NERACOOS

ATN • MBON • OTN

MAY 6–7, 2019
UNIVERSITY OF NEW HAMPSHIRE
DURHAM, NEW HAMPSHIRE

U.S. NORTHEAST ATLANTIC BIOLOGICAL OBSERVATIONS WORKSHOP SUMMARY REPORT

Identifying Regional Needs and Priorities for Animal Telemetry and Biodiversity Observations of Aquatic Species

IN MEMORIAM

RU MORRISON

This workshop report is dedicated to Dr. Ru Morrison, the first NERACOOS Director. We had no way of knowing that this event would be one of the last times many of us would get to spend time with Ru, our friend and colleague. Several months after the workshop, Ru was diagnosed with an aggressive form of brain cancer. He underwent treatments and fought bravely against the disease, but sadly we lost him in November 2020. A visionary and highly respected oceanographer, Ru had a passion for ocean science that was well known. He was the founder of NERACOOS and put his full-self into constructing it to be the ocean observing flagship of the Northeast Region.

Ru was first and foremost a proud family man and chief of Clan Morrison, a Scottish clan based in the Isle of North Uist, which he visited frequently. We all have fond memories of the sparkle in his eyes as he shared with us pictures of his latest visit to his home in the Outer Hebrides. His contributions were far-reaching, and his fervor for collaboration and partnerships was limitless. He was tireless and always there to lend a hand. Rest well, good friend; you have earned it.

Report Contents

Cover Photo: Humpback whale and whale watching vessel at Stellwagen Bank National Marine Sanctuary

Photo Credit: Jeremy Winn

WORKSHOP PARTICIPANTS

A complete list of workshop participants can be found on pages 36 and 37.

NERACOOS WORKSHOP PLANNING COMMITTEE

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WORKSHOP SPONSORS

NERACOOS
NORTHEASTERN REGIONAL ASSOCIATION OF COASTAL OCEAN OBSERVING SYSTEMS

IOOS
Integrated Ocean Observing System

ATN
ANIMAL TELEMETRY NETWORK

NROC
Northeast Regional Ocean Council

Thanks to our planning committee and all who helped to make this workshop a success. Special thanks to Helen Worthington for her valuable assistance in preparing this report.

WORKSHOP OUTLINE

This is one in a series of U.S. regional workshops convened to identify priority stakeholder needs for regional telemetry and other types of observations of aquatic species that could be served by the Animal Telemetry/Marine Biodiversity Observation Network/ Ocean Tracking Network (ATN/MBON/OTN) baseline network. An additional priority was to examine whether the type and extent of existing telemetry and biodiversity observing assets could adequately satisfy these requirements. **The observing assets identified herein reflect those referenced and/or managed by workshop attendees. There are numerous additional assets in the region operated by others who were not able to attend this workshop, which are not captured in this report.** NERACOOS, the Northeastern Regional Association of Coastal Ocean Observing Systems, partnered with the U.S. ATN, the U.S. MBON, and the Canadian OTN to convene this regional stakeholder workshop in Durham, New Hampshire on May 6–7, 2019. Approximately 60 participants from multiple federal and state agencies, organizations, and universities worked together over the two days to address these four objectives:

Objective I. Identify and prioritize stakeholder marine animal telemetry and biodiversity monitoring and observational needs in the Northeast Atlantic region.

Objective II. Identify the existing telemetry and biodiversity observing assets and scientific capabilities in the region.

Objective III. Document regional stakeholder-specific uses of marine animal telemetry and biodiversity data.

Objective IV. Identify infrastructure and data management challenges and opportunities that exist in the region.

Twenty-five speakers covered topics that provided perspectives from the natural resource/conservation management, commercial/ private, and research communities.

BREAKOUT SESSIONS

Two breakout sessions were organized, and participants were asked to consider the following questions:

Session 1. Identify stakeholders in the NERACOOS region and their observation data and information needs.

1. Summarize the stakeholders in the region that were identified this morning.
2. List the types of telemetry and biodiversity observation data and information that can best address the needs of these stakeholders.
3. Identify any existing observing assets/capabilities in the region that can satisfy these needs.

Session 2. Identify challenges and concerns with implementing an animal telemetry and biodiversity observation sustained network in the NERACOOS region.

1. What are the benefits of having a regional baseline observation network approach versus individual research efforts?
2. How could a sustained baseline observation network of marine animal movement and behavior, species diversity, distribution, and abundance be integrated within the Northeast Integrated Sentinel Monitoring Network (ISMN) framework? What are the challenges to building that network and what actions can be taken to address those challenges?

A summary of the breakout session discussions is provided on pages 23–25.

The key findings and recommendations published in this and other ATN-MBON-OTN Regional Workshop Reports have been synthesized at both the national and regional levels and can be found in the *ATN Regional Workshops Summary* document at https://ioos.noaa.gov/project/atn/ under the documents tab.

https://ioos.noaa.gov/project/atn/
https://ioos.noaa.gov/project/bio-data/

AGENDA

DAY 1

08:00–08:30 **Check-in, light breakfast**

08:30–08:45 **Welcome, introductions, review objectives and agenda**

08:45–09:15 **Overview of ATN, MBON and OTN Programs**
Bill Woodward, U.S. IOOS, Animal Telemetry Network
Gabrielle Canonico, U.S. IOOS Marine Biodiversity Observation Network
Fred Whoriskey, Ocean Tracking Network

09:15–09:30 **Integrated Sentinel Monitoring Network for Change in Northeast U.S. Ocean and Coastal Ecosystems**
Jeff Runge, University of Maine/GMRI and ISMN Director

09:30–10:30 **Session 1, Natural Resource/Conservation Management Sector**
Sean Lucey, Northeast Integrated Ecosystem Assessment
Grace Moses, Army Corps of Engineers
Sigrid Keuhnemund, WWF Canada

Session 1 Panel Discussion (15 minutes)

10:30–10:45 **Break**

10:45–11:45 **Session 1, Natural Resource/Conservation Management Sector (continued)**
Jason Goldstein,Wells National Estuarine Research Reserve
Kalle Matso, Piscataqua Regional Estuaries Partnership
Ben Cowie Haskell, Stellwagen Bank National Marine Sanctuary

Session 1 Panel Discussion (15 minutes)

11:45–13:00 **Session 2, Commercial/Private Sector**
Véronique Nolet, Green Marine
Zack Klyver, Bar Harbor Whale Watch
Laura Morse, Ørsted
Cynthia Wigren, Atlantic White Shark Conservancy

Session 2 Panel Discussion (15 minutes)

13:00–14:00 **Lunch**

14:00–15:15 **Session 3, Biological Data Management**
ATN Data Assembly Center (DAC): Rob Bochenek, Axiom Data Science
MBON Data Portal: Rob Bochenek, Axiom Data Science
NERACOOS/ISMN Data and Product Management: Riley Young-Morse, GMRI
Northeast Ocean Data Portal: Emily Shumchenia, NROC

Session 3 Panel Discussion (15 minutes)

15:15–15:30 Break

15:30–16:45 **Breakout Session**
Identify stakeholders in the NERACOOS region and their observation data and information needs.
1. Summarize the stakeholders in the region that were identified this morning.
2. List the types of telemetry and biodiversity observation data and information that canbest address the needs of these stakeholders.
3. Identify any existing observing assets/capabilities in the region that can satisfy these needs.

16:45–17:00 **Report from Breakouts and Wrap-up**

17:00 **Hosted Evening Reception - Three Chimney's Inn**

DAY 2

08:00–08:30 **Check-in, light breakfast**

08:30–08:45 **Recap/Describe Today's Agenda**

08:45–10:15 **Session 4, Research Sector**
Nathan Furey, University of New Hampshire
James Sulikowski, University of New England
Graham Sherwood, Gulf of Maine Research Institute
Greg Skomal, Massachusetts Division of Marine Fisheries
Heidi Sosik, Woods Hole Oceanographic Institution

Session 4 Panel Discussion (15 minutes)

10:15–10:30 **Break**

10:30–11:45 **Session 4, Research Sector (continued)**
Sean Hayes, Northeast Fisheries Science Center
Samir Patel, Coonamessett Farm Foundation
Bill Hoffman, Massachusetts Division of Marine Fisheries
Alison Watts, University of New Hampshire

Session 4 Panel Discussion (15 minutes)

11:45–12:45 **Lunch**

12:45–14:00 **Breakout Session**
Identify challenges and concerns with implementing an animal telemetry and biodiversity observation sustained network in the NERACOOS region.

1.What are the benefits of having a regional baseline observation network approach versus individual research efforts?

2. How could a sustained baseline marine animal movement and behavior, species diversity, distribution, and abundance observation network be integrated within the NE ISMN framework? What are the challenges to building that network, and what actions can be taken to address those challenges?

14:00–14:15 **Report from Breakouts**

14:15–14:45 **Plenary Discussion**
How does/can our vision for a NE Atlantic Biological Observing Network fit into the ISMN framework and if so, how can we make it happen?

14:45–15:00 **Next Steps and Final Thoughts**

15:00 **Workshop Closes**

OPENING REMARKS

The ATN: Providing Unity, Stability, and Continuity to the U.S. Animal Telemetry Network

Bill Woodward, Network Coordinator, U.S. Animal Telemetry Network, U.S. IOOS Program Office, NOAA/NOS, Silver Spring Maryland

A considerable amount of marine animal telemetry infrastructure and expertise exists in the U.S., but it is currently limited in its coordination and connectivity. The U.S. Animal Telemetry Network (ATN) vision is to create an alliance of collaborating partners, which enables science by assembling these national capabilities into a cohesive network, completing the network incrementally where needed, and providing a stable, unifying, long-term underlying infrastructure—including a data aggregation and management capability for it.

The multi-agency ATN was established in 2016 and is implemented on three foundational pillars: 1) building alliances and collaborations; 2) providing telemetry data aggregation, management, display, and delivery; and 3) funding high-priority, regional baseline animal telemetry observations. Governance is provided by a steering group of representatives from nine federal agencies and four nonfederal institutions.

At the heart of the ATN data management vision is a centralized data assembly center (DAC), which is a community resource where regional telemetry data are aggregated in a single place, and one-stop-shopping is provided for access to all U.S. national animal telemetry data. The DAC serves national stakeholder needs effectively and enables cost/time savings for principal investigators. Examples of current ATN community support include two regional acoustic node data managers, a National Marine Fisheries Service-funded DAC data coordinator, a Georgia Department of Natural Resources acoustic receiver array, and financial support of the Argos data collection fees for ATN satellite tag researchers. https://www.argos-system.org/

The U.S. Marine Biodiversity Observation Network

Gabrielle Canonico, Manager, U.S. Marine Biodiversity Observation Network, U.S. IOOS Program Office, NOAA/NOS, Silver Spring Maryland

The Marine Biodiversity Observation Network (MBON) was borne out of the *Census of Marine Life* and the recognition that, while huge investments are made in ocean observing systems and biodiversity monitoring, there is no systematic and integrated global effort to observe life in the sea that can tell us about status, trends, and shifts over time, and further—how that impacts people. In the U.S., MBON is emerging as a long-term, multi-sector, multi-disciplinary network to observe marine life and ecosystem interactions.

The network started in 2014 with three demonstration projects, expanding in 2019 to six projects covering the Arctic, California Current, Pacific Northwest, Gulf of Maine, and South Florida. MBON priorities include making data available from existing biodiversity monitoring efforts and filling gaps where they exist, integrating remote sensing with in-situ observations, and advancing new technologies and approaches (remote-sensing based Seascapes and other approaches, acoustics, environmental DNA, still and video imagery, and machine learning)—all in the service of users and stakeholders such as National Marine Sanctuaries, Integrated Ecosystem Assessment, state management agencies, federal managers, and others.

Like ATN, MBON seeks to build communities through alliances and collaborations in the U.S. and globally, support baseline observations, and advance data management and delivery.

Bar Harbor Whale Watching Vessel. Photo Credit: Bar Harbor Whale Watching Company

The Ocean Tracking Network: Global Infrastructure and Research Network for Aquatic Animal Research

Fred Whoriskey, Executive Director, Ocean Tracking Network, Dalhousie University, Halifax, Nova Scotia, Canada

The Ocean Tracking Network (OTN) is a collaborative, globally-linked infrastructure platform and research network originally formed as an International Joint Venture from the *Census of Marine Life*. OTN uses electronic telemetry to research animal movements and survival and their link to environmental conditions to achieve its overall goal of advancing conservation and management of aquatic biological resources. Headquartered in Canada, the OTN includes more than 400 investigators from 20 countries detecting over 140 individual marine animal species.

The OTN infrastructure includes global acoustic telemetry networks and world class glider and data teams. They are an Associate Data Unit of the International Oceanographic Commission's (IOC's) International Oceanographic Data and Information Exchange (IODE), and a Tier 2 Ocean Biodiversity Information System (OBIS) node. Their research projects are focused on:

- Managing fisheries (assigning spatially-linked quotas and monitoring endangered and highly valued species)
- Assessing Marine Protected Areas
- Understanding changing animal distributions due to climate change
- Performing environmental impact assessments
- Conducting ecosystem and fundamental science research

OTN recently renewed funding support for infrastructure for 5 years beginning in 2018 with no obligatory sunset provision. They are adding additional gliders and receivers, seeking new research funding to pair with their infrastructure (e.g., Strategic Project Grants; SeaMonitor; Industry/OFI, working to enable new Canada International funding), and implementing a new data node for MigraMar (Central, North, and South America).

Great White Shark.
Photo credit: Greg Skomal,Massachusetts Division of Marine Fisheries

KEYNOTE TALK

Integrated Sentinel Monitoring Network for Change in Northeast U.S. Ocean and Coastal Ecosystems

Jeff Runge, Professor of Oceanography, University of Maine; Research Scientist, Gulf of Maine Research Institute; Director, Integrated Sentinel Monitoring Network

The Integrated Sentinel Monitoring Network (ISMN) has been established to provide a deeper, more integrated look at ocean biodiversity and ecosystem health in the Northeast region of the U.S., covering ecologically and economically rich ecosystems that span from Long Island Sound to the Canadian border in the eastern Gulf of Maine. The development of this partnership was lead by NERACOOS and the Northeast Regional Ocean Council (NROC)and collaboratively developed with other partners. This network seeks to extend observations into the Gulf of Maine that are focused on filling the gaps in current understanding of pelagic habitat biodiversity and ecosystem health.

Climate change, living resource harvesting, and increasing human populations are altering the structure and function of these ecosystems. Because these ecosystem changes are threatening the sustainability of marine and human communities, marine resource managers must make difficult decisions about how to cope with these new conditions that have high degrees of uncertainty.

The vision is for ISMN to be a regional coordinating network serving the distribution of ecosystem datasets and derived products for the northeast region. ISMN is part of the global Marine Biodiversity Observation Network (MBON) and will extend the reach of the program to watch for key ecosystem changes to inform stakeholders and the broader community for ecosystem-based decision making in one of the regions of U.S. waters most susceptible to climate change. It will also support an integrated, ecosystem-based management framework for adaptive responses to ecosystem changes.

ISMN aims to collect observational data where there are gaps in key ecosystem variables, serve as an access portal for other regional observational datasets, and facilitate integrated interpretation of ecosystem changes. A key observational goal is sentinel monitoring. Sentinels are key ecosystem variables that provide mechanistic understanding of ecosystem functions and responses to environmental change when known. A primary goal is also to build the ISMN into a regional coordinating center for ecosystem data that have been quality controlled and can be accessed using international standards. Leveraging the NERACOOS data management system, the Gulf of Maine Research Institute (GMRI) Ocean Data Products team will develop a data portal for integration and access to projected data.

Harbor seals in Chatham, Massachusetts. Photo credit: Greater Atlantic Regional Fisheries Office

SPEAKERS

NATURAL RESOURCE/CONSERVATION MANAGEMENT, COMMERCIAL/PRIVATE, BIOLOGICAL DATA MANAGEMENT AND RESEARCH

Topics covering natural resource/conservation management, commercial/private, biological data management, and research perspectives were presented by invited speakers in four sessions with 15 minutes of group discussion following each set of speakers.

NATURAL RESOURCE/CONSERVATION MANAGEMENT PERSPECTIVES

NOAA Integrated Ecosystem Assessment (IEA) Program

Sean Lucey, Fisheries Biologist, Ecosystems Dynamics and Assessments Branch/Northeast Fisheries Science Center/National Marine Fisheries Service

NOAA's Integrated Ecosystem Assessment (IEA) is an approach that engages scientists, stakeholders, and managers to integrate all components of an ecosystem, including human needs and activities, into the decision-making process so that managers can balance trade-offs and determine what is more likely to achieve their desired outcomes. Administered by the National Marine Fisheries Service Science and Technology Office, this approach provides the science necessary to carry out ecosystem-based management and is a key part of NOAA's ecosystem science enterprise. IEA provides a consistent national approach while still being scalable, collaborative, and adaptable to the five IEA regional needs (Northeast Shelf, Gulf of Mexico, California Current, Pacific Islands, and Alaska Complex) and their partners (Fisheries Management Councils, National Marine Sanctuaries and State/Tribal Management Councils). Common regional IEA products include: conceptual diagrams, ecosystem status reports and risk assessments. For example, IEAs are being used to provide advice to managers who are facing the rapid and unprecedented changes being observed in the NE Region ecosystem. For example, the Northeast U.S. shelf is one of the fastest warming water bodies globally, and the Gulf Stream north wall positions are the most northerly ever recorded.

Marine animal telemetry and biodiversity observations support the IEA process with vital information by providing better localized information to identify how species distributions are shifting and quantitative measures of how community structures are changing and are being impacted by anthropogenic disturbances. Long-time series of the data are essential because they "allow us to perceive changes, and there is no way to collect the data after the fact." As the living marine resource managers strive to balance environmental stewardship and human activities, the breadth of information the observations provide enables them to deliver the valuable "So What" message to funders.

Data Utilization for Siting an Ocean Dredged Material Disposal Site for Northern Massachusetts, New Hampshire, and Southern Maine

Grace Moses, Biologist, U.S. Army Corps of Engineers, New England District

A primary responsibility of the U.S. Army Corps of Engineers (USACE) is to conduct investigations to assess the spatio-temporal extent of potential environmental impacts caused by their activities. Among the factors that are considered for an ocean dredged material disposal site designation are oceanic conditions, water quality/ecology and nearby natural resources. An example was given of assessment work performed for a location off the Isles of Shoals-North as a potential deposit site for the Portsmouth Harbor Navigation Improvement Project. The work included imaging surveys/analysis of the sediment type and composition, bathymetric surveys, a geospatial assessment of the benthic community successional stages with bottom trawling, measuring commercial multi-year herring fishing activity, lobster assessments from lobster pot trawl transects, marine transportation vessel density traffic, and nearby shipwrecks/obstructions.

ATN and MBON data would aid USACE in both their project impact assessments and in implementing best management practices (e.g., time of year restrictions, observers, haul routes) by providing consistently updated data showing project site usage year-round for marine animals, mammals, turtles, and endangered species. Additionally, real-time data of animal locations and behaviors during project activities could help avoid impacts to the resource and aid in the planning of future work. USACE would require the data to be accessible, reliable, and queryable.

World Wildlife Fund (WWF) - Canada

Sigrid Keuhnemund, Vice President Wildlife and Industry, World Wildlife Fund - Canada

World Wildlife Fund (WWF) Canada is the country's largest science-based international conservation organization. As part of the global WWF-International, which began in 1961, they are guided by the best scientific analysis and Indigenous knowledge and work to conserve species at risk, protect threatened habitats, and address climate change. Their long-term vision is simple: to create a world where nature and people thrive. Their "Living Planet Report" (2016) (https://www.worldwildlife.org/pages/living-planet-report-2016) took a national look at the state of wildlife loss and reported that 50% of wildlife species in Canada are in decline with an 83% average decline in them plus a 38% decline in Atlantic Canada marine fish. It also predicted that Arctic ice-free summers are only 30 years away. WWF believes there is a critical need to know where the fishery habitats are and to manage the impacts on them; ATN and MBON data can help them understand where the animals travel and when. Additionally, ensuring a commitment to successful long-term biological observations requires global-wide collaboration.

A Climate of Change and Challenges for Sustaining Healthy Coastal Ecosystems

Jason Goldstein, Research Director, Wells National Estuarine Research Reserve (Wells NERR)

The Wells NERR, located in Wells, Maine, is one of a network of 29 estuarine areas/reserves established across the nation for long-term innovative research, education, and coastal/estuarine stewardship. The reserves operate through partnerships between the coastal states and territories and the NOAA/NOS Office for Coastal Management, which administers the reserve system. One of four reserves in the New England states, the Wells NERR Research Program is focused on studying and monitoring changes in Gulf of Maine estuaries, coastal habitats, and adjacent coastal watersheds, as well as producing science-based information needed to protect, sustain, or restore them. All of the reserves are aimed toward long-term bio-monitoring programs and hence are at the forefront of research about the effects of climate change. Wells NERR uses this theme of climate change as a major argument for the value of their work to their funders.

The significant amount of resource/conservation management and research activities underway at the Wells NERR includes the Sentinel Site Program to monitor long-term changes in tidal marshes and the System Wide Monitoring Program (SWMP). The SWMP is an issue-driven, long-term monitoring program that embraces biological monitoring to assess changes in habitats and biodiversity (fish/plants) with relevance to management issues and can improve understanding and inform decisions affecting estuaries and coastal watersheds.

Specific monitoring efforts include community composition and species abundance/distribution, ocean-coastal acidification, ichthyoplankton, marine invasive species, soundscape ecology, larval fish, and eDNA for rare aquatic species. The Wells NERR recognizes acoustic animal telemetry as a primary tool for investigating "sentinel" crustaceans—lobster, Jonah crab, green crab, etc. Overall, the NERR System provides an excellent model for long-term sustained biological monitoring through collaboration/integration/extension of observation methods, especially with stakeholders.

Environmental Protection Agency (EPA) National Estuary Program (NEP)

Matt Liebman, Environmental Scientist, Ocean and Coastal Protection Unit, EPA Region 1

The NEP is an EPA place-based program to protect and restore the water quality and ecological integrity of estuaries of national significance. Currently, 28 estuaries located along the Atlantic, Gulf, and Pacific coasts and in Puerto Rico are designated as estuaries of national significance. Six of these are located in New England including the Casco Bay Estuary Partnership and the Piscataqua Regional Estuaries Partnership. Each NEP focuses within a study area that includes the estuary and surrounding watershed. The NEPs are located in a variety of institutional settings, including state and local agencies, universities, and individual nonprofits. In overseeing and managing the national program, EPA provides annual funding, national guidance, and technical assistance to the local NEPs.

Each NEP functions as a collaborative, consensus-based, convener of people. They each develop 5–10 year Comprehensive Conservation and Management Plans (CCMPs), which contain actions to address water quality and living resource challenges and priorities. Located at the University of Southern Maine, the Casco Bay Estuary Partnership (CBEP) is engaged in ongoing efforts to collect water quality monitoring information for Casco Bay. In 2016, CBEP created a Casco Bay Monitoring Network to identify shared monitoring priorities among the growing number of entities that are monitoring the waters within Casco Bay and its watershed. The network acts as the steward of monitoring in the bay and ensures that monitoring is adaptive to changing circumstances. The Piscataqua Regional Estuaries Partnership (PREP) is hosted and administered by

the University of New Hampshire and works with 200 different partners in 52 municipalities to carry out 82 action plans to improve water quality and environmental conditions throughout the Piscataqua Region Watershed. The Partnership work includes summarizing data from monitoring programs in the region using 23 different environmental and social indicators (e.g., water quality, shellfish resources, land use, critical species, habitats), which are measureable markers that help interpret the condition of the environment and how it changes over time. The EPA NEP is a non-regulatory program established by Congress and was authorized by section 320 of the Clean Water Act in 1987.

Greg Skomal Tagging Sharks from Bow Pulpit
Photo credit: C. Sanders

Stellwagen Bank National Marine Sanctuary (SBNMS): A Natural Resource, A Natural Opportunity

Ben Haskell, Deputy Superintendent, Stellwagen Bank National Marine Sanctuary, NOAA

The SBNMS was formally designated in 1992 and covers 638 square nautical miles of the Atlantic east of Boston, Massachusetts between Cape Ann and Cape Cod; it is New England's only National Marine Sanctuary. Historically important as a fishing ground, the sanctuary has also become a premier whale watching destination while continuing to support commercial and recreational fishing. The many shipwrecks lying on the bottom within the sanctuary serve as time capsules of our nation's maritime history. The U.S. Marine Sanctuary network includes a total of 14 national marine sanctuaries and Papahānaumokuākea and Rose Atoll marine national monuments. The National Marine Sanctuaries Act of 1972 calls for coordinated conservation, maintaining the natural biological communities, and supporting research; it guides the SBNMS mission to conserve, protect, and enhance the biodiversity, ecological integrity, and cultural legacy of the sanctuary while allowing for compatible use. The research activities in the SBNMS encompass several decades of "tagging and listening" including 20 years of animal telemetry (Argos satellite seabird tracking, whale tagging with DTAG and CAT tags, acoustic fish tags), large arrays of passive acoustic sensors, real-time right whale acoustic detection buoys, and studies of large whale entanglement and ship strikes.

Meeting the marine resource protection and management objectives in the SBNMS requires an understanding of the relative inputs of sound sources within the sanctuary and the possible effects of these sounds on marine animal behavior. The extensive passive acoustic monitoring and research efforts in the SBNMS have been implemented through multiple partnerships and are focused on educating stakeholders on the importance of listening underwater, both for marine wildlife and for humans, and on highlighting the role that marine protected areas play and can continue to play in managing ocean noise. While recording sounds is relatively easy, making sense of them is more difficult. The sound recordings are specifically used to characterize the holistic soundscape and further the understanding of sound-producing species' behavior, patterns in sound production, and human-made sound inputs. By comparing other data sources, it is possible to assess how the components of soundscapes relate to specific behaviors of fish, marine mammals, and humans. The SBNMS strongly supports the concept of a long-term sustained network to collect 'priceless biological observations' but recognizes the challenge of securing the resources to fund it.

COMMERCIAL/PRIVATE PERSPECTIVES

Mitigating the Risk of Ship Strikes through a Collaborative Approach

Véronique Nolet, Project Manager-Marine Habitat, Green Marine-Canada

Green Marine is an environmental certification program for the North American marine industry aimed at reducing the environmental footprint of marine operations by exceeding regulatory compliance and promoting a culture of continual improvement. It is a voluntary, transparent, and inclusive initiative with more than 130 participants in the U.S. and Canada and addresses key environmental issues through its 12 performance indicators. Participants are ship owners, ports, terminals, seaway corporations, and shipyards. As an expansion of their underwater noise performance indicator, Green Marine actively addresses the ship strikes of whales. The negative impact on the marine sector from the Canadian government reaction to the 2017 whale strike crisis that imposed a static speed limit of 10 knots motivated the shipping industry to seek a more comprehensive solution in partnership with the government and North Atlantic right whale (NARW) scientists. The shipping industry "wanted to be part of the solution," which included a shared concern for the survival and recovery of the NARW and for an approach that could deliver on both whale protection and the need for effective and safe marine transportation within vital commercial corridors.

Inspired by the U.S. model, the Canadian solution includes focusing static speed limits on "known high aggregation areas" and managing shipping corridors (outside the aggregation areas) through dynamic management—allowing vessels to navigate at normal operational speed when NARW are not observed. While dynamic management is working, the effectiveness of mitigation measures can be improved by employing a combination of whale detection technologies. In particular, enhancing detection capacity by deploying acoustic monitoring in the "dynamic shipping lanes" is a much-needed step. Having access to the data from such a long-term sustained biological observation network in the Northeast region would be beneficial for everyone, as long as it has a publicly shared database.

Whale Watching

Zack Klyver, Bar Harbor Whale Watch Company (BHWW)

During their more than 30 years of operation, BHWW has taken over 1 million people from around the world to see whales in the Gulf of Maine. BHWW was the first whale watching company in Maine to be certified under the whale SENSE program. This is a voluntary education and certification program offered to commercial whale watching companies in the U.S. Atlantic and Alaska regions, which is sponsored by NOAA Fisheries, Stellwagen Bank National Marine Sanctuary, and Whale and Dolphin Conservation and recognizes whale watching companies that are committed to responsible practices. The economic value and observational capacity of the whale watching industry is enormous. For example, in 2008 it was worth $126,000,000 in direct and indirect value and carried 910,000 observers.

BHWW has a longstanding research partnership with Allied Whale, the marine mammal laboratory at College of the Atlantic, which has been using photographic identification techniques to study humpback and finback whales for over 40 years. They published the first North Atlantic Humpback Whale Catalogue in 1977, which contained 120 individual humpback whales. Currently, it contains over 9,000 animals from all the known feeding and breeding/calving grounds in the North Atlantic. Allied Whale also maintains the Antarctic Humpback Whale Catalogue, an internationally collaborative project with over 6,400 photographs of humpback whales between the Southern Ocean and lower latitude waters. Similarly, the Provincetown Center for Coastal Studies has studied individual humpback whales since the 1970s and curates the Gulf of Maine Humpback Whale Catalog. An estimated 25% of photographs in this catalogue have been contributed by whale watch collaborators. Updated maps of commercial whale watching activity are now available to view in the recreation theme map and in the Data Explorer of the Northeast Ocean Data Portal.

All observations (whales, puffins, pelagic seabirds, harbor porpoises) collected by the BHWW tours contribute to a better understanding of climate change occurring in the Gulf of Maine region.

Whale tail with attached sensor in the Stellwagen Bank National Marine Sanctuary. Each humpback whale tail is unique and can be used to identify individuals. Photo credit: Dr. Elliott Hazen under NOAA Fisheries permit number 14245

A Developer's Perspective: Value of Biological Observation Networks

Laura Morse, Environmental Manager, Ørsted Offshore North America

Ørsted develops, constructs, and operates offshore and onshore wind farms, solar farms, energy storage facilities, and bioenergy plants, and provides energy products to its customers. Their vision is a world that runs entirely on green energy. Laura Morse joined Ørsted in 2017 and has 25+ years of experience as a marine mammal field biologist and regulatory specialist. Ørsted Offshore North America has a geographically diverse portfolio of U.S. offshore wind assets with the potential for generating 8–10 gigawatts of power. One of the first movers on new wind turbine technology, Ørsted is at the forefront of implementing installation concepts and incorporating extensive global collaboration with universities and research institutions into their activities. Their work carefully takes into account the U.S. protected species relevant laws (e.g., NEPA, ESA, MMPA), plus the requirements to establish a mitigation and monitoring plan, acquire the U.S. Bureau of Ocean Energy Management's offshore wind regulatory approvals (e.g., lease issuance, SAP, COP) and MMPA Incidental Take Authorizations, as well as to generate the required Environmental Assessments and Impact Statements.

The offshore wind industry requires an innovative approach to monitoring and mitigation to achieve their environmental protection goals and to have buildable projects that can deliver on their Power Purchase Agreement commitments. They recognize that the primary value of the ATN and MBON observations is to increase situational awareness in real time. For example, an enhanced marine mammal sighting network can: i) provide more efficient and effective mitigation, ii) benefit conservation through increased awareness in the maritime community of whale presence (especially in Dynamic Management Areas) to reduce ship strikes, and iii) assist the research community in assessing status of the species (e.g., health assessments, population abundance). Additionally, the value of a long-term biological observation network specifically to wind energy development applications includes improving pre-activity assessments, mitigating impacts to protected species, monitoring effects from other activities (shipping/fishing), identifying other sources of impacts to improve ecosystems.

Awareness Inspires Conservation

Cynthia Wigren, Atlantic White Shark Conservancy (AWSC), Chatham, Massachusetts

Since 2013, the nonprofit Atlantic White Shark Conservancy (AWSC) has collaborated with shark science experts, community partners, public and government officials, researchers, donors, friends, and followers. Their mission is focused specifically on supporting white shark research, improving public safety, and educating the public to inspire shark conservation; telemetry data are used in all three of these mission areas. In fact, they declare they "would be flying blind" without the telemetry data.

Located on Cape Cod in Chatham, Massachusetts, AWSC is geographically positioned to assist with managing the outcomes that have resulted from the large predator and prey population rebound of the gray seal and white shark species in the region. The rebound is a result of the gray seal protections instituted in the 1970s and the white shark protections in the 1990s. Even though this is a conservation success story, the locals are not yet popping the champagne in response because of the mixed opportunities and challenges it has brought. For example, the increased availability of opportunities for more shark research, eco-tourism, and citizen science is countered by the strong public perception of the safety risk associated with sharks swimming close to shore. AWSC is responding to this challenge with education through events and exhibits at their visitor's center, local school programs, plus community outreach with lectures in the local and greater New England area. Although their messaging is focused on conservation and management of the species, the idea of outright killing of the sharks is nevertheless espoused by some who suggest that, "A cull of white sharks is needed to fully and completely address the Cape Cod shark problem." AWSC offsets this with more measured solutions that include helping to establish a joint Regional Shark Working Group of local leaders and scientists, developing the "Sharktivity" app for iPhones to help raise public awareness, installing beach-based safety messaging billboards, and deploying real-time acoustic detection buoys to detect the presence of tagged sharks. "Awareness inspires conservation" is the overall message of the AWSC.

Acoustic telemetry gear loaded aboard a contract vessel and awaiting deployment in Penobscot Bay on a foggy morning.
Photo credit: Northeast Fisheries Science Center - Orono Maine

BIOLOGICAL DATA MANAGEMENT PERSPECTIVES

ATN Data Assembly Center (DAC) and MBON Data Portal

Rob Bochenek, Information Architect and CEO, Axiom Data Science

The ATN data management vision includes a regionally distributed data collection, management, and sharing capacity that builds on and integrates as many existing telemetry data links as possible to enable local and regional needs to be addressed. At the heart of this system is a centralized data assembly center (DAC) and ATN data portal located at Axiom Data Science. This DAC is a community resource where regional telemetry data are aggregated in a single place, and one-stop-shopping is provided by the portal for access to U.S. animal telemetry data. The DAC serves national stakeholder needs effectively and enables cost/time savings to principal investigators.

Axiom can handle the large volumes of data associated with the DAC by adopting a shared infrastructure approach to leverage multiple applications, systems, and hardware across several partners (including U.S. IOOS, ATN, MBON, and numerous other national and regional partners). Under this model, functional improvements can be funded by one partner and shared with the collective to accelerate progress. By using community developed software, standards, and protocols, Axiom ensures interoperability through standardized systems and interfaces across partners. Axiom has a scalable computing and storage infrastructure to keep pace with data growth and availability which includes: ~5,000 processor cores, ~1.5 petabytes of functional storage/5 petabytes of actual storage (~1,500 hard drives) and a Level 2 Fat Tree Infiniband Network (40 gigabytes per second node to node and 240 gigabytes per second cluster to cluster.)

The MBON Data Portal is a data exploration tool with a customized public web interface that allows scientists, managers, and the general public to discover and access public marine biodiversity data. The portal integrates datasets from many different sources. You can search or browse real-time conditions, operational and research forecasts, satellite observations, and other spatially referenced datasets that describe regional biological, chemical, and physical characteristics. Datasets in the portal can be interactively mapped or charted using advanced features, such as the ability to create comparisons between data sources, bin data by time, and plot climatologies and anomalies.

For both the ATN and MBON portals, Axiom utilizes an approach that applies custom services to manage the flow of data throughout the entire data lifecycle—from data creation to use, reuse, and transformation. Short-term storage and documentation exist for access and sharing by colleagues. Long-term secure archiving exists for preservation and future access and discovery by a larger audience.

NERACOOS/ISMN Data and Product Management

Riley Young-Morse, Data Management and Cyberinfrastructure (DMAC) Lead for NERACOOS/ Gulf of Maine Research Institute

The NERACOOS data management capability is focused in four functional areas: acquisition, integration, discovery, and dissemination of Northeast regional data. Although the observations have concentrated historically on physical, near real-time data including 19+ years of continual monitoring with buoys, land-based observations, and model outputs—plus satellite, HF radar, and glider data—the NERACOOS system is easily scalable to include chemical and biological datasets. Recent projects have added new protocols that enable ingestion of nutrient observatory data as well as alkalinity/ocean acidification and harmful algal bloom/phytoplankton data. Data standards are essential, and the system leverages and applies the proper standards to allow data of diverse types (e.g., physical, biological) to be ingested directly from the provider as well as from post-recovery buoy observations (both time-series and discrete sampling events) while ensuring QA/QC compliance for both. Also included are metadata standards (ISO, CF compliant, common vocabularies/ontologies), which are crucial for ensuring successful data discovery.

The NERACOOS system also applies THREDDS and ERDDAP, state-of-the-art tools, to ensure both human-readable and machine-to-machine accessibility of all the available data and can produce hundreds of thousands observations in seconds. The standards also ensure interoperability and enable sharing among regional and national systems including the MBON Data Portal, ATN Data Assembly Center, NOAA/National Center for Environmental Information (permanent archiving), and the Northeast Ocean Data Portal. While the NERACOOS Data Management System is operational and extremely robust and agile, challenges still remain and are being addressed. These include, among others: i) prioritizing data/stakeholder requirements, ii) assessing data readiness and getting legacy data/metadata from the providers, iii) managing data updates (continuous/discrete) and easing the burden to provide/acquire metadata, and iv) integrating data into the system and generating products.

Northeast Ocean Data Portal: Maps and Data for New England's Oceans

Emily Shumchenia, Northeast Regional Ocean Council

The Northeast Regional Ocean Council (NROC) was established by New England governors in 2005 as a voluntary forum for states, regional organizations, and federal agencies. The NROC Ocean Planning Committee, which supported the development of the Northeast Ocean Plan through the former Northeast Regional Planning Body, developed the Northeast Ocean Data Portal in 2009. The portal is the source of over 4,000 map products showing the footprint of activities and resources as well as data provided by federal, state, and other stakeholders. Its display is customized to address regional stakeholder and agency needs. It can summarize real-time data into map displays and illustrate how the ocean space is being used, for example, by locating a newly deployed moored buoy. The data products available on the portal can be regional scale summaries or snapshots and can use multiple datasets to characterize a resource. Examples of these include New England Fishery Management Council Clam Amendment preferred alternatives and Habitat Management Areas, 2017 passenger vessel transit counts, proposed offshore wind project envelopes, proposed cable routes and lease areas, squid fishing vessel activity and wind energy lease areas, sediment stability, deep-sea coral habitat suitability, and Northeast Canyons and Seamounts Marine National Monument.

The wide array of portal applications and uses include: i) planning and management (U.S. Coast Guard waterways management: deploying aids to navigation and ice breaking assets; New York State Energy Research and Development Authority Offshore Wind Master Plan; Boston Harbor Barrier Feasibility Study) ii) regulatory and siting (NERACOOS wave buoy sited in Cape Cod Bay to inform mariners transiting the canal; Vineyard Wind Environmental Impact Statement; Northeastern Massachusetts Aquaculture Center (NEMAC) Mussel Farm sited in Massachusetts Bay—first shellfish farm in federal waters on Atlantic Coast), and iii) education and research (University of Massachusetts-Dartmouth and Boston University; University of Maine; Brown University). A significant portion of the portal activities is dedicated to outreach in the form of workshops, training, and demonstrations, aimed at, among other things, inspiring K–12 students to investigate the ocean ecosystems and ocean uses and collaborating with agencies on modeling improvements.

RESEARCH PERSPECTIVES

Integrating Telemetry into Ecology: Lessons from the Pacific

Nathan Furey, Department of Biological Sciences, University of New Hampshire

Nathan Furey's research interests are centered on movement ecology, predator-prey interactions, bioenergetics, and landscape ecology. He had recently transferred from the University of British Columbia to the Department of Biological Sciences at the University of New Hampshire (UNH). He reported primarily on some results of previous work he had done with others using acoustic tracking of sockeye salmon smolts to the ocean in Alaska and along the west coast of British Columbia to further their understanding of why the smolt-to-adult survival is declining in that region. Researchers have been aware that survival of smolts migrating from their birthplace of Chilko Lake in British Columbia to the Pacific Ocean is extremely low. On average, 10–40 million smolts leave Chilko Lake every year, and only about 1.5 million return as adults two years later. By implanting small acoustic tags into the smolts before they departed Chilko Lake and monitoring the signals with strategically placed receiver arrays, the researchers were able to track survival of the fish over the course of their migration. Among other things, they learned that the survival of smolts traveling to the ocean is poorest at the beginning of their travel due to significant predation from the bull trout who binge-feed on them—particularly in the clear waters at their initial outmigration. They also discovered that the smolts can maximize their chances of survival by swamping the predators. In short, any given predator can eat only a certain number of prey, so by swamping these predators with high smolt densities, each individual smolt lowers his or her chances of being picked off, particularly in the high mortality landscapes.

Some conclusions from the work in the Pacific that can be applied to a long-term telemetry/biological observation network in the Northeast region include i) the power of telemetry is compounded when combined with other techniques and perspectives; ii) networks facilitate and drive higher-impact science by leveraging resources, asking bigger questions (spatial and temporal scales), and implementing novel observations/meta-analyses; and iii) students/trainees benefit from all of these. The Northeast region is a prime location for development of an integrated telemetry and biological observation network. As an example, the Fish and Movement Ecology Lab at the UNH, led by Dr. Furey, is using telemetry to track the movements of adult rainbow smelt in Great Bay New Hampshire. This project is quantifying smelt migration rates and survival post-spawning and identifying important estuarine habitats.

Satellite and Acoustic Shark Tracking

James Sulikowski, Professor, Department of Marine Science, University of New England

The University of New England (UNE) School of Marine and Environmental Programs serves as an incubator for forward-looking marine research. Their goal is to create new knowledge in a wide variety of interdisciplinary fields, including marine science, marine ecosystems, conservation, restoration, business, sustainable fisheries, and ecological aquaculture, social-ecological systems, and marine sustainability science. Fisheries science creates the knowledge and data used for fisheries management to make the best possible policies to manage a fishery, and policies in turn create the framework for fisheries science to design and conduct research. A primary focus of the UNE Marine Science Center is understanding the behavior, movement, and mortality of a variety of species in the Northeast region including porbeagle, tiger and white sharks, and Atlantic sturgeon. With multiple collaborating partners from Canada to Florida, their studies include the use of acoustic tags and telemetry arrays in the Saco River and Bay, plus satellite tagging along the entire East Coast. Movement patterns determined from telemetry studies are specifically used to help fishermen to adapt their techniques to avoid bycatch of porbeagles. Satellite tagging has also been used to study seasonal and life-stage variation in the reproductive ecology of some species and has demonstrated significant differences in the movement patterns of pregnant and non-pregnant females. In an effort to protect nursery grounds, they are also in the process of developing a "birth-tag," a novel intrauterine satellite tag designed to pinpoint the timing and location of pupping of highly mobile shark species. Significantly more telemetry studies could be possible by directing at least 1% of the $250 billion recreational fishing industry income toward funding them.

Gulf of Maine Research Institute (GMRI) Research Overview

Graham Sherwood, Gulf of Maine Research Institute

The GMRI is a private, nonprofit research institute whose mission is to pioneer collaborative solutions to global ocean challenges. Their core commitments are i) science (increase understanding of the Gulf of Maine ecosystem and economy through interdisciplinary, collaborative, and action oriented research), ii) education (build Maine middle school students' critical thinking skills and understanding of the nature of science through participation in authentic science experiences), and iii) community (engage marine stakeholders to share knowledge, learn, and make decisions that nurture ecologic and economic resilience in the Gulf of Maine). GMRI research scientists are engaged in a variety of fisheries ecosystem studies that help to identify variations in movement patterns and distribution of fish that may be responding to changes in ocean conditions (e.g., warming) and food-web structure (e.g., predator loss/addition). The study approaches include using acoustic tagging with large receiver arrays to investigate, for example, if different cod ecotypes display variable movement and residency, as well as how haddock are using the offshore closed area.

While telemetry has played a role in these studies, they have not yet found a way to incorporate it into longer-term monitoring due to the costs associated with doing so. The challenge for longer-term work is primarily funding. The Casco Bay Aquatic Systems Survey (CBASS) has the greatest potential for telemetry to add value to their regional monitoring efforts. CBASS is a long-term monitoring effort led by GMRI to help gain a better understanding of the pace and direction of observed changes like dramatic declines in groundfish, an explosion of lobsters, habitat loss and recovery periods for critical species like alewives, and the appearance of more southerly species such as black seabass. A primary goal of CBASS is to provide a baseline of current fishery ecosystem conditions in coastal Maine waters for comparison with future conditions, as well as to use catch trend data to validate the eDNA monitoring technique.

A white shark is tagged off the coast of Cape Cod, Massachusetts. Copyright: Atlantic White Shark Conservancy/Wayne Davis

Movement Ecology of the White Shark in the North Atlantic

Greg Skomal, Recreational Fisheries Program Manager, Massachusetts Division of Marine Fisheries

The Massachusetts Division of Marine Fisheries (MADMF) Shark Research Program collaborates with multiple partners to study many aspects of the biology of sharks in Massachusetts and adjacent waters, including ecology, distribution and movements, relative abundance, essential habitat, natural history, and physiology. Seasonal white shark sightings off the Massachusetts coast have increased in recent years; the outer beaches of Cape Cod are a popular location for white sharks due to the growing population of gray seals living there. As a result, there is now predictable access to white sharks in the North Atlantic. To study the movement of this species, the MADMF program has tagged hundreds of individual white sharks off the eastern coast of Cape Cod since 2009. These tags show that white sharks move more broadly throughout the North Atlantic than previously thought. When they leave Cape Cod in the late fall, they migrate to overwintering habitat off the southeastern U.S. and the Gulf of Mexico. Larger white sharks (>9 feet) move into the open Atlantic to as far as the Azores, while diving to depths as great as 3,000 feet. Many of the tagged white sharks return to Cape Cod each year.

The program uses a combination of individual sightings, aerial surveys, and acoustic and satellite telemetry to study both fine-scale and broad-scale movements in and around the Massachusetts/Cape Cod area as well as along the entire U.S. East Coast and into the North Atlantic. Hundreds of thousands of acoustic tag detections are helping them seek answers to questions like what specifically is driving shark movements (e.g., lunar phase), examining their deep diving behavior, and why there are no sharks in Vineyard Sound/Buzzards Bay areas.

This research helps the MADMF achieve its goals of i) fostering cooperative research, ii) participating in state, regional, and federal management processes, and iii) providing public education on these shark species.

Great White Shark. Photo Credit: Greg Skomal, Massachusetts Division of Marine Fisheries

Linking Pelagic Community Structure with Ecosystem Dynamics and Production Regimes on the Changing Northeast U.S. Shelf

Heidi M. Sosik, Woods Hole Oceanographic Institution

To address ecological questions that cannot be resolved with short-term observations or experiments, the National Science Foundation (NSF) established the Long-Term Ecological Research (LTER) program in 1980 with two distinct components that differentiate LTER research from other NSF projects: 1) the research is located at specific sites chosen to represent major ecosystem types or natural biomes, and 2) it emphasizes the study of ecological phenomena over long periods of time based on data collected in five core areas. These are: 1) primary production, 2) population dynamics and trophic structure, 3) organic matter accumulation, 4) inorganic inputs and movements of nutrients through the ecosystem, and 5) patterns and frequency of disturbances. NSF currently supports 28 LTER sites, one of which is the Northeast U.S. Shelf (NES) LTER program. This program integrates observations, experiments, and models to aid in understanding and predicting how planktonic food webs are changing through space and time in the region in response to changes in the physical environment, and how those changes may impact the productivity of higher trophic levels. It is implemented through a partnership among the Woods Hole Oceanographic Institution, the University of Rhode Island Graduate School of Oceanography, the University of Massachusetts-Dartmouth, Wellesley College, and the NOAA National Marine Fisheries Service.

By conducting long-term studies of shelf-wide pelagic dynamics on the NES, the program addresses its overarching science question: How is climate change impacting the pelagic NES ecosystem and, in particular, affecting the relationship between compositional (e.g., species diversity and size structure) and aggregate (e.g., rates of primary production, and transfer of energy to important forage fish species) variability?

The main NES-LTER program components are observations (ships and observatories), experiments (processes and rates), and models (ocean and ecosystem). Observations are collected from ship transects, from the Ocean Observatories Initiative Pioneer Array (surface moorings, moored profilers, gliders, AUVs) and from the Martha's Vineyard Coastal Observatory (MVCO). For example, environmental parameters are measured in real-time from South Beach, Martha's Vineyard, Massachusetts, from a tower one mile offshore. Also, both high resolution and long duration plankton time series from flow cytometry and imaging-in-flow cytometry are provided from MVCO.

Northeast Fisheries Science Center (NEFSC) Protected Species Branch: A Few Snapshots

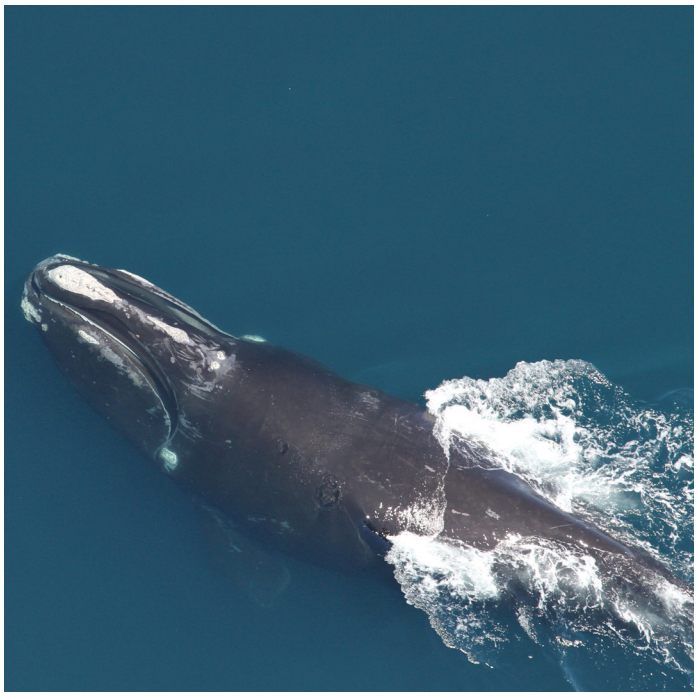
Sean Hayes, Chief, Protected Species Branch/Northeast Fisheries Science Center

The National Marine Fisheries Service (NMFS) mission, and in particular, the Protected Species Branch of the Northeast Fisheries Science Center (NEFSC), is governed specifically by the Magnuson–Stevens Act (MSA), Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA) and the National Environmental Policy Act (NEPA). All are statutes that regulate marine fisheries management in U.S. federal waters and collectively seek to prevent the 'tragedy of the ocean commons.' The NMFS programs support a wide range of stakeholders' needs—fishing, offshore energy (wind/tidal/oil), agriculture, water, hydropower-freshwater, aquaculture, defense, conservation, shipping, eco-tourism, and recreational water use—as they search for results that will inform important fisheries management questions. These include, "Where do the fish and marine animals go? Why do they go there? Are those reasons changing? Are people doing things there, too? (i.e., is there a conflict?)." This is where telemetry applications can help to provide the answers for both protected and unprotected species, although there are different approaches and scales in how they are applied for each.

The Atlantic Marine Assessment Program for Protected Species or AMAPPS is one example of a broad-scale, multiyear ecosystem study supported by the Bureau of Ocean Energy Management (BOEM) and other federal agencies to collect long-term ecological data on protected species in the Atlantic to, among other things, understand the potential effects of BOEM-related activities on these species. Satellite animal telemetry and passive acoustic monitoring were among the methods used. Another example is Platforms of Opportunity or PlatOpus, an NEFSC-University of Maine collaborative monitoring program in the Gulf of Maine that uses opportunistic acoustic telemetry platforms (drifters, gliders, lobster traps, arrays) to host acoustic tag detection and passive acoustic monitoring receivers and from which 17 different species were detected.

For individual species, tracking acoustic telemetry provides a "hands off" method of learning more about animal behavior and uses a stationary array or "network" of receivers. In 1997 Atlantic salmon telemetry studies began to help further understanding about Narraguagus River smolt movements to sea. These studies have continued and expanded with hundreds of smolts now being tagged in four Maine rivers.

Tracking data is also used to evaluate the success of ecosystem management activities and to provide reference data for offshore energy development, construction sites, etc. North Atlantic right whale monitoring, especially in seasonal and dynamic management areas, is critical in the Gulf of Maine region. Satellite tags are an essential component of advancing cetacean science preferably with noninvasive tag attachment methods. LIMPET (Low Impact Percutaneous Electronic Transmitter) tags with minimally-invasive tag attachments have shown some promise for cetacean tagging. Additional collaborative single species NEFSC projects include gray seal satellite tracking, gray seal/shark dynamics with acoustic detections, harbor seal satellite tracking, codfish tracking through combined active and passive acoustic techniques and the Integrated Technologies for Deep Diver Ecology Program (ITS.DEEP), which integrates multiple technologies to study cryptic/deep diving cetaceans off Georges Bank in the North Atlantic.



Right whale sighted during survey. Image collected under MMPA Research permit number 17355. Photo credit: NOAA Fisheries/Christin Khan.

Coonamessett Farm Foundation (CFF) Loggerhead Research Program

Samir Patel, Marine Biologist, Coonamessett Farm Foundation, East Falmouth, Massachusetts

The CFF is a nonprofit organization that conducts scientific research and generates educational products that support sustainable fisheries, aquaculture, and agricultural industries. Their turtle research project dates back two decades when it was centered primarily on bycatch research motivated by a steady uptick in turtle interactions with scallop gear in the mid-Atlantic bight (MAB). Technical efforts aimed at bycatch mitigation included testing and development of turtle chain mats to reduce water column interactions, which became mandatory for the scallop fishing industry in 2006. This was followed by eight years of development and testing on a turtle deflector dredge to reduce turtle bycatch on bottom, which became mandatory in 2013 for all seasonal scallop fishing west of 71°W. In parallel, an ecological research program for the turtles was implemented using satellite telemetry deployments during the migratory phase of the North Atlantic foraging population, biological and morphometric sampling, in-water videography (ROV/action cams), and habitat assessments (sampling Sargassum, jellyfish, and plankton).

From 2009–2018, the CFF captured and satellite tagged 201 loggerhead turtles in the MAB region. Because the average lifetime of a tag was 318 days, an extensive, long-term dataset was created with which they were able to specifically assess the value of the oceanographic data collected by satellite tagged loggerhead turtles in this mid-latitude ocean region. Extensive analyses of the dataset included i) filtering to bound specific locations within the MAB from May through October for years 2009–2018, ii) identifying the signature of the Cold Pool Water (CPW) by filtering temperature profiles that reached depths between the 30–70 m isobaths, iii) comparing temperature data from turtle-borne tags to shipboard CTD and regional oceanographic models, and iv) determining thermal habitat preference for loggerheads in the MAB. The results illustrated that the turtles spent significant time in the CPW and clearly recorded the temperature signature from this feature.

A comparison of temperture profiles among turtle-borne tags, shipboard CTD data, and three oceanographic models (FVCOM, HYCOM, ROMS) showed close relationships between the tags and the ship CTD, while there were significant differences between the tags and the models that ranged from -10 °C to +10 °C. Proposed next steps for the temperature profile data are to update ocean models by incorporating turtle-derived data and glider data, and thus be able to project suitable thermal habitat for loggerheads through 2100 using climate change models, and continue to deploy ocean profiling tags on loggerheads in the MAB.

Massachusetts Division of Marine Fisheries (MADMF) Acoustic Telemetry Research

Bill Hoffman, Senior Marine Biologist, Massachusetts Division of Marine Fisheries

The MADMF manages the marine resources of the commonwealth. A team of seven in-house researchers manages fisheries-dependent investigations and advanced fisheries research projects, most of which focus on species important to Massachusetts recreational and commercial fisheries. Beginning in 2008, much of their work has been conducting acoustic telemetry studies, addressing seven different species with 1,502 fish tagged. Nearly 1,400 acoustic receivers were deployed (2008–2018) on moorings mostly in Massachusetts waters. Many projects involve discard mortality (DM) studies on Atlantic cod, haddock, and cusk. These collaborative studies use specifically designed, controlled methods for catching, recording retrieval/handling time and angler skill level, establishing a standardized 'condition of the animal' score, and carefully releasing the animal where it can be observed over time within a known array of acoustic receivers—including a VPS array for finer scale detections. The study results include identifying: i) physical injury as the greatest predictor of cod DM after release from recreational fisheries, ii) releasing at depth via a descending device, which reduces cusk DM, and iii) season and total fish length influenced haddock DM after release (greater mortality for small fish released in warmer months).

Another large MADMF acoustic telemetry project investigated the impact on the dispersal of Atlantic cod spawning aggregations after a fishery opening. Because dense cod aggregations are localized and spawners return to the same areas, once they are 'found' the aggregations are vulnerable to heavy exploitation. For this project 55 cod were caught and measured (length, weight, sex, maturity), 10 of which were tagged with acoustic transmitters, and a fine-scale VPS receiver array was deployed, resulting in establishment of seasonal and rolling fishery closure zones.

Since 2008 the MADMF has invested in acoustic telemetry to inform fisheries management decisions. The data collected generates essential information that is used to create time-area fishery closures and to make best practice recommendations to reduce DM for several groundfish species.

This research tool is vital to furthering our knowledge about species that are commercially and recreationally important to the commonwealth. The MADMF perspective is that a long-term sustained biological observation network in the Northeast region is essential for efficiently sharing and retrieving information, reducing workload for researchers while improving data quality.

Environmental DNA (eDNA) Methods to Monitor Marine Systems

Alison Watts, Assistant Research Professor, Department of Civil Engineering, University of New Hampshire

Biological monitoring programs are essential to effective management of estuaries and coasts, but they can be expensive to conduct and traumatic to the target species. Advancements in DNA methods now make it possible to identify the organisms in an area by the DNA they leave behind. All living things have and shed DNA. Environmental DNA, or eDNA, is DNA released from an organism into the environment and can come from hair, scales, skin, waste products, reproductive cells, and entire organism (diatoms). The key advantages of eDNA sampling are cost and speed, sensitivity and accuracy, plus it is noninvasive and enables a multi-trophic approach targeting multiple phyla in single sequence runs, thus enabling the linking of trophic networks. Although extremely attractive, it is not magic. eDNA can i) provide information on species presence, ii) help target field sampling programs, iii) reduce sampling effort, and iv) provide a nondestructive, noninvasive sampling method. It cannot, however: i) confirm absolute absence, ii) determine species abundance, iii) determine life stage or condition, or, iv) identify species without known DNA sequences.

For manatees and other hard-to-spot species, the answer to how to protect a species you can't see might lie in the minute particles of DNA they leave behind as they move through their environments. The collaborative ADEON (Atlantic Deepwater Ecosystem Observatory Network), led by the University of New Hampshire (UNH), was established to collect long-term observations of living marine resources and marine sound. They are using eDNA sampling and have detected >1,000 species. For long-term monitoring, eDNA has both strengths and challenges. Strengths include a) powerful, relatively low cost and becoming more accessible, b) DNA extractions can be archived and reanalyzed for more/different species, and c) interdisciplinary. Challenges include a) lack of standards, b) very large data sets with associated metadata, c) interdisciplinary, and d) it's harder than you think!

The pilot eDNA program is a collaboration among UNH and six National Estuarine Research Reserve sites nationwide. Scientists and staff from these reserves are working with university researchers and a technical advisory team to develop eDNA sample collection and analysis protocols. The project is sponsored by a grant from the NERRS Science Collaborative. Resource managers and key stakeholders worked to identify a list of estuarine species to target using eDNA methods; the pilot eDNA sampling has been conducted in coordination with existing monitoring programs including larval fish tows, purse seining, and crab trapping, to allow direct comparison and verification between methods. Our goal is to assess the value of eDNA monitoring at research reserve sites and provide end users with key training to support informed decisions regarding the implementation and use of eDNA monitoring in estuarine systems.

A recovered acoustic telemetry receiver attached to a concrete mooring. The receiver and mooring rest on the estuary or bay substrate with the hydrophone of the receiver pointing upwards toward the surface.

Photo Credit: Northeast Fisheries Science Center - Orono Maine

PLENARY SESSION

Observing Change in the Pelagic Ecosystem - North Atlantic Right Whales as an Indicator

Jeff Runge, Professor of Oceanography, University of Maine; Research Scientist, Gulf of Maine Research Institute; Director, Integrated Sentinel Monitoring Network

The Gulf of Maine lies at the epicenter of the most rapid warming trend in U.S. coastal waters. Evidence is mounting that recent warming is affecting ecosystem structure and services. Combining data from observation networks within the Northeast Integrated Sentinel Monitoring Network (ISMN) provides the capability to facilitate integrated interpretation of change in the pelagic Gulf of Maine ecosystem. The Gulf of Maine food web lies at the southern margin of the subarctic North Atlantic biome and includes characteristic subarctic pelagic species such as *Calanus finmarchicus* (*C.fin*), herring, capelin, sandlance, and cod.

The observed warmer and saltier water in the eastern Gulf of Maine is linked to the weakening of AMOC (Atlantic Meridional Overturning Circulation) and the northward shift of the Gulf Stream. The result is that the transport into the Gulf of Maine previously from the *Calanus*-rich Scotian Shelf is now more from the *Calanus*-poor Atlantic slope water off the Northeast Channel. Consequently, the North Atlantic right whales (NARW) respond to lower *C.fin* concentrations by shifting foraging areas away from the Gulf of Maine and more to the Gulf of St. Lawrence.

The ISMN fills a sampling gap and facilitates integration of multiple datasets aimed at predicting future NARW foraging distributions. The datasets include i) monthly sampling at Coastal Maine Time Series (CMTS) and Wilkinson Basin Time Series (WBTS), which are strategically located stations to observe the phenology of change in plankton production cycles and ii) a suite of biodiversity estimates, from eDNA to jellyfish, to observe ecosystem change and complement Canada's long-term Atlantic Zone Monitoring Program (AZMP) and NOAA Ecomon/MARMAP surveys. The management of these multiple data sets is integrated within the Center for Analysis, Prediction and Evaluation (CAPE) project, which is a key part in ISMN's role as a centralized hub for information synthesis of observing data indicating change in lipid-rich zooplankton—a key sentinel variable supporting the Gulf of Maine pelagic food web. This approach, integrated with coupled biological-physical models that help predict the spatial landscape of *C.fin* (lipid) concentration and NARW foraging distribution, has strengthened confidence in the correlation between the significant decrease in sightings of right whales in the Bay of Fundy since 2010 and the lower *C.fi*n abundance in the eastern Gulf of Maine.

Acoustic Tag Detection Receivers. Photo Credit: Greg Skomal, Massachusetts Division of Marine Fisheries

BREAKOUT SESSIONS

Two breakout sessions were organized, and participants were asked to consider the following questions:

Session 1. Identify stakeholders in the NERACOOS region and their observation data and information needs.

1. Summarize the stakeholders in the region that were identified this morning.
2. List the types of telemetry and biodiversity observation data and information that can best address the needs of these stakeholders.
3. Identify any existing observing assets/capabilities in the region that can satisfy these needs.

Session 2. Identify challenges and concerns with implementing an animal telemetry and biodiversity observation sustained network in the NERACOOS region.

1. What are the benefits of having a regional baseline observation network approach versus individual research efforts?
2. How could a sustained baseline observation network of marine animal movement and behavior, species diversity, distribution, and abundance be integrated within the Northeast Integrated Sentinel Monitoring Network (ISMN) framework? What are the challenges to building that network and what actions can be taken to address those challenges?

GROUP 1

TOPIC A – Regional Stakeholders and their Data/Information Needs

This group organized those regional stakeholders who would benefit from telemetry and biodiversity observations into an all-encompassing array of functional and native/institutional/organizational categories. The functional categories include, among others, commercial and recreational fisheries management, aquaculture, eco-tourism, Section 7 of the Endangered Species Act, hydro/wind/tidal power generation, shipping, Integrated Ecosystem Assessments for Sanctuaries, and MPA management and HABs warnings. Those in the other categories include educators/researchers, Indigenous/Tribal/First Nations stakeholders, federal and state governments, NGOs, and the media. In terms of observations that serve these stakeholders, the group noted that it is not only data that are needed, but also in many cases information products derived from the data are even more helpful to the user. The types of data identified as needed were animal movement from acoustic/satellite tags, abundance of phytoplankton communities, phenologies, trophic interactions, and reproductive success. High importance was given to information products that would enable better understanding of habitat usage, movements of species and migration corridors, population dynamics, foraging patterns, community structures, and biodiversity indices/richness.

The group developed a comprehensive list of existing observing assets/capabilities in the region that have the potential to serve the regional data needs. The principal ones are included in the *Workshop Findings, Objective II* of this report. Others identified include NMFS plankton trawl surveys, passive acoustic hydrophone arrays, URI-Narragansett decades-long time-series trawls, Massachusetts and Maine/New Hampshire DNR seasonal trawls, University of Maine Annual Sentinel Survey, eDNA from University of Maine/NERRS/Northeast Shelf LTER, and fisheries observer data.

TOPIC B – Challenges and Concerns

There was consensus among this group that a regional baseline observation network provides significant advantages versus individual efforts. A regional approach brings a broader and more engaged stakeholder community, incentivizes standardized observing methods and cost sharing, can capture information at many different scales, and enables individually collected data to contribute to the larger regional scale perspective. A consistent observing approach helps the interpretation of data as long as the right things are measured from the beginning.

The recommended first step in integrating a sustained biological observation network into the Integrated Sentinel Monitoring Network is to revisit the ISMN Implementation Plan and modernize it by, among other things, expanding the telemetry footprint to develop a baseline regional measurement capacity with more receiver arrays using common data formats (networks) at multiple scales and apply modeling capabilities to integrate between arrays. A "platforms of opportunity" approach/capacity could be implemented to access data available from existing buoys (e.g., NDBC, USCG). An eDNA component should also be implemented to establish the needed baseline to assess biodiversity changes over time, especially those associated with wind energy development. Consideration should also be given to incorporating Global Ocean Observing System essential ocean variable measurement capabilities. The greatest challenge to building this network is how to fund it. This requires a solid network rationale and strategy, building on the successful OTN approach, for example, that will convince funders to have the long vision needed to properly sustain it.

GROUP 2

TOPIC A – Regional Stakeholders and their Data/Information Needs

This group listed the Northeast regional stakeholders:

NOAA
- National Marine Fisheries Service
  - ◊ Northeast Fisheries Science Center
  - ◊ Greater Atlantic Regional Fisheries Office
- National Ocean Service
  - ◊ National Estuarine Research Reserve System
  - ◊ Center for Operational Oceanographic Products and Services
  - ◊ National Centers for Coastal Ocean Science
  - ◊ Sanctuaries and MPAs

Department of the Interior
- U.S. Geological Survey
- U.S. Fish and Wildlife Service

Bureau of Ocean Energy Management

U.S. Navy

U.S. Coast Guard

Environmental Protection Agency

U.S. Army Corps of Engineers

Smithsonian Institution

Marine Mammal Commission

Massachusetts/Maine/New Hampshire
- Division of Marine Fisheries
- Department of Environmental Protection
- Lobstermen's Association

First Nations
- New England Tribes treaty rights
- Subsistence fishing

Fishing Industry
- Commercial
- Recreational

Co-Management Entities: regional councils

Department of Fisheries and Oceans-Canada

Nongovernmental Organizations (NGOs)
- World Wildlife Fund
- Nature Conservancy
- Atlantic White Shark Conservancy
- Center for Coastal Studies
- New England Aquarium

Consulting
- Nordemdeu
- RPS
- Santec

Shipping Industry

Right Whale Consortium

North Atlantic Salmon Conservation Organization

New York State Energy Research and Development Authority

General Public

Among the regulatory drivers that require this data/information and are administered by some of the above stakeholders are: National Environmental Policy Act, Endangered Species Act, National Marine Sanctuary Act, Marine Mammal Protection Act, Migratory Bird Treaty Act, and Coastal Zone Management Act.

Similar to Group 1, this group noted that the types of data needed to support these stakeholders included biodiversity and telemetry observations that: 1) describe specific species aggregation information (hotspots [heat maps with time scales], migration corridors and bottlenecks, connectivity, spawning), 2) enable studies of behavioral state (foraging, sleeping, socialization, response to the environment including storm events/climate change) and, 3) anthropogenic response to noise, physical structures, sediment disturbance, EMF cables, etc.

Also included was that models (e.g., movement, habitat and state-space models) are needed to be able to connect the dots. For specific biodiversity observations, the group referenced the extensive list provided in the ISMN Implementation Plan (https://www.sentinelmonitoring.org/).

Existing assets in the region identified by this group are also covered in the Workshop Findings, Objective II of this report with the following special consideration given to: Environmental Monitors on Lobster Traps (eMOLT), glider data (Woods Hole Oceanographic Institution, University of Maine School for Marine Science and Technology [SMAST], University of Massachusetts Dartmouth, MARACOOS) and the Ocean Observatories Initiative Pioneer Array supported regionally by NERACOOS, which has a time series of 15+ years of data collected by the University of Maine, University of Connecticut, and University of New Hampshire.

TOPIC B – Challenges and Concerns

The challenges are many and include the need for a coordinated and sustained long-term biological observing system that is founded on a state-of-the-art cyberinfrastructure system. The primary challenge is the lack of adequate funding to support these critical functions.

A state-of-the-art, robust and interoperable central data repository is needed to handle all components of data handling for a variety of assets. This system will also provide additional capabilities and efficiencies in streamlining data collection, downloading, aggregation, management, access, visualization, and delivery to stakeholders.

The Northeast is uniquely positioned to increase regional collaboration through ISMN but faces obstacles due to the complexity of scope and lack of funding. It was recommended that a review of the ISMN Implementation Plan be conducted to strengthen and clarify message and vision. Additionally, there may be opportunities to collaborate with the Northeast U.S. Shelf Long Term Ecological Research (LTER) program. The ultimate goal is to build out an integrated and sustained operational biological observing component in ISMN.

NERACOOS geographic region. Photo credit: https://ioos.noaa.gov/regions/neracoos/

WORKSHOP FINDINGS

OBJECTIVE I: Identify and Prioritize Stakeholder Marine Animal Telemetry and Biodiversity Monitoring and Observational Needs in the Northeast Atlantic Region

THEME A: Long time-series of the data are essential because they allow us to perceive changes and there is no way to collect the data after the fact.

THEME B: Meeting the marine resource protection and management objectives in the Stellwagen Bank National Marine Sanctuary requires an understanding of the relative inputs of sound sources within the sanctuary and the possible effects of these sounds on marine animal behavior.

THEME C: While dynamic management for whale strike mitigation is working, the effectiveness of mitigation measures can be improved by employing a combination of whale detection technologies.

THEME D: The offshore wind industry requires an innovative approach to monitoring and mitigation to achieve their environmental protection goals and to have buildable projects that can deliver on their Power Purchase Agreement (PPA) commitments.

FEDERAL AGENCIES

NOAA/NMFS Integrated Ecosystem Assessments (IEA)

Long time-series of the data are essential because they "allow us to perceive changes and there is no way to collect the data after the fact."

U.S. Army Corps of Engineers (USACE)

A primary responsibility of USACE is to conduct investigations to assess the spatio-temporal extent of potential environmental impacts caused by their activities. Among the factors that are considered for an ocean dredged material disposal site designation are oceanic conditions, water quality/ecology, and nearby natural resources.

USACE needs consistently updated data showing project site usage year-round for marine animals, mammals, turtles, and endangered species. Additionally, real-time data of animal locations and behaviors during project activities could help avoid impacts to the resource and aid in the planning of future work. USACE requires the data to be accessible, reliable, and queryable.

Wells National Estuarine Research Reserve (NERR)

The Wells NERR Research Program is focused on collecting a wide range of ecological and environmental data/observations needed for studying and monitoring changes in Gulf of Maine estuaries, coastal habitats, and adjacent coastal watersheds, and producing science-based information needed to protect, sustain, or restore them.

Stellwagen Bank National Marine Sanctuary (SBNMS)

Information on sound sources within SBNMS are needed to meet marine resource protection and management objectives.

National Science Foundation (NSF)- Northeast U.S. Shelf LTER Program

Biological and physical observations are needed to understand and predict how planktonic food webs are changing through space and time in the region in response to changes in the physical environment, and how those changes may impact the productivity of higher trophic levels.

STATE AGENCIES

Massachusetts Division of Marine Fisheries (MADMF)

The MADMF is responsible for managing the marine resources of the commonwealth. A team of seven in-house researchers manages fisheries-dependent investigations and advanced fisheries research projects. Most are management-based and focus on species important to the Massachusetts recreational and commercial fisheries—including Atlantic cod, cusk, striped bass, black sea bass, haddock, alewife, and American shad.

The MADMF White Shark Research Program requires data indicating the time and locations of white shark sightings and acoustic/satellite telemetry detections in and around the Massachusetts/Cape Cod area, along the U.S. East Coast, and into the North Atlantic. They also are interested in this type of data collected by innovative methods/platforms such as autonomous underwater vehicles.

NGOs

World Wildlife Fund (WWF)-Canada

WWF believes there is a critical need to know where the fishery habitats are and to manage the impacts on them; ATN and MBON data can help to understand where the animals travel and when.

Green Marine

While dynamic management for whale strike mitigation is working, the effectiveness of mitigation measures can be improved by employing a combination of whale detection technologies. In particular, enhancing detection capacity by deploying acoustic monitoring in the "dynamic shipping lanes" is a much needed step.

Gulf of Maine Research Institute (GMRI)

GMRI needs a variety of observations to help them better understand the pace and direction of observed changes like dramatic declines in groundfish, an explosion of lobsters, habitat loss and recovery periods for critical species like alewives, and the appearance of more southerly species such as black seabass.

COMMERCIAL/PRIVATE SECTOR

Ørsted Offshore North America

The offshore wind industry requires an innovative approach to monitoring and mitigation to achieve their environmental protection goals and to have buildable projects that can deliver on their Power Purchase Agreement commitments.

Bar Harbor Whale Watch

- Track whale movement to determine where are they going, why and when.
- Identify which species are increasing/decreasing due to climate change.
  - ◊ Is the seasonality and abundance of pelagic seabird sightings changing?
  - ◊ What drives the huge boom of jellyfish in some years?
  - ◊ Which species of forage are driving success of seabird colonies?

OBJECTIVE II: Identify the Existing Telemetry and Biodiversity Observing Assets and Scientific Capabilities in the Region

FEDERAL AGENCIES

U.S. Army Corps of Engineers (USACE)

The work typically included in a USACE investigation includes: imaging surveys and analysis of the sediment type and composition, bathymetric surveys, a geospatial assessment of the benthic community successional stages with bottom trawling, measuring commercial multi-year herring fishing activity, lobster assessments from lobster pot trawl transects, marine transportation vessel density traffic, and nearby shipwrecks/obstructions.

Wells National Estuarine Research Reserve (NERR)

Specific monitoring efforts include community composition and species abundance and distribution, ocean-coastal acidification, ichthyoplankton, marine invasive species, soundscape ecology, larval fish, eDNA for rare aquatic species, and the National System Wide Monitoring Program (SWMP). The Wells NERR sees acoustic animal telemetry as a primary tool for investigating "sentinel" crustaceans such as lobster, Jonah crab, green crab, etc.

Stellwagen Bank National Marine Sanctuary (SBNMS)

- Whale Watch Database 1979–present - 400,000 sightings (baleen whales) in partnership with Whale Center of New England and Provincetown Center for Coastal Studies
- Monitoring for whale entanglements and ship strikes
- 20 years of animal telemetry (Argos satellite seabird tracking, whale tagging with DTAG and CAT tags, acoustic fish tags), large arrays of passive acoustic sensors, real-time right whale acoustic detection

National Science Foundation (NSF)- Northeast U.S. Shelf LTER Program

- Transect cruises (underway measurements and discrete sampling):
  - ◊ A suite of meteorological observations
  - ◊ ADCP and CTD/PAR/oxygen/fluorescence profiles
  - ◊ Particulate organic carbon and nitrogen
  - ◊ CDOM, inorganic nutrients, pigments, and other parameters
- Observatories
  - ◊ Martha's Vineyard Coastal Observatory (MVCO) sites provide real-time and archived coastal oceanographic and meteorological data. Phytoplankton are observed using FlowCytobot and Imaging FlowCytobot (IFCB) deployed at MVCO; an IFCB was also used for underway sampling during broadscale and transect cruises.
  - ◊ Ocean Observatories Initiative Coastal Pioneer Array provides time series data from:
    - ◆ Surface moorings
    - ◆ Moored profilers
    - ◆ Gliders
    - ◆ AUVs

NOAA/NMFS/Northeast Fisheries Science Center/Protected Species Branch

The Northeast Fisheries Science Center (NEFSC) collaborative single-species projects include gray seal satellite tracking, gray seal/shark dynamics with acoustic detections, harbor seal satellite tracking, and codfish tracking through combined active and passive acoustic techniques and the Integrated Technologies for Deep Diver Ecology Program (ITS.DEEP). NEFSC is integrating multiple technologies to study cryptic/deep diving cetaceans off Georges Bank in the western North Atlantic.

In 1997 NEFSC began Atlantic salmon telemetry studies to learn more about Narraguagus River smolt movements to sea. These studies have continued and expanded with hundreds of smolts now being tagged in four Maine rivers.

Environmental Protection Agency (EPA) National Estuary Programs (partially federally-funded)

The National Estuary Program (NEP) is an EPA place-based program to protect and restore the water quality and ecological integrity of estuaries of national significance. Currently, 28 estuaries located along the Atlantic, Gulf, and Pacific coasts and in Puerto Rico are designated as estuaries of national significance. Six of these are located in New England including the Casco Bay Estuary Partnership and the Piscataqua Region Estuaries Partnership.

- **Casco Bay Estuary Partnership (CBEP):** Located at the University of Southern Maine, the CBEP is engaged in ongoing efforts to collect water quality monitoring information for Casco Bay. In 2016, CBEP created a Casco Bay Monitoring Network to identify shared monitoring priorities among the growing number of entities who are monitoring the waters within Casco Bay and its watershed.
- **Piscataqua Regional Estuaries Partnership (PREP):** Hosted and administered by the University of New Hampshire, PREP works with 200 different partners in 52 municipalities to carry out 82 action plans to improve water quality and environmental conditions throughout the Piscataqua Region Watershed. The partnership work includes summarizing data from monitoring programs in the region using 23 different environmental and social indicators (e.g., water quality, shellfish resources, land use, critical species, habitats), which are measureable markers that help interpret the condition of the environment and how it changes over time.

STATE AGENCIES

Massachusetts Division of Marine Fisheries (MADMF)

The MADMF maintains a network (>100) of acoustic detection receivers in various locations along the coastline of Massachusetts.

ACADEMIA

University of New England – Marine Science Center

The University of New England Marine Science Center studies include the use of acoustic tags and telemetry arrays in the Saco River and Bay, plus satellite tagging along the entire East Coast.

University of New Hampshire (UNH)

The pilot eDNA program is a collaboration among UNH and six National Estuarine Research Reserve sites nationwide. Scientists and staff from these reserves are working with university researchers and a technical advisory team to develop eDNA sample collection and analysis protocols. The project is sponsored by a grant from the NERRS Science Collaborative. Resource managers and key stakeholders worked to identify a list of estuarine species to target using eDNA methods. The pilot eDNA sampling has been conducted in coordination with existing monitoring programs (including larval fish tows, purse seining, and crab trapping) to allow direct comparison and verification between methods.

NGOs

Gulf of Maine Research Institute (GMRI)

The Casco Bay Aquatic Survey System (CBASS) is a long-term monitoring effort led by GMRI to help gain a better understanding of the pace and direction of observed changes like dramatic declines in groundfish, an explosion of lobsters, habitat loss and recovery periods for critical species like alewives, and the appearance of more southerly species such as black seabass. Primary goals of CBASS include to provide a baseline of current fishery ecosystem conditions in coastal Maine waters for comparison with future conditions, as well as to use catch trend data to validate the eDNA monitoring technique.

Coonamessett Farm Foundation (CFF)

CFF conducts extensive satellite tagging of loggerhead turtles.

OBJECTIVE III: Document Regional Stakeholder Specific Uses of Marine Animal Telemetry and Biodiversity Data

THEME A: "We would be flying blind without the telemetry data."

THEME B: Marine animal telemetry and biodiversity observations support the Integrated Ecosystem Assessment (IEA) process with vital information.

THEME C: The NEFSC acoustic and satellite telemetry programs support a wide range of stakeholders needs as they search for results that will inform important fisheries management questions.

THEME D: The offshore wind industry sees a primary value of the ATN and MBON observations to be that they can increase situational awareness in real time.

FEDERAL AGENCIES

NOAA/NMFS Integrated Ecosystem Assessments (IEA)

Marine animal telemetry and biodiversity observations support the Integrated Ecosystem Assessment (IEA) process with vital information by providing: i) better localized information to identify how species distributions are shifting, and ii) quantitative measures of how community structures are changing and are being impacted by anthropogenic disturbances.

NMFS/Northeast Fisheries Science Center (NEFSC)/Protected Species Branch

The NEFSC acoustic and satellite telemetry programs support a wide range of stakeholders needs—including fishing, offshore energy (wind/tidal/oil), agriculture, water, hydropower-freshwater, aquaculture, defense, conservation, shipping, eco-tourism, and recreational water use—as they search for results that will inform important fisheries management questions. These include:

- Where do the fish and marine animals go?
- Why do they go there?
- Are those reasons changing?
- Are people doing things there, too? (i.e., is there a conflict?)

Tracking data is also used to evaluate the success of ecosystem management activities and to provide reference data for offshore energy development, construction sites, etc.

U.S. Army Corps of Engineers (USACE)

ATN and MBON data would aid the USACE in both their project impact assessments and in implementing best management practices (e.g., time of year restrictions, observers, haul routes) by providing consistently updated data showing project site usage year-round for marine animals, mammals, turtles, and endangered species. Additionally, real-time data of animal locations and behaviors during project activities could help avoid impacts to the resource and aid in the planning of future work. USACE would require the data to be accessible, reliable, and queryable.

Wells National Estuarine Research Reserve (NERR)

The significant amount of resource/conservation management and research activities underway at the Wells NERR includes the Sentinel Site Program to monitor long-term changes in tidal marshes and the System Wide Monitoring Program (SWMP). SWMP is an issue-driven, long-term monitoring program that embraces biological monitoring to assess changes in habitats and biodiversity (fish/plants) with relevance to management issues and can improve understanding and inform decisions affecting estuaries and coastal watersheds. Organized like the EPA National Estuary Program (NEP), the Wells NERR is part of a national network of 29 NERR sites, all of which operate a similar SWMP. Other nearby NERRs are located in Great Bay, New Hampshire; Waquoit Bay, Massachusetts; and Narragansett Bay, Rhode Island.

Stellwagen Bank National Marine Sanctuary (SBNMS)

The SBNMS mission is to conserve, protect, and enhance the biodiversity, ecological integrity, and cultural legacy of the sanctuary while allowing for compatible use. Years of seabird satellite tagging, whale behavior, and acoustic fish tagging data have been collected in support of this mission. Passive acoustic sound recordings are specifically used to characterize the holistic soundscape and further the understanding of sound-producing species' behavior, patterns in sound production, and human-made sound inputs. By comparing other data sources, it is possible to assess how the components of soundscapes relate to specific behaviors of fish, marine mammals, and humans.

National Science Foundation – Long-Term Ecological Research (LTER) Program

Through observations, experiments and models, the Northeast U.S. Shelf LTER program seeks answers to the following questions:

- What are the main factors controlling patterns of plankton species composition and biological production?
- How is variability in the feeding and distribution of fish linked to variability in plankton species, sizes, and production?
- What is the vulnerability and resilience of the Northeast U.S. Shelf ecosystem (and the services it provides) to climate-induced environmental changes?

Environmental Protection Agency (EPA) National Estuary Programs (partially federally-funded)

- The Casco Bay Monitoring Plan seeks answers to four Priority Topic questions: Are anthropogenic nutrients making the Bay less healthy? Are coastal habitats of Casco Bay both healthy and abundant enough to support ecosystem processes and protect the vitality of the Bay? Is the food web of Casco Bay changing and does it support marine biodiversity, food production and key ecosystem services? How do humans derive material and cultural benefits from the Bay?"
- The Piscatagua Regional Estuaries Partnership summarizes data from monitoring programs in the region using environmental and social indicators, which are measurable markers that help interpret the condition of the environment and how it changes over time. The Partnership currently tracks 23 different indicators of water quality, shellfish resources, land use, critical species and habitats, and social behavior and every five years publishes a status and trends report called the State of Our Estuaries.

STATE AGENCIES

Massachusetts Division of Marine Fisheries (MADMF)

Since 2008 the MADMF has invested heavily in acoustic telemetry to inform fisheries management decisions. The data collected generates essential information that is used to create time-area fishery closures and to make best practice recommendations to reduce discard mortality for several groundfish species. It is a research tool that is vital to furthering our knowledge about species that are commercially and recreationally important to the commonwealth.

The MADMF Shark Research Program uses data from a combination of individual sightings, aerial surveys, and acoustic and satellite telemetry to study both fine-scale and broad-scale movement ecology of white sharks in and around the Massachusetts/Cape Cod area, as well as along the entire U.S. East Coast and into the North Atlantic. These observations/data help MADMF to achieve its goals of: i) fostering cooperative research, ii) participating in state, regional, and federal management processes and iii) providing public education on these shark species.

ACADEMIA

University of New Hampshire (UNH)

By implanting small acoustic tags into juveniles and monitoring the signals with strategically placed receiver arrays, it is possible to track survival of the fish over the course of their migration.

The goal of the collaborative pilot eDNA program at UNH is to assess the value of eDNA monitoring at research reserve sites and provide end users with key training to support informed decisions regarding the implementation and use of eDNA monitoring in estuarine systems.

University of New England – Marine Science Center

Movement patterns determined from telemetry studies are specifically used to help fishermen adapt their techniques to improve bycatch avoidance of porbeagle sharks.

Satellite tagging has been used to study seasonal and life-stage variation in the reproductive ecology of some species and has demonstrated significant differences in the movement patterns of pregnant and non-pregnant females. In an effort to protect nursery grounds they are also in the process of developing a "birth-tag," a novel intrauterine satellite tag designed to pinpoint the timing and location of pupping of highly mobile shark species.

NGOs

Green Marine

An acoustic monitoring capability for real-time detection of whales in "dynamic shipping lanes" currently does not exist but is an essential component for a whale strike dynamic management mitigation strategy to be effective.

Atlantic White Shark Conservancy

The Atlantic White Shark Conservancy mission is focused specifically on supporting white shark research, improving public safety, and educating the public to inspire shark conservation; telemetry data are used in all three of these mission areas. In fact, they declare they "would be flying blind" without the telemetry data.

Gulf of Maine Research Institute (GMRI)

GMRI research scientists are engaged in a variety of fisheries ecosystem studies that help to identify variations in movement patterns and distribution of fish that may be responding to changes in ocean conditions (e.g., warming) and food-web structure (e.g., predator loss/addition). Their study approaches include using acoustic tagging with large receiver arrays to investigate, for example, if different cod ecotypes display variable movement and residency, as well as how haddock use the offshore closed area. A primary goal of the Casco Bay Aquatic Survey System is to provide a baseline of current fishery ecosystem conditions in coastal Maine waters for comparison with future conditions, as well as to use catch trend data to validate the eDNA monitoring technique.

Coonamessett Farm Foundation (CFF)

The CFF turtle research project dates back two decades when it was centered primarily on bycatch research motivated by a steady up-tick in turtle interactions with scallop gear in the mid-Atlantic bight. Technical efforts aimed at bycatch mitigation included the testing and development of several methods that became mandatory for the scallop fishing industry. A parallel ecological research program for turtles aims at understanding the migratory phase of the North Atlantic foraging population and how their habitats are being impacted by warming waters in the western North Atlantic.

NMFS/Northeast Fisheries Science Center/Coonamessett Farm Foundation deploying a suction cup camera tag on a leatherback turtle. ESA Permit number 22218. Photo Credit: Heather Haas

COMMERCIAL/PRIVATE SECTOR

Ørsted Offshore North America

The offshore wind industry sees a primary value of the ATN and MBON observations to be that they can increase situational awareness in real time. For example, an enhanced marine mammal sighting network can: i) provide more efficient and effective mitigation, ii) benefit conservation through increased awareness in the maritime community of whale presence, especially in Dynamic Management Areas, to reduce ship strikes, and iii) assist the research community in assessing status of the species (e.g., health assessments, population abundance). Additionally, the value of a long-term biological observation network, specifically to wind energy development applications, includes improving pre-activity assessments, mitigating impacts to protected species, monitoring effects from other activities (shipping/fishing), identifying other sources of impacts as well as the value of wind farms to improving ecosystems.

Bar Harbor Whale Watch

Bar Harbor Whale Watch has identified the following needs for telemetry and biodiversity data, which include:

- Monitoring herring, sand lance, and plankton abundance to better understand what drives forage-based dynamics
- Understanding how animals are using habitat and what is important to them for survival
- Linking the movement of species with changes in oceanography
- Learning how trophic cascades work in the Northeast

Right whale mother and calf sighted during survey. Image collected under MMPA Research permit number 17355.
Photo credit: NOAA Fisheries/Christin Khan

OBJECTIVE IV. Identify Infrastructure and Data Management Challenges and Opportunities that Exist in the Region

OPPORTUNITIES

- **Observations**
  - ◊ The breadth of information the ATN/MBON observations can provide enables them to help deliver the valuable "So What" message to funders.
  - ◊ Estuarine Research Reserves are at the forefront of research about the effects of climate change.
  - ◊ We need to update ocean models by incorporating turtle-derived data and glider data.
  - ◊ Stellwagen Bank is a microcosm of changes happening in the Gulf of Maine; it is a national resource and a natural opportunity.
  - ◊ State-of-the-art mitigation tools are recommended during geological and geophysical surveys.
  - ◊ Acoustic telemetry is a research tool that is vital to furthering our knowledge about species that are commercially and recreationally important to the commonwealth.
  - ◊ Satellite tagging data is not effort-dependent and thus better reflects true animal distributions.
  - ◊ The Casco Bay Aquatic Systems Survey has the greatest potential for telemetry to add value to regional monitoring efforts.
  - ◊ eDNA strengths: a powerful, relatively inexpensive technique, which is becoming more accessible; DNA extractions can be archived and reanalyzed for more/different species.
  - ◊ The Northeast region is a prime location for development of an integrated telemetry and biological observation network.
  - ◊ Significantly more telemetry studies could be possible by directing at least 1% of the $250 billion recreational fishing industry income toward funding them.
  - ◊ The MADMF perspective is that a long-term sustained biological observation network in the Northeast region is essential for efficiently sharing and retrieving information, reducing workload for researchers while improving data quality.
- **Applications/Products**
  - ◊ Envision suitable thermal habitat for loggerheads through the year 2100 using climate change models.
  - ◊ Fund real-time monitoring and mitigation solutions to reduce vessel strike risk and minimize harassment.
- **Data Accessibility/Management**
  - ◊ Implementing tool integration – for example, linking the Northeast real-time acoustic network (Robots 4 Whales/digital acoustic monitoring instrument [or DMON] buoy, Stellwagen Bank North Atlantic Right Whales Listening Network, Coastal Acoustic Buoys) to existing ocean observing systems.
  - ◊ The NERACOOS Data Management System applies THREDDS and ERDDAP, state-of-the-art tools, to ensure both human-readable and machine-to-machine accessibility of all the available data and can produce hundreds of thousands of observations in seconds.
  - ◊ The Integrated Sentinel Monitoring Network fills a sampling gap and facilitates integration of multiple datasets aimed at predicting future North Atlantic right whale foraging distributions.
  - ◊ The Northeast Ocean Data Portal is the source of over 4,000 map products showing the footprint of activities and resources—as well as data provided by federal, state, and other stakeholders, and its display is customized to address regional stakeholder and agency needs.
- **Community Building/Collaboration**
  - ◊ Convene diverse and often competing stakeholders to solve complex problems. We work with partners and networks to leverage knowledge, relationships, and resources to increase shared impact.
  - ◊ Develop innovative partnerships aimed at long-term solutions.
  - ◊ Compound the power of telemetry by combining with other techniques and perspectives. Thus, integrated networks facilitate and drive higher-impact science by leveraging resources, asking bigger questions (spatial and temporal scales), and implementing novel observations/meta-analyses.

◊ Atlantic White Shark Conservancy is responding to the public perception of the safety risk from sharks close to shore with education through events and exhibits at their visitor's center and local school programs, plus community outreach with lectures in the local and greater New England area. They have also developed the "Sharktivity" app for iPhones to help raise public awareness, installed beach-based safety messaging billboards, and deployed real-time acoustic detection buoys to detect the presence of tagged sharks.

CHALLENGES

- **Observations**
  - ◊ Arctic ice-free summers are only 30 years away.
  - ◊ Global collaboration is needed to ensure a successful commitment for long-term biological observations.
  - ◊ While telemetry has played a role in our ecosystem research studies, we have not yet found a way to incorporate it into longer-term monitoring due to the costs associated with doing so.
  - ◊ The Gulf of Maine is warming faster than 90% of the world's waters!
  - ◊ A sustained biological network is essential. However, there are "priceless data to be collected but nobody wants to pay for it."
  - ◊ eDNA challenges include: lack of standards, very large data sets with associated metadata, and "It is harder than you think!"
  - ◊ An acoustic monitoring capability for real-time detection of whales in dynamic shipping lanes currently does not exist, but is an essential component for an effective whale strike dynamic management mitigation strategy.
  - ◊ How can we get funding for research/field assistants and science monitoring?
- **Data Analysis/Accessibility/Management**
  - ◊ Data need to be accessible, reliable, and queryable.
  - ◊ How can we better collect/share monitoring information?
  - ◊ Integrating observations of organisms using different methods is difficult (i.e., every sampling and every analysis method "filters" the in-situ community).
  - ◊ Harmonizing taxonomic groups between different datasets is especially challenging if some data are molecular operational taxonomic units.
  - ◊ How can we contribute data to improve ecosystem management?
  - ◊ Having access to the data from a long-term sustained biological observation network in the Northeast region would benefit everyone, as long as there is a publicly shared database.
- **Community Building/Collaboration**
  - ◊ Global collaboration is needed to ensure a successful commitment for long-term biological observations.
  - ◊ The growing shark population increases opportunities for more shark research, eco-tourism, and citizen science. It is countered, however, by the strong public perception of the beach safety risks associated with sharks swimming close to shore.

Wells National Estuarine Research Reserve, Wells Maine. Photo Credit: Intrepid Aerial Photography, Wells NERR

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Stellwagen Bank National Marine Sancturary file photo courtesy of On The Water, LLC

Portland Head Light
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