Summary of DOOS Recommendations

1. Define deep ocean EOVs, create or improve specifications, and integrate these into GOOS EOV panel deliberations.
2. Identify and develop expanded and enhanced deep-ocean observing capabilities (e.g., through more efficient use of vessel servicing platforms and collaborations with industry). Mainstream deep-observing considerations into the UN Decade for Ocean Science for Sustainable Development.
3. Support an advanced cyberinfrastructure for comprehensive data mining, integration, and FAIR principles (findability, accessibility, interoperability, reusability) across the three main disciplines.
4. Identify deep-ocean data gaps and needs through gap analysis, communicate these to appropriate large program leads and the broader science community.
5. Initiate a committee of large program deep observing leads to communicate and coordinate observing activities among programs and to the broader scientific community.
6. Expand, update, and maintain a deep-ocean observing inventory, facilitating access to program metadata.
7. Develop demonstration projects that address questions of scientific and societal significance, integrate observing across disciplines, act to help mature observing technologies, and provide a template for future observing efforts.
8. Develop communication tools to inform the science community and convey deep-ocean observing needs and advances across disciplines, regions, sectors and jurisdictions.
9. Develop or improve connections to stakeholders, in particular in the economic and political sector to raise support for- and sharpen requirements of DOOS.

Visit DOOS Online

deepoceanobserving.org

Join the Community

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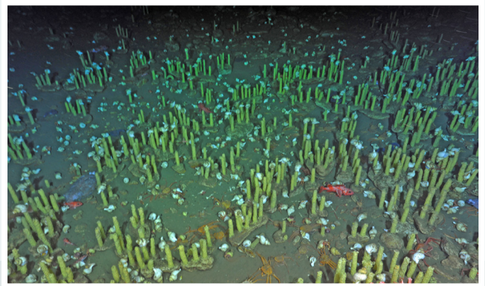
The Global Ocean Observing System GOOS

DOSI DEEP-OCEAN STEWARDSHIP INITIATIVE

DEEP OCEAN OBSERVING STRATEGY

Science and Implementation Guide

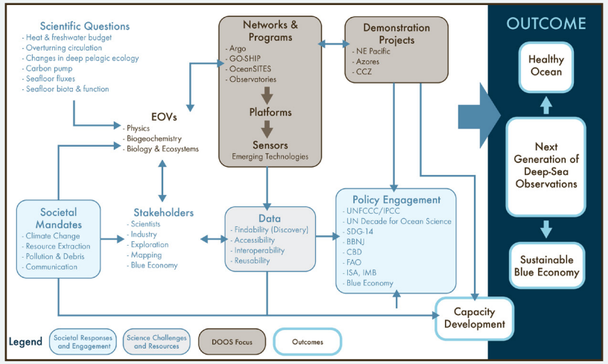
Executive Summary



The Deep Ocean Observing Strategy (DOOS) envisions a globally integrated network of systems that can observe the deep ocean effectively in support of strong science, policy and planning for sustainable oceans.

deepoceanobserving.org

What is DOOS?



DOOS represents a coalition of international deep-ocean stakeholders from science, management, government, and industry for waters within and beyond national jurisdiction. Ocean observers, data managers, and data users are all encouraged to participate in guiding DOOS. Researchers, educators, regulators, policy makers, Non-Governmental Organizations, Intergovernmental Organizations, and the public are among the beneficiaries of DOOS.

Download the DOOS SIG

http://deepoceanobserving.org/reports/doos-science-and-implementation-guide/

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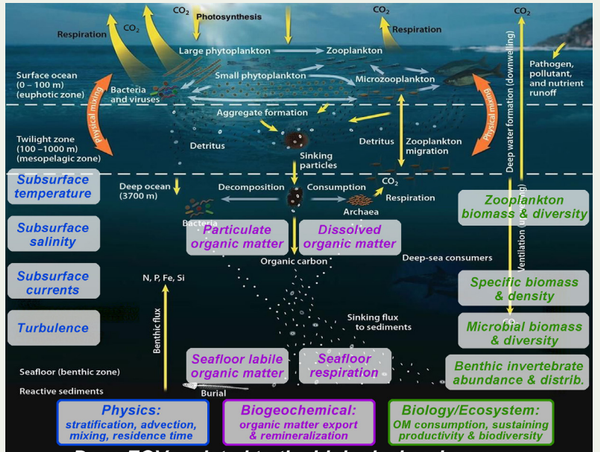
What is the Science Focus?

The deep ocean is a dynamic, yet poorly explored system that provides critical climate regulation, hosts a wealth of hydrocarbon, mineral, and genetic resources, and represents a vast repository for biodiversity. The sustainability of the deep ocean and its services, however, relies on scientific understanding.

DOOS focuses on ocean depths below the main thermocline (> 2000 m), with additional attention to shallower processes and mechanisms that are poorly sampled below the photic zone (> 200 m) that influence the deeper depths. Three overarching science goals provide the basis for DOOS:

- Understand global deep and bottom water formation rates, their variability, and the time scales of their global property changes while assessing global heat, salt, and freshwater budget dynamics;
- Document deep-ocean tracer transport and ventilation processes and assess their impact on ocean biogeochemical processes including the biological pump (Figure 2), both on the seafloor and in the water column; and
- Understand marine deep-sea biodiversity and ecosystem services in light of human-induced and natural changes. Understanding these processes will also contribute to national and global sustainability efforts and climate forecasting and policy decisions.

Sustained, multidisciplinary observations throughout the water column are necessary to fully capture the biological pump, and its temporal evolution.



Deep EOVs related to the biological carbon pump

Main Objectives

1. Identify Essential Ocean Variables (EOVs) and evolve their specifications to fully consider deep-ocean perspectives across physical, biogeochemical, biological, and ecological variables over the next decade. This includes adding the deep-ocean perspective to existing Global Ocean Observing System (GOOS) EOVs and adding additional deep-ocean EOVs (Table 1). The development of these EOVs will improve understanding of the state of the deep ocean, characterize existing conditions, constrain the deep ocean state in ocean climate models, and quantify its response to climate variability and human disturbance.

2. Showcase the value of integrating deep-ocean observing efforts towards maturing capability and capacity, technology readiness, and deep-ocean data findability (discovery), accessibility, interoperability, and reusability (FAIR). Demonstration projects can help mature nascent platforms and sensors, develop strategies for global-scale deployment, and work to integrate observing efforts across disciplines. Demonstration projects are currently proposed for the Clarion Clipperton Fracture Zone, the Northeast Pacific, and the Azores Archipelago.

3. Serve as a communication hub for a broad spectrum of stakeholders in the deep-ocean science, data, and information user communities. Specifically, these efforts focus on facilitating cross-disciplinary information transfer among physicists, biogeochemists, biologists, engineers, technology experts, data managers, law and policy specialists, and social scientists addressing the deep ocean.

4. Provide an avenue through which the deep ocean research community and the data they produce can reach policy makers and inform policy decisions.

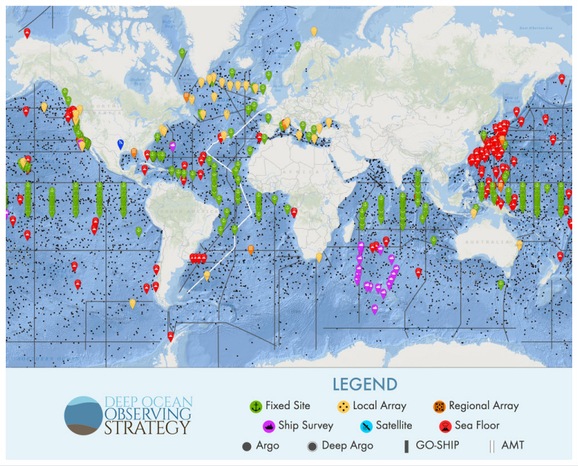
Essential Deep-Ocean Variables

	Physics	Biogeochemistry	Biology & Ecosystems
GOOS EOVS	Sea state	Oxygen	Phytoplankton biomass and diversity
	Ocean surface stress	Nutrients	Zooplankton biomass and diversity
	Sea ice	Inorganic carbon	Fish abundance and distribution
	Sea surface height	Transient tracers	Marine turtle, bird, mammal abundance and distribution
	Sea surface temperature	Particulate matter	Hard coral cover and composition
	Subsurface temperature	Nitrous oxide	Seagrass cover
	Surface currents	Stable carbon isotopes	Macroalgal canopy cover
	Subsurface currents	Dissolved organic carbon	Mangrove cover
	Sea surface salinity	Ocean colour	Ocean sound
	Subsurface salinity		Microbe biomass and diversity (emerging)
	Ocean surface heat flux		Benthic invertebrate abundance and distribution (emerging)
EOV's under consideration	Ocean Bottom Pressure	Seafloor labile organic matter	Body size
	Seafloor Fluxes	Seafloor respiration	Seafloor sponge habitat cover
	Ocean Turbulence	Seafloor fluid and gas effluxes (focus on methane)	Connectivity of species
		Litter including microplastics	

Status of Deep-Ocean Observing

DOOS is conducting and will maintain an inventory that seeks to assess the status of deep-ocean observing with respect to water depths, platforms, sensors, variables measured, and temporal and geographic coverage. It is designed to inform the development of DOOS by identifying potential partners and providing a common statement of requirements, as well as an initial strategy for sustained global deep ocean observations.

Inventory of sustained deep-ocean observing.
Interactive map available online at
deepoceanobserving.org/observations/deep-ocean-observations/



Relation to the Observing Community

In preparation for Ocean Obs '19, DOOS led the development of a community white paper (CWP) focused on deep-sea observations.

Download the CWP:
"Global Observing Needs of the Deep Ocean"
http://deepoceanobserving.org/reports/cwp-global-observing-needs-of-the-deep-ocean/

As a GOOS project, DOOS was launched in order to develop a strategy for sustained observation of the deep ocean. While DOOS is managed independently of GOOS, their activities and priorities are aligned through utilization of the Framework for Ocean Observing (FOO) as a guiding set of central processes and principles – e.g. the concept of EOVs and the development of a fit-for-purpose observing system through the maturation of requirements, technologies, and information, all driven by science and societal need.

- DOOS is engaged with existing deep-ocean scientific networks, large deep-ocean observing programs, and seafloor observatories, including the Deep Ocean Stewardship Initiative (DOSI), the International network for scientific investigation of deep-sea ecosystems (INDEEP) and, the Southern Ocean Observation System (SOOS).
- Additionally, DOOS will contribute to the Group on Earth Observations (GEO) and the GEO System of Systems (GEOSS) to deliver environmental data and decision-support tools to academic, industry, and government end users.
- Development of protocols and standards for collection of biodiversity observations in the deep ocean by DOOS can be incorporated into the Marine Biodiversity Observation Network (MBON) of the GEO Biodiversity Observation Network (GEO BON) and GEO Blue Planet.
- DOOS will collaborate with the Ocean Best Practices (OBP) working group of the Intergovernmental Oceanographic Commission (IOC) to store standards and methods, and has made a joint voluntary commitment (with DOSI and INDEEP) to Sustainable Development Goal (SDG) 14 to build global scientific capacity to address SDG 14 targets as they relate to the deep ocean.
- DOOS will also consult with major global modeling efforts, such as the international CLIVAR Ocean Model Development Panel (OMDP) and the Ocean Modeling Intercomparison Project (OMIP) in support of CMIP6.

Looking Forward: Science to Inform Policy

Ultimately, DOOS strives to unlock critical knowledge about the deep ocean to deliver scientific and societal benefits for the future. Advances in emerging technology, increasing resource pressures, and climate change result in the expanded relevance and need for deep-ocean observations. International commitments to end poverty, protect the planet, and ensure prosperity for all, as embodied in the UN's 2030 Agenda for Sustainable Development and its 17 SDGs, are driving demands for increased science to inform decision making. The deep ocean has a fundamental role to play in these decisions.

DOOS anticipates facilitating input from deep-ocean observations to the United Nations Framework Convention on Climate Change and the Paris Agreement, the Intergovernmental Panel on Climate Change, the Decade of Ocean Science for Sustainable Development, the UN Regular Process (World Ocean Assessment), the International Seabed Authority, the Food and Agriculture Organization, the International Maritime Organization, the BBNJ treaty negotiations, and regional entities.

Additionally, DOOS seeks to contribute to capacity building efforts with developing states and early career scientists to strengthen the deep-ocean observing community. The next century promises expanding uses and new stakeholders for deep-ocean observations.