits, websites, and educational programs that reach millions of aquarium visitors, students, teachers, and the public. The two institutions work together to identify significant aspects of MBARI research and how best to share that information and content. The collaborative effort supports summer week-long sessions for teachers, as well as day-long sessions throughout the year. The aquarium's online professional community for educators provides a platform for connecting, collaborating, and supporting one another with new activities structured around pressing environmental issues that face our planet.

A video of the unusual barreleye fish (*Macropinna microstoma*), with its transparent head, captured the imagination and interest of millions of web visitors worldwide.

Communicating through the media

Providing accurate and up-to-date information to engage disparate audiences can be challenging. Years ago, people relied primarily on traditional media such as newspapers, journals, television, and radio. Now, traditional media compete with everything from respected Internet news sources such as the online version of the *New York Times* to Facebook, blogs, and Twitter for youthful attention. MBARI takes a broad approach to reporting. We distribute important news as press releases to traditional media. We use eye-catching images from the MBARI archives to expand our reach via the web, broadcast media, and film. The MBARI news story and images of Davidson Seamount generated significant media coverage and led to the extension of the Monterey Bay National Marine Sanctuary to include the seamount. The media continue to revisit our news release on anchovy and sardine fisheries off North and South America years after it was posted. The news release and YouTube video of the barreleye fish, *Macropinna*, brought the wonders of the deep sea to millions of readers and viewers around the world. As MBARI's use of new media develops, our stories and images will help us connect people around the world to the ocean realm.

to appropriate external parties, including educators, media outlets, and the general public.

Strategy 4.1: Engage actively with the Monterey Bay Aquarium to develop new exhibits and programs that illustrate the wonders, workings, threats to, and benefits of the ocean to the general public.

Strategy 4.2: Enhance the impact of MBARI's oceanographic research efforts by establishing more direct lines of communication and coordination with public policy and educational organizations. Build on the Packard Foundation efforts to bring together representatives of California state government, education, and philanthropy to review strategic directions in ocean science, policy, education, and conservation, and identify synergistic opportunities.

Strategy 4.3: Extend these policy and education interactions nationally and internationally through strategic alliances and through the use of new media

Strategy 4.4: Expand access by undergraduate, graduate, and postdoctoral scholars to MBARI's unique resources and encourage educational opportunities with surrounding institutions.

Metrics of success

MBARI's progress towards meeting our mission, vision, research objectives, and commitment to technology dissemination and outreach can be evaluated with the following criteria:

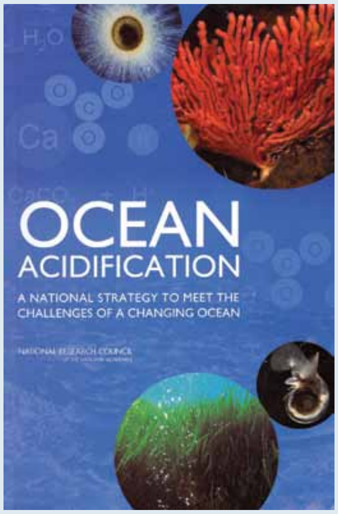
Immediate

- MBARI research is published in top-tier journals and heavily cited in ocean science and engineering literature.

- MBARI developments are highlighted in technology publications.
- MBARI news, images, and data are widely and readily available and used outside the institute for research and education and to inform policy makers.
- MBARI staff are recognized internally and in the greater oceanographic community for effectively disseminating their research results and technological developments.
- MBARI technology is in demand for adoption by groups external to the institution through licensing, copying, or other strategies as appropriate.
- MBARI's research and development activities are consistent with the overarching goals of the Packard Foundation.

Five-year time frame

- MBARI—the institution, not just the individuals—is recognized internationally, by more than just oceanographers.
- Contributions from external collaborations enhance MBARI research and development programs by increasing access to facilities and financial support that would not be available from the Packard Foundation, and by providing intellectual and creative stimulation.
- Results of MBARI research and development shape the direction of external research programs by focusing research topics and indicating promising technical approaches.
- MBARI staff serve on national and international committees, as distinguished lecturers, as adjunct professors, and provide testimony to Congress and other policy making bodies.



MBARI contributed to the National Research Council's report on ocean acidification.

Informing policy makers

Many policy makers and the public do not yet grasp the profound consequences of oceanic change. MBARI research and developments have the potential to enhance understanding of how the ocean affects all life on the planet. Lessons learned in Monterey Bay can be translated to research and conservation on state, national, and international levels. The Intergovernmental Panel on Climate Change (IPCC), the National Academies, and researchers from around the world acknowledge MBARI contributions toward understanding the combined impacts of climate change: ocean acidification, warming, changes in coastal upwelling, and declining oxygen in the ocean. MBARI researchers contributed to the National Research Council's science strategy on ocean acidification and the 2007 IPCC working group—recognized with the Nobel Peace Prize—that reported on climate change impacts on the ocean. MBARI's ocean imaging capabilities could provide baseline information and support for monitoring California's marine protected areas and for conservation-based management of the ocean outlined in an executive order by President Obama.

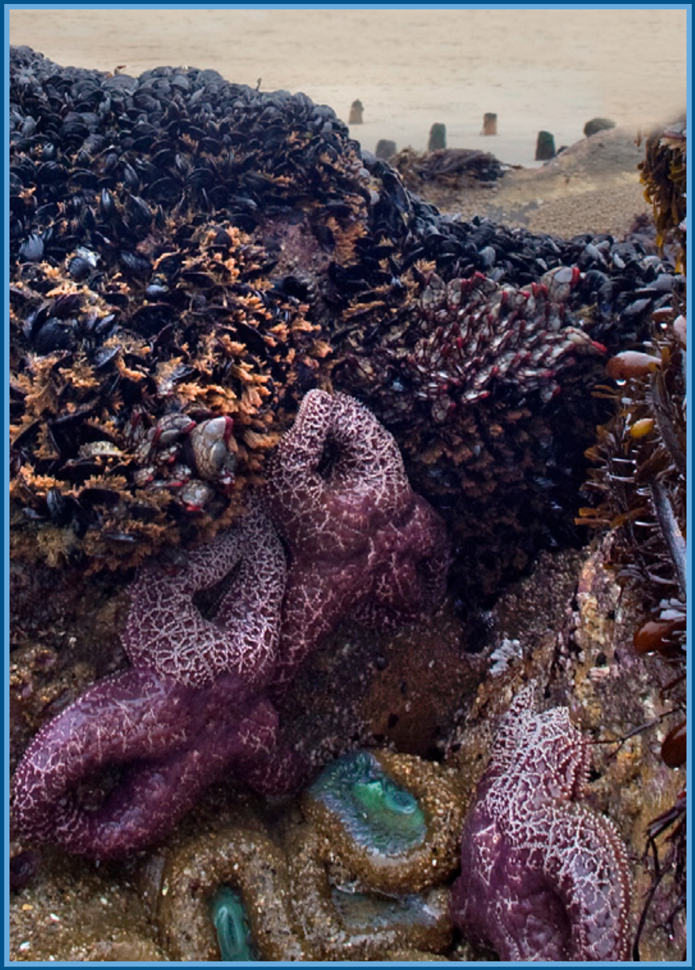
This summer intern studied picophytoplankton while at MBARI.

Inspiring the next generation

MBARI recognizes that young scholars are important sources for new ideas and potential channels for technology transfer. Each summer MBARI invites a small group of teachers and college students from around the globe to Moss Landing for an intensive 10-week summer internship program exposing them to research, engineering, and science communication. For many of these interns, the summer at MBARI has been a defining experience as they plan their careers. Each intern works with a designated mentor in his or her field of interest. Support from MBARI staff has been critical to the success of the program. The primary outcome for the program is that the interns leave with a better understanding of their future options. MBARI has hosted 188 interns from 32 states and 12 countries since 1997, many of whom have gone on to careers in science, technology, or education.

Ten-year time frame

- MBARI technology defines industry standards.
- MBARI research results have contributed to raising public awareness about the health and future of the ocean.
- MBARI discoveries help shape ocean policy.
- MBARI interns and postdoctoral fellows, and other students affiliated with the institute, become the next generation of ocean champions and science, engineering, and communications professionals.



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