



C A P I T O L
H I L L
O C E A N S
W E E K
2 0 0 2

Proceedings

Executive Summary

Preface

Capitol Hill Oceans Week 2002, a bi-partisan series of educational meetings and events highlighting our ocean and coasts, was held on Capitol Hill June 4-6, 2002. Leading up to World Oceans Day on June 8, 2002, the week brought together a wide-range of stakeholders to discuss issues relevant to Earth's oceans, including the coral reef environment. An action agenda designed to increase ocean awareness among both children and adults was also highlighted. Capitol Hill Oceans Week 2002 provided a substantive focus on key ocean issues, including emerging ocean technology, education and ocean literacy, and the challenges facing the coral reef environment.

The events began with a Capitol Hill reception Tuesday, June 4th, followed by two days of panel discussions. The first day, entitled *Connecting the WOW! (Wonders of the Ocean World): Creating an Ocean Literate Society*, consisted of panel discussions and keynote speeches about how to create an ocean literate society. The panels urged the expansion of ocean science on a coordinated national level to achieve this goal. Developing awareness and appreciation of the marine environment, and ways to improve educational programs and venues, were explored and outlined. The panels consisted of teachers, researchers, scientists, and members of the National Marine Sanctuary Program. Their recommendations included a need for strong partnerships among educators and researchers, increased funding in educational programs, and effective ways to use the media in public outreach.

The final day of Capitol Hill Oceans Week was dedicated to coral reef issues. Coral Reef Day, held on June 6, 2002, focused primarily on the causes, consequences, and potential solutions of the coral reef crisis. It specifically addressed some of the key threats to global coral reefs, including fishing, reef species trade, pollution, coastal impacts, climate change, and disease. The symposium brought members of Congress, Capitol Hill staff, Executive branch employees, industry and academic leaders, experts from non-profits, leading scientists, and concerned citizens together to investigate the issues affecting coral reefs through substantive discussion of the causes and consequences of coral reef degradation, identification of key actions needed to reverse or mitigate the coral reef crisis, and discussion of current successful actions and solutions. The panel recommended a number of actions needed to conserve and sustainably manage coral reef ecosystems.

Capitol Hill Oceans Week was coordinated by the National Marine Sanctuary Foundation in partnership with the U.S. Senate Commerce, Science and Transportation Subcommittee on Oceans, Atmosphere and Fisheries and the U.S. House Oceans Caucus, and co-sponsored by the American Petroleum Institute, the Consortium for Oceanographic Research and Education, the Cruise Industry Charitable Foundation, the National Fish and Wildlife Foundation, the National Geographic Society, the National Ocean Industries Association, Oceana /American Oceans Campaign, Ocean Futures Society, the Sea Grant Association, the Walt Disney Company, and various federal agencies including the U.S. Department of Commerce, the U.S. Department of the Interior, the U.S. Department of State, and the U.S. Agency for International Development.

The executive summaries are intended to give a brief overview of the panels' presentations and recommendations. To view these and complete speakers' remarks, visit the National Marine Sanctuary Foundation's website at www.nmsfocean.org, or at the House Ocean Caucus at www.house.gov/greenwood/OCEAN/.

Field Code Changed

Table of Contents

Preface	2
Connecting the WOW! (Wonders of the Ocean World): Creating an Ocean Literate Society	
Introduction	4
Panel Overviews	5
Findings and Recommendations	6
Panel I: Connecting the WOW!: Formal Education	6
Panel II: Connecting the WOW!: Informal Education	7
Panel III: Connecting the WOW!: Non-Traditional Education	9
Panel IV: The Future of WOW!: Increasing Ocean Literacy	11
Panel V: Setting an Action Agenda	13
Coral Reefs at Risk: Challenges and Solutions	
Abstract	14
Introduction	15
Panel Overviews	17
Findings and Recommendations	18
Panel I: Coral Reefs at Risk	18
Panel II: Sustainable Reef Fisheries	21
Panel III: Sustainable Coastal Development	23
Panel IV: Responding to Climate Change	24
Conclusions	27

Connecting the WOW! (Wonders of the Ocean World): Creating an Ocean Literate Society

Wednesday, June 5, 2002
Hart Senate Office Building, Room 216
United States Senate
Washington, D.C.

"Knowledge of the oceans is more than a matter of curiosity. Our very survival may hinge upon it."

President John F. Kennedy
March 1961 message to Congress

Introduction:

Over the past century, major innovations in technology have allowed us to explore the ocean depths and exploit the sea's abundant riches as never before. However, as we enter the 21st century, we face a critical challenge – how to continue to explore and use the ocean's resources while maintaining the sea's integrity and the lifeline it provides us.

The significant impacts of activities, such as over-fishing, wetland destruction, and pollution, are all too apparent. Yet the public remains largely complacent, unaware of how the oceans contribute to our physical and economic survival, how the sea relates to our own lives, and the true extent of the problems that exist. Even those who do not value the natural beauty of a coral reef or a school of dolphins can, when informed, appreciate the economic impact of over-fishing or the damaging results of pollution.

Education about the ocean and related environmental issues is vital. Ocean education efforts initiated during the last 30 years generally fall into three categories: formal, informal and non-traditional. Experts representing each of these educational groups participated in 'Connecting the WOW!' during Capital Hill Oceans Week 2002.

The challenge in ocean education and outreach is to engage and inform people from all walks of life, living in all regions of the United States, to create an ocean literate society. It is only through an informed and caring public that there will be support for and even the demand for, the protection of our precious marine resources. *Connecting the WOW! (Wonders of the Ocean World): Creating an Ocean Literate Society* was held as just one step towards the creation of an educated, aware and ocean literate society.

Panel Overviews:

Panel I: Connecting the WOW!: Formal Education

This panel stressed the need for stronger partnerships among educators and researchers to advance ocean science at all levels of formal education, and called for a nationally coordinated ocean science education program to achieve excellence and to promote the dissemination of new knowledge. It highlighted the notable successes of programs, such as the *Consortium for Oceanographic Activities for Students and Teachers* (COAST), the *SEA Semester*, and the *JASON Project*, and provided an inside view from alumnae. The panel also cited the need for a nationally coordinated effort to improve ocean literacy.

Panel II: Connecting the WOW!: Informal Education

This panel discussed highly effective informal ocean education efforts, such as *Ambassadors of the Environment* and the *National Sea Grant Program*, as a means of providing firsthand experience with oceans, fresh-water and coastal habitats, and cutting edge science research. It outlined the benefits of popular informal education venues, such as aquariums and zoos, and how these entities might improve their education efforts. The panel also talked about successful government-sponsored community education and outreach efforts, highlighting the work of the Florida Keys National Marine Sanctuary.

Panel III: Connecting the WOW!: Non-Traditional Education

This panel stressed the use of media, primarily radio, television and the Internet, in non-traditional ocean education and outreach efforts, and highlighted some particularly successful partnerships. It demonstrated that non-traditional education programs play a crucial role in both educating and engaging people of all ages about ocean, fresh-water and coastal habitats. The panel also highlighted successful non-traditional education programs, including *Rivers to Reef* and *KidScience*, which enhance classroom education.

Panel IV: The Future of WOW!: Increasing Ocean Literacy

This panel recommended specific steps that would help establish ocean literacy, not as an abstract goal, but as a national imperative. It requested more funding, better programs to educate our next generation of professionals, and greater collaboration to educate the public and our political leaders about ocean and coastal issues. Major emphasis was placed on expanding ocean science curriculum at all levels of formal education to insure that ocean science research would not suffer in the future. The panel also challenged all ocean education and outreach programs to make their messages meaningful to every person, regardless of age or background.

Panel V: Setting an Action Agenda

This was an open forum inviting members of the audience to share their thoughts about an action agenda for the future.

- C. Formal education programs can inspire people of all ages to become committed to the preservation of oceans
- D. Formal education programs inspire some students to choose ocean sciences or a related field as a career
- E. Field experiences greatly enhance classroom education
- F. There are no simple answers, but with proactive partnerships and sustained funding we can improve ocean education and thus the world's oceans

III. Recommendations

- A. Create a nationally coordinated ocean science education program
- B. Educate teachers so they can better teach science, using real data and updated ocean research information
- C. Incorporate ocean sciences as case studies in the National Science Education Standards when the standards are revised in 2005
- D. Follow-up is required for key recommendations of the President's Ocean Exploration Panel in 2000, including:
 - 1. Map the oceans at new scales and in areas that have not been previously observed
 - 2. Explore ocean dynamics and interactions at new scales
 - 3. Develop new sensors and systems so as to regain U.S. leadership in marine technology
 - 4. Reach out in new ways to stakeholders to improve the scientific literacy among people of all ages with respect to ocean issues
- E. Show people of all ages their intrinsic connections to our world of water
- F. Create a common infrastructure and focus to facilitate more efficient collaboration among government agencies
- G. Continue efforts, such as COAST, which proactively engage minority teachers in the ocean sciences
- H. Develop more programs that allow students to share in the excitement of ocean science discoveries via live broadcasts
- I. Provide funds to sustain critical teacher training and successful programs

Panel II: Connecting the WOW!: Informal Education

Panelists:	Dr. Richard Murphy Dr. Valerie Chase Dr. Elizabeth Day Billy Causey	Ocean Futures Society National Aquarium in Baltimore National Sea Grant Program Florida Keys National Marine Sanctuary
------------	--	---

I. Findings

- A. Informal education programs provide a firsthand experience with oceans, fresh-water and coastal habitats, and the latest science discoveries, as exemplified by:
 - 1. *Ocean Futures Society's Ambassadors of the Environment* – camp experience teaches the principles of sustainability, using aspects of the ocean environment
 - 2. *National Sea Grant Program* – 30 university-based programs in the coastal and Great Lakes states work in partnership with NOAA, to provide educational opportunities for kids and adults on aquatic and coastal issues
- B. Informal education programs encourage students to become environmental stewards.
- C. Informal ocean education centers, such as aquariums, are invaluable because they attract a large volume and variety of people
- D. Informal education programs must answer directly to funding sources, so they are often evaluated for their effectiveness
- E. The informal science education community is highly engaged in formal science education – a 1996 survey found that one-half of all in-service science education for teachers was provided by informal science educators
- F. Informal education efforts are effective at highlighting local environmental issues

II. Discussion

- A. It's never too early to teach a child about the ocean and coastal habitats and it's best to begin as early as possible
- B. It's important not only to educate children about the oceans but also to inspire them so they become informal teachers themselves
- C. Informal ocean education opportunities often involve firsthand experiences with marine life that cannot be duplicated in a classroom
- D. Informal education experiences can also teach children lessons about leadership and team building
- E. Informal education is often misunderstood to mean a program that is unstructured or disorganized – a more accurate term might be “free choice learning” because the student is free to choose what they learn from an exhibit, an IMAX experience, a video, a book or an internet program, without intercession from a teacher
- F. Informal education programs often partner successfully with formal education programs
- G. Zoos and aquariums do an excellent job of interpreting the biological side of ocean sciences, as well as providing important ocean conservation information, while museums and science centers are more inclusive in

their definition of ocean sciences, giving earth and physical science more exhibit space

- H. Volunteers and the media are important partners in informal education efforts
- I. Informal ocean science education inspires some students to seek a career in ocean sciences

III. Recommendations

- A. Zoos and aquariums should do a better job of incorporating physical and earth systems in their ocean science education programs
- B. More funding is required for comprehensive ocean science exhibits at large venues, such as aquariums and zoos
- C. Informal education efforts should continue to reach the general public, as well as schools, because they are invaluable as outreach efforts
- D. Informal education programs should collaborate as often as possible with formal education to enhance the classroom experience
- E. Media, such as TV, Radio & the Internet, should be used to the fullest extent to communicate with the general public, as well as with students

Panel III: Connecting the WOW!: Non-Traditional Education

Panelists:	Cathy Sakas	Gray's Reef National Marine Sanctuary
	Sharon Hussey	Girls Scouts of the USA
	Patty Miller	Hawaii Department of Education
	Dr. Ellen Prager	Rosenstiel School of Marine and Atmospheric Sciences, University of Miami

I. Findings

- A. Interactive television, broadcast media and the Internet are especially beneficial when first-hand field experience on a large scale is impractical, as exemplified by:
 - 1. The educational module *Rivers to Reef* – includes a video about the Altamaha River Watershed and its connection to Gray's Reef and Georgia's coastal waters. *Rivers to Reef* will ultimately be offered to public and commercial television
 - 2. *KidScience* – a program that uses the natural beauty of Hawaii as a backdrop for live interactive ocean science broadcasts via television to grades 4-8 in Hawaii, across the U.S., into Micronesia and American Samoa
- B. Non-traditional education programs play a crucial role in both educating and engaging people of all ages about oceans and coastal habitats, as exemplified by:

1. Gray's Reef National Marine Sanctuary
 - a. *Coastal Naturalist*, a documentary series produced for Georgia Public Television
 - b. *The Natural South*, a 22-part cable series about environmental issues across the southeast, produced for Turner South
 2. *Our Ocean World* – daily public radio features, produced by Finger Lakes Productions, with input from scientists at the Rosenstiel School of Marine and Atmospheric Sciences
- C. Non-traditional education efforts sometimes allow kids to become role models for their peers
- II. Discussion
- A. Radio is underutilized and underestimated in its ability to reach a wide variety of people
 - B. It's important that non-traditional education and outreach efforts involve and reach every age and education level
 - C. Non-traditional ocean education can enhance the experience of other non-traditional education efforts, such as Girl Scouts
 - D. Now, more than ever, ocean outreach and education efforts need the support of our nation's political, financial and media leaders
 - E. National Marine Sanctuaries face a major challenge in educating people who may never experience ocean or coastal habitats firsthand
- III. Recommendations
- A. The media, including radio, television and the Internet, must be exploited to the fullest extent
 1. Incorporate multi-media aspects into non-traditional education efforts
 2. Create partnerships for radio, TV and documentary projects that can be used for various forms of education programs
 - B. Non-traditional ocean education programs should build more partnerships with groups such as Girls Scouts and Boy Scouts
 - C. News coverage should be fully explored wherever possible as a form of non-traditional education and outreach
 - D. Non-traditional ocean education and outreach efforts should use incentives, such as competitions and awards, for both the media and students
 - E. More funding is needed to create and support successful non-traditional education and outreach efforts

Panel IV: The Future of WOW!: Increasing Ocean Literacy

Panelists:	Francesca Cava	National Geographic Society
	Dr. Carolyn Thoroughgood	Consortium for Oceanographic Research and Education
	Conrad Lautenbacher	National Oceanic and Atmospheric Administration
	Roger T. Rufe, Jr.	The Ocean Conservancy
	Captain Ted Thompson	International Council of Cruise Lines
	Dr. Sylvia Earle	National Geographic Society
	Jean-Michel Cousteau	Ocean Futures Society

I. Findings

- A. While 92% of Americans consider the oceans essential for human survival, only 14% actually recognize that people are the greatest source of ocean pollution
- B. Few people know the oil they drain from their cars and the fertilizer they use on their lawns cause ocean pollution, and few understand that the choices they make at the market and in restaurants contribute to over-fishing and ultimately to habitat destruction
- C. The cruise ship industry reported that it has made great strides in reducing its effect on oceans and has made conservation education a priority – in some cases, cruise lines also perform a vital service to ocean science research and education, as exemplified by:
 - 1. Carnival Cruise Lines has allied with Turner Broadcasting's Captain Planet Foundation, which promotes environmental awareness with edutainment cartoons broadcast on in-cabin television
 - 2. Holland America presents a video on the special environmental concerns of Alaska
 - 3. Royal Caribbean has installed Eco-learning Centers that provide tours and environmental education for passengers
 - 4. Explorer of the Seas Cruise Ship – shares valuable atmospheric and undersea data with scientists
- D. Experiences at sea and firsthand exposure to field research provide knowledge well beyond the subject of oceans. They teach team building and leadership and build character
- E. It's possible, even with little funding, to bring the ocean experience into the classroom – for example, classroom education benefits greatly from storytellers, as well as interactive television projects.
- F. Current university structure and the realities of grant funding place much more importance on research results, giving faculty little time or encouragement to educate or reach out to the public

II. Discussion

- A. It will take sustained efforts for a generation to fully implement the education ideas presented during Capitol Hill Oceans Week 2002 – it's time to get started
- B. Ocean literacy must be seen not as an abstract goal, but as a national imperative
- C. We must connect people to the oceans so they realize the true value of our undersea treasures – the power of the people, so to speak
- D. It is critical to ocean literacy that we have facilities to train the ocean scientists of tomorrow
- E. We must fully exploit every chance to bring oceans to the forefront of the national agenda
- F. Volunteer efforts, such as the International Coastal Cleanup, give us hope that we can accomplish great things with the support of public opinion
- G. We are at the same point with oceans that conservationist were with land early in the 20th century – we should emulate leaders such as President Teddy Roosevelt who initiated the efforts that resulted in the creation of our national park system
- H. The advances of the industrial age are contributing to our detachment from oceans and nature in general – education efforts should take that into account
- I. The weather phenomenon *El Nino*, which causes billions of dollars in damage, is a costly reminder that the oceans drive weather and climate for people everywhere in the Western Hemisphere and the vision for building an ocean literate society needs to extend beyond the coasts
- J. People are largely ignorant of how much the ocean impacts their health and economic well being until disaster strikes

III. Recommendations

- A. Use the media to promote the endeavors of ocean explorers who interest and inspire the public, such as Jean-Michel Cousteau, Dr. Sylvia Earle and Dr. Robert Ballard
- B. Emulate the public awareness campaigns of NASA
- C. Use popular entertainment vehicles, such as films, to promote ocean literacy
- D. Empower teachers so they can incorporate the oceans in a variety of academic disciplines
- E. Begin educating children about the oceans at the kindergarten level
- F. Create ocean textbooks for K through 12
- G. Expand ocean curriculum in higher education so we ensure that we have the professionals to continue expanding ocean science research in the 21st century

- H. Reward higher education faculty and other researchers for including education and outreach efforts within their research – from funding to field experiences
- I. Increase and strengthen partnerships among government agencies, nonprofits and private industry
- J. Increase our outreach efforts and directly link the oceans to our economic and physical health
- K. Empower the media to report responsibly and extensively about our oceans
- L. Promote national and international volunteer efforts, such as the International Coastal Cleanup
- M. Present the entire picture – how each marine ecosystem and organism depends upon the other and how mankind affects and is affected by oceans
- N. Create more partnerships with cruise lines to promote ocean literacy
- O. Make our national marine sanctuaries a top priority because they set an example for the future

Panel V: Setting an Action Agenda

There were no panelists – this was an open forum and the following are summaries of the key recommendations:

- A. Expand the goal to create an ocean literate society internationally. Also, national ocean literacy must include a proper perspective of the U.S. role in both the problems and the solutions regarding oceans
- B. When it's not possible to make oceans the agenda, carefully weave oceans into the agendas that are receiving notice
- C. Address population growth in efforts to address ocean issues
- D. Form a group that can create a core ocean curricula for all levels of formal education
- E. Encourage school districts to incorporate marine sciences into their curriculum requirements
- F. Include teachers in the dialog because they know better than anyone what is needed in classrooms, K-12
- G. Encourage textbook authors to use oceans and coastal habitats in their lessons

Coral Reefs at Risk: Challenges and Solutions

Thursday, June 6, 2002
Rayburn House Office Building, Rooms B338/B339
United States House of Representatives
Washington, D.C.

“We must no longer think of the sea as ‘mysterious’ ... There are no longer ‘mysteries’; there are only problems to which we must find the answers.”

Jacques-Yves Cousteau

Abstract:

Coral reefs are one of the world's most biologically diverse ecosystems. Covering less than 1% of the world's surface, living reefs provide food, recreation, coastal protection and other products and services for millions of people, many of who derive their entire livelihoods from these valuable ecosystems. It is estimated that over 58% of the world's reefs are seriously threatened by human activities such as over-fishing and destructive fishing practices, coastal development, land-based pollution and global climate change. Already, 10% of the world's coral reefs have been severely damaged or destroyed.

The meeting held on June 6, 2002, in the House of Representatives of the U.S. Congress convened panels of science, management and policy experts to identify key actions needed to reduce threats to reefs, and provide recommendations for how U.S. legislators can help solve problems facing coral reefs. The meeting focused on how to address three main threats to coral reef ecosystems: 1) adverse impacts of fishing and other extractive uses; 2) adverse impacts coastal development; and 3) impacts of global climate changes. Scientists from universities, federal agencies, and non-governmental agencies (NGOs), natural resource managers, and user groups including fishermen and private industries presented information, solutions, and recommendations for identifying and reducing the impacts of these threats on coral reefs. Many promoted sustainable use and management to ensure healthy coastal environments.

Introduction:

Coral Reefs have existed for hundreds of millions of years. Today, their exploitation provides an income to millions of people worldwide. Without major action to reduce and eliminate human impacts, experts estimate that 60% of the world's coral reefs could be lost by 2030 (Status of Coral Reefs of the World 2000). Corals are extremely diverse and long-lived, with some reefs reflecting thousands of years of history. They are the marine equivalent of old-growth forests.

Most reef building corals are limited to tropical and subtropical waters. However, corals are known to exist even in sub-polar waters. A key to the survival of a coral reef is the success of a highly specific symbiotic relationship between the coral and its associated algae. This relationship requires very consistent environmental parameters in order for the reef to thrive and grow. Corals typically require a narrow temperature range, high salinity water, constant and high light regimes, and low turbidity and sedimentation. Reef diversity is generally dictated by latitude. The number of species in a reef decreases in higher latitudes up to about 30° north and south, beyond which reef corals are rare.

Coral reefs are threatened with numerous hazards, including natural events, disease, predation, and anthropogenic practices such as pollution, over-fishing, and climate change. Estimates suggest that 10% of all coral reefs are degraded beyond recovery and that 30% are in critical condition and may die within 10 to 20 years. Experts predict that if current pressures are allowed to continue unabated, 60% of the world's coral reefs may die completely by 2050 (Coral Reef Task Force, 2000).

Weather and other events such as cyclones and hurricanes often damage reefs by churning up sediment, creating heavy waves that break coral branches, and blocking out sunlight, but natural events themselves rarely cause irreparable harm. In many cases, the effects of natural disturbances are heightened by other stressors, such as pollution, sedimentation and over-fishing, which prohibit coral ecosystems from recovering on their own.

Disease outbreaks are another stressor to coral reef ecosystems and are caused by both biological factors, such as bacteria, fungi, viruses, and non-biological factors that include radiation and temperature change. Disease contributes to large-scale coral mortality and the death of many other coral reef organisms, such as fish and sea urchins.

The effects of predation also weaken coral reef ecosystems. While predation is a natural process and part of the life cycle of an ecosystem, there is some evidence to suggest that predation of corals is increasing. Some over-fishing practices have reduced the numbers of large predatory fish, which normally keep the numbers of smaller fish and other species in check. Smaller reef species then proliferate beyond normal and feed excessively on corals. Often, algae grows over the damaged coral area, preventing re-colonization and recovery.

Human activities also threaten the viability of coral reefs and associated ecosystems. Coastal development practices, sedimentation, dredging, shoreline modification, agricultural practices, deforestation, sewage treatment, boating, over-fishing, and marine debris are all human-controlled processes that compound the stress to coral reefs. When pollutants and chemicals are discharged into the water around a coral reef, the level of nutrients in the water is severely altered, increasing the likelihood of algal blooms and eventually stripping nutrients and oxygen from the water column. This excess algal growth not only competes with coral growth, but also may decrease the amount of light available for the corals themselves. In addition, fuel, petroleum, anti-fouling paints, and other chemicals can also leach or spill into the water, thus lowering water quality and altering the chemical composition of the water.

In addition to pollution, many coral reefs are over-fished and overexploited for both recreational and commercial purposes, such as seafood harvesting and coral trade. Corals are often harmed, destroyed, trampled, and broken by fishing gear, careless divers, boats, and marine debris. Fishing techniques can be destructive to fish and coral habitats. Blast fishing, for example, uses dynamite and other explosives to stun fish for easy capture. The blasting breaks coral apart and stresses the surrounding ecosystem so that coral colonies often expel their required symbiotic algae (zooxanthellae) – a phenomenon known as “coral bleaching”. Another practice, cyanide fishing, involves spraying or dumping cyanide onto reefs to stun and capture live fish. This often results in the death of corals and other reef organisms. Other damaging fishing techniques, such as deep-water trawling, are used in many countries. Many times fishing gear is abandoned and becomes tangled around the coral reefs and ensnares marine animals.

Climate change and the increased concentrations of carbon dioxide and other greenhouse gases pose a serious threat to the chemical composition of the global oceans. It is a threat that will require increasing attention and likely years to understand and mitigate. As mentioned previously, corals prefer a narrow temperature range, and overheating conditions often cause the stressed corals to bleach. Without their associated algae, bleached corals cannot photosynthesize and are left exposed. If temperatures return to normal, zooxanthellae may return to the corals. This has been documented in many reef areas that previously experienced coral bleaching. However, prolonged exposure and bleaching may result in death of the corals. Other natural climatic phenomena, such as *El Niño*, compound the threat to the corals and can have long-term devastating effects on coral reefs. *El Niño* often leads to increased sea-surface temperatures, altered salinity due to increased rainfall, and minor decreases in sea level.

Threats to coral reefs are numerous and each one of them diminishes the ability of coral reef ecosystems to cope with additional stress factors. If there is any hope of survival for the coral reef in an era confronted with changing climate and human impacts, such as uncontrolled coastal development and pollution, it is imperative the threats be reduced or eliminated.

Panel Overviews:

Panel 1: Coral Reefs at Risk

Coral reefs are some of the most diverse and productive communities on Earth. They are found in the warm, clear, shallow waters of tropical oceans worldwide. Reefs provide food and shelter to many fish and invertebrates, protect the shore from erosion, provide food and livelihood to millions of people worldwide, and serve as attractions and education tools to thousands. The reef-building corals, and their symbiotic unicellular algae (zooxanthellae), are the source of primary production in reef communities. However, degradation of these precious resources is apparent worldwide, and is largely due to climate change and human impacts, including over-fishing, exploitation, and increased greenhouse gas emissions. Integrated monitoring and management, increased public awareness, sustainable tourism, and reduction of greenhouse gas emissions are important steps towards increasing coral reef health.

Panel 2: Finding Solutions, Sustainable Reef Fisheries

Economics are a powerful driver of action worldwide, and commercial use of coral reef ecosystems is no exception. There is great demand for coral reef resources as food (fishing), coral souvenirs, and tropical and exotic aquarium species. Regardless of whether the demand is to fill local needs or international trade, it can provide a driver for destructive fishing practices and over-fishing. The use of poisons, the removal of live rock, and the destruction of essential habitats can have serious impacts on the coral reef ecosystem. They can also reduce the productivity and value of reefs to local communities who depend on them, threaten food security and the livelihoods of those local communities, and threaten the natural treasure and worldwide interests of those who visit the reefs. To address these issues, possible solutions include retraining fishers in the use of environmentally friendly practices, providing incentives for sustainable use and collection practices, strengthening the management and enforcement of coral reef areas, increasing the number and effectiveness of Marine Protected Areas, and creating incentives for alternative and sustainable practices such as environmentally safe tourism.

Panel 3: Finding Solutions, Sustainable Coastal Development

In many areas, the decline of coral reefs is linked to a variety of human impacts including sedimentation, over-fishing, destructive fishing practices, anchor damage, hurricanes, diseases, and over-development. Unwise and unsustainable coastal development can cause significant impacts on coral reefs, and is increasing in many areas. Sustainable and sound development practices are essential to avoid impacts on reef environments. Potential strategies include: national education and advertising campaigns; increased partnerships among managers, stakeholders, researchers and policy makers; focusing on managing natural capital; utilizing impact reduction technologies; integration of traditional knowledge in development of management plans; integrated watershed management practices; the establishment and enforcement of additional Marine Protected Areas, and increased coherent legislation and appropriate management of human activities affecting coral reefs.

Panel 4: Finding Solutions, Responding to Climate Change

Climatic effects are quickly becoming a driving force of the coral reef decline. As local and regional anthropogenic stresses continue, they add to and may accentuate natural and human-caused climate effects. Regardless of what action is taken now or in the immediate future, current science suggests that if global trends continue, climatic stress on coral reefs will continue to increase over the coming decades. Panelists suggested that action to reduce impacts from other, non-climate impacts was critical to help increase the ability of coral reef organisms to survive climate-associated impacts. The panel also highlighted the need to strategically focus on areas with the best chance of surviving climate changes, and perhaps prioritizing action to protect the least damaged reefs in order to preserve both the genetic stock and living reef. Increased establishment of Marine Protected Areas was recommended as a key management tool to address these needs. In addition, the panel highlighted the need for increased scientific research efforts and funding as vital to progress in this area. Recommendations were made to include integrated process science, remote sensing, local institution support, an in-depth study of coral diseases, sustained long-term monitoring and mapping, and the reduction of greenhouse gas emissions in order to mitigate existing threats.

Findings and Recommendations:

Panel I: Coral Reefs at Risk

What are coral reef ecosystems, how are they changing, and why are they at risk?
What are the causes and consequences of coral reef loss? Why should we care?

Panelists: Dr. John Pandolfi Smithsonian Institution
 Lauretta Burke World Resources Institute
 Dr. John Ogden Florida Institute of Oceanography

- I. Findings
 - A. Corals are in serious danger due to a developing synergy between natural and manmade perturbations
 - B. There is need for improved planning and management of fisheries, coastal and upland resources
 - C. Improved management is in the long-term economic self-interest of coastal communities

- II. Discussion
 - A. Coral reefs and their associated systems of mangroves and sea grasses are the most diverse, complex, and productive communities in the sea
 - B. Occupying 0.2% of the area of the ocean's floor, coral reefs contain 25% of the ocean's species diversity

- C. Reefs are built over long periods of time by corals and other reef organisms
- D. Reefs have functions ranging from providing food and shelter for fish and invertebrates to protecting the shores from erosion
- E. People depend on coral reefs because they provide fisheries for food, material for new medicines, and income from tourism and recreation, as well as protect coastal communities from storms
- F. Recent reports estimate that over 50% of the world's coral reefs are threatened by human activities (Reefs at Risk: A Map-Based Indicator of Threats to the World's Coral Reefs [<http://www.wri.org/reefsatrisk/>]; Status of Coral Reefs of the World: 2000 [<http://www.coral.noaa.gov/grcmn/>])
- G. Overexploitation and coastal development are the most pervasive threats to coral reefs:
 - 1. Sediment and pollution from inland sources also threatens an estimated 22% of reefs
 - 2. Although a significant factor locally, marine-based pollution is the least pervasive threat examined, threatening fewer than 10% of the world's reefs
- H. Why save coral reefs?
 - 1. Many people depend on the reefs for their livelihood and well-being
 - 2. Ecology and maintenance of a diverse ecosystem is important
- I. Overarching Problem: Human Disturbance
 - 1. Between 50 to 80% of the global human population lives within 50 miles of the coastline
 - 2. Categories of disturbance include:
 - a. Poor land-use practices, including sewage disposal, toxic pollution, and land destabilization
 - b. Fishing, including both the removal of fishes from the ocean and the direct damage of fishing gears on ocean ecosystems
 - c. Global climate change including ocean warming, sea level rise, and coral bleaching
 - i. Corals bleach when stress, including high temperatures, stimulates the coral animal to expel its intra-cellular single-celled plant symbionts, which are characteristic of all reef-building corals and critical to coral health
 - ii. Bleaching does not immediately kill corals and they are capable of recovery if the stress is removed, but if it is prolonged corals may die

J. Information and Monitoring

1. It is estimated that fewer than 10% of the world's coral reefs have ever been monitored
2. Significantly fewer coral reefs are the subject of repeat monitoring, which allows evaluation of changes on coral reef condition
3. A good, widely applied indicator of coral reef conditions is lacking
 - a. The limited data that has been produced through monitoring programs typically do not find their way to a centralized data repository. This hampers evaluation and comparison of trends in coral reef health across large areas
 - b. Integrated monitoring programs are needed which couple changes in population and socioeconomic activities with changes in environmental conditions (such as sediment and nutrient levels), and ultimately, with changes in coral reef habitat condition, productivity and value

K. The Role of Science

1. Science plays a critical role in our understanding of the extent and impact of human disturbances to the oceans and in our efforts to manage human behavior
2. Scientific uncertainty should not hinder common sense application of the tools currently available to manage and conserve coral reefs

III. Recommendations

- A. Improve management of coastal and fisheries resources
- B. Improve management of existing Marine Protected Areas (MPAs), expand protected areas networks (especially marine reserves, which are fully protected from extractive human activities)
- C. Halt the use of destructive fishing
- D. Reduce over-fishing
- E. Regulate the trade in live reef organisms
- F. Implement integrated monitoring and improve information available to support better management
- G. Raise public awareness
- H. Develop sustainable tourism
- I. Adopt policies to reduce greenhouse gas emissions and climate change
- J. Implement a decade-long effort to create an ocean-use plan for the U.S. Exclusive Economic Zone (EEZ)

Panel II: Sustainable Reef Fisheries

Solutions and recommendations for reducing the impacts of fishing on coral reefs and promoting sustainable reef fisheries

Panelists: Dr. Jim Bohnsack NOAA Marine Fisheries Service
Anthony Iarocci Fisherman, Member of the South Atlantic
Fishery Management Council
Gerry Davis Division of Aquatic and Wildlife Resources,
Guam
Dr. Barbara Best U.S. Agency for International Development

I. Findings

A. Excessive fishing on coral reefs can deplete reef populations, disrupt ecosystem structure and function, and damage local and regional economies

II. Discussion

A. Coral reefs are extremely complex fisheries and are important for:

1. Food, employment, revenue, sport, and entertainment
2. Aesthetics (which has growing economic importance)

B. Extractive fisheries and non-extractive fisheries depend on healthy coral reef ecosystems

C. Over-fishing occurs when people remove organisms faster than they can regenerate. Impacts to the fisheries include:

1. Bycatch (non-target fish killed incidentally)
2. Fishing can destroy or damage habitat
3. International trade in coral reef animals and products is a major contributor to overexploitation of reef resources
4. Aquarium trade, wild pet trade, and coral jewelry
5. Individual consumers, and importing and exporting countries should jointly create incentives for sustainable collection and management

D. Marine Protected Areas

1. Four types:
 - a. Permanent closure with no take allowed
 - b. Permanent closure with some take allowed
 - c. Limited duration closure with no take allowed
 - d. Limited duration closure with take allowed

- E. No Take Marine Reserves
 - 1. Benefits include:
 - a. Abundance increases overtime
 - b. Increases diversity
 - c. Spillover effect
 - d. Increased reproduction

III. Recommendations

- A. Involve and educate people regarding the importance of healthy reefs for fish and fisheries: individuals, governments, organizations, and non-governmental organizations
- B. Marine Protected Areas are powerful tools to protect coral reefs and sustained reef fisheries. They also have been used to manage natural and cultural resources, provide educational and research opportunities, and enhance commercial and recreational activities. To be truly effective, MPAs should include:
 - 1. No take reserves that focus on biological sustainability
 - 2. Evaluate and address cultural and socio-economic components
 - 3. Involve community in planning efforts
 - 4. Sound baseline data and monitoring needed
 - 5. Areas must be well defined, well enforced, and the goals and objectives must be clearly understood
 - 6. Places to protect should not be chosen arbitrarily
- C. International trade in coral reef animals need additional attention, specifically:
 - 1. Promote mutually supportive trade and environment policies through international mechanisms, such as the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the World Trade Organization (WTO)
 - 2. Work with exporting and importing countries to establish trade regulations and stewardship incentives
 - 3. Consider recommendations of the U.S. Coral Reef Task Force on trade in coral reef species

Panel III: Sustainable Coastal Development

Examples, solutions and recommendations to help reduce the impacts of coastal development, pollution and other land-based human activities on coral reefs, and promote sustainable coastal development

Panelists: Dr. Robert Richmond University of Guam
 Janice Hodge Department of Natural Resources, USVI
 Dr. Richard Kenchington International Coral Reef Action Network
 Dr. James Ray Shell Global Solutions (U.S.) Inc. and the
 Flower Garden Banks National
 Marine Sanctuary

I. Findings

- A. Coastal watersheds contribute to coral reef health by absorbing rainfall, cushioning run-off, and trapping nutrients among other roles
- B. Land-based human activities within coastal watersheds are having serious impacts on coral reefs in many areas
- C. The flow of sediment, nutrients and other pollutants from land-based sources can have significant impacts on the condition of coral reefs

II. Discussion

- A. A variety of land-based activities may affect coral reefs. Types of land use include: farming and grazing; water extraction, drainage, and flood mitigation; industrial sites; transportation infrastructure; and, urban and residential development
 - 1. Consequences of these lands uses include:
 - a. Changes drainage and water flow patterns
 - b. Pollution of water with sediment
 - c. Agricultural chemicals, manure, industrial and urban wastes and by-products, sewage, storm run-off
 - d. Changing demand for access to and recreational use of coastal areas
 - e. Reduced salinity causes decline in coral reproduction and development
- B. Existing legislation guiding coastal zone management and coral reefs include:
 - 1. Rivers and Harbors Act, Fish and Wildlife Coordination Act
 - 2. National Environmental Policy Act
 - 3. Coastal Zone Management Act
 - 4. Endangered Species Act, Clean Water Act
 - 5. Council of Environmental Quality 40 CFR 1500-1508
 - 6. Executive Order 13089

- C. Several case Studies were presented, including:
 1. Fish Bay Watershed, St. John, U.S. Virgin Islands – Experiences significant non-point pollution from sediment; is receiving funding from NOAA to develop a Watershed Management Plan and to implement a road stabilization project
 2. Flower Garden Banks National Marine Sanctuary – Designated as NMS in 1992; is currently healthy (50.5% live coral cover vs. 3%-22% in Florida Keys); hands-on educational programs for public schoolteachers; cooperative partnerships formed

III. Recommendations

- A. Implement technologies that reduce impacts of land use activities
- B. Employ integrated watershed management practices
- C. Establish and enforce an extensive network of coral reef Marine Protected Areas (MPAs)
- D. Educated and develop community awareness that pollution impacts downstream users and resources (the solution to pollution is NOT dilution)
- E. Emphasize the economic benefits of healthy coral reefs (ex: Guam receives \$84 million/yr from coral-related activities)
- F. Recognize importance of subsistence fishing, cultural uses of coastal zone
- G. Engage governments, NGO's, communities in providing solutions
- H. Remove regulation of permitting activities that affect coral reefs away from the U.S. Army Corps of Engineers and transfer to the EPA/USFW/NOAA or a new Department of Oceans
- I. Long-term funding commitment
- J. Standardize reporting procedures
- K. Develop a technical expertise resource pool for small Island communities
- L. Work with U.S. Coral Reef Initiative, International Coral Reef Initiative, the International Coral Reef Action Network, U.S. Commission on Ocean Policy

Panel IV: Responding to Climate Change

An understanding of why and how climate change affects coral reefs locally, the global impacts and consequences, and possible responses and solutions

Panelists:	Dr. Robert Buddemeier	University of Kansas
	Dr. Robert Halley	U.S. Geological Survey
	Dr. Lara Hansen	World Wildlife Fund
	Dr. John McManus	National Center for Caribbean Coral Reef Research

I. Findings

- A. The world is experiencing large scale changes in climate that impact ocean conditions, such as increasing seas surface temperatures, rising sea levels, and altered nutrient regions in coastal areas
- B. Climate changes are associated with increases in atmospheric CO₂ and growing human populations
- C. Increasing seas surface temperatures and other climate-related changes have resulted in increased bleaching and mortality of corals in many areas over the past 10 years
- D. It may take decades to centuries after emissions of greenhouse gases are reduced before the effects on seas sea surface temperature stabilizes
- E. There are a number of actions needed to respond to climate impacts to coral reef ecosystems, such as increasing the ability to understand and forecast climate impacts and implementing management actions to compensate for climate impacts

II. Discussion

- A. The human-caused increase in atmospheric CO₂ and the increasing temperature and variability is moving the environment outside its natural historic fluxes in global climate
 - 1. Flushing by waves and currents is important in breaking down thermal stratification that leads to bleaching and promotes calcification
- B. Coral cover – Florida Keys National Marine Sanctuary coral cover has declined from 10% in 1996 to 6% in 2000
- C. Bleaching events in some reef areas are occurring more frequently. Massive coral bleaching events in 1998 were associated with large scale changes in climate and sea surface temperatures
- D. Historical records (paleontology) can be used to determine past conditions of coral reefs and climate change, and improve future forecasts
- E. Human impacts from pollution, over-fishing, over-use and other activities that stress corals may decrease their ability to tolerate climate-related stresses. Climate change and other stresses may act synergistically to reduce the tolerance of coral reef species to other threats (such as diseases)
- F. Managers and policy makers can and should be considering (and planning for) impacts of climate change on today's coral reef management decisions
- G. Well planned networks of coral reef protected areas could be designed to help compensate for long-term impacts of climate change on coral reef ecosystems

III. Recommendations

- A. Additional scientific efforts are needed to respond to climate impacts on coral reef ecosystems, including:
 - 1. Increase and improve integrated scientific efforts among physical oceanographers, biochemists, ecologists, geochemists, biologists and others
 - 2. Establish a center for the study and control of coral reef diseases
 - 3. Build an integrated observing system for coral reefs by supporting current monitoring stations and creating new long-term monitoring sites
 - 4. Increase the use of remote sensing tools and mapping to document changes in coral reefs over time
 - 5. Develop coral reef forecasting system to track and predict reef conditions and climate change
 - 6. Support the rapid development and dissemination of scientifically-based, management-oriented literature
- B. Pass new legislation to help developing nations protect coral reefs (Coral Reef & Coastal Marine Conservation Act) and support existing legislation promoting conservation and management of coral reef ecosystems
- C. Support legislation that limits greenhouse gases (Clean Power Act, Renewable Energy and Energy Efficiency Investment Act, McCain-Leiberman Economy Wide Cap and Trade)
- D. Adopt and implement the U.S. National Action Plan to Conserve Coral Reefs, the U.S. National Coral Reef Action Strategy and other recommendations from the U.S. Coral Reef Task Force
- E. Adopt and implement recommendations of the U.S. Commission on Ocean Policy and the Pew Oceans Commission
- F. Improve integration of agencies and organizations working on coral reefs (especially Department of Commerce and Department of Interior)
- G. The National Science Foundation should develop a coral reef program to which academics could make proposals in support the science needed for dealing with coral reef problems
- H. Solutions to reduce local impacts of human activities on coral reefs need to be applied locally and regionally because of the interconnectedness of marine systems
- I. Use information on possible climate changes and other impacts to design and establish networks of coral reef Marine Protected Areas, including small and large reserves (no take areas)

- J. Increase funding to support ongoing coral reef conservation efforts and implement the above recommendations, including:
1. Increase funding to the International Coral Reef Action Network (ICRAN)
 2. Increase funding for remote sensing
 3. Institutions – Award 5 year budgets to research institutions, based on submitted strategic plans

Conclusions:

On June 6, 2002, panelists participating in the forum Coral Reefs at Risk: Challenges and Solutions presented extensive recommendations to the U.S. House of Representatives and other decision-makers for addressing current and future risks to coral reefs. Not only did legislators learn about the challenges facing coral reef ecosystems, but they were also advised of potential solutions for coral reef repair and protection. As coral reefs continue to decline in many areas due to serious adverse impacts from coastal development, extractive uses such as fishing, and global climate change, it is essential that finding and implementing solutions for sustainable coral reef management be high on the national agenda.