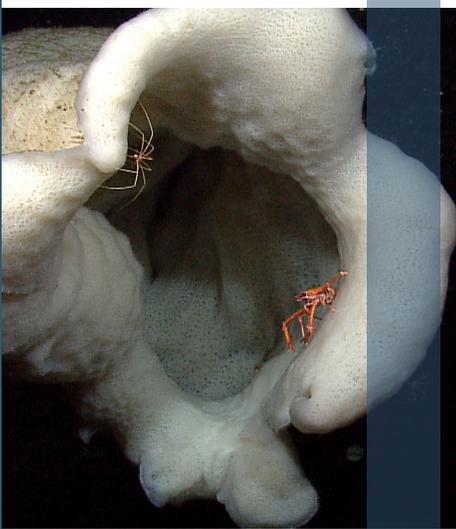
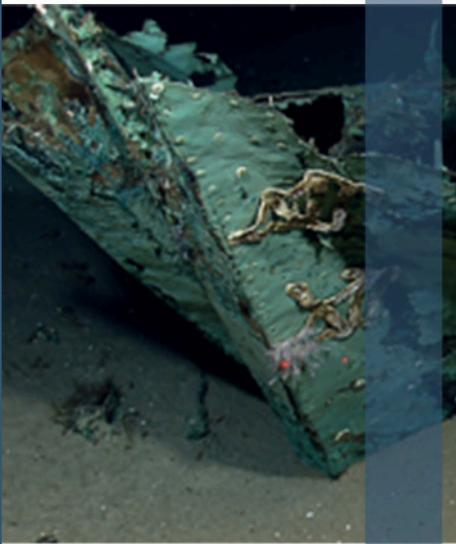




# Ocean Exploration's Second Decade

A Report from the NOAA  
Science Advisory Board

December 2012



## **December 2012**

### **Cover Page Photo Credits**

Top Photo: Chrysaora jellyfish from the 2002 Arctic Expedition.  
Courtesy of NOAA's Office of Ocean Exploration and Research.

Second Photo: 19th century Gulf of Mexico shipwreck  
explored for the first time by the *Okeanos Explorer* in 2012.  
Courtesy NOAA's *Okeanos Explorer* Program.

Third Photo: Mid Cayman Rise photo from graphic's key  
Courtesy NOAA's *Okeanos Explorer* Program.

Bottom Photo: Courtesy NOAA's *Okeanos Explorer* Program.

# Ocean Exploration's Second Decade

## Decadal Independent Review of the U.S. Ocean Exploration Program Invited by NOAA Science Advisory Board

In February 2012 the chairman of the NOAA Science Advisory Board (SAB), Raymond Ban, invited an expert review of our nation's Ocean Exploration Program, for which NOAA is the lead agency through its Office of Exploration and Research (OER). The charge to the reviewers is available at <http://explore.noaa.gov/about-oer/> under the "Program Review" tab, as well as a link to download this report.

The members of the Panel, operating as a working group of the SAB, were chosen to span domains of ocean exploration (e.g., geology, biology, archaeology); the public and private sectors; science, technology and education; and individuals with and without prior involvement with the Ocean Exploration Program. Co-chairs Jesse Ausubel and Paul Gaffney met in person three times with professional staff members of the Ocean Exploration Program before the meeting of the full group. The professional staff members carried out an extensive historical documentation of the program, as well as a written self-evaluation to the Panel. The full Panel met May 7-8, 2012 in Silver Spring, MD.

Many members of the NOAA Office of Ocean Exploration and Research attended the two-day meeting, as well as representatives of other Federal agencies and leading non-governmental participants, including Robert Ballard and Larry Mayer, co-chairs of the Ocean Exploration Advisory Working Group to NOAA's SAB. The presentations from the meeting are available, together with other materials relating to the review at <http://explore.noaa.gov/about-oer/> under the "Program Review" tab.

The Panel relied on Ocean Exploration Program staff, the Ocean Exploration Advisory Working Group Co-chairs, and others during the review meetings.

These participants included:

Larry Mayer (co-chair, Ocean Exploration Advisory Working Group)	Bob Ballard (co-chair, Ocean Exploration Advisory Working Group)	Michael T. Jones (Chief Technology Advocate, Google, Inc.)
David Balton (Deputy Assistant Secretary for Oceans and Fisheries, State Department)	Brian Midson (National Science Foundation)	Katy Croff Bell (Ocean Exploration Trust)
Bob Detrick (Assistant Administrator, Office of Oceanic and Atmospheric Research (OAR))	Craig McLean (Deputy Assistant Administrator, OAR)	Cynthia Decker (Executive NOAA SAB)
Steve Hammond (OER)	Tim Arcano (Director, OER)	Sharon Hamilton (OER)
Sharon Mesick (NESDIS)	John McDonough (Deputy Director, OER)	Paula Keener (OER)
	Fred Gorell (OER)	David McKinnie (OER)
		Craig Russell (OER)
		Nathalie Valette-Silver (OER)

## 2012 Panel Members

### Jesse Ausubel

Co-Chair. Director, Program for the Human Environment, The Rockefeller University, Member President's Panel on Ocean Exploration (2000); member of Ocean Exploration Advisory Working Group to NOAA's Science Advisory Board

### VADM Paul Gaffney USN (Ret.)

Co-Chair. President, Monmouth University

### Susan Avery

Director, Woods Hole Oceanographic Institution

### Rodey Batiza

Program Director, Division of Ocean Sciences National Science Foundation

### Jean May-Brett

Math Science Partnership Program Coordinator, Louisiana Department of Education

### James Delgado

Director, Marine Heritage Program, Office of National Marine Sanctuaries, NOAA

### Terry Garcia

Vice President Mission Programs, National Geographic Society

### Hon. Cameron Hume

Former U.S. Ambassador to Indonesia, South Africa and Algeria

### Jeffrey Karson

Dept. of Geology, Syracuse University

### James Kendall

Regional Director, Alaska OCE Region Bureau of Ocean Energy Management, Department of Interior

### Eric Lindstrom

Physical Oceanography Program, National Aeronautics and Space Administration

### Marcia McNutt

Director, U.S. Geological Survey, Dept. of Interior, Chair President's Panel on Ocean Exploration (2000)

### Steven Ramberg

Chief of Naval Research Chair, National Defense University

# Summary

The Panel offers one finding and ten recommendations.

## Finding:

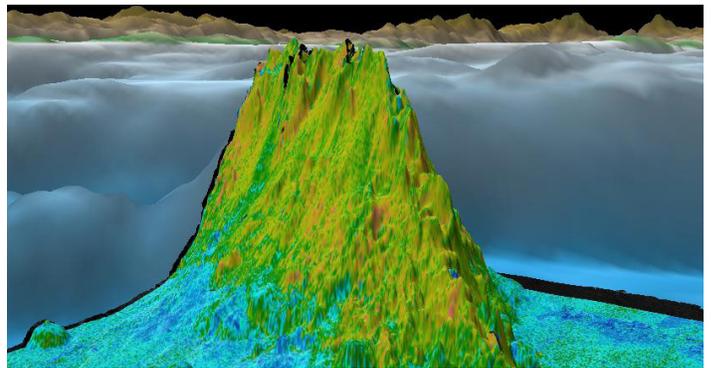
There is undiminished motivation for ocean exploration.

### Recommendations:

1. Strategic Goals and Priorities
2. NOAA Leadership Support Required
3. A National Forum on Ocean Exploration
4. Radical New Management Models
5. Targeted Expeditions
6. *Okeanos Explorer*
7. Technology
8. Extended Continental Shelf
9. Branding
10. Ocean Exploration Advisory Board



The joint Indonesia-U.S. ocean exploration partnership (INDEX) team in front of the *Okeanos Explorer*, 2010. Courtesy of NOAA.



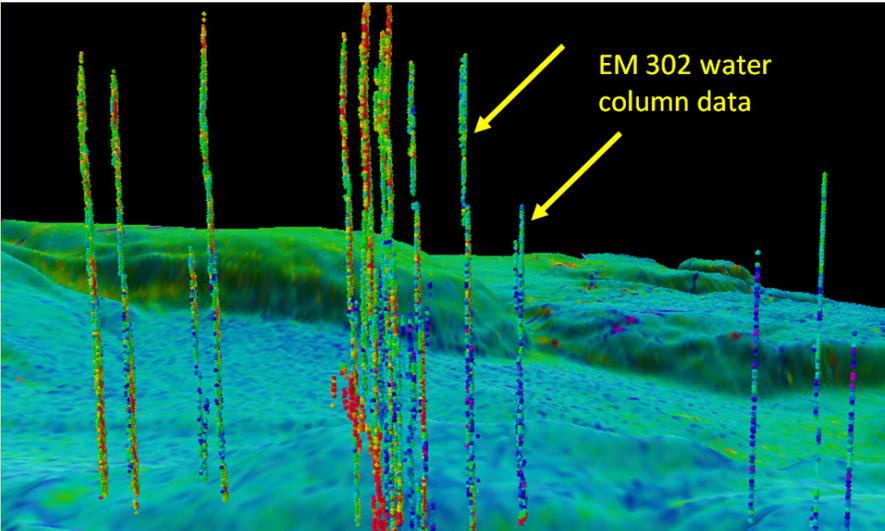
A multibeam image of the San Juan Seamount from *Okeanos Explorer* data, 2011. Courtesy of NOAA.

## Finding: There is Undiminished Motivation for Ocean Exploration

- The Ocean Exploration Program has had success in science, mapping, data management, education, politics, and diplomacy
- But vast unexplored regions remain, including the U.S. Exclusive Economic Zone and the Extended Continental Shelf
- Ocean exploration is part of American greatness and spirit

Consistent with the Congressional Oceans Acts of 1999 and 2000, in June 2000 in an Executive Directive, President Clinton requested the Secretary of Commerce to convene a Panel of leading ocean explorers, scientists, and educators to develop a national strategy for exploring the oceans and the Great Lakes. The 2000 Panel's report (pp. 252-326 at <http://explore.noaa.gov/about-oer/> under the "Program Review" tab, "Guiding Documents" link) *Discovering Earth's Final Frontier: A U.S. Strategy for Ocean Exploration*, delivered in October 2000, recommended: The U.S. undertake a national

This graphic shows seeps imaged by multibeam backscatter data acquired during the *Okeanos Explorer's* Gulf of Mexico expedition in 2012. Courtesy of NOAA.



program in ocean exploration in which discovery and the spirit of challenge are the cornerstones. Multidisciplinary exploration approaches, covering all three dimensions of space, as well as the fourth dimension of time, should include natural and social sciences as well as the arts. The U.S. Ocean Exploration Program should be global in scope, but concentrated initially in areas under U.S. jurisdiction. Results must be carefully documented and widely disseminated; the program must be innovative and bold.

The 2000 Panel recommended the U.S. government establish the Ocean Exploration Program for an initial period of 10 years, with new funding at the level of \$75 million per year, excluding capitalization costs. The 2000 Panel's recommendations are listed to the right.

The present Panel affirms the brief definition of exploration of the 2000 Panel: Exploration is the systematic search and investigation for the initial purpose of discovery and the more elaborated definition of the US Navy: Systematic examination for the purposes of discovery; cataloging/documenting what one finds; boldly going where no one has gone before; providing an initial knowledge base for hypothesis-based science and for exploitation.

The Panel affirms that Ocean Exploration is distinct from comprehensive surveys (such as those carried out by NAVOCEANO and NOAA Corps) and at-sea research (sponsored by National Science Foundation, Office of Naval Research, and other agencies), including hypothesis-driven investigations aimed at the ocean bottom, artifacts, water column, and marine life.

The present Panel finds undiminished motivations for the U.S. National Program in ocean exploration. In fact, spurred in part by the Ocean Exploration Program, a renaissance of ocean exploration has occurred during the past decade, both nationally and globally. Most famously, in March 2012 "Titanic" film director James Cameron's vertical torpedo visited the Mariana Trench's Challenger Deep, Earth's deepest valley. The first human to visit the Challenger Deep since 1960, Cameron descended in 2 hours and 36 minutes and ascended in a remarkable 70 minutes. The project involved many partners, including the National Geographic Society, Rolex Corporation, Alfred P. Sloan Foundation, and Cameron's own enterprises. It attracted billions of web hits, more than any prior event. Among other highly visible ventures in ocean exploration during the past decade were the cooperative international Census of Marine Life, the Russian flag-laying at the North Pole seafloor, and the renewed visits to the RMS *Titanic*.

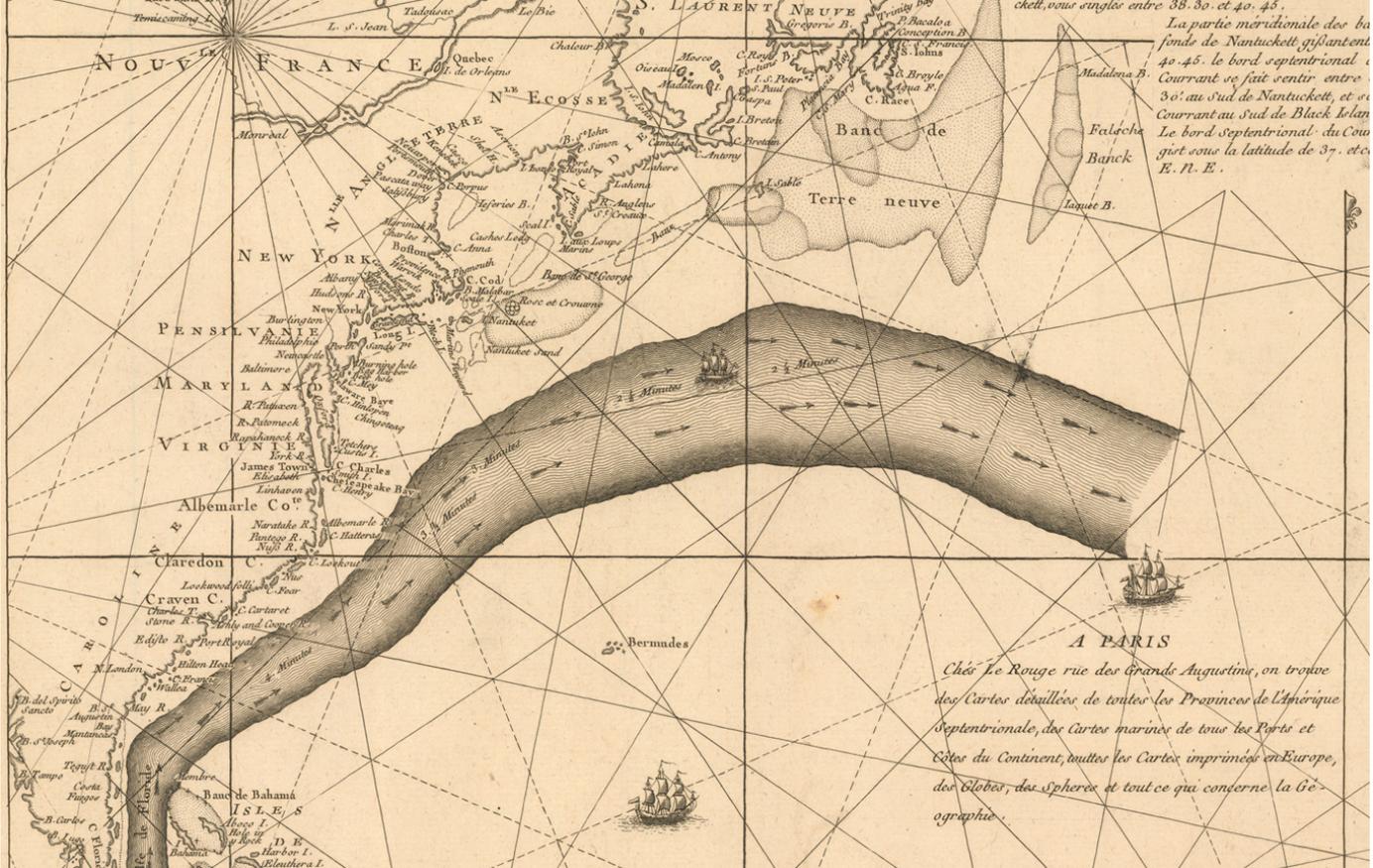
## 2000 Panel Recommendations

- Interdisciplinary voyages of discovery within high-priority areas, including the U.S. Exclusive Economic Zone (EEZ) and the continental margin, the Arctic, and poorly known areas of the southern oceans and inland seas. The U.S. inventory of the living and nonliving resources in the ocean should be second to none, particularly within our own EEZ and continental margins.

- Platform, communication, navigation and instrument development efforts, including the capitalization of major new assets for ocean exploration, in order to equip our explorers with the very best in marine research technology.

- Data management and dissemination, so that discoveries can have maximum impact for research, commercial, regulatory, and educational benefit.

- Educational outreach, in both formal and informal settings, to improve the science competency of America's schoolchildren and to realize the full potential of a citizenry aware and informed of ocean issues.

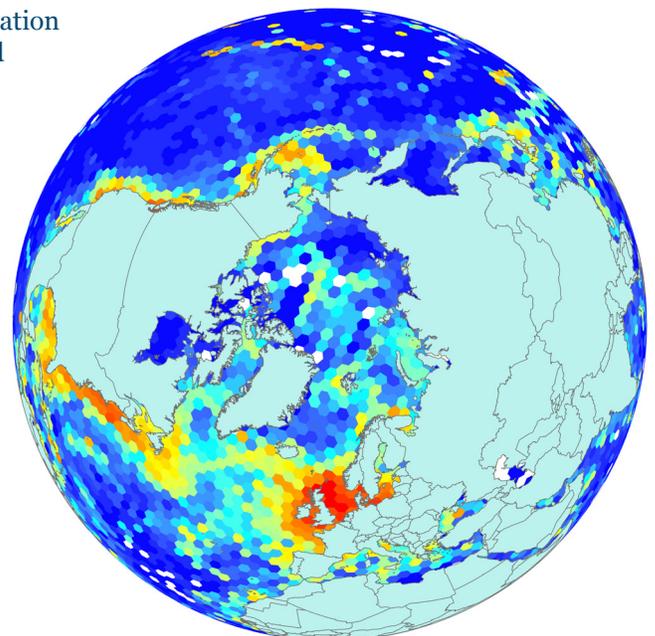


Benjamin Franklin and his cousin, Nantucket mariner Timothy Folger, produced the first chart of the Gulf Stream in 1768. This version was printed in Paris in 1785. Accessed from the Princeton University Library web site at <http://tinyurl.com/d2e4uka>

As the documentation prepared by the Ocean Exploration Program proves, Ocean Exploration Program has itself, and more often in partnership, generated impressive successes in science (for example, in discovery of new species and of unexpected locations of outgassing methane); mapping (for example, in parts of the Arctic Extended Continental Shelf); education (through innovative use of telepresence multiplying the number of young Americans experiencing exploration); and politics and diplomacy (for example, in unprecedented joint programs exploring Indonesian waters). The quantity of success in relation to cumulative expenditure through the Ocean Exploration Program's first decade (about \$185 million in direct expenditures) motivates continuation.

Moreover, the present Panel finds the work of the Ocean Exploration Program is unfinished. For example, vast areas of the Arctic and Eastern Pacific remain unexplored. Vast volumes of mid-waters of the deep ocean, Earth's largest habitat, also remain unexplored. And new technologies and sensors make revisiting areas that were explored with older approaches fresh and urgent. Immense areas of the U.S. ECS and EEZ have still not been mapped in a contemporary way, much less systematically sampled.

Since Benjamin Franklin took measurements of what he called the Gulf Stream on his transatlantic crossings in 1775 to 1776 and published the first map of it in 1785, ocean exploration has been part of American greatness and spirit. May ocean exploration continue as an inspirational and fruitful part of the American experience.



(Pictured at right) The marine biodiversity of the Arctic continues to offer tremendous opportunities for exploration. White indicates no records, blue indicates few records, and red indicates many records. Image courtesy of Edward Vanden Berghe, using the IOC's Ocean Biogeographic Information System (OBIS) data.

# 1. Set Strategic Goals & Priorities

## The Ocean Exploration Program must establish processes in order to define program boundaries and set measurable goals and priorities mindful of the particular nature of exploration that is, accepting of risk and unpredictability

As the Ocean Exploration Program enters its second decade, its most fundamental need is to revisit strategic goals and priorities, including those established by the 2000 Panel, and to have a regular and transparent process to update them. *De facto* priorities during the first decade included recruiting staff members, developing contracting and granting procedures, and securing the *Okeanos Explorer* as well as participating opportunistically in expeditions. The time is now right to set substantive goals for the program, actively. The fact that OER operates at a level of about \$20 million per year rather than the \$75 million the 2000 Panel recommended adds urgency to setting goals and priorities.

The present Panel did not itself seek to set priorities or, for example, recommend cruise tracks. We believe goal setting and prioritization should be the continuing responsibility of OER, assisted by the Advisory Board now in formation, in a transparent process involving the larger community, including stakeholders of various kinds. In fact, the first action NOAA needs to take is to set the process for definition of program boundaries and development of goals and priorities.

We are mindful that voyaging into the unknown should and will bring surprises, and that OER should accept a higher level of risk than more traditional research funders. However, broad priorities can be set about, for example, geography or habitat, and targets for number of expeditions, days at sea, and leveraging. Finally, the Ocean Exploration Program will be evaluated by inputs (such as ship days), processes (such as competitive procedures used to select expeditions), and outcomes (such as discoveries, mapped seafloor, data volume, publications, and increased public understanding). The Ocean Exploration Program should have goals and priorities with respect to inputs, processes, and outcomes.

A possible major goal is resource stability over a decade, starting at \$20 million per year. This amount would be without any financial obligations associated with the National Undersea Research Program (NURP), which has sometimes been managed in conjunction with the Ocean Exploration Program. An area for especially careful articulation is cooperative international expeditions, which may be politically directed, and for which there should be clear benefits, such as unique access to an EEZ and a (substantially) paying partner.

The Ocean Exploration program uses telepresence to allow scientists in multiple locations to study species, like this crab from Indonesia's deep ocean, in real time. *Courtesy of NOAA's Okeanos Explorer Program.*



ROV *Little Hercules* hovers above tube worms. *Courtesy of NOAA's Okeanos Explorer Program.*





Vice President Hubert Humphrey in 1967 at the swearing-in ceremony of the membership of the Commission on Marine Sciences, Engineering and Resources—the Stratton Commission—whose report led to the creation of NOAA. *Courtesy of NOAA’s Office of Ocean Exploration and Research.*

## 2. NOAA Leadership Support Required

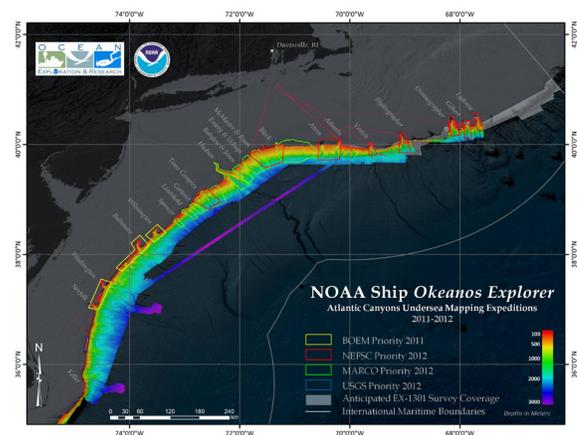
### Top NOAA Leadership must publicly and repeatedly articulate the importance of ocean exploration to the nation and to NOAA’s own mission

As persuasively presented in the 2000 Presidential Panel report, reasons abound for support for ocean exploration for the United States and for the U.S. government. The 2000 Presidential Panel recommended designation of a lead agency for the national program, and the White House and Congress appropriately chose Commerce/NOAA. Success in ocean exploration inspires values in citizens that set the context for much of NOAA’s other work. It also provides information that sets the context for action not only by NOAA, but also many other federal as well as state agencies.

The Panel stresses that as lead agency, NOAA and its own top leadership must consistently advocate for top achievement in ocean exploration.



NOAA Administrator Jane Lubchenco addresses the media about the 2010 Ocean Exploration expedition in Indonesia. *Courtesy of NOAA.*



Ocean Exploration searches the deep sea, discovering unknown biodiversity and geologic features. This map shows new areas the *Okeanos Explorer* surveyed through a collaboration with other NOAA, and U.S. agencies, along with the Mid-Atlantic Regional Council on the Oceans. *Courtesy of NOAA’s Okeanos Explorer Program.*

# 3. A National Forum on Ocean Exploration

The Ocean Exploration Program should implement Public Law 111-11's requirement to establish and enable an annual high-level National Forum on Ocean Exploration across sectors to encourage partnerships, investments, technology development, and expeditions

- Engage federal and state agencies, nonprofits, private foundations, for-profit companies
- Initiate the Forum domestically, then perhaps broaden it to international stakeholders
- Consider providing related service functions to support exploration such as help with permitting; information clearing house

The 2000 Presidential Panel recommended establishing an Ocean Exploration Forum to encourage partnerships and promote communication among commercial, academic, private, non governmental organizations and government stakeholders. The recommendation has yet to be implemented. At the same time, we observe that many of the most successful OER and other ocean exploration efforts of the past decade span a broad range of public and private stakeholders.

The present Panel urges OER to test the recommendation to establish an annual high-level National Ocean Exploration Forum and substantially fund it. While informal networking has achieved some important partnerships (described in the OER's internal evaluation), a more systematic effort might achieve yet more. The Forum could be a kind of marketplace where explorers could present ideas to individuals and organizations that could help in a variety of ways, including permits, technology, risk assessment, funds, and communications.

The Forum might also provide creative opportunities to integrate education and outreach into exploration from its outset. The K-20 educational community as well as experts in workforce development would bring valuable perspectives and networks.

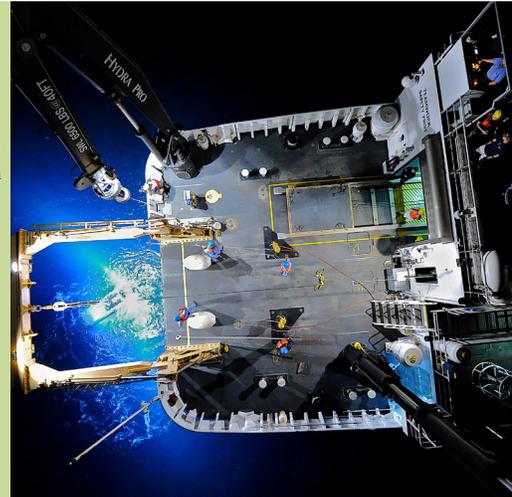
It would seem practical to experiment with the Forum first on the national level, to learn what kind of agenda is most useful and how the event might be organized. Subsequently, the Forum might expand to international scope.

To conceive the Forum, the Ocean Exploration Program might hold a small brainstorming session with representatives from organizations likely to be interested. This group might evolve into a planning committee for the actual first Forum. Operating the Forum would constructively place the Office of Ocean Exploration and Research at the nexus of much of the ocean exploration going on in America and the world.

A National Forum on ocean exploration would provide opportunities to introduce leading ocean explorers to the general public. Dr. Robert Ballard with the Hercules ROV. *Courtesy of Ocean Exploration Trust.*



A National Forum would provide a venue for forming partnerships to advance the national ocean exploration endeavor. The *Okeanos Explorer* during the 2011 Galapagos Rift Expedition. *Courtesy of NOAA's Okeanos Explorer Program.*



A National Forum would allow scientists to share information and results from ocean exploration expeditions sponsored by government agencies, universities, foundations, and the private sector. Scientist Rolf Gradinger in the Arctic. *Courtesy of NOAA's Office of Ocean Exploration and Research.*



## 4. Radical New Management Models

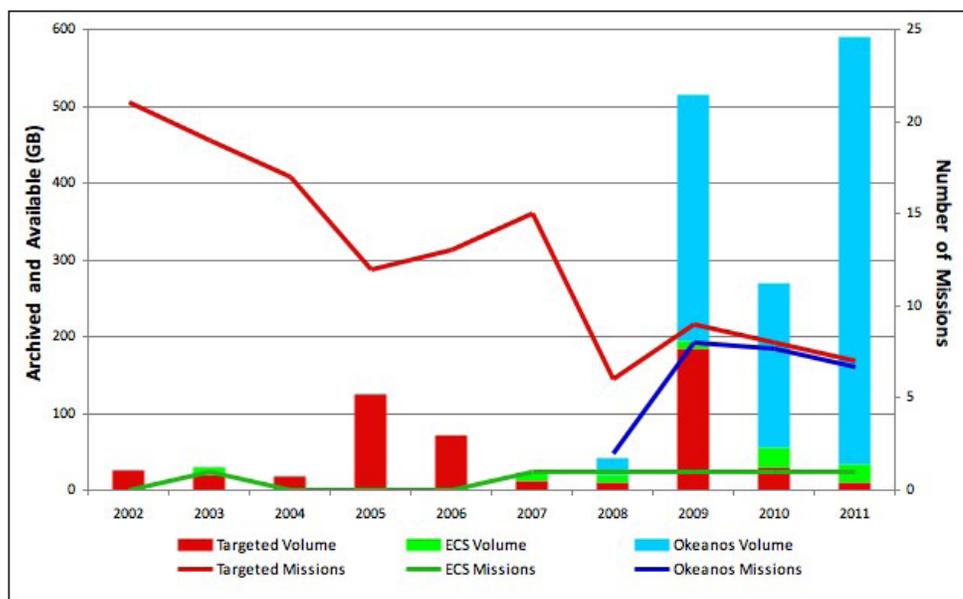
Consider providing related service functions to support exploration such as help with permitting; information clearing house

- Carefully evaluate administrative overhead and business processes in both Ocean Exploration and the relevant parts of NOAA
- Improve the transparency of expenditures and commitments
- Credibly value partnerships
- Consider competitive Cooperative Institute models
- Explore multi-year funding strategies
- Consider crowd-sourcing, prizes, medals
- Check new models for consistency with Congressional intent

As the chart below indicates, OER has experimented with several modes of operation, and allocated effort among them. These include spending on external or targeted competitions, its own dedicated vessel, and mapping of the Extended Continental Shelf. Especially in light of the prospect that the OER will continue with a budget of about \$20 million per year, far short of the \$75 million per year (plus capital expenditures) recommended by the 2000 Panel, efficiency and leverage matter. Thus, the present Panel makes a series of recommendations consistent with the analyses that the OER program staff prepared for the Panel that will clarify costs and revenues (including partnerships and their dollar value where appropriate).

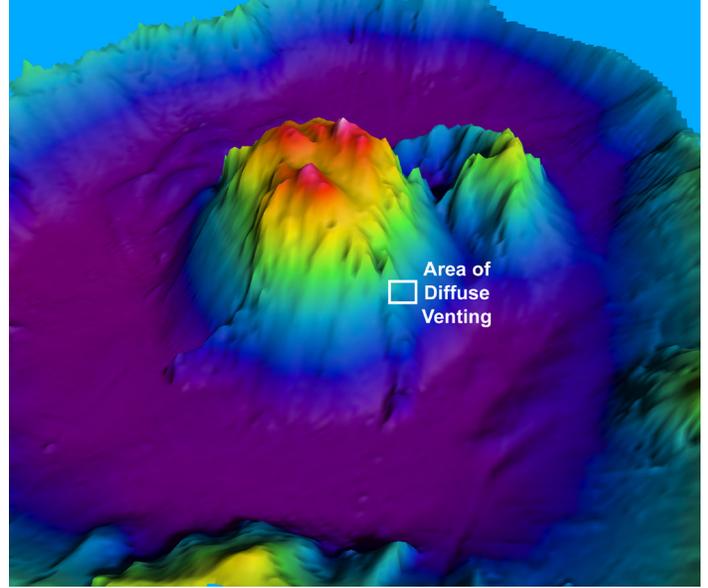
The Panel also recommends consideration of shifting a major part of OER funds to a NOAA Cooperative Institute model. In this model, NOAA would issue a competitive request for proposals (RFP) to operate a Cooperative National Institute on Ocean Exploration. Such a competition could produce valuable new matches and partnerships and possibly lower some costs. It could also involve, and the Panel recommends, a multi-year commitment, which would give greater stability to the Ocean Exploration Program, which has tended to fluctuate harmfully from year to year. The RFP might also be a way to introduce new styles of activity, including crowd sourcing and prizes.

In considering new management models, data management looms large. The Panel notes the good performance of the



Ocean Exploration Program in its first decade in data quality assurance and quality control, archiving, and dissemination, and the valuable role played by the OER partnership with NOAA's National Environmental Satellite, Data, and Information Service (NESDIS, especially the National Coastal Data Development Center).

The Legislative as well as Executive branch must maintain enthusiasm for ocean exploration, if the Ocean Exploration Program is to succeed. Consideration of new management models might offer a chance to engage with members of Congress and the professional staffs, to learn their views about how the program might be strengthened.



The UNOLS vessel *Thomas G. Thompson*, operated by the University of Washington, is one of many ships NOAA and partner scientists use to explore the earth's oceans. Here the *Tommy Thompson* holds station over Maug Caldera in the Northern Mariana Islands during the 2004 Ring of Fire Expedition. The multibeam image of the caldera is one expedition result. *Images courtesy of NOAA's Office of Ocean Exploration and Research.*

## 5. Targeted Expeditions

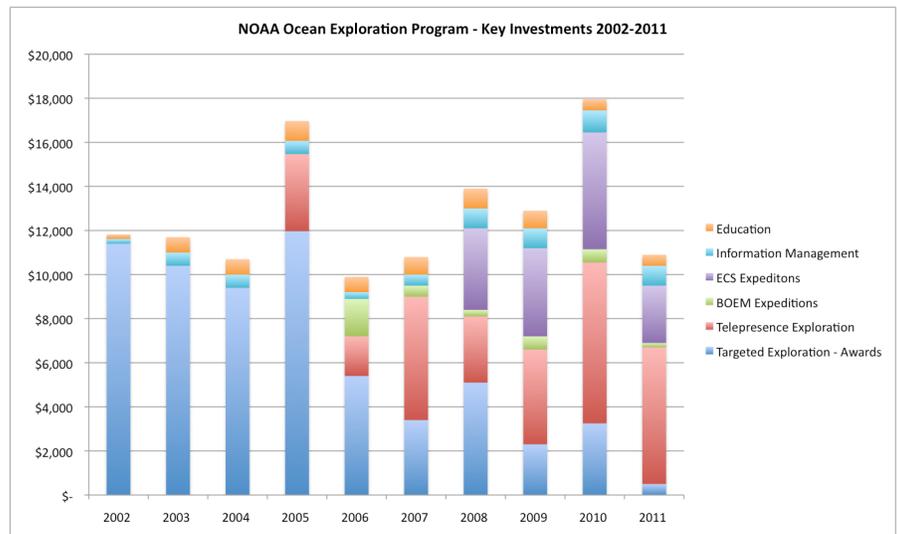
The Ocean Exploration Program should:

- Restore the extramural Targeted Expedition program to at least \$10 million every year
- Derive targets from the Strategic Plan. These may be geographic, thematic, and/or phenomenological (e.g. Arctic, vents, ocean acidification)

In 2005 the Ocean Exploration Program achieved a peak expenditure of more than \$15 million on targeted expeditions, including both external awards and telepresence exploration. Since 2005, targeted expedition expenditures have exceeded \$10 million only once, and less than half the amount has gone for external, competitive awards (blue parts of bars). The funding in 2002-2005 stimulated the American exploration community; many excellent proposals were submitted, and truly exceptional ones funded, such as the Arctic Hidden Ocean and the Deep Sargasso Sea expeditions.

The lack of opportunity in recent years has created frustration. The Panel recommends a return to at least the level of 2002-2005. Priorities should be derived from the strategy developed in Recommendation No. 1. The 2012 Panel notes the special attention the 2000 Panel gave the Arctic Ocean and the high payoffs from the work of the Ocean Exploration Program in the Arctic.

The Panel again stresses the need for a richer picture of the commitments of NOAA and the entire US government in ocean exploration. The 2000 Presidential Panel sought to catalyze an enhanced national effort, not only an effort of one office of one agency. While the present Panel emphatically recommends a larger OER targeted extramural expeditions program, it also appreciates that OER's success cannot be judged by its own budget and allocations alone.



## 6. *Okeanos Explorer*

### The Ocean Exploration Program should:

- Consider diverting all *Okeanos Explorer* funds for targeted exploration charters
- Confirm the *Okeanos Explorer*'s real continuing annual and daily costs

The 2000 Presidential Panel recommended that the Ocean Exploration Program operate a flagship vessel, the symbol of America's ocean exploration program and an indispensable platform for it. The Ocean Exploration Program refurbished the *Okeanos Explorer* for this purpose and is the only vessel owned by the U.S. government dedicated to ocean exploration. A 68-meter former Navy vessel, the *Okeanos Explorer* launched in 2010 has conducted successful expeditions to Indonesia, Galapagos Rift, and Mid-Cayman Rise. Equipped with cameras that allow real-time viewing for scientists and the public, the *Okeanos Explorer* has pioneered use of "telepresence technology." Davisville, RI is the homeport of the *Okeanos Explorer*.

The Ocean Exploration Program, in search of leverage and complementary capabilities, has also worked extensively with the Exploration Vessel (E/V) *Nautilus*, a 64-meter research vessel currently based in Bodrum, Turkey which is operated by the Ocean Exploration Trust under the direction of Dr. Robert Ballard. *Nautilus* also has a high-bandwidth satellite system to facilitate remote science and education, often via the Inner Space Center at the University of Rhode Island, which shares a live feed with Exploration Command Consoles located around the world.

The concept of a flagship vessel made sense in the framework of a larger Ocean Exploration Program, and it retains attractive aspects. However, in light of likely budgets, the Panel recommends careful consideration of alternate uses of the Ocean Exploration funds for exploration charters. The questions of lock-in to a homeport and ship are major. Weighing benefits and costs requires full accounting of the costs of the *Okeanos Explorer*, including expenditures within NOAA outside the direct OER program, and the extent to which funds now used for the *Okeanos Explorer* could be redirected.

In the course of its work, the Panel received estimates that the full annual operating costs of the *Okeanos Explorer* for FY12 ranged from \$6.1 million to more than \$8 million. Accurate, consistent, complete information for prior years was also unavailable to the Panel. Part of the difficulty is that OER budgets for core program operations aboard the *Okeanos Explorer*, while other funds come in ship-time equivalent funded by NOAA's Office of Marine and Aviation Operations and what OER pays for additional days at sea. NOAA, OER, and OMAO must have full, consistent, timely information on *Okeanos Explorer* costs in order to make both strategic and operational decisions.



The *Okeanos Explorer*, photographed in the Gulf of Mexico in 2012. Courtesy of NOAA's *Okeanos Explorer* Program.



The Ocean Exploration Program partner Ocean Exploration Trust operates *Nautilus*, which has explored extensively in the Mediterranean and Black Seas. Courtesy of Ocean Explorer Trust.

# 7. Technology

## Ocean Exploration must partner to stay abreast of new technologies:

- **Development of sensors, exploration instruments and vehicles, and information technology (hardware and software) costs too much for Ocean Exploration alone to lead**
- **Ocean Exploration pioneered telepresence, but the context is changing fast and staying abreast is critical**

The 2000 Presidential Panel report recommended and anticipated a major role for the Ocean Exploration Program in technology development. In ocean exploration, “technology” could include sensors, exploration instruments (CTDs, grabs, water column samplers, etc.,) and all the on-deck hardware to support these instruments (some of which may include UUVs and ROVs), and IT (hardware, software, antennae, communications suites and all the “stuff” that makes telepresence work).

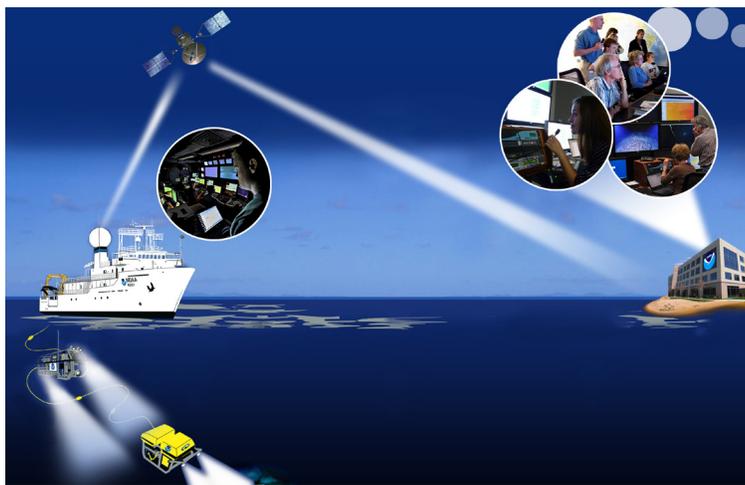
In practice, technology development and deployment have proven too costly to manage with the reality of the OER budget. OER expeditions have, however, been early adopters and creative users of relevant technologies. For example, the 2006 Sargasso Sea expedition on the NOAA ship *Ron Brown* used the MOCNESS (Multiple Opening/Closing Net and Environmental Sensing System) to sample marine life as deep as 5000 meters at 5 stations in the Western North Atlantic, depths from which soft animals had rarely been retrieved intact. The system consists of multiple nets of various meshes opened and closed by computer control at desired depth. The Panel recommends imaginative applications of technology continue as a criterion for setting priorities for exploration.

The important exception in technology development has been telepresence, in which Ocean Exploration showed foresight and has been a leader. Telepresence matters greatly because it can multiply by very large factors the people who experience or contribute to ocean exploration. Sensors and other equipment delivering real time data that can challenge students in both formal and informal settings and assist problem solving and conduct of citizen science. In 2012 telepresence is widely accepted. Students in fact are very comfortable with the idea of watching action at a distance and controlling it on a tablet computer or with a video game controller.

With the rapid development of telepresence (and associated technologies such as gliders and drones where human operators are remote), the challenge is to stay abreast of development. In particular, the notion of a “Command Console” or NASA-like command center is moving toward a more distributed and miniaturized model. The Panel recommends Ocean Exploration brainstorm about the next 5-10 years of telepresence with experts from within and outside ocean sciences, and maintain this multiplier of participation as a key dimension of the program.



The *Okeanos Explorer* in the Gulf of Mexico. The ship transmits and retrieves vital communication such as video, audio and computer information through use of the Very Small Aperture Terminal (VSAT). *Courtesy of NOAA's Okeanos Explorer Program.*



Systematic Telepresence - enabled Exploration (STE) allows scientists on shore—as well as the public—to participate in ocean exploration expeditions in real time. *Courtesy of NOAA's Office of Ocean Exploration and Research.*

## 8. Extended Continental Shelf

**The Program has achieved outstanding results, and political demand is high. But OER should accelerate its work to finish its share in three years.**

Located in the Atlantic, Pacific, Arctic, Gulf of Mexico, and Caribbean Sea, the U.S. Exclusive Economic Zone (EEZ) is the largest in the world, covering 11,351,000 square kilometers. The shelf area covers 2.2 million square kilometers, the 4th largest, after Russia, Canada, and Australia, and larger than Alaska and Texas combined.

The portion of the continental shelf beyond the 200 nautical mile limit is known as the Extended Continental Shelf (ECS). Countries wishing to delimit their outer continental shelf beyond 200 nautical miles must submit information on their claim to the Commission on the Limits of the Continental Shelf. Countries were supposed to lodge submissions within ten years of the UN Conference on the Law of the Seas (of which the U.S. is not a signatory) coming into force in the country or by May 13, 2009.

In six areas the U.S. likely has an ECS: Atlantic Margin, Arctic Ocean, Bering Sea, off the west side of Guam/Northern Mariana Islands, and in two areas in the Gulf of Mexico. In nine areas the U.S. may have an ECS: Gulf of Alaska, western end of the Aleutian Islands, Northern Mariana Islands, Hawaii's Necker Island, Johnston Atoll, Kingman Reef and Palmyra Atoll, and three areas off the U.S. west coast.

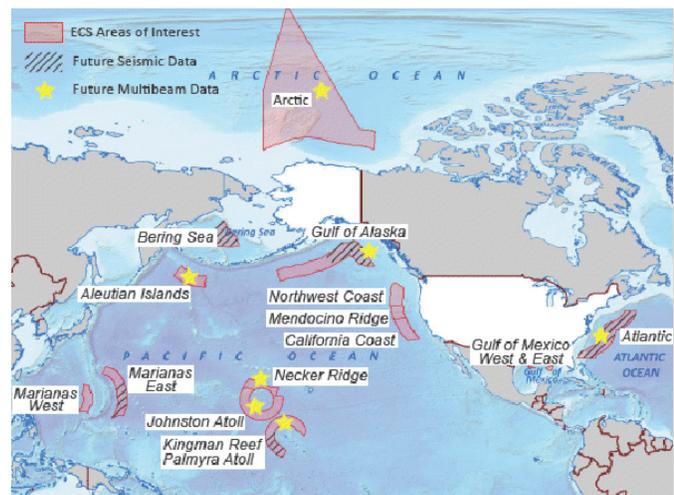
Preliminary studies indicate that the U.S. ECS totals at least one million square kilometers, about twice the size of California, or one half the size of the Louisiana Purchase. The process to determine the outer limits of the U.S. ECS requires collection and analysis of data describing the depth, shape, and geophysical characteristics of the seabed and sub-sea floor. Since 2003, U.S. agencies have been engaged in gathering and analyzing data to determine the outer limits of the U.S. ECS.

The Panel recognizes that NOAA (and OER) are not leading the U.S. ECS effort, where the Navy (NAVOCEANO), University-National Oceanographic Laboratory System, and U.S. Coast Guard play much larger roles. However, OER can finish its appropriate pieces soon, say, in three years, and the relevance of the program ought to be articulated in the Strategic Plan. A key benefit is that while carrying out ECS geophysical surveys, Ocean Exploration explores many other phenomena while “mowing the grass” for operational survey purposes. In 2009 the *Okeanos Explorer* undertook test missions on the Mendocino Ridge and Necker Ridge surveying more than 30,000 square kilometers, the size of Maryland.

The Panel judges the work of the ECS program, including its OER component, excellent and urges acceleration, so that the survey of potential U.S. ECS regions appropriate for OER is completed by the end of 2015.



The USCG Healy icebreaker during an Extended Continental Shelf mission. *Courtesy of NOAA's Office of Ocean Exploration and Research.*



This graphic shows areas of potential new Extended Continental Shelf holdings for the United States. *Courtesy of <http://continentalshelf.gov/>*

## 9. Branding



OER could highlight the benefits of ocean exploration by cultivating a network of iconic ocean champions like Hollywood director James Cameron. *Image source National Geographic at <http://tinyurl.com/cvzyjob8>*



OER works with technology proponents such as OpenROV co-founder Eric Stackpole to promote deep sea exploration. *Courtesy OpenROV.*

### The Ocean Exploration Program should:

- **Develop icons**
- **Cultivate champions**

While most people know the U.S. government has a space program, few know that the U.S. government has an ocean exploration program. The Panel found the website of the Ocean Exploration Program excellent and current in terms of content, and noted several major successes with national and global media about Ocean Exploration-supported discovery, for example, about marine life in the Arctic and Indonesia. The Ocean Exploration website is a major provider of educational material, giving NOAA an entry into secondary school and collegiate classroom instruction, aquariums, and state marine resource agencies. The value of this connection for ocean exploration, for NOAA, and for the U.S. government needs more careful evaluation.

The Panel recommends the Ocean Exploration Program, as part of its strategic planning, clarify its priorities about meriting wider and deeper public understanding of America's achievements in ocean exploration, of the U.S. government program, of NOAA's particular contributions, or simply of the substance of the discoveries themselves.

Whatever the priorities, the Panel notes the importance of icons and champions in successful engagement programs.

A possible goal for the Ocean Exploration Program is to be associated constructively and authentically with almost every major achievement in ocean exploration carried out in large part by Americans or American organizations or in the U.S. EEZ.

## 10. Ocean Exploration Advisory Board

**The Ocean Exploration Program should establish an Ocean Exploration Advisory Board and:**

- **Coordinate with the NOAA Science Advisory Board to multiply influence and achieve efficiencies**
- **Avoid conflicts of interest**

**The new Advisory Board should assist the Program in the development of a five-year Strategic Plan and monitor implementation progress.**

Through 2011, the Ocean Exploration Advisory Working Group of the SAB provided guidance to the Ocean Exploration Program. 2010 legislation calls for the establishment of an Ocean Exploration Advisory Board reporting directly to the Administrator. The Panel recommends prompt appointment of the new Board. Because of the need to harmonize the Ocean Exploration Program with other NOAA efforts, for example, in research and data management, the Panel recommends the new Board operate in close conjunction with the SAB, perhaps occasionally meeting back-to-back or with some overlap in schedules, so the groups can exchange views directly. Some joint memberships might also be useful.

A principal role of the new Board can be to advise the OER program office in carrying out Ocean Exploration's federal responsibility to set strategic goals and priorities, the Panel's first recommendation. We close by repeating the first and most fundamental recommendation of the Panel: To set strategic goals and priorities for Ocean Exploration's second decade.

The Panel thanks NOAA for the opportunity to serve America's interests in ocean exploration and acknowledges excellent, fully open support from the Ocean Exploration staff members, especially Tim Arcano, John McDonough, and David McKinnie. In the bottom left photo taken on May 8, 2012, the Panel members are from left to right: James Delgado, Susan Avery, Paul Gaffney, Jean May-Brett, Terry Garcia, Steven Ramberg, Marcia McNutt, Rodey Batiza, Jesse Ausubel, Eric Lindstrom, Cameron Hume, Jeffrey Karson, James Kendall, and Jerry Schubel (liaison with NOAA SAB).



The Ocean Exploration Review Panel. *Courtesy of NOAA*



The Ocean Exploration Review Panel at work. *Courtesy of NOAA*

