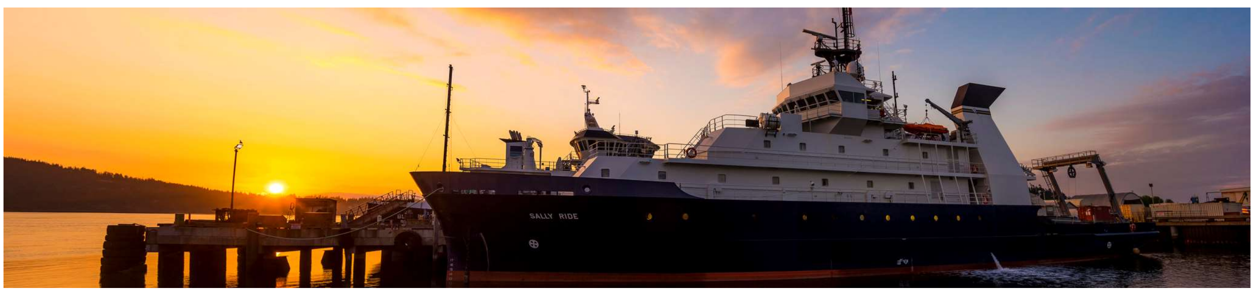
ORAP
Ocean Research Advisory Panel
A United States Federal Advisory Committee

IMPROVING THE BALANCE BETWEEN OCEAN INFRASTRUCTURE AND OCEAN RESEARCH IN THE U.S.



Ocean Research Advisory Panel
January 2017

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Cover Images: (Top) *R/V Sally Ride* – a *Neil Armstrong* Ocean class research vessel owned by the U.S. Navy and operated by Scripps Institution of Oceanography; ©Erik Jepsen/ UC San Diego Publications. **(Middle)** TAO buoy is deployed in Pacific Ocean as part of the Global Tropical Moored Array Program to better understand and predict climate variations related to ENSO; Lieutenant Elizabeth Crapo/ NOAA Corps. **(Bottom)** Research scientists and U.S. Coast Guards travel aboard the USCGC Healy icebreaker as part of NASA's ICESCAPE mission in the Arctic; Kathyrn Hansen/ NASA.

EXECUTIVE SUMMARY

The Ocean Research Advisory Panel (ORAP) was tasked by the National Ocean Council (NOC) to review and report on recommendations for balancing ocean science infrastructure with ocean research support across the Federal government under an assumption of no "new funding". Ocean science research and ocean science infrastructure in the United States is now a complex, multidisciplinary, global, and sustained enterprise embedded in a rapidly developing international context. **It is clear to ORAP that ocean research and ocean research infrastructure priorities must be considered together**. Without question, however, the need does exist for systematic processes to guide the balance between ocean research and ocean infrastructure investments in a constrained funding environment. That said, these processes must recognize the evolved state of both ocean research and infrastructure and the benefit of greater coordination and collaboration both internationally as well as within the United States. While technical research endeavors have become more complex, management has, in many cases, struggled to stay abreast thus resulting in suboptimal decisions, especially in terms of balancing the trade-off between investments in infrastructure and research. Finding an optimal balance between ocean science infrastructure and research spending is especially daunting at the Federal and internal level given the myriad of involved agencies and organizations and shifting priorities. Hence, there is a great need to develop systematic processes to guide the balance between ocean science research and infrastructure in a constrained funding environment.

The ORAP recommends the establishment of general oversight at the Federal level by the National Ocean Council of all major Federal agency ocean research and "shared" ocean infrastructure investments. The oversight must span all the relevant Federal ocean agencies and consider both present and planned private sector and international activities. At a minimum, this implies a decadal strategic investment plan reviewed biannually and updated if necessary at intervals of 5-7 years. It does not pre-empt the need for individual agencies, focused on their individual mission requirements, to conduct strategic reviews of their own ocean research and ocean research infrastructure portfolios. The strategic investment plan must include specific guidance on transitioning mature research (and research infrastructure) to operational agencies and "sun-setting" research and research infrastructure that is no longer of the highest priority, or may have already realized its' primary objectives. **The end-result must be identification of the over-riding national priorities for individual agency support,** consistent with the guidelines provided by the National Ocean Policy and the NOC's continuing efforts to foster interagency coordination, inclusion of the private sector, and alignment of U.S. ocean research and infrastructure investments with the long-term strategic science plans of the U.S. and our international collaborators.

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I. INTRODUCTION

A. THE NOC TASKING

The tasking from the National Ocean Council (NOC) was to - under the assumption of no new funding - develop recommendations on how to balance the need to advance ocean sciences with the need to develop and maintain the infrastructure required to do so. **The Ocean Research Advisory Panel (ORAP) has interpreted this to mean that relative federal investment (as indexed to inflation) will continue at the present level.** At the same time, the NOC tasking requested that the ORAP include consideration of opportunities for Federal agencies to maximize investments and optimize the use of infrastructure and scientific data to address multiple needs and to also identify barriers to these mechanisms and opportunities.

In answering this tasking from the NOC, the ORAP began work on this report in 2013. To garner information and input, the ORAP invited experts from outside the committee to the January 2013 ORAP meeting. These experts provided information about the ocean research and infrastructure in the United States and also in Australia. Work continued through 2013, as reflected in ORAP meeting agendas from August, December 2013, and May/June 2016. From 2013 to the present the membership of ORAP evolved. ORAP membership and the names of the invited experts are listed in the agendas.

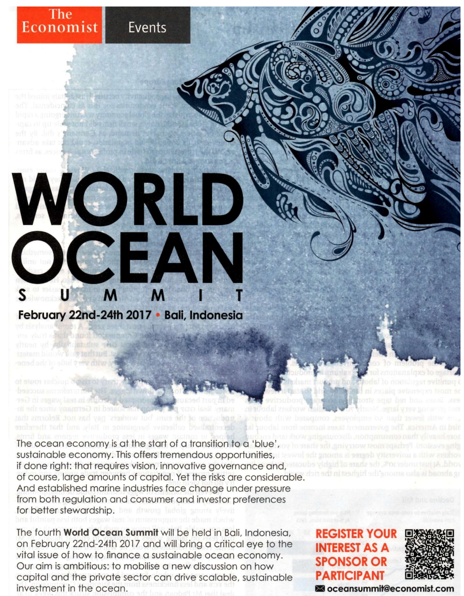

Figure 1 The World Ocean Summit of February 2017 highlights the growth in global interest in the ocean or 'blue' economy. Key to the U.S. moving successfully forward in this context is a healthy ocean research effort support by the required ocean research infrastructure. (Graphics drawn from meeting brochure available at http://www.economist.com/events-conferences/asia/ocean-summit-2017?cid1=eve/Eloqua/home/home/none/na/none/Eloqua/WOS/WOS-Eloqua-forms/none/none/asia/none).

The assumption of no new funding is significant given that under-investment could result in damage and loss of ecosystem services provided by the ocean research enterprise and the ocean infrastructure that far exceed the cost of the research needed to better utilize those services [Figure 1]. A solution to this inherent conundrum is beyond the scope of this study, however, the ORAP notes that the three necessary "pillars" of the U.S. research enterprise identified in the National Research Council (NRC) Report "Furthering America's Research Enterprise" (2014) as:

1) A Talented and Interconnected Workforce,
2) Adequate and Dependable Resources [funding, infrastructure, tools, organizations, etc.], and
3) World-Class Basic Research.

The NOC task to the ORAP could be viewed as providing advice only on the balance within the second pillar. However, all three are essential and interdependent.

The 2014 NRC report also highlights three U.S. trends over the past several decades which are relevant to this discussion. First, while the overall fraction of U.S Gross Domestic Product (GDP) invested in research has been relatively steady since the 1950's, the Federal share has steadily fallen while the shares of industry and "other nonprofits" have risen (see Fig.2-1 of the 2014 NRC Report). Also, noted therein is the consequent reduction in the percentage of U.S. investment for basic research relative to applied research, as well as the major shift of Federal basic research investments into the National Institutes of Health (NIH) from other sectors. For the U.S. ocean research enterprise, which has depended largely on Federal basic research investments, these trends conspire together to the detriment of sustaining the three pillars essential to the ocean research enterprise, which provides an extra challenge to achieving a proper balance between them.

The ORAP acknowledges the value and need for processes to effectively guide U.S. investments in ocean research and infrastructure and thus to make the best use of the funding that does exist. At the same time, though, the enhanced investment level and consequent newly developed ocean research and infrastructure capabilities in other countries, together with growth in private sector, offer new opportunities for leveraging limited Federal funds

The ORAP also notes that this charge (and context) is like one that the National Science Foundation (NSF) made to the National Research Council (NRC) panel, which recently prepared the report entitled: "Sea Change 2015-2025 Decadal Survey of Ocean Sciences". They too were asked to consider how to best balance the costs of infrastructure and basic research, albeit in the more restricted context of NSF's Ocean Sciences Division (OCE). That said, their focus was on how to reduce expenditures in specific large elements of NSF supported infrastructure: The International Ocean Drilling Program, the academic research fleet, and the Ocean Observatories Initiative (OOI). An impetus was that the operational and maintenance costs for OOI had been originally budgeted as part of a projected OCE budget increase which did not materialize and that rising fuel (and personnel) costs were also making the research fleet more expensive.

The NOC specified that "infrastructure" included the U.S research fleet, satellites, autonomous underwater vehicles, in-situ arrays, shore-based laboratories, and relevant additional elements. Further, the purpose of the relevant infrastructure was both to support basic ocean research and to provide the data needed to "address urgent societal concerns" such as enabling stewardship of the environment, protecting life and property, promoting economic vitality, and increasing fundamental scientific understanding. **The ORAP interprets this to mean that <u>its task is to focus on the Federal component of U.S. ocean research and infrastructure investments</u> which may include infrastructure funded by the Federal agencies and subsequently**

transferred to or operated by private institutions so long as the infrastructure is operated with shared access for the entire research community.

The NOC noted that the competition between investing in research and developing, operating, and maintaining infrastructure for multiple users was a continuing tension and cited the NRC's Ocean Studies Board (OSB) report "Critical Infrastructure for Ocean Research and Societal Needs in 2030." In developing this report, the Ocean Research Advisory Panel (ORAP) will rely upon the definition of infrastructure used in that study:

".... the full [national] portfolio of ***platforms, sensors, data sets and systems, models,*** *supporting personnel,* ***facilities,*** *and enabling organizations that the nation can bring to bear to answer questions about the ocean, and that is (or could be) shared by or accessible to the ocean research community as a whole."*

However, herein the ORAP focuses primarily on the bolded items in the above definition, which excludes not only workforce related issues, but also oceanographic equipment available to individual research groups or institutions that is unique, recognizing that such prototypes often develop into infrastructure available to the entire research community (e.g., the Deep Submergence Facility at WHOI that operates *ALVIN*, *JASON* and *NEREUS*). The ORAP also restricts its discussion to infrastructure primarily used by the ocean research community and does not include infrastructure (in some cases with identical capability) that serves primarily or exclusively other users such as offshore resource enterprises (e.g., remotely operated vehicles operated by oil companies), maritime transportation activities, and individual mission agencies (e.g., the research aircraft used by NOAA in its hurricane missions). This said, the overlap of infrastructure used by the research and non-research ocean communities is an important consideration. Lastly, the definition adopts a U.S. national perspective at a time when ocean observations are increasingly an international enterprise. The ORAP addresses this aspect as well in this report.

Some (e.g., Press, Science, 2013) believe that increased funding from industry, state and local government, and non-profits will, to a considerable extent, offset flat Federal research funding in the U.S. Without question, there are new opportunities to leverage U.S. in that other countries (in particular, China and the European Union, but also South Korea and Japan) have substantially increased their funding for ocean research and ocean research infrastructure over the last decade or more. Elements of infrastructure need not necessarily be duplicated so long as the data sets, analyses, and models resulting from their use are freely shared across the international research community.

B. THE CONTEXT

It is important to acknowledge that the context in which the ORAP addresses balance between ocean science research and infrastructure investments is one that has seen considerable evolution and change in recent decades. Key aspects of this evolution are summarized below:

OCEAN RESEARCH as an activity has continued to mature. Increasingly complex and multidisciplinary topics (e.g., ocean acidification, Arctic ice melt, anthropogenic pollution, sea level rise, invasive species, the El Nino Southern Oscillation [ENSO], and the effects of underwater sound on marine life) are among those being addressed, requiring the use of increasingly sophisticated observational tools. In addition to expeditionary field campaigns of limited duration and footprint, there are now large scale, long-term programs addressing basin and global spatial scales and decadal and inter-decadal temporal scales. The ocean research enterprise is less dominated by U.S. ocean researchers and programs, and benefits from the increasing capabilities, participation, and leadership of other nations. Multinational and international programs play a major role in guiding, developing, and executing research and driving infrastructure needs. In addition to the ocean research community's desire to better understand the ocean and its processes, growing societal needs for knowledge about the ocean's role in climate dynamics, global changes in living marine resources, the increasing frequency and intensity of extreme weather events, and the impacts of rapid warming in polar regions motivate research and infrastructure investments.

OCEAN INFRASTRUCTURE developments have included marked expansion of sampling and observing throughout the global ocean, including greater depth coverage. The present infrastructure includes more sustained and more multidisciplinary observations; and the expectation is that the need for these will increase over the coming decades. International collaborations play an increasingly key role in the support of the ocean infrastructure; and many elements of the ocean- observing infrastructure also have operational roles (e.g., regarding ENSO, hurricane, and tsunami prediction). As earlier noted, although U.S. Federal investment has to date remained relatively flat, other nations have significantly increased their investment in both ocean research and infrastructure, with new ships, observing platforms, sensor and instrument development, research facilities, and field campaigns. For example, when the research vessels already under construction are launched, China alone will operate well over 50% of the global oceangoing research fleet, and significant additional construction has been planned and budgeted over the coming decade. Remote sensing of the ocean continues to rapidly mature. An example is the addition of NASA's *Aquarius* satellite, which allows for the remote sensing of salinity.

PRIVATE SECTOR AND OPERATIONAL USE of the oceans continues to expand. U.S. philanthropic foundations now support research vessels and facilities, fund oceanographic observations and research, and support sensor development. Although there has been a decline in global shipping after the 2008/2009 recession, on a longer time scale, global maritime trade has increased (e.g., more and larger ships and larger capacity ports and canals) and new shipping routes, the increasingly ice free Arctic, are already being utilized. Energy production and resource extraction activities have moved into deeper waters (e.g., offshore wind farms and mining for fossil fuels and metals). At the same time, there continues to be a depletion of fisheries world-wide, and there are increased national and international marine environmental regulations. There is increased integration of ocean data (e.g., tsunami warning buoy data and Pacific ENSO observing system data) into economically significant warnings and forecast products and into projections of ocean trends (e.g., sea level rise and ocean acidification) with global societal impact. Increasingly, other nations (e.g., Japan, China, and India in the tropical Pacific and Indian Ocean) are engaged in ocean data collection for private sector and operational use.

The examples above of trends in research, infrastructure, and private sector ocean operations are not meant to be exhaustive, but are indicative of a growing global dependence on the ocean and its resources. When combined, the trends across sectors act synergistically and amplify change within the ocean research community. In part, there has been a continuation of the transition from a research community that was dominated by single investigator efforts with associated modest infrastructure to endeavors increasingly organized around large cooperative research programs with multidisciplinary teams of investigators. At the same time, there has been development of and investment in large infrastructure elements and observing capabilities managed on behalf of the community, at times as part of a global observing network, and intended to provide long and continuous coverage.

To build and sustain the global ocean observing system needed to address the most pressing research questions requires integrated planning and coordinated investment across the Federal agencies in partnership with the private sector and the international community, as is being done elsewhere (e.g., in Australia under the Integrated Marine Observing System and in Europe where there is a European Union funding umbrella for marine science and infrastructure that coordinates and supplements funding by individual nations). The EU has steadily increased investment in marine science and infrastructure [Figure 2]. At present EU investments are

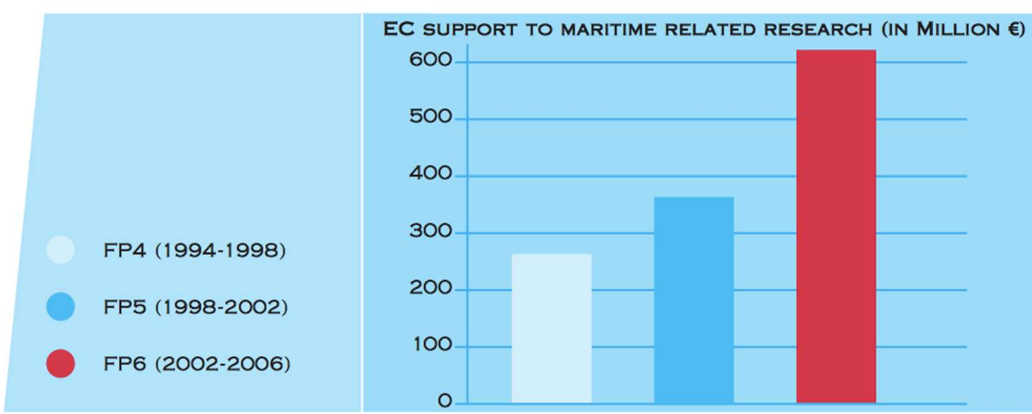

Figure 2 The European Commission (EC) brings additional funds to European investment in marine research. These funds supplement national funds and often work to improve coordination across nations and to develop shared ocean research infrastructure. This graphic shows the trend of significant increases in support in successive EC Framework Programs in the 1990s and 2000s. (European Commission. *Marine-related Research and the Future European Maritime Policy.* Luxembourg: Office for Official Publications of the European Communities, 2006. Print. ISBN 92-79-02687-9)

approximately 2B Euro per year. The ORAP notes that the GDP and GDP per capita of the U.S. and the EU are approximately the same.

The increase in Chinese investment within the past decade (whose GDP is not yet equal to the U.S.) is even more remarkable. Chinese ship-building activities have already been noted, but there have also been a number of new shoreside laboratories and research complexes constructed (and staffed), such as the Ocean University of China (http://eweb.ouc.edu.cn/), which recently signed a cooperative agreement with its South Korean equivalent Pukyong National University and Qingdao National Laboratory for Marine Science and Technology (http://www.qnlm.ac/en/index). The Chinese also operate a research submersible capable of working at greater depths than any present U.S. vehicle.

Unfortunately, the recent evolution of ocean science has not been accompanied by an increase in the resources and coordination in the U.S. necessary to support this new and evolving paradigm in ocean sciences research and its associated infrastructure requirements. Moreover, efforts to coordinate resource allocation across nations (and regions) are in their infancy. For the U.S., which contributed disproportionately to development of global ocean observing systems (such as the Argo float program and the ENSO observing system), the result has been that ongoing infrastructure cost increases have threatened national research capabilities (as earlier noted in the context of the NSF sponsored "Sea Change" report).

The gravity of the present situation is highlighted in the U.S. Ocean Policy Report Card 2012 by the Joint Ocean Commission Initiative which assigns a grade of D- in the area of funding and states that "ocean programs continue to be chronically underfunded …."

C. NRC OCEAN INFRASTRUCTURE FOR 2030 REPORT AS A STARTING POINT

The NRC infrastructure report includes four societal themes relevant to assessing infrastructure needs:

- enabling stewardship of the environment,
- protecting life and property,
- promoting sustainable economic vitality, and
- increasing fundamental scientific understanding.

These themes cover all elements of the U.S. ocean enterprise. They must be given equal priority, and funding must clearly go beyond the purely research context, which is appropriate for this ORAP task as well. The NRC study also offered some useful criteria by which (research) infrastructure investments could be prioritized:

1. Ability to address the science

2. Affordability, efficiency, and longevity
3. Ability to serve other missions or applications

This ORAP task requires consideration of additional criteria, as developed in Section III of this report.

NRC also provided two specific recommendations:

> *Federal ocean agencies should establish and maintain a* ***coordinated national strategic plan for critical shared ocean infrastructure*** *investment, maintenance, and retirement. Such a plan should focus on trends in scientific needs and advances in technology, while taking into consideration life-cycle costs, efficient use, surge capacity for unforeseen events, and new opportunities or national needs. The* ***plan should be based upon a set of known priorities and updated through periodic reviews****.*

> *National* ***shared ocean research infrastructure should be reviewed on a regular basis (every 5-10 years) for responsiveness*** *to evolving scientific needs, cost effectiveness, data accessibility and quality, timely delivery of services, and ease of use in order to ensure optimal federal investment across a full range of ocean science research and societal needs.*

The ORAP has bolded text to emphasize the recommendations that ORAP re-emphasizes and develops further in this report.

D. JOINT CONSIDERATION OF OCEAN RESEARCH AND OCEAN RESEARCH INFRASTRUCTURE

The increased complexity of ocean research and the increasingly global conduct of ocean research points to the need in many cases for long lead time planning, for advance allocation and scheduling of the infrastructure required by the research, and for coordination across agencies and with other nations. **Thus, the ORAP concludes that the processes that address the sought-after balance in investments must consider both ocean research and ocean infrastructure plans and activities at the same time.**

Section II below provides a brief synopsis of prior attempts to achieve a U.S balance in ocean science research and infrastructure investments. Section III provides the ORAP recommendation for how to achieve a coordinated Federal plan for ocean research and infrastructure to support societal ocean research needs. Section IV highlights some of the challenges that need to be addressed and opportunities that exist. Section V provides a more detailed discussion of how to address the recommendation made in Section II for the development of a strategic plan. Section VI is a summary of the ORAP's reasoning and recap of its primary recommendations.

II. A SYNOPSIS OF THE PAST FEDERAL APPROACH TO BALANCING AND COORDINATING OCEAN SCIENCE RESEARCH INVESTMENTS

The inventory of shared ocean observational capabilities is broad and getting more so as the field advances to address increasingly complex issues and more societal demands are placed upon the outcomes of the research. This is, in the ORAP's view, a logical and necessary evolution. Such systems are operated by government or academic institutions; however, in both cases, the overwhelming majority of the funding has been provided by the Federal government. At the same time, oceanographic research now involves significant use of shared infrastructure and is often closely linked to or integrated with international partners. Bringing together international research partners and international research infrastructure (e.g., ships and/or aircraft from other nations) requires years of lead time and the ability of U.S. agencies to plan (and budget) ahead. As discussed below, this can be challenging within our present budget process.

Four agencies provide most of the infrastructure available to the oceanographic research community – NSF, ONR, NOAA and NASA – with the latter restricted to satellite (or satellite-related: e.g., ground truth sensor verification) infrastructure. Historically there has been limited coordination between these four agencies.

Research ships are a major element of ocean science infrastructure. The academic research fleet – largely owned by the government, but operated mostly by academic institutions – reflects an agreement between NSF and ONR that the U.S. Navy would be the primary investor in large ship construction, and NSF would focus on smaller vessels. This agreement paved the way for the establishment of UNOLS (Universities National Oceanographic Laboratories System), which manages the shared Federal research fleet on behalf of the community. Academic institutions compete to operate the vessels. In recent years, NOAA has participated more directly in UNOLS; and, where mutually beneficial, ship time has been exchanged or shared between the NOAA and UNOLS fleets.

Because NOAA vessels and infrastructure are operated by the agency, rather than by academic institutions, its ship construction and utilization planning processes are much more internal than UNOL's. The external research community has had little input to discussions of the national need for and consequent capabilities of NOAA oceanographic research (in contrast to NOAA fisheries or hydrographic survey) vessels. It is worth exploring whether NOAA's internal scientific needs for oceanographic vessels could be more cost-effectively addressed by a UNOLS operated vessel, regardless of which agency funded construction. NOAA has had great difficulty maintaining its present global class vessel. Such chartering would permit NOAA (and its Office of Marine and Aircraft) to focus limited resources upon their hydrographic and expanding fisheries fleets.

The U.S. Coast Guard has also provided major investments for shared infrastructure of polar capable vessels, but increased scientific need for high latitude work suggests the need for better coordination between planning for and construction of ice-capable research ships and ice breakers. In this next fiscal year, the Norwegian icebreaker *ODIN* is being used by NSF Polar Programs rather than the USCG *HEALY*. Moreover, present USCG planning for a new icebreaker does not address scientific needs.

NASA and NOAA have made significant investments in remote observing infrastructure for oceanographic applications. These investments include global ocean temperature observations from the NOAA polar orbiting constellation and NASA's Earth Observing System; ocean color measurements from NASA's Satellite borne instruments, including the Coastal Zone Color Scanner, Sea-Viewing Wide Field-of-View Sensor, and Moderate Resolution Imaging Spectroradiometer and recently NOAA's Visible Infrared Imaging Radiometer Suite on the Suomi National Polar-Orbiting Partnership MISSING; and ocean topography imaging from NASA's TOPEX/POSEIDON satellite, which has transitioned to the JASON mission managed by NOAA. Ocean winds have been observed by numerous NASA, DOD and international platforms (SeaSat, QuikSCAT, NSCAT, MetOp, AQUA, ADEOS-II, and many others). That is, there are also robust collaborations with Europe, France, Japan, China, India, etc., which provide integrated observations of ocean parameters from space.

With respect to global ocean observing infrastructure, until recently, NOAA has played the major U.S. role. This infrastructure includes Argo profiling floats, surface drifters, moorings (including the tropical arrays), and sampling from Volunteer Observing Ships. Much of this is coordinated internationally, and as with the ships, many operational activities (e.g., Argo float development, deployment and data quality control and dissemination) are conducted in collaboration with U.S. academic institutions. As noted earlier in the context of the Sea Change report, NSF provided support for the recent Ocean Observatories Initiative (OOI). Although the potential impact of operating and maintaining OOI is well recognized (including the ship-time required), there has not yet been a substantive dialogue between NOAA and NSF about the transition of this new capability to sustained long-term operations beyond the planned life of OOI under the NSF.

There have been several examples of effective interagency research coordination. One is the U.S. component of the Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP) for repeat hydrographic and chemical oceanographic sampling on cross basin sections roughly every 5 to 10 years, which is jointly supported by NOAA and NSF. Another is the U.S. CLIVAR (Climate Variability) project involving NOAA, NSF, ONR, and DOE. Agency representatives participate in community-wide U.S. CLIVAR annual meetings where progress and plans are discussed. Furthermore, U.S. CLIVAR is interfaced to the international CLIVAR initiative, which operates under the umbrella of the World Climate Research Program. NSF and NOAA also jointly funded and participated in the U.S. GLOBEC (**GLOB**al Ocean **EC**osystems Dynamics) program, which was a major component of international GLOBEC. A final example of effective interagency research coordination can be found in the Great Lakes. Since the Great Lakes are internationally shared between the U.S. and Canada, larger research and monitoring efforts are coordinated under the auspices of the Great Lakes Water Quality Agreement and the Great Lakes Fishery Convention. Local and regional academic institutions and non-governmental organizations are often involved in these efforts.

Many ocean research initiatives involve multiple investigators from different agencies but are planned (and funded) within one agency. Other ocean research activities are based on bottom-up proposals submitted by one or more investigators to a specific agency. Coordination of this research is still needed when it involves major infrastructure resources (e.g., ships) and has constraints, such as needing to be in the field at a specific place at a specific time of year.

While all agencies have internal processes to prioritize major infrastructure and research investment, these plans are rarely made public before they receive approval and commitment of the Executive Branch. Obviously agencies are reluctant to change those plans at that point even if they do get substantial suggestions from subsequent public review. Agencies do coordinate through the Interagency Working Group on Facilities and Infrastructure on a Federal Fleet Status Report. The most recent such report (March 2016) clearly illustrates the shrinking fleet capacity with or without NSF plans for new Regional Class Research Vessels (RCRVs). That said, the charge and purview of this working group does not include long-term strategic planning across agencies; and what is presented is subject to the limitations described above. The work conducted by the working group is largely a compilation of purely internal planning exercises. There are exceptions, such as NASA planning for major missions, which are truly decadal, and DoD budget submissions to Congress that have multiyear plans (the "FYDP").

Sharing large infrastructure investments across federal agencies is difficult in the U.S. This is understandable because agencies are never sure of whether their component of a jointly planned effort will be approved within their agency, accepted by the Executive Branch, and approved by Congress. Consequently, shared plans and funding become a risk to success because of the "weakest link." Informally, of course, agencies often consider the investments of which they are aware and attempt to provide unique or needed infrastructure within the restrictions of their missions and/or planning processes. The inability to plan and then act together on longer term horizons is a major shortcoming of the U.S. government's ability to efficiently execute timely large ocean infrastructure investments. The lack of action on the acknowledged national need for icebreaker capability is a well-known example of this disconnect. U.S. high latitude research activities (much less search and rescue capabilities) have become increasingly dependent upon foreign icebreaker capacity. While a plan is finally in place to address this (and its inception within the U.S. Navy budget), it will take a decade or more to fully implement.

The Office of Management and Budget (OMB) plays a key role in defining the infrastructure that will be available to both the agencies and the external research/academic community, as well as defining the level of research support that will be available. Ocean research programs within agencies must prove to their internal administration, OMB, and Congress that proposed infrastructure is necessary to address important national research needs and that it does not duplicate that which is already available to the community. These constraints are understandable and well justified. Nonetheless, because budgetary decisions within OMB and Congress are aligned according to individual agencies (and often individual Congressional committees) rather than across them, it is often difficult for an agency to justify infrastructure that is broadly shared among agencies. Improvements in budget process (and practice) are needed to address this issue.

The point that the ORAP wishes to make is that there is considerable room for improvement in cooperation at the Federal level with respect to major ocean research infrastructure investment. Some cooperative efforts have worked well but others have not. More importantly, the overall Federal ocean research enterprise is clearly not being managed in a coherent or optimal fashion. At the same time, the ocean observation inventory has gotten broader, the financial consequences of unresolved ocean science questions have risen, and budget growth has stagnated.

III. A COORDINATED FEDERAL STRATEGIC PLAN FOR INVESTMENT IN OCEAN RESEARCH AND SHARED OCEAN RESEARCH INFRASTRUCTURE

A coordinated plan is achievable under the auspices of the NOC. Such a plan should have a decadal planning horizon, be reviewed (and if necessary updated) biannually, and must include *inter alia* a short description of expected trends with respect to the three societal need(s): relevant research and technology development, international and private partnership opportunities, and the development of supporting technologies. Such a plan must be tied to a set of national priorities, which may or may not encompass all the priorities of individual agencies. These and other aspects are discussed below.

A candidate infrastructure element for inclusion in the plan must, at a minimum, establish that:

a) It supports a national priority in one or more of the four societally relevant themes (from the NRC report).
b) It is accessible by any user funded by the Federal government or any non-federal partners in the plan. This may include use of the infrastructure element itself or the data that it yields. If there is a charge for this use or the output, it must be the same for all users.
c) For an existing infrastructure element, the life cycle costs and user base must be documented for comparison to alternatives to meet the priority need today and in the future.
d) For a proposed infrastructure element, the capital investment together with life cycle costs must be shown as well as the intended source of that funding.
e) It will serve the needs of a substantial user base over its projected lifetime.

The above infrastructure elements should be covered in some detail for the 10-year horizon of the plan. Beyond that timeframe general trends and potential alternatives should be discussed with respect to the same attributes.

To be included in the plan, the following three criteria adapted from the NRC report must also be addressed:

1. Ability to address the primary cited need(s).
2. Affordability, efficiency, and longevity.
3. Ability to serve other needs, missions or applications.

The ORAP believes that the relative priority of these criteria is important and should be as ranked above so that a critical infrastructure element serving a single high priority need, but no other, is not automatically excluded in favor or an infrastructure element that to some extent serves the needs of many different users. Once part of the coordinated Federal plan, all infrastructure elements should have agreed upon 5-6-year future budget profiles within the agencies where they reside. Particularly large investments (e.g., icebreakers or satellites) will require even longer budget profiles. This should be part of the Administration's annual submission to Congress, which implies that the Plan has been, at least in concept, vetted with and approved by both the Office of Science and Technology Policy (OSTP) and OMB. An individual in each of these Offices should be assigned to oversee the plan and the annual budget submissions by the respective agencies.

The plan should also describe how the infrastructure element is expected to evolve over the next 10 years in terms such as:

- trends in the needs (use, efficiency, accuracy, etc.)
- advances in technology
- surge capacity for unforeseen events

- retirement and/or replacement if it must be sustained
- provision(s) for new partnering opportunities or growing national needs.

This list is intended to be illustrative, not proscriptive. It is typically the case that an infrastructure element serves a need by virtue of the data it provides and that it is the data stream which must be sustained, not necessarily the particular infrastructure element currently providing that data. Thus, alternatives to more cost-effectively sustain a data stream must be explored in any robust plan. The sustenance of an infrastructure element cannot become an end-in-itself.

In parallel with the development, review, and updating of the 10-year infrastructure plan, it is also essential that under the auspices of the NOC a complementary 10-year plan for ocean research be developed and maintained. The primary goals are to: 1) foster cross-agency and international cooperation in support of large research efforts that are either very expensive and/or involve major infrastructure commitments and 2) achieve efficiencies to make U.S. funds available for ocean research more effective by leveraging resources across agencies and internationally.

In developing these plans, the NOC must consider how to better engage and involve the private sector in ocean research and infrastructure. Ship time and instrument development funding are, to some degree, now being provided by non-profit foundations, and ocean observing activities and products derived from them are of interest to the private sector. Examples include the activities of the Schmidt Ocean Foundation, which owns and operates the RV *Falkor* (as well as limited ocean technology development) and the volunteer observing ship programs that provide commercial vessel platforms, including the *OceanScope* program (http://scor-int.org/Publications/OceanScope_Final_report.pdf). This was formulated by an international working group composed of government and academic scientists along with representatives of relevant industries, such as ship builders and operators and ocean instrument manufacturers.

IV. ORAP REMARKS ON MAJOR INFRASTRUCTURE TRENDS AND CHALLENGES

In assessing the balance between investments in ocean science research and infrastructure, the ORAP has reviewed several major trends:

SHIPS: The ORAP finds no clear definition of a "national oceanographic fleet", and use of the present aging fleet system is already greatly challenged by fuel costs unanticipated at the time of construction and level funding (an effective reduction) in the budget available for conducting shipboard scientific research. The evolution of new observing systems, such as autonomous vehicles, and the expansion of many in-situ platforms (including multidisciplinary, moored sensor suites) have not eliminated, but in some cases increased, the need for research vessels. The ongoing international repeat hydrography program includes a number of lines to be occupied by the U.S., and the related cruises require Global Class ships if they are to house the large number of scientists and technicians necessary. While the U.S. has put new Ocean Class vessels into its fleet and Regional Class vessel construction is planned, no new global vessels are currently planned (although the current U.S. global class vessels are undergoing "service life extensions"). Since this challenge is faced by a number of nations, it argues for a global access fleet that is planned and managed internationally. The U.S. cannot achieve "stewardship of the environment" without human access to the ocean on a broad front for a wide range of scientists and operators. As noted earlier, this need is well recognized outside the U.S. and is reflected in E.U. and Asian (primarily China) investment in new oceangoing research vessels.

SATELLITES: The ocean enterprise has come to rely on satellite data streams for global scale remote-sensing. Future planning should consider the key role of satellites in ocean sampling and research. The ORAP supports improved and efficient satellite data ingest systems for community-wide data products and international sharing of relevant data products. International coordination and future planning under CEOS (Committee on Earth Observation Satellites) looks to the U.S. to be a model for considering international planning and coordination of major ocean infrastructure. Moreover, since the systematic data collection required to ground truth (or verify) satellite observations cannot be sustained by the research fleet, the ORAP notes with approval the increasing utilization of commercial ships of opportunity in this context (e.g., NASA support of surface temperature instrumentation and the World Meteorological Organization support of the Voluntary Observing Ships program).

AUTONOMOUS AND REMOTE VEHICLES: Over the past several decades, the capability of autonomous and remotely operated vehicles (ROVs) has expanded rapidly. ROVs are now routinely used by research scientists and industry operators to perform complex tasks that were previously impossible or far more costly to execute. Autonomous vehicles are now available in a variety of forms and capability, both subsurface and surface. The endurance and instrument payload capacity of some of these vehicles has started to rival the capability of manned vessel surveys. Given their rapid improvement and cost advantage, ROV and autonomous vehicle usage will continue to expand. There is great potential that this technology will ultimately reduce the cost of ocean science observations. However, given the immature nature of this new technology there is also a need for agencies to proactively coordinate their activities to avoid redundancy, share lessons learned, and accelerate the maturing process.

TELEPRESENCE COMMUNICATION TECHNOLOGY: Until 15 years ago, real-time shipboard and ROV-collected data was available only to the scientists aboard the ships. This greatly limited the participation of ocean scientists in field research. With the advancements of telepresence communications technology and the ability to stream video, audio, and data feeds from the depths of the ocean in real-time over the commodity Internet, there is now great potential for the broader ocean science community, including the private sector, to participate in research expeditions and take advantage of streaming data. In addition to broadening the participation in these relatively expensive operations, scientific parties can control the vehicles from shore-based facilities and reduce scientists' time at sea. All the new ships in the U.S. academic research fleet have been equipped with telepresence systems, and many of the older vessels have been retrofitted with this capacity.

GLIDERS AND FLOATS: The rapid advances in float and glider technologies have produced a remarkable increase in large-scale ocean sensing with data sets that now represent the bulk of ocean sampling. The U.S. bears the majority of the costs for the global ocean observations conducted using floats and drifters. These systems represent a very large increase in efficiency in ocean sensing, but this highlights the necessity of greater cost sharing across more nations. The community desires even more capable floats and drifters, and the addition of sensors will create further challenges by requiring more power and thus reducing the longevity of individual platforms. To maintain the same distribution of sampling will therefore require even more platforms. Furthermore, broader use of autonomous platforms creates the need for international cooperation (and consistent Federal policies) given the challenges of multiple Exclusive Economic Zones, extended continental shelves, and coastal state approval processes.

OCEAN DRILLING: The Ocean Drilling Program has had an enviable record in uncovering Earth history and will continue to do so within the context of an international program. These efforts, when combined with sea floor and seismic mapping, remain the primary tool for study of geotectonics and earthquake hazards off U.S. shores. Important issues at hand include a question as to whether or not any one nation, even the U.S., can or should own and operate its own drilling vessel(s). There is a need for ongoing evaluation of the level of U.S. investments in ocean drilling versus the now more diverse and extensive portfolio of ocean infrastructure that the agencies support. Notably, the "Sea Change" report earlier cited has tasked NSF Ocean Sciences with finding additional support for the drilling program from the U.S. international partners.

STATIONARY BUOYS AND MOORINGS: The traditional form of sustained sensing presence, using moorings, is a vital part of U.S. observing capability. The availability of more capable, multidisciplinary sensors and more affordable and higher bandwidth satellite data telemetry is providing increased and diverse data in real-time from buoys and moorings. Mooring capabilities have grown to where the records for some key parameters now exceed four decades. However, as earlier noted, such moored arrays require routine ship support. This is an area where investments in new technologies and methods that increase capabilities and global coverage should be paired with improved planning for the required ship support and for both interagency and international coordination, including maximization of shared use of the generated data.

COMPUTING/DATA REPOSITORY RESOURCES: To an extent, the ORAP supports the continued support of databases developed for specific observing elements or programs, such as GO-SHIP, OOI, GLOBEC, the World Ocean Circulation Experiment, and the current global drifter and Argo float array programs. Work remains to coordinate data and supporting metadata generation, to develop unified databases, and to develop more facile sharing of ocean data as well as of parameter fields generated by ocean models.

CABLED SYSTEMS: Cabled observatories have been fielded recently, including those off Washington and Oregon as part of the OOI. As with other elements of the in situ observing infrastructure, there are significant continuing costs with the operation of these systems, and planning must address lifetime, as well as installation, costs to ensure sufficient funding for research that utilizes the data generated.

CENTRALIZATION, FACILITIES, AND CAPABILITIES: Development, operation, and maintenance of ocean infrastructure require specialized staff and expertise. The ORAP sees these capabilities being localized at fewer institutions and that there is a trend to the establishment of facilities that serve a community of users, such as the National Deep Submergence Facility. Fewer institutions, for example, have standing groups dedicated to a capability such as shipboard hydrography and more rely on facilities like the Scripps Institution of Oceanography Oceanographic Data Facility. Whether such facilities grow in number or not, there are implied commitments by agencies to sustain such groups and capabilities; and whether or not these commitments are coordinated with multi-year plans for observing infrastructure and research activities. This appears to be shifting the need for support from multiple investigator groups, each with organic capability, to centralized facilities and may blur the planning of research versus infrastructure investments. Other examples would be the research groups that deploy Argo floats, surface drifters, and moorings; the expertise is now being located at fewer and fewer institutions. This new reality presumably offers cost savings due to economies of scale and must be considered in evaluating the overall research-infrastructure balance in ocean science.

V. ILLUSTRATING THE CHALLENGES AND OPPORTUNITIES

The advocacy expressed above for a coordinated planning process by the ORAP stems from the panel's understanding that:

- The Federal agencies engaged in ocean research and infrastructure cannot and do not sufficiently share explicit out year plans for major investments in research and infrastructure.

- The current federal budget processes and practices do not encourage and foster collaborative and synergistic planning of ocean research and infrastructure development and maintenance across Federal agencies and between the U.S. and other nations.

- The Federal government could do more to facilitate the role of the private sector in ocean research and infrastructure.

- There is insufficient planning for the sustained operation and governance of major elements of the ocean research infrastructure, as evidenced by the community-wide angst as major infrastructure investments by NSF in OOI are being transitioned from construction to operations funded under the overall same budget line in NSF Ocean Sciences.

- Opportunities such as the new EU funding for trans-Atlantic cooperation in ocean research and ocean observing do exist and could be capitalized upon.

- Other nations (or regions like the EU) look for a single federal point of contact and a U.S. upfront commitment for work in the Atlantic, but neither exist.

- Other nations (and regions like the EU) continue to enhance (rather than diminish or maintain) their level of investment in ocean research and infrastructure.

- Hurdles remain with respect to public/private research collaboration, including:
    - A recognized "place" to meet particularly across disciplines
    - Inherent commercial business obstacles (proprietary information / licensing)
    - Project management and coordination of sufficient scale
    - Mechanisms to 'blend funding'
    - The need to make a "business case" for investments (a notable exception here has been cruise line investment in *OceanScope* in that the activity is of interest to their passengers and the research concerns a primary business "asset" – the health and attractiveness of tropical oceans and coral reef reach destinations)

VI. STRIKING THE BALANCE

Historically, ocean research, like many other science disciplines, has relied principally on the efforts of individual or small groups of investigators. In the past few decades, this paradigm has been shifting - scientists are increasingly being asked to help address pressing societal needs, which often requires: i) large teams covering multiple disciplines, ii) sophisticated and expensive infrastructure, and iii) large geographic and/or long temporal coverage. This paradigm shift was not too painful as long as funding was growing robustly, but in the past decade or so, funding growth has stalled. As a result, there is an increasing need to find ways to balance the demands of large-scale science projects that require heavy infrastructure investments, while at the same time sustaining the important science contributions that still come from smaller projects involving individuals and small groups.

In the absence of funding growth, the only alternative is to do more with less – to become more efficient. As should be obvious from the preceding pages, ORAP believes some major efficiencies could be achieved in ocean science by improving cross-agency collaboration, international partnerships, and private sector participation. To achieve this, ORAP supports developing a national decadal strategic plan to guide national investment in ocean research and the shared ocean research infrastructure on which it depends. The plan would be reviewed bi-annually and updated by the NOC as required.

The review would be conducted under the auspices of the NOC but would rely upon both federal and external expert reviewers with respect to ocean science and operations. Consideration should be given to utilizing an NRC ad hoc study committee or vetting plan reviewers through a process similar to the process used by the NRC. Candidates could be drawn from the scientific advisory bodies for the various NOC agencies but should also include members from international and private industry advisory bodies.

At least some of the reviewers will need to be knowledgeable with respect to the existing system of sensors and sensor platforms with a view to identifying opportunities for improvements. Agencies can provide prediction and analysis systems to guide this process by identifying observations that could improve ocean state estimates and forecast model skill. NASA currently employs such a system of Observing System Simulation Experiments before deploying any new satellite sensors, and NOAA has committed to using the same methodology with respect to hurricane and ocean observations. The ORAP supports this kind of quantitative analytical approach to evaluating system efficacy before committing to construction (much less final deployment).

International cooperation provides many opportunities to leverage sparse funds. This is already being done to some degree. For example, the EU funding package called Horizon 2020 supports the Atlantic Ocean Research Alliance which is providing scientific, technical, and logistical support to the European Commission in developing and implementing trans-Atlantic, ocean research cooperation between the EU, U.S., and Canada. Another Horizon 2020 initiative is the cooperative Atlantic Ocean observing effort (AtlantOS) designed to develop an advanced framework for an integrated Atlantic Ocean Observing System. These efforts are supporting the U.S., Canadian, and EU implementation of the "Galway Statement," an agreement signed in Galway, Ireland (May 2013) by the U.S. EU, and Canada to promote cooperative ocean research and ocean infrastructure development in the Atlantic. In an era of flat research budgets, more efforts like this are needed.

In summary, the plan must be as quantitative as possible, be set against the contexts of improved international collaboration, and be cognizant of the evolving technical state of ocean infrastructure. Most important of the review of infrastructure plans must be conducted in synchronization with ongoing review of ocean research. While it is not possible to foresee all elements of investigator-driven, bottom up ocean research, the activities of the Federal agencies do now reach ahead for decades as longer-term observing is sustained and as ocean science increasingly addresses dynamics, variability, and change at inter-annual and longer time scales, such as the meridional overturning circulation (MOC), El Nino/Southern Oscillation (ENSO) cycles, and the Pacific Decadal Oscillation (PDO).

VII. SUMMARY AND RECOMMENDATIONS

The scientific guidance that leads the infrastructure debate has been refreshed with agreement on four national goals: "enabling stewardship of the environment, protecting life and property, promoting sustainable economic vitality, and increasing fundamental scientific understanding".

In assessing these goals, the ORAP notes that:

1) The U.S. Ocean Environment stretches from the Alaskan ice to the Hawaiian corals and that a multiplicity of infrastructure is need to study this diverse environment. New and rapidly emerging trends include the threat posed by ocean acidification to corals, north Pacific mollusks and the entire Arctic food chain; rapidly disappearing polar ice; ocean de-oxygenation that will adversely impact the entire U.S. West Coast from the Mexican border to the Aleutians; the poleward migration of marine species in response to global warming; and accelerating sea level rise.
2) For the protection of life and property, as well as national security, improved ocean-weather forecasting that incorporates climate change trends is imperative, as is improved prediction and detection capacities related to extreme events, tsunamis, and the ENSO. Enhanced knowledge of offshore geotectonics is also essential. These are equally relevant to the national security missions of the U.S. Departments of Defense and Homeland Security.
3) Economic vitality concerns encompass the long-term viability of coastal cities, fishing (commercial and recreational), recreational boating, coastal tourism, and the offshore

energy industry as major factors (as well as others). The fishing industry is already being challenged by marine population migration across regulatory boundaries, advancing poleward some 10-20 km per year, as migrations as are driven largely by upper-ocean warming. Growing human coastal populations and urban development (and consequently enhanced vulnerability) magnify the U.S. risks from hurricanes, making vital enhanced forecasting capacities. The rapid growth of the offshore oil and gas industry had been neglected by the traditional ocean science community. That fundamentally changed when the Deepwater Horizon oil spill occurred, an event that galvanized the ocean science community and attracted worldwide attention. Today well over 200 U.S. scientists are engaged in research addressing these matters, often at the fundamental level. This event is likely to be just one of a number of episodic events requiring a managed response by the research community.

4) In "increasing fundamental scientific understanding" the ORAP notes that there has been a sustained transition in the ocean sciences from a field that was initially dominated by exploratory observations to the current field that is based more on quantifying fundamental properties and processes at all spatial and temporal levels. This has proceeded in concert with advances in modelling the physical, chemical, geological, and biological functioning of the ocean and its invaluable natural resources. The ORAP also notes that the ocean sciences have transitioned from a field that was dominated by ONR support during the Cold War to a field that is funded by a much broader basis (and perception of information needs). Lastly, the ORAP note again that U.S. increases in fundamental knowledge have been driven by new observing technologies, such a floats and gliders, ROVs and AUVs, and modern sensors. U.S. ocean scientists continue to use research ships as platforms, but must extend their uses far beyond the purposes envisaged during their initial construction. Satellites have played a key role in understanding the large-scale aspects of the ocean and will continue to do so for the foreseeable future.

It is important to acknowledge that the context for addressing the balance between research and infrastructure investment is, for the ocean sciences, one of considerable evolution and change. There are a number of key aspects of this evolution. Societal need for knowledge about the ocean and the value to society of ongoing and new observations is increasingly acknowledged. One example is the international investment in sustained observing arrays in the global tropics for the purpose of predicting weather and climate variability driven by the tropical oceans (such as the ENSO events). The efforts by many nations to preserve their fish stocks by increased regulation and the necessary implementation of "ecosystem based management" are other examples. Observing capabilities have expanded and matured dramatically, such as the new remote sensing capacity provided by the Aquarius satellite mission. In addition, the level of international collaboration has increased with the implementation of large multi-national research programs (e.g., CLIVAR and GLOBEC described above and more recently IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) conducted under the International Geosphere-Biosphere Program), as well as through the Global Ocean Observing System initiative. The scientific community participation in ocean observation and research has markedly increased over the last decade, both in the U.S. and internationally. Finally, as the ocean increasingly serves as a primary source of food, energy generation, and other natural resources, the private sector is increasingly engaged in ocean research and the development and use of related infrastructure.

The ORAP's primary recommendation is for a **Coordinated Federal Strategic Plan for Ocean Research and Shared Ocean Research Infrastructure to be developed under the auspices of the NOC.** Such a plan should have a detailed planning horizon out to 10 years, be updated biannually, and must include a short description of expected trends thereafter with respect to the societal need(s) being addressed, relevant research progress and technology development, and both international and private sector partnership opportunities. Such a plan must be tied to a set of national priorities, which may or may not encompass all the priorities of individual agencies. Such a plan must be developed in close coordination with planning for future ocean research. The infrastructure must be there to support planned ocean research, but must be flexible enough to enable and facilitate both the discovery process and the evolution of ocean research.

APPENDIX: ORAP MEETING AGENDAS

JANUARY 14-16, 2013 MEETING

Location: Consortium for Ocean Leadership, 1201 New York Ave NW Fourth Floor, Washington DC 20005, Conference Room ABC

Day 1: January 14, 2013

09:00 Call to Order *(DFO Cleveland)*

09:00 - 09:20 Introduction

a) Welcome; Introductions *(M. Leinen)*
Invited Experts: Jon Alberts (UNOLS) (via phone), Phil Bell (University of Washington), Debborah Colbert (AZA), William Dewey (Taylor Shellfish, Inc), Robert Duce (Texas A&M University), Carl Gouldman (U.S. IOOS), Marlene Kaplan (NOAA), Jill Karsten (NSF), Stuart Levenbach (OMB), Camsie McAdams (Dept of Ed), Tim Moltmann (Australian IMOS), Lisa Rom (NSF), Shawn Rowe (Oregon State University), Gail Scowcroft (URI) (via phone), Bruce Tackett (Resource Access International), Bob Winokur (Navy, SOST)
b) Review Agenda *(M. Leinen)*
c) Membership Update *(DFO Cleveland)*

09:20 - 09:50 Update from the National Ocean Council (NOC) *(Deerin Babb-Brott)*

09:50a - 12:00 Briefing: Balancing Ocean Infrastructure with Ocean Research *(B. Weller)*

a) Presentations
   i. Bob Winokur, Navy, Subcommittee on Ocean Science and Technology (SOST)
   ii. Stuart Levenbach, Office of Management and Budget (OMB)
   iii. Tim Moltmann, Australian Integrated Marine Observing System (IMOS)
   iv. Carl Gouldman, U.S. Integrated Ocean Observing System (IOOS)

11:00 - 11:15 *Break*

b) Panel Discussion (Invited Discussants: Jon Alberts - UNOLS Executive Secretary, via phone)

12:00 - 13:00 *Lunch*

13:00 - 15:00pm Briefing: Leveraging Ocean Education Opportunities *(S. Ramberg)*

a) Presentations
   i. Shawn Rowe, Oregon State University
   ii. Phil Bell, University of Washington
   iii. Debborah Colbert, Association of Zoos and Aquariums
b) Panel Discussion (Invited Discussants: Jill Karsten – NSF, Gail Scowcroft – URI, via phone, Marlene Kaplan – NOAA, Lisa Rom – NSF, Camsie McAdams – Department of Education, via phone)

15:00 - 15:15 *Break*

15:15 - 16:30 Review of Draft: Implementing Ecosystem-Based Management (*A. Rosenberg)*

16:30 - 17:00 Update from the Interagency Working Group on Ocean Acidification *(Ned Cyr, NOAA)*

Day 2: January 15, 2013

--- CLOSED WORKING SESSION ---

Day 3: January 16, 2013

09:00 Reconvene *(M. Leinen)*

09:00 - 10:00 Review of Progress from Sub-Group Meetings
a) Ocean Infrastructure *(B. Weller)*
b) Ocean Education *(S. Ramberg)*
c) Ecosystem Based Management *(A. Rosenberg)*

10:00 - 10:30 ORAP Membership and Tasking Process *(M. Leinen & J. Cleveland)*

10:30 - 10:45 Break

10:45 - 11:45 Open Discussion on Current and Future ORAP Topics, Including Policy Issues for NOC Consideration *(M. Leinen)*
a) ORAP Meeting Schedule (note: next meeting scheduled for May 21-23, 2013)

11:45 - 11:55 Review of Action Items *(M. Leinen)*

11:55 - 12:10 Public Comment Period *(DFO Cleveland)*

12:10 Adjourn *(DFO Cleveland)*

AUGUST 21-22, 2013 MEETING

Location: Marine Acoustics, Inc., 4100 Fairfax Drive, Suite 730, Arlington, VA 22203

Day 1: Wednesday, August 21, 2013

08:30 Light Breakfast for Members and Invited Guests

09:00 Call to Order (DFO J. Cleveland)

09:00 - 09:30 Introduction
a) Welcome; Introductions (M. Leinen)
b) Review Agenda (M. Leinen)
c) Discussion of Minutes from May 21-22 Meeting (M. Leinen)
d) Membership & Panel Support Update (DFO J. Cleveland)

09:30 - 10:00 Update from the National Ocean Council (Deerin Babb-Brott)

10:00 - 10:30 Updates from NOC Report Subgroups
a) Balancing Ocean Infrastructure with Ocean Research (B. Weller)
b) Leveraging Ocean Education Opportunities (S. Ramberg & G. Scowcroft)
c) Implementing Ecosystem-Based Management (A. Rosenberg)

10:30 - 10:45 *Break*

10:45 - 11:15 Update on OSB Decadal Survey of Ocean Sciences: Guidance for NSF on National Ocean Research Priorities (Susan Roberts and Deb Glickson, NAS)

11:15 - 12:30 *Lunch (to be ordered-in)*

12:30 - 13:30 Panel on Gulf of Mexico Public-Private Research Partnerships (moderator M. Leinen)

a) National Academy of Science / British Petroleum-funded Deep Water Horizon research activity: Maggie Walser (NAS staff)
b) Gulf of Mexico Research Initiative / British Petroleum-funded oil spill research activity: Chuck Wilson (Chief Scientist of GoMRI)

13:30 Adjourn Public Session for Day 1

--- CLOSED WORKING SESSION ---

13:30 - 13:45 Closed Administrative Session…Chair and Vice Chair Elections

13:45 - 17:30 Task Working Groups

a) Balancing Ocean Infrastructure with Ocean Research (MAI Large Conference Room)
   ORAP Members: Bob Weller (lead), Dan Costa*, Steve Ramberg, Margaret Leinen, Michael Bruno, Peter Brewer, Bruce Tackett
b) Leveraging Ocean Education Opportunities (MAI Small Conference Room)
   ORAP Members: Gail Scowcroft & Steve Ramberg (co-leads), Kelton Clark, Dan Costa*, Dennis Bartels, Bill Dewey, Jane Davis*, Kerry St Pe*
c) Implementing Ecosystem-Based Management (ONR Room 260; Joan will escort, you will need your driver's license)
   ORAP Members: Andy Rosenberg (lead), Molly McCammon, John Gannon, Bruce Tackett

   * Previous ORAP Members

18:30 No Host Reception & Dinner (Pinzimini at The Westin Arlington Gateway, 801 N Glebe Rd., Arlington, VA 22203. Phone: 703.537.4200)

Day 2: Thursday, August 22, 2013

8:30 am Light Breakfast for Members and Invited Guests

9:00 am Reconvene (M. Leinen)

9:00-10:30 am Review of Progress from Task Working Groups

a) Ocean Infrastructure (B. Weller)
b) Ocean Education (G. Scowcroft / S. Ramberg)
c) Ecosystem Based Management (A. Rosenberg)

10:30-11:00am Open Discussion on Future ORAP Topics, Including Policy Issues for NOC (M. Leinen)

11:00-11:15 am *Break*

11:15-11:30 am	ORAP Future Meetings (M. Leinen & J. Cleveland) a) Teleconference for approval of report(s) in early October b) Next meeting scheduled for 2-6 Dec, location TBD c) Spring meeting last week of March or early April
11:30-11:45 am	Review of Action Items (M. Leinen)
11:45 am-12:00	Public Comment Period (DFO J. Cleveland)
12:00 pm	Adjourn (DFO Cleveland)

Invited discussants: Lisa Rom (NSF), Marlene Kaplan (NOAA), Jill Karsten (NSF), Jon Andrechik (NOC)

DECEMBER 3-4, 2013

Location: QinetiQ North America, 4100 N Fairfax Drive, Suite 800, Arlington, VA 22203

This meeting is open to the public. Any members of the public (including Federal employees that are not invited speakers) that expect to attend, please inform DFO J. Cleveland of your intention to attend, providing name, affiliation and citizenship, 3 days in advance in order to facilitate your access to the suite.

Day 1: Tuesday, December 3, 2013

08:30	Light Breakfast for Members and Invited Guests
09:00	Call to Order *(DFO Cleveland)*
09:00 - 09:30	Introduction a) Welcome; Introductions *(R. Weller)* b) Review Agenda *(R. Weller)* c) Approval of Minutes from Oct 7, 2013 Meeting *(R. Weller)* d) Membership & Panel Support Update *(DFO Cleveland)*
09:30 - 10:00	Update from the National Ocean Council *(B. Moran)*
10:00 - 10:30	Future ORAP Topics and Discussion of ORAP approach to potential topics *(R. Weller)*
10:30 - 10:45	*Break*
10:45 - 12:15	Learning about the Uncertainty Topic *(R. Weller)* a) NRC Briefs on Prior Uncertainty Reports *(R. Ban)* b) Thoughts on uncertainty in prediction *(R. Somerville)*
12:15 - 13:15	*Lunch*
13:15 - 13:45	Discussion and Approval of Ecosystem Based Management Report *(A. Solow, M. McCammon)*
13:45 - 14:30	Discussion and Approval of Education Report *(S. Ramberg, G. Scowcroft)*
14:30	Adjourn Public Session for Day 1

--- CLOSED WORKING SESSION ---

14:30 - 17:30 Task Working Groups

a) Balancing Ocean Infrastructure with Ocean Research (Location TBD)
   ORAP Members: Bob Weller (lead), Steve Ramberg, Margaret Leinen, Michael Bruno, Peter Brewer, Bruce Tackett, Bob Duce, Dan Costa*
b) Leveraging Ocean Education Opportunities (Location TBD)
   ORAP Members: Gail Scowcroft & Steve Ramberg (co-leads), Kelton Clark, Dan Costa*, Dennis Bartels*, Bill Dewey, Jane Davis*, Kerry St Pe*
c) Implementing Ecosystem-Based Management (Location TBD)
   ORAP Members: Andy Rosenberg (lead), Molly McCammon, John Gannon

18:30 No Host Reception & Dinner (TBD)

Day 2: Thursday, December 4, 2013

08:30 Light Breakfast for Members and Invited Guests

09:00 Reconvene *(R. Weller)*

09:00 - 09:30 Discussion and wrap up on EBM and Education Reports

09:30 - 10:30 Discussion of Infrastructure Report Status and Writing

10:30 - 11:00 Open Discussion on Future ORAP Topics, Including Policy Issues for NOC *(R. Weller)*

11:00 - 11:15 Break

11:15 - 11:30 ORAP Future Meetings *(R. Weller & J. Cleveland)*

a) Teleconference for approval of report in early January
b) Next meeting scheduled for ??, location TBD
c) Summer/fall meeting??

11:30 - 11:45 Review of Action Items *(R. Weller)*

11:45 - 12:00 Public Comment Period *(DFO Cleveland)*

12:00 Adjourn *(DFO Cleveland)*

Invited discussants: Maggie Thomas (NRC), Jon Andrechik (NOC), Marlene Kaplan (NOAA), Michalopoulos Christos (NOAA)

MAY 31 - JUNE 1, 2016

Location: Vencore, 4100 Fairfax Drive, Suite 800, Arlington, VA 2220

Day 1: Tuesday, May 31, 2016

--- CLOSED WORKING SESSION ---

08:30 - 09:00 Panel member check-in at meeting site

09:00 - 12:00 Closed session for administrative matters

a) Welcome, Introductions *(Weller)*
b) Administrative *(Drake)*
c) Swearing in new member, brief on FACA procedures, FACA rules and ethics
d) Updates *(Weller, Drake)*

12:00 - 12:45 Lunch (on your own)

13:00 Public session commences

a) Introductions *(Weller)*
b) Review and approval of last meeting's minutes *(Weller)*
c) Review of new charter *(Drake, Weller)*

14:00 - 14:45 National Ocean Council Comments

14:45 - 15:00 Break

--- PUBLIC WORKING SESSION ---

15:00 - 17:00 Public session continues

a) Review of terms of reference *(Drake)*
b) Work on pending report "Mechanisms for Balancing Ocean Infrastructure and
c) Ocean Research in the U.S. and Internationally" (or "Balance" Report)
d) The statement of the task for the report *(Weller)*
e) Summary of the committee's approach to report *(Ramberg)*
f) Overview of the report *(Ramberg, Weller)*
g) Discussion of report *(Weller)*

17:00 Adjourn Public Session for Day 1

18:00 No host gathering *(location TBD by panel)*

Day 2: Wednesday, June 1, 2016

09:00 - 15:00 Public session

09:00 Reconvene *(Weller)*

09:00 - 11:00 Discussion of "Balance" Report and writing assignments *(Weller)*

11:00 - 11:30 Pick up lunch and bring back to meeting room *(on your own)*

11:30 - 14:00 Open Discussion on Future ORAP Topics *(Weller)*

14:00 - 14:30 Time allocated for Public comment *(Weller & Drake)*

14:30 - 15:00 Final remarks and closing *(Weller & Drake)*