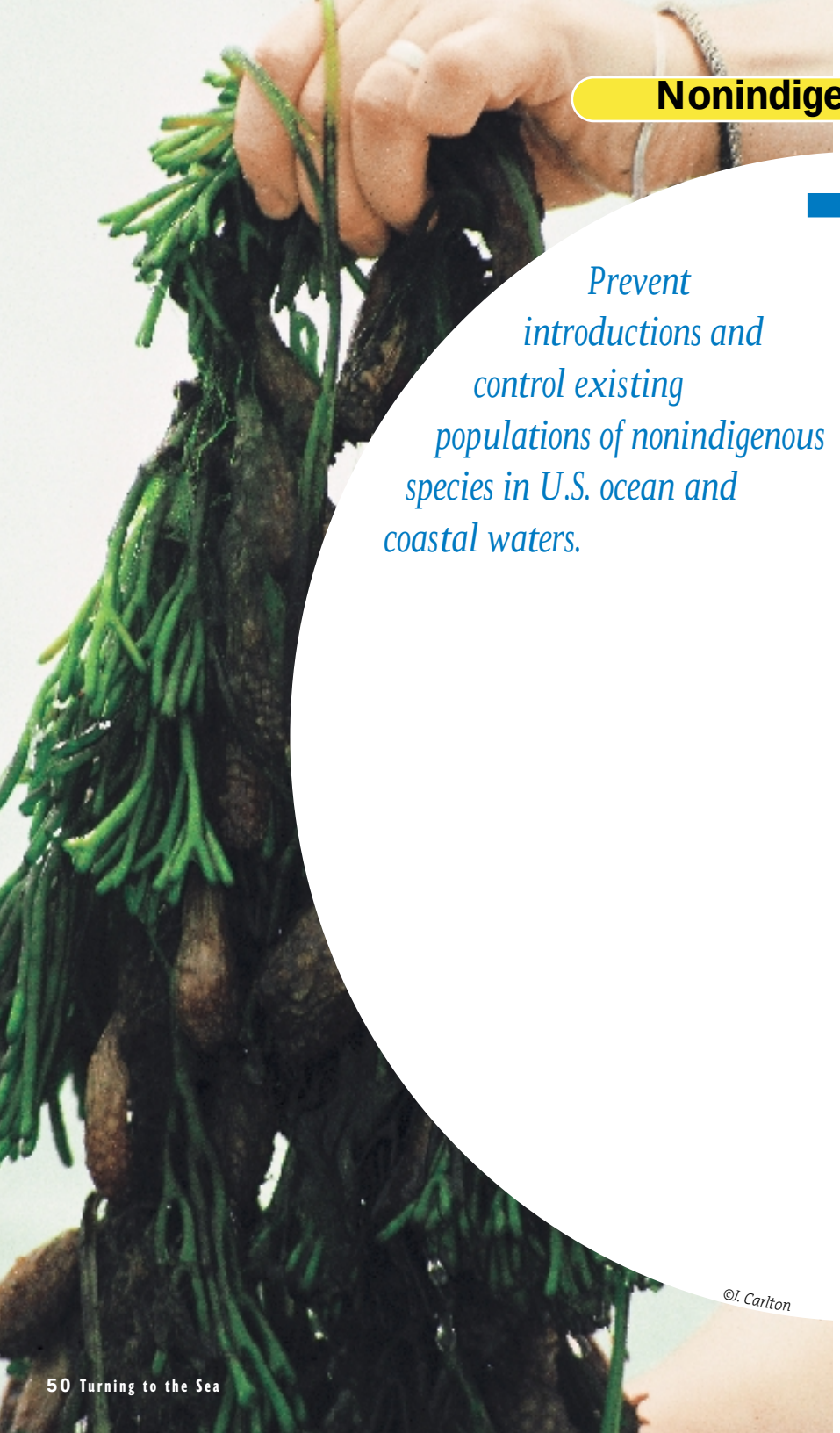


©J. Carlton

Nonindigenous Species

Prevent introductions and control existing populations of nonindigenous species in U.S. ocean and coastal waters.

The spread of nonindigenous species, such as zebra mussels, Asian clams, shipworms, and aquatic weeds, is one of the most serious threats to the nation's ocean and coastal ecosystems and the communities and economies that depend on them. One of the primary sources of aquatic nonindigenous species is discharge of ballast water in ships arriving from foreign ports. Every minute 40,000 gallons of foreign ballast water that may contain exotic species, including disease-causing pathogens, are discharged into U.S. harbors. Other sources include aquaculture, introductions of stocks for sportfishing, ship hulls, and floating debris.

Hundreds of nonindigenous species have now become established in the nation's coastal waters; over 240 nonindigenous species are found in San Francisco Bay alone. Once established, these species are almost impossible to eradicate. Nonindigenous species have displaced and eliminated native species, impacting fisheries and costing communities billions of dollars every year in control measures. For example, in 1996, foreign viruses reduced U.S. aquaculture production of shrimp by 50% , and failure to control the nonindigenous ruffe fish in the Great Lakes may cost over $500 million in losses to sport and commercial fisheries by 2005. Some nonindigenous species, such as cholera bacteria and some algae, have also had negative impacts on human health.

In February 1999, President Clinton established the U.S. Invasive Species Council through Executive Order 13112. The Council, chaired by the Secretaries of Interior, Agriculture, and Commerce, is responsible for fulfilling the Executive Order's mandates, including the development and implementation of a national action plan to address invasive nonindigenous species. While the action plan is a significant start, immediate and substantial progress is still required.

Ongoing Concerns

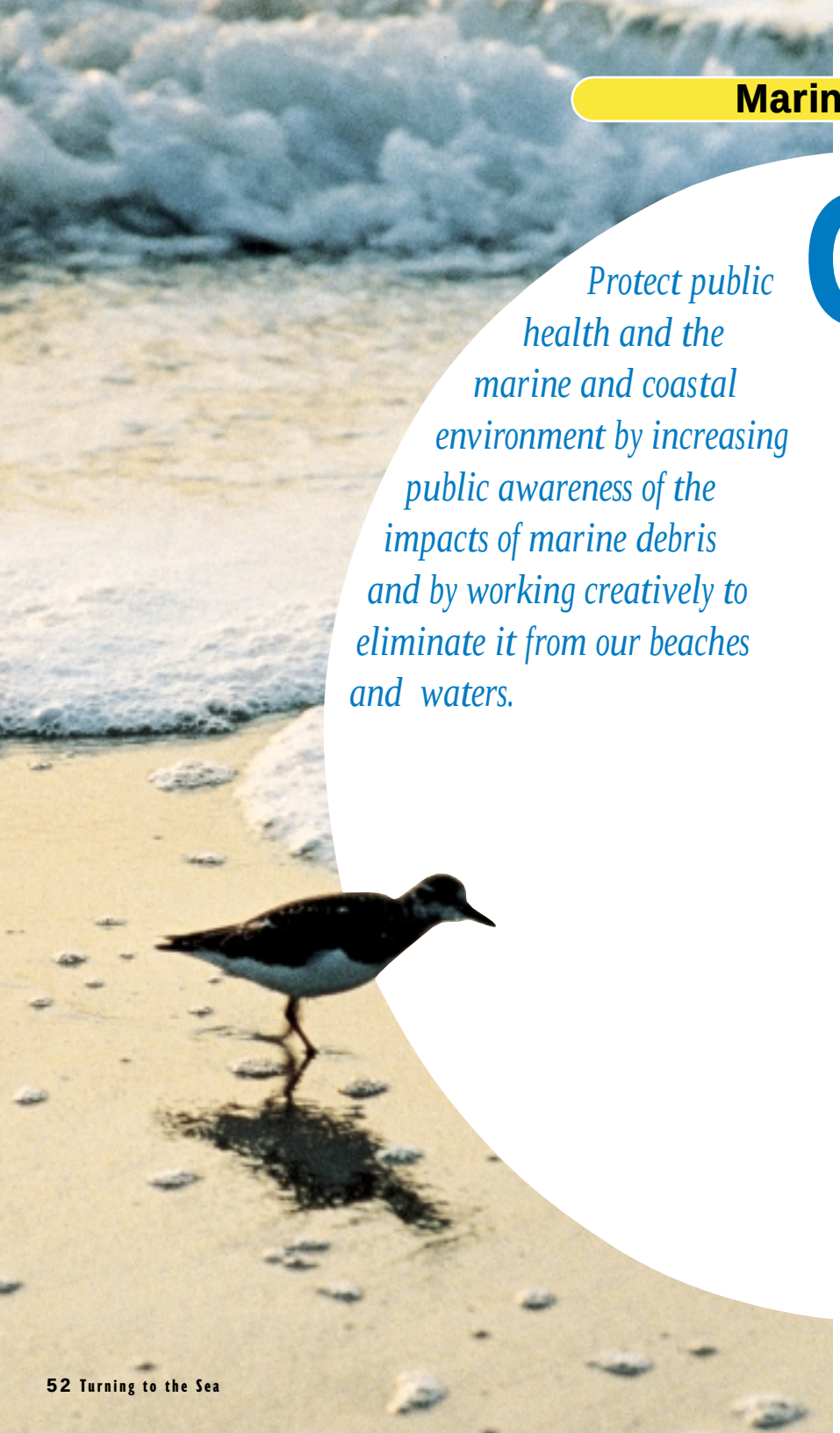
- The U.S. lacks comprehensive, coordinated strategies and actions to prevent the introduction and spread of nonindigenous species in ocean and coastal ecosystems and to identify and respond to nonindigenous species present in coastal areas.
- Little information is available on the potential threats of nonindigenous species, how to prevent their introduction, or their costs to marine and coastal ecosystems.
- U.S. efforts to date have focused on controlling existing introductions, and relatively little has been done to effectively reduce the continuing influx of nonindigenous aquatic species into coastal areas.
- There is no international system for controlling introduction of marine nonindigenous species.

Recommendations

- Increase efforts to prevent and control introductions of nonindigenous species into marine and coastal ecosystems through the Aquatic Nuisance Species Task Force established under the Non-Indigenous Aquatic Nuisance Prevention and Control Act of 1990.
- Increase support for existing regional initiatives in the Great Lakes, Pacific, and Gulf of Mexico to control and prevent introductions of nonindigenous species.
- Develop and implement coordinated regional strategies in other areas, and integrate all regional efforts into a national strategy as part of the national nonindigenous species plan required under Executive Order 13112.
- Fully implement the National Ballast Water Information and the National Aquatic Nuisance Clearinghouses to provide a centralized location for information on ballast water treatment, coastal nonindigenous species, research, and education.
- Develop effective monitoring, education, research, and rapid-response capabilities to quickly identify and eliminate nonindigenous species before they become established.
- Support international efforts to prevent the introduction of nonindigenous marine species, such as the International Maritime Organization's Marine Environmental Protection Committee's Ballast Water Working Group.

For more information

- http://www.great-lakes.net/envt/exotic/exotic.html
- http://www.anstaskforce.gov/
- http://www.uscg.mil/hq/g-m/mso4/first.htm
- http://www.nfrcg.gov/nas/



Marine Debris

Protect public health and the marine and coastal environment by increasing public awareness of the impacts of marine debris and by working creatively to eliminate it from our beaches and waters.

Often called "beach litter," marine debris is a major problem on beaches and in coastal waters, estuaries, and oceans. Close to 80% of debris is washed, blown, or dumped from shore, while 20% is from recreational boats, ships, fishing vessels, and ocean platforms. Most marine debris is man-made and slow to degrade, such as cigarette butts, soda cans, plastic bags, and fishing gear. Studies have shown that marine debris threatens over 265 different species of marine and coastal wildlife through entanglement, smothering, and interference with digestive systems. "Ghost fishing" – entrapment of fish and marine mammals by lost or abandoned nets, pots, and gear – is reducing fish and wildlife populations. In addition, certain types of marine debris, such as broken glass and medical waste wash-ups, can pose a serious threat to public health, causing beach closures and swimming advisories and robbing coastal communities of significant tourism dollars. The U.S. Army Corps of Engineers spends $9.4 million annually to remove drifting and floatable debris from the New York/New Jersey Harbor alone.

Ongoing Concerns

- Implementation of effective marine debris control measures is currently hampered by a lack of consistent monitoring and identification of sources of debris.
- Implementation and enforcement of local anti-litter regulations and management of debris entering and exiting sewer systems are inadequate to effectively address the marine debris problem.
- Marine debris can be the result of small-scale pollution by individuals who consider their discharges or littering to be of negligible impact compared with large-scale polluters. However, the cumulative impact of continuous, small-scale pollution can be dramatic.
- Plastic makes up about 60% of the debris found on beaches. The increase in the use of various kinds of plastic as durable, lightweight packaging has heightened the need for proper management and disposal.

Recommendations

- Reestablish an interagency marine debris working group to coordinate development and implementation of monitoring, source identification, control, and education programs to address and find creative solutions to the marine debris issue.
- Improve controls on potential sources of marine debris, including working with communities to implement and enforce anti-litter laws, improve floatable controls for local sewer systems, and employ statistical marine debris monitoring protocols.
- Accelerate cooperative efforts with industry, with tribal, state, and local governments, and with environmental and fishing groups to find creative ways to prevent and clean up marine debris and to increase public awareness of its impacts.
- Support and encourage research efforts to pursue new packaging technology, and increase recycling opportunities, particularly for plastics.

During the 1998 International Coastal Cleanup Campaign, coordinated by the Center for Marine Conservation and sponsored by private and government donors, over 159,000 people removed approximately 3.3 million pounds of marine debris from 6,888 miles of U.S. shorelines. The Campaign's efforts have led to increased recycling efforts, more trash bins at beaches, and better federal and state laws to keep coastal areas litter-free.

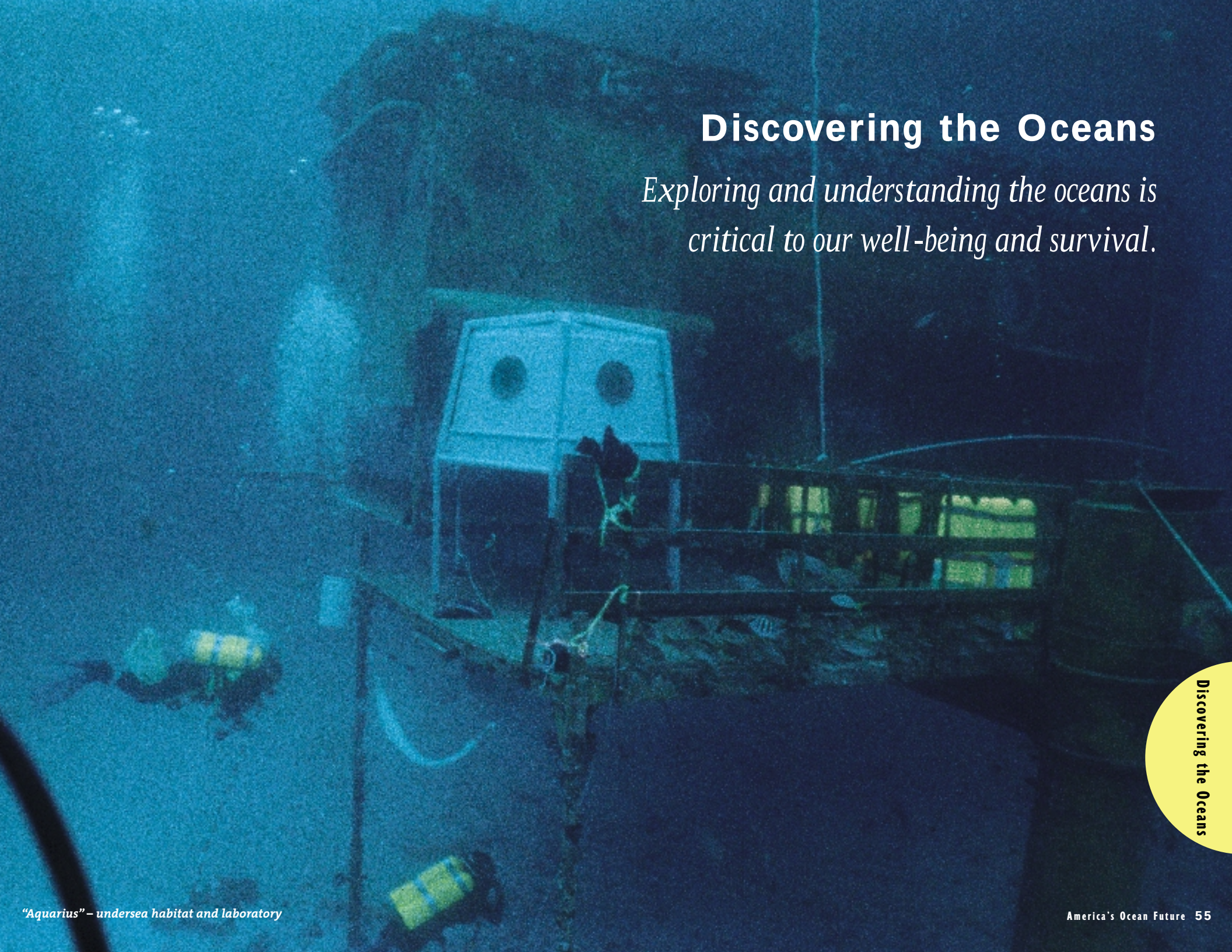
http://cmc-oceans.org/mdio/MDIO.html

For more information

- http://www.epa.gov/owow/oceans/debris/index.html
- http://www.uscg.mil/hq/g-m/nmc/seapart.htm
- http://www.yoto98.noaa.gov/books/debris/debris1.htm

" I really don't know why it is that all of us are so committed to the sea, except I think it's because in addition to the fact that the sea changes, and the light changes, and ships change, it's because we all came from the sea…. We are tied to the ocean. And when we go back to the sea – whether it is to sail or to watch it – we are going back from whence we came."

— President John F. Kennedy



Discovering the Oceans

Exploring and understanding the oceans is critical to our well-being and survival.

"Aquarius" – undersea habitat and laboratory

Ocean Education

Use ocean discoveries to heighten public awareness of the full range of ocean issues and inspire the next generation of ocean scientists and explorers.

People are drawn to the oceans by their beauty, power, and infinite possibilities. Their inspirational power is demonstrated in centuries of literature, art, and music. Yet relatively few people understand the complex relationship between the oceans and the Earth's atmosphere, or grasp the magnitude of human impacts on fragile marine resources.

A recent survey found that many Americans have misleading ideas about the ocean and coastal environment. For example, only one in six knows that the leading source of petroleum pollution in rivers, lakes, and bays is car oil washed off streets into local waterways; most people think the leading sources are oil rigs, tankers, and refineries. Similarly, the majority of adults recently surveyed are unaware that the leading cause of entanglement of marine wildlife is abandoned fishing lines and nets. And four out of five Americans do not identify pollution running off the land as a problem for the oceans, although it is the leading source of marine pollution.

As part of the U.S. Coast Guard Sea Partners Campaign, active duty, reserve, and auxiliary Coast Guard members have helped over 2,000,000 people understand the effects of oil, hazardous chemicals, waste, debris, and what specific actions they can take to protect the marine environment.

http://www.uscg.mil/hq/g-m/nmc/seapart.html

Continuing intensification of human activity near the coasts presents complex issues about marine and coastal ecosystems and societal choices. Comprehensive ocean awareness is critical to effective citizen participation in decision-making processes. Citizens have increasing needs for informal education and lifetime learning, as well as basic scientific literacy, to be capable of making sound choices. Children in particular need to be engaged in ocean and coastal marine science. Young students have been motivated by hands-on experiences, such as the National Ocean Sciences Bowl®, aquarium programs, GLOBE, Sea Partners, and Sea Camp. The ocean science community has the opportunity to make the oceans a major context in which to study the interactions of science, technology, and society.

Ongoing Concerns

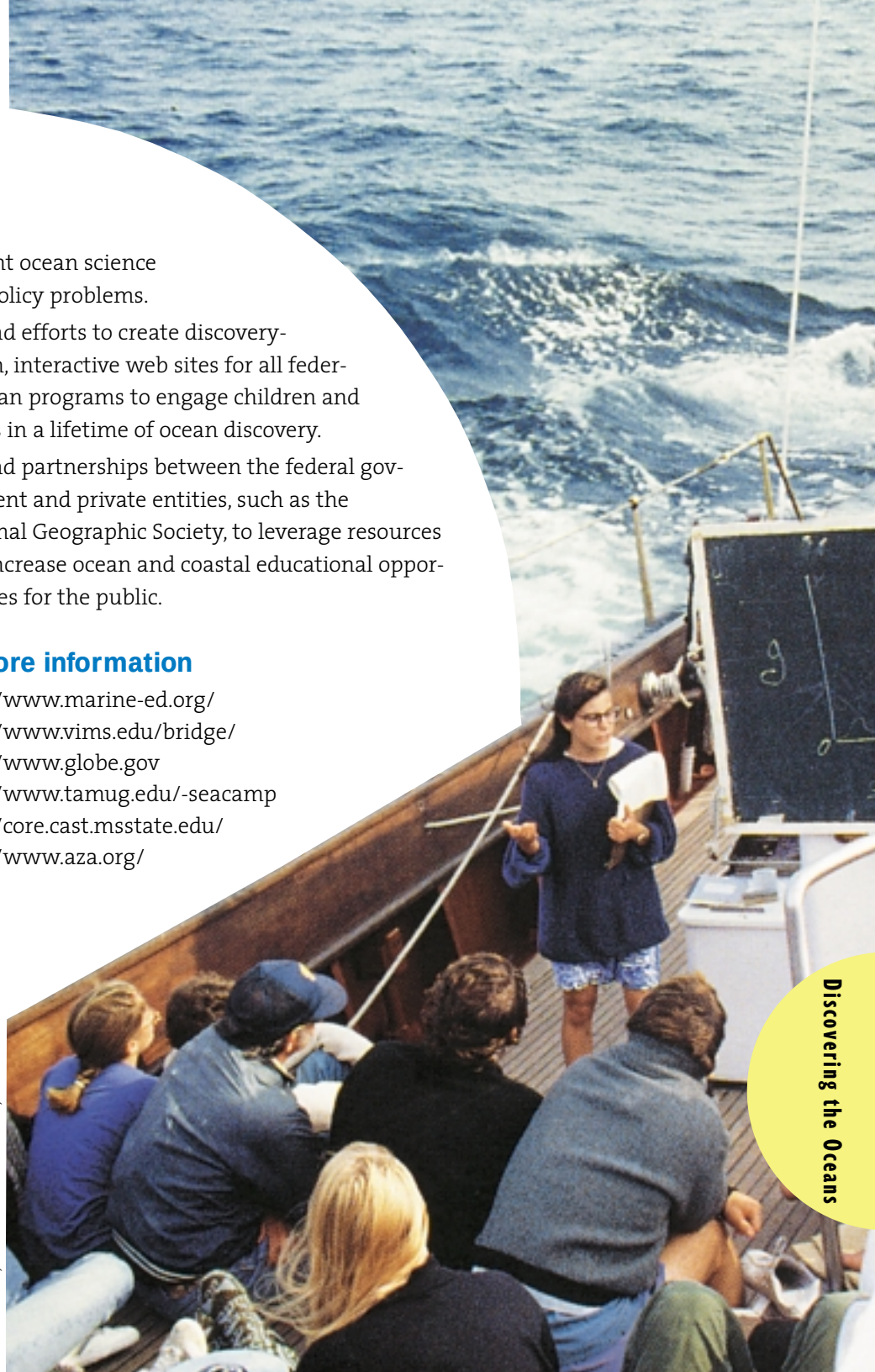
- Although the government and private institutions support ocean science education and outreach programs, these efforts are rarely driven by a specific plan to assess and improve the quality of ocean science education for students, teachers, and the general public.
- Current ocean and coastal educational materials are not as effective or useful to educators as they could be because they are often not closely related to mandatory curricula and are highly variable in quality.
- Teacher education is critical, yet opportunities for it are limited.
- Federal agencies often have very specific educational responsibilities, such as boater education, safe handling of seafood, conservation, and pollution prevention. Many of these can benefit from and contribute to basic ocean educational materials and programs.

Recommendations

- Establish a nationally coordinated effort to improve and promote ocean science education.
- Make ocean science education materials widely available to educators and the general public.
- Develop partnerships and networks with education groups, such as the National Marine Educators Association, the National Science Teachers Association, and the American Zoo and Aquaria Association, to facilitate interaction between the ocean community and educators.
- Develop model programs, such as the Model Congress program, that bring students together to debate and create solutions to current ocean science and policy problems.
- Expand efforts to create discovery-driven, interactive web sites for all federal ocean programs to engage children and adults in a lifetime of ocean discovery.
- Expand partnerships between the federal government and private entities, such as the National Geographic Society, to leverage resources and increase ocean and coastal educational opportunities for the public.

For more information

- http://www.marine-ed.org/
- http://www.vims.edu/bridge/
- http://www.globe.gov
- http://www.tamug.edu/-seacamp
- http://core.cast.msstate.edu/
- http://www.aza.org/



A. Stander, Sea Education Association, Inc.

Ocean Observations

Develop a coordinated, comprehensive system of worldwide ocean observations to support a wide range of societal needs.

Inside the Aquarius habitat

Recent technological developments have significantly improved ocean-observing systems. Satellites, ships, and buoys collect many kinds of data on and within the ocean, but these observations are not comprehensive. Gaps exist in coastal, open-ocean, and seafloor data sets. In addition, the federal programs collecting ocean observations are poorly integrated. By improving the coordination of data collection, storage formats, and dissemination processes, an integrated ocean-observing system would provide comprehensive near-real-time information on ocean and coastal conditions for the full range of users. Such a system would improve weather forecasting, detect and forecast oceanic components of climate variability, facilitate safe and efficient marine operations, make U.S. ports more competitive, and provide daily tactical support of military operations worldwide.

Marine ecosystems and living marine resources would also be better protected if more complete and accurate data were collected on ocean temperature, salinity, and dissolved chemicals and nutrients that affect commercial fish stocks, marine mammals, marine ecosystems, and coastal habitats. An integrated system would make more accurate predictions of natural hazards possible, allowing for mitigation of damage from hurricanes, coastal flooding, icebergs, tsunamis, and seafloor disturbances causing pipeline and telephone cable ruptures. The advanced warning derived from observing systems and climate predictions saved an estimated $1 billion in California alone from losses related to El Niño, which totaled $15 billion nationally in 1997-98. Global ocean observations could even protect public health by collecting the necessary data to understand the fate of pollutants, pathogens, harmful algal blooms, and other health hazards that close our beaches and shellfish beds. This system would also support fundamental scientific research and enhance public education and awareness of ocean issues.

Ongoing Concerns

- Current ocean-observation efforts are limited in scope. For example, volunteer merchant vessel observations are limited to shipping lanes; most satellites can only make surface-water or very shallow-water measurements; research

vessels are limited to short-term, small-area observations; and Navy data are not always publicly available. Where data do exist, there are no mechanisms to fully integrate them.

- No clear mechanisms exist for translating large-scale, international ocean experiments into long-term, operational observation efforts, or for transitioning emerging new ocean-observation technologies to operational use.
- Data from different sensors, such as satellites, drifting floats, and buoys, do not share commonalities in data format, access, and dissemination, and cannot be rapidly integrated to serve the many different users.

The Argo program is deploying a global array of 3,000 instruments to observe the waters below the ocean's surface. The Argo array will be a critical addition to an ocean-observing system equivalent to the existing atmospheric observation system; and in combination, these systems will collect data necessary to forecast weather, predict phenomena that influence global climate, and support national security and basic research needs.

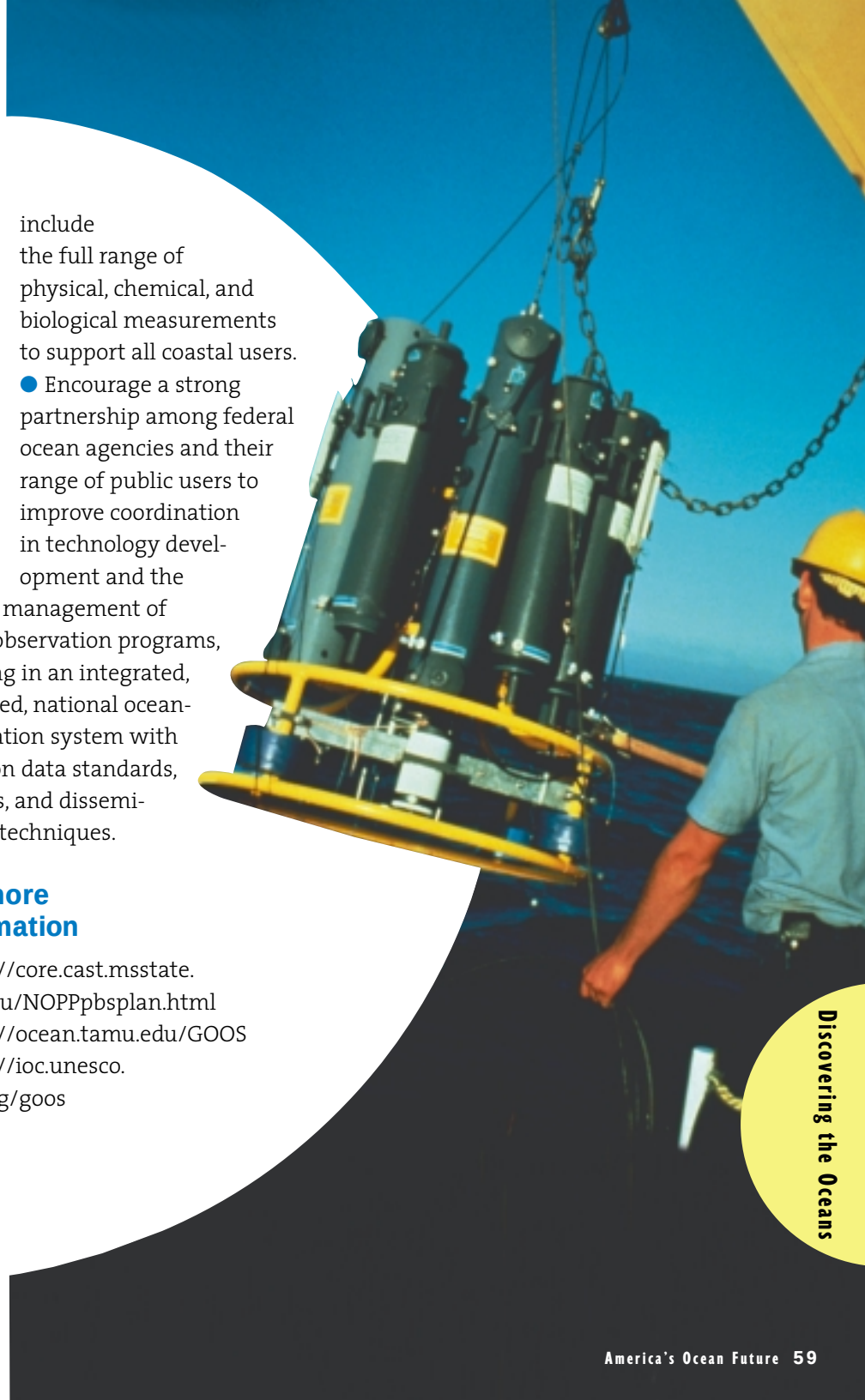
http://www.argo.ucsd.edu

Recommendations

- Expand open ocean-observing capabilities to enhance sampling of the full water column. In complement with satellite observations of the ocean surface, this will advance our understanding of ocean circulation and air/sea interactions to improve weather prediction and our understanding of climate change, and support basic research, fisheries, and national security.
- Expand and integrate seafloor observation capabilities to improve basic knowledge of the Earth's temperature, chemistry, and structure. This will support pipeline and cable-laying operations, national security and research needs, and improved disaster warnings from seafloor disturbances.
- Expand and coordinate coastal-observing capabilities to include the full range of physical, chemical, and biological measurements to support all coastal users.
- Encourage a strong partnership among federal ocean agencies and their range of public users to improve coordination in technology development and the management of ocean-observation programs, resulting in an integrated, sustained, national ocean-observation system with common data standards, formats, and dissemination techniques.

For more information

- http://core.cast.msstate.edu/NOPPpbsplan.html
- http://ocean.tamu.edu/GOOS
- http://ioc.unesco.org/goos



© James Broadus-WHOI

Ocean Research

Develop a vigorous, interdisciplinary ocean and coastal research program and cutting-edge research infrastructure.

Over the last century, human activities have increasingly produced serious chemical, physical, and biological changes in the oceans. Water and air pollution are adding to the oceans vast quantities of fertilizers and pesticides that modify the chemistry of ocean water, particularly along the coasts. Overfishing, habitat destruction, invasive species, and pollution are contributing to the decline of fish, marine mammals, and other species and reducing the biological diversity of marine ecosystems. And climate change has the potential to produce changes in ocean temperature, salinity, sea level, circulation patterns, and other physical characteristics vital to marine and terrestrial life.

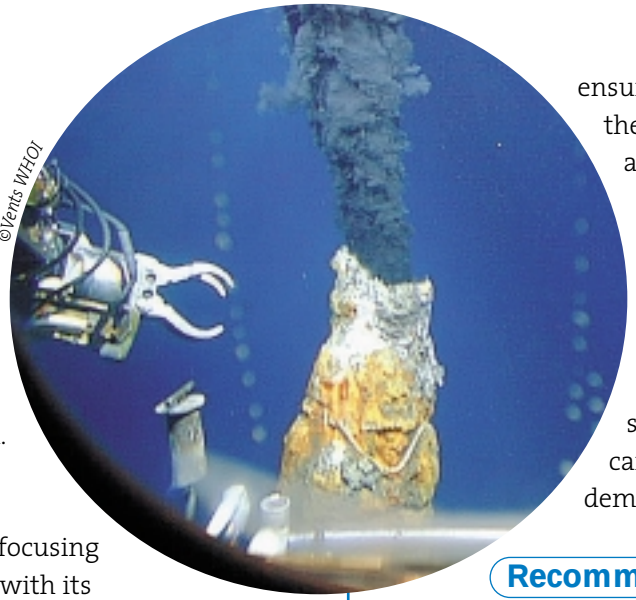
Issues such as *Pfiesteria* outbreaks, red tides, brown tides, the "dead zone" in the Gulf of Mexico, introductions of nonindigenous species, and preserving Pacific salmon highlight the limits of our present scientific understanding. Fortunately, powerful new technologies are enhancing our ability to manage our precious marine resources and answer immediately pressing and long-term questions about preserving biodiversity, climate change, and other critical issues facing us in the 21st century. We can harness advanced information theory and computational systems to assemble and analyze data. We can use new tools – from gene sequencers to autonomous vehicles and global satellites – to simultaneously explore questions about the oceans at subcellular and global scales.

Because the oceans are characterized by complex interacting physical, chemical, and biological systems, research to understand ocean processes cuts across many different scientific fields. A number of federal agencies have interests in ocean research, and each agency funds research that meets its specific mission needs.

The Ocean Drilling Program, a 20-nation cooperative effort to drill and study core samples from the ocean floor, has established the mechanisms and timing of global glaciations and climate change; traced the history of changes in the circulation, chemistry, and biology of the ocean; and confirmed the theory of plate tectonics. A recent core sample from the Caribbean Sea revealed a detailed record of a giant meteorite impact, which supports the theory that dinosaurs became extinct after a meteor raised huge dust clouds, blocking the sun and triggering climate change.

http://www.oceandrilling.org/

Ocean research could benefit from coordinated research programs across agencies and disciplinary boundaries. To encourage such coordination, in 1997 Congress established a new National Ocean Partnership Program. The heads of twelve agencies oversee a program that provides funding for new government/industry/university partnerships in research and education. In addition, the National Science and Technology Council's Committee on Environment and Natural Resources is focusing on improved interagency coordination with its FY 2000 budget initiative, "Integrated Science for Ecosystem Challenges." One component of this program is slated to increase research on harmful algal blooms and other coastal water quality issues. The National Ocean Partnership Program and the Committee on Environment and Natural Resources provide mechanisms by which agencies can agree on priorities for cooperative ocean research. Early efforts have been promising, but more needs to be done.



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Ongoing Concerns

- Oceanography and marine ecosystem science need an increased interdisciplinary approach, linking the fields of physics, biology, chemistry, and geology, and allowing a better view of the Earth as an integrated system.
- Current ocean and coastal research efforts do not take full advantage of opportunities for increased coordination, both in research objectives and in shared research infrastructure.
- There is a lack of standardized practices and procedures to ensure the integrity and accuracy of large, complex, and widely distributed data sets.
- Our coastal and ocean research infrastructure, from submersibles and research vessels to laboratories, is aging and cannot meet the technological demands of the 21st century.

Recommendations

- Develop an integrated, interagency science program with the necessary infrastructure to meet ocean and coastal ecosystem challenges, using a coordinated research strategy that integrates relevant ocean science disciplines and advances both basic and applied research in ocean and coastal issues.
- Actively develop cooperative agreements with academia and the private sector to expand access to specialized exploration and research infrastructure and data.

For more information

- http://www.aoml.noaa.gov/ocd/globec/
- http://www.fmri.usf.edu/ecohab/Default.htm
- http://www.hpl.umces.edu/coop/

Seafloor hydrothermal vents-WHOI

Ocean and Coastal Exploration

Explore and discover the unknown regions of the oceans.

Individual deep-diving suit

Exploring the oceans has been an important human goal for centuries. Yet, while we have spent much of our history learning about what lies at the ocean's surface, we still know relatively little about what lies below. In just the past 50 years, we have discovered that the greatest mountain chains and canyons on Earth exist beneath the sea. Only 20 years ago, we discovered totally new chemosynthetic life forms that exist around deep-sea hydrothermal vents. Considered by some to be one of the most significant biological discoveries in the latter half of this century, these organisms derive energy from chemicals – not the sun, revolutionizing theories of photosynthesis as the basis of all life. These organisms have adapted to living in a highly pressurized, sunless, superheated environment, and may provide insight into our understanding of the origins of life on Earth and other planets.

Alice Alldredge, UCSB

Such discoveries demonstrate that the deep ocean remains the last great frontier of our planet for exploration and discovery. Although no one can predict what exploration will yield, exploration and research have led to discoveries that have changed our lives fundamentally and have provided knowledge critical to sustainably managing our natural resources.

Ongoing Concerns

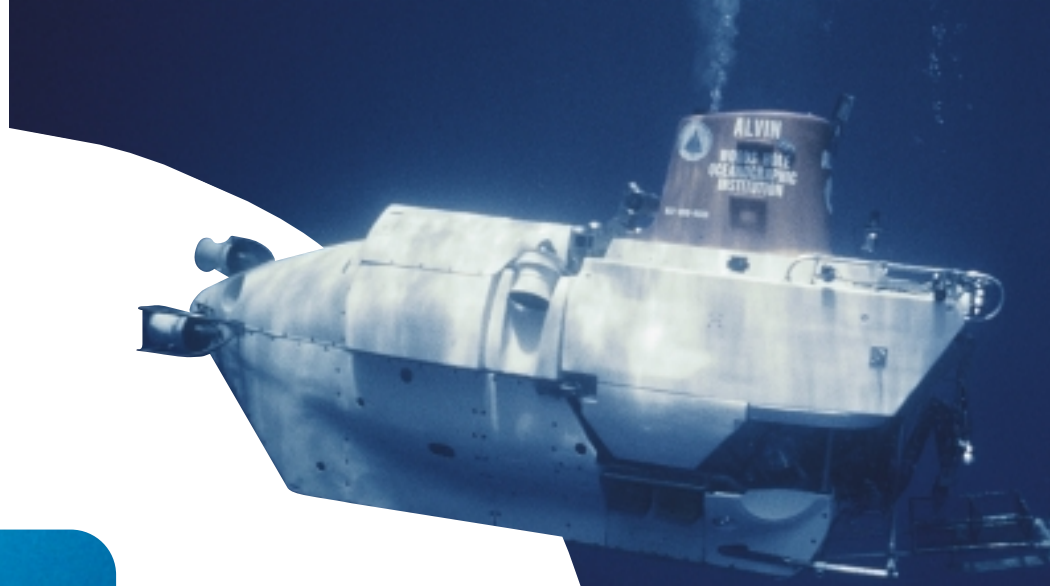
- There is a lack of information about many ocean ecosystems, including the ocean's deepest regions, affecting our ability to manage them and to develop new uses and potential products.
- Only four manned submersibles in the world, none of them operated by the U.S., are capable of descending to half the ocean's maximum depth. The deepest-diving U.S. manned submersible currently operating (the *ALVIN*) can reach only an estimated 63% of the ocean floor.
- Not enough effort is made to bring the excitement of ocean exploration – truly the last frontier on Earth – to the public and to popular media.

Recommendations

- Establish a national strategy to expand exploration of the oceans, including more in-kind support by federal agencies for private ocean exploration initiatives.
- Support exploratory research in geographic areas, such as the deep-sea vent sites, and topical areas, such as undiscovered deep-sea species.
- Invest in the development of cutting-edge technologies and vehicles to observe and explore the oceans from the surface to the seafloor.
- Develop ways to explore the oceans remotely, including new observatories and sensors and innovative uses of technologies.

On Earth Day 1999, private and federal partners launched the historic Sustainable Seas Expedition to explore and map the nation's 12 National Marine Sanctuaries, providing the first comprehensive study of some of the organisms and physical characteristics in these areas.

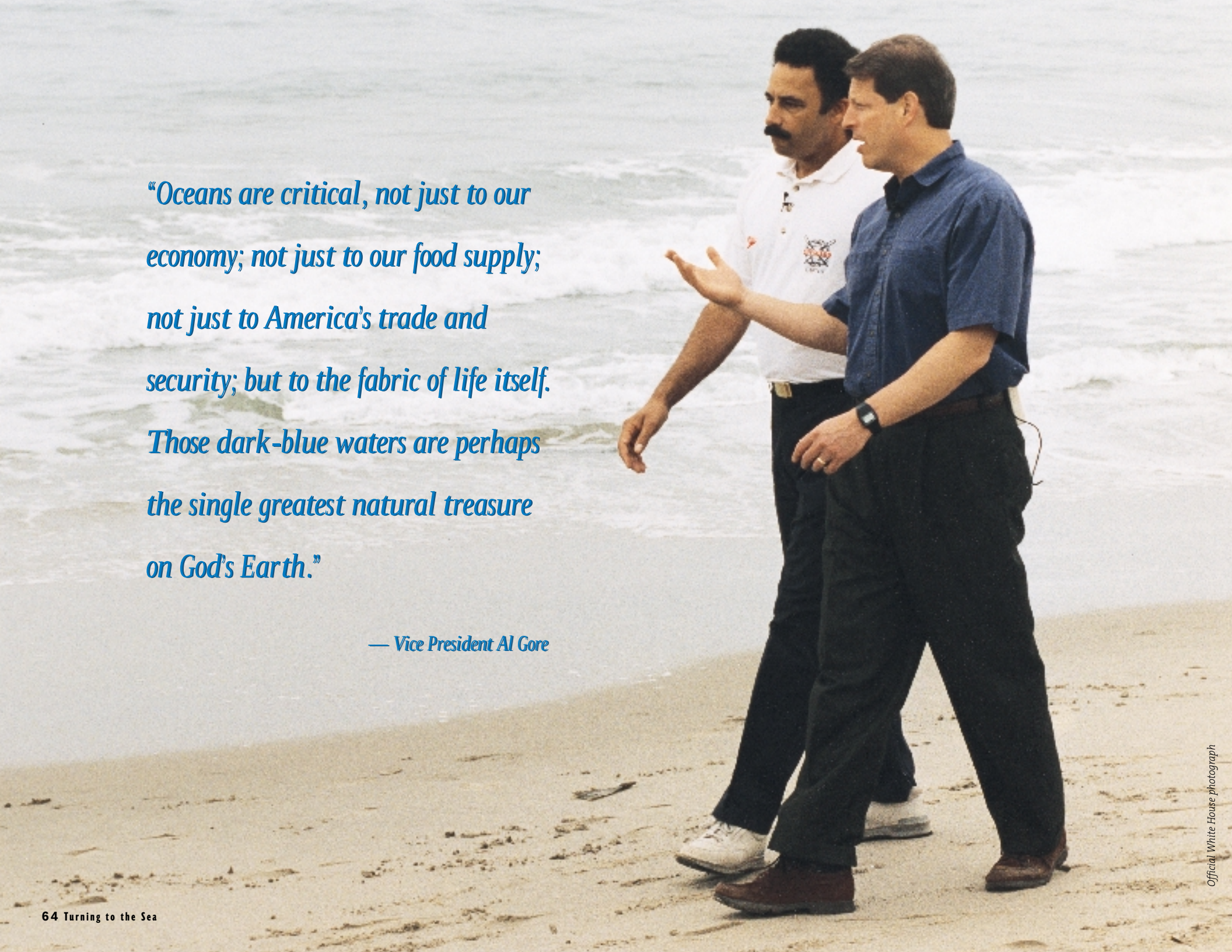
http://www.sustainableseas.noaa.gov



The ALVIN-deep diving (over 2.5 miles) submersible, WHOI

For more information

- http://www.nurp.noaa.gov
- http://www.nationalacademies.org/nrc
- http:www.whoi.du/index.html



"Oceans are critical, not just to our economy; not just to our food supply; not just to America's trade and security; but to the fabric of life itself. Those dark-blue waters are perhaps the single greatest natural treasure on God's Earth."

— Vice President Al Gore

Official White House photograph