NOPP PWG - Background Doc #1 (List of NOPP Projects)

List of NOPP projects with IOOS involvement:
(see https://nopp.org/projects/nopp-project-table/ for all NOPP Projects)

Year	Project	Funding	IOOS entity involved	Funding Amount
~~FY11 - FY15~~	~~Implementation of the U.S. Integrated Ocean Observing System~~	~~NOAA~~	~~All 11 RAs~~	NOAA funding only
FY11 - FY16	Multi-sensor Improved Sea-Surface Temperature (MISST)	NOAA, NASA	IOOS Office	$4M total
FY14 - FY18	Initiating an Arctic Marine Biodiversity Observing Network (AMBON)	NOAA, BOEM, Shell Oil	AOOS	~$5.9M
FY14 - FY18	National Marine Sanctuaries as Sentinel Sites for a Demonstration Marine Biodiversity Observation Network	NASA	GCOOS, SECOORA, CeNCOOS	~$5.8M
FY14 - FY18	Demonstrating an Effective Marine Biodiversity Observation Network in the Santa Barbara Channel	NASA, BOEM	SCCOOS	~$4.1M
FY19 - FY21	The CeNCOOS MBON: Integrating remote sensing, in situ data and models to understand central California ecosystem responses to environmental change	NASA	CeNCOOS	~$1.15M
FY19 - FY21	MBON expansion into the Gulf of Maine: the NERACOOS/NROC Integrated Sentinel Monitoring Network (ISMN)	NOAA, BOEM	NERACOOS	~$1.15M
FY19 - FY21	Marine Biodiversity Observing Network in the Northern California Current: Understanding patterns and drivers of biodiversity and ecosystem functioning from plankton to seascapes	NASA, NOAA	NANOOS	~$1.15M
FY19 - FY21	A sustainable, integrated AMBON in the Chukchi Sea	NOAA, NASA, ONR	AOOS	~$1.15M
FY19 - FY21	Implementing a Marine Biodiversity Observation Network (MBON) in South Florida to Advance Ecosystem-Based Management	NOAA	SECOORA	~$1.27M

FY19 - FY21	Southern California Bight Marine Biodiversity Observation Network	NASA	SCCOOS	~$1.15M
FY20	Demonstrating an Estuarine Soundscape Observatory Network in the Southeast: Understanding baseline rhythms of biological sounds and correlations to traditional biodiversity measurements to support long-term sustainable monitoring	NOAA	IOOS Office, SECOORA	$100K
FY21 - FY22	Piloting Bo-GO-SHIP on US cruises: Towards a global analysis of large-scale changes to ocean plankton systems	NOAA (cross-LO), NSF, NASA	MARACOOS, NANOOS as conduit for funds to academic partners	$100K to IOOS of $320K total NOPP project; leveraged $1.2M GOMO investment
FY22 - FY26	The CeNCOOS MBON: Marine biodiversity information in support of a healthy Blue Economy in the central California Current	NOAA (cross-LO)	CeNCOOS	~$1.15M
FY22 - FY26	Quantifying marine biodiversity through movements and feeding: Assessing coastal marine ecosystem dynamics near estuary mouths	NOAA, ONR	NERACOOS	~$1.15M
FY22 - FY26	Louisiana Deltaic Estuaries MBON: Sea Level Rise Sentinels	NASA	GCOOS	~$1.15M
FY22 - FY26	AMBON (Arctic MBON) – linking biodiversity observations in the Arctic	NASA, ONR	AOOS	~$1.15M
FY22 - FY26	The Southeast US Marine Biodiversity Observation Network (MBON): Toward Operational Marine Life Data for Conservation and Sustainability	NASA	SECOORA, GCOOS	~$1.27M
FY23	mCDR projects TBD (NOFO)	US IOOS to provide funding	TBD	TBD

DRAFT Overview: "NOPP 2.0" and What Constitutes Future NOPP Projects

The 25-year-old National Oceanographic Partnership Program (NOPP) is experiencing a renaissance of support in recent years spanning White House administrations and including strong bipartisan support from Congressional authorizers and appropriators. This interest comes from recognizing the discoveries and innovations that have been facilitated through past NOPP support and the potential for NOPP 2.0 as a mechanism to further expand the scope of potential partners outside the federal space, with particular attention on advancing public-private partnership and leveraging the recent expansion of philanthropic-based investments in ocean science through novel collaborations to tackle the large and urgent challenges facing the ocean.

This short public document aims to codify the vision for NOPP 2.0 to focus the direction of the interagency working group on NOPP, operating on behalf of the Ocean Policy Committee, in championing future projects and to guide the reconstituted NOPP Program Office charged with supporting the program and providing opportunities for community engagement.

As a baseline, a NOPP project involves more than one federal agency in either performance or sponsorship; at least two of the three sectors of public, private, and academia; and involves coordination and review by the agencies involved. NOPP 2.0 is ambitious in expanding the scope of potential NOPP partnerships, so while not explicitly stated in the authorization, Tribal Nations and Indigenous communities, non-governmental organizations, philanthropic entities, and local and State governments can and should be considered as eligible partners within the oceanographic community in the areas of science, data, technology development, resources, education, and communication. Agencies that may not have traditionally ocean-focused missions are encouraged to newly participate in NOPP, for example, on topics of health, transportation, infrastructure, and technological innovation. All NOPP projects demonstrate the meaningful contributions of the participants in their conception, execution, and outcomes.

NOPP projects are typically established through a federal funding opportunity announcement, though creative approaches for meeting the above criteria have been quite successful in the past and are encouraged. NOPP's authorization[1] affords the participating agencies the ability to enter into contracts and award grants using appropriated funds to resource projects that meet the goals of NOPP, as well as use other implementing mechanisms that the Ocean Policy Committee considers as appropriate, which could include memoranda of understanding, cooperative research and development agreements, challenges and prizes, and any similar instruments.

The program was primarily built to foster collaboration, coordination, and communication between federal agencies regarding ocean[2] projects that spanned federal jurisdictions. Dedicated competitive pots of funding were formed to augment project costs, leveraging interagency coordination and helping to advance an ocean initiative. However, the scope of NOPP-designated projects need not be constrained by NOAA's and ONR's limited dedicated NOPP funding; the spectrum and size of potential partnerships between federal agencies and external collaborators greatly expand the capability and reach of NOPP. NOPP Interagency Working Group (IWG) members, and potential external NOPP partners, are

[1] NOPP's reauthorization in the Fiscal Year 2021 National Defense Authorization Act and enacted law via U.S. Code.

[2] Consistent with the Ocean Policy Committee, "ocean" includes the open ocean, coasts, estuaries, coastal watersheds, and Great Lakes.

encouraged to pose ideas for potential NOPP ocean initiatives early in the ideation and development stage and to participate using other authorized funds where mission space and outcomes would be leveraged through partnerships.

Objectives for Moving Forward in New Ways

The summary of the White House Summit on Partnerships in Ocean Science and Technology[3] and the report on Opportunities and Actions for Ocean Science and Technology (2022-2028)[4], which identified several cross-cutting ocean priorities, target the need for developing partnerships with the private sector, philanthropy, academia, and non-governmental organizations, and in doing so, recognize the need to enhance and support existing and new partnership mechanisms through NOPP. Realizing that the ocean-related projects and ideas themselves drive NOPP partnership participation, the IWG members have a frontline responsibility to help implement the recommendations and directions from the Ocean Policy Committee and Congress, which include but are not limited to:

- Collaborate with other ocean-related interagency working groups, which already coordinate on subject-matter-focused projects as part of their portfolios, to help drive NOPP support, expand federal and non-federal partnerships, and elevate project attention. This effort also requires reaching down and across member agencies to find the right people for a particular effort.

- Continue expanding the scope of projects considered within the NOPP-IWG forum to include larger projects that are often fully funded by one ocean agency but actually have a shared need across government, academia, philanthropy, and industry. Far too often, one agency has the burden of carrying the budget request and executing the funding for a large ocean project when many federal and non-federal partners in the community also have a direct stake in its success. NOPP, as a coalition, can serve as a mechanism for identifying the shared risk of these large projects, coordinating messaging, recognizing a project's expansive user community more clearly, and, by extension, broadening its advocacy.

- Expand government participation beyond the federal sector that incorporates State, Local, and Tribal participation for appropriate projects with cross-jurisdictional parameters.

- Conduct regular and meaningful consultations with Tribal officials and Indigenous, Alaska Native, Pacific Islander, and Native Hawaiian communities officials in developing ocean science and technology projects.

- Enhance long-term partnership strategies by further articulating the "use" of science and technology applications to better manage the ocean for federal and non-federal decision-makers. Connecting the dots will also help establish linkages to entities outside of the Federal government, including Tribes, states, energy developers, and local communities, for stakeholders to see and understand how NOPP-coordinated projects will help inform their decisions and processes at a level desirable for them.

[3] Ocean Policy Committee (2019) Summary of the 2019 White House Summit on Partnerships in Ocean Science & Technology. https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/12/Ocean-ST-Summit-Readout-Final.pdf

[4] Subcommittee on Ocean Science and Technology (2022) Opportunities and Actions for Ocean Science and Technology (2022-2028). https://www.whitehouse.gov/wp-content/uploads/2022/04/03-2022-SOST-Opportunities-and-Actions-for-Ocean-Science-and-Technology-2022-2028.pdf

- Incorporate best practices from federal agencies to increase participation by disadvantaged and historically excluded groups in the ocean community through new and strengthened existing partnerships with Minority Serving Institutions (MSIs), Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), Hispanic Serving Institutions (HSIs), and Asian American, Native American and Pacific Islander Serving Institutions (AANAPISIs) to create pathways for early ocean STEM engagement and retention of diverse talent.

- Leverage emerging opportunities to highlight U.S. ocean science and technology leadership and strengthen the U.S. ocean science and technology enterprise globally, such as through supporting U.S.-led efforts related to the United Nations Decade of Ocean Science for Sustainable Development.

- Encourage NOPP projects to articulate potential broader impacts of the project, such as benefits to individuals, communities, or institutions who have been historically excluded from sciences or the benefits of scientific knowledge; long-term plans for engagement with partners or local communities; and connections between researchers and the end users of scientific products/services. Such impacts should be formulated during the planning stages of projects, engaging external partners and potential audiences on the front end, not as an afterthought on the back end.

- Encourage NOPP projects to create, archive, and serve data that meet FAIR[5] principles of Findability, Accessibility, Interoperability, and Reusability, and CARE[6] principles of Collective benefit, Authority to control, Responsibility, and Ethics.

- Evaluate the program's annual and historical awards to assess portfolio balance among institutions, geography, principal investigator personal demographics, and other criteria to understand the diversity of NOPP awardees and the reach of NOPP.

Considerations for Implementation

Meeting these new objectives and achieving the expectations of NOPP supporters in the Administration and Congress means broadening our participation and moving out in new or non-traditional ways. Some recommendations require actions by each agency to undertake; others involve leveraging the new NOPP Program Office. Considerations include:

- The NOPP Program Office is contracted to host two forums each year. Federal agencies, through the IWG-NOPP, should provide that team with focused forum topics versus a broad call for input to enhance the valuable actions and recommendations of the forums. These forums would benefit from an expanded partnership network that involves non-federal and non-traditional partners. While most partnership participation will be topic-driven, organizing one forum specifically to engage philanthropic organizations in ocean science and technology on emerging federal projects and opportunities could be useful.

- NOPP-sponsored forums should strive for a diverse group of participants and ensure an inclusive environment, and the NOPP-IWG members should consider supporting travel for participants

[5] https://www.nature.com/articles/sdata201618
[6] https://www.gida-global.org/care

from diverse backgrounds to attend NOPP forums, particularly from disadvantaged and historically excluded groups in the ocean community.

- The content and requirements within NOPP opportunity announcements should be revisited, which could include, among other changes, integrating work-based learning opportunities in NOPP opportunity announcements.

- Ocean agencies could better actively exploit intra-departmental or interagency relationships with non-ocean programs that could help to either broaden project participation with non-traditional partners or provide novel financial mechanisms for moving money. This occurs on an agency-by-agency basis. One example is that NOAA could take better advantage of working with other bureaus within the Commerce Department, such as NIST, EDA, MBDA, and NTIA, that already develop public-private partnerships, facilitate tech transfer, and work with local communities on economic development projects and research incubators.

- Though options may be limited, NOPP agencies could expand the scope of known financial vehicles for transferring money outside our programs to support NOPP projects more quickly and directly and try to overcome the lag and disconnect caused by incongruent financial transfers between agencies. Agencies should also look beyond grants and contracts, including, but not limited to, Other Transfer Authorities and innovative funding mechanisms within our agencies and parent departments to move funds more creatively. Furthermore, better leveraging non-monetary contributions and in-kind services between agencies, such as sharing science and technical personnel, maximizing research platforms, and collaborating on components of a project's data pipeline (including archives), must always be considered.

- Before creating new MOUs and CRADAs with philanthropic vessel operators, of which many arrangements are currently in place and some are underutilized, the IWG should inventory what agreements already exist and with whom. While these agreements are specific between one agency and one operator and typically do not transfer funding, NOPP projects involving the agreement's agency can potentially leverage resources and in-kind services, especially valuable ship time, to deploy gear and collect samples and support other at-sea activities.

THE OFFICIAL MAGAZINE OF THE OCEANOGRAPHY SOCIETY

Oceanography

CITATION

Decker, C.J., and C. Reed. 2009. The National Oceanographic Partnership Program: A decade of impacts on oceanography. *Oceanography* 22(2):208–227, doi:10.5670/oceanog.2009.50.

The National Oceanographic Partnership Program

A Decade of Impacts on Oceanography

BY CYNTHIA J. DECKER AND COLIN REED

ABSTRACT. The National Oceanographic Partnership Program (NOPP) was created by the Fiscal Year 1997 Defense Authorization Act. It called for the establishment of a partnership program to promote the national goals of assuring national security, advancing economic development, protecting quality of life, and strengthening science education and communication through improved knowledge of the ocean. Fifteen US federal agencies comprise this partnership, which has expended more than $295M over ten years on a variety of activities. NOPP has been a true partnership among equals that has substantially moved the United States forward in the areas of ocean research, operations, technology, education, and natural resource management. NOPP's funding requirements have spurred the ocean research and education communities to develop strong, long-term collaborations among different sectors—academia, government, industry, and nongovernmental organizations. NOPP has allowed agencies to leverage their funds, increasing the impact of individual agency investment and accelerating the agencies' abilities to meet their high-priority goals. This leveraged investment results in more high-priority tasks getting done in the same time period than would occur if each agency were to fund the work individually. The combination of enhanced, effective partnerships among both funders and performers has resulted in accelerated research in some areas and a stronger voice for oceanography in the research and education communities. This article provides a history of NOPP. It also identifies and discusses specific areas in which NOPP involvement and/or influence has led to significant accomplishment, both through funded research and through intellectual stimulation and inspiration.

INTRODUCTION

In 1992, the National Research Council published a report entitled *Oceanography in the Next Decade: Building New Partnerships* (NRC, 1992). This report was the result of an analysis carried out by the Ocean Studies Board with funding from the Office of Naval Research (ONR), the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the US Geological Survey (USGS). The report addressed the challenges facing the field of oceanography as it moved forward into the twenty-first century. It emphasized the need for both funding agencies and the funded scientific community to advance the field through improved mechanisms for working together. The report provided a number of specific recommendations targeting federal agencies with ocean science and policy missions, and the academic research community. A recurring theme was the need for multiple federal agencies and scientists from all sectors to work together to address research and technology issues, to develop more-effective partnerships, and to better leverage the available financial and human resources. This NRC report formed the basis for the design of the National Oceanographic Partnership Program (NOPP).

Language in the Fiscal Year 1997 Defense Authorization Act (PL 104-201) directed the US Secretary of the Navy to establish NOPP. Since then, the NOPP coalition of 15 federal agencies has fostered the development of an Integrated Ocean Observing System (IOOS), promoted the establishment of a strong ocean education network, enhanced the development and use of advanced modeling and data assimilation techniques, encouraged improvements to ocean research and operational infrastructure and technology, and promoted science-based management of the nation's ocean resources. It has accomplished all of these things by identifying and funding specific topics in ocean sciences, by sponsoring workshops and working groups to develop concepts and plans, and by preparing strategic documents for use by federal agencies, research institutions, the private sector, and the general public. In recognition of NOPP's ten-year anniversary and to inform the federal ocean governance structure of its accomplishments and "lessons learned," this article summarizes NOPP's history, considers its impacts over the past decade, and describes resulting changes in federally funded ocean programs and performers.

NOPP STRUCTURE AND FUNCTION

The original NOPP governance structure responded to the following objectives listed in the FY1997 Defense Authorization Act:

1. To promote the national goals of assuring national security, advancing economic development, protecting quality of life, and strengthening science education and communication through improved knowledge of the ocean.

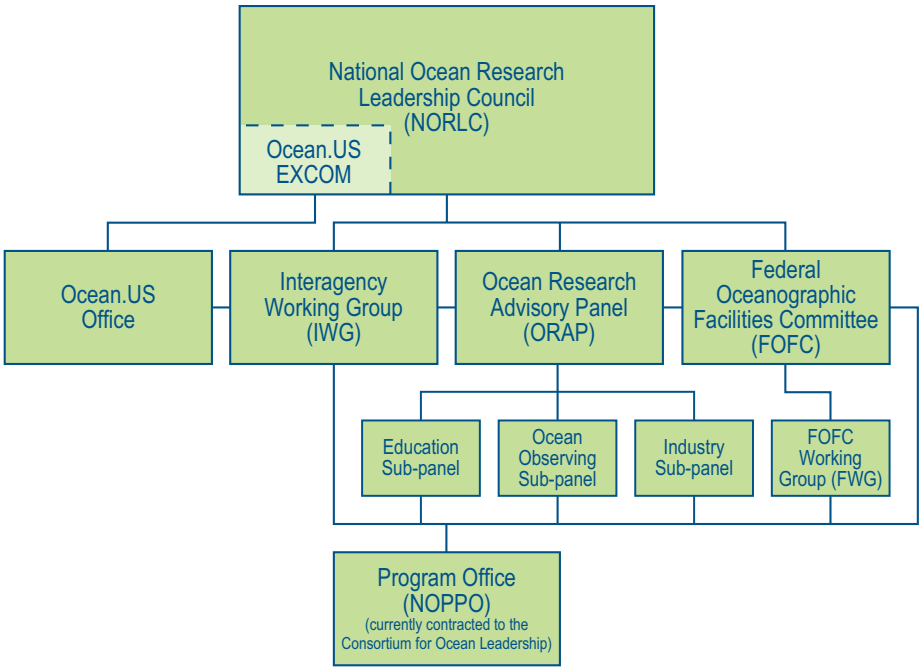

Figure 1. National Oceanographic Partnership Program structure as created by the 1997 Defense Authorization Act (PL 104-201) and modified over nine years into today's structure (Figure 2).

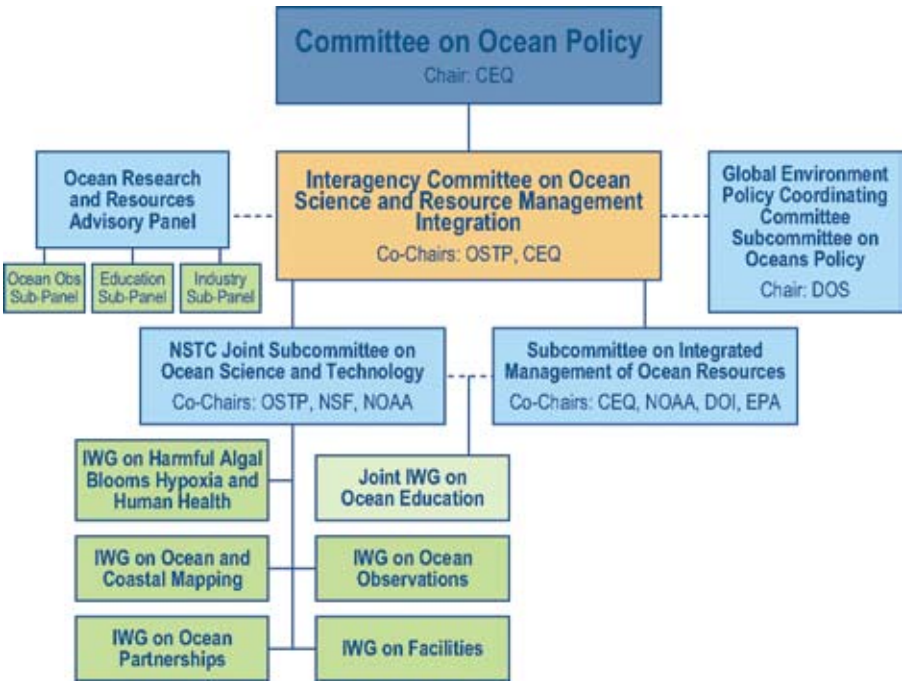

Figure 2. The Ocean Governance Structure created in 2004 by Executive Order 13366 and the accompanying US Ocean Action Plan (CEQ, 2004) originally established this governing body. This group has since expanded to include many of the interagency working groups and subcommittees listed above.

2. To coordinate and strengthen oceanographic efforts in support of those goals by
   a. identifying and carrying out partnerships among federal agencies, academia, industry, and other members of the oceanographic scientific community in the areas of data, resources, education, and communication, and
   b. reporting annually to Congress on the program.

Figure 1 shows the original NOPP structure. The National Ocean Research Leadership Council (NORLC), the Ocean Research Advisory Panel (ORAP), and the NOPP Program Office were specifically created under the 1997 legislation.

In 2006, the NOPP structure transitioned into a broader ocean governance structure (Figure 2) that was created in 2004 by Executive Order 13366 and the accompanying *US Ocean Action Plan* (OAP; see CEQ, 2004). The Executive Order and the OAP constituted the Bush Administration's response to the 2004 report of the US Commission on Ocean Policy, *An Ocean Blueprint for the 21st Century* (USCOP, 2004). The NOPP program, and its functions and responsibilities, continue to exist under this structure. NORLC was subsumed into the Interagency Committee on Ocean Science and Resource Management

Cynthia J. Decker *(cynthia.decker@noaa.gov) is Executive Director, National Oceanic and Atmospheric Administration (NOAA) Science Advisory Board, Silver Spring, MD, USA.* **Colin Reed** *is on the staff of the National Oceanographic Partnership Program Office, Consortium for Ocean Leadership, Washington, DC, USA.*

Integration (ICOSRMI), and the NOPP Interagency Working Group (IWG) became the IWG on Ocean Partnerships (IWG-OP) under the Joint Subcommittee on Ocean Science and Technology (JSOST). ORAP remains as advisory to the ICOSRMI; it has taken resource management under its purview and now operates as the Ocean Research and Resources Advisory Panel (ORRAP).

The current functions of NOPP are defined under the NOPP *Ten-Year Strategic Plan* (NOPP, 2004). Funding is organized around the four strategic goals and investment areas identified by the plan:

- to achieve and sustain an Integrated Ocean Observing System (IOOS)
- to promote lifelong ocean education
- to modernize ocean infrastructure and enhance technology development
- to foster interagency partnerships that will increase and apply scientific knowledge

These four areas build on strengths that NOPP developed in its formative years, yet look to the future of oceanography in the twenty-first century.

NOPP'S IMPACT

From 1997 to 2008, NOPP member agencies oversaw the expenditure of $295M on 132 ocean research and education projects (Figure 3). Additional funding was committed by nonfederal entities as well as by the agencies for activities that were inspired by NOPP but are not specifically under NOPP control. An assessment of the impacts that the NOPP program has had on the "ocean enterprise" in the United States, however, cannot be gleaned simply from looking at the total dollar amounts expended and number of projects supported. One of NOPP's key impacts has been its influence beyond specific projects, including reports and analyses on research policy, concepts that have evolved out of discussions among the various ocean sectors, and changes that have occurred in the ocean funding and research communities as a result of all these activities. NOPP is a relatively small program in comparison with full agency research programs, but when the number of studies implemented and dollars spent are measured against the influence it has wielded, its impact on the ocean sciences has been well beyond what might have been expected for such a limited program. The discussion presented here identifies specific topic areas in which NOPP involvement and/or influence has led to significant accomplishments, not only through funded research but also through intellectual stimulation and inspiration.

Ocean Observations

Ocean observations have been a theme since the program's inception. As a reflection of this focus, the first goal of NOPP's *Ten-Year Strategic Plan* (NOPP, 2004) is to "achieve and sustain an Integrated Ocean Observing System (IOOS)." NOPP has addressed the topic of ocean observations in many ways. Establishment of ocean observatories was a topic of the NOPP research Broad Agency Announcement (BAA) in its first year and has continued to be a focus in every BAA since then. The 1997 BAA called for proposals in broad-based research on infrastructure, including "regional consortia approaches for ocean and atmosphere observing capabilities, development and application of advanced and/or long-term capabilities for in situ and remote observations." The proposals funded in this area formed the basis for the first regional observing

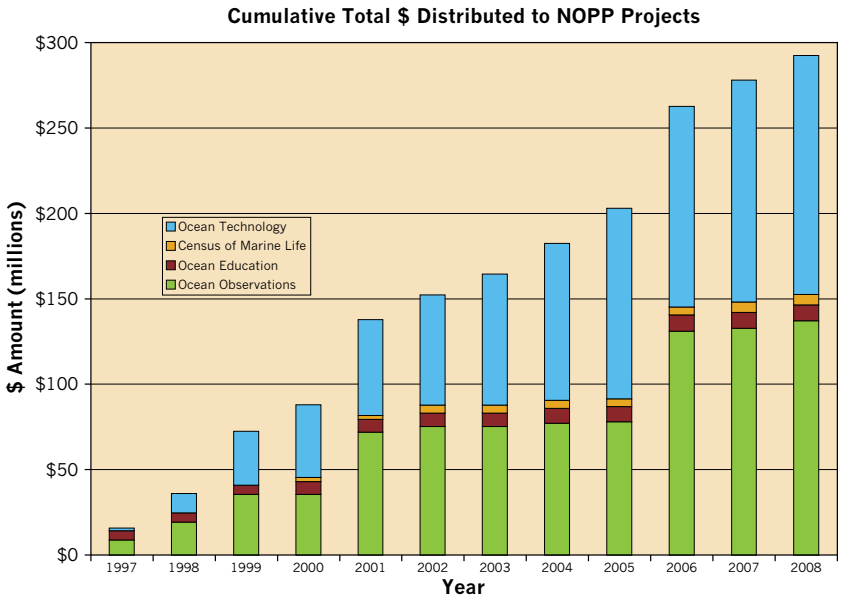

Figure 3. Cumulative total dollars distributed to NOPP projects. From 1997 to 2008, NOPP member agencies oversaw the expenditure of $295M on 132 ocean research and education projects. *Courtesy of the NOPP Program Office*

systems in the United States and were followed thereafter by others funded through NOPP and, eventually, through ONR, NOAA, and other federal agencies outside of the NOPP process, in locations around the country. There are currently 11 Regional Associations (RAs) that form parts of the IOOS (Figure 4). Several of these RAs can directly trace their lineage to either NOPP-funded proposals or to agency funding that was later linked to the NOPP program (Frye et al., 1999; Blaha et al., 2000; Glenn et al., 2000a, 2000b; Glenn and Schofield 2003, this issue; Seim 2000; Seim et al., 2003; Seim and Mooers, 2008). Each of these research efforts served as the basis for an operational regional coastal ocean observing system; these RAs and systems have become the key operational component of IOOS being implemented today.

In addition to funding the first few ocean observatories in the field, NOPP—in its second year—initiated the conceptual development of the nationwide IOOS. In August 1998, Rep. Curt Weldon (R-PA) and Rep. James Saxton (R-NJ) requested that NORLC "propose a plan to achieve a truly integrated ocean observing system." This request followed the National Ocean Conference (Year of the Oceans) in June 1998 and a House hearing on ocean observations in July 1998. NORLC established a Task Team that released a report in April 1999 entitled "Toward a US Plan for an Integrated Sustained Ocean Observing System" (Nowlin and Malone, 1999). This plan formed the basis for the development of the US IOOS. It first articulated what an integrated, sustained system should look like and the crucial issues to be addressed, including the societal needs that such a system would help address. This report built on work done for the Global Ocean Observing System (GOOS) to identify the critical US components of the open-ocean and coastal systems. However, it only briefly examined what would be needed to implement such a system.

In mid 1999, ORAP empaneled a second Ocean Observations Task Team to build on the first report. In December 1999, this group submitted to NORLC a successor report entitled "An Integrated Ocean Observing System: A Strategy for Implementing the First Steps of a US Plan" (Frosch et al., 1999). This report, unlike its predecessor, examined the governance, management, and funding structure that would be required for a successful integrated ocean observing system. It also addressed ocean infrastructure and education needs as part of the overall system. Following publication of these two reports, the federal agencies set up Ocean.US, the National Office for Integrated and Sustained Ocean Observations, in 2000 to coordinate IOOS efforts. NOPP agencies also convened a process with the oceanographic community that resulted, by mid 2003, in detailed IOOS development and implementation plans.

In the same time frame as the events described above (2001–2004), the President signed into law the Oceans Act of 2000 (PL 106-256), which established the US Commission on Ocean Policy (USCOP). This advisory body spent three years examining all aspects of ocean issues in the United States and produced a comprehensive report on the subject (USCOP, 2004). One entire chapter of that report was dedicated to "Achieving a Sustained, Integrated Ocean Observing System." Building on the work of NOPP and Ocean.US, the Commission considered the testimony of hundreds of individuals around the country and formulated 12 recommendations for an integrated ocean observing system. These recommendations formed the basis for a set of OAP actions that address the development of IOOS. Although still part of the NOPP structure, IOOS governance has moved beyond NOPP with the

Figure 4. Eleven Regional Associations that form part of the Integrated Ocean Observing System. Several of these can directly trace their lineage to NOPP-funded proposals. *Courtesy of NOPP Program Office*

establishment in 2006 of the Interagency Working Group on Ocean Observations (IWGOO) under JSOST. Through the ocean governance structure established by OAP, the federal government will be better able to implement IOOS.

IOOS is the perfect example of an effort that required multiple agencies to work together to be successful, and it has resulted in a nascent system that is greater than the sum of its parts. Without the chain of events that started under NOPP and culminated in the congressional testimony presented in the summer of 1998, the request from Representatives Weldon and Saxton to develop the IOOS might not have happened—neither within an interagency context nor possibly at all. If not for NOPP, development of the technology, communications networking, and data management required for a successful IOOS would not have started in as short a time frame. If not for NOPP, IOOS would not have created the interagency, intersector governance and implementation structure that it has now.

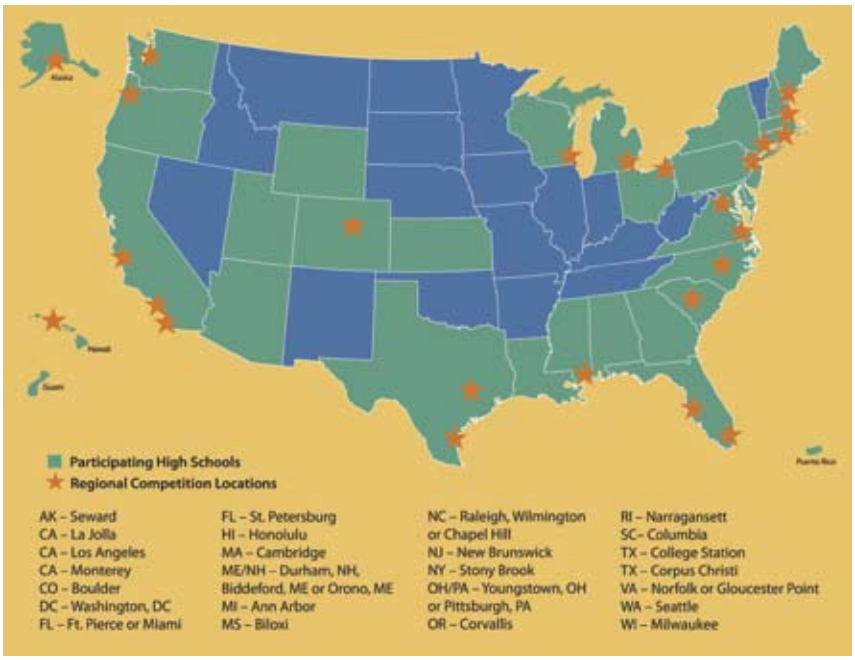

Figure 5. Twenty-five National Ocean Science Bowl Regional Sites supported by NOPP involving students from more than 30 states and territories. *Courtesy of NOSB Program Office*

Ocean Education

As with observations, one of the first topics to receive attention from NOPP was education. Earlier documents, such as the *Oceans 2000* report (Spinrad and Watkins, 1996), noted that, in order to garner broad public support for ocean research and management, it is crucial for people to receive accurate information about the ocean, starting early in life and continuing into adulthood. The NOPP legislation specifically reflected this position. Although the NOPP agencies firmly believed in the importance of providing support for ocean education, gaining support within NOPP agencies has been difficult. Each agency supports education at different levels—K–12, undergraduate, graduate, and postgraduate. Some agencies are able to support all categories while others can justify support only for graduate or postgraduate studies. However, K–12 education has been identified by interested educators as a particular need in the ocean sciences because the ocean is an area of study that usually emerges as a topic only after high school and is not typically taught below that level.

NOPP agencies chose to provide funding immediately for K–12 ocean education projects under the first BAA in 1997. NOPP funded five projects at that time:

- Bridge (http://www.vims.edu/bridge) (Clark et al., this issue)
- Project Oceanography (http://www.marine.usf.edu/pjocean)
- COAST: PILOT (http://www.create.cett.msstate.edu/cett/coast-pilot.asp)
- The LEO-15 COOL Classroom (http://www.coolclassroom.org/home.html)
- The Jason Project (http://www.jasonproject.org/).

NOPP also later endorsed another education program that was already being supported by many of the member agencies: the National Ocean Sciences Bowl (NOSB; http://www.nosb.org). NOSB is a high school competition in which teams compete at the regional and national levels (Figure 5). The program strives to inspire students to continue to study the ocean sciences as they go on to college.

Because of the concern over lack of agency support for ocean education, ORAP also chose to focus some of its efforts on this issue. In early 2001, ORAP members indicated concern that

the NOPP agencies had not developed a long-term strategy for ocean education that would include mechanisms for sustaining the extremely successful NOPP-supported education projects. Also in 2001, the NOPP IWG established an ad hoc advisory group on ocean education. This group developed a brief set of recommendations that were brought to ORAP in early 2002. By September 2002, ORAP had produced a report entitled "A National Strategy to Improve Ocean Literacy and Strengthen Science Education through Improved Knowledge of the Oceans and Coasts." This report formed the basis for the goal in the NOPP *Ten-Year Strategic Plan* to "promote lifelong ocean education."

Highlighting the importance of ocean education, USCOP dedicated a chapter of its report to this subject and articulated 17 recommendations for moving the federal government forward on this topic (USCOP, 2004). USCOP drew its inspiration from the ORAP findings in many areas, and many of its recommendations echo those in the ORAP Education Strategy. As a response to this report, the OAP contains a section called "Promoting Lifelong Ocean Education." This emphasis has been carried forward into the OAP structure with the establishment of the Joint Interagency Working Group on Ocean Education, which operates under both JSOST and Subcommittee on the Integrated Management of Ocean Resources (SIMOR) (Figure 2).

Without NOPP, the initial ocean education projects would not have been funded and sustained; these projects have provided the intellectual seeds leading to significant ocean education programs at NSF, NOAA, and other agencies. From an initial investment by ONR of just over $5M in FY1997 for five projects over two years, to approximately $9.5M spent in FY2005 by NSF and NOAA, ocean education efforts in the United States supported by the federal government have grown and may increase. Given that it is often difficult for mission agencies to fund education projects, the success of NOPP education projects has enabled some of these agencies to better justify such efforts and move forward to develop and fund ocean science education efforts.

In addition to helping change the culture of ocean education funding at some of the federal agencies, the support that NOPP provided also helped change the perception of education at some academic institutions. The funded projects allowed faculty at universities to cross the cultural divide between research and education communities to spend time and effort on ocean education below the graduate level. In this way, NOPP has contributed to a new pattern of support for ocean education at the K–12 level among science faculty and graduate students. Increased ocean literacy in the United States may owe some of its success to the first small projects funded through NOPP.

Ocean Technology

NOPP has a long-standing commitment to the new and innovative technology required to answer important questions about the ocean in the twenty-first century (Figure 6). The technology used by oceanographers has expanded greatly in the last century beyond samplers requiring long post-cruise processing times, manned platforms, and labor-intensive systems for data input and analysis. Huge advances in environmental sensors to gather both in situ and remote data and the platforms that hold them have been made just in the past ten years. In addition to methods for collecting data, the hardware and software for data communications and analysis have also greatly improved. In

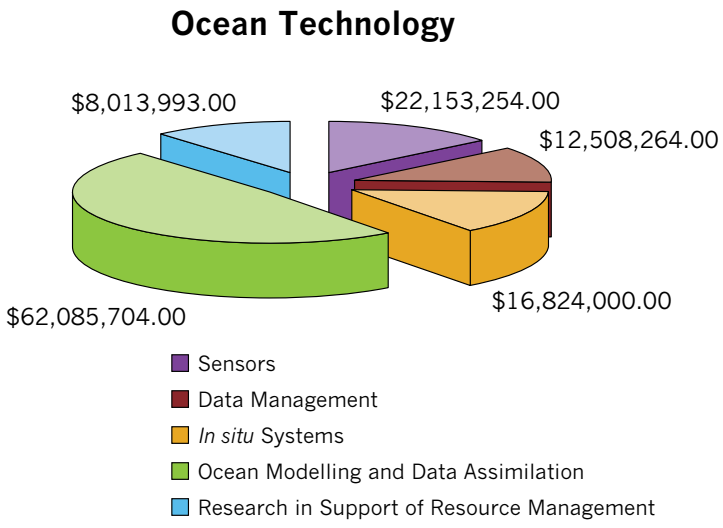

Figure 6. Total NOPP dollars spent on ocean technology. *Courtesy of the NOPP Program Office*

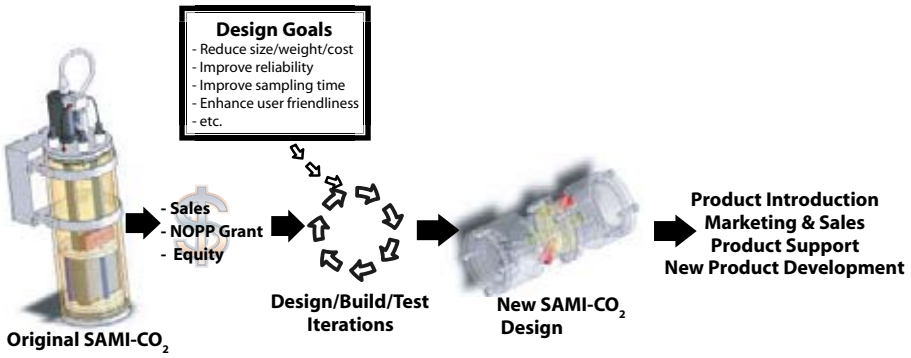

Figure 7. Funded under the 2004 Broad Agency Announcement, Michael DeGrandpre and his partners used NOPP funding to promote commercialization of the SAMI-CO_2, a sensor developed for autonomous measurements of the partial pressure of CO_2 (pCO_2). *Courtesy of M. DeGrandpre and J. Beck*

combination, these technologies have significantly increased understanding of the ocean.

NOPP has funded and fostered the development of a number of new sensors, particularly in the disciplines of chemistry and biology, which lag behind advances in measuring and providing data on physical parameters. These sensors range from those that measure particulate inorganic carbon from profilers (Bishop, this issue) to DNA molecular probes for use with small water samples (Scholin et al., this issue). NOPP has also focused on transitioning sensors from research to commercial use (Figure 7). Each of the projects funded under this topic already had an in situ sensor designed, built, and tested for use in academic research, and nearly ready to be taken up by the commercial sector to be produced for routine use. In each case, the sensor required a little more development and testing in order for it to evolve from a custom-designed, custom-made product to one that is mass-produced and readily available to a broader clientele. These funds were specifically given to research-industry partnerships with the end product being a sensor ready to become commercial, off-the-shelf technology (Martz et al., 2006; Seidel et al., 2008).

In addition to ocean sensor development, NOPP agencies have funded several projects on the design and development of platforms for deploying the sensors. These platforms include autonomous drifters, unmanned vehicles, and a fixed, cabled observing system. Many areas of the ocean are not accessible to humans from surface ships, moored arrays, or manned submersibles. Even accessible areas cannot be sampled continuously from traditional platforms. The Argo program is the fruit of a concept for using autonomous drifting buoys that are rugged enough to remain at sea for long time periods, collecting temperature and salinity profiles and sending these data back routinely via satellite. The data are made available via the Internet to anyone and can be used for a variety of purposes (Argo Science Team, 2001; Gould et al., 2004; Roemmich, this issue). Remotely operated or autonomous vehicles of various kinds have been developed and are now being relied upon for exploration of and access to many ocean areas over longer time periods. NOPP has been on the forefront of this technology by supporting several projects, ranging from design and development of new vehicles to advanced use of existing vehicles (Eriksen and Perry, this issue). One of the first NOPP awards made possible the initial design concept of the North-East Pacific Time-Series Undersea Networked Experiments (NEPTUNE), a fixed system off the coast of Washington state (NEPTUNE Phase I Partners, 2000). This project was originally conceived as a geophysical project to "wire" an entire continental plate in order to gather data on the processes that govern the behavior of such structures (Figure 8). NEPTUNE has evolved since the initial design phase into a concept for monitoring and conducting experiments on an entire ecosystem, from the inshore zone to deep waters, including communities associated with geologically active zones, fisheries, and complex current systems. The cabled network makes up one piece of the NSF Ocean Observatories Initiative (OOI) that is beginning to construct networks of ocean observatories for research purposes (Given, 2007). OOI represents an exciting new multi-million-dollar investment in oceanographic infrastructure of the kind that has been reserved in the past for other disciplines such as astronomy, high-energy particle physics, and geology. Early investments by NOPP in ocean observatories and technology paved the way for the success of this effort.

In addition to sensors and platforms, another aspect of technology that has received considerable attention from

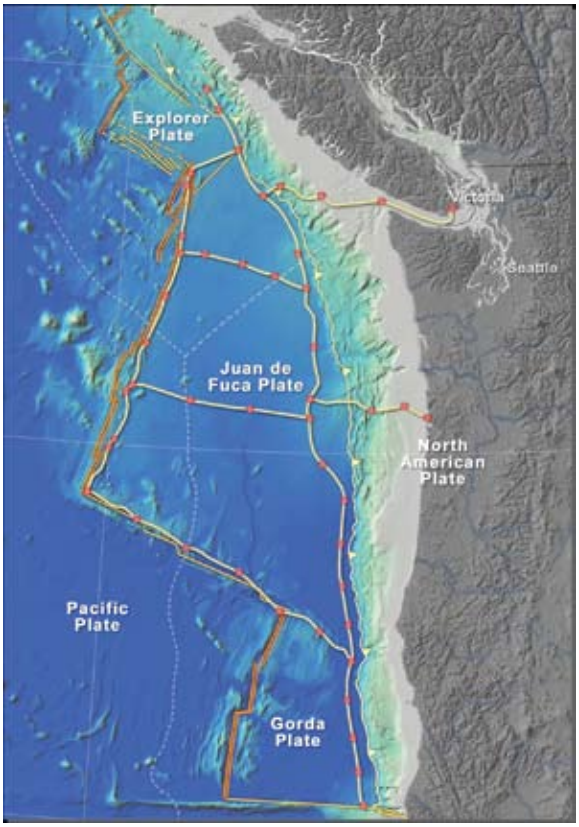

Figure 8. Layout of the originally proposed NEPTUNE undersea cabled network off the coast of Washington and Oregon. *Courtesy of the OOI Program Office*

the NOPP program is information technology and data management. The advent of satellite remote sensing and real-time streaming of physical oceanographic and atmospheric data from these instruments as well as from those that can be used on aircraft or deployed on moored or drifting floats in the water has created a need for systems that can handle large volumes of electronic data. Large amounts of data must be stored, processed, archived, and made accessible to a wider community. In oceanography, as in most of the environmental sciences, the accumulation rate of data is outstripping the ability of computing and data centers to handle it. Although NOPP quickly recognized that improving the performance of both hardware and software is not within its purview and, indeed, is being addressed by other entities, it was clearly within the mandate of NOPP to examine how ocean data are being archived and served to the larger community. At the same time, the NOPP agencies recognized that each of them had been tackling the issue of data management separately and that there must be an effort to coordinate agency activities and provide a common means for all ocean data to be handled. As a result, NOPP funded the formation of a National Virtual Ocean Data System (NVODS) that continues to evolve with the science and technology (Cornillon, this issue).

At the same time that NOPP funded NVODS, it also chose to support another data management effort, the Ocean Biogeographic Information System (OBIS) (http://www.iobis.org/). The central concept of OBIS is a Web-based portal that can be used to search for and access marine biological data held and managed at locations around the world (Figure 9). OBIS and NVODS were the first significant efforts made in the US ocean community to break away from the concept of holding data in a physically central location and move toward a distributed "system of systems."

Although NOPP is not the only program that has fostered the work on sensors, platforms, and data analysis and communications, it has done so in the context of its broader theme of ocean observatories and has emphasized the need for better and real-time measurements in chemical and biological parameters. Without NOPP, this research would have proceeded but likely not in as focused a way nor in the context of the need for an integrated ocean observing system.

Ocean Modeling and Data Assimilation

One of the largest areas of NOPP investment has been multi-investigator projects to advance the modeling of oceanographic processes. Because of the NOPP project requirement for participation among different sectors, scientists put together several innovative and highly successful collaborations between academia and government. These projects ranged from global circulation models to geographically

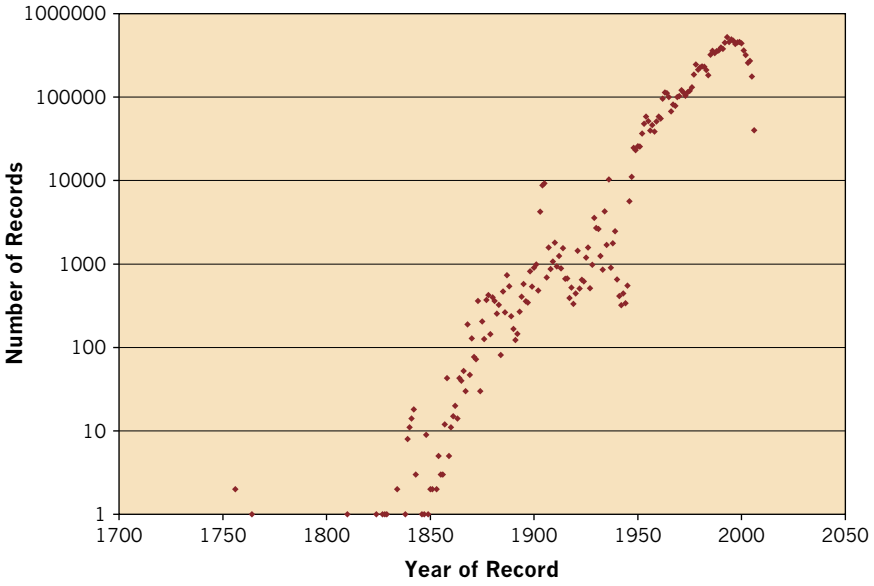

Figure 9. The Ocean Biogeographic Information System (OBIS) is used to search for and access marine biological data held and managed at locations around the world. The graph shows the number of records in the OBIS database for each year of collection. *Courtesy of E. Vanden Berghe, OBIS Secretariat*

specific models (Babson et al., 2006) and from hurricane storm surges (Graber et al., 2006) to ecosystems (Doney et al., 2004; Rothstein, 2006). Notable among these projects is the HYbrid Coordinate Ocean Model (HYCOM) (Chassignet et al., 2006; Hurlburt et al., 2008) and Estimating the Circulation and Climate of the Ocean (ECCO) (Stammer et al., 2002, 2003; Wunsch and Heimbach, 2007; Wunsch et al., this issue). These global modeling efforts combined basic academic research innovations with the operational systems of mission agencies (NASA, NOAA, US Navy) to provide significant advancements in climate and operational models used for predictive purposes (Figure 10). HYCOM and ECCO were also part of the Global Ocean Data Assimilation Experiment (GODAE), major aspects of which were supported by NOPP. The HYCOM and ECCO projects allowed GODAE to move forward by effectively building research infrastructure into operational agencies (Chassignet et al., 2006, this issue). As a result of the successful HYCOM and ECCO efforts, NOPP

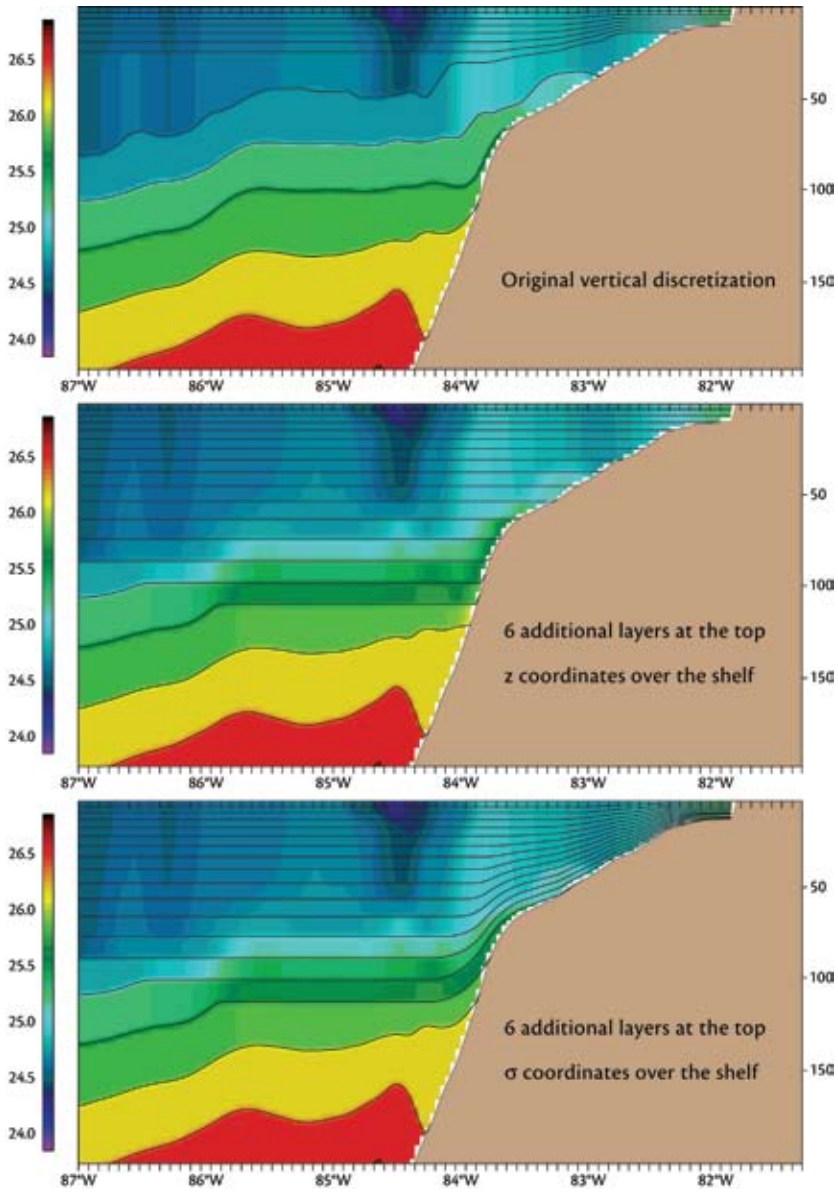

Figure 10. Example of model products from the HYbrid Coordinate Ocean Model (HYCOM; Chassignet et al., 2006).

funded three spin-off projects, collectively called the Coastal Ocean Data Assimilation Experiment (CODAE), that use the GODAE models to establish the boundary conditions necessary to run predictive models in the more physically complex nearshore zones of the Untied States.

NOPP also identified several more narrowly focused topics in the realm of data assimilation that have allowed mission agencies to work together to demonstrate ways to assimilate specific data sets in an operational mode (Barron and Kara, 2006; Castro et al., 2008; Chassignet et al., 2007; Gentemann et al., 2008, this issue; Chang and Jelenak, 2006; Jelenak and Chang, 2008; Chang et al., this issue).

None of the large modeling projects would likely have been funded by any single agency at the level provided through NOPP. The program fostered discussions of modeling and data assimilation among the agencies and led to the support of this suite of studies as pilot projects. These projects have proven to be of great use to the entire community by improving basic understanding of ocean processes and improving operational predictions. The narrower data assimilation projects were equally unlikely to be funded by either the research or the operational agencies alone, but NOPP provided an opportunity for these agencies to agree on a way to work out funding for these transition projects. Each of the projects has resulted in a capability being implemented within an operational agency that allows for better collection and processing of data on a routine, long-term basis.

Research in Support of Resource Management

Although NOPP is essentially a research program, its governance by a number of mission agencies as well as science agencies has led to some emphasis on the transition of research results into applications. NOPP has sponsored research that is directly tied to information critical for the management of both living and nonliving marine resources. Topics funded include research on marine mammals, techniques for finding finfish, and exploration of the Gulf of Mexico's natural and cultural resources. These topics provide examples of how the partnering and leveraging nature of NOPP works equally well in the research application realm.

In 2000, the Alfred P. Sloan Foundation, a not-for-profit organization, and the NOPP agencies agreed to introduce a biological oceanography theme consistent with the NOPP paradigm of decentralized data archives and partnered ocean observing programs. In this context, a marine mammal topic was introduced to NOPP in 2002 under the OBIS framework. At the same time, many federal agencies shared interests in examining the questions surrounding the impacts of anthropogenic sound on these organisms. These two issues resulted in the funding of a suite of projects aimed at collating existing data on marine mammals, turtles, and birds as well as a set focused on the impact of sound on marine mammals. Projects funded included a database of marine mammal, bird, and reptile distribution and abundance around the world (SEAMAP), as part of the larger OBIS system (Halpin et al., this issue). Another project, Tagging of Pacific Predators (TOPP), was funded as part of a call for innovative technologies. This project employed microprocessor-based satellite tags for use in tracking large, open-ocean organisms, including seabirds, whales, sea lions, sea turtles, fish, and other species (Figure 11; Shaffer et al., 2006; Biuw et al.,

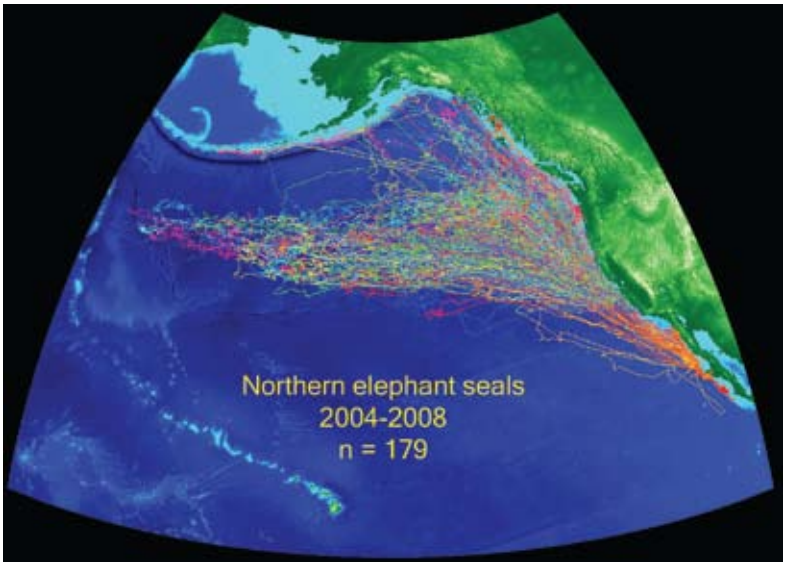

Figure 11. An example of Tagging of Pacific Predators (TOPP) technology used to track elephant seals. *Image courtesy of Patrick Robinson, TOPP-UC Santa Cruz*

2007; Charrassin et al., 2008; Kuhn et al., 2008; Villegas-Amtmann et al., 2008). This project provided a means of delivering both biological and physical oceanographic data in amounts and areas of coverage previously impossible to deliver by any other measurement. The sponsoring partners of these projects included both science and resource agencies.

As per the NOPP model, the marine mammal research has allowed the agencies to leverage each other's funds, increasing the impact of individual agency investment. This leveraged investment resulted in more high-priority tasks being accomplished in the same time period than would have occurred if each agency had funded the work individually. NOPP accelerated the ability of those agencies to meet their goals for marine mammal research. In addition, the NOPP peer-review process added a layer of unbiased review of the scientific merit of these projects to the often controversial topic of marine mammal research. This review improves confidence in the independence and quality of scientific papers and other products that result from the research.

NOPP initiated several projects to explore new methods for finding and mapping finfish and their habitats in FY2005. Particular emphasis was placed on the use of low-frequency acoustic methods, including signal processing and comparison to other methods, and use of improved advanced acoustic and optical methods (Anderson et al., 2007; Benoit-Bird, in press; Churnside, 2008, 2009a, 2009b; Horne, 2008; Makris et al., 2006, 2009). This information will be useful for agencies trying to develop means of sustainably managing commercially important living resources by providing more accurate data on the use of areas by fish and the factors that cause these patterns of use.

The development of energy resources from the deep sea is becoming increasingly important to the US economy. In the US Exclusive Economic Zone, the western Gulf of Mexico has become an area with a great deal of exploratory and extractive activity by the oil and gas industry. At the same time, a number of diverse and vibrant communities of organisms have been found at great depths, and there is concern that these unique communities might be adversely impacted by energy exploration and extracting activities if they are not identified and assessed. In addition to the natural communities, the Gulf is also the site of a number of historically important shipwrecks. The location of both natural and human cultural resources was investigated through several NOPP-funded projects. The CHEMO (Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico) project explored the unique deep-water, cold-seep communities, ultimately comparing them with similar communities elsewhere (Cordes et al., 2007). Another project explored both natural and cultural resources by examining the use of World War II shipwrecks as artificial reefs (Church et al., this issue). The value of developing and funding this work through NOPP was that it allowed the Minerals Management Service (MMS), the agency with responsibility for issuing oil and gas leases, to partner with NOAA, the agency with the mandate and capabilities to explore and document new biological communities and cultural heritage sites in the deep ocean. NOPP provided the best available mechanism for these two agencies to combine their interests and leverage funding.

OCEAN INFRASTRUCTURE

The NOPP program addresses the big issues facing ocean science. For that reason, it has also tried to ensure coordination in the ocean science community on the status and future of the infrastructure needed to support ocean research. Oceanography has always been carried out from sea-going ships; the advent of satellites and other forms of remote sensing has not changed this tradition. If anything, the use of satellites for oceanography has increased the need for ships. The dependence of the ocean research community on ships means that a dedicated research fleet must be maintained. A nonfederal consortium, the University-National Oceanographic Laboratory System (UNOLS), oversees the operations of the academic oceanographic fleet. In addition to the academic fleet, there are a number of oceanographic vessels that the mission agencies of the federal government maintain. Universities and federal laboratories also build and maintain smaller research platforms such as remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), manned submersibles, and underwater cabled observatories.

To ensure coordination among the federal agencies for the ships and other research platforms, NOPP adopted an existing federal group, the Federal Oceanographic Fleet Coordinating Council (FOFCC), expanded its charter, revised its name to reflect this broader mandate (Federal Oceanographic Facilities Committee, FOFC), and

incorporated it into the NORLC reporting structure. In 2006, FOFC was transitioned into the new OAP ocean governance structure as the Interagency Working Group on Facilities (IWG-Facilities). After incorporation under NOPP, FOFC issued a strategic plan for renewal of the academic research fleet (FOFC, 2001) as well as a small brochure that described the government-sponsored fleet of aircraft dedicated to ocean research. This 2001 Fleet Plan was revised and expanded in 2007 (IWG-Facilities, 2007). Although FOFC existed before NOPP, NOPP provided it with a more effective reporting structure and entrained a larger group of agencies to provide input and coordination. IWG-Facilities continues efforts to identify the range of other existing oceanographic platforms that could be managed or at least overseen in a more coordinated fashion, such as ROVs, AUVs, gliders, and submersibles. To date, however, most of those vehicles remain experimental and have not transitioned into the true operational status that would require the kind of coordination that UNOLS and IWG-Facilities provide for ships and aircraft.

IMPACT SUMMARY

NOPP has accomplished a great deal in a relatively small amount of time and with limited funding. It has been responsible for advancing ocean science and education in a number of critical areas on a rapid timeline. It has fostered the creation of a cadre of ocean researchers who are comfortable working collaboratively among sectors in ways that were not common ten years ago. The development of partnerships among researchers, particularly among the various sectors—academia, government, industry, and nongovernmental organizations—has increased and, arguably, become easier through the NOPP process. Initially, most proposals submitted to NOPP came from members of the academic community with perhaps a few government investigators. Industry was usually listed as a partner if the research group planned to purchase an instrument from a commercial firm as part of the research. The funding agencies, however, saw this problem and moved quickly to educate the community on the need for "real" partnerships, that is, genuinely collaborative work in which all partners had a vested interest in the results and worked together as part of a team. Early NOPP grantees bore the brunt of the learning curve on this new way of doing business, but the NOPP agencies helped the new projects develop the necessary management skills. In addition, NOPP created the Excellence in Partnering Award (see Box 1) to recognize investigators who succeeded in creating good partnerships and could, therefore, stand as models to the scientific and education communities. After ten years, NOPP has nurtured a group of ocean scientists and program managers across sectors of the oceanographic community that has the vision and skills to work together in large, relatively long-term efforts toward a common goal. NOPP has helped bring these communities into partnered research more quickly and comprehensively than might have happened if they had continued to be funded in the usual way, as single investigators on single-discipline projects of interest to only one agency.

NOPP has produced a well-established process by which the federal ocean agencies identify and fund topics in which they have a shared interest, leveraging limited funding and accelerating the research to address these topics. Although the NOPP funding agencies quickly came to understand and foster partnerships among researchers, achieving the same kind of synergy among the agencies themselves has been a challenge. As with the different research sectors, each agency has its own "culture." The first step was to develop a common understanding among the NOPP agencies of the constraints on each other's funding processes. In addition, federal agencies are restricted from moving appropriated funds to other federal agencies if not on a reimbursable basis, forcing the NOPP partners to find the best ways to leverage each other's abilities to fund various topics and projects. This limitation has been a challenge to progress, but efforts continue even as NOPP has moved into the OAP structure of governance. It is important, as the OAP structure evolves, that the NOPP agency participants be included in that structure so that they can bring their expertise and extensive knowledge of cross-agency funding mechanisms and provide recommendations on ways to improve the system. The lessons learned through the NOPP process, and the trust developed among the participants, have been crucial elements to NOPP's success. Those qualities must not be lost.

NOPP, as originally conceived, was aimed at partnering on three levels—among scientific investigators, among federal agencies, and among congressional committees that have responsibility for authorizing and appropriating funds for ocean activities.

BOX 1. NOPP EXCELLENCE IN PARTNERING AWARD

The emphasis in NOPP on partnering means that funded projects must be carried out by investigators representing different sectors. Because this way of doing research is not typical for most oceanographers, it means that the successful NOPP Principal Investigator (PI) must learn how to coordinate the work of people from organizations with differing missions, priorities, and cultures in order to achieve a successful outcome. In 2001, NOPP agencies decided to recognize PIs who proved to be particularly successful at organizing and coordinating these efforts, and thus instituted the NOPP Excellence in Partnering Award. The award has two purposes: (1) to recognize the successful efforts of the partners in conducting a superior project and (2) to identify to the ocean sciences community and its supporters what constitutes a successful NOPP effort. Typically, the award is given annually to one completed NOPP-funded project that best exemplifies NOPP partnership objectives and successfully addresses at least one of the national goals put forth in the National Oceanographic Partnership Act (national security, economic development, quality of life, science education). Each of the winners of this award exemplifies a study with equal commitment by all the partners that has resulted in products that could not have been achieved without the participation of all the different sectors.

The following projects have been awarded the NOPP Excellence in Partnering Award.

2001 | The Bridge Project

Bridge, whose title connotes the bridge of a ship rather than a bridge over an obstacle, is meant to be a filter for high-quality Web sites on marine science education. It is a collection of high-quality, online educational tools for science teachers at the K–12 level. Criteria used to select sites to appear on the Bridge's Web site are usefulness, content, level of Web technology, and ease of use.

Partners

- Virginia Institute of Marine Sciences
- NOAA, Virginia Sea Grant College Program
- National Marine Educators Association

2001 | The South Atlantic Bight Synoptic Offshore Observational Network

The South Atlantic Bight Synoptic Offshore Observational Network (SABSOON) uses Navy towers built off the coast of Georgia for military training purposes. The towers provide power and high-speed data access to SABSOON's oceanographic sensors. The objectives of the project are basic interdisciplinary research, coastal ocean monitoring, sensor testing, and outreach and education. Areas of interest for research include cross-shelf exchange of water masses, optics, air-sea interaction, and fisheries.

Partners

- Skidaway Institute of Oceanography
- University of North Carolina, Chapel Hill
- US Navy (Tactical Air Combat Training System, Naval Warfare Assessment Station)
- University of Georgia
- US Environmental Protection Agency
- South Carolina Department of Natural Resources
- NOAA, Gray's Reef National Marine Sanctuary

Continued next page...

2002 | Coastal Marine Demonstration Project

The Coastal Marine Demonstration Project (CMDP) was a two-year effort funded by NOPP that developed, improved, delivered, and evaluated experimental marine forecast products for mariners of the Chesapeake Bay and surrounding coastal ocean. The partnership was a collaboration of academic, private industry, government, and private citizens. CMDP provided high-resolution model information, down to 800 m, which was not otherwise available to users and forecasters. The high-resolution forecast fields were based upon models with appropriate regional resolution that are capable of reproducing the atmospheric, oceanic, and estuarine circulation seen in the coastal environment. Important forecast fields were surface winds, waves, water level, currents, water temperature, salinity, visibility, and ship ice accretion.

Partners

- University of Maryland, Horn Point Laboratory
- NOAA, National Ocean Service
- NOAA, National Weather Service
- Litton-TASC
- Weather Services International
- Princeton University
- University of Rhode Island

2003 | The Argo Project: An Integrated System for Real-time CTD Profiling Float Data on Basin Scales

The US NOPP-Argo project is a five-year implementation (2001–2006) of the US contribution to the international Argo program. The float program and its data management system began with regional arrays in 1999, scaled up to global deployments by 2004, and achieved its target of 3,000 active autonomous instruments in 2007. The Argo array will provide unprecedented real-time views of the evolving physical state of the ocean (temperature, salinity, and currents). It will reveal the physical processes that balance the large-scale heat and freshwater budgets of the ocean and will provide a crucial data set for initialization and assimilation in seasonal-to-decadal forecast models. Argo is a major initiative in oceanography, with research and operational objectives, providing a global data set for climate science and many other applications.

Partners

- Scripps Institution of Oceanography, University of California, San Diego
- NOAA, Atlantic Oceanographic and Meteorological Laboratory
- NOAA, Pacific Marine Environmental Laboratory
- Woods Hole Oceanographic Institution
- University of Washington
- Lamont-Doherty Earth Observatory, Columbia University
- US Navy, Fleet Numerical Meteorology and Oceanography Center

2004 | Coordinated Regional Benefit Studies of Coastal Ocean Observing Systems

The NOPP-sponsored project on estimating the potential economic benefits from new investments in regional coastal ocean observing systems in US waters was a two-year (2002–2004) effort involving a team of researchers from around the country. The team developed techniques for estimating potential economic benefits from coastal ocean observing information, and applied these to a set of industrial and recreational activities in ten regions encompassing all coastal waters of the United States. The findings suggest that annual benefits to users from the deployment of ocean observing systems are likely to run in the multiple hundreds of millions of dollars per year.

Partners

- Woods Hole Oceanographic Institution
- University of Southern Maine
- Louisiana State University
- University of North Carolina at Chapel Hill
- Delta Research Co.
- University of California, Los Angeles
- Louisiana State University
- Northern Economics
- University of South Florida

2006 | Deep Wrecks Project: The Artificial Reef Effect in Deep Water

This multidisciplinary study focused on the biological and archaeological aspects of six World War II era shipwrecks lost in the north-central portion of the Gulf of Mexico as a direct result of wartime activity between early May and late July 1942. Water depths at the investigation sites range from 87 m to 1964 m. The sites were investigated using a remotely operated vehicle to determine site boundaries, National Register potential, preservation state and stability, and the potential for manmade structures or objects to function as artificial reefs in deepwater. An educational component was implemented along with the scientific and historical components of the project in order to incorporate public outreach as an equal partner in every phase of the expedition planning.

Partners

- C & C Technologies Inc.
- Droycon Bioconcepts Inc.
- University of Alabama/Dauphin Island Sea Lab
- Harte Research Institute for Gulf of Mexico Studies/Texas A&M University-Corpus Christi and University of Alaska, Fairbanks
- University of West Florida
- PAST Foundation
- Montana State University

2007 | US GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)

During five years, a broad partnership of institutions collaborated in developing and demonstrating the performance and application of eddy-resolving, real-time global and basin-scale ocean prediction systems using the HYbrid Coordinate Ocean Model (HYCOM). The systems run efficiently on a variety of massively parallel computers and include sophisticated, but relatively inexpensive, techniques for assimilation of satellite and in situ data. The partnership represents a broad spectrum of the oceanographic community, bringing together academia, federal agencies, and industry/commercial entities, spanning modeling, data assimilation, data management and serving, observational capabilities, and application of HYCOM prediction system outputs. The partnership provided an opportunity to leverage and accelerate the efforts of existing projects, producing products that collectively should serve users better than would the individual projects. In addition, this project offered an outstanding opportunity for NOAA-Navy collaboration and cooperation ranging from research to operational levels.

Partners

- Florida State University/Center for Ocean-Atmospheric Prediction Studies
- University of Miami/Rosenstiel School of Marine and Atmospheric Science
- Woods Hole Oceanographic Institution
- University of North Carolina
- Rutgers University
- University of South Florida
- Laboratoire des Ecoulements Géophysiques et Industriels
- Nansen Environmental and Remote Sensing Center

Continued next page...

- Naval Research Laboratory/Stennis Space Center
- Naval Oceanographic Office
- US Navy Fleet Numerical Meteorology and Oceanography Center
- Naval Research Laboratory/Monterey
- NOAA/National Centers for Atmospheric Prediction/Marine Modeling and Analysis Branch
- NOAA National Ocean Service
- NOAA Atlantic Oceanographic and Meteorological Laboratory
- NOAA Pacific Marine Environmental Laboratory
- NOAA/National Weather Service/Ocean Prediction Center
- NASA Goddard Institute for Space Studies
- Service Hydrographique et Océanographique de la Marine
- Planning Systems, Inc.
- The Open Source Project for a Network Data Access Protocol
- Horizon Marine Inc.
- Roffer's Ocean Fishing Forecasting Service Inc.
- Shell Oil Company
- ExxonMobil Corp.

2008 | Multi-sensor Improved Sea Surface Temperature for GODAE

The Multi-sensor Improved Sea Surface Temperatures (MISST) for the Global Ocean Data Assimilation Experiment (GODAE) project focused on producing improved, high-resolution, global, near-real-time, sea surface temperature (SST) analyses through the combination of satellite observations from complementary infrared and microwave sensors, and then demonstrating the impact of these improved SSTs on operational ocean models, numerical weather prediction, and tropical cyclone intensity forecasting. SST is one of the most important variables related to the global ocean-atmosphere system. Its importance to accurate weather forecasting of both severe events and daily weather has been increasingly recognized over the past several years.

Partners

- Remote Sensing Systems
- NOAA Environmental Technology Laboratory (now a component of the Earth Systems Research Laboratory)
- NOAA Office of Research and Applications (now the Center for Satellite Applications and Research)
- NOAA National Oceanographic Data Center
- NOAA National Climatic Data Center
- NOAA Atlantic Oceanographic and Meteorological Laboratory
- Naval Research Laboratory Stennis Space Center
- Naval Research Laboratory Monterey
- University of Colorado
- Florida State University
- University of Miami Rosenstiel School of Marine and Atmospheric Science
- University of Maryland College Park
- University of Edinburgh
- National University of Ireland
- NASA Jet Propulsion Laboratory
- Naval Oceanographic Office
- European Space Agency International Global High-Resolution Sea Surface Temperature Pilot Project (GHRSST-PP) Office

NOPP's greatest achievement has been in fostering collaborations among diverse sectors of the ocean research community and among the federal agencies at the individual program level. Under the original NOPP concept, the benefits of partnering were intended to lead to increased support at high levels in the participating agencies as well as coordinated budget submissions that would have been recognized by appropriators, resulting in a program that grew in funding and influence. While this vision has not been fully realized to date, many inside and outside of government have recognized the advances in the ocean community that NOPP has enabled.

CONCLUSION

It is useful to look back at the original legislation that created NOPP to determine if the program has, after ten years, achieved the stated goals—creation of research partnerships that "promote the national goals of assuring national security, advancing economic development, protecting quality of life, and strengthening science education and communication through improved knowledge of the ocean." Have NOPP activities and projects supported them? If one "maps" the NOPP-supported projects to these goals, it seems clear that the program has accomplished much in this context. The various efforts to develop an ocean observing system and model both the open and nearshore ocean environments have contributed to national security. The projects that advance ocean technology and transition it to commercial applications have supported economic development, as have the projects on mapping finfish populations. Quality of life in the Unites States has been addressed through the projects that target natural resources. Further, the NOPP focus on education has certainly strengthened the entire nation's capabilities in this area.

In spite of many challenges, NOPP has proven to be successful at identifying a wide variety of topics important to more than one agency. The program has brought forth novel ideas for exploration and funded interesting and sometimes surprising projects. At the heart of the program are the professional relationships that have evolved among the various agency programs and led to joint calls for proposals and support for a variety of efforts. These efforts have been complemented by the community of oceanographers, and have evolved into partnerships that address topics identified by both scientists and program managers. Although NOPP will evolve, as all programs do, the goal is to learn from, maintain, and build on the progress already made through NOPP in ocean research, technology, education, and collaboration. The NOPP structure has changed over the years, but the scientific and program partnerships that were created continue to function, and the future looks bright for collaborative ocean research among academia, government, and industry.

ACKNOWLEDGEMENTS

The authors would like to thank staff at the Consortium for Ocean Leadership for their help with this article, including Susan Banahan, Ben Chicoski, Jason Mallett, and Leigh Zimmerman. The article also greatly benefited by the review and input from agency program managers, including Reg Beach, Margot Bohan, Mel Briscoe, Jim Eckman, Scott Harper, Eric Lindstrom, Roxanne Nikolaus, Michael Wiese, and Stan Wilson. Finally, many of the NOPP investigators provided thoughtful comments on the NOPP process that greatly enhanced the article. They also contributed in more tangible ways with references and figures. The willingness of so many to help with this is yet another example of outstanding partnering!

REFERENCES

Anderson, C.I.H., J.K. Horne, and J. Boyle. 2007. Applying a robust probabilistic classification technique to multi-frequency fisheries acoustics data. *Journal of the Acoustical Society of America* 121:EL230–EL237, doi:10.1121/1.2731016.

Argo Science Team. 2001. Argo: The global array of profiling floats. Pp. 248–258 in *Observing the Oceans in the 21st Century*. C. Koblinsky and N. Smith, eds, Godae Project Office, Bureau of Meteorology Melbourne, Australia.

Babson, A.L., M. Kawase, and P. MacCready. 2006. Seasonal and interannual variability in the circulation of Puget Sound, Washington: A box model study. *Atmosphere-Ocean* 44(1):29–45.

Barron, C.N., and A.B. Kara. 2006. Satellite-based daily SSTs over the global ocean. *Geophysical Research Letters* 33, L15603, doi:10.1029/2006GL026356.

Benoit-Bird, K.J., W.W.L. Au, and D.W. Wisdom. In press. Nocturnal light and lunar cycle effects on diel migration of micronekton. *Limnology and Oceanography*.

Biuw, M., L. Boehme, C. Guinet, M. Hindell, D. Costa, J.-B. Charrassin, F. Roquet, F. Bailleul, M. Meredith, S. Thorpe, and others. 2007. Variations in behavior and condition of a Southern Ocean top predator in relation to in situ oceanographic conditions. *Proceedings of the National Academy of Sciences of the United States of America* 104(34):13,705–13,710.

Blaha, J., G. Born, N. Guinasso, H. Herring, G. Jacobs, F. Kelly, R. Leben, R. Martin, G. Mellor, P. Niiler, and others. 2000. Gulf of Mexico Monitoring System. *Oceanography* 13(2):10–17. Available online at: http://www.tos.org/oceanography/issues/issue_archive/13_2.html (accessed May 11, 2009).

Castro, S.L., G.A. Wick, D.L. Jackson, and W.J. Emery. 2008. Error characterization of infrared and microwave satellite sea surface temperature products for merging and analysis. *Journal of Geophysical Research* 113, C03010, doi:10.1029/2006JC003829.

CEQ (Council on Environmental Quality). 2004. *U.S. Ocean Action Plan: The Bush Administration's Response to the US Commission on Ocean Policy*.

39 pp. Available online at http://ocean.ceq.gov/actionplan.pdf (accessed May 6, 2009).

Chang, P.S., and Z. Jelenak. 2006. *NOAA Operational Ocean Surface Vector Winds Requirements Workshop Report*. 52 pp. Available online at http://manati.orbit.nesdis.noaa.gov/SVW_nextgen/SVW_workshop_report_final.pdf (accessed May 14, 2009).

Charrassin, J.-B., M. Hindell, S. R. Rintoul, F. Roquet, S. Sokolov, M. Biuw, D. Costa, L. Boehme, P. Lovell, R. Coleman, and others. 2008. Southern Ocean frontal structure and sea-ice formation rates revealed by elephant seals. *Proceedings of the National Academy of Sciences of the United States of America* 105(3):11,634–11,639.

Chassignet, E.P., H.E. Hurlburt, O.M. Smedstad, G.R. Halliwell, A.J. Wallcraft, E.J. Metzger, B.O. Blanton, C. Lozano, D.B. Rao, P.J. Hogan, and A. Srinivasan. 2006. Generalized vertical coordinates for eddy-resolving global and coastal ocean forecasts. *Oceanography* 19(1):20–31. Available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/19_1/19.1_chassignet_et_al.pdf (accessed May 18, 2009).

Chassignet, E.P., H.E. Hurlburt, O.M. Smedstad, G.R. Halliwell, P.J. Hogan, A.J. Wallcraft, R. Baraille, and R. Bleck. 2007. The HYCOM (HYbrid Coordinate Ocean Model) data assimilative system. *Journal of Marine Systems* 65:60–83.

Churnside, J.H., 2008. Polarization effects on oceanographic lidar. *Optics Express* 16:1,196–1,207.

Churnside, J., R. Brodeur, J. Horne, P. Adam, K. Benoit-Bird, D.C. Reese, A. Kaltenberg, and E. Brown. 2009a. Combining techniques for remotely assessing pelagic nekton: Getting the whole picture. Pp. 345–356 in *The Future of Fisheries Research in North America*. R. Beamish and B. Rothschild, eds. Springer, Berlin.

Churnside, J.H., E. Tenningen, and J.J. Wilson, 2009b. Comparison of data-processing algorithms for the lidar detection of mackerel in the Norwegian Sea. ICES. *Journal of Marine Systems* 66, doi:10.1093/icesjms/fsp026.

Cordes, E.E., S.L. Carney, S. Hourdez, R.S. Carney, J.M. Brooks, and C.R. Fisher. 2007. Cold seeps of the deep Gulf of Mexico: Community structure and biogeographic comparisons to Atlantic equatorial belt seep communities. *Deep-Sea Research I* 54:637–653.

Doney, S.C., M.R. Abbott, J.J. Cullen, D.M. Karl, and L.M. Rothstein. 2004. From genes to ecosystems: The ocean's new frontier. *Frontiers in Ecology and the Environment* 2(9):457–466.

FOFC (Federal Oceanographic Facilities Committee). 2001. *Charting the Future for the National Academic Research Fleet: A Long-Range Plan for Renewal*. A report from the Federal Oceanographic Facilities Committee (FOFC) of the National Oceanographic Partnership Program (NOPP) to the National Ocean Research Leadership Council (NORLC), Washington, DC, 32 pp. Available online at http://www.geo-prose.com/pdfs/fleet_report.pdf (accessed May 6, 2009).

Frosch, R., and The Ocean Observations Task Team. 1999. *An Integrated Ocean Observing System: A Strategy for Implementing the First Steps of a US Plan.* A report prepared by the Ocean Research Advisory Panel for the National Ocean Research Leadership Council (NORLC), 39 pp. Available online at: http://www.coreocean.org/Dev2Go.web?id=220672 (accessed May 6, 2009).

Frye, D., K. von der Heydt, M. Johnson, A. Maffei, and B. Butman. 1999. New technologies for coastal observatories. *Sea Technology* 40(10):29–35.

Gentemann, C.L., P.J. Minnett, P. Le Borgne, and C.J. Merchant. 2008. Multi-satellite measurements of large diurnal warming events. *Geophysical Research Letters* 35, doi:10.1029/2008GL035730.

Given, H.K., S. Banahan, and S. Williams. 2007. The US National Science Foundation's Ocean Observatories Initiative at preliminary design. Pp. 1–8 in *Oceans 2007*. Proceedings of the MTS/IEEE Meeting, September 29–October 4, 2007, Vancouver, Canada.

Glenn, S.M., and O. Schofield. 2003. Observing the oceans from the COOLroom: Our history, experience, and opinions. *Oceanography* 16(4):37–52. Available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/16_4/16.4_Glenn.pdf (accessed May 11, 2009).

Glenn, S.M., W. Boicourt, B. Parker, and T.D. Dickey. 2000a. Operational observation networks for ports, a large estuary and an open shelf. *Oceanography* 13(1):12–23. Available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/13_1/13.1_glenn_et_al.pdf (accessed May 11, 2009).

Glenn, S.M., T.D. Dickey, B. Parker, and W. Boicourt. 2000b. Long-term real-time coastal ocean observation networks. *Oceanography* 13(1):24–34. Available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/13_1/13.1_glenn2_et_al.pdf (accessed May 11, 2009).

Gould, J., and the Argo Science Team. 2004. Argo profiling floats bring new era of in situ ocean observations. *Eos, Transactions, American Geophysical Union* 85(19):11.

Graber, H.C., V.J. Cardone, R.E. Jensen, D.N. Slinn, S.C. Hagen, A.T. Cox, M.D. Powell, and C. Grassl. 2006. Coastal forecasts and storm surge predictions for tropical cyclones. A timely partnership program. *Oceanography* 19(1):130–141. http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/19_1/19.1_graber_et_al.pdf (accessed May 11, 2009).

Horne, J.K. 2008. Acoustic ontogeny of teleost fish. *Journal of Fish Biology* 73:1,444–1,463, doi:10.1111/j.1095-8649.2008.02024.x.

Hurlburt, H.E., E.P. Chassignet, J.A. Cummings, A.B. Kara, E.J. Metzger, J.F. Shriver, O.M. Smedstad, A.J. Wallcraft, and C.N. Barron. 2008. Eddy-resolving global ocean prediction. Pp. 353–382 in *Eddy-Resolving Ocean Modeling*. M. Hecht and H. Hasumi, eds, AGU Monograph Series, Washington, DC.

IWG-Facilities (Interagency Working Group on Facilities). 2007. *Federal Oceanographic Fleet Status Report*. 36 pp. Available online at http://www.geo-prose.com/pdfs/fofc_report.pdf (accessed May 6, 2009).

Jelenak, Z., and P.S. Chang. 2008. *NOAA Operational Satellite Ocean Surface Vector Winds QuikSCAT Follow-On Mission: User Impact Study Report*. 90 pp. Available at http://manati.orbit.nesdis.noaa.gov/SVW_nextgen/QFO_user_impact_study_final.pdf (accessed May 11, 2009).

Kuhn, C.E., D.E. Crocker, Y. Tremblay, and D.P. Costa. 2008. Time to eat: Measurements of feeding behaviour in a large marine predator, the northern elephant seal *Mirounga angustirostris*. *Journal of Animal Ecology* 78(3):513–523.

Makris, N.C., P. Ratilal, D.T. Symonds, S. Jagannathan, S. Lee, and R.W. Nero. 2006. Fish population and behavior revealed by instantaneous continental shelf-scale imaging. *Science* 311:660–663.

Makris, N.C., P. Ratilal, S. Jagannathan, Z. Gong, M. Andrews, I. Bertsatos, O.R. Godoe, R. Nero, and M. Jech. 2009. *Science* 323:1,734–1,737.

Martz, T.R., A.G. Dickson, and M.D. DeGrandpre. 2006. Tracer monitored titrations: Analysis of total alkalinity. *Analytical Chemistry* 78:1,817–1,826.

NEPTUNE Phase 1 Partners (University of Washington, Woods Hole Oceanographic Institution, Jet Propulsion Laboratory, Pacific Marine Environmental Laboratory). 2000. *Real-time, Long-term Ocean and Earth Studies at the Scale of a Tectonic Plate*. NEPTUNE Feasibility Study. Prepared for the National Oceanographic Partnership Program, University of Washington, Seattle, 118 pp. Available online at: http://www.neptune.washington.edu/documents/FEASBL/hi-res_whole.pdf (accessed May 14, 2009).

NRC (National Research Council). 1992. *Oceanography in the Next Decade: Building New Partnerships*. National Academies Press, Washington, DC, 202 pp.

NOPP (National Oceanographic Partnership Program). 2004. *Ten-Year Strategic Plan*. National Oceanographic Partnership Program Office, Consortium for Oceanographic Research and Education, 8 pp.

Nowlin, W., and T. Malone. April 1999. *Toward a US Plan for an Integrated, Sustained Ocean Observing System*. A report prepared on behalf of the National Ocean Research Leadership Council (NORLC), 85 pp. Available online at: http://www.nopp.org/Dev2Go.web?id=207784 (accessed May 6, 2009).

Rothstein, L.M., J.J. Cullen, M. Abbott, E.P. Chassignet, K. Denman, S.C. Doney, H. Ducklow, K. Fennel, M. Follows, D. Haidvogel, and others. 2006. Modeling ocean ecosystems: The PARADIGM program. *Oceanography* 19(1):22–51. Available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/19_1/19.1_rothstein_et_al.pdf (accessed May 11, 2009).

Seidel, M.P., M.D. DeGrandpre, and A.G. Dickson. 2008. A sensor for *in situ* indicator-based measurements of seawater pH. *Marine Chemistry* 109:18–28.

Seim, H. 2000. Implementation of the South Atlantic Bight Synoptic Offshore Observation Network. *Oceanography* 13(2):18–23. Available online at: http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/13_2/13.2_seim.pdf (accessed May 11, 2009).

Seim, H., and C.N.K. Mooers. 2008. Prologue to SEACOOS. *Marine Technology Society Journal* 42(3):14–16.

Seim, H., B. Bacon, C. Barans, M. Fletcher, K. Gates, R. Jahnke, E. Kearns, R. Lea, M. Luther, C. Mooers, and others. 2003. SEACOOS: A model for a multi-state, multi-institutional regional observation system. *Marine Technology Society Journal* 37(3):92–101.

Shaffer, S., Y. Tremblay, H. Weimerskirch, D. Scott, D.R. Thompson, P.M. Sagar, H. Moller, G.A. Taylor, D.G. Foley, B.A. Block, and D.P. Costa. 2006. Migratory shearwaters integrate oceanic resources across the Pacific Ocean in an endless summer. *Proceedings of the National Academy of Sciences of the United States of America* 103(34):12,799–12,802.

Spinrad, R.S., and J.D. Watkins. 1996. *Oceans 2000: Bridging the Millennia, Partnerships for Stakeholders in the Ocean*. Consortium for Oceanographic Research and Education, Washington, DC, 51 pp.

Stammer, D., C. Wunsch, I. Fukumori, and J. Marshall. 2002. State estimation in modern oceanographic research. *Eos, Transactions, American Geophysical Union* 83(27):289 and 294–295.

Stammer, D., C. Wunsch, R. Giering, C. Eckert, P. Heimbach, J. Marotzke, A. Adcroft, C. Hill, and J. Marshall. 2003. Volume, heat and freshwater transports of the global ocean circulation 1992–1997, estimated from a general circulation model constrained by WOCE data. *Journal of Geophysical Research*, doi:10.1029/2001JC001115, 2002 C1.

USCOP (US Commission on Ocean Policy). 2004. *An Ocean Blueprint for the 21st Century.* Final Report. Washington, DC, 28 pp. Available online at http://oceancommission.gov/documents/full_color_rpt/welcome.html (accessed May 6, 2009).

Villegas-Amtmann, S., D.P. Costa, Y. Tremblay, S. Salazar, and D. Aurioles-Gamboa. 2008. Multiple foraging strategies in a marine apex predator, the Galapagos sea lion *Zalophus wollebaeki*. *Marine Ecology Progress Series* 363:299–309.

Wunsch, C., and P. Heimbach. 2007. Practical global oceanic state estimation. *Physica D* 230:197–208.