

**NSF/Ocean Sciences reply to:
NRC/NAS's "Sea Change (2015-2025 Decadal Survey of Ocean Sciences)"
May 11, 2015**

Overview

NSF received the National Research Council/National Academy of Sciences (NRC/NAS) report “*Sea Change: A Decadal Survey of Ocean Sciences, 2015-2025*” in late January 2015. A history and background of the report’s origin is found in *Sea Change* (Chapter 1), and further context is provided by Conover and Bronk (EOS, April 15, 2015).

This communication constitutes NSF’s reply to *Sea Change*. We first express our gratitude to the NRC/NAS committee and staff for the thoughtfulness and care put into the report’s development. NSF has carefully evaluated the report and engaged multiple aspects of the community to gauge reaction to the report’s recommendations. Although opinions are diverse in detail, the overall community response has been supportive of *Sea Change*, reflecting the clear challenges that rising infrastructure costs pose to NSF’s fundamental mission to support core scientific research and technological innovation. As discussed here, NSF is also broadly supportive of *Sea Change*.

Many of the infrastructure components identified in *Sea Change* were initiated at a time when NSF’s budgetary investment in geosciences was anticipated to grow. Recent budget levels and prudent planning, however, suggest the flat funding scenario that was used as the forecast in *Sea Change* is the most realistic one. Over the past year, in this funding environment, we have taken steps to initiate rebalancing between ocean sciences infrastructure and research/technology funding.

Sea Change’s Recommendations will result in the desired portfolio rebalancing. Accordingly, we endorse, with a few exceptions as noted in this communication, *Sea Change*’s Recommendations 1-8 and are proceeding with implementation plans. These cuts in infrastructure, however, present difficult choices and will affect our ability to achieve OCE’s research mission.

Using the criteria of *Sea Change*, and its budgetary baseline of FY2014, all financial figures mentioned here are based on an assumption of flat budgets for OCE for the foreseeable future. If budgets grow, then the key recommendation from *Sea Change* to increase the core science and technology programs would be revisited, resulting in further restoration. Conversely, if OCE’s budget is reduced, there will need to be additional decreases in infrastructure funding to a greater degree than outlined here, as well as perhaps decreases to core science and technology funding.

Science Priorities

Chapter 2 of *Sea Change* outlines eight “Ocean Science Priorities for 2015-2025” anticipated to be of greatest interest and relevance in the coming decade. NSF supports this assessment. These “Ocean Science Priorities” are helpful to assess a broad portfolio,

and NSF will continue to support excellent oceanographic research and technology development in the context of NSF's long practiced "gold standard" of external and internal merit review, regardless of the specific research topic.

Ocean Observatories Initiative (OOI)

NSF is in the process of fulfilling its commitment to the oceanographic community by completing construction of the OOI and transitioning to operations in Summer 2015. In the past year there have been many successes for this unique federation of observing systems. These achievements include installation of the last two "Global" moorings in the Southern Hemisphere, enhanced study of Axial Seamount and other geological and oceanographic features in the Regional Scale Network and Endurance Array in the Pacific Northwest, and starting the formal process of data flow from the Pioneer Array in the coastal Atlantic region. The OOI offers the oceanographic community an unprecedented opportunity to study ocean processes in a way never before attempted by the U.S. academic community, and contributes significantly to collaborative international observing efforts.

Sea Change recommends an approximately (~) 20% reduction in operating costs for OOI (Recommendation 4). NSF supports this recommendation. As part of NSF's actions, a one-time savings of ~\$2M in OOI operations funding will be transferred to core research and technology programs. Moving forward, given that the current Cooperative Agreement (CA) for OOI expires in April, 2017, NSF intends to issue a solicitation for a new CA that is likely to have several key features: (1) The total budget to operate the OOI will reflect the ~20% reduction recommended by *Sea Change*, that is, a total budget of no more than ~\$45M/year; (2) The capability to provide real-time and near real-time data to the community will be reinforced; (3) The opportunity will exist to allow for U.S. and international partnerships involving academic, commercial, governmental, and/or non-profit institutions; and (4) The responders will be able to draw upon guiding documents such as *Sea Change*, OOI science planning documents, and other community driven efforts, to structure their response in terms of geographic coverage, scientific focus, technological capability, and other aspects. The above plan is seen as a better alternative to the "immediate" 20% reduction proposed by *Sea Change*. Allowing OOI to be fully functional will provide critical information for potential proposers to assess and chart the future directions of the facility.

As OOI moves beyond construction and into operations, NSF intends to work with the University-National Oceanographic Laboratory System (UNOLS) Ocean Observing Science Committee and the community to develop an independent and robust advisory structure that will serve the needs of OOI operation and maintenance, engage and grow the research community working on OOI-based science, and serve as the public face of OOI to the national and international community at large. NSF will also dedicate additional Program Officer support in the Integrative Programs Section to help provide oversight of OOI and the OOI Advisory Structure.

International Ocean Discovery Program (IODP)

Over the past decades, NSF has made significant investments in the IODP and its predecessor scientific drilling programs. Most recently, these include the reconstruction of the drillship *JOIDES Resolution*, a restructuring of the overall Program, and a new Cooperative Agreement (CA) with Texas A&M University (TAMU) to be the Implementing Organization of the IODP. As noted by *Sea Change*, these developments have significantly reduced the cost of operating the *JOIDES Resolution*, with recent savings estimated to be ~\$8M per year.

Sea Change recommends an ~10% reduction in operating costs for IODP (Recommendation 4). NSF supports this recommendation. While some of these savings have already been implemented by enhanced regional planning, as noted by *Sea Change*, significant financial restructuring cannot be achieved without increased funding from international partners. *Sea Change* accurately identifies a fundamental financial imbalance between the U.S. contribution and contributions by IODP's international partners. The financial model must be realigned to more accurately reflect that the *JOIDES Resolution* is the central platform of scientific ocean drilling and serves the greatest number of U.S. and international scientists. We look forward to pursuing this financial realignment in collaboration with the *JOIDES Resolution* Facilities Board (JRFB) and IODP/TAMU.

NSF will also continue to work with the JRFB and IODP/TAMU to identify and implement additional savings in operations, including a re-examination of shipboard laboratory capabilities (including cyber-infrastructure), regional planning, and funding support for core repositories.

Academic Research Fleet

Sea Change recommends an ~5% reduction in operating costs for the Academic Research Fleet (Recommendation 4). NSF supports this recommendation. Over the past three years, the reduction in the overall size of the Fleet has resulted in reduced operating costs. In addition, decreases in fuel costs due to the global market, while not to be counted upon for long-term planning, provide some further immediate savings. In FY2015, we will be transferring a portion of these savings to core research programs and reinvesting a portion in Fleet maintenance.

Sea Change accurately identifies the importance of the Academic Research Fleet to OCE's overall basic science mission. Virtually all of OCE's research portfolio touches upon research ship operations in some way. Furthermore, the U.S.'s capability to provide leadership in large field campaigns of international scope (e.g., CLIVAR, GEOTRACES, GeoPRISMS, etc.) depends on access to a safely-operated state-of-the-art research Fleet.

Regional Class Research Vessels (RCRVs): At its May 2015 meeting, the National Science Board (NSB) authorized Dr. France Córdova, the Director of NSF, to include construction of two RCRVs in future budget requests. This agrees with *Sea Change's*

Recommendation 5. These ships would be essential to support science-based understanding of the ocean, including all eight of the “priority science questions” posed by *Sea Change*. The addition of these vessels would occur as part of the continued “right-sizing” plans described by UNOLS that decreases the Fleet from 21 to 16 ships. However, with these two RCRVs and the recent addition of the R/V *Neil Armstrong*, R/V *Sally Ride*, and R/V *Sikuliaq*, as well as the potential for Service Life Extensions (SLEs) of the Global-class ships R/V *Thompson*, R/V *Revelle*, and R/V *Atlantis*, the Fleet would be well-positioned to serve the needs of the oceanographic community into the 2030 time frame.

Sea Change Recommendation 5 encouraged reconsideration of the design of the RCRV vessels and suggests that there has been “capability creep”. The RCRV design has increased capabilities when compared to the current Regional-class vessels. NSF is designing the RCRV vessels to suit OCE’s research and technology portfolio in the broader context of federal fleet requirements.

Marine Seismic Research: NSF will continue to support the capability to perform both 2-Dimensional (2D) and 3D seismic research of high national interest. Many large-scale scientific research questions such as understanding sea level rise, probing the structure of the deep crust, and assessing geohazards such as earthquakes and explosive volcanism, require specialized seismic infrastructure capable of operating throughout the global ocean.

The primary capability to perform marine seismic imaging by the U.S. academic community is currently centered on the R/V *Marcus G. Langseth*, a 235-foot vessel owned by NSF and operated by the Lamont Doherty Earth Observatory of Columbia University.

As *Sea Change* describes, operation of this vessel is costly under the current model, with rates on the order of \$65,000 per day for 2D seismic imaging and \$90,000 per day for 3D imaging, for an annual operating cost of ~\$14M. This financial model is unsustainable.

Current contractual obligations and commitments to funded seismic projects during FY2015-16 will continue to move forward using the R/V *Langseth*. Beyond that time frame, NSF is exploring ways to ensure the continued capability to support marine seismic research. First, NSF is considering investing in portable components, complete with a modular streamer with top-side electronics and cable-leveling devices configurable for 2D and 3D arrays, that will enable academic researchers to perform high quality seismic research using other UNOLS vessels. This will provide the U.S. academic community with access to 2D and shallow 3D seismic capability in a way that enhances flexibility for planning and executing research cruises. If long-offset, top quality source components are feasible with this portable approach, then ~75% of the U.S. academic marine seismic need could be achieved, as determined by a self-study of the number of proposals received requiring seismic capability over the past 5 years. Second, NSF will pursue conducting an open solicitation for ownership of the R/V *Langseth* that would provide NSF with a to-be-determined number of days at sea per year to serve the U.S.

academic research community with state-of-the-art source, long offset 2D, and a baseline 3D capability. If NSF, as a federal agency, no longer owns the vessel, the remaining R/V *Langseth* time would be available to support the business model of the new owner. Third, in order to further enhance efficiency of marine seismic research requiring deep crustal imaging, including 3D, NSF intends to strategically schedule these operations via regional planning over a period of several years. This research capability could potentially be supported by R/V *Langseth* through a new ownership model, by international partners, and/or through strategic contractual arrangements with industry.

Manned and Unmanned Vehicles: *Sea Change* recommended NSF examine the National Deep Submergence Facility (NDSF), the impact of the human operated vehicle (HOV) *Alvin* on the availability of the Global-class R/V *Atlantis*, and the potential Phase 2 upgrade of *Alvin* that would give her the ability to dive to 6500 m water depth. NDSF also includes the ROV *Jason* and the AUV *Sentry*, and NSF supports a number of institutionally owned and operated underwater vehicles that are not part of NDSF (e.g., gliders).

NSF anticipates no changes in the NSF-NDSF relationship and notes that the technological and engineering innovations developed by NDSF and other operators of manned/unmanned vehicles such as gliders represent exciting opportunities for progress in ocean science research. NSF currently has no specific plans to implement the Phase 2 *Alvin* upgrade and will likely work with the NDSF at the appropriate time to potentially increase *Alvin*'s capabilities during scheduled overhauls.

NSF anticipates that on average R/V *Atlantis* will support *Alvin*-based science for ~100 days per year, which leaves this Global-class vessel with significant time available for general purpose oceanographic research.

Impact on Funding for Science and Technology

The budgetary realignment between infrastructure and core science and technology is intended to reverse the decline in the proportion of OCE's budget devoted to supporting PI-driven research proposals. In support of the *Sea Change* recommendations, NSF will reverse this decline by allocating the monies resulting from the decrease in infrastructure operation and maintenance spending to the core programs for research and technology. Increased support will be provided to general core science and technology funding, as well as for new initiatives within core programs.

Sea Change also noted that funding for the Ocean Technology and Interdisciplinary Coordination (OTIC) program has decreased significantly. NSF agrees that this needs to be addressed. We are currently studying how to best stimulate technological innovation, for example by increasing funding to OTIC itself, increasing the amount or type of technology-driven funding in the core programs, or both. As part of its deliberations during construction of the FY2017 budget, OCE will look to increase opportunities for technological innovation.

Given that the overall goal of *Sea Change* is to restore support for research and technology, NSF further notes that increased attention will be paid to enhancing support for intellectually and/or technologically “high risk – high reward” research.

Other Considerations

Infrastructure Planning: NSF endorses *Sea Change*’s Recommendations 6 and 7 regarding infrastructure reviews and the establishment of “a high-level standing infrastructure oversight committee”. As required for sound management, the dynamic interplay between science support and infrastructure capabilities will continue to be assessed. NSF intends to initiate such activities in FY2015-16.

Collaboration and Partnerships: NSF endorses *Sea Change*’s Recommendation 8 on the potential opportunities presented by other federal agencies, the international community, and other sectors. As noted by *Sea Change*, ocean sciences is critical to U.S. national interests as well as those of the global community overall. We look forward to working with the community on these endeavors.

Cyber-infrastructure (CI): CI was not discussed by *Sea Change* as a stand-alone entity. NSF is concerned, however, by the increasing cost of CI throughout OCE’s portfolio. Such costs are within infrastructure components (e.g., OOI, IODP, and U.S. Academic Research Fleet) and are also included as external databases and data management systems associated with specific programs and projects. NSF appreciates that individual data management entities offer valuable products and services, and that CI can stimulate new lines of scientific inquiry. Nonetheless, we will be studying OCE’s CI investments seeking ways to reduce costs.

Details on the various activities related to implementation of *Sea Change* will be forthcoming as NSF moves forward. We further note that *Sea Change* Recommendation 3 includes “...an immediate 10% reduction in major infrastructure costs in their next budget, followed by an additional 10-20% decrease over the following five years.” NSF will assess the effectiveness of the shifting of funding that addresses *Sea Changes*’ immediate 10% reduction that are described in this communication, in order to inform later budgets in the full context of Recommendation 3.