NOAA Technical Memorandum NMFS

AUGUST 2014

MEETING OUR NATION'S NEEDS FOR BIOLOGICAL AND ENVIRONMENTAL MONITORING: STRATEGIC PLAN AND RECOMMENDATIONS FOR A NATIONAL ANIMAL TELEMETRY NETWORK (ATN) THROUGH U.S. IOOS

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NOAA-TM-NMFS-SWFSC-534

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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NOAA-TM-NMFS-SWFSC-534

U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service
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This document should be referenced as follows:

Moustahfid H., M. Weise, S. Simmons, B. Block, K. Holland, J. Ault, J. Kocik, D. Costa, S. T. Lindley, B. Mate, S. Hayes, C. M. Holbrook, A. Seitz, M. Arendt, J. Payne, B. Mahmoudi, C. Alexander, P. Moore, J. Price, D. Wilson. 2014. D š] v P } µ Œ E š] } v [• v • (} Œ] } o } P] o v v À] Œ } v u v š Strategic plan and recommendations for a National Telemetry Network (ATN) through U.S. IOOS. U.S. Department of Commerce, NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-534, 7 p.

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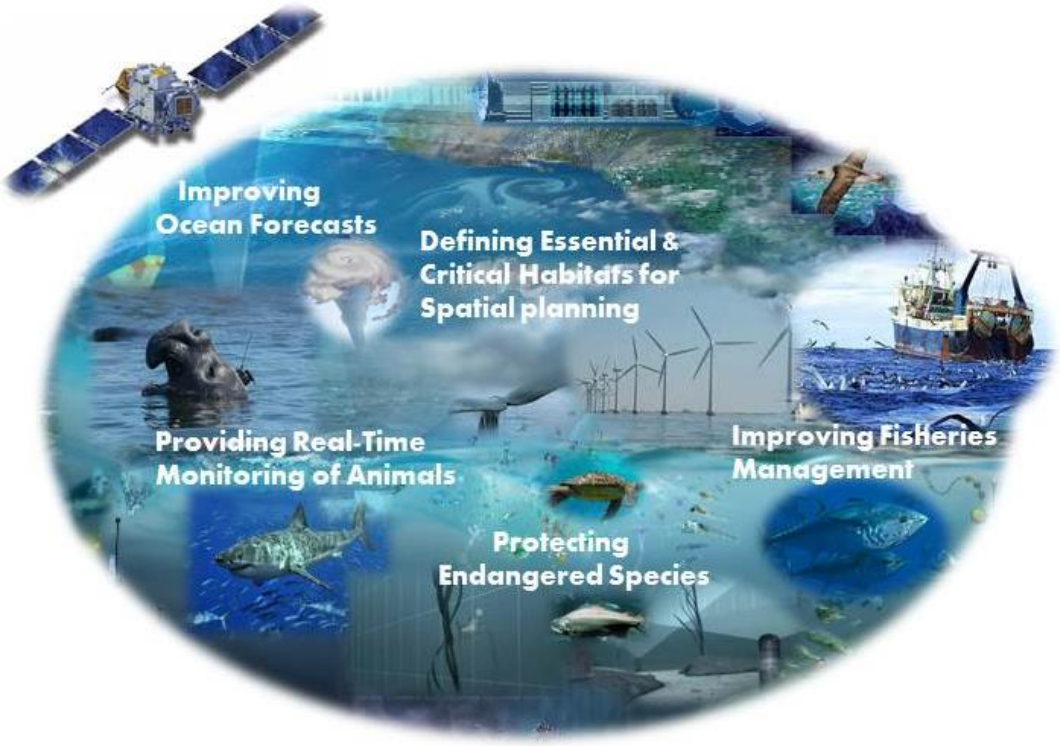

Benefits of a National Animal Telemetry Network

Summary

Animal telemetry is the science of elucidating the movements and behavior of animals as they move š Z Œ } µ P Z š Z Á } Œ o [• } v • U } • š o Œ] À Animal telemetry µ Œ À]] • • v – ^ š P Œ • _ š • o l yield detailed data regarding animal responses to the coupled ocean-atmosphere and physical environment through which they are moving. This can be done in near-real time, or by use of archival tags in which the data are stored or later transmitted to an array of sensors or satellites. Animal species tagged have ranged from 6-gram salmon smolts to 150-ton whales. Detailed observations of animal movements and behavior in relation to critical habitats in their aquatic environment have significantly improved our understanding of ecosystem function and dynamics. These observations are critical for sustaining populations, conserving biodiversity and implementing ecosystem-based management through an increased understanding of ecosystem structures, functions, and processes, as well as, their importance to ecosystem services and values. Sensors carried by animals have recently come of age and deliver high resolution physical oceanographic data at relatively low costs. Animals are particularly adept at helping scientists identify critical habitats, spawning locations, and important oceanographic features (e.g., fronts, eddies and upwelling areas). They also provide important insights into regions of the oceans that are difficult and expensive to monitor (e.g., offshore environments, Arctic). Animal telemetry observations can inform federal and state resource managers through improved spatial models of animal dynamics, and improve the basis of conservation and sustainable-use fishery management policies. A national Animal Telemetry Network (ATN) through the U.S. Integrated Ocean Observing System (U.S. IOOS) will integrate a range of operational telemetry technologies that enable monitoring of a host of aquatic life over multiple temporal and spatial scales. A national ATN will provide exciting and important short and long-term benefits, including enhancing fisheries and ecosystem-based management, filling oceanographic knowledge gaps and improving ocean modeling and forecasting, and advancing many of the National Ocean Policy (NOP) Implementation Plan priority objectives.

Animal Telemetry: What is it?

Animal telemetry is the process of obtaining both biological and physical oceanographic data remotely (via a "tag" secured to the animal). Currently about 10 standard tag types exist with distinct position and sensor capabilities, and the technology can be thought of in three broad categories distinguished by the method of data recovery: archival, satellite and acoustic.

ARCHIVAL: In the simplest configuration all data collected are archived in the tag and a complete record is reconstructed when the tag is physically recovered. Because all of the archived record can be accessed, records from archival tags are often the most detailed. However, recovery of the animal/tag is not always predictable or feasible.

SATELLITE: Data collected by these tags can be relayed in real-time (or delayed mode) via satellite. Due to limited bandwidth in these transmissions not all of the data can be relayed. This results in a need for some data-processing on the tag and only a subset or summary of the data being recovered. However, as the instrument does not have to physically be recovered these tags can be deployed on animals not suitable for archival tags alone.

ACOUSTIC: There are two forms of acoustic telemetry: active and passive. Active telemetry involves following tagged animals with some type of pursuit vessel equipped with a directional

hydrophone. Passive telemetry includes tags that record animal and environmental sounds, and utilizes arrays of underwater receivers to detect and record signals transmitted by tags on animals that come within range. Some tags actively transmit data such as temperature and depth and the identification of the tagged animal. Acoustic telemetry is particularly useful for studying aquatic species that do not surface often (making data recovery via satellite impractical) or are too small to carry archival or satellite tags.

Animal Telemetry: Why is it Significant?

Using animal telemetry, it is now possible to record the ocean environment and fine-scale behavior of]v]À] µ o• À v]v šZ u}•š Œ u}š Œ P]}v• }(šZ Á}Œo [• } v•X d P vertical oceanographic profiles throughout the upper 1500 m of the water column and in some cases deeper (3000m). Animals travel to regions that are relatively inaccessible to other ocean observing technologies, such as the polar oceans beneath seasonal or permanent sea ice or remote atolls such as those in the Northwest Hawaiian Islands. Additionally animals move into locations and sample where ARGOS floats are often pushed away (upwelling zones) and across political boundaries. This technology allows researchers to investigate how animals use their three-dimensional world and can provide valuable, additional oceanographic data to augment other ocean observing technologies. These data can be used to improve ocean forecasting models by reducing ocean model initial condition errors.

Autonomous platforms are the backbone of the global *in situ* ocean observing system. In the last 25 years, technological advances have made it possible to use animals as ocean observing platforms to carry remote-sensing devices. Animals carrying sensors are mobile autonomous platforms that are relatively inexpensive to deploy (compared to ocean gliders or Autonomous Underwater Vehicles) and provide important insights into U.S. coastal and EEZ areas, and are particularly useful in the open oceans that are difficult and expensive to monitor (e.g. Arctic and Antarctic regions). Animals are adept at finding areas of particular interest to oceanographers, including surface and sub-surface fronts, eddies, and confluences that aggregate prey. Data collected by animal telemetry include: oceanographic water column profiles (temperature, conductivity, light level, oxygen, and tag derived variables such as chlorophyll proxies from light extinction) as well as behaviors in (} Œ P] v P ^ Z } š • ‰ } š • U _ } o } P] o interactions, migration routes and habitat utilization patterns. Animal telemetry complements gliders and other autonomous vehicle products to provide unique and cost effective data from poorly sampled ocean regions, and is rapidly becoming an integral component of the Global Ocean Observing System, especially at high latitudes (i.e. Antarctica).

The combination of position technology, plethora of tag sensors, and variety of data recovery options provide a tremendous capacity to investigate how animals use their three-dimensional world, to quantify important physical and biological aspects of their environments and begin to elucidate their ecosystem functions. Thus animal telemetry observations can inform federal and state fisheries management, conservation and sustainable use management policies, and provide unique datasets for resource management and ocean modelers. Furthermore, the inclusion of biological resources in ocean observation is critical to advancing National Ocean Policy priority objectives, particularly Ecosystem-Based Management and marine planning. Monitoring aquatic species via animal telemetry is valuable not only in terms of increasing the perceived value of protected and exploited resources and minimizing human impacts, but also for the data those species deliver as roving reporters about the oceans, our changing climate and by extension our terrestrial weather.

Vision and Value of a National Animal Telemetry Network (ATN) through U.S. IOOS

The U.S. Integrated Ocean Observing System (U.S. IOOS) is a national-regional partnership working to provide new tools and forecasts to improve safety, enhance the economy, and protect our environment. The U.S. IOOS is a partnership of 18 Federal agencies, 11 Regional Associations (RAs), the Alliance for Coastal Technologies (ACT), and the U.S. IOOS Coastal and Ocean Modeling Test bed. The list of the U.S. IOOS federal agencies and RA partners can be found at http://www.ioos.noaa.gov. A national ATN through U.S. IOOS will provide integrated data on aquatic ecosystems from species to environment. This network will complement existing ocean observing assets and will inform ecosystem-based management, fisheries and biodiversity, marine planning, ocean modeling and forecasting, and National Ocean Policy priority objectives.

Core principles of the ATN:

- An observing system that can track aquatic animals and their habitats is critical for the conservation and sustainable management of commercially harvested species, protected species and other marine resources.
- A multidisciplinary approach is the only way to address the problems confronting aquatic species conservation and management.
- Shared data structures for biological and ocean data will facilitate multidisciplinary work of physical oceanographers and biological scientists.

To achieve a collective vision of sustainable marine resource use and conservation, a national ATN will engage and meet the biological and environmental monitoring needs of multiple end-users including 1) Federal and state agencies; 2) fisheries, marine mammal, sea turtle and bird conservation and management communities; 3) tribal communities; 4) the energy sector; 5) the tourism sector; 6) the general public; 7) educational institutions; 8) private industry.

Potential benefits and beneficiaries of a national ATN through U.S. IOOS include:

- **Provide the scientific basis for marine fisheries and protected-endangered species management.** This includes fisheries management as mandated under the Magnuson-Stevens Act, Ecosystem-Based Management (EBM) as mandated under the National Ocean Policy implementation plan, and management decisions for the recovery of protected marine species, such as marine mammals, fish and turtles as mandated under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). The ATN will provide near real-time geospatial data integral to realistic parameterization of spatially explicit population and fishery assessment models. Such models assist with the conservation of species and the maintenance of biodiversity ensuring U.S. adherence to international agreements that provide a policy framework for effective management of trans-boundary fisheries and global oceans, such as the United Nations (UN) Convention on the Law of the Sea, the UN Fish Stocks Agreement, and the International Convention on Biological Biodiversity. (Beneficiaries: Primarily NOAA, USFWS, and state agencies as the primary agencies charged with aquatic species management in coastal waters t secondarily any other agency or researcher whose activities may impact those species).
- **Define essential or critical habitats** for species protected under the ESA and MMPA through the investigation of regional connectivity of marine biological resources and integration of ocean

observation systems across large marine ecosystems, sanctuaries, and marine protected areas. NOAA and USFWS among other agencies will benefit from such efforts.

- **Provide real-time monitoring of marine fish, turtles, birds, and mammals** that facilitate management of marine protected areas, identification of operational windows for construction/dredging or other industrial activities, assess the impact of major environmental events, and the enforcement of fisheries regulations, to avoid harming sensitive stocks and to improve fisheries harvests. Beneficiaries from such data include: NOAA, NPS, NAVY, and BOEM.
- **Evaluate the potential effects of anthropogenic disturbances.** ATN will provide the critical baseline for behavior and movement of aquatic species that will aid agencies and industries that are required to assess the impact of their activities (e.g. coastal/estuarine/riverine development, ocean thermal energy conversion and wind farm energy development, aquaculture sites, military activities, shipping, sewage treatment facilities, and marina development) under U.S. environmental regulations. Among the beneficiaries: BOEM, DOE (Bonneville Power), USFWS, NAVY, NOAA, OR&R, USACE, coastal state resource agencies and private industry.
- **Improve coupled ocean-atmosphere observation and forecasting models.** Animal telemetry provides large volumes of oceanographic water column profiles (temperature, conductivity, light level, oxygen, chlorophyll), and complements gliders and other autonomous vehicle products to provide unique and cost effective data from poorly sampled ocean regions. ATN data will also provide increased understanding of ecosystem processes and improve predictions of future ecosystem conditions including storms, floods, drought, climatic variation and other weather. Beneficiaries: NAVY/NAVOCEANO, NOAA/NCEP, USCG, State agencies and private industry.

Integrating ATN into U.S. IOOS

Although tremendous telemetry infrastructure exists in the U.S. these assets are currently operated independently by multiple agencies and institutions. Many, but not all, of the existing programs have the capability to provide live updates on animal movements, behavior, and oceanographic environment data. Some of the programs are organized within regional networks (e.g., California Fish Tracking Consortium) but there are limited connections between the regional networks. Thus data display, quality control, and availability or recovery of data varies across the current infrastructure. A national ATN that employs common data standards and practices, maintains and disseminates an integrated data display and coordinated data storage of animal telemetry data gathered by private, academic, local, state and federal institutions is needed to fully realize the value and potential of existing infrastructure and maximize future development. A national ATN will reduce any redundancy among academic and federal ocean, coastal, and Great Lakes animal telemetry programs; identify and address gaps in the coordination and implementation among federal, state, and academic animal telemetry programs; and increase integration of best available science in marine resource management and increased leveraging of resources across federal, academic, and private entities.

The National Ocean Policy calls for strengthening the U.S. capacity to observe our n š] } v [• } v • U coastal waters, estuaries, rivers and great lakes. The U.S. IOOS is providing a framework for the integration of ocean, coastal, and great lakes observing capabilities. The development of U.S. IOOS initially focused on the acquisition and integration of physical and chemical oceanographic data. With this system now operational, U.S. IOOS is ready to add the acquisition of relevant biological observations, and to enhance the acquisition of physical and chemical oceanographic observations via ATN platforms.

Animal telemetry is currently at a grassroots level and U.S. IOOS is poised to take a leadership role nationally and internationally. Similar national and international telemetry enterprises already exist in several other national ocean observing programs (such as the Integrated Marine Observing System (IMOS): http://www.imos.org.au/ in Australia and the Ocean Tracking Network (OTN) in Canada: http://oceantrackingnetwork.org/). By developing, maintaining and disseminating an integrated data display and archive of animal and telemetry data gathered by private, academic, local, state and federal institutions, U.S. IOOS has the capacity to lead and strengthen our national ocean observing capabilities in this area. Improved ATN ocean observing capabilities will augment our knowledge and understanding of ocean ecosystems and our ability to engage in science-based decision-making and ecosystem-based management.

Recommendations

The following are recommendations for how U.S. IOOS can integrate ATN efforts into a national, and ultimately international system to deliver critical information on biological resources and ecosystem functions, as well as oceanographic data that will complement and enhance existing observing capability:

1. Invest in, deploy and maintain a combination of key assets (archival, satellite and acoustic tags and infrastructure) through the U.S. IOOS Regional Associations forming the backbone of a national ATN.
2. Develop and maintain a national data management capacity by establishing common data standards and an infrastructure for animal telemetry data flowing through the Regional Associations and interoperable with international systems.
3. Develop a plan for sustained long-term support for a) maintenance of infrastructure for receiving data (such as acoustic receiver arrays), b) tag deployment through the U.S. IOOS Regional Associations (e.g. animals carrying sensors on all coasts), c) data management system and capacity challenges, and d) advancement of technology to ensure ongoing biological and geophysical animal telemetry observations.
4. Synthesize animal telemetry products and increase their availability to support aquatic species management, to promote training in relevant emerging disciplines (e.g. GIS, sensor technologies),and advance the NOP Implementation Plan.
5. Advance the national capacity for accessing animal oceanographic telemetry data in near-real time via the Global Telecommunications System (GTS), and enhance the capacity to assimilate ATN data daily into ocean models.
6. Establish pathways for rapid data sharing and maintenance at regional, national and international levels. This will help avoid duplication of effort and ensure data are compatible and accessible for analyses and assimilation by computer models.
7. Promote investment in new and lower cost tags and sensors (e.g. pH and oxygen sensors) in response to growing concerns about the potential impacts of ocean acidification and hypoxia on marine biological resources and the health of marine ecosystems.
8. Expand animal telemetry outreach and education programs. Animals are a way to foster public understanding of the value of the ocean, coasts, great lakes and ocean observing systems.

List of Agency Acronyms:

NOAA- National Oceanic and Atmospheric Administration
NCEP- National Centers for Environmental Prediction
USFWS- US Fish and Wildlife Service
BOEM- Bureau of Ocean Energy Management
DOE - Department of Energy
OR&R- Office of Response and Restoration
NAVOCEANO- Naval Oceanographic Office
USACE- US Army Corps of Engineers