The Global Ocean Observing System
STEERING COMMITTEE

GOOS SC-12

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Reports from GOOS components

Deep Ocean Observing Strategy

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unesco Intergovernmental Oceanographic Commission
WORLD METEOROLOGICAL ORGANIZATION
UN environment United Nations Environment Programme
International Science Council

1. Achievements and Highlights

DOOS is a community-driven, grass roots, international initiative with the goal to help strategically align the deep ocean observing community toward collective solution-based science. Our goal is to connect national and international programs to one another and create direct lines of communication to other programs and linkages to societal needs. This includes improving cooperation across the physical, biogeochemical and biological disciplines, and better integrating the modeling community to inform deep ocean observing networks about observing gaps and specific needs.

A successful iDOOS involves the creation of a community-driven network of networks that tackles large challenges in the deep sea and can continue forward on its own momentum wherein the project creates road maps to transition from network coordination activities to funded research projects.

In late 2021, two key things happened to elevate DOOS into a position to create this network of networks. First, we were endorsed as a UN Ocean Decade Programme, providing us with global visibility and access to the community via Decade sponsored events. Second, NSF awarded four years of funding from the US NSF AccelNet program that supported us to begin initiatives, hold community events, and spin up our early career program, the DOERs (Deep Ocean Early Career Researchers).

Interactions with the International Community

Since 2021, DOOS has published four peer-reviewed articles, given almost 20 presentations, hosted webinars and conference events, met with UN agency representatives, and put together a virtual annual meeting with over 260 registered attendees from over 40 countries, 57% of which were ECOPs.

The theme of the 2022 Annual Meeting was “Addressing Global Challenges in the Deep Sea through Collaboration.” The goal was to bring together the global deep ocean community to engage in and help focus initiatives that address global challenges in the deep sea. Attendees shared ideas and priorities to help focus the pathway DOOS would take to leverage global expertise, find new areas for collaboration, and chart a course ahead for deep sea science for the next decade. ECOPs were a focal point of the annual meeting as they were featured as plenary speakers, gave many of the community presentations, and engaged with the broader community through a Meet the DOERs event. Further details and recordings/presentations can be found on our website.

Other DOOS-led events included a UN Ocean Decade Satellite activity for the Predicted Ocean Laboratory, an Ocean Sciences Meeting Town Hall, and sessions at the summer ESIP meeting

and OBPS Workshop. A summary of DOOS presentations and publications is included at the end of the Report.

DOOS-led Initiatives

The goal of each of the above community interactions was to connect the deep ocean community closer together to align individual efforts toward shared aims of addressing challenges in the deep sea. Instead of developing and promoting an agenda, DOOS facilitates communications that allow communities to identify priorities and key actions of DOOS initiatives.

DOOS working groups address global deep sea challenges at the intersection of communities and disciplines. Since 2021, a series of working groups have been developed. Much of the early work in these efforts involved engaging the global deep ocean community through participation in community events, an online interest survey, and focused discussions to establish a list of the key challenges in the deep-sea to tackle as a community. Each of these were then developed into working group efforts led by DOOS co-PIs or ECOPs and incorporating participants and input from others in the community (ECOPs and senior).

With this in mind, working groups were designed with community input to determine priority actions, leverage existing research efforts and resources, and address defined challenges and gaps together. The result has been a series of initiatives designed to add value to the work of the global volunteers leading to novel research collaborations and external funding opportunities. We continue to explore this model as a means to strategically align the community to make meaningful changes, without perpetuating cycles of over committing volunteer efforts.

Below are summaries of several DOOS-led initiatives.

Support of GOOS EOVs

EOVs are vital in deep ocean research across disciplines. As such, DOOS has engaged in efforts to (1) examine existing GOOS EOVs in terms of special requirements for deep-sea research, in order to ensure each reflects a deep-ocean perspective and (2) work to draft EOV specifications supporting documentation for a prospective set of physical, BGC, and biological/ecological EOVs considered crucial for deep-ocean observing. EOV efforts are summarized below.

Physics

- Ocean Bottom Pressure was named an Essential Ocean Variable!
- Ocean Turbulence was presented to OOPC Oct 2022, received feedback, and revised documents were submitted for review
- Geothermal Heat Flux efforts are in development

Biogeochemistry

- Methane - Engaged the observing community, including meetings with GO-SHIP and OCB. Expert peer-review process to begin shortly.
- Seafloor Labile Organic Matter and Seafloor Respiration - review to initiate soon

Biology/Ecosystems

- Invertebrates - Submitted a perspective paper
- Deep Corals - EOV spec sheet for deep nearly done, liaising with BioEco panel, socializing at Deep Coral workshop in Edinburgh in May
- Sponges - EOV spec sheet for sponges in development, liaising with BioEco panel

Engagement with UN Agencies

DOOS met with UN agency representatives from the Convention on Biological Diversity, Food and Agriculture Organization, Intergovernmental Oceanographic Commission-UNESCO, GESAMP, World Heritage Program, Bureau of Ocean Energy Management (US), PICES, and ICES to discuss current deep ocean observing activities and learn about deep-sea science needs of these organizations. These meetings have spun up a series of desktop projects that are currently underway to fill needs identified by these organizations. These include:

- **State of the Ocean Report and the Deep Sea:** Review of the new IOC June 2022 State of the Ocean Report to identify deep-sea science needs and prepare inputs for the next update. Status: Complete.
- **Assessing data gaps for understanding climate change:** Review IPCC Reports (SROCC, AR6), WOA I &II to identify major data gaps (geographical, depth, variable, platform) that limit our understanding of the present and future state of the deep ocean physics, biogeochemistry and biology. Status: Community review in progress.
- **Oceanography in RFMO Deliberations:** Conducting an overview of oceanographic data collected and used by FAO's Regional Fishery Management Organizations (RFMOs) and identifying other existing deep data of use. Status: Planning underway.
- **GESAMP and Deep-sea Science Gaps:** Communicate the science gaps identified in Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) reports to DOOS network members and work with GESAMP on thematic gaps for the deep ocean (e.g., biodiversity). Status: Pending

Science-based Conservation

We are working to improve datastream planning activities for managed marine spaces such as National Marine Sanctuaries and marine protected areas, offshore wind development areas and more. Last year began a four-phase effort with phase one including starting a case study for the US west coast. This first phase included an inventory of applicable data. Later phases include gap analysis and planning to get gap filling observations and conduct onward modeling (see LaScala-Gruenewald et al. 2022).

"Cheap & Deep" Technology Development

DOOS has begun some foundational work with the deep ocean technology community to support open sourcing of technology plans and best practices to make them more accessible to the broader community. Additionally within DOOS working group sessions and presentations,

technology solutions, particularly low-cost and accessible technology are being promoted and shared to new communities and users. Currently the team is working to synthesize the current status of cheap & deep technology into a brief scene-setting publication. Plans for the next year include, developing an open-source online repository of current cheap & deep solutions to increase their accessibility, promotion of these solutions in a journal special issue, and training the next generation of technology developers and users at a summer school. This work is being done in close collaboration with the Ocean Discovery League.

Modeling & Observing Synergies for Addressing Climate Gaps

The observing and modeling communities both heavily rely on each other and rarely work directly with each other. The aim of this working group is to bring together these communities with the focused aim of finding synergies to help constrain gaps in our understanding of climate change in the deep sea. Work in this realm has progressed in two main areas - (1) Coordinated modeling for observing system assessment & design and (2) Determining needs for improved interconnected physics/BGC/ecosystem modeling.

Observing system assessment and design:

- Initial modeling experiments to interrogate oxygen sampling strategy for deep Argo; Received funding from NSF Chemical Oceanography to further test oxygen sampling strategy and existing constraints from Deep Argo Pilot arrays
- Collaborations on the funded investigation of SMART OBP/OBT deployment in the North Atlantic “SMART Subsea Cables: Implementing for Geophysics, Early Warning and Oceans, Vanuatu-New Caledonia to Global”
- Support in planning the CLIVAR AMOC workshop in July 2023, including AMOC-related observational priorities for ecosystem applications and integration of AMOC arrays with other observing networks

Improving interconnected physics/BGC/ecosystem modeling

- Received funding from US CLIVAR POS & OCB to organize and interdisciplinary workshop on surface to deep climate connections in Spring 2024

Supporting a FAIR Data Landscape

Work on promoting and supporting a FAIR (Findable Accessible, Interoperable, Reusable) data landscape has fallen along three main pathways.

1) Synthesizing and developing guidance for (Deep) ocean data management through co-design with data creators and data managers. This work was conducted in collaboration with and funding support from Earth Science Information Partners (ESIP) and included a session at the ESIP summer 2022 meeting with data managers, a facilitated co-design session with data creators within the DOOS community, the creation of an interactive resource infographic, presentation at the AGU 2022 fall meeting, and publication in DOSI “Deep Sea Life.”

2) Improving discovery of deep sea data through a collaboration with the NSF-funded DeCODER project.
3) Teaching the next generation of scientists on good data practices with quarterly trainings for the DOERs. Materials are also available on the DOOS website.

Early Career and Capacity Development Efforts

The project supports 6 Early Career Researchers (ECRs) that are mentored by the project Co-PIs, director, and others in the iDOOS Community. These ECRs are integral to the leadership structure of DOOS creating and leading their own working group efforts. Additionally, ECRs from across the international DOOS community have been integrated into each of the working group efforts and in many cases have taken on leadership roles.

The DOERs early career professional development program was spun up in early 2022. The program has over 130 participants from around the world. ⅔ of which are from outside the United States, and many of which are from developing countries or small island nations. In year 1 of the program, quarterly professional development events were held around the theme of leading interdisciplinary, international programs, including community building exercises, an event focused on exploring the Framework for Ocean Observing which included a GOOS representative, and a career panel of leaders from ocean observing programs from around the world. This years training efforts have focused on good data practices, as noted in the above section.

2. Opportunities

We always welcome the opportunity to collaborate with the GOOS community on all of our efforts. A specific opportunity for engagement is the upcoming virtual Annual Meeting from 9-11 May (Register here). We are also excited to engage closely with GOOS in the new Ocean Observing Decade Coordination Office.

3. Issues or barriers

Currently the only funding for DOOS is through a 4-year NSF grant that ends in 2025. This provides a challenge in two ways:

1) There are limited avenues within this grant for DOOS to be able to support our community outside of the US. As such, all of our international collaborators volunteer their efforts, which is not a sustainable model and makes DOOS appear more US-centric than desirable.
2) Short term funding could limis our ability to address long-term challenges in the deep sea. Global efforts may lose critical momentum if future funding for DOOS cannot be secured and prevent a lapse. Sustained funding is required to make meaningful, lasting progress.

4. Future

Short-term goals

- Engage with the global deep ocean community at the DOOS (virtual) Annual Meeting 9-11 May 2023
- Continue DOOS initiatives that seek collective solutions to global deep-sea challenges, increase the breadth of participants, and create deliverables that can serve as roadmaps to transition these efforts into research projects.
- Deep dive with a small representation from the community to accelerate efforts to address these deep sea challenges at a small, in person workshop at Scripps Institution of Oceanography 2-5 Oct 2023.

Mid-term

- Identify and launch additional working group efforts, based on the interests expressed at the Annual Meeting and other venues. For example, ramping up efforts in the area of climate intervention strategies, based on conversations at the recent Ocean Visions Summit.
- Seek new funding to support DOOS project management once the current grant ends Oct 2025

Long-term (5y)

- An integrated deep-ocean community collaborating across disciplines on collective solution-based science to address global deep-sea challenges, and fostering the next generation of leaders.
- Create a long-term, sustained operational structure and funding model for DOOS to provide continual support for project management and

5. Questions for the Steering Committee

How can we further solidify our connection and ties together as we work toward shared aims?

ANNEXES

A summary of DOOS presentations and/or contributions in workshops, symposia, and UN Ocean Decade events is as follows:

- Participation in UN Decade Co-Design Workshop: Deep Sea Capacity Development in the tropics: Aug 2021)
- Led Satellite Activity for A Predicted Ocean Decade Laboratory: Sep 2021
- BGC-ARGO meeting presentation: Oct 2021
- Ocean Decade: Deep sea Research and Management CoP kick-off call: Jan 2022
- Contribution to iAtlantic newsletter: Jan 2022
- Contribution to DOSI newsletter (Deep-Sea Life) Jan 2022
- Ran Ocean Sciences Meeting Townhall (TH45 Deep-sea Connections): Feb 2022
- Panelist for A Clean Ocean Decade Laboratory: Feb 2022
- Década do Oceano e Ano Internacional da Pesca Artesanal – Conexão Global Local Ocean Sciences Meeting Brazilian Hub event: Feb 2022
- Presentation for APERO: Mar 2022
- Presentation for UN Ocean Decade Forum as part of Monaco Ocean Week: Mar 2022
- Contribution to Workshop to Coordinate Biological Observing Programmes of the UN Decade of Ocean Science for Sustainable Development: Apr 2022
- Presentation for Global Ocean Oxygen Network, Liege Belgium: May 2022
- DOOS and MBON presentation re: Co-designing applied ocean models to support community decision making in the NE Pacific as part of a virtual satellite event of the G7-sponsored International Digital Twins of the Ocean Summit: May 2022
- Presentation for 22nd United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea, New York: Jun 2022
- GOOS BioEco presentation including DOOS context, Contributions of ocean observation to understanding and conserving biological diversity, 22nd United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea, New York: Jun 2022
- Presentations (for Carbon & Climate Section, ECOP workshop, Ocean Decade Workshop) and poster at PICES Annual Meeting, Busan, South Korea: Sep 2022
- Co-led session at OBPS Workshop VI “Technology Best Practices: Building Capacity for Deep Ocean Observing”: Oct 2022
- Presentations at COP 27
- Briefing for NOMEC Council: Dec 2022
- Presentation at POGO meeting: Jan 2023
- Presentation at Ocean Visions Summit, Atlanta, GA: Apr 2023

DOOS Publications

Smith, Leslie M. and Cimoli, Laura and LaScala-Gruenewald, Diana and Pachiadaki, Maria and Phillips, Brennan and Pillar, Helen and Stopa, Justin E. and Baumann-Pickering, Simone and

Beaulieu, Stace E. and Bell, Katherine L.C. and Harden-Davies, Harriet and Gjerde, Kristina M. and Heimbach, Patrick and Howe, Bruce and Janssen, Felix and Levin, Lisa A. and Ruhl, Henry A. and Soule, Adam and Stocks, Karen and Vardaro, Michael F. and Wright, Dawn J. (2022). The Deep Ocean Observing Strategy: Addressing Global Challenges in the Deep Sea Through Collaboration. Marine Technology Society Journal. 56 (3) 50 to 66. doi:https://doi.org/10.4031/MTSJ.56.3.11

LaScala-Gruenewald, Diana E and Low, Natalie H and Barry, James P and Brown, Jennifer A and King, Chad and Chavez, Francisco P and Ruhl, Henry A. (2022). Building on a human-centered, iterative, and agile co-design strategy to facilitate the availability of deep ocean data. ICES Journal of Marine Science. doi:https://doi.org/10.1093/icesjms/fsac145

Levin, Lisa A and Cimoli, Laura and Gjerde, Kristina and Harden-Davies, Harriet and Heimbach, Patrick and LaScala-Gruenewald, Diana and Pachiadaki, Maria and Pillar, Helen R and Smith, Leslie M and Stocks, Karen and Stopa, Justin E. and Wright, Dawn J. (2022). Designing, generating, and translating deep-ocean observations for and with international policy makers. ICES Journal of Marine Science. doi:https://doi.org/10.1093/icesjms/fsac143

Maria Pachiadaki, Felix Janssen, Marina Carreiro-Silva, Telmo Morato, Carreira P. Gilberto, Frazão C. Helena, Patrick Heimbach, Isabel Iglesias, Frank E. Muller-Karger, Miguel Santos, Leslie M. Smith, Michael F. Vardaro, Fleur Visser, Joanna J. Waniek, Ann-Christine Zinkann, Ana Colaço, 2022: Co-designing a multi-disciplinary deep-ocean observing program at the Mid-Atlantic Ridge in the Azores region: A blueprint for synergy in deep ocean research and conservation. ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsac189