Opportunities for enhanced Ocean-Bottom Seismic (OBS) capabilities

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It has been 20 years since the NSF's Marine Geology and Geophysics program created the Ocean-bottom Seismology Instrumentation Program (OBSIP) to support individual PI-driven science projects and community experiments using seismic tools in the oceans. Recently reformed as the Ocean-Bottom Seismology Instrument Center (OBSIC), the program democratized the ability to conduct cutting-edge marine seismic research programs, and has been hugely successful. The 2019 Final Report for the OBSIP program documents nearly 60 individual experiments involving dozens of unique PIs and co-PIs, as well as OBS data downloaded by nearly 4000 unique users. Demand for the instruments is high; as of December 2020, NSF has recommended funding 10 OBSIC-supported projects, effectively saturating instrument availability through 2023.

In this document, the OBSIC Operations Subcommittee (OBSIC-OS[1]) provides a community perspective on opportunities to enhance OBSIC-enabled science and improve the current state of OBS technology. Presently, the OBSIC facility operates a heterogeneous mix of instrumentation to support natural-source, broad-band (BB) seismic experiments, as well as short-period (SP) instruments that are used for both natural-source and active-source experiments[2]. These instruments use over 20-year-old technology, which limits their scientific potential, and makes them expensive to operate and maintain:

- The small number of SP instruments (~30) makes it impossible for US scientists to conduct frontier, state-of-the-art experiments with close instrument spacing for high-resolution active source imaging and for precise earthquake relocation. It also results in inefficient active-source experiments that require complex deployment – shoot – recovery – redeployment – shoot – recovery sequences using heterogeneous instruments from multiple providers. Such strategies limit the scientific return (reducing on-bottom time and 3D recording opportunities) and are expensive in terms of manpower and ship time.
- The high cost of BB OBS deployments severely restricts the spatial scale and/or imaging resolution of ocean-bottom experiments. The OBSIC BB instruments have high power consumption and use expendable single-use lithium battery packs that cost $1000s per instrument. Their aging sensors and dataloggers require substantial technician time to prepare and operate. As a result, with few exceptions (primarily community experiments), most BB deployments to date have been limited to 30 instruments or fewer. In contrast, on-land BB experiments routinely deploy two to three times this number of sensors, with associated expansion in scientific capability.
- The usefulness of both the BB and SP instruments for rapid event response is effectively eliminated by their limited numbers, large size and weight (requiring slow shipping via container), and complex shipboard-handling procedures that typically require Intermediate-class or larger research vessels of the Academic Research Fleet for deployment and recovery operations.

- Performance of individual SP and BB sensor components is often poor, which increases the cost per useful datum, and further reduces the effective number of instruments and science output overall.

Recent changes in seafloor technology provide an opportunity to develop and build a new generation of OBS instrumentation that elevates the scientific capabilities of the OBSIC program to a new level. Several seismic instrument vendors now offer products specifically for the seafloor environment. These instruments offer low-power sensors, data loggers, clocks, rechargeable battery systems, and procedures for faster and easier deployment and recovery that will result in lower technician costs and less ship time. For BB deployments, these improvements will enable the development of higher-resolution and/or larger-aperture experiments to study key seismological problems inaccessible to the current fleet, with project budgets that are within reach of core programs at NSF. For SP operations, vendors in the energy industry have developed highly specialized systems that are compact and easy to operate in numbers well above OBSIC capabilities. These instruments could form the nucleus of a new, and substantially enlarged, OBSIC SP fleet. This fleet will enable 2D active- and natural-source experiments at unprecedented spatial scales and density, increase flexibility for conducting amphibious deployments, allow for 3D experiments that are currently impossible, and provide a rapid-response capability long sought by the community.

As representatives of the US science community engaged in OBS-based research, we encourage the OBSIC facility to pursue new funding that will enable it to take advantage of technological advancements that provide new opportunities for science. At this time, we specifically encourage development in two priority areas:

1) Develop and procure a new BB fleet. Since the technology for a new BB instrument is available, the OBSIC facility should finalize detailed evaluation, comparison, and testing of competing components and designs and engage in procurement and construction of instruments for community use. The design should capitalize on new lower-power components that enable lower-cost (possibly rechargeable) power systems and thus cheaper and/or longer duration deployments, and resilient, low-maintenance titanium and syntactic foam materials. It should enable deployment and recovery procedures that reduce reliance on dedicated OBSIC technical staff. The fleet should include a mix of larger and more expensive "very broadband" sensors providing low-noise sensitivity out to ~200 s, and less expensive, small, and light narrower-band instruments with sensitivity to ~100 s. Other detailed specifications should follow the "Technical Specifications" guidance of previous OBSIP/OBSIC committees[3] wherever possible.
2) Develop and procure a new SP fleet. Most recent advances in SP OBS have been driven by the energy industry, so direct adaptation of these instruments is not feasible due to their limited maximum depth and expensive (generally remotely-operated vehicle) deployment methods. New OBSIC SP designs should incorporate key components of the latest industry models: rechargeable power systems; small, easy-to-handle designs that streamline deployment, recovery, and data download; and reduced reliance on dedicated OBSIC staff at sea. Other detailed specifications should follow the "Technical Specifications" guidance of previous OBSIP/OBSIC committees[3] wherever possible.

The role of the OBSIC-OS is to provide operational guidance and assistance to the OBSIC facility in serving the NSF community. While we do not have a specific role in instrument development, it has become clear from our interactions with the OBSIC facility, as well as from experiences in the user community, that an infusion of new instrumentation would greatly enhance the effectiveness of the facility for supporting science. We encourage the OBSIC facility operator to pursue funding opportunities to support these developments.

Submitted by the current and recent membership of the OBSIC Operations Subcommittee:

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[1]For details on OBSIC-OS see https://www.unols.org/committee/ocean-bottom-seismometer-instrument-center-operations-sub-committee-obsic-os

[2]For details of the OBSIC facility and available instrumentation, see https://obsic.whoi.edu

[3]http://www.obsip.org/instruments/functional-specifications/