



U.S. Marine Biodiversity Observation Network (MBON)

All-Hands Meeting

Friday, May 26, 2017, 8:30 a.m. - 4:30 p.m.

Capitol Ballroom I

Holiday Inn Washington-Capitol, 550 C St SW, Washington, DC 20024

Note: Presentation PDFs are hosted by NASA at <https://cce.nasa.gov/cce/mbon_2017/agenda.html>

I. **Welcome, Introductions, and Marching Orders**

Woody Turner called the meeting to order.

Four years ago, a call for National Oceanographic Partnership Program (NOPP) proposals resulted in the selection of the three demonstration Marine Biodiversity Observation Network (MBON) projects. The fundamental purpose of the MBON demonstration projects, along with the Smithsonian Institution's Tennenbaum Marine Observatories Network (TMON), was to link observations gathered from individual sites to create a national marine biodiversity network. This network would then be used to inform a global biodiversity observation network known as the [Group on Earth Observations Biodiversity Observation Network \(GEO BON\)](#). With the three MBON demonstration projects entering the fourth year of their five-year terms, it has become essential to begin the process of integrating projects to fulfill the national network objective. Throughout the meeting, all attendees should focus on four topics related to the goal of building a national MBON. The topics are as follows:

1. Working collaboratively across the MBON demonstration projects and TMON
2. Progressing on shared priorities, such as data management and accessibility, eDNA, and Seascapes
3. Addressing the question of MBON sustainability and identifying new users/partners
4. Facing challenges and embracing successes

Though all topics will be discussed, two topics will be examined in more detail. Selected topics and further discussion questions are as follows:

1. Progressing on shared priorities such as data management and accessibility, eDNA, and Seascapes
 - a. *Discussion question:* How should the MBON demonstration projects manage data while making data accessible and useful for all users?
2. Addressing the question of MBON sustainability and identifying new users/partners
 - a. *Discussion question:* How can the MBON demonstration projects sustain their efforts past the initial five-year end date?
 - b. *Discussion question:* What stakeholders within States, regional efforts, or international consortia can be leveraged to establish new sources of support?

The work accomplished by the MBON demonstration projects has been excellent and the continued existence of MBON is essential. The meeting discussions will hopefully help move the MBON demonstration projects toward building a truly sustainable national biodiversity observation network.

II. MBON Status

A. Project Updates

Arctic MBON (Lee Cooper and Jackie Grebmeier)

The focus of the Arctic MBON (AMBON) is to develop an “end-to-end” approach in the Arctic Chukchi Sea, i.e., monitoring regional marine biodiversity along the full taxonomic spectrum from microbes to whales. AMBON aims to synthesize a time series of historical data to understand the changing Arctic climate and develop a metric for observing networks.

AMBON had a successful field season in 2015. Due to a recent partnership established with NSF, AMBON will be able to use NSF shiptime funding to support, in part, the 2017 summer field season. In addition, AMBON has been successful in contributing unique biodiversity-related sampling activities and protocols to the [DBO](#) (Distributed Biological Observatory). AMBON continues to face challenges of maintaining a relevant and current presence in the IARPC (Interagency Arctic Research Policy Committee) community, especially given that BOEM and NOAA’s funding direction and budget may change as early as the next fiscal year.

Discussion

Q: *How does AMBON conduct the phytoplankton work? By counting or genomics?*

A: The phytoplankton research discussed in AMBON’s presentation derives from phytoplankton genomics. However, AMBON also is receiving data on phytoplankton taxonomy through a collaboration with Polish colleagues.

Q: *Do you regard the Chukchi Sea as a single ecosystem or is there a sensible partitioning?*

A: Overall, the Chukchi Sea is regarded as a single-ecosystem because of its heavy influence from the Bering Sea inflow. However, predictable regional differences can be seen in the data. There is a predictable sand dollar belt from Point Barrow to south of the Bering Strait. In the region northeast of the Chukchi Sea, there is a complex mixing of currents and water masses, resulting in an abundance of clams and establishing an offshore feeding ground for walruses. The southern Chukchi Sea and Barrow Canyon in the NE Chukchi Sea are the highest productivity regions in the Chukchi Sea.

AMBON has two primary project sites, located in the northern and southern Chukchi Sea, to compare regional measurements across the single ecosystem.

Q: *Given that the physical situation in the Arctic is quickly changing, does AMBON conduct temporal comparisons using historical data in the region?*

A: Yes. A 30-year archive synthesis paper has been developed, looking at regional datasets ranging from physics to whales. This paper is published in the *Progress in Oceanography* journal. The immense data accumulation effort for the synthesis research was supported by funding from the North Pacific Research Board. Some datasets are

openly available as synthesis products on the Earth Observing Laboratory data archive and are now connected to the NSF Arctic data site.

AMBON Principal Investigators receive regular inquiries regarding the use of the Arctic synthesis datasets. The Pacific Marine Arctic Regional Synthesis ([PacMARS](#)) was published in 2015 and has led to many inquiries for data. AMBON spatial coverage was built on existing data and time series locations and thus continues data collection from past efforts.

Q: *Have there been any interactions between AMBON and the NASA field programs, [Arctic-COLORS](#) (COastal Land Ocean inteRactionS in the Arctic) and/or [ABoVE](#) (Arctic-Boreal Vulnerability Experiment)?*

A: Lee Cooper, an AMBON Principal Investigator, helped develop the science plan for Arctic-COLORS. Recently, NASA issued a solicitation for proposals related to Arctic-COLORS through the [ROSES 2016 A.30 Remote Sensing of Water Quality](#) RFP amendment. Proposals were due in March of this year for FY17/FY18, but a panel review remains to be completed.

AMBON is not associated with the ABoVE program. However, AMBON has developed partnerships with NASA through other international collaborations. Through the DBO, AMBON has been working with NASA and Japanese researchers to investigate the possibility of using seasonal satellite data to observe changes in species compositions. The Japanese researchers have already conducted cruises to measure the genetics of phytoplankton functional groups.

With respect to the DBO NASA efforts that are associated with AMBON, this year marks DBO's fifth and final year; a renewal is pending with NSF (newly funded as of July 2017). This work is in collaboration with Canadian researchers on the CCGS Sir Wilfrid Laurier. Concurrently, Japanese, Korean, and Chinese researchers will also be conducting biodiversity measurements in the region through DBO and this will contribute to a knowledge and network function associated with AMBON efforts.

Another NASA solicitation that could be of interest to AMBON is the [A.50 Group on Earth Observations \(GEO\) Work Programme](#) call for proposals. A panel review will be conducted in the near-term; awardees will be selected by late June.

Q: *What do you see as the nature of a sustainable MBON in the Arctic? And how do you plan to continue such efforts?*

A: To ensure the most effective sampling regime in the Arctic, it is important to sample every year. However, due to financial constraints, AMBON is currently sampling every other year. Significant changes in sea ice have been detected on a timescale of less than a year. For the U.S. to remain a world leader in Arctic research, U.S. agencies should consider a more frequent sampling regime to properly track sea ice change and its impacts on biodiversity and the rest of the ecosystems.

Katrin Iken is the overall research lead for the AMBON project. Jackie Grebmeier is one of the lead PIs for AMBON and is also a co-lead for the [Marine Ecosystems Collaboration Team](#) under IARPC. The AMBON project is referenced within one sub-theme of the Team's performance elements from the Arctic Research Plan; while, the

DBO is addressed across three performance element sub-themes. To develop a more sustainable AMBON, the project will need to focus on cross-leveraging interagency resources, as well as international resources. International partners would contribute large regional datasets, new icebreakers, annual data meetings, and a total of 5 research cruises within the region as shown on the 2017 PAG/DBO cruise table (see PAG and DBO NOAA website). Collaboration across boundaries is imperative to effectively cover the Arctic region, spatially and temporally.

Q: *Can you elaborate on the relationship between the DBO and AMBON?*

A: The DBO serves as a framework for international research coordination, demonstrating the benefits of an international and interagency sampling and data-sharing approach to the investigation of biological responses to a rapidly changing Arctic marine ecosystem. The DBO is a collaborative research initiative that otherwise would be too difficult for a single program to support.

The DBO is independent of AMBON; however, AMBON is unique in providing a biodiversity focus, complements data on some ecosystem components not sampled by the DBO, especially data on epifauna and fish, and is a primary contributor of microbial and microfaunal genetics data in the Chukchi Sea region. Without AMBON, the DBO would lose its richness of genomic datasets. AMBON researchers are working on a manuscript to define an effective genomics sampling regime that supplements the baseline sampling regime outlined by the DBO and on a manuscript that compares the biodiversity focus of the AMBON sampling with the hotspot focus of the DBO.

Even though AMBON contributes significant data to the DBO, the project lacks national and international recognition. AMBON plans to increase its presence in the IARPC community through actively participating in the monthly DBO Implementation Team teleconferences. Additionally, AMBON is interested in contributing to an Atlantic DBO by expanding research efforts, a process already in development. The Atlantic DBO will be a six-year program, targeting five regional sites of high biodiversity. AMBON, in partnership with Canadian researchers, is considering applying a genomics sampling regime in the Beaufort Sea.

Santa Barbara Channel MBON (Bob Miller)

The Santa Barbara Channel (SBC) MBON is based at the University of California in Santa Barbara and includes 12 co-investigators from Scripps, USGS, and NOAA Southwest Fisheries Center, with a variety of Federal and state partners including the Channel Islands National Marine Sanctuary.

SBC MBON has three broad goals:

1. To integrate biodiversity data to enable inferences about regional biodiversity.
2. To develop advanced methods and improve existing methods using imagery and genomics in monitoring biodiversity.
3. To implement a tradeoff framework that optimizes allocation of sampling effort.

The objective of the goals described above is to produce a decision tool to help MBON allocate sampling efforts based on the data collected and the cost incurred. The production of this tool would aid MBON in expanding its projects or creating new MBONs.

SBC MBON presented the following updates:

- Projects involving kelp forests made the following progress:
 - Created a regional biodiversity picture within California's kelp forests.
 - Modeled and analyzed complex and multi-scale drivers of kelp forest communities.
 - Quantified kelp forest canopy cover, biomass, and net primary production.
 - Examined kelp health using chlorophyll-carbon ratios with hyperspectral remote sensing data.
- Other updates include:
 - Coordinated study design through data cleaning.
 - Improved automated image analysis with deep learning model techniques.
 - Enhanced convolutional segmentation to improve the identification of image pixels.
 - Creating hierarchical models for more effective identification.
 - Monitored marine mammals with acoustics.
 - Identified diversity and abundance of plankton from microbes to ichthyoplankton through genomics.
 - Modeled larval dispersal, deep-water biodiversity, and phytoplankton communities based on pigments.
 - Identified pelagic ichthyoplankton with metabarcoding.

Future Actions:

- Comparison of eDNA and photography sampling across all the MBON demonstration projects.

Discussion

Q: *What portions of the SBC MBON project can be shared more broadly with the larger network observation system, i.e. deep learning for photo analysis?*

A: The deep learning tool is already available and useful for those who need an online cloud-based tool to annotate and store images. Models for the data should be available online within the next few months. Derivative algorithms are also available for use with hyperspectral data. The algorithms are able to connect data with conditions including genomics. Data management is essential to integrating numerous data sets into the larger network observation system. With broader MBON assistance, collecting and integrating biodiversity data can be provided to make a larger more useful MBON network.

Q: *How is SBC MBON sharing knowledge and resources with the other projects to create a larger united network?*

A: SBC MBON is connecting with other MBON demonstration projects through data management, genomics, and image analysis. The MBON Data Management Committee

has made progress in evolving a data management structure to allow for global incorporation of several types of data as well as identification. The labs of Craig Carlson and Debora Iglesias-Rodriguez have been working closely with the Florida sanctuaries team on genomics, specifically, coordinating primer choices, testing primers, and pipelines. The SBC has also developed an imaging analysis tool that will be available online within the next few months for use by any project.

Q: *What relationships has SBC built or plans to build that could lead to sustainability of the project past year five?*

A: SBC has been working with local program representatives from BOEM to identify long-term sources of funding both within BOEM, the State of California, [West Coast Governors Alliance](#), the [National Center of Ecological Analysis and Synthesis](#), and other programs. Further assistance on identifying new partnerships has been provided by the new BOEM program representative, Donna Schroeder, and the Channel Islands National Marine Sanctuary Science Adviser, Chris Caldow. SBC has partnered with the [Southern California Coastal Ocean Observation System \(SCCOOS\)](#) on multiple endeavors, including the submission of a letter of intent to the SCCOOS renewal proposal to possibly incorporate MBON data management into the future of SCCOOS. This would allow an ongoing incorporation and updating of SBC data within SCCOOS. SBC MBON and SCCOOS have also submitted a ROSES proposal to develop the MBON Data Management and Communications (DMAC) team's data management tool.

Q: *What were the challenges SBC MBON faced when integrating the legacy historic datasets and did the process bring partners together differently?*

A: The process of integrating the historic datasets allowed representatives from each program who collected and managed the data to communicate. The most challenging component of integrating the historic data was to decide how to make the data useful to multiple programs focused on different questions, e.g. identifying various levels of taxonomic resolution. To integrate the data, all units were homogenized and then codes were written to join the data at different levels of resolution, depending on each program's need.

Sanctuaries MBON (Frank Muller-Karger and Francisco Chavez)

The Sanctuaries MBON pilot project uses the Florida Keys, Flower Garden Banks, and Monterey Bay National Marine Sanctuaries as demonstration sites for MBON. The national-level goal for Sanctuaries MBON is to provide a framework to inform the National Marine Sanctuaries' Condition Reports. The international-level goal is to contribute to a global MBON framework.

Sanctuaries MBON provided an update on their efforts, including developing Marine Essential Biodiversity Variables (EBVs), collaborating with OBIS, developing Seascapes, managing and visualizing data, providing communications and outreach, and contributing

to Pole-to-Pole MBON efforts. In addition to the overarching goal of making MBON operational, upcoming work includes expanding along the West Coast, collaborating with Blue Planet to create a product for Sustainable Development Goal (SDG) 14, and making eDNA deployable and cost-effective.

Discussion:

Q: *Who is responsible for identifying funding to sustain MBON?*

A: The program managers view it as a joint effort between themselves and the MBON demonstration projects. The program managers will be working to identify funding networks; however, the MBON demonstration projects should also work to identify opportunities as well.

Q: *Does Sanctuaries MBON address all EBVs listed in the presentation? Are there any EBVs not currently incorporated that need to be advanced to make it complete?*

A: It is not possible to measure all forms of life, so in that sense it is incomplete. Sanctuaries MBON is not measuring everything that is listed as an EBV. However, Sanctuaries MBON is working to expand the range of data from microbes to whales by combining eDNA and surveys. They are also working to strategically and systematically identify key biodiversity indicators so there is a justification for the measurements they do collect. They are particularly focused on genetic composition, which incorporates the presence/absence, abundance, and distribution of key organisms. Key organisms include foundational organisms, organisms relevant to fisheries management, organisms that are of interest to the sanctuary, and some indicators of ecosystem health. Rather than lumping everything together in one biodiversity index, Sanctuaries MBON is first working to determine the best way to measure biodiversity within each of the relevant taxonomic groups, e.g. determining how to measure biodiversity of corals or determining the best way to measure phytoplankton diversity.

Q: *Who has been involved in processing the 20-year AOML dataset mentioned in the presentation?*

A: Over the years, there have been several people involved in collecting physical oceanography data in the Florida Keys, as a part of NOAA AOML's South Florida program. This data was unprocessed, so it was given to Matt Howard, who has now processed almost 20 years' worth of observations. The data now sits in GCOOS (Gulf of Mexico Coastal Ocean Observing System).

Q: *At the end, this will be transitioned to someone, and that should be a group of scientists as well. How is that going?*

A: The goal is to have a system that is operational for science, which people can use and contribute data to. Getting people to contribute data is complicated because people want their data to be acknowledged, so they do not lose credit for collecting the data as it moves down the line and is used by other people. Adequate acknowledgement is one of the biggest challenges.

Q: *Can you elaborate on the California group's efforts to expand with CalCOFI?*

A: Jarrod Santora and Francisco Chavez have been working with CalCOFI since before MBON. What they are trying to do now is expand the footprint, not just with CalCOFI. They are going to collect samples for rockfish and other organisms all along the West Coast and try to match these efforts with environmental missions. This is Jarrod Santora's effort.

Q: *How is working with other BONs going?*

A: There are monthly telecons to touch base with the PIs in the cross-MBON group, which program managers are invited to participate in. There is also collaboration within the different themes. For example, everyone is interested in gaining access to the Seascapes, so Maria has been all over and has done tremendous work collaborating with different parts of different MBONs. Another example is the eDNA group, which has also been very active in collaborating with the different MBON groups as well as inviting other groups, such as the NOAA genomics group, to join the discussion. Sanctuaries MBON is also working to develop a prototype product for SDG 14. Other MBON groups are part of the discussion, though it is not clear how to engage people more in this effort. One possibility for engagement could be testing the SDG 14 products. There are many areas where collaboration is being discussed.

Q: *How are the collaboration efforts with the Integrated Ecosystem Assessment (IEA) going in the Southeast?*

A: Sanctuaries MBON is not involved in the IEA discussions in the Southeast. The Sanctuaries MBON team has been very engaged with the California Current IEA process in through the sanctuaries. The idea to develop infographics is, in part, a result of the IEA partnership.

Tennenbaum Marine Observatories Network (Maria Murray)

The Tennenbaum Marine Observations Network (TMON), a Smithsonian-endowment-funded program, directs the Marine Global Earth Observatory (MarineGEO). MarineGEO is an international network of coastal observation and research sites. MarineGEO sites range from the intertidal zone to scuba depths, with overarching research themes that address the dynamic relationship between humans and coastal ecosystems.

The current aim of MarineGEO site development is to establish a pole-to-pole global network by first focusing on the Americas. A core research program is coordinated across each site to allow spatial and temporal comparison of experiments. MarineGEO sites include partners within regional academic institutions, national and international agencies, and local National Estuarine Research Reserves.

Moving forward, MarineGEO is working on a Pacific expansion, launching sites in Hawai'i and British Columbia. The program is also working on an integrated data management system and exploring opportunities for external funding.

Discussion

Q: *Can you further explain the new MarineGEO site in the Gulf?*

A: The new Gulf site is in partnership with Texas A&M University-Corpus Christi. The University will integrate marine ecology research courses into their curriculum, allowing students to participate in the collection of biodiversity data. University funding will be easier to obtain if a research project is related to a course.

The regional National Estuarine Research Reserve, Mission-Aransas, is also interested in participating and are currently developing their own MOU. The Mission-Aransas Reserve is administered by the University of Texas Marine Science Institute; therefore, a dual academic partnership will be established through the development of this MarineGEO site, providing greater access to Gulf-related funds.

Q: *At the MarineGEO Hawai'i site, is the UAV mapping conducted using radiometry or standard video?*

A: Currently, the UAV mapping is conducted using standard video. However, researchers are investigating other drone-compatible imaging gear.

Q: *MBON Sanctuaries is interested in developing a kick-off network, similar to the pole-to-pole efforts by TMON. Can you elaborate on those efforts?*

A: The overall network design is composed of regulatory observatory sites with a voluntary citizen science component. Participants vary by individual events and are contacted through email blasts or other outreach techniques.

MarineGEO has yet to develop a well-coordinated, centralized system for data management. The individual MarineGEO sites collect their own data; however, there are inter-site communications. Prior to the development of a new research site, an MOU must be completed.

MarineGEO's pole-to-pole research effort is currently expanding towards a partnership with the OBIS data network. They are interested in incorporating data with greater detail than presence/absence species data.

MBON encouraged MarineGEO/TMON to seek partnerships with IOOS regional associations that coincide with MarineGEO sites. GCOOS is associated with Texas A&M University-College Station and would greatly benefit the new MarineGEO Gulf site development.

Q: *How would you define the type of research conducted by MarineGEO's international partner sites? And how do these groups interact with management practices?*

A: MarineGEO's international partners are primarily academic researchers. This allows a level of freedom for research initiatives; however, it creates a disconnect at the intergovernmental level. MarineGEO is focusing efforts on collaboration with GEO BON, the MBON demonstration projects, and GOOS (Global Ocean Observing System) to develop a centralized management framework.

Q: *What areas of overlap do you see between TMON and Global MBON? Areas of mutual benefit?*

A: TMON/MarineGEO has investigated acoustics measurements for biodiversity, similar to some MBON initiatives. Additionally, TMON is in the beginning stages of eDNA research development. The Autonomous Reef Monitoring System (ARMS) group is working on a biodiversity sampling verification project.

Due to their limited staff, MarineGEO would benefit from MBON's developments in image processing and analysis. MarineGEO has considered citizen science engagement for image processing. Through the Smithsonian, MarineGEO/TMON have a strong connection with public and educational outreach.

Q: *In terms of sustainability, how do you see MarineGEO/TMON moving forward?*

A: TMON is not a federally-funded program; instead, it is funded by endowments. The endowment funds are not enough to grow the staff and ensure ongoing success of the projects. TMON plans to apply for federal funding opportunities; however, there are some restrictions that apply to Smithsonian-related projects. These restrictions are agency and program dependent. This introduces an interesting discussion on how to define the Smithsonian as a GEO member.

III. **Animal Telemetry Network (Bill Woodward)**

The Animal Telemetry Network (ATN) program is a multi-agency program hosted within the IOOS Program Office. The ATN includes partners from Federal and state agencies; the fisheries, marine mammal, sea turtle, and bird conservation and management communities; tribal communities; the energy and tourism sectors; the general public; educational institutions; and private industry.

The core principles of ATN are:

- To serve as a multi-disciplinary observation system that provides, conserves, and sustains the management of commercially harvested species, protected species, and other marine resources.
- To ensure animal telemetry data structures are available for use and can be easily shared.

ATN presented the following updates:

- The [ATN Implementation Plan](#) was approved by the Office of Science and Technology Policy at the end of 2016.
- The Data Assembly Center (DAC) became operational in January 2017.
- Workshops determining observation priorities and encouraging stakeholder involvement took place in Annapolis, MD in February and Tampa, FL in March.
- ATN has reached out to the following potential partners: Florida Atlantic Coast Telemetry (FACT); Atlantic Cooperative Telemetry Network (ACT); and [iTAG](#).
- The Hopkins Marine Station at Stanford is now operating the centralized data assembly center.

- The ATN Steering Group was established for guidance and leadership is setting priorities. Its first meeting is scheduled for June 5th- 6th, 2017.

Future Actions:

- ATN will work with the NCEI Science Group to continue shifting DAC toward a permanent archiving tool.
- The newly-hired database manager will remodel the data interface.
- ATN will work with its Canadian counterpart, Ocean Tracking Network (OTN), to establish acoustic nodes for aggregating all data.
- Further observation priority workshops will take place in late 2017 or early 2018 in Alaska, Hawaii, and the Gulf of Mexico region.
- The ATN is scheduled to move forward with its implementation plan in the next 6-8 months.
- In 2017, 2018, and 2019, ATN will define and fund multi-agency collaborative baseline observation projects.

Discussion

Q: *What is the relationship between ATN and MBON and how can it be utilized?*

A: The relationship between ATN and MBON has yet to be determined, but a valuable collaboration is possible. As a program observing marine animal movement, ATN can contribute and expand the MBON project's capability to measure animal movement and behavior and create a more complete integrated biological ocean observing program. The process of creating a collaboration is still unclear but MBON has created a foundation that could feasibly integrate ATN and MBON. Further discussion called for help from the community to determine and prioritize what ocean variables must be observed to allow for sustainable use of the oceans that benefits all users.

Q: *Are you looking for a merger between ATN and MBON?*

A: ATN and MBON should not merge because there are unique aspects of each program that should to be preserved. However, by combining the unique aspects of ATN and MBON, a more holistic picture of the system could be generated. Linking movement and behavior changes captured by ATN with biodiversity data captured by MBON could help managers create larger connections and inform local communities about potential impacts. ATN and MBON should work together to move beyond the physical oceanographic conditions and make a broader collaborative biological network that can advise local communities as well as contribute to a global network. While unique aspects of ATN and MBON should be preserved, identifying shared needs is also essential. A formal process for identifying data management solutions and developing new products are two areas where ATN and MBON can work together. The likelihood of sustained commitment and funding is much greater if assets can be joined.

Further comments were made about how NOAA would be able to create space for a new initiative. If the ATN and MBON demonstration projects were to continue, would the agency build new capacities or add to existing responsibilities?

IV. Data Management Progress and Solutions (Bob Miller, Abby Benson, and Jennifer Bosch)

Bob Miller (Presentation)

Without a global MBON to act as a clearinghouse, data management within the MBON demonstration projects is critical to bringing the data together in a cohesive and coherent manner. MBON project managers collaborated in 2016 to align their data management plans. The high-level MBON data management goals are to make data usable for researchers, managers, and policy-makers; to make the data easy to locate and search; and to tag or organize the data according to appropriate data vocabularies. Updates on each of the MBON demonstration projects' progress on these data management goals were provided. In addition, the need to formalize a metadata ontology for EBVs and the possibility of collaborating with DataOne were discussed. DataOne has already worked on this issue with the ecosystem ontology (ECSO).

Discussion

Q: *Does ECSO already exist or is it something that needs to be created?*

A: ECSO already exists; the next step is developing some ontologies for population data, etc. DataOne is interested in using MBON as a use case. There is already a lot of MBON data in DataOne.

Abby Benson & Jennifer Bosch (Presentation)

Abby Benson and Jennifer Bosch developed a diagram to illustrate what the data pipeline structure of MBON could look like. The diagram outlines data flow and processes from data producer to data user from the perspective of an overarching MBON, rather than the individual projects. Abby and Jennifer envision users finding data in four main places: the MBON portal, OBIS, IOOS, and DataOne. In addition, users will be able to access the data through NCEI archives. The importance of consistency and standards to end users was emphasized.

Discussion

Q: *DataOne links back to the repository, which is valuable because it allows users to find further information and to access the entire dataset. Does OBIS have this discovery and access capability?*

A: The digital object identifier (DOI) for the repository can be included in OBIS.

Q: *The purpose of DataOne is to provide access to the datasets, in their original repositories, whereas the purpose of OBIS is not to confederate these repositories, is that correct?*

A: Yes, the purpose of OBIS is to integrate the data, not to confederate the datasets. Abby Benson envisions data integration as the end goal for MBON.

Q: *In reference to the data pipeline diagram, who is issuing the original data DOI and applying the Darwin Core Event Core?*

A: The dotted lines on the MBON data pipeline diagram refer to future possible relationships that have not yet been formalized. However, the DMAC team has noted that it is critical to archive both the original canonical dataset and the OBIS dataset because some small details from the original dataset might be left out of the OBIS dataset. By archiving both datasets, all information can be preserved for the long-term. For the DOIs, NCEI will mint DOIs for all datasets that they archive. In addition, if the dataset has already been minted with a DOI, for example by DataOne, the archived DOI will reference the original DOI, so that it can always be linked back to the original.

Q: *The presentation mentioned integrating environmental data that has been collected concurrently with the biological data into OBIS by using Darwin Core Event Core; is that limited to event-based environmental data or does it allow for data that is coming in from data loggers automatically at frequent intervals?*

A: If the data logger has a species associated with it, then it can be brought into OBIS. Because taxa are the granular data in OBIS, the data must have an associated taxon to be incorporated.

Q: *If the data are linked to a sample ID number or a location that has multiple species, can it be automatically populated for all taxa at that place?*

A: Essentially, yes. With OBIS, there are three different files for the event, which link the event with measurements and facts about the event, as well as occurrences that are associated with the event. These files are linked with an event ID. In that scenario, the data could be linked by using these unique IDs.

Q: *What does data citation look like for OBIS? For example, if someone was using data that pulled from 400 different datasets, would they need to cite each of those datasets individually or could they just cite OBIS and the search criteria?*

A: Currently, they would need to cite each DOI. OBIS is working towards dynamic data citations, so that searches that call back records from multiple datasets could be cited with a dynamic DOI. However, OBIS USA is applying data to both OBIS and GBIS; GBIS does have the ability to create a DOI for a downloaded dataset.

Margaret O'Brien noted that the field of data citation is in its infancy. In theory, it is possible to attach a DOI almost anywhere; however, the field is still working to determine what is worthy of a DOI. There is an expectation of permanence associated with a DOI, so typically repositories are the ones that can assign DOIs because they can provide this permanence or, if they do not have the capacity or funding in the future, they have a plan for transferring resources.

Q: *Data producers want to feel confident that an end user will use their data. Dialogue with end users about their needs can steer what data is collected, how it is collected, how data moves through the system, etc., thus ensuring that the data will be used. Groups like OBIS and IOOS can facilitate the movement of data from*

producer to user. Is MBON on the right path to provide this service for both producers and users of biodiversity data?

A: From an OBIS perspective, MBON is well positioned to provide connectivity between data producers and end users because of OBIS' ties to GEO BON, GOOS, and the UN. These connections provide a pathway to policy-makers, which is how the data will be used. In addition, researchers can access the data through OBIS' API.

Q: *OBIS is a worldwide resource containing millions of records of marine species, but it does not constitute an MBON. How will OBIS meet this function in the future? For example, how will managers be able to use OBIS to understand changes to biodiversity in their region?*

A: Abby Benson and Jennifer Bosch envision that the MBON demonstration projects will develop new and innovative ways to combine these datasets, which will provide information about biodiversity status, as well as inform policy in general. In addition, one of the advances of Darwin Core Event Cores is that OBIS can now incorporate not just the occurrence and abundances of a species, but also include data about the environment in which the species was recorded. The incorporation of the environmental data is a way to link the many disparate datasets.

Q: *Hypothetical: a program manager is trying to figure out the biodiversity of fishes in all of the sanctuaries together. How could this be done using OBIS? Is it possible to list all the fishes?*

A: A well-known text could be entered. It is possible to list all of the species within a geographic region with the R OBIS package.

Bob Miller noted that, without information on the sampling effort, etc., this data could not be used to assess biodiversity in this scenario.

Sampling effort, sampling protocol, and other information can be included with Darwin Core. That data can be put in the Ecological Metadata Language (EML), which is what DataOne does. OBIS presents a different way to access the same information.

General Discussion of Data Management

OBIS as an MBON Data Repository

The efficacy of using OBIS as a repository for MBON data was discussed. OBIS is currently useful for occurrence data and will soon be able to incorporate abundance data. However, concerns were raised about whether or not OBIS is the appropriate clearinghouse for all MBON data. Centering the details of measurements is essential to providing data that is useful to biodiversity research and management. Both OBIS and DataOne only provide cryptic descriptions of measurement details.

It was suggested that, while determining the specifics of granularity is important, it is also important to be contributing to this larger infrastructure in the meantime. The purpose of the data pipeline diagram was to lay out a strategy for pulling that granularity out into the bigger picture and incorporating MBON data into existing international structures and standards.

The MBON community wants to make data accessible through OBIS as well as through the MBON portal.

SBC MBON expressed enthusiasm for collaborating with OBIS to create a system to communicate with other repositories, bring in data relevant to biodiversity, and visualize it. However, it was noted that, while OBIS has many strengths now and will be improved in the future, bringing all of the data into one repository will not, in and of itself, create an MBON.

Linking Data to Taxonomic Groups

It is important for EBV data to be tied to a specific taxa. At the international level, many EOVs have been proposed that are not necessarily tied to a specific taxa or genetic OTU. Having these measurements associated with a specific taxonomic group is essential to understanding changes in biodiversity.

MBON & Knowledge Organization Systems

Different forms of knowledge organization systems (KOS) and their appropriateness for MBON data were discussed. KOS, in order of increasing complexity, include: lists, glossaries, taxonomies, thesauruses, and ontologies. EBVs, for example, are a list, while Darwin Core is a taxonomy. More complex descriptions of a measurement provide more analytical power. Computer reasoning can be done on the more complex end of the spectrum.

It was suggested that a cost-benefit analysis be conducted to assess what level of KOS complexity would provide the most benefit for resource input. The most complex KOS might not be the most cost-effective. A simple knowledge organization system (SKOS) was suggested, which is what the Federal Geographic Data Committee is using for ISO 19115-1. Many use SKOS vocabularies because it provides a good starting point with taxonomic trees and basic relationships between trees. However, at the thesaurus level, where SKOS is, it is not possible to import vocabularies from outside. Going one step further there is a little more complexity, but there is also the added ability to import lower level vocabularies from outside. For example, rather than needing to define taxa independently, as would be necessary with SKOS, the vocabulary could define taxa according to WoRMS. As a result, an increase in complexity offers significant opportunities for leveraging outside work.

SBC MBON is a proponent of creating an EBV ontology, i.e. using the EBVs as a data management and data discovery tool. The cross-BON work, made possible by a supplement from NASA, was beneficial to working towards this goal. SBC MBON also submitted a proposal to work with SCCOOS and DataOne on a set of the EBVs related to harmful algal blooms – work that could also benefit the other projects. This project leverages ongoing NSF-funded work by DataOne.

Q: *Is there potential for the MBON portal to be valuable to users?*

A: The MBON portal has potential, but it needs to be reorganized so data discovery is easier and the options for what can be visualized are more obvious. These revisions could happen by providing feedback to Axiom.

Q: *As a community, what can we do to achieve those top-level goals? How can we converge? Is it practical to build a hybrid approach from the ground up and will it provide enough interoperability?*

A: Given this problem's highly technical nature, it was suggested that this should be addressed by the cross-MBON DMAC. The rest of the community, as well as the three goals laid out by Gabrielle Canonico, could provide direction.

Q: *Can the DMAC accomplish this work? Is this something that can be done in the next 6 months?*

A: At last year's workshop, the committee finished the first year of a four-year plan. During the workshop, they determined that there are points of convergence between the projects and that it would be possible to make data management cross-compatible. However, they did not have enough time to finish. Supplemental funding would be needed to further this work because it does not fall within the scope of the data managers' work for individual projects.

Q: *What can get done within a year? Would it be possible to do the four-year plan in one year?*

A: DMAC could make progress on these goals. They might be able to finish years two and three in one year.

Scope of MBON data management goals

Developing a complete global approach to MBON data management is a massive undertaking. Because the MBON demonstration projects are pilot projects, Sanctuaries MBON has taken a more targeted approach, tailoring their data management goals to specific products they would like to create for users, rather than trying to tackle all of the data management issues that would need to be resolved for an MBON. It was suggested that MBON take this targeted approach, instead of trying to create a complete global MBON data management system or KOS. If the community could identify a target set of data that they want to be the MBON data product, then they could focus on solving those specific problems and on developing a path to achieving those specific goals. The work could be incorporated into existing structures.

Sanctuaries MBON emphasized that the MBON demonstration projects are demonstration projects and that they have passed the midway point. It was noted that the MBON demonstration projects are on the right track; however, it is important for the projects to limit their scope and demonstrate their value in concrete ways. Sanctuaries MBON suggested that developing an ontology is beyond the scope of the projects. Choosing a perfect standard is unnecessary; it is more important to choose a standard and follow it, continuing to standardize data and provide it through web portals so that it is accessible and can be used with tools like R and Python.

SBC MBON has a broader vision for MBON and hopes to continue this work beyond the five-year term. SBC MBON is already providing data products for specific users, such as for BOEM and the NMS condition reports, and focuses its data management effort on creating data products that are citation quality and in long-term, accessible repositories. However, in addition to this work, they would like to develop a system for pulling data together over a wider MBON network.

NOAA stated that focusing on near-term results does not preclude this long-term work. However, it is important to identify what data should be prioritized for further collection and determine the power of integrating different data together. NASA emphasized that demonstrating results in the near-term would allow MBON to continue in the long-term.

Sanctuaries MBON noted that they have products today, including a complex tool built by Axiom. However, this level of complexity is more useful for researchers than managers. Sanctuaries MBON is working to build a simpler tool that is easier for day-to-day use in management. This tool would also improve managers ability to communicate the information to their public and stakeholders.

SBC MBON is working with other customers as well. BOEM needs biodiversity data for work on decommissioning oil platforms in California and other spatial management issues. The State of California, IOOS, and NMFS are other potential customers.

Abby Benson and Jennifer Bosch have been collaborating to determine how to operationalize this system and make it a part of IOOS; the data pipeline diagram lays out a framework for this system.

Q: *What resources will be needed to move forward and accomplish this work?*

A: There is some confusion about how IOOS interacts with the MBON committee. There needs to be a discussion about what IOOS' needs are and how the committee can respond to them. This discussion could be done in a smaller group.

***Action:** Gabrielle Canonico, Woody Turner, and Jim Price will meet to discuss possibilities for liberating resources if the projects can be clear about resource needs to advance data management.

***Action:** Gabrielle Canonico will initiate a small-group discussion regarding the MBON portal, and what functionality is most needed by the community.

It was noted that, from a user's perspective, it is difficult to understand the full scope of the work the different projects are doing. It would be useful to understand the reasoning behind project design and the projects' accomplishments. It would also be helpful to see what the differences between the projects are, how the projects might complement each other, and where the gaps are. A common catalog of work, organized by keyword, could convey this information simply. It would not need to be sleek, but it needs to be possible for users to find all relevant datasets.

V. **Global MBON and SDG 14 Product Development (Frank Muller-Karger)**

In 2016, an MBON team was tasked with developing a product that could compile observations made by the global GEO and be ready for presentation by USGEO during the global [GEO-XIV Plenary](#) on October 25th and 26th, 2017 in Washington D.C. When designing the product, targets listed in the [United Nations SDG 14](#), "Life Below Water," were used as its foundation.

Specifically, [SDG14 targets #14.2 and #14.a](#) will be highlighted in the project. Though the U.N. targets describe a global view of ocean management and ocean health, the MBON team used data from the Sanctuaries MBON to frame the larger global issues. Using MBON data, a simple product including a map or infographic was derived to show a summary of biodiversity, temperature, or chlorophyll measurements for sanctuary environments that are generic enough to be used by global resource managers with similar environments. Further work will be performed at an August 2017 meeting in Monterey, CA, with the goal of finalizing a deliverable product prototype. The product is being tested with resource managers within the United States, but further assistance is needed in establishing connections with international partners to test the product and provide feedback. Only one or two international GEO partners would be needed for testing, but testing would need to begin within the next few weeks.

Discussion

Q: *Is it possible to receive help from GOOS?*

A: This is a possibility if we can be clear about what we are asking for. Albert Fischer will need to be contacted, but agreement should be reached first by the MBON team and sponsors.

Moving forward, Program Directors in the [NOAA Large Marine Ecosystem \(LME\) Program](#) could possibly assist with creating international connections by reaching out to country focal points. During the upcoming LME Steering Committee meeting, suggestions on reaching out to international managers for assistance can be made. The tight schedule for testing the SDG product could be problematic given that the LME is preparing for the upcoming [Ocean Conference](#) from June 5th to 9th in New York.

VI. Future of MBON

Meeting participants contributed to a group discussion, addressing the overarching issues of MBON sustainability beyond the demonstration projects and best practices to ensure MBON activities can continue effectively and efficiently.

Emerging Partnerships and New Ideas

Ensuring a sustainable MBON hinges on the expansion of partnerships and being able to identify the key users for future involvement. MBON has a close partnership with IOOS and the IOOS regional associations. Through this collaboration, MBON has been able to identify key users/ stakeholders.

MBON has been exploring symbiotic relationships with NOAA's Integrated Ecosystem Assessment Program, Coral Reef Conservation Program (CRCP), and Ocean Acidification Program (OAP). MBON has begun working with NOAA's OAP to understand the biological impacts of ocean acidification and investigate the best sampling practices for *in situ* species monitoring. Additionally, MBON has been working with NOAA's CRCP to observe shallow-water and deep-sea corals, from both data management and indicator development perspectives. MBON must focus on effectively articulating the value of its work to sustain these partnerships and the partnerships with NOAA Sanctuaries.

IOOC Task Team for Biological Observations

MBON Program Officers recently met with the IOOC (Interagency Ocean Observation Committee) co-chairs to propose the development of an IOOC Task Team to advise and organize the community around biological observing needs for IOOS. The IOOC provides guidance and support to the IOOS's 17-agency mission and is co-chaired by Eric Lindstrom (NASA), David Legler (NOAA), and Bob Houtman (NSF). The Task Team will focus on answering the question of what the biological ecosystem observing component of IOOS should look like. There are a lot of observing networks currently in place, so it would be beneficial to explore and establish a national network that can be sustained more efficiently.

If/when such a task team is established, MBON Program Officers would invite representatives from across the MBON community to participate. Areas of opportunity for participation might include steering teams and community workshops, where representatives can come together to discuss best practices for conducting measurements, technology applications, types of infrastructure, and associated costs. The goal is to create a collective effort across multiple federal ocean agencies.

Q: Is there support from the IOOC?

A: Eric Lindstrom (NASA) was very interested in the prospect of developing a robust discussion on biological observing capabilities. There may be a potential for MBON to coordinate a workshop at OceanObs'19 in Honolulu, Hawai'i (Sept. 16-20, 2019). Bob Houtman (NSF) supports coordinated research network activities that correspond with NSF priorities. As of this year, NSF become an MBON partner, providing funding support from its Polar Programs group to the AMBON project. David Legler (NOAA) was strongly supportive and excited about the potential collaborations with GOOS.

From the perspective of IOOS, successful projects are those that leverage cross-agency partnerships. IOOS is interested in exploring more partnership projects like the ATN and MBON demonstration projects. IOOS has seven mission areas that span across all partner agencies, which include focus areas from ecosystem forecasting and sustained biodiversity to saving lives and coastal properties. To alleviate funding restrictions, IOOS is focused on reaching out to other federal agencies with similar research interests to exchange data and modeling capabilities for external funding. It is important to rationalize the program moving forward; bringing in more funding partners and determining best management practices will help leverage more resources.

MBON needs to consider funding opportunities in the near-term and should build partnerships with other agencies or programs with overlapping project missions and research goals. If MBON wants to eventually take their efforts to the Hill, they need to first determine a cohesive case to advocate for.

Moving forward, participants focused their discussion on brainstorming possibilities for ways MBON can demonstrate their successes. It was suggested that the MBON demonstration

projects should collaborate on a paper, outlining the consistent needs in biodiversity across agencies. NOAA's Office of National Marine Sanctuaries (ONMS) Condition Reports can be used a framework for collaboration. The ONMS developed a national report that created a comprehensive review of all individual marine sanctuary sites. The national report highlighted 10 cross-sectional issues that applied to each site: climate change and ocean acidification, fishing impacts, human health, marine debris, invasive species, heritage resources, ocean noise, shipping/ vessel impacts, water quality, and wildlife health.

MBON should focus on developing a list of high-priority needs and goals. MBON Sanctuaries has begun this approach, but input from the other the demonstration sites, ATN, and other agencies would help define a robust list of priorities.

Q: *How should we focus future efforts of MBON?*

A: MBON should focus on prioritizing essential keystone parameters that can influence decision-making activities and management practices. By filling in the current data gaps in biodiversity observations, MBON can work with other programs and agencies to effectively address the concerns of stakeholders. The ONMS Condition Reports can be used as a template for an MBON metric, but applied on a wider scale.

It was also suggested that MBON conduct a high-level economic analysis to define the program's economic value. Moving forward, it will be important to quantify different biodiversity impacts and socioeconomic issues related to fisheries and their management. In addition to the condition reports, the ONMS has developed a framework for an economic approach. The ONMS has started to develop ecosystem service reports, which rate the status and trends of certain ecosystem services, such as commercial fishing or coastal tourism/ recreation.

The development of deliverables and stories will be an essential first step towards seeking funding support from private foundations. As a beta test for near-term deliverables, it was suggested that Steve Gittings and the ONMS collaborate with Frank Muller-Karger on the SDG 14 product development. These deliverables are set to be presented at the GEO-XIV Plenary meeting in October, which will provide a preliminary review by national and international agencies of the selected high-priority variables. This collaborative MBON effort will demonstrate to the IOOC how MBON can provide products for agencies and constituents. Once MBON has established high-priority deliverables across the IOOC and GEO, they can confidently introduce their efforts to the greater global marine community.

Q: *How can we present our variables/ deliverables to allow for agency feedback?*

A: From the SDG 14 perspective, there is the [Ocean Action Hub](#) associated with The Ocean Conference. The Ocean Action Hub hosts an Ocean Forum to engage stakeholders on the challenges and opportunities related to SDG 14 implementation. However, it is uncertain if the Ocean Forum will remain active after the Ocean Conference (June 5-9, 2017), as it is a preparatory process tool for the conference.

SBC MBON is working with BOEM to develop products to best meet agency information needs. Products will be disseminated via the Marine Cadastre spatial information clearinghouse, as well as MBON data repositories. SBC will consult with the West Coast Governor’s Alliance to meet State needs.

The ONMS is currently developing the condition report for the Channel Islands National Marine Sanctuary, which will have clear contributions from the MBON project. SBC MBON has been actively engaged in condition report development workshops. The condition report will be published in two volumes: (1) status and conditions and (2) ecosystem services: status and trends. The first volume is set to be released later in 2017, while the second volume will not be released until 2018.

The ONMS has not been using the Axiom tool for the Santa Barbara sites, but there are plans to incorporate it into the development of future status reports in Florida. The Axiom tool is a solid behind-the-scenes tool, but may require some tweaking to increase its user-friendly compatibilities. It was suggested that a day-long virtual collaboration for research coordinators be developed.

VII. Final Thoughts

The program managers thanked participants for a productive meeting. Moving forward, the program managers will meet with PIs regarding data management and will create an approach and schedule for doing so. Work on the SDG 14 project will continue, which will offer an early demonstration of MBON’s ability to develop products of use. This opportunity will demonstrate to agencies the power of what MBON can do both within the US and abroad.

Meeting adjourned.

Action Items:

Action	Point Person	Due Date
Gabrielle Canonico, Woody Turner, and Jim Price will meet to discuss possibilities for liberating resources if the projects articulate resource needs to advance data management.	Gabrielle Canonico Woody Turner Jim Price	Before next meeting
Gabrielle Canonico will initiate a small-group discussion regarding the MBON portal, and what functionality is most needed by the community.	Gabrielle Canonico	Before next meeting

Meeting Participants:

Name	Agency	E-mail
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