Atlantic Deepwater Ecosystem Observatory Network (ADEON): An Integrated System

Jennifer L. Miksis-Olds
School of Marine Science and Ocean Engineering
University of New Hampshire
24 Colovos Rd.
Durham, NH 03824-3515
Phone: (603) 862-5147   Fax: (603) 862-0839   Email: j.miksisolds@unh.edu

John Macri
University of New Hampshire
Space Science Center, Institute for the Study of Earth Oceans and Space
Durham, NH 03824-3525
Phone: (603) 862-2793   Email: john.macri@unh.edu

LONG-TERM GOALS

ADEON will generate long term measurements of the natural and human factors that describe the ecology and soundscape of the Outer Continental Shelf 9OCS). Ocean processes, marine life dynamics, and human ocean use are each inherently three-dimensional and time-dependent, and each occur at many spatial and temporal scales. No single measurement system (*in situ* or remote) is sufficient for describing any of the ocean state variables, and a "multi-platform, multi-variable" observational approach integrated with models is required (Seim et al., 2009). This program combines acoustic information with contextual data from space-based remote sensing, hydrographic sensors, and mobile platforms to fully comprehend how human, biologic, and natural abiotic components create the soundscape and influence ecosystem dynamics of the OCS. Measurements made within this research program will serve as a baseline for pattern and trend analyses of ambient sound and the ecosystem components contributing to the OCS soundscapes.

OBJECTIVES

1) Establish an ecosystem observation network that provides baseline monitoring and supports predictive modeling of the soundscape and its relationship to marine life and the environment of the Mid- and South Atlantic Planning Areas.
2) Develop standardized measurement and processing methods and visualization metrics for comparing ADEON observations with data from other monitoring networks.

3) Assess baseline soundscape and ecosystem conditions in support of predictive environmental modeling and trend analyses in the planning areas.
   - How do soundscape and ecosystem components vary with water depth across the OCS?
   - How do the soundscape and ecosystem components vary with latitude along the OCS?
   - Where are the hot spots of human activity for consideration in ecosystem/habitat health impacts?
4) Assess the spatial and temporal distribution of the soundscape and biological scatterers, including their expected variation and correlation with distance from the mooring locations.
   - What are the environmental factors that define and constrain the horizontal range of appropriate extrapolation of observations measured at the stationary mooring sites?
5) Develop and apply new methods for the effective visualization of five-dimensional (5D – time, latitude, longitude, frequency, and depth) soundscape data to interactive visual analysis tools that enable users to explore, analyze, and integrate ancillary ecosystem data streams with the 5D soundscape.
6) Develop a robust data management system that archives and provides public access to multiple data streams to encourage future development of ecological models targeted at questions beyond the scope of this study.

APPROACH AND WORK PLAN

1. ADEON goes beyond basic ocean measurements and derived data products related to ecosystem components. Unique and innovative attributes of the work scope include 1) a standardization task aimed at developing and implementing acoustic metrics and practices across ADEON components and recommending these approaches to other international monitoring programs, 2) network design to identify the appropriate range of extrapolation for point samples, 3) ecological and soundscape modeling to predict potential influence of long-term change on the marine ecosystems, and 4) web-based tools to access and visualize multi-dimensional data streams.

   To achieve the objectives, a four-phase research program has been developed: I) Network Design, Procurement, and Deployment, II) Data Acquisition and Network Maintenance, III) Data Processing, and IV) Data Integration and Visualization. These are complimented by overarching tasks that weave through all phases to manage data and standardize measurement, processing, and visualization metrics for the acoustic data sets. The outputs of the standardization effort will allow effective comparison of acoustic results between locations and research groups. Baseline assessment of the soundscape and contributing environmental components is critical to assessing long-term patterns and trends of individual ecosystem components and synergistic relationships, as well as providing the input parameters in support of the development of predictive models that integrate multiple data streams to determine future

soundscapes and impacts resulting from environmental changes related to human activity, climate change, or other identified factors.

2. Our team includes world leaders in collecting and managing acoustic, oceanographic, and remote sensing data. With respect to the static moorings, Phase I lead Bruce Martin (JASCO) has extensive experience designing and deploying complex moorings including vertical and horizontal line arrays that provide excellent acoustic data. Martin's experience is complemented by the technical expertise of the Lead PI, Dr. Jennifer Miksis-Olds (UNH), who has integrated backscatter measurements with static acoustic measurements for over a decade, and Phase III lead Dr. Kevin Heaney (OASIS, Inc.) who has successfully gathered horizontal line array data from gliders during numerous at-sea missions. Phase II lead, Dr. Joseph Warren (Stony Brook University), has years of field experience with biologic and physical oceanographic data acquisition and analysis from the Atlantic Ocean. Dr. Timothy Moore (UNH) is a leading remote sensing investigator who has worked well with our team members in the past and specializes in the processing of high resolution satellite image data for derivations of biological parameters. Finally the collection of data is of limited value if the data are not managed, standardized, and accessible. Our team is committed to developing a standardized approach to data acquisition, analysis, access and visualization so that the data processing and integration phases of the project, led by Dr. Anthony Lyons (UNH), advances our understanding of the contributions from different sources to the spectral, temporal, and spatial complexity of the soundscape. Dr. Elliott Hazen (NOAA) brings expertise in ecological modeling to the team and will work closely with Lyons to fully integrate the multiple data streams to better understand the overarching ecosystem dynamics. Data Management lead, Patrick Messer, Director of the UNH Research Computing Center, has devoted his career to large project data management, and Standardization lead Michael Ainslie (TNO) has been at the forefront of developing underwater acoustic standards for the international community.

3. The focus of effort in the upcoming year will be: 1) network design review, 2) equipment procurement and assembly, 3) deployment of moorings during the first scheduled ADEON cruise, and 4) development of the data management infrastructure. The team will hold its annual PI meeting at UNH February 8-10, 2017 to review the materials accumulated to date, identify gaps, select mooring locations, select transects for vessel based measurements, refine mooring designs, finalize the remote sensing data collection plan, and prepare updated vessel requests to BSEE. Following the ADEON team meeting, equipment will be ordered and assembled in support of the upcoming deployment cruise. The first ADEON deployment cruise is scheduled for 3 weeks starting at the end of September 2017. In parallel to the cruise preparations, the data management and standardization teams will be developing the protocols and infrastructure to receive and process data following the completion of the first cruise.

WORK COMPLETED

Initial efforts within the first 3 months of the ADEON program focused on assembling background information from a wide variety of sources to best inform the mooring site selection process. Communication was established with other ongoing or planned regional programs (AMAPPS-Atlantic Marine Assessment Program for Protected Species, SECOORA – SouthEast Coastal Ocean Observing Regional Association, USGS South Atlantic Bight initiative, etc.). Fisheries activity in the ADEON project area was assessed, and initial modeling of AIS traffic data for consideration of mooring placement and soundscape modelling was completed. A draft Cruise Plan for the September 2017 cruise was completed, and the data management team has begun to acquire sample data from ADEON team members upon which to develop the data management infrastructure and data access. Lastly, and initial standardization kick-off meeting was held, and it was agreed to use standard ISO or IEC frequency bands (one tenth of a decade) and to follow the international terminology standard ISO 18405 for processing of ADEON passive acoustic data

RESULTS

One of the objectives of ADEON is examining `soundscape portability', that is, the similarity between soundscapes as a function of range and noise covariates such as distance to shipping lanes, current profiles, water depth, and habitat suitability for different species groups. We have setup a framework that analyzes recorder locations and generates a log-spaced histogram of recorder spacings. This allows us to determine if the recorders will help us answer the soundscape portability question. Examples of the recorder distributions for the original recorder locations and slightly adjusted locations are shown in Figure 1.
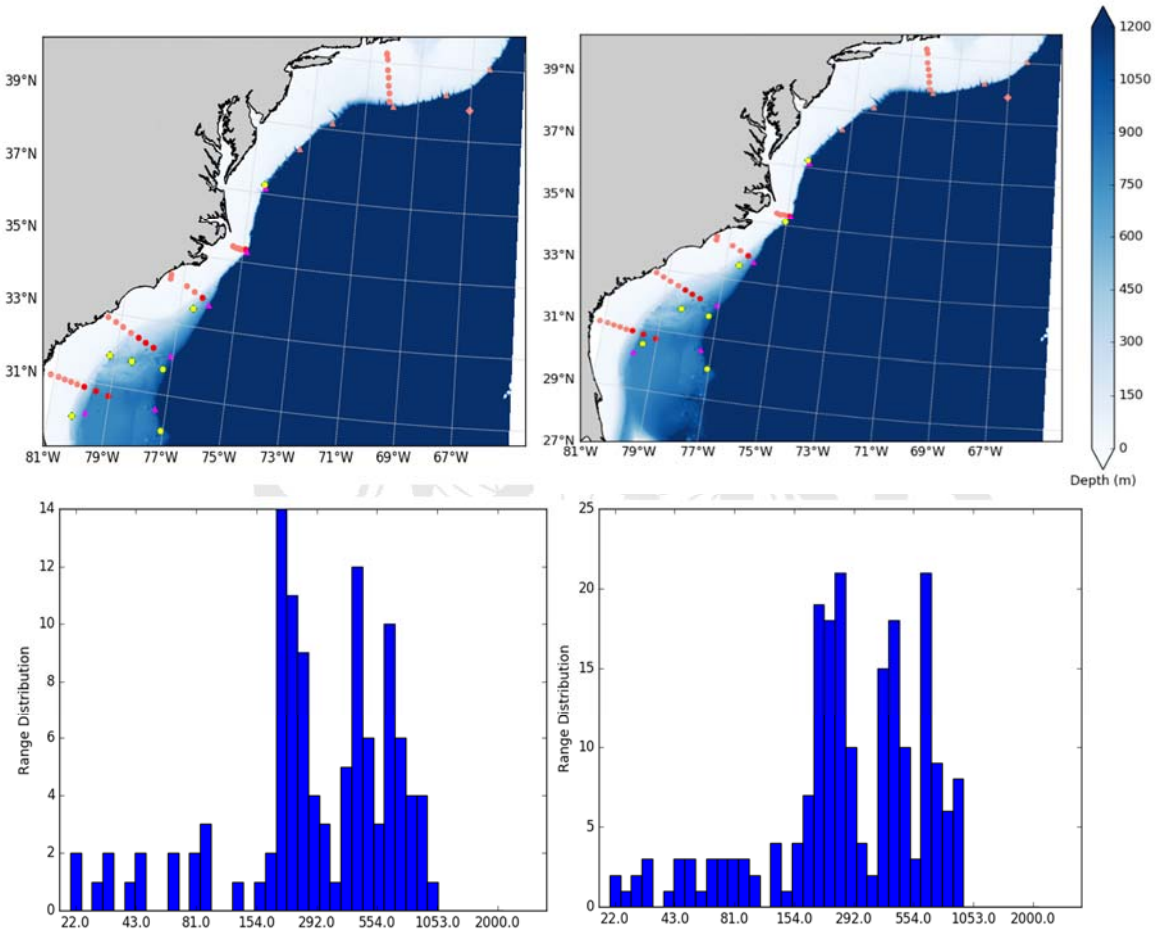
Figure 1. (left) Originally proposed ADEON recorder locations and range distributions, and (right) updated locations and range distributions as of 12 Dec 2016. Top: recorder locations, bottom: range distributions including ranges to the AMAPPS MARU and HARPS recorders. The updated locations provided a better sampling of soundscapes at ranges up to 100 km than the original locations. In the figures salmon coloured recorders are from AMAPPS but are outside of ADEON's project area and are not included in the range distributions. Magenta triangles are HARP recorders, red circles are the AMAPPS MARU recorders, and yellow circles are the proposed ADEON locations.

IMPACT AND APPLICATIONS

1. **National Security**
   Active and passive sonar systems operate against environmental noise. An increased understanding of ambient ocean sound will aid in the development of Naval acoustic systems.

2. **Economic Development**
   The Outer Continental Shelf is an environment being considered for offshore energy development. ADEON will establish an ecosystem monitoring program to provide a baseline against which future impacts can be assessed.

3. **Quality of Life**
   Acoustic technology provides information from which indices of biodiversity and ecosystem health can be assessed. In addition to proving an environmental baseline, ADEON will integrate multiple data streams to track and predict future ecosystem changes.

4. **Science Education and Communication**
   ADEON will develop innovative data exploration and visualization tools to view and manipulate multi-layered environmental data streams to better understand the relationship between ecosystem components. Both raw and processed data products will be accessible to the public through a data management system online.

TRANSMISSIONS
Not applicable at this early stage in the program.

RELATED PROJECTS
There are multiple ongoing and developing projects in the targeted ADEON project area of the OCS. AMAPPS-Atlantic Marine Assessment Program for Protected Species (http://www.nefsc.noaa.gov/psb/AMAPPS/) is developing models and associated tools to provide seasonal, spatially-explicit density estimates incorporating habitat characteristics of marine mammals, turtles and seabirds in the western North Atlantic Ocean. ADEON is communicating with AMAPPS researchers to coordinate the most optimal ADEON mooring locations. SECOORA – SouthEast Coastal Ocean Observing Regional Association (http://secoora.org/), is devoted to integrating coastal and ocean observing data in the Southeast United States to inform decision makers and the general public. The ADEON data management team is communicating with the SECOORA regional data center to develop an ADEON data structure that will be compatible with the archiving system of SECOORA for potential long term data storage and access beyond the life of ADEON. The USGS and BOEM are in the processes of developing a collaborative, comprehensive program with the SE Atlantic Coast Bight. ADEON has again initiated conversations to coordinate mooring locations to be of the largest benefit to both programs.

REFERENCES
Seim, H.E., Fletcher, M., Mooers, C.N.K., Nelson, J.R., Weisberg, R.H. (2009). Towards a regional coastal ocean observing system: An initial design for the Southeast Coastal Ocean Observing Regional Association. Journal of Marine Systems 77, 261-277.

PRESENTATIONS

Ainslie, M. (2016). Introduction of Atlantic Deepwater Ecosystem Observatory Network (ADEON) project, Meeting of the EU Technical Group on Underwater Noise (EU TG-NOISE), 19-20 October 2016, Ministry for the Sea, Lisbon, Portugal.

Miksis-Olds, JL (2016). ADEON: Atlantic Deepwater Ecosystem Observatory Network – an integrated system. Center for Coastal and Ocean Engineering/ NOAA-UNH Joint Hydrographic Center Seminar Series. 30 September, 2016. Durham, NH.