

Breakout Group Descriptions for the Workshop on Charting the Future of Ocean Passive Acoustics: From Observations to Science and Management

Overview

The *Workshop on Charting the Future of Ocean Passive Acoustics: From Observations to Science and Management* will start with context-setting plenary presentations, following by 2.5 days of mostly breakout sessions to gather community input to develop plans for future activities related to ocean passive acoustic monitoring, including continued implementation of the Ocean Sound Essential Ocean Variable.

The following breakout group titles and descriptions are intended to help registrants indicate the groups of most interest to them. The final set of groups may be modified, depending on responses from registrants, including combining some related groups, splitting some groups, and adding new group topics identified by registrants. The workshop planning committee will use input from registrants to refine the meeting plans.

The topics are grouped into five themes, with Theme 1 groups meeting on the afternoon of the first day of the workshop, Theme 2 and 3 groups meeting on the second day of the workshop, and Theme 4 and 5 groups meeting on the third day of the workshop. Reports back from each group will be held in plenary session after each set of groups meet, so that the work of earlier groups can inform the work of later groups.

Theme 1. Observing Infrastructure, Sensors, and Calibration

1.1 Expanding Vibroacoustic Measurements

This group will identify priority needs for particle motion and substrate vibration (vibroacoustic) measurements and evaluate where vector sensors should be more widely deployed. Discussions will address technical limitations, observational gaps, standards development, coordination of research and observations, and pathways for integrating vibroacoustic measurements into the broader Ocean Sound EOVS framework. Particular emphasis will be placed on how these observations can improve understanding of biologically and geophysically important sound sources.

1.2 Low-Cost Technologies, Capacity Building, and Equitable Participation

This group will review progress on development of the IQOE low-cost acoustic recording system, evaluate the outcomes of beta testing, and define next steps for refinement, scaling, and deployment. Participants will discuss how affordable, standardized systems can expand participation in Ocean Sound EOVS observations, particularly in under-sampled regions and low-resource settings, schools, and community-based monitoring programs. Discussions will include training needs, equitable access to technology, and mechanisms for strengthening long-term participation in Ocean Sound EOVS implementation.

1.3 Increasing Deployment of Acoustic Recording Systems on GOOS Platforms

Many GOOS platforms—including Argo floats, drifters, moorings, and gliders—do not feature widespread incorporation of hydrophones. This group will identify technical, logistical, and

organizational steps needed to integrate acoustic sensors into existing GOOS and non-GOOS observing systems and to incorporate resulting data into a coordinated Global Ocean PAM Network. Discussions should emphasize the transformative impact that distributed acoustic observations could have on implementation of the Ocean Sound EOV and related GOOS priorities.

1.4 Reducing the Cost of Calibration and Advancing *In Situ* Calibration Techniques

The scientific value and interoperability of PAM observations increase substantially when systems are calibrated; however, calibration often requires costly access to specialized facilities. This group will identify pathways to reduce barriers to calibration before and after deployment, explore scalable calibration services, and evaluate emerging approaches for *in situ* calibration of deployed systems. Participants will discuss how calibration advances can improve comparability and long-term utility of Ocean Sound EOV products.

1.5 The Role of Industry in Advancing Sensors and Systems for the Ocean Sound EOV

Global implementation of the Ocean Sound EOV will require substantial increases in the production of affordable, interoperable, and calibratable acoustic systems. This group will discuss how industry partnerships can accelerate innovation, reduce costs, improve standardization, and increase access to high-quality observing technologies across nations with differing economic capacities. Discussions should also address incentives, procurement models, and opportunities for co-development between researchers, governments, and manufacturers.

1.6 Developing Standardized Ocean Sound EOV Products and Applications

The ocean PAM community has developed methods to convert acoustic recordings into standardized, comparable soundscape metrics, including hybrid millidecade spectra produced with tools like MANTA and PyPAM. This group will identify barriers and opportunities for broader adoption, focusing on software maintenance, interoperability, training, reproducibility, and incentives from journals and funders. Participants will also examine how standardized products support scaling Ocean Sound EOV implementation across GOOS. The Ocean Sound EOV Implementation Plan lists several candidate products, but additional ones may be needed to meet emerging scientific, operational, and societal priorities. The group will identify high-impact EOV products, prioritize use cases, and outline pathways for turning PAM observations into actionable indicators and decision-support tools, with emphasis on biodiversity, climate change, ecosystem health, maritime activity, conservation, and ocean management.

Theme 2. Data Products, Standards, AI, and Soundscape Analysis

2.1 Identifying Sound Sources and Developing Standards for Categorization

Building on progress made through the Global Library of Underwater Biological Sounds (GLUBS), this group will discuss approaches to improving the identification, classification, and quality control of biological, physical, and anthropogenic sound sources. The group will identify priorities for expanding sound source libraries, improving interoperability, and strengthening standards needed to support scalable Ocean Sound EOV products and analyses.

2.2 Accelerating the Use of AI for PAM Processing for Scientific and Management Applications

Artificial intelligence and machine learning are increasingly central to scalable PAM processing. This group will identify where AI approaches can most effectively accelerate tasks such as sound detection, source identification, soundscape characterization, anomaly detection, quality control, and data integration. Discussions will also address transparency, validation, training data requirements, computational infrastructure, and equitable access to AI tools. This group will also review the current state of soundscape analysis, evaluate existing products and methodologies, and identify emerging scientific and management applications. Participants will discuss how soundscape products can support ecosystem assessment, marine spatial planning, biodiversity monitoring, climate research, and broader GOOS objectives.

2.3 Developing Open-Access Databases of Ocean Sounds

This group will discuss next steps for extending the GLUBS framework beyond biological sounds to include physical and anthropogenic sound sources. Topics will include governance, long-term funding, interoperability, metadata standards, confidentiality concerns, and sustainable institutional support for multi-decadal curation of global sound databases. Discussions should emphasize the foundational role of open-access reference databases in enabling Ocean Sound EOV products and global collaboration.

2.4 Implementing ASA and ISO PAM Metadata Standards

The International Standards Organization (ISO) and Acoustical Society of America (ASA) have developed metadata standards for passive acoustic monitoring, but widespread implementation remains limited. This group will identify barriers, incentives, and practical pathways for implementing metadata standards consistently across the next generation of PAM observations and Ocean Sound EOV products. Discussions should focus on interoperability, FAIR principles, discoverability, and integration across international observing systems.

2.5 Leveraging Uncalibrated Recordings in EOV Products

Many historical and contemporary acoustic recordings lack formal calibration or fail to meet QA/QC standards. This group will identify best practices for extracting scientifically useful information from uncalibrated datasets and clarify which Ocean Sound EOV products can appropriately incorporate such observations. Participants will also address transparency, uncertainty characterization, and pathways for integrating historical data into long-term assessments.

2.6 Engaging Ocean Sound EOV User Communities and Building Societal Understanding and Advocacy for the Ocean Sound EOV

Long-term success of the Ocean Sound EOV will depend on broad societal understanding of the importance of ocean sound observations and their applications. Ocean Sound EOV products must ultimately serve the needs of diverse user communities, including researchers, policymakers, indigenous communities, managers, industry, educators, and the public. This group will discuss processes for co-designing EOV products with users, identifying priority applications, and ensuring that products are accessible, relevant, and actionable. Participants will discuss communicating societal benefits, building constituencies that advocate for sustained

investment, and strengthening the visibility of ocean sound within broader ocean observing and environmental policy frameworks.

Theme 3. Global Coordination, Networks, and Data Management

3.1 Identifying Spatial Gaps in Existing Ocean PAM Observations

This group will review the IQOE Ocean PAM metadata to assess current spatial and temporal coverage and identify critical observational gaps. Discussions will prioritize regions and observing strategies that would have the greatest impact on Ocean Sound EOV implementation and associated GOOS priorities. Participants also evaluate how acoustic modeling can help optimize sampling locations, durations, and frequencies.

3.2 Recovering Historical Ocean Sound Data

Large volumes of historical ocean acoustic data remain inaccessible in non-digital formats such as magnetic tapes and other legacy media. This group will identify priority archives, challenges to digitization, funding opportunities, and security considerations associated with recovering and digitizing historical ocean sound datasets. Participants will discuss the long-term scientific value of extending acoustic baselines for Ocean Sound EOV analyses.

3.3 Integrating PAM Observations from GOOS Platforms into a Global Ocean PAM Network

This group will identify the technical and organizational steps required to integrate observations from Argo floats, OceanSITES moorings, gliders, ocean bottom seismometers, autonomous vehicles, and other platforms into a coordinated Global Ocean PAM Network. Discussions will emphasize interoperability, operational sustainability, and alignment with GOOS observing strategies.

3.4 Developing Coordination Frameworks for a Global Ocean PAM Network and Ocean Sound EOV after IQOE

Most GOOS observing networks are supported through formal international coordination structures, yet no equivalent mechanism currently exists for ocean sound observations. This group will discuss governance models, coordination mechanisms, funding strategies, and institutional partnerships needed to sustain an internationally coordinated Ocean Sound EOV and Global Ocean PAM Network. This group will develop a strategy for sustaining and expanding international coordination beyond IQOE, including governance structures, funding pathways, partnerships, and future working groups. Discussions will identify priority activities needed to sustain momentum toward implementing the Ocean Sound EOV and supporting a Global Ocean PAM Network.

3.5 Scaling Data Management for a Global Ocean Sound EOV

Implementation of the Ocean Sound EOV will require coordinated international approaches to data stewardship, interoperability, and long-term archiving. This group will explore how institutional, regional, and national systems can evolve into a globally connected data management framework that aligns with GOOS requirements and FAIR principles. Discussions should address governance, infrastructure, sustainability, metadata standards, cloud services, access policies, and long-term institutional support.

Theme 4. Capacity Building, Training, and Societal Engagement

4.1 International Training Programs and Workforce Development

A limited number of international training programs currently exist in ocean acoustics and bioacoustics. This group will identify the educational, technical, and workforce development needs required to support long-term implementation of the Ocean Sound EOV. Participants will discuss summer schools, online training, regional hubs, mentoring networks, and strategies for increasing participation from underrepresented regions.

4.2 Citizen Science Contributions to the Ocean Sound EOV

Low-cost recording systems create new opportunities for citizen science and community-based observing programs. This group will discuss how citizen-generated observations can contribute meaningfully to the Ocean Sound EOV while ensuring appropriate quality control, metadata standards, processing workflows, and archival practices. Participants will also consider how citizen science can strengthen public engagement and ocean literacy, including through arts.

Theme 5. Strategic Planning, Governance, and GOOS Integration

5.1 Developing a Global Ocean PAM Network

Many components of a Global Ocean PAM Network already exist, but they remain fragmented and insufficiently coordinated. This group will identify pathways for linking observing systems, harmonizing operations, and establishing sustained international coordination across acoustic observing platforms and institutions. Discussions should focus on how a coordinated Global Ocean PAM Network can accelerate implementation of the Ocean Sound EOV and strengthen integration with GOOS.

5.2 Advancing Recognition of the Global PAM Network as a GOOS Network

Formal recognition of a Global Ocean PAM Network as an Emerging GOOS Network would significantly strengthen implementation of the Ocean Sound EOV. This group will identify the scientific, technical, governance, and operational elements required for a successful GOOS proposal, as well as leadership responsibilities and timelines for advancing the effort.