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Written Testimony of Dr. Timothy Cowles, Program Director, Ocean Observatories Initiative (OOI)

Vice President and Director, Ocean Observing Activities, Consortium for Ocean Leadership

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NSF Major Research Equipment and Facilities Construction Management: Ensuring Fiscal Responsibility and Accountability

Chairman Brooks, Ranking member Lipinski, and distinguished members of the Subcommittee, thank you for the opportunity to testify about the MREFC process. My name is Tim Cowles, I am the Program Director and Principal Investigator of the Ocean Observatories Initiative (OOI). I also serve as Vice President and Director of Ocean Observing Activities within the Consortium for Ocean Leadership.

I will begin with an overview of development of the OOI MREFC project from its creative start to today's mid-point of project construction. My testimony also will address the questions posed to me by the committee.

Overview of the Ocean Observatories Initiative

The Vision

The dream of long-term observatories in the ocean has been explored for more than twenty years. It has long been recognized that expeditionary-based ocean research provides essential insights into ocean processes occurring during and within the region of the expedition. However, such focused research often lacks a temporal and spatial context for interpretation. The extensive spatial and temporal variability of ocean processes complicates interpretation of focused studies, thus driving the need for sustained measurements across a range of spatial scales, from the sea surface to the seafloor. In addition, the critical linkages between physical, biological, chemical and geological processes in the ocean require that a wide range of properties be measured.

Sustained observing from the ocean surface to the ocean floor will certainly yield unexpected insights into ocean processes, just as satellite remote sensing revolutionized our understanding of global surface processes. Occasional 'snapshots' of portions the global surface were replaced by 'movies' created by repeated orbits of satellite sensors – these 'movies' provided new, dynamic, and unpredicted structures in the images of the surface layer of the ocean. We eagerly await the opportunity to replace our 'snapshots' of ocean and seafloor processes with the 'movies' that the OOI will provide through sustained observations of many ocean properties, through the full ocean depth range.

As early as 1988, the ocean sciences community began discussions about the scientific themes, design concepts, and engineering challenges of modern ocean research observatories. These early discussions and workshops led to the formation of the International Ocean Network (ION) in 1993. The first national committee was formed in 1995 with NSF funding, and broadened into the

Dynamics of Earth and Ocean Systems (DEOS) committee, tasked with providing a focus for exploratory planning for an ocean observatory network that built upon the compelling scientific themes unable to be addressed through other oceanographic research approaches.

The first International Conference on Ocean Observing Systems was held in 1999 in San Rafael, France, and focused interest on fixed and mobile observing systems. The international Global Eulerian Observatory (GEO) committee was formed the same year and later (2003) became *OceanSITES*.

Momentum for research-oriented ocean observing built further upon two National Research Council (NRC) studies in 2000 and 2003 ("Illuminating the Hidden Planet: The Future of Seafloor Observatory Science" [2000]; "Enabling Ocean Research in the 21st Century" [2003]), along with a series of community workshops that stressed the scientific and societal benefits of sustained observations. Building on this momentum, the OOI was approved by the National Science Board (NSB) in 2000 as a potential Major Research Equipment and Facilities Construction project for inclusion in a future National Science Foundation budget, thus allowing for focused planning efforts under NSF financial support.

Setting the Foundation

In 2003 and 2004, the U.S. Commission on Ocean Policy and the Pew Oceans Commission issued reports containing recommendations designed to improve society's use and stewardship of, and impact on, the coastal and global ocean. These recommendations highlighted key areas that require continuous, sustained investigation to enable timely and sound decision-making and policy development. Global, regional, and local climate variability and its impacts, coastal hazards, ecosystem-based management and the relationship between the ocean and human health were among the critical issues noted in the Commissions' recommendations that pointed to the need for a sustained, research-driven, ocean observing capability.

In response to recommendations from these reports and at the direction of the Administration, in 2006 the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology developed the *Charting the Course for Ocean Science for the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy* document (ORPP), which provided a framework for research investments to advance current understanding of critical ocean processes and interactions that facilitate responsible use of the ocean environment. The ORPP identified *ocean observing* as one of three key areas for research and management.

Early Planning and Conceptual Design

In 2004, the NSF Division of Ocean Sciences (NSF/OCE) established the OOI Project Office to coordinate further OOI planning. In 2005, the OOI Project Office asked for the ocean research community's help in developing the OOI network design by soliciting Request for Assistance (RFA) proposals, using the science themes of ocean observing to structure the request. A total of 48 proposals were submitted by 549 individually-named proponents representing 137 institutions, agencies and industries in 35 states. These proposals were subjected to peer review and formed the basis for the initial Conceptual Design of the OOI.

Using the responses from the RFA process and associated review results, the OOI Project Office and external Advisory Committees developed an initial Conceptual Network Design (CND) for the

OOI, which then served as the focus of community discussion at the OOI Design and Implementation Workshop in March 2006.
In July 2006, NSF assembled a Science Panel to provide a merit review of whether the CND would provide the ocean research community with infrastructure capable of addressing high-priority science questions motivating the OOI. This Panel endorsed the OOI as a worthy investment that, when implemented, would advance our understanding of the Earth and the oceans. In August 2006, NSF convened a Conceptual Design Review (CDR) to assess the Project's technical feasibility and budget, the Project's Management Plan, including schedules and milestones, and education and outreach plans. The CDR Panel affirmed that the scientific and technical basis of the OOI, as proposed, would transform oceanographic research in the coming decades.

Formation of the Project Team

The major partners in the OOI construction process, three of the four OOI Implementing Organizations (IO), were selected in 2007 by a competitive acquisition process similar to that used in large federal acquisitions. Subawards were established with the University of Washington as the IO for the *Regional Scale Nodes*, the University of California San Diego (UCSD) as the IO for the *Cyberinfrastructure*, and the Woods Hole Oceanographic Institution with two consortium partners, Scripps Institution of Oceanography and Oregon State University, as the IO for the *Coastal and Global Scale Nodes*. The fourth IO, Rutgers, The State University of New Jersey, was selected in 2011 as the IO for the *Education and Public Engagement* software infrastructure component, with its partners University of Maine and Raytheon Mission Operations and Services.

It is important to note that the OOI project team builds upon the strengths of public, private, and non-profit institutions, along with industry partners. This integration of complementary capabilities is a powerful recommendation for the MREFC process, and represents an efficient use of public funds.

With three of the Implementing Organizations on-board in 2007, the OOI Project Team worked towards generating the Preliminary Network Design (PND). The PND development was guided by recommendations and principles established by the advisory structure and the NSF Large Facilities Office, taking into consideration long-standing program and design concepts, the OOI Science User Requirements and the project cost constraints.

As part of the external review process, NSF convened a second Science Review Panel in October 2007 to assess the OOI Network Design and its ability to provide transformative research capabilities for the ocean science community. This Panel stated that the OOI would provide opportunities to address "broad and compelling interdisciplinary scientific questions that cannot be adequately investigated with current methodologies" and offered a series of recommendations on design, management, and public engagement.

Path Toward a Construction Baseline

The Preliminary Design Review (PDR), convened by NSF in December 2007, assessed the current state of planning for the OOI. The PDR Panel was very positive about the progress of planning for the OOI and about the transformative scientific rationale for the initiative. The OOI Team responded to the recommendations of the PDR Panel and then underwent the Final Design Review (FDR) in November 2008, which scrutinized the technical, programmatic, cost and

schedule readiness of the Project. The FDR Panel noted the technical readiness of the Project and recommended that the OOI proceed with construction in July 2010.

After the FDR, extensive discussions were held in early 2009 within NSF to address the need for the OOI Network to increase the focus on urgent issues in ocean science research. Given the ocean's vital role in the global transfer of heat, carbon and water, it was decided to focus on developing facilities to better understand oceanic climate signals as well as the impact of carbon cycling on ocean acidification, ocean carbon sequestration and the impact on coastal marine ecosystems. As a result, NSF identified a variation on the OOI Network Design using ocean infrastructure and sensors deemed to be construction-ready at the FDR. This modified network design incorporated enhancements to the Coastal/Global Scale Nodes (elements that had been part of earlier design iterations) and reductions to the Regional Scale Nodes. A Review Panel in March 2009 expressed support for the infrastructure additions and noted that the intellectual merit and the broader impacts of OOI were very high and perhaps unique in the Earth and Ocean science communities as a whole. The project baseline that emerged from this review process formed the basis for the request to the National Science Board. On May 14, 2009, the National Science Board authorized the Director of NSF to award funds for the construction and initial operation of the OOI. On September 2, 2009, NSF and the Consortium for Ocean Leadership signed the Cooperative Agreement that initiated the construction phase of the OOI.

The OOI project is now 30 months through the 66-month construction phase. During those 30 months, the project's accomplishments include the successful installation of 880 kilometers of cable (power, communications) across the seafloor off Oregon and Washington, the development and release of the first stage of Cyberinfrastructure software, ocean tests of four different mooring systems and configurations, the procurement of autonomous vehicles and sensors, as well as the successful completion of the NEPA process for the OOI.

It is a pleasure and an honor to work within a project team that possesses the creative vision, technical expertise and commitment to complete the full infrastructure of the OOI. The short- and long-term societal benefits of the OOI more than justify the hard work.

What was the MREFC approval process experience for OOI?

Early members of the project office (2006-2009) had some government experience with large projects (NOAA, DoE), and others involved in the early planning had extensive ocean research experience and expertise. That oceanographic perspective is reflected in the recommendations included in many of the workshop reports, NRC reports, and review panel reports from the late 1990s through the mid-2000s. These documents provide a historical record of the early stages of moving the OOI from a concept to a tangible infrastructure.

The approval process (Conceptual Design Review, Preliminary Design Review, Final Design Review, NSB approval) can be viewed from at least two perspectives. On the one hand, as a project moves into and through the MREFC approval process, the creative leaders of the project must move smoothly from a research project viewpoint (their career perspective) to a more structured, systems engineering and project management viewpoint. This is widely recognized within the large facility community as one of the biggest challenges for a new MREFC project. On the other hand, the approval process educates the initial project team about the essential rigors of System Engineering, the need for a 'technical baseline,' the importance of vigilant oversight of processes and budgets, the requirement to track the performance metrics of earned value

management, and the need to search for cost efficiencies and approaches within construction that will carry over into Operations and Maintenance.

A number of overarching science objectives guided the early planning stages of the OOI. As described in the initial section of this testimony, those science objectives informed the Request for Assistance (RFA) process that solicited proposals from the ocean sciences community. The integration of the 48 submissions from that process led to the consolidation of many excellent research themes and approaches and resulted in an observatory vision that included 10 Global sites, 6 Coastal sites, and a seafloor cabled array with 5 sites on the Juan de Fuca plate. The experts comprising the Conceptual Design Review panel, in concert with the NSF, acknowledged the vision as important and worth pursuing, but requiring a more extensive analysis of scope and costs. The identification of Implementing Organizations in March 2007 permitted the Program Management Office at the Consortium for Ocean Leadership, as prime awardee, to begin integrating system engineering processes across the project while detailed cost analyses were conducted on the various envisioned elements of the observatory. The cost analyses led to a revision of the conceptual design, with external advisory committees consisting of experienced ocean scientists providing input to the team and to the NSF following Conceptual Design Review. At the time of Preliminary Design Review (December 2007), the scope of the OOI had been identified as 3 Global Sites, 2 Coastal Arrays (Pioneer and Endurance), and 5 major sites on the Juan de Fuca tectonic plate that would be connected to the undersea cabled array. This extensive consolidation of scope reflected the transition from 'science ideas' to 'engineering/budget reality.' It was during the interval between Conceptual Design Review and Preliminary Design Review that the OOI team also developed the extensive technical documentation required by the MREFC process, including, at the top level, a Project Execution Plan, Systems Engineering Management Plan, Configuration Management Plan, science to design requirements traceability, etc. The distributed team enhanced its understanding of the technical needs of an MREFC project during this phase of planning and preparation.

The interval between Preliminary Design Review and Final Design Review led to further refinement of the technical data package (policies, procedures, cost bases, etc). The recommendations of the Final Design Review panel in November 2008 included a strong recommendation for additional 'risk' to be considered during the construction phase. The panel recommendation was incorporated in the next risk estimation for the project in early 2009.

In summary, the multi-step MREFC approval process forged the distributed implementing organizations into a cohesive observatory team, while refining the technical and budgetary boundaries of the project. From the point of view of the OOI, the MREFC approval process was an essential, and positive, experience.

What were the strengths and weaknesses of the process?

The MREFC approval process provided the planning team with important external advice and guidance, assisting the team in developing documentation and cost estimates for each successive level of review. The clear structure of the MREFC process greatly facilitates the development of a strong team. For example, one key area of strength of the MREFC process for the OOI team was the requirement for incremental incorporation of increased technical and budgetary rigor - this discipline was extremely beneficial to the OOI team and built confidence across the project during the pre-construction phase. In addition to the benefits to the OOI team, the rigor of the process, and its transparency, benefits the sponsoring agency, the ocean sciences community, and the public.

Another important strength of the process is the opportunity for sophisticated management coordination to develop between NSF and the project team. This coordination, and the cooperative exchange of ideas and solutions, is vitally important as the project moves from approval to construction. This management coordination also assures more efficient use of public funds during construction and operations.

From the point of view of the OOI and our experience to date, there are no obvious weaknesses in the MREFC process. It has worked well for us. While each MREFC project has unique characteristics and unique technical challenges, it is necessary for the NSF and the Large Facilities Office to sustain a framework that supports the development and maturation of a project team during the early inception and subsequent approval stages. It is also important that the MREFC process have sufficient flexibility to adapt if a particular project encounters unusual challenges with scope, budget or schedule.

What have been the biggest challenges you have faced with the project thus far and how were they rectified?

The project began construction in September 2009 with fewer staff than the work plan required. It was more difficult than anticipated to reach full staffing levels during the first year of construction. We addressed this challenge and reached our staffing targets by involving the institutional leadership of each Implementing Organizations in the solution.

The OOI faced several challenges in environmental assessment during the first year of construction, particularly in responding to public comments and for completion of the environmental assessment within the project timelines. Through close coordination of informational events and public feedback events by the OOI team, NSF, and interested stakeholders, the project completed the environmental assessment and NSF signed a Finding of No Significant Impact for the OOI.

How is OOI currently managed?

The OOI has a hierarchical structure, with the Consortium for Ocean Leadership (a non-profit) as the 'prime' and each Implementing Organization as a 'subawardee.' A Cooperative Agreement between Ocean Leadership (OL) and the NSF establishes a set of terms and conditions for the project, which flow down to each subawardee. The OOI Program Management Office at Ocean Leadership is responsible for project compliance to those terms and conditions, including reporting of financial status and technical progress against milestones. On a functional basis, the program management office monitors and coordinates the work within the milestone-driven project schedule through daily interactions between Ocean Leadership and each major subawardee (via Contracting Organization Technical Representatives (COTRs) and project managers). Several teleconferences are conducted each week by the Program Management Office to facilitate communications across the geographically-distributed team.

Discussions and meetings occur with NSF several times each week. The development and submission of monthly progress reports by the Program Management Office to the NSF also serves as an important management tool for the Program Management Office, as these reports involve the monthly integration of Earned Value metrics as well as assessment of monthly project progress against schedule milestones.

The Executive Committee of the Board of Directors of the Consortium for Ocean Leadership provides project oversight, both through direct interaction with the OOI Program Director and

through reports from the OOI Program Advisory Committee (an external panel of non-conflicted senior ocean scientists).

What are the roles and responsibilities of the facility staff and the roles and responsibilities of NSF in the management and oversight of OOI?

I serve as the OOI Program Director, coordinating leadership actions with the senior staff at each Implementing Organization, and communicating on a regular basis with the NSF. I report to the CEO of the Consortium for Ocean Leadership. The OOI Senior Project Manager, reporting to the Program Director, has responsibility for overall project management and engineering integration for the entire project. The other members of the senior management team of the OOI at Ocean Leadership are responsible for numerous areas, including System Engineering, Safety, Quality, Science, Communications, and Environmental Compliance. As mentioned in an earlier section, the COTRs assigned to each Implementing Organization are responsible for the coordination and integration of day-to-day work, and function as the conduit for effective communication to and from the Program Management Office.

The Program Management Office also assures that project activities are governed by the OOI technical baseline (approved policies and procedures) and are administered via formal 'change control' procedures when necessary. All project actions are documented, reported, and archived.

Under the Cooperative Agreement, the Program Management Office has specific reporting and procurement compliance responsibilities to the NSF, with the clear distinction that the OOI team is responsible for *execution* and the NSF is responsible for *oversight*. In addition, prudent project management dictates that the OOI team maintains open channels of communication with the NSF about all project activities. We therefore have frequent interaction and information exchange (often daily). This level of interaction has been extremely beneficial through the approval process as well as through this phase of construction.

How do you work with NSF to ensure that the American taxpayer is getting a return on this investment?

The overarching scientific justification of the OOI project is the sustained delivery of many types of ocean data across a range of temporal and spatial scales, from the sea surface to the seafloor. This data delivery will have direct, short-term societal and economic benefits (coastal storm hazards, linkages between offshore and near-shore processes, improved ocean circulation modeling, seasonal ecosystem responses, etc), which will develop into long-term improvements in forecasting of ocean conditions. These connections between ocean research and 'broader impacts' are at the core of NSF's science objectives. The OOI is therefore perfectly poised to provide significant return on the taxpayer's investment.

To optimize that outcome, NSF and the OOI collaborate to maintain significant connections with other projects and other entities involved in ocean observing. The Consortium for Ocean Leadership has a Memorandum of Understanding with Ocean Networks Canada, a seafloor observing facility off Vancouver Island, British Columbia. The NSF co-chairs an Interagency Working Group on Ocean Observing (coordinated at Ocean Leadership) that facilitates the cost-effective development of observing capabilities across the federal family. Of particular note is the cross-agency and cross-project collaboration between NSF, NOAA, the OOI, and the Integrated Ocean Observing System (IOOS). The two agencies are co-funding a data management project that will assure interoperability between the NSF and NOAA systems.

As described earlier in this testimony, the OOI project team builds upon the strengths of public, private, and non-profit institutions, along with industry partners. We feel that this integration of complementary capabilities is an efficient use of taxpayer funds.

At a more detailed level, the taxpayer benefits from the cost efficiencies that resulted from the several stages of review of the OOI scope of work and the aggressive actions to reduce the costs to build and operate that scope. On an annual basis, the OOI project team is mandated by the Cooperative Agreement to develop and submit to NSF an Annual Work Plan that describes the work to be completed in the coming year, along with the funding request for that work. Only after review and approval by NSF, often involving sequential edits and revisions of the Annual Work Plan by the OOI team, is funding provided to Ocean Leadership for allocation to the work elements of the project, via subawards to the Implementing Organizations. We use monthly tracking of expenses and completed work compared the project baseline to generate Earned Value metrics, thus giving us valuable performance metrics for each Implementing Organization. Every month the project submits a formal report to NSF with extensive data on progress as well as challenges. We also work closely with NSF on procurements of capital equipment or major services to assure that appropriate acquisition procedures are followed. Each of these steps represents a collaboration between the OOI team and NSF to be cost-effective.

How is the entire life cycle of the project, including management and operations after construction, taken into account in the management and oversight of the construction project?

The initial, steady-state phase of Operations and Maintenance (O&M) of the OOI will begin in 2015 following the completion of Construction. The OOI team initially developed an Operations and Maintenance Plan in preparation for Preliminary Design Review. Since that time, the O&M Plan has been revised and updated to reflect the maturation of the construction schedule and an improved understanding of operational assumptions and expenses. During construction, the O&M team is integrated into *design reviews* and *production readiness reviews* to assure that operational issues (e.g., service costs, replacement costs) have been considered during the design and acquisition of subsystems or their components. The technical issues identified during construction, for any element, are included within the deliverables that accompany that element in its transition from construction to operations.

This aspect of life cycle considerations has been an active topic of discussion at each of our external reviews, and is a priority for the project managers in construction and O&M.

Mr. Chairman and members of the Subcommittee, I wish to thank you for this opportunity to answer questions about the MREFC process and the Ocean Observatories Initiative. I would be happy to discuss any of these topics with you during the hearing.