THE NATIONAL ACADEMIES
REPORT IN BRIEF

Science at Sea

Meeting Future Oceanographic Goals with a Robust Academic Research Fleet

The U.S. academic research fleet is an essential national resource, and it is likely that scientific demands on the fleet will increase. Oceanographers are embracing a host of remote technologies that can facilitate the collection of data, but will continue to require capable, adaptable research vessels for access to the sea for the foreseeable future. Maintaining U.S. leadership in ocean research will require investing in larger and more capable general purpose Global and Regional class ships; involving the scientific community in all phases of ship design and acquisition; and improving coordination between agencies that operate research fleets.

Growing awareness of the ocean's critical role in environmental processes means that understanding issues such as climate change, carbon and water cycles, ocean acidification, harmful algal blooms, sea level rise, and tsunami generation is an increasingly high priority for national and global health and security. The U.S. academic research fleet consists of 22 ships that provide U.S. and international researchers with a platform for innovative research in chemical, biological and physical oceanography, marine geology and geophysics, atmospheric science, and emerging interdisciplinary areas.

Managed since 1971 by the University-National Oceanographic Laboratory System (UNOLS), a consortium that unites research institutions, federal agencies, and state and private interests, ships in the UNOLS academic fleet function as mobile research stations that allow oceanographers to collect measurements and analyze data in waters ranging from near-shore coastal zones to deep, remote waters far from land.

In recent years, rapid advancements in ocean-observing technology have raised questions about how the U.S. academic research fleet could evolve to take advantage of new technologies. Data collection tools could be made more efficient through the addition of autonomous vehicles and sensor systems that can observe ocean processes, as well as provide data essential for the development and validation of advanced ocean and climate models.

However, there are concerns that the increased cost of operating UNOLS vessels, due to rising fuel and personnel costs, could impact abilities to conduct oceanographic research in the future. The possibility of extending partnering mechanisms such as UNOLS to manage the fleet is also raised.

In order to investigate these issues, the Office of Naval Research and the National Science Foundation asked the National Research Council

to convene a committee to assess the impacts of incorporating advanced technologies into the evolution of the research fleet.

Anticipating and Supporting Future Science Needs

Because of the long life-span of research fleet ships—typically 30 or more years—long-term planning is needed to ensure that the fleet remains capable of supporting ocean research well into the future. This means that efforts must be made to anticipate the direction that oceanographic research will take, assessing the mix of different types of ships that make up the fleet to ensure that a broad range of oceanographic missions are supported.

In recent years, there has been a shift towards research cruises with larger scientific teams that are engaged in interdisciplinary research. The fleet of the future will support these increasingly complex, multidisciplinary, multi-investigator research projects, including those in support of autonomous technologies, ocean observing systems, process studies, remote sensing, and modeling. Accommodating larger groups of researchers and more advanced technology will require more laboratory, deck, and personnel space.

One of the most serious issues facing federal agencies that support ship borne science, ship operating institutions and science at sea is the increasing cost of operating research vessels. Because ship operating costs are dependent on the size, design, and location of the vessel, ship time cost considerations are important in determining the composition of the fleets of the future.

Between 2000 and 2008, the total operating costs for the fleet have increased 75 percent, driven mainly by crew and fuel cost factors. Recent market volatility of crude oil led to extremely high fuel costs in 2008 and more expensive daily ship rate. For the same time period, the total number of operating days decreased by 13 percent, meaning that average cost per ship per day doubled.

Ships in the Global category are generally the most expensive to build and operate, but are in high demand and receive heavy usage. The increasing cost of ship time and the economies of scale associated with larger ships may lead to greater usage of Global class vessels, which have laboratories, deck space, and berthing capabilities that can support multiple science operations. With these vessels, complex programs are less likely to require multiple legs, thus lowering overall operational costs.

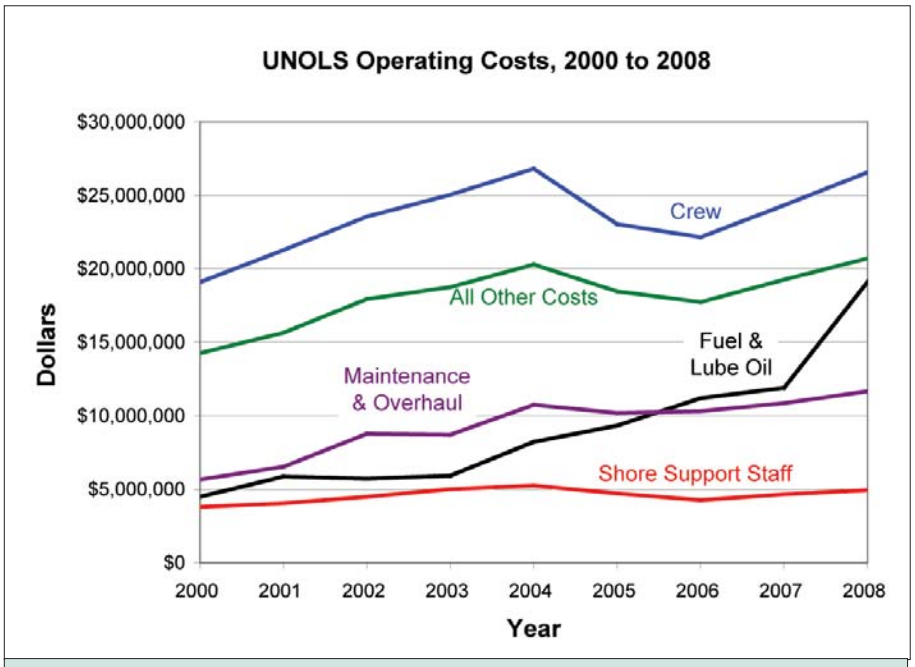

Figure 1. Because ship operating costs are dependent on the size, design, and location of the vessel, ship time cost considerations are important in determining the composition of the fleets of the future.

Regional ships are required for working in waters close to shore and collection of a greater variety and volume of sediment, biological, and water samples in areas that are difficult to access using stationary or autonomous instruments, especially in response to unpredictable events.

Recommendation: Federal agencies supporting oceanographic research should implement a comprehensive, long-term research fleet renewal plan, to retain access to the sea and maintain the nation's leadership in addressing scientific and societal needs.

Recommendation: The future academic research fleet requires

investment in larger, more capable, general purpose Global and Regional class ships, to support multi-disciplinary, multi-investigator research and advances in ocean technology.

Technological Advancements and Vessel Design

The growing use of autonomous vehicles has already changed the role of the research fleet—increasingly, ships are used as platforms to support the operations of multiple vehicles at one time, requiring the ability to carry more instruments, equipment, and personnel. Ships will also be needed to support the installation, operations, and maintenance of other new technologies, including observing systems.

Satellite data and more advanced ocean modeling are providing scientists with valuable analysis tools. Increased access to satellite remote sensing data and ship-to-shore communications will promote interdisciplinary process studies and enhance the need for ship-based calibration and validation of satellite data. This technology will also provide greater opportunity for land-based researchers to remotely participate in research cruises, increasing the efficiency of ship-based science.

The ship acquisition process often does not emphasize inclusion of the scientific community in decision-making regarding design and specifications, although a recent NSF-led project benefited from community-driven ship design, allowing the users to participate more fully and create optimal designs within cost constraints

Recommendation: All future UNOLS acquisitions, beginning with planned Ocean class vessels, should involve the scientific community with the preconstruction phase through post delivery of the ship.

Types of Ships in the Academic Fleet

Global—Large ships capable of working worldwide. Can stay at sea for 50 or more days, and can carry 30-38 scientists.

Ocean—General purpose ocean-going vessels, able to stay at sea up to 40 days and carry 25 scientists.

Intermediate—Ocean-going vessels with berths for 18-20 scientists.

Regional—Serve coastal oceanography needs, can stay at sea for 30 days and carry 20 scientists.

Regional/Coastal—Used close to port, often conducting short cruises. Can stay at sea for 30 days and accommodate 20 scientists.

Local—Used close to shore, can stay at sea for about 20 days and accommodate about 15 scientists.

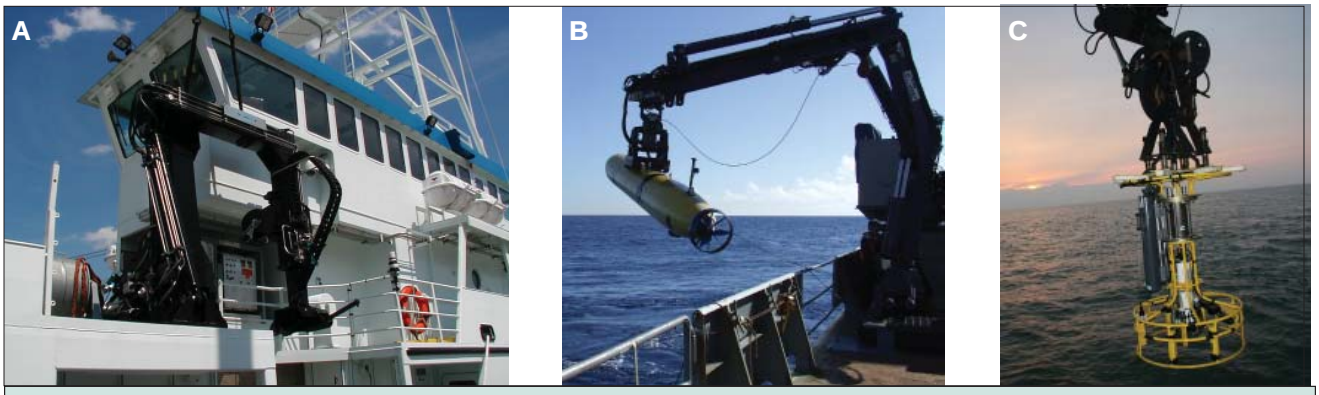

Figure 2. The increasing use of autonomous vehicles means that ships are often used as platforms to support the operations of multiple vehicles. A. Custom handling system is used to lower equipment over the side of the ship and into the ocean. B. An autonomous underwater vehicle is lowered into the ocean, to carry out tasks such as high-resolution sea-floor mapping and measuring the temperature and salinity of seawater. (Image courtesy of ODIM Brooke Ocean). C. A conductivity-temperature-depth sensor is deployed using a handling system that keeps the sensor at a designated depth, regardless of the motion of the ship (A and C courtesy of William Byam, University of Delaware).

Partnerships

The UNOLS partnership brings research scientists, ship operating institutions, and federal agencies together to coordinate economical and cost-effective use of the U.S. research fleet. The ships are operated as shared-use facilities, and are equally available to a wide range of science community users. The committee found that overall, the partnership between federal and state agencies, academic institutions, and private interests successfully serves national oceanographic research objectives and is anticipated to continue in the face of changing science priorities and technological advances.

However, there are many assets that are not integrated between organizations, leading to sub-optimal use of the full U.S. research fleet and a mismatch between available ship time and research-needs to support national goals, a trend likely to continue in the future. In particular, opportunities exist to better integrate icebreakers operated by the U.S. Coast Guard and supported by the National Science Foundation's Office of Polar Programs with the UNOLS management structure, and to fulfill some part of National Oceanic and Atmospheric Administration's identified needs for significantly more ship time by utilizing unused UNOLS ship days. A stronger partnership between these organizations would allow the National Oceanic and Atmospheric Administration to better fulfill its mission and UNOLS to increase efficient use of the fleet.

Recommendation: The National Oceanic and Atmospheric Administration should identify which of its 13,200 unmet ship-day needs could be supported by the UNOLS fleet. The National Oceanic and Atmospheric Administration and UNOLS should work together to develop a long-term plan to increase the usage of UNOLS fleet ships in support of the National Oceanic and Atmospheric Administration mission.

Recommendation: The National Science Foundation Division of Ocean Sciences, Office of Polar Programs and the U.S. Coast Guard should improve coordination of ship operations and support between University-National Oceanographic Laboratory System and polar research fleets.

The Committee on The Evolution of the National Oceanographic Research Fleet: Ronald Kiss *(Co-Chair)*, Webb Institute (ret.); **Dick Pittenger** *(Co-Chair)***,** Woods Hole Oceanographic Institution; **Francisco Chavez,** Monterey Bay Aquarium Research Institute; **Margo Edwards,** University of Hawaii, Manoa**; Rana Fine,** University of Miami, Florida**; Nancy Rabalais,** Louisiana Universities Marine Consortium**; Eric Saltzman,** University of California, Irvine; **James Swift,** University of California, San Diego**; William Wilcock,** University of Washington, Seattle; **Dana Yoerger,** Woods Hole Oceanographic Institution**; Deborah Glickson** (*Associate Program Officer*), National Research Council.

The National Academies appointed the above committee of experts to address the specific task requested by the Office of Naval Research and the National Science Foundation. The members volunteered their time for this activity; their report is peer-reviewed and signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

For more information, contact the Ocean Sciences Board at (202) 334-2714 or visit http:/nationalacademies.org/osb.

Copies of *Science at Sea: Meeting Future Oceanographic Goals with a Robust Academic Research Fleet* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.