OCEAN OBSERVATORIES INITIATIVE (OOI) $51,000,000
+$5,700,000 / 12.6%

Ocean Observatories Initiative Funding
(Dollars in Millions)

FY 2021 Actual	FY 2022 (TBD)	FY 2023 Request	Change over FY 2021 Actual Amount	Percent
$45.30	-	$51.00	$5.70	12.6%

Brief Description

OOI is a networked observatory that includes deployed ocean instrumentation delivering long-term, time-series ocean data sets for multidisciplinary oceanographic research. All data and metadata are openly available to the public at the OOI website.[1] OOI consists of a system of five arrays of instrumented platforms located at critical locations in the ocean, a fleet of autonomous underwater vehicles, and a cyberinfrastructure to deliver the data. The five arrays include:

- Two Global Arrays:
  - Station Papa Array in the Gulf of Alaska
  - Irminger Sea Array off Greenland.
- One Regional Cabled Array (RCA) in the ocean basin off the coast of Oregon and Washington.
- Two Coastal Arrays:
  - Endurance Array with one mooring line off the Washington coast and one off the Oregon coast.
  - Pioneer Array (PA) deployed 55 nautical miles south of Martha's Vineyard, MA.

Data from the OOI instruments are processed, stored, displayed, and served by the OOI cyberinfrastructure.[2]

Scientific Purpose

OOI provides the oceanographic research and education communities with continuous, interactive access to the ocean through an integrated network of observatories. Deployed in critical parts of the global and U.S. coastal ocean, OOI's instrumentation captures climate, carbon, ecosystem, and geodynamic changes on the time scales at which they occur. Data streams from the air-sea interface through the water column to the seafloor are available to educators and researchers in any discipline, making oceanography available to citizens and scholars who might never go to sea. Science themes for OOI include the ocean carbon cycle and its response to global change, ocean acidification, the impact of climate variability and ocean circulation, coastal ocean dynamics, ecosystem response, and the interplay of tectonically driven fluid flow on the carbon cycle, deep ocean ecosystems, and earthquakes.

[1] www.oceanobservatories.org/
[2] www.oceanobservatories.org/data-portal/

Status of the Facility

The RCA cabled digital still camera, redeployed in 2015 by the Canadian ROV ROPOS, lights up the active hydrothermal vent called El Gordo in the international District Hydrothermal Field, located at the summit of Axial Seamount nearly a mile beneath the ocean surface. *Credit: UW/NSF-OOI/CSSF.*

OOI began full operations in FY 2016. A maintenance cruise is conducted annually at each Global Array and the RCA and bi-annually at each Coastal Array to install refurbished and re-calibrated instruments and deploy replacement gliders. A subsample of the data collected on the instruments at the Global and Coastal Arrays is transmitted ashore in near-real time via satellite communications and all data are stored onboard the in-water instruments until retrieved during the maintenance cruises. The subsampling interval has a complex dependence on the parameter being measured as well as on the available bandwidth and battery lifetime. All data collected by the RCA are transmitted ashore in real-time via the underwater fiber-optic cable. The OOI cyberinfrastructure supports data handling, processing, and serving through the OOI data portal.

The OOI Facility Board (OOIFB, described below under External Governance) conducted a survey of users during FY 2019 and provided NSF with a report that was shared with Woods Hole Oceanographic Institution (WHOI), the managing organization, and the broader OOI team, comprising staff at each of the participating organizations. Report recommendations were used to inform the redesign of the OOI data portal user interface and the OOI website. The OOI team continues strong efforts to engage the community of scientific users, including a hybrid Town Hall and a virtual booth at the Fall 2021 American Geophysical Union meeting in New Orleans, LA.

NSF is collaborating with the science community on the relocation of the PA. The PA was originally planned to be relocated every five years to a new region of scientific interest. It has now been in place since 2016, and by working together with the stakeholders through a series of Innovation Labs, NSF has decided the new location of the PA will be in the Mid-Atlantic Bight region-the coastal area roughly from Massachusetts to North Carolina. The relocation efforts will be conducted in three phases: 1) Planning: July 2021 – April 2022; 2) Engineering: May 2022 – December 2022; and 3) Implementation: January 2023 – April 2024. The PA will be deployed in its new location and configuration by mid-2024.

Summary of COVID-19 Impacts

COVID-19 has impacted the OOI team by limiting the access of team members to the laboratories required for equipment refurbishment activities. In addition, planned at-sea marine infrastructure recovery and deployment activities have been limited due to requirements for personnel testing and isolation before embarking on the ships. The number of OOI team members embarked on the ships

for the maintenance cruises was reduced to meet requirements to mitigate the potential spread of COVID-19. Despite the limitations, in 2021 the OOI team was able to conduct maintenance cruises for all of the arrays and thereby significantly mitigated the potential for loss of valuable in-water infrastructure. There were some limited instances in 2021 where reduced battery power required adjustments to the instrument sampling rates, resulting in reduced data flow.

Meeting Intellectual Community Needs

The overarching scientific themes of OOI, developed in close collaboration with and in response to the needs of the science community, span six multi-disciplinary domains, with each theme incorporating a multitude of research questions.

- *Ocean-Atmosphere Exchange*. Quantifying the air-sea exchange of energy and mass, especially during high winds, is critical to providing estimates of energy and gas exchange between the surface and deep ocean, and improving the predictive capability of storm forecasting and climate-change models.
- *Climate Variability, Ocean Circulation, and Ecosystems*. As both a reservoir and distributor of heat and carbon dioxide, the ocean modifies climate, and is also affected by it. Understanding how climate variability will affect ocean circulation, weather patterns, the ocean's biochemical environment, and marine ecosystems is a compelling driver for multidisciplinary observations.
- *Turbulent Mixing and Biophysical Interactions*. Mixing occurs over a broad range of scales and plays a major role in transferring energy, materials, and organisms throughout the global ocean. Mixing has a profound influence on primary productivity, plankton community structure, biogeochemical processes (e.g., carbon sequestration) in the surface and the deep ocean, and the transport of material to the deep ocean.
- *Coastal Ocean Dynamics and Ecosystems*. Understanding the spatial and temporal complexity of the coastal ocean is a long-standing challenge. Quantifying the interactions between atmospheric and terrestrial forcing, and coupled physical, chemical, and biological processes is critical to elucidating the role of coastal margins in the global carbon cycle and developing strategies for managing coastal resources.
- *Fluid-Rock Interactions and the Subseafloor Biosphere*. The oceanic crust contains the largest aquifer on Earth. Thermal circulation and reactivity of seawater-derived fluids modify the mineralogy of oceanic crust and sediments, lead to the formation of hydrothermal vents that support unique micro- and macro-biological communities, can form economically-important mineral deposits, and concentrate methane to form massive methane gas and methane hydrate reservoirs. The role that transient events (e.g., earthquakes, volcanic eruptions, and slope failures) play in these fluid-rock interactions and in the dynamics of benthic and sub-seafloor microbial communities remains largely unknown.
- *Plate-Scale, Ocean Geodynamics*. Lithospheric movements and interactions at plate boundaries at or beneath the seafloor are responsible for short-term events such as earthquakes, tsunamis, and volcanic eruptions. These tectonically active regions are also host to the densest hydrothermal and biological activity in the ocean basins. The degree to which active plate boundaries influence the ocean from a physical, chemical, and biological perspective is largely unexplored.

The science community is continuing its use of the OOI data through downloads of both raw data and derived products. In October 2020, OOI launched a new data discovery tool, Data Explorer, designed based on input from the science community, that allows users to explore, use, and visualize OOI data in new ways that will help advance understanding of the ocean, its processes, and how it is changing.

Feedback from users in the scientific community has been positive, and both the number of users and amount of downloaded data have increased in FY 2022.

Governance Structure and Partnerships

NSF Governance Structure

OOI is managed and overseen by a two-person team in OCE that receives advice and oversight support from BFA, the Office of the General Counsel, the Office of Legislative and Public Affairs, CISE, and the Large Facilities Office.

External Governance Structure

A new cooperative agreement for O&M of OOI started in FY 2019 with WHOI as the awardee. The OOI program director at WHOI is responsible for overall operations and maintenance, including data management, and serves as the Principal Investigator on the award from NSF. WHOI has subawards with three Implementing Organizations:

- Oregon State University (OSU) – Endurance Coastal Array and the OOI Cyberinfrastructure Data Systems Center
- University of Washington – RCA

The OOIFB, established by NSF in FY 2017, comprises ocean science community representatives and is charged with providing independent input and guidance to NSF regarding the management and operation of OOI. The OOIFB assists in the process of communicating the community science use perspective to NSF and to the project teams involved in deploying and operating OOI. A subcommittee of the OOIFB called the Data Systems Committee (DSC) evaluates and recommends improvements to the data services policies and practices of OOI that will lead to more efficient and effective scientific use of OOI data. The DSC will be conducting a follow-up to the FY 2019 community survey in FY 2022 to gather updated information from the science community on the utility of the OOI data portal.

Coastal Endurance Surface Buoy with sea lions. *Credit: Coastal Endurance Array Team, OSU.*

Funding

Total Obligations for OOI
(Dollars in Millions)

	FY 2021	FY 2022	FY 2023	ESTIMATES[1]				
	Actual	(TBD)	Request	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028
Operations & Maintenance	$45.30	-	$51.00	$51.00	$51.00	$51.00	$51.00	$51.00

[1] Outyear estimates are for planning purposes only. The current cooperative agreement ends September 2023.

The FY 2023 Request includes $51.0 million for OOI, with an increase above FY 2021 planned to continue the recapitalization of the primary in-water infrastructure. The projected cost for recapitalization of the OOI facility is $8.5 million and includes the planned replacement of the G2 ocean and coastal gliders, with upgraded vehicles. Additional upgrades for OOI will support near-real time collection, analysis, and distribution of the OOI data to the public through cyberinfrastructure and data user portal.

Reviews

A mid-award review was conducted in November 2020 and covered all aspects of the OOI Program including: Management, Refurbishment, Deployment and Recovery, Community Engagement, Cyberinfrastructure, and Science Products.

In its report, the review panel commented: "The Panel unanimously recommends that the NSF renew the contract [executed as a cooperative agreement] with WHOI to operate the OOI infrastructure. We find that the current project team is maintaining and operating the infrastructure in an effective manner and has successfully managed operational difficulties and budgetary uncertainties. The Program has successfully engaged science users to build the Program's platforms and data into proposals for new projects. Observations from OOI are now appearing in the scientific literature at a rate comparable to other large geoscience facilities. The OOI has already supported transformational science and continues to serve as the foundation for future discoveries by the scientific community. It is also in an excellent position to advance engineering and technology needed for ocean exploration using remote observatories."

NSF completed a tailored Business Systems Review (BSR) of the WHOI OOI Program in October 2021. The BSR Team determined that the administrative business systems supporting the OOI facility are in alignment with federal regulations and meet compliance requirements. The report noted some areas that could be further strengthened to better meet NSF's expectations. These findings have been acknowledged by the Awardee institution and will serve as agenda items in future Annual Reviews.

Renewal/Recompetition/Termination

NSF completed the process of recompeting the O&M award through an open, merit-based external peer-review process, resulting in an award to WHOI as the Program Management Office, which started October 1, 2018 and runs through September 30, 2023. NSF is evaluating the inputs received from the mid-award performance review and the BSR with an expectation of making a decision whether to renew or recompete the O&M award in early 2022. Currently there are no plans for divestment of this facility.