Summary Report

Synchro Co-design Session II & III: Marine Protected Areas (MPAs), Sanctuaries & designing an offshore wind case study

Purpose:
1) Review the state of the art and future directions in meeting the needs for marine protected area (MPA) and Sanctuary assessments, which sets the stage for:
2) Designing a two-year offshore wind case study with fieldwork and assessment exercise towards informing ocean observing for baseline and impact assessment.

Executive Summary:
This comprehensive report summarizes the proceedings of a two-day conference focused on marine protected areas (MPAs) and offshore wind development. The purpose of the meeting was twofold: 1) to review the current state of marine protected area and sanctuary assessments and 2) to lay the groundwork for designing a two-year offshore wind case study, with a focus on informing ocean observing for baseline and impact assessment.

During Session II of the meeting, participants were provided with an overview of the evolving practices for MPA monitoring and National Marine Sanctuary Condition Reports. Strengths and needs arising from California and national offshore assessments were detailed, along with highlighting unmet observing needs and promising technology and tools applicable to both MPAs and Sanctuaries that could be adapted to the offshore wind development context. The identified data and technology gaps in MPA monitoring encompassed biological, ecosystem, and physical parameters, emphasizing the need for more spatial and temporal coverage of managed ocean spaces. Integration of physical and biological data was advocated to achieve ecosystem-level views of ocean spaces. The adoption of emerging methods and technologies such as eDNA, passive acoustic monitoring, and autonomous sampling was also recognized, but challenges regarding data management, validation, and usability were identified as areas for improvement.

Take-home messages

MPAs and Sanctuaries
The most significant data and technology gaps in MPA monitoring include biological, ecosystem, and physical data gaps. There is a need for more integration between physical and biological data to understand ecosystem-level changes. Participants highlighted the importance of low-cost technology and emerging methods, such as eDNA and passive acoustic monitoring. Data management and access should be streamlined, and data visualization should be intuitive and compelling. The barriers to adopting new technology include industry differences, standardized methods, funding limitations, and technology disparities. Promising technologies to meet monitoring needs include AUVs, integrated data systems, monitoring technologies for marine life, and satellite telemetry, among others.

Offshore Wind
For the validation of prototype technology and planning offshore wind projects, building upon previous initiatives and existing data platforms is essential. Integrating different sensors on existing sampling methods, enhancing data sharing, and implementing standardized methods can optimize data collection. Using autonomous platforms, drones, and animal telemetry networks can monitor species and environmental parameters. Adaptive sampling, remote sensing, and moorings in upwelling centers can provide comprehensive data for decision-making. Environmental impact assessments and citizen science involvement are crucial for sustainable offshore wind development.

This report provides valuable insights into the current state and future directions of MPA and sanctuary assessments, as well as the potential for technology to monitor offshore wind development.

Objectives:
Session II
- Provide an overview of the current and evolving practices for MPA monitoring and National Marine Sanctuary Condition Reports
- Detail strengths and needs arising from CA and national offshore assessments
- Highlight unmet observing needs and potential promising technology and tools for MPAs, and Sanctuaries that might translate well to an offshore wind (OSW) need context

Session III
- Provide an overview of evolving ocean observing needs and perspectives in relation to OSW development
- Discuss and prioritize ocean observing elements with a primary emphasis on biology and ecosystem variables, and supporting biogeochemistry and physics needs
- Set the stage for designing a two-year offshore wind case study with fieldwork and assessment exercise focused on informing ocean observing for baseline and impact assessment

DAY 1: MPAs and Sanctuaries Baseline Assessments & Monitoring

Lightning talks MPAS and Sanctuaries: how do we manage and assess their effectiveness?
MPA Decadal Management Review, Management perspective - Sara Worden (CDFW)*
MPA Decadal Management Review, Science perspective - Mark Carr (UCSC)*
CA IOOS MPA Dashboard - Marine Lebrec (CeNCOOS)*
NMS Condition Reports & Infographics - Andrew DeVogelaere (MBNMS)*
Benthic assessments, data characterization and visualization - Dirk Rosen (MARE)*
Biodiversity Program and 30 by 30 - Katie Cieri (OPC)*

Breakout Session 1: Identifying strengths and needs of existing monitoring/research efforts

What are the most significant data and technology gaps in MPA monitoring?

According to participants the most significant oceanographic data gaps generally fell into three categories: biological, ecosystem, and physical parameters. **Biological observations** are currently lacking in the invertebrate monitoring niche (e.g. benthic infauna, benthic & midwater invertebrates); megafauna (pinnipeds and seabird colonies); and microbial observations. There were also suggestions: identifying/monitoring more sentinel species as proxies for ecosystem health; improving age/length information for fish species; and better ground truthing of larval dispersal patterns from MPAs. **Ecosystem level monitoring** suggestions were: focus on climate change impacts, identifying changes to estuaries, and improved monitoring of current and historical human activities (e.g. legacy oil & gas infrastructure, military dumping grounds, DDT barrels). Lastly, **physical characteristics** that were called out in this session were: chemistry and physics of water near the benthos; more subsurface measurements; improved spatial coverage of temperature, salinity, and dissolved oxygen; and more chemical parameters (e.g. nutrients).

The technological gaps and general suggestions on how monitoring is approached suggested a strong need for more spatial and temporal coverage of managed ocean spaces. Monitoring for a variety of different scales was brought up a handful of times in this session. This is a bit difficult to pin down because the scale which researchers monitor largely depends on what factor is being monitored. Largely the take-home message was more data, more often.

Participants also favored the idea of more integration between physical and biological data to get an ecosystem level view of ocean spaces. This idea aligns with the ‘ecosystem-based management’ concept that authorities strive for in managing ocean spaces. Building a stronger understanding of the interplay between physical processes and biological responses would be crucial as large scale environmental and climate changes occur.

With the need for larger amounts of data volumes collected, data engineers need to create new and automated methods for extracting useful information and actionable insights. For example, artificial intelligence has become a common tool for rapid classification of imagery data. AI’s capacity is continuously growing and sciences are notably lagging behind industry’s uptake of machine learning capabilities. The new Ocean Vision AI seeks to push forward the incorporation of rapid imagery assessment.

Specific technology focus areas which participants specifically highlighted were eDNA and passive acoustic monitoring. Technology and methods around monitoring eDNA are still very much emerging and questions around how to interpret the data remain. PAM technology is fairly mature and cost effective, yet scientists are still grappling with integrating them into ocean observing systems and determining how best to analyze and use their data outputs.

Lastly, the participants brought up a lot of comments about data management & use, which should be a major focus as more oceanographic data are collected. The means of how we validate, store, access, quality control, visualize, and disseminate data all have opportunities for improvement. participants supported a streamlined and intuitive approach to accessing quality controlled datasets from a managed repository. When pipelining data sources, repository managers should give special consideration to keeping data in standard units and adhering to quality control best practices, while making metadata more visible. Data stream priorities should be focused on real-time data from diverse sources (including integration of data from neighboring regional associations, because ecosystems don’t care about our institutional boundaries). Furthermore, backend systems should be frequently checking to ensure real-time data streams are up and being continuously ingested into the repository.

When thinking about your most pressing ecological research questions, what types of tech or innovation would you like to see developed to address them?

The answer to this question was overwhelmingly: less expensive, easy-to-use data collection technology and methods. In recent years (and likely following years), our ability to collect data has gotten much more expensive: due to hardware costs, operation & maintenance, and increasing labor costs. As noted in the previous section, despite the high cost of data we desire more data, more often to answer increasingly complex questions about our ocean spaces and assess increasingly more wide-spread impacts of human activities. Efforts by science, engineering, and industry should aggressively focus on developing widely accessible technology to continue and broaden our sensing capabilities. We’ll discuss ‘low cost’ technology in more detail in the next section.

Ecological research priorities included migratory tracking and larval movement; identification of climate change induced effects; better understanding of the mesopelagic region of the California current; fate & transport of microplastics; and improved fisheries management strategies.

How do you define “low cost” technology and what are some examples?

The hallmarks of ‘low cost’ technology are those technologies which are less costly to procure and easier to use than present technology or practices. It is difficult (and probably unnecessary) to try to arrive at a price point for what low cost means, due to many intrinsic reasons. The term ‘cost’ does not only mean the upfront hardware cost, but also includes costs of operation & maintenance (O&M). Typical O&M factors are calibrations, repairs, consumable materials, and staff time. Technology users should be clear on all of these costs when considering the procurement of a piece of scientific hardware and manufacturers could estimate that information on their technology’s specification sheet. Ideally, low cost hardware either doesn’t require calibration or can be user-calibrated. If a component breaks or needs to be replaced, either the whole unit is replaced or the component can be replaced by the manufacturer or the user (so long as they accept the risks of manipulating the hardware).

Easy and intuitive use of the technology is a key factor for ‘low-cost’ technology. The user interface should be minimalist, non-technical, and feature real-time troubleshooting steps. The technology should be accessible to non-technical users.

The impact of ‘low-cost’ technology should come from the broad adoption and use of the technology by users of many different organizations (e.g. NGOs, government, academia, etc) or even hobbyist/recreational users (e.g. surfers, SCUBA divers, fishers, or boaters).

Breakout Session 2: Current and unmet observing needs and potential promising technology/approaches

What are the barriers for you and/or your organization to start using emerging/maturing technology, and what enables you to make such transitions?

- Cultural differences and attitudes towards change
- Impact analysis, tech requirements, and regulations
- Confidentiality concerns and data accessibility
- Technology disparities and compatibility issues
- Deep water challenges and limited technical skills
- Funding limitations and cost considerations
- Technology validation and skepticism
- Time investment, training availability, and usability
- Research vs. operational divide and knowledge of available technologies
- Value, cost-benefit, and necessity assessment
- Standardizing workflows and developing baseline information
- Policy and regulatory mechanisms

What are your go-to resources for support while adopting a new technology into your program?

Technical Support:
- Manufacturers of equipment or software
- User groups and communities

Online Resources:
- Internet forums and chat platforms (e.g., Reddit, Stack Overflow)
- YouTube tutorials and instructional videos
- Ocean Data View: User-friendly software for oceanographic data analysis

Specific People:
- Academic partners
- Tech-savvy staff
- Tech-specific experts
- Stakeholders
- Data Managers
- Funders
- Engagement with early-career experts

Collaboration and Cooperation:
- Access to collaborative agreements, grants, and iterative testing
- Training programs
- Leveraging different agencies and organizations
- Conferences

What technology is most promising at meeting needs across MPAs, Sanctuaries and possibly the developing offshore wind assessment information needs?

- Automated Underwater Vehicles (AUVs) and Auto-sampling Capabilities
- Integrated Data Management Systems
- Vessel Monitoring System (VMS) Data
- Monitoring technologies for fish, whales, birds, and upwelling
- Human Impact and Resource Use Monitoring
- Data integration platforms and cloud repositories
- Modeling under Future Climate Scenarios
- Remote Operated Vehicles (ROVs), Drones, and AUVs
- Satellite telemetry and real-time data transmission
- Passive acoustic monitoring
- AI data characterization
- Fiber optic cables
- Radar/LIDAR/3D Thermal Imaging
- Multibeam bathymetry
- Regional Ocean Modeling Systems (ROMS)
- Drones for kelp, seabird, and seal Monitoring
- Environmental DNA (eDNA)

- Crowdsourced/citizen science data

The following comments were made after the meeting and completion of the summary report:

1) It is extremely difficult to evaluate the state MPA performance without high (1 km or less) spatial information on fishing activity and take. The state needs support in developing technology that would collect info on fishing distribution, rates and species composition and then make those data available on an annual basis.

2) Regarding larval transport, this is all about population connectivity across the state MPA network. For this, we need more spatially and temporally refined ROMS models and information about larval behavior (e.g. higher resolution spatial and depth time series of larval concentrations to see how larvae distribute themselves relative to currents).

3) The ROMS and connectivity models need to be developed through the marine heatwave (2013 and beyond) and into the future with climate scenarios to predict how oceanographic changes associated with climate change will impact network connectivity. This informs the potential adaptive management of the network.

4) Just reinforcing that what better informs sanctuary assessment, better informs the state MPA network and vice versa. The two are inextricably linked.

DAY 2: Offshore Wind Case Study Planning

Lightning talks on Government, NGO, and Industry perspectives and priorities for OSW
Synthesis of Environmental Effects Research (SEER), information needs prioritizations, technology development efforts - Joy Page (DOE)*
Technology advancement initiative - Daphne Molin (CEC)*
Baseline and impact assessment - Donna Schroeder (BOEM)*
Baseline and impact assessment - Jay Staton (CDFW)
Perspective and priorities for offshore wind - Yi-Hui Wang (OPC)
Priorities for OSW baseline and impact assessment work - Matt Koller (CSLC)

Tribal energy sovereignty & OSW - William (Bill) Matsubu (Blue Lake Rancheria)*
Offshore baseline monitoring efforts - Deanna Meier (Tetra Tech)*
Full lifecycle support for OSW infrastructure - Marge McInnis (Furgo)
Toolkit for monitoring ocean ecosystems (primers)
Biogeochemistry/Bio-Eco ocean observing - Francisco Chavez (MBARI)*
Passive Acoustic Monitoring (PAM) - John Ryan (MBARI)
Imaging - Henry Ruhl (CeNCOOS)*
Acoustic Tagging & Telemetry - Barb Block (Stanford/Hopkins)
Environmental DNA (eDNA) - Collin Closek (Stanford/Hopkins)*
Ocean observing design: Lessons from the East Coast - Mike Crowley (MARACOOS)*
Platforms, models, and possible scenarios primer - Henry Ruhl (CeNCOOS)*

Breakout Session 1: Validation requirements for advancing development progression of a prototype technology

What initiatives have already employed (cross) validation work and what were their approaches?

- Ground-truthed data collected from digital images of the intertidal: The study mentioned in the provided link discusses the use of ground-truthed data from digital images to validate machine learning classification of habitat data in intertidal areas.

- Validation of acoustic tags using visual observations: Acoustic tags have been validated using visual observations of marine species such as white sharks, humpbacks, blue whales, and tuna.

- Integration of different technologies into one system: There is ongoing progress in integrating various technologies, such as fiber optics sensing strain coupled with hydrophones or cameras on remotely operated vehicles (ROVs), as described in the referenced article.

- CA State Lands Commission coastal studies: The California State Lands Commission conducts coastal studies related to renewable energy and other coastal management activities. The provided link leads to their website.

- AOSN and ASAP: These preceded the CANON project and involve studying physics during upwelling using gliders to measure water movement. The CANON studies include eDNA sampling with different markers.

- Upwelling study using HF radar: Jeff Paduan's research involves studying upwelling using high-frequency (HF) radar. The provided link leads to a publication on this topic.

- PAM system on MARS: The PAM (Passive Acoustic Monitoring) system is used on the Monterey Accelerated Research System (MARS) to monitor underwater sounds and marine life. The referenced article provides more information on this system.

- eDNA integrated with long-term monitoring and spatial planning: The provided link leads to a document discussing the integration of environmental DNA (eDNA) with long-term monitoring and spatial planning in lentic (still water) and lotic (flowing water) systems.

- MBARI Spray glider with hydrophone: The Monterey Bay Aquarium Research Institute (MBARI) employs a spray glider equipped with a variety of sensors for research purposes. The provided link leads to a document describing this technology.

- Hake cross-validated with eDNA and acoustic surveys: A study mentioned in the provided link involves cross-validation of hake populations using environmental DNA (eDNA) and acoustic surveys.

- Happy Whale: Citizen science-based app/website, for marine mammal photo ID data collection

- Big Sur PAM/tagged whale research: The referenced article discusses passive acoustic monitoring (PAM) and tagged whale research in the Big Sur region.

- GPS tracking for high-resolution movement data: GPS tracking is used to obtain high-resolution data on the movement and migratory corridors of marine animals.

- Cross-validation of animal tracking from tags and passive acoustic sensing: The provided link leads to a study that discusses cross-validation of animal tracking data obtained from tags and passive acoustic sensing.

- Presence of fish and corals with ROV and AUV imagery/CTD-imagery: The research conducted by Meredith Everett involves studying the presence of fish and corals using remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), and CTD (Conductivity, Temperature, and Depth) imagery. The Deep Sea Coral Data website mentioned provides further information.

What challenges arose with the aforementioned approaches?

- Tagging Limitations: Some life stages, such as juveniles, may not be suitable for tagging, and there may be limitations on the size of tags used.

- Time Intensiveness: Many data collection methods can be time-consuming, requiring significant effort and resources.

- eDNA Data Interpretation: The quantitative capacity of environmental DNA (eDNA) data may be limited, and there may be uncertainties regarding the interpretation of eDNA data, leaving open questions.

- Cost of Validating Imaging: Validating imaging data can be expensive, adding to the overall cost of data collection and analysis.

- Spatial and Satellite Coverage Limitations: Gaps in spatial receiver coverage and limited satellite coverage can restrict data collection in certain areas.

- Lack of Visual Confirmation: Some species, like demersal fish, may not allow for visual confirmation after tagging, making it challenging to track their movements.

- eDNA contamination: eDNA sampling may introduce species into the water column that have not been routinely observed in that location, potentially confounding the data.

- Funding: Adequate funding is crucial for conducting comprehensive data collection and analysis in ecological research.

- Data Collection Costs: Collecting and processing large amounts of data can be expensive, requiring resources for equipment, personnel, and analysis.

- Knowledge of Available Data: It is important to be aware of existing data resources for cross-validation purposes and to avoid duplicating efforts.

- Timescales and Shifts: Understanding the timescales involved in ecological processes is essential for detecting and analyzing shifts in populations and ecosystems.

- Data Sharing: Sharing data among researchers and institutions promotes collaboration and facilitates a more comprehensive understanding of ecological systems.

- Staff Time Requirements: The amount of staff time required for data collection, analysis, and interpretation should be considered when planning research projects.

- Lack of Geographic Scale Overlap: eDNA and Acoustic Telemetry Network (ATN) data collection may not overlap in terms of geographic scale, limiting opportunities for cross-validation.

- Sampling Mismatch: eDNA sampling captures a broader range of species compared to tagging individuals, potentially causing a mismatch in the scope of sampling modes.

- Integration of Technologies: Different data collection technologies, such as eDNA and standard survey methods, can complement each other when properly integrated.

- PAM Guidance for Tagging: Passive Acoustic Monitoring (PAM) can be used to guide the selection of locations for tagging individuals.

- Complementary Taxa Identification: While eDNA and standard survey methods may not always match 100%, the overlap can be valuable, as each method may identify different taxa.

- PAM and Tagging Data Volume: PAM generates large amounts of data, while tagging methods may provide data on a sufficient number of species or individuals.

How might we build upon previous initiative efforts and existing data analytical platforms for optimizing informative deliverables?

Integrating new sensors on existing sampling modes:

- One example is integrating hydrophones on Animal-Borne Telemetry (ATN) animals and using eDNA sensors on gliders or Autonomous Underwater Vehicles (AUVs). This allows for collecting additional data on hydrophone recordings and genetic information, respectively, alongside existing sampling methods.
- Incorporating microscopic imaging on Long-Range Autonomous Underwater Vehicles (LRAUVs) can provide high-resolution visual data for analysis.

Extracting new information from historical data: Analyzing frozen seawater samples for eDNA can be used to create time series data, providing insights into the presence and abundance of specific organisms over time.

Developing standardized methods:

- Establishing standard methods for specific procedures such as eDNA sample processing, image processing, and Passive Acoustic Monitoring (PAM) analysis can ensure consistency and comparability of results across different studies.
- Platforms like Protocols.io can be used to document and share these standardized methods, facilitating reproducibility and collaboration within the scientific community.

Enhancing connectivity between data repositories and tools: Improving connectivity between different data repositories and integrating tools can enable efficient integration and analysis of disparate data sources, leading to a more comprehensive understanding of the studied ecosystems.

Considering specific factors in data collection:

- Ontogenetic variation in tagging methods should be considered to account for changes in behavior and movement patterns of tagged animals throughout their life stages.
- Designing sample boxes appropriately is crucial to ensure accurate and representative sampling, avoiding bias or artifacts in collected data.
- Establishing an archive on platforms like Synchro with manuals providing standard methods can help cross-validate image data, ensuring consistency and reliability.

Leveraging LRAUVs to replace ship time: Using LRAUVs instead of traditional ship-based sampling can be a cost-effective and efficient alternative, allowing for extended and autonomous data collection in various locations and environments.

Using different methods for measuring biological communities: Employing multiple techniques such as eDNA sampling and AUVs can provide complementary data on different biological communities within upwelling locations. Understanding animal movements can help guide the selection of eDNA sampling locations.

Low-cost camera floats for data collection: Deploying low-cost camera floats, as suggested by Oscar Pizarro and Chris Roman, can offer a cost-effective means of gathering visual data, expanding the scope of research and monitoring efforts.

GLOBEC initiative: GLOBEC, an international effort, emphasizes the importance of planning ahead and integrating physical and biogeochemical data collection, fostering a holistic understanding of marine ecosystems.

Validation and specificity of data collection methods: Validating each other's methods, as emphasized in TOPP, John Ryan's, and Barbara Block's presentations, helps ensure the accuracy and reliability of collected data, allowing for cross-validation and comparison of results.

Breakout Session 2: Offshore Wind Case Study Planning

Species of Interest

- Whales
- Sea Turtles (e.g. leatherbacks)
- Sharks
- Tuna
- Seabirds
- Sea Lions
- Other fish

Physics of Interest

- Upwelling magnitude
- Upwelling fronts
- Ocean current
- Wind

~Chemistry of Interest
- Nutrients
- Primary Productivity
- Temp/Salinity
- eDNA

Technology for monitoring
- PAM (hydrophone, sound tracking)
- Tagging/telemetry/receivers
- Echosounder
- BGC sensor (T,S, Nitrate, Chl-a, backscatter)
- Imaging (micro and macro)
- MET stations
- ADCPs
- Drift cameras
- eDNA

Where to monitor
- Establish transects: across and along shelf; spanning known upwelling centers/gradients
- Mooring in the upwelling center (subsurface TSN measurements, echosounder, PAM, vertical flux?)

Platforms to monitor with
- Spray gliders
- Wave gliders
- LRAUVs
- Ship/CTD
- Drones
- Moorings
- Micro-trawl fish surveys

Thank you for reading this summary report and participating in our co-design sessions. Also, please visit our website: oceansynchro.io

Sincerely,
Synchro Co-design Committee