ANIMAL TELEMETRY NETWORK IMPLEMENTATION PLAN 2016-2021

PRODUCT OF THE
NATIONAL OCEAN COUNCIL

December 2016

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL OCEAN COUNCIL
WASHINGTON, D.C. 20502

December 19, 2016

Dear Colleagues:

We are pleased to transmit to you the *Animal Telemetry Network Implementation Plan 2016-2021*, a summary of a preliminary design for coordinating aquatic animal telemetry research, operations, and data management across the United States. This document was produced by the Animal Telemetry Network (ATN) Task Team of the Interagency Ocean Observations Committee (IOOC), which is organized under the Subcommittee on Ocean Science and Technology (SOST) of the National Science and Technology Council's Committee on Environment, Natural Resources, and Sustainability (CENRS). The SOST also functions as the Ocean Science and Technology Interagency Policy Committee under the National Ocean Council. The document was developed in the context of international animal telemetry data standards and best practices. It should be considered as a companion to the IOOC ATN Task Team developed *Strategic Plan and Recommendations for a National Animal Telemetry Network (ATN) through U.S. IOOS*.

The *Animal Telemetry Network Implementation Plan 2016-2021* responds to actions within the National Ocean Policy Implementation Plan concerning the development of ocean biological variables, including the charge to advance technologies to explore and better understand biological interactions in the ocean. Specifically, the National Ocean Policy Implementation Plan calls for the extension of current ocean biological data standards to allow for increased interoperability with other biological, physical, and social data systems. This document also responds to recommendations developed by the United States ocean observing community during the U.S. Integrated Ocean Observing System (U.S. IOOS®) Summit. Specifically, Summit participants identified the need to more effectively integrate biological and ecosystem observations into ocean and coastal information systems.

Sincerely,

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About the National Ocean Council

The National Ocean Council (NOC) is charged with implementing the National Ocean Policy established in July 2010 under Executive Order 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes. The NOC released the National Ocean Policy Implementation Plan in April 2013 to translate the National Ocean Policy into specific actions Federal agencies will take to address key ocean challenges, streamline Federal operations, save taxpayer dollars, and promote economic growth. Federal agencies, states, tribes, and regional fishery management councils may choose to form regional planning bodies to provide communities greater collaborative input in these efforts. More information is available at www.whitehouse.gov/administration/eop/oceans.

About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development (R&D) enterprise. One of the NSTC's primary objectives is establishing clear national goals for Federal science and technology investments. NSTC prepares R&D packages aimed at accomplishing multiple national goals. The NSTC's work is organized under five committees: Environment, Natural Resources, and Sustainability; Homeland and National Security; Science, Technology, Engineering, and Mathematics (STEM) Education; Science; and Technology. Each of these committees oversees subcommittees and working groups that are focused on different aspects of science and technology. More information is available at www.whitehouse.gov/ostp/nstc.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President in policy formulation and budget development on questions in which science and technology are important elements; articulating the President's science and technology policy and programs; and fostering strong partnerships among Federal, state, and local governments, and the scientific communities in industry and academia. The Director of OSTP also serves as Assistant to the President for Science and Technology and manages the NSTC. More information is available at www.whitehouse.gov/ostp.

About the Council on Environmental Quality

The Council on Environmental Quality (CEQ) coordinates Federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives. CEQ was established within the Executive Office of the President (EOP) by Congress as part of the National Environmental Policy Act of 1969 (NEPA), and additional responsibilities were provided by the Environmental Quality Improvement Act of 1970. Through interagency working groups and coordination with other EOP components, CEQ works to advance the President's agenda. It also balances competing positions, and encourages government-wide coordination, bringing Federal agencies, state and local governments, and other stakeholders together on matters relating to the environment, natural resources, and energy. CEQ co-chairs the National Ocean Council, along with OSTP. More information is available at www.whitehouse.gov/ceq.

About the Subcommittee on Ocean Science and Technology

The purpose of the Subcommittee on Ocean Science and Technology (SOST) is to advise and assist on national issues of ocean science and technology. The SOST contributes to the goals for Federal ocean science and technology, including developing coordinated interagency strategies, and fosters national ocean science and technology priorities. The SOST also serves as the Ocean Science and Technology Interagency Policy Committee under the NOC, and ensures the interagency implementation of the National Ocean Policy and other priorities for ocean science and technology objectives. More information is available at www.whitehouse.gov/administration/eop/ostp/nstc/oceans.

About the Interagency Ocean Observations Committee

The purpose of the Interagency Ocean Observations Committee (IOOC) is to advise and assist the SOST on matters related to ocean observations, including coordination of Federal activities on ocean observations and other activities as described in the Integrated Coastal and Ocean Observation System Act of 2009 (P.L. No. 111-11, Subtitle C).

About the IOOC Animal Telemetry Network Task Team

The IOOC established the Animal Telemetry Network Task Team (ATN-TT) to distribute and socialize the *Strategic Plan and Recommendations for a National Animal Telemetry Network (ATN) through U.S. IOOS* and develop an ATN implementation plan for aquatic species.

About this Document

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Executive Summary

Aquatic animal telemetry is the science of elucidating the movements and behavior of animals as they move through the world's oceans, coastal rivers, estuaries, and Great Lakes. Current capacity to track aquatic animals has found uses in many fields of marine science ranging from the study of animal behavior to the study of the oceanic and freshwater systems these animals inhabit. In the past two decades, rapid advances in transmitters, receivers, and data storage tags that are attached to animals have made it possible to collect high-quality biological and oceanographic observations on timescales varying from days to years as the animals move through aquatic habitats. These observations provide scientific information that is used to inform the management of marine fisheries and endangered and protected species; assess the potential effects of anthropogenic disturbances on aquatic species; and improve ocean modeling and forecasting.

The United States is a global leader in aquatic animal telemetry, with considerable telemetry infrastructure and technical expertise in telemetry operations. These research assets, however, are often owned and operated independently by multiple Federal agencies and non-Federal institutions with limited or no connectivity. Lack of institutional connections prevents the scientific community from efficiently coordinating data and thereby best serving societal needs. The *Strategic Plan and Recommendations for a National Animal Telemetry Network (ATN) through U.S. IOOS* (United States Integrated Ocean Observing System (U.S. IOOS®)) (swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-534.pdf) and this document are designed to address these issues.

The ATN is supported by multiple Federal agencies that have been involved with developing this plan through participation in an Animal Telemetry Network Task Team of the Interagency Ocean Observations Committee (IOOC), which is organized under the Subcommittee on Ocean Science and Technology (SOST) of the National Science and Technology Council's Committee on Environment, Natural Resources, and Sustainability. The SOST also functions as the Ocean Science and Technology Interagency Policy Committee under the National Ocean Council. The U.S. IOOS (Program Office will implement the ATN in partnership with the Interagency Ocean Observations Committee (IOOC) member agencies and in collaboration with the community of U.S. IOOS Regional Associations (U.S. IOOS RAs) and regional experts. This plan describes the Network Governance by a Network Coordinator who will work in close collaboration with the ATN Steering Group (SG), which will include IOOC Federal agency representation and U.S. IOOS RAs, and which will be responsible for the coordination of ATN activities and operations throughout U.S. IOOS regions.

The ATN, under the auspices of the U.S. IOOS, will provide a mechanism to facilitate and empower an alliance among Federal, industry, academic, state, local, tribal, and non-Federal organizations (hereafter referred to as Federal and non-Federal entities) to coordinate aquatic animal telemetry infrastructure and operations. By maximizing collaborations within the community and simplifying access to aquatic animal telemetry data and information products, the ATN will support U.S. IOOS in delivering data that provides societal benefits. Additional data will improve predictions of climate change and help inform decisions about protecting and restoring healthy coastal ecosystems. Federal and non-Federal entities have natural resource management requirements that can be met by information derived from aquatic animal telemetry. Federal agencies routinely collect aquatic animal telemetry data to manage marine fisheries and protected species under Federal legislation such as the Magnuson-Stevens Fisheries Conservation and Management Act, the Marine Mammal Protection Act, the Endangered Species Act, and the National Marine Sanctuaries Act. Other Federal and non-Federal entities conduct activities that could affect the environment, so telemetry data are collected to support compliance with Federal statutes such as the National Environmental Policy Act, Marine Mammal Protection Act, and Endangered Species Act. Additionally, integrating biological information into ocean observations is critical in the United States for advancing the National Ocean Policy, particularly ecosystem-based management and marine planning. While sensor and tag development is an active field, aquatic animal telemetry technology is now considered mature and operational with observing data and products that are ready to be integrated into the U.S. IOOS.

Aquatic animal telemetry programs operate in almost all U.S. IOOS regions, which represent significant telemetry infrastructure, technical expertise, and manufacturing capability. It is estimated that in 2012, more than 2,800 acoustic receivers used to detect tagged animals (only a fraction of total ATN assets) were deployed at a value of over $6 million (M). Despite these efforts, there is a lack of a sustained commitment to maintain the infrastructure necessary to develop a reliable and long-lasting data stream based on animal telemetry. Electronic tags and tagging equipment decay, and data are lost when grants and contracts expire. This plan describes how the ATN will maximize the benefit of existing investments by providing a mechanism for sustained operations and consistent delivery of aquatic animal telemetry data across the United States and in conjunction with international ocean observing systems.

The ATN data management approach involves receiving, handling, and distributing diverse data types from archival, satellite, and acoustic tag platforms that originate from a variety of individual Federal and non-Federal researchers and large programs using consistent metadata standards and best practices. The core of the ATN data management system will be a quasi-centralized National ATN Data Assembly Center (ATN DAC) that will receive and distribute data and data products to U.S. IOOS RAs and other partner organizations using U.S. IOOS Data Management and Communications data standards and services. This plan provides guidelines for how the ATN will share data and data products to comply with emerging requirements regarding federally funded research, namely that such research be open and accessible, while protecting an extramural researcher's ability to publish findings in a timely fashion. Additionally, this plan outlines how the ATN will encourage common data standards and practices, implement and maintain an integrated DAC structure, and support data storage and archiving of aquatic animal telemetry data gathered by Federal and non-Federal entities.

The ATN is intended to be a long-term component of the U.S. IOOS program, so this plan is designed to be a living document that will be updated periodically to reflect the evolving requirements for aquatic animal telemetry data, applications, and knowledge.

1. Background

1.1 General Overview

Aquatic animal telemetry is the technology that allows scientists to elucidate the behavior of aquatic animals as the animals move through the ocean and freshwater systems. Animal telemetry devices ("tags") yield detailed data regarding animal responses to the coupled ocean-atmosphere and physical environment through which they are moving. 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 overall understanding of ecosystem function and dynamics. In the past two decades, rapid technological advances in electronic tags that attach to animals have made it possible to collect high-quality biological and physical oceanographic observations as the animals move through their habitats. The tags provide oceanographic and climatological data as well as data on animal movement and behavior on time scales varying from days to years, including in areas that are otherwise difficult and expensive for humans to monitor (e.g., Arctic and Antarctic regions).

Animal tracking can be conducted in real time with radio, acoustic, and satellite telemetry or in "archival" mode, in which information is reconstructed from time-series data that are either transmitted on a time-delayed basis via satellite or are analyzed when a tagged animal is recaptured and the tag physically recovered. Fish, marine mammals, ocean reptiles, and seabirds have been tagged routinely with sophisticated instruments that sample:

- Life history and other biologically-driven behaviors (e.g., diving, migrations, preferred habitats, reproduction, feeding);
- Oceanographic variables (e.g., pressure, light, temperature, salinity);
- Position (through the Global Positioning System (GPS);
- Acoustics (e.g., animal vocal behavior, tail beats, respirations, environmental sounds); and
- Physiology (e.g., body temperature, heart rate, blood or tissue oxygen saturation).

GPS coordinates of tagged animals coupled with oceanographic data collected from instruments attached to the animals enable assessments of animal foraging hotspots, ecological interactions, migration routes, and habitat utilization patterns. Animals tend to congregate in areas of particular interest to oceanographers, including surface and sub-surface fronts, eddies, and confluences that aggregate prey. Information collected at these locations using tagged animals can be used by oceanographers to describe and map key ocean features and processes. Animals travel to regions that are relatively inaccessible to other ocean observing technologies. Aquatic Animal telemetry technology allows researchers to investigate how animals use their three-dimensional (3D) world and can provide valuable, additional oceanographic data to augment other ocean observing technologies.

Federal, state, academic, and commercial organizations routinely collect aquatic animal telemetry data that range in geographic scope and scale from rivers and near-shore ocean and shelf waters to full ocean basins. Because this type of data collection is now widespread, regional data sharing networks have emerged in the United States (Figure 1). Large-scale global aquatic animal telemetry programs have also emerged, such as the Australian Animal Tagging and Monitoring System (animaltracking.aodn.org.au), Global Tagging of Pelagic Predators (TOPP) (gtopp.org), the global Ocean Tracking Network (OTN), (oceantrackingnetwork.org), and Southern Elephant Seals as Oceanographic Samplers (biology.st-andrews.ac.uk/seaos). Many of the aquatic animal telemetry programs already have the capability to provide live updates on animal movements and behavior as well as oceanographic data. National and international programs have succeeded in delivering these oceanographic data to the US IOOS (ioos.noaa.gov) and the

Global Ocean Observing System (www.ioc-goos.org). Programs have also delivered biodiversity data to the Ocean Biogeographic Information System (www.iobis.org). Aquatic Animal telemetry projects have demonstrated that animal-borne sensors are reliable, inexpensive platforms for delivering high-quality animal behavior and oceanographic data. These projects also demonstrate that animal telemetry observations are mature and operational, and the data is ready to be integrated within an Animal Telemetry Network (ATN), as well as the U.S. IOOS.

The ATN is envisioned as an observing system that can track aquatic animals and their habitats to provide data critical for the conservation and sustainable management of commercially harvested species, protected species, and other marine resources. The ATN 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 implementation.

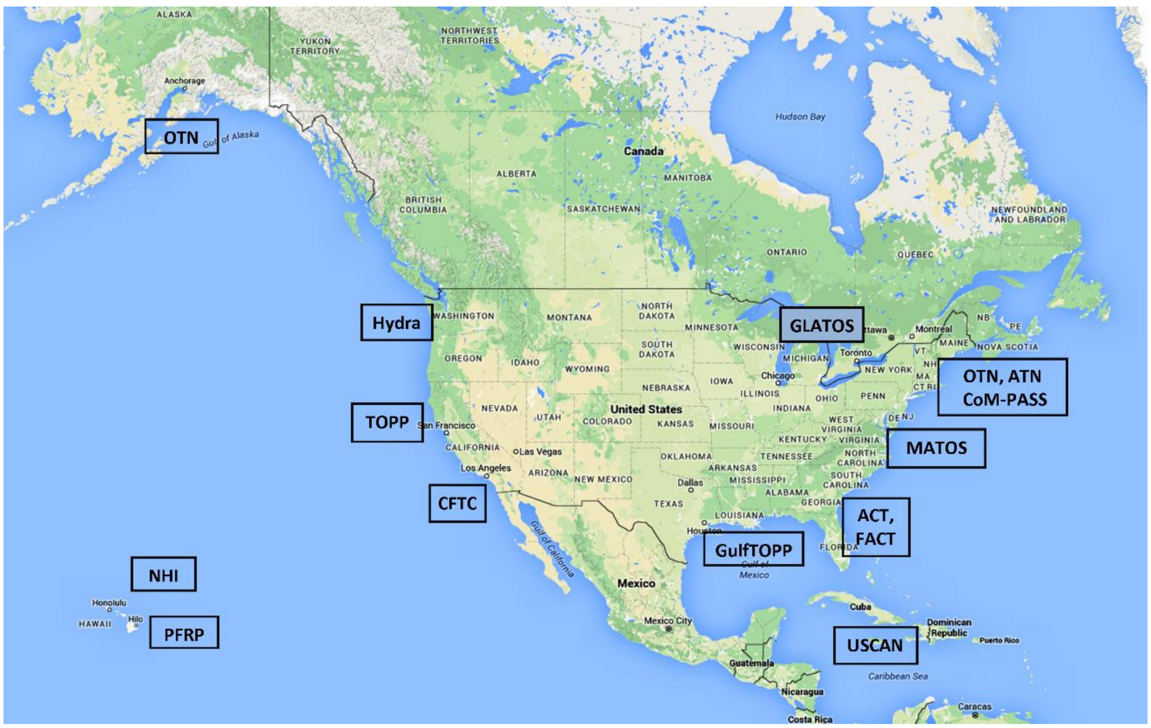

Figure 1. Location of some large United States regional aquatic animal telemetry programs. Acronyms used in the figure are: Atlantic Coastal Telemetry (ACT) Network, Mid-Atlantic Acoustic Telemetry Observation System (MATOS), Florida Atlantic Coast Telemetry (FACT) Sea Turtle Network, Pelagic Fisheries Research Program (PFRP) in Hawaii, Great Lakes Acoustic Telemetry Observation System (GLATOS), the Pacific Northwest Sound data management project (Hydra), California Fish Tracking Consortium (CFTC), Gulf of Mexico TOPP (GulfTOPP), U.S. Caribbean Acoustic Network USCAN), Tagging of Pelagic Predators (TOPP), Ocean Tracking Network (OTN), Coast of Maine Passive Acoustic Sensor System (CoM-PASS), and Northwest Hawaiian Islands array (NHI).

1.2 Aquatic Animal Telemetry Applications

The benefit of improvements to understanding aquatic animal movement and behavior are outlined in the *Strategic Plan and Recommendations for a National Animal Telemetry Network (ATN) through U.S. IOOS*[1] and can be seen in a multitude of applications, which include:

- Providing scientific information for marine fisheries and protected species management;

- Evaluating the potential effects of anthropogenic disturbances; and
- Improving coupled ocean-atmosphere observation and forecasting models.

1.2.1 Fisheries and Protected Species Management

Aquatic animal telemetry is central to elucidating behavioral patterns of commercial fish species, informing stock assessments, and identifying essential or critical habitat. Tag-derived movement data helped to improve management of Atlantic Bluefin tuna through delineation of stock structure and demonstration of movement patterns.[2] On the West Coast of North America, discoveries about the unexpectedly large extent of green sturgeon movements were used to designate Federally-mandated critical habitat for the Endangered Species Act-listed (threatened) southern stock.[3] Knowing the locations frequented by commercial fish species and when those locations are occupied may also improve management of marine resources. For example, aquatic animal telemetry has revealed information critical to salmon conservation in West Coast river systems. Migrating smolt survival through the Columbia River hydropower system was revealed to be better than previously believed, and survival through the Sacramento River Basin was deemed uniformly poor throughout the river as opposed to concentrated in the river delta.[4] In both regions, Federal and state agencies spend millions of dollars per year to increase species survival.[5]

Information gleaned from aquatic animal telemetry data impacts other species and has been instrumental in informing and improving population censuses and stock assessment activities, and defining essential and critical habitat for species listed as endangered or threatened. Tracking data were important in the decision to list the black-footed albatross as an endangered species by the U.S. Fish and Wildlife Service and by BirdLife International. Such data were also essential for the development of a management plan for endangered Australian and New Zealand sea lions.[6] Leatherback sea turtles have been observed to use corridors shaped by persistent oceanographic features such as the southern edge of the Costa Rica Dome and the highly energetic currents of equatorial Pacific.[7] These findings have led to an International Union for Conservation of Nature resolution to conserve leatherback sea turtles in the open seas. Similarly, tracking data were used to develop a marine protected area off the coast of Baja California to protect loggerhead sea turtles and to assess the efficacy of an implemented marine protected area to protect Olive Ridley sea turtles off the coast of Gabon. [8-9]

Data combined from many species can be used to identify “hot spots,” high-value ecosystems, and regional connectivity among these areas, which aids in marine planning, defining essential and critical habitat, and creating marine protected areas. [10-11] Additionally, combining data from many species provides information necessary for ecosystem-based management and coastal environmental intelligence (i.e. actionable information).

1.2.2 Anthropogenic Disturbances

By identifying habitat utilization patterns, aquatic animal telemetry helps to identify, avoid, and mitigate conflicts among ocean resource development activities, as well as with other industrial and military activities.[12] Operational windows for proposed human development (e.g., construction, dredging, pile driving, and military activities) have been coordinated with the times when tagged animals are not in close proximity. Distribution and migration data from a variety of taxa have been overlaid on oceanographic data to develop predictive mapping tools that help Central Pacific longline fishers minimize bycatch of protected loggerhead sea turtles.[13] Telemetry data from marine mammals are being used to alter shipping lanes to reduce impacts on protected species.[14] Additionally, behavioral data from tagged animals can be used to better understand both baseline behavior and the behavioral responses of animals to sound exposure during military activities.[12] Private industry also benefits from aquatic animal telemetry data when designing and implementing projects, such as renewable energy installations, dams, and marinas.

1.2.3 Ocean Modeling

Animal-borne tags have integrated oceanographic sensors capable of providing high-accuracy sea-surface and vertical measurements of temperature, salinity, and fluorometry throughout the upper 1500 meters (m) of the water column and in some cases deeper (up to 3000 m). Animals can travel to and deliver data from regions that are relatively inaccessible to other ocean observing technologies. For example, polar oceans under seasonal or permanent pack ice are particularly difficult to study because of the highly changeable amounts of ice and the dynamic nature of openings in the ice.[15-16] Other remote areas include atolls, such as those in the Northwest Hawaiian Islands. Additionally, animals are able to move into coastal locations and sample regions where floats and autonomous vehicles are often challenged (e.g., upwelling zones and mesoscale eddies). Animals also are able to move freely across political boundaries.

Animal-borne tags that collect high temporal resolution measurements of key physical oceanographic variables complement traditional oceanographic data collection methods. Animal-borne data are now being collected and assimilated into ocean circulation models. These data are used to improve ocean forecasting systems by supplying the ocean models with *in situ* data. A recent pilot project with TOPP, the Office of Naval Research, and U.S. IOOS demonstrated the capability of aquatic animal telemetry observations to deliver high-quality, real-time oceanographic observations to operational Navy ocean models (Figure 2) and the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) (ioos.noaa.gov/project/atn). Comprehensive ocean observation data are needed meet a wide range of requirements, from operational demands to climate modeling. A sustained ocean observation system should combine a fleet of different platforms and sensors that complement each other to best serve the various needs of the ATN and oceanographic communities.

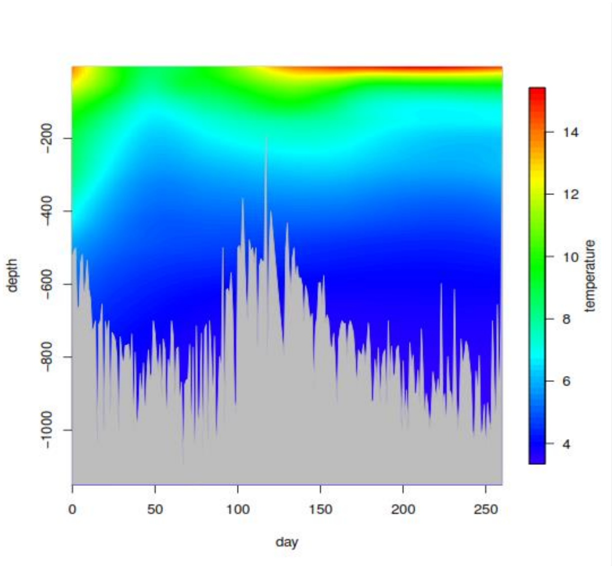

Figure 2. Animal-borne tags on elephant seals simultaneously record movements, diving behavior, and in situ *oceanographic properties. Shown here is a vertical section of the ocean temperature measurements derived from a tagged elephant seal that travelled from Año Nuevo, California, across the North Pacific transition zone (the interface between cold, nutrient-rich polar water to the north and warmer, nutrient-poor water to the south).*

1.3 State of Aquatic Animal Telemetry Observing System and Technology

The aquatic animal telemetry community, working together with engineers and tag manufacturers, has built a range of tags with high-precision sensors that permit dynamic measurements of animal movements and their environments. Currently, there are approximately 10 standard tag types with distinct position and sensor capabilities. Sharks, tunas, salmon, marine mammals, reptiles, and seabirds have been tagged routinely with sophisticated instruments that sample a variety of biological and physical parameters (Table 1). Data complexity and memory capacity varies depending on the type of tag and sensors and the goals of the mission. Together, these technologies provide the means to track animals for multiple years, which provides seasonal, annual, and climatological time-series data.

In addition to electronic tags that record data from environmental sensors, other increasingly sophisticated tags are emerging. Camera tags with high definition video, tri-axial accelerometers (measuring acceleration), magnetometers (measuring magnetization), and devices that measure depth and temperature provide animal behavior are now being deployed.

Some tags transmit data via encoded acoustic waves to underwater receivers. In many cases, these tags are smaller than the previously noted satellite and archival tags. Acoustic tag technology provides a cable-free underwater network for recording animal observations. This is particularly useful for studying small species (e.g., smolts of salmon) that are incapable of carrying relatively large satellite tags and aquatic species that do not surface often or long enough to make radio transmission of data useful to employ. The decreasing size and longer life of new batteries as well as the increasing sophistication of acoustic transmitters provides the ability to monitor the behavior of a wide range of species across great distances using networks of underwater receivers that span multinational boundaries. The emerging use of satellite-enabled acoustic receivers and unmanned mobile gliders or marine mammals fitted with acoustic receivers complements these networks and together provides the potential for a “wired ocean.” By investing in and maintaining fixed underwater receiver networks (passive and active) and mobile receiver platforms that uplink to Iridium satellite receivers or cell networks, the opportunity and ability now exists for long-term monitoring.

Table 1. Currently, there are approximately 10 standard tag types with distinct position and sensor capabilities. The method of data recovery separates the technology into three broad categories: archival, satellite, or acoustic.

Category	Tag Type	Archival Capability	Deployment Duration	Route for Data Return	Depth	Temperature	Geo-Location	3D Accelerometers/ Magnetometers	GPS	Other
Satellite	Location only	No	Varies by settings, >1 year	Real time via Argos						
	Location plus depth	Yes	<400 days	Real time via Argos	X	X	X	X		
	Location plus GPS	Varies	Varies by settings, >1 year	Real time via Argos	X	X	X	X	X	
	Pop-up Satellite and Archival Tag	Yes	Varies by settings, >1 year	Argos Endpoint Only (detailed data upon recovery)	X	X	X	X	X	
	Conductivity, Temperature, Depth - slant 45° linear depolarization Conductivity, Temperature, Depth (CTD) Satellite Linked Dive Recorder (SLDR)	Yes	9-12 months	Real time via Argos and recovery	X	X	X		X	
	Global System for Mobile (GSM)/GPS	Yes	<400 days	Recovery or real time	X	X			X	
Archival	Data Storage	Yes	Varies, up to 365 days	Recovery/GPS	X	X				
	Physiology	Yes	<10 days	Recovery	X	X				Temp, lactic acid, Oxygen/Carbon dioxide partial pressure)
	Kinematic	Yes	<14 days	Recovery	X			X		
Acoustic	Passive acoustic recording	Yes	<72 hours	Recovery	X	X		X		dual hydrophones ~10 Hertz (Hz)--150 kilo-Hertz (kHz)
	Acoustic transmitter and receiver	No	Up to 5 years	Recovery of receivers, Iridium	X	X		X		

Recently, new tags have emerged that estimate animal positions with a combination of GPS Iridium or cell phone-assisted GPS. Because aquatic animals such as cetaceans and seals spend relatively limited time at the water's surface, fixing a position is often not achievable with traditional GPS and instead requires instruments tailored specifically for marine environments, such as Fastloc® GPS. Some new tags are now using the cell phone assisted GPS (e.g., global system for mobile (GSM)) for transmission of animal dive and position data, which increases real-time data recovery, particularly in coastal regions with good cell phone coverage (Figure 3).

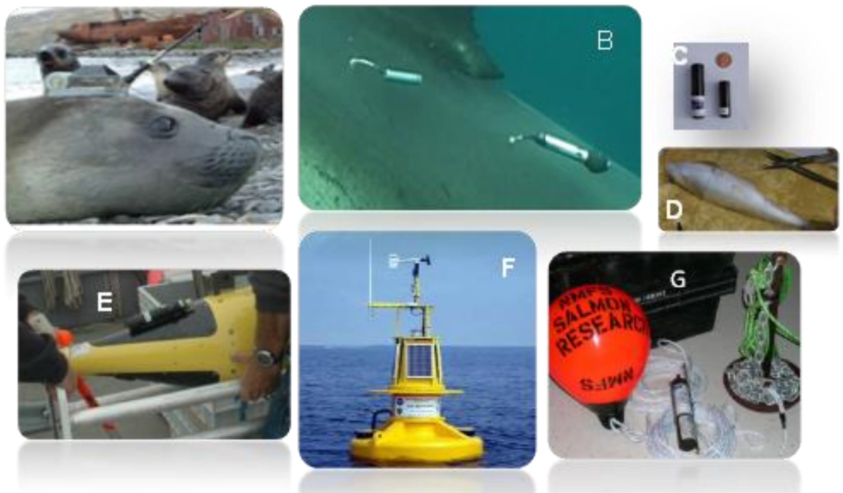

Figure 3. Examples of sensors or tags used on marine animals. A. Sea Mammal Research Unit conductivity temperature depth tag on an elephant seal (Source: Michael Fedak, University of St. Andrews, United Kingdom). B. Wildlife Computers pop-up satellite archival tag and Lotek temperature depth recorder archival tag on a shark. (Source: Barbara Block, Stanford Univ., California). C. VEMCO acoustic tags. D. Salmon smolt tagged with VEMCO tag, (Source: John Kocik, NOAA. Fisheries). E. Seaglider fitted with VEMCO tag (Source: John Payne, University of Washington, Pacific Ocean Shelf Tracking). F. Cabled acoustic receiver in a Chesapeake Bay Interpretive Buoy System Buoy (Source: Doug Wilson, NOAA Chesapeake Bay Office). G. VEMCO receiver VR2 used by National Marine Fisheries Service (NMFS) Salmon Research Group in Maine (Source: John Kocik, NOAA Fisheries).

1.4 Aquatic Animal Telemetry Data Requirements

Federal and state agencies, conservation organizations, tribal entities, the general public, educational institutions, private industry, and the research community have identified animal telemetry observation data as information necessary to manage marine resources and assess the potential effects of human activities on marine environments. Several statutes require the type of information that animal telemetry data can provide. For example, U.S. fisheries are among the world's largest and are managed by NOAA's National Marine Fisheries Service (NMFS) under the Magnuson-Stevens Fisheries Conservation and Management Act. Marine ecosystems and coastal communities benefit from the Marine Mammal Protection Act and the Endangered Species Act that protect many species such as marine mammals, fishes, and sea turtles. The National Marine Sanctuaries Act protects marine areas of special national significance. When Federal agencies undertake activities, such as permitting, the National Environmental Policy Act requires an assessment of the potential impact of these activities on marine resources. The data agencies require to comply with these statutes may include information on animal behavior and movements, migratory and residency patterns, habitat use, foraging behavior and locations, physiology, and survival and mortality rates, which are obtainable through the use of animal telemetry. Given the lack of data on larger vertebrate aquatic species, even basic data such as time and position of animals observed contributes to understanding and conservation. Advances in sensor technology in recent years have resulted in an increase in the number and diversity of data streams collected by tags and vastly improved understanding of animal movement, behavior, and habitat (Table 2).

Table 2. Aquatic animal telemetry data requirements for inclusion in various Federally and non-Federally maintained data repositories. Observation derived from electronic tags, measurements specifications, requiring agency or private sector, and some of the applications for telemetry information are included for each requirement category.

Observation Derived	Measurement Requirement	Information Specifications	Requiring Entity	Application
Real-time temperature/ conductivity/ depth	Broken-stick water column profile of temperature and salinity	Temperature Range -5 - 35; Accuracy +/- 0.005 Celsius Conductivity/Salinity Range: 0-80 milliSiemens (mS)/centimeter (cm); Accuracy: +/- 0.001 mS/cm Depth Resolution: 0.5 m <2000 m:	Navy Oceanographic Office, NOAA National Centers for Environmental Prediction	Improve the skill of operational oceanographic nowcast and forecast models
Archival temperature, oxygen, chlorophyll-a	Detailed water column profile of temperature, oxygen, chlorophyll-a sample up to 32 times /second	Temperature Range -5 - 35; Accuracy +/- 0.005C; Conductivity/Salinity Range: 0-80 mS/ cm; Accuracy: +/- 0.001 mS/cm Depth Resolution: 0.5m <2000 m:	Naval Oceanographic Office, NOAA National Centers for Environmental Prediction	Contribute to hindcast oceanographic modeling
Date, time, latitude/ longitude, dive depth, swim speed, acceleration. 3D position	Animal movements and behavior, home range, habitat use, foraging behavior and locations, migration patterns, residency patterns, mortality, survival	Depth Resolution: 0.5m Max: <2000m Acceleration Resolution: 0.05 m/s/s Location Argos: +/- kilometer (km) GPS: +/- m	NOAA/NMFS U.S. Geological Survey (USGS), National Science Foundation (NSF), U.S. Fish and Wildlife Service (USFWS), Office of National Marine Sanctuaries (ONMS)	NMFS: Managing fisheries and protected/endangered species, ecosystem-based management, marine spatial planning; evaluating efficiency marine protected areas, ecological connectivity between habitats and management areas. USGS/NSF: Climate change, ecosystem health, Arctic/Antarctic, water resources (USGS). USFWS: Conserve, protect, and enhance fish and wildlife populations and habitat. ONMS: ecosystem-based management in areas of special national significance

Date, time, latitude/ longitude, dive depth, swim speed, acceleration, 3D position	Animal movements and behavior, home range, habitat use, foraging behavior and locations, migration patterns, residency patterns, mortality, survival	Depth Resolution: 0.5 m Max: <2000 m Acceleration Resolution: 0.05 m/s/s Location Argos: +/- km GPS: +/- m	Federal Agency: Navy, Bureau of Ocean Energy and Management, National Science Foundation, Department of Energy, Army Corps of Engineers Private industry: Oil and gas industry, power and water industry, fisheries sector	Evaluate the potential effects of human activities on aquatic resources

2. ATN Design

2.1 Network Overview

The United States ATN will be an alliance among Federal, state, tribal, regional, academic, and industry tagging partners to: maximize collaborations within the ATN community and access to animal telemetry data; generate information products; provide science-based information for species- and ecosystem-based management; and promote economic, social, and environmental benefits nationally and globally. The ATN is designed as a distributed technology and information network that applies consistent international data standards and best practices to achieve seamless integration of data, not only among various ATN observing assets and animal telemetry efforts but with other observing systems.

This Implementation Plan covers a phased approach over a 5-year period, from 2016 to 2021. To implement the recommendations in the *Strategic Plan and Recommendations for a National Animal Telemetry Network (ATN) through U.S. IOOS*, the ATN phases will include:

- Phase I (Initiate ATN in 2016):
  - Coordinate, support, and enhance planned and funded aquatic animal telemetry efforts, including activities coordinated through participating U.S. IOOS RAs and individual partners; and
  - Implement a national data management system to meet the needs of Federal and non-Federal entities by developing metadata standards, providing quality assurance/quality control (QA/QC), archiving aquatic animal telemetry data in standard formats, and making the data accessible through common web services.
- Phase II (Initiate field efforts by 2018):
  - Facilitate and support baseline observations of the aquatic species movements and behaviors that are required to support resource and protected species management, identify critical habitat and habitat use, engage in real-time monitoring, contribute to understanding of how disturbances affect these species and their habitats, and collect data to improve ocean modeling and forecasting; and

- Coordinate, support, maintain, and enhance existing national aquatic animal telemetry infrastructure and capability, including activities coordinated through participating U.S. IOOS RAs.

2.2 Network Components

The ATN will be structured as an alliance of United States-led tagging projects and programs that occur in state, Federal, and international waters. This alliance will include the following:

- A national ATN Steering Group (SG, see Section 2.1) will facilitate development and continuity of the ATN by representing U.S. IOOS RA and Federal agency research interests, identifying and fostering coordinated long-term strategies, and providing operational guidance and decision-making for the overarching ATN. The SG will include U.S. IOOS RA representatives, independent subject matter experts, and Federal and non-Federal entities that provide funding or in-kind support to the ATN consistent with the Federal Advisory Committee Act (FACA).

- An ATN Network Coordinator (NC, see Section 4.1.4) in the IOOS Program Office will serve as the ATN network's primary point of contact, facilitate communication and information exchange among partners, provide administrative support, and coordinate overarching planning, and resource management. The NC will work to harmonize the aquatic animal telemetry needs of the SG, the U.S. IOOS Program Office (U.S. IOOS PO), U.S. IOOS RAs, Federal agencies, and stakeholders.

- An ATN Data Assembly Center (DAC, see Section 2.4) will integrate and distribute ATN data to improve national accessibility of aquatic animal telemetry data and to develop a unique set of data products. Satellite-linked tags will provide real-time data to the DAC. The data will also be distributed via the Global Telecommunications System (GTS), as well as to the public via the DAC web services. The SG and NC will work with the NOAA National Center of Environmental Information (NCEI) to develop a long-term preservation and stewardship plan for all aquatic animal telemetry data. Data-sharing agreements will be arranged across all sectors of the ATN as necessary.

- Aquatic animal telemetry programs and individual Partners located at academic institutions; Federal, tribal, state, and local government entities; and private organizations within the U.S. IOOS RA geographical areas will offer a range of contributions, including support for National infrastructure (e.g., acoustic receiver lines and animal telemetry equipment), individual research partners that handle tag deployments and tag recovery, and larger and more integrated programs with multiple researchers who deploy multiple tag platforms at diverse locations.

- ATN assets include aquatic animal telemetry equipment (e.g., tags, tagging equipment and supplies, acoustic receiver arrays, facilities) funded by participating agencies through the SG, and managed and operated by aquatic animal telemetry programs and individual partners, the NC, and the DAC.

2.3 Phase I - Coordination

Phase I of the ATN begins in 2016. One of the top priorities is coordination, specifically to facilitate collaboration and cooperation within the tagging community, integrate disparate data sets, and operate and maintain the existing tagging and acoustic receiver infrastructure as a cohesive network. The ATN SG and NC will work closely with the U.S. IOOS PO, U.S. IOOS RAs, and individual partners to create a coordinated network that will enable the SG to represent the ATN community's research interests by working with stakeholders to identify and address gaps in coordination and implementation among Federal and non-Federal aquatic animal telemetry programs, consistent with FACA. Collaborations within and among regional aquatic animal telemetry programs will contribute biological and physical observations to U.S. IOOS RAs, which will then make these data available to the DAC. Aquatic animal telemetry project collaborators will also be able to contribute observations and data directly to the central DAC.

2.4 Phase I – Data Management System

A sophisticated data management system will be required to realize the ATN vision. Such a system will need to handle diverse types of archival, satellite, and acoustic animal telemetry data from an array of individual researchers and large programs. Guidelines for user data and metadata will be critical to provide QA/QC, archive data in standard formats, and distribute data through common web platforms to support value-added services for data submitters and users. The ATN data management system will both address the needs of the ATN and subscribe to the Data Management and Communication (DMAC) guidelines of the U.S. IOOS (ioos.noaa.gov/data/contribute-data). The ATN data will be fully accessible through the U.S. IOOS RA portals and the U.S. IOOS Data Catalog. The implementation of this data management strategy will be in compliance *with Executive Order 13642: Making Open and Machine Readable the New Default for Government Information* (www.whitehouse.gov/the-press-office/2013/05/09/executive-order-making-open-and-machine-readable-new-default-government). As used here, the term "data" refers to raw tag and receiver data, processed data, published data, and metadata.

2.4.1 ATN Data Flow System

The ATN's national capability will be derived from different tagging/telemetry technologies with different configurations distributed throughout the U.S. IOOS RAs and other partner organizations. Data will be centralized through the U.S. IOOS ATN DAC (Figure 4). Each tag type (i.e., acoustic, archival, and satellite) and receiver will provide data to U.S. IOOS RA databases and other partner organizations, or directly to the ATN DAC. Data that are not directly provided into the DAC will be aggregated at each U.S. IOOS RA or partner organization, formatted following U.S. IOOS DMAC data and metadata standards, and transferred to ATN DAC in a standard format that includes a number of metadata variables. The ATN DAC will then aggregate the real-time data into collections or deployments. After the data are quality checked based on U.S. IOOS DMAC best practices, the data will be served to users and may be distributed through additional channels. These aggregations will be served to the public via U.S. IOOS standard services (ioos.noaa.gov/data/contribute-data) such as NOAA's Environmental Research Division's Data Access Program (ERDDAP) or other U.S. IOOS DMAC services (e.g., Sensor Observation Service, Web Map Services, OpenDAP). For example, real-time data from satellite tags belonging to the Sea Mammal Research Unit at the University of St. Andrews that collect environmental data are downloaded from the Argos Data Collection and Locations System global processing center and currently undergo quality control and assessment at the University lab before being distributed on the GTS for applications, including meteorological and ocean model assimilation and validation. All acoustic, archival, and real-time data coming into the ATN DAC will be permanently archived at the NCEI, pending the establishment of an agreement with NCEI.

The prototype ATN DAC is a quasi-centralized system, with data fed into servers at the NOAA Southwest Fisheries Science Center (SWFSC) in Santa Cruz, California, and Stanford University. At Stanford University, the data are processed from providers (e.g., Collecte Localisation Satellites (CLS)/Argos, Iridium, users returning archival tags), backed up at several locations (e.g., Hopkins Marine Station, Stanford University main campus, and the NOAA SWFSC), served to the NOAA SWFSC, and displayed on the ATN DAC user interface (oceanview.pfeg.noaa.gov/ATN). The DAC web display and interface was made possible by leveraging prior developments for tag data management (e.g., TOPP, Global TOPP, Gulf of Mexico TOPP) into a single system with an intuitive front end, capable of delivering and visualizing United States telemetry data streamed from multiple animal and platform types.

The ATN DAC in its current version has access to four data streams:

1. Real-time data from animal-borne platforms report automatically from Argos satellites via codes that directly download from CLS/Argos to Stanford University servers and then deliver location and data sets to the DAC in near-real time;
2. Acoustic data are collected directly from archival receivers and via automated Iridium satellite-linked acoustic receivers mounted on stationary buoys or mobile platforms such as Wave Gliders;
3. Pop-up satellite tags collect data while the tags are attached to an animal and are pre-programmed to release and float to the surface after a specified period of time. Once the tags reach the surface, the data take up to 20 days to download and transmit to CLS/Argos and then to the DAC via the Stanford University servers. The DAC servers collect position as well as oceanographic and behavioral data, which are both rapidly displayed and archived on the tag; and
4. Archival-based data are drawn from the thousands of animal tracking deployments and datasets collected by various tagging programs using implantable archival tags and pop-up archival tags that have been recovered.

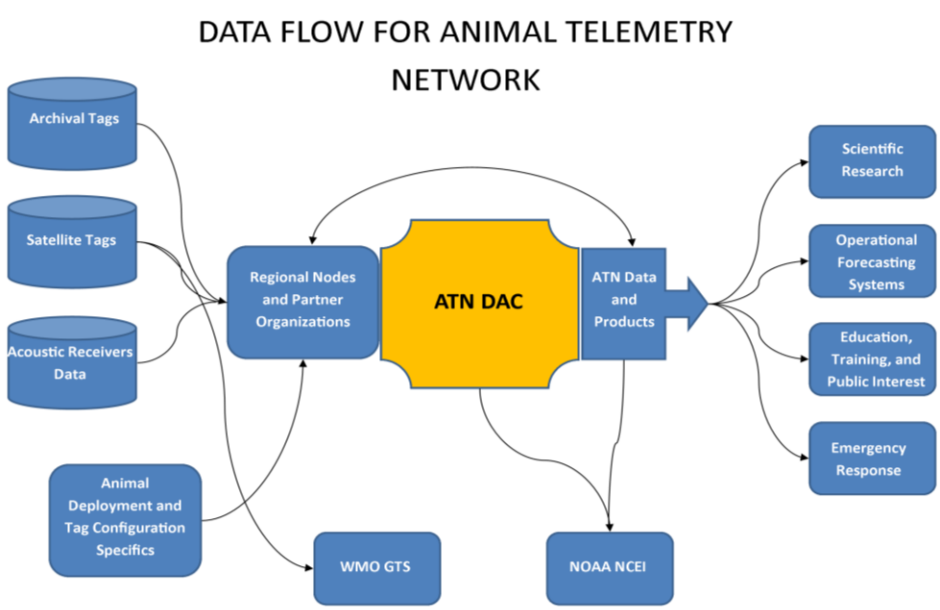

Figure 4. Proposed ATN data flow (left to right), with different tagging/telemetry technologies centralized through the U.S. IOOS ATN DAC and distributed to the U.S. IOOS Ras and other partner organizations. WMO GTS is the World Meteorological Organization Global Telecommunication System. NOAA NECI is the National Centers for Environmental Information.

2.4.2 ATN DAC Web Display and Interface

Currently, the ATN DAC provides graphical displays or downloads of oceanographic profile data, animal location data for tracking visualization in real-time, and acoustic detection data. These data can be downloaded via U.S. IOOS standard service (e.g., ERDDAP), and are accessible at oceanview.pfeg.noaa.gov/ATN (Figure 5).

The ATN DAC graphical display uses a Google Maps-based user interface that was created with simple, color-coded icons representing six distinct tag platform types: real time satellite tags with oceanographic data; satellite tags with position-only; pop-up satellite archival tags; archival tags; acoustic tags; and autonomous buoys with receivers for acoustic detection. For each platform type, the user can display additional data types (e.g., animal or glider track, acoustic detections) and metadata (e.g., platform type, date, and duration of deployment) by clicking on the icon. An icon click also presents the user with a variety of additional options that vary by tag platform.

The default view of the ATN DAC interface shows the most recent data; users can select from 10-, 60-, or 90-day displays. The interface features a pull-down data menu which allows users to view or hide datasets from each species and platform by clicking check-boxes arranged in a hierarchical, nested structure similar to that used in Google Earth to activate and deactivate various data layers. At the individual tag level, users can also view, download, or access the data through an ERDDAP server directly from the data menu (i.e., without having to locate that specific tag on the map first). The ERDDAP server enables users to quickly query, visualize, and download data in 37 formats, including CSV (Comma-Separated values), NetCDF (Network Common Data Form), MatLab (Matrix Laboratory), KML (Keyhole Markup Language), and Shape. More importantly, once the user has created a query, ERDDAP provides a Uniform Resource Locator (URL) for that query that can be incorporated directly into other systems (e.g., websites, Matlab routines, and models) that require ongoing access to those data streams.

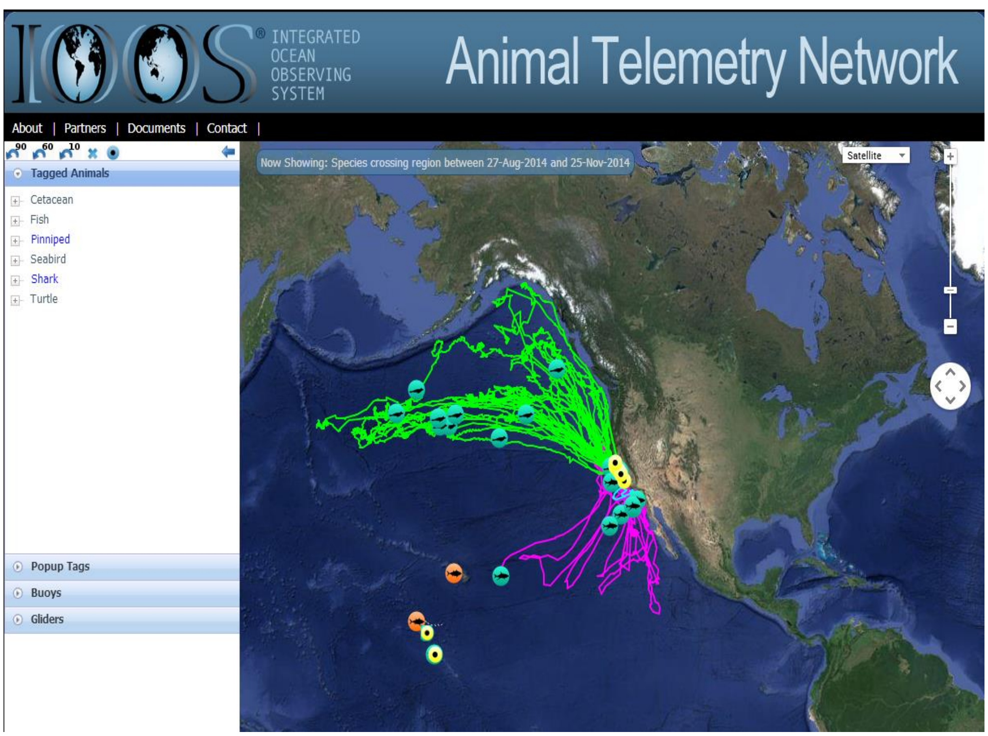

Figure 5. ATN DAC web portal graphical display that includes location data for track visualization in real-time, downloads of ocean profile data, and acoustic detection data. These data can be downloaded via U.S. IOOS standard service (e.g., ERDDAP). This website is accessible at oceanview.pfeg.noaa.gov/ATN.

2.4.3 DAC Data Products

The ATN will provide routine aquatic animal telemetry data and data products via the ATN DAC web interface to meet Federal and non-Federal requirements. For all tag types (satellite, archival, and acoustic), tag deployment and recovery metadata will be available on the ATN DAC website. For acoustic tags, receiver deployment metadata will also be available.

Some satellite tags provide real-time access to location only, whereas other satellite-linked, time-depth recorders provide real-time access to location, temperature, salinity, fluorometry, and depth data, which are transmitted via the GTS and archived in the World Oceanographic Data Center. Raw, unfiltered datasets are available on the ATN DAC website, and the latest simulated model animal tracks are displayed on the web interface, including confidence intervals around individual daily Argos or Fastloc® locations.

For archival tags and pop-up archival tags, raw datasets are available upon recovery of the tags, or the tag data are transmitted via satellite after release from the animal. Quality-controlled, processed, light-based geolocation tracks and state-space modeled tracks, including confidence intervals around individual daily locations, will be available via the ATN DAC. Detailed depth and/or temperature utilization plots and interpolated position-depth-temperature plots will also be available.

Real-time acoustic and historical detection data (per receiver, where available) will be plotted and available for download on the ATN DAC web interface. Acoustic receivers can also be mounted on mobile platforms, as is currently done with Wave Gliders, and plotted on the ATN DAC website. In some cases, stationary or mobile platforms are satellite linked and can deliver near-real-time tag detection data married to platform location data.

A centralized ATN DAC web interface does not replace the need for the U.S. IOOS RAs to display aquatic animal telemetry data and to use these data to produce products of particular interest for individual regions.

2.4.4 ATN Relational Database Management Systems

For ATN DAC internal data transport and storage, a relational database management system provides an effective interoperable solution. Data and metadata in the ATN DAC warehouse will be managed with open source web content and relational database systems (e.g., Linux, PostgreSQL, PostGIS, R) and accessed using a variety of common Geographic Information System (GIS) protocols (e.g., Geoserver, OpenDAP).

2.4.5 Data Element-level Metadata

Metadata standards are particular ways of writing metadata. Metadata are becoming more important because the volume of data generated in scientific studies is increasing rapidly. Metadata standards are becoming critical as data are increasingly shared online across national boundaries, among different languages and cultures, and automatically by capable computer servers.

The ATN will not create new metadata standards, but work with international partners to develop or actively promote existing metadata standards and provide guidance on what metadata standards are vital to ATN data management.

To this end, the U.S. IOOS PO has worked with experts to identify useful metadata standards for particular types of data. The U.S. IOOS PO and the Northwest Association of Networked Ocean Observing Systems (NANOOS), worked with Pacific Ocean Shelf Tracking, TOPP, NOAA, OTN, Australian Animal Tagging and Monitoring System, Great Lakes Acoustic Telemetry Observation System (GLATOS), the Pacific Northwest Sound data management project (Hydra), and others to develop metadata standards for acoustic telemetry (code.google.com/p/ioostech/wiki/AnimalAcousticTelData). Groups such as TOPP have made significant steps toward creating metadata for satellite and archival tags.

2.4.6 Discovery–level Metadata

Currently, the U.S. IOOS recommends using International Organization for Standardization (ISO) 19115 (www.ngdc.noaa.gov/wiki/index.php?title=ISO_Metadata_Standard) metadata standards for DMAC. Use of ISO metadata with controlled vocabulary identification and documentation will enable ATN data to be easily found through an open data discovery process and will link easily to the U.S. IOOS Catalog and other national catalogs. In addition, ERDDAP provides a service to translate metadata inputs with ISO 19115 and Federal Geographic Data Committee compliance.

2.4.7 Future Development of Metadata Standards

The ATN will continue to work with international collaborators toward development of metadata standards for aquatic animal telemetry in collaboration with data contributors and data aggregators. Standards will continue to evolve as new technologies become available, so it is important for the ATN to work closely with practitioners in the field and experts on international metadata standards.

A practical way to proceed is to prioritize variables, working first on minimum simple sets of sharable data prior to the more complex data. Once the ATN adopts metadata standards, the standards will be useful only to the extent that the standards are adopted and used by scientists. A further necessary step is the publication and promotion of the metadata standards to researchers. To further these efforts, the ATN will:

- Convene meetings with experts in the field of aquatic animal telemetry and related fields, as well as experts in metadata standards, to discuss the adoption and refinement of metadata standards;
- Ensure that researchers understand how to use the metadata standards that are adopted by the ATN;
- Facilitate cooperation between the ATN data managers and the U.S. IOOS DMAC and U.S. IOOS RA data management teams to further the adoption of these metadata standards by U.S. IOOS RA members; and
- Encourage efforts by U.S. IOOS RAs and other data aggregators to promote ATN standards to their members and to independent researchers in the field; this would include development of tools for field collection and for submitting data and metadata.

2.4.8 ATN Data Archive and Stewardship

The ATN DAC will meet a critical aquatic animal telemetry community need by developing an archive and stewardship agreement with NOAA to ensure that the ATN data are properly archived. The archival decision-making process will follow the NOAA Procedure for Scientific Records Appraisal and Archive Approval (www.ngdc.noaa.gov/wiki/images/0/0b/NOAA_Procedure_document_final.pdf). This procedure specifies a mechanism to formally document and maintain the steps NOAA takes in identifying, appraising, and approving what scientific records are preserved in a NOAA archive.

2.5 ATN Implementation Plan – Phase II

2.5.1 Infrastructure and Capability

The United States, with a tremendous telemetry infrastructure, is a global leader in the field of animal telemetry. A recent survey of United States ATN assets revealed more than 2,800 acoustic receivers, at a cost of more than $6M

(Figure 6). These assets are often owned and operated independently by multiple agencies and institutions with limited to no connectivity. There are aquatic animal telemetry programs owned and operated in almost all U.S. IOOS regions, which possess considerable expertise in tagging and receiver array operations and currently operate with different Federal, state, academic, or regional objectives (See Appendix). In addition, the OTN has invested in aquatic animal telemetry infrastructure (acoustic receiver lines) in several United States regions (e.g., Pacific Islands (Hawaii), Gulf of Mexico, Northwest Pacific, and Northwest Atlantic). Sharing across these and other studies could form a powerful network. For example, from 2000 to 2014, the TOPP program alone deployed more than 6,000 electronic tags on 24 pelagic fish species, 3 pinniped species, 2 whale species, 2 turtle species, 3 seabird species, and multiple squid species (Figure 7).

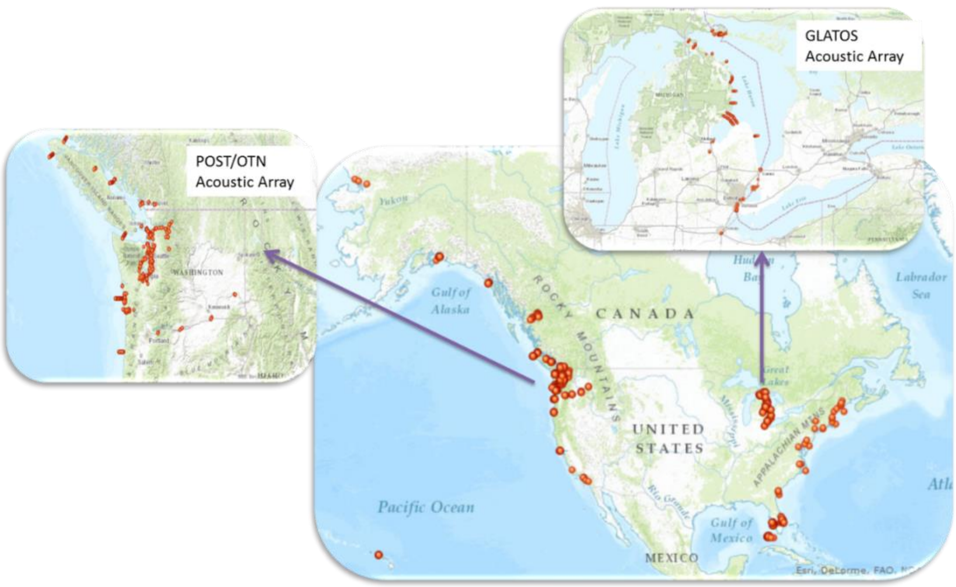

Figure 6. Existing acoustic receiver deployments in United States waters based on a 2012 survey of ATN assets within the United States. Insets: The GLATOS acoustic array (upper right inset) and what was formerly the Pacific Ocean Salmon Telemetry acoustic array, currently operated by the OTN (upper left inset).

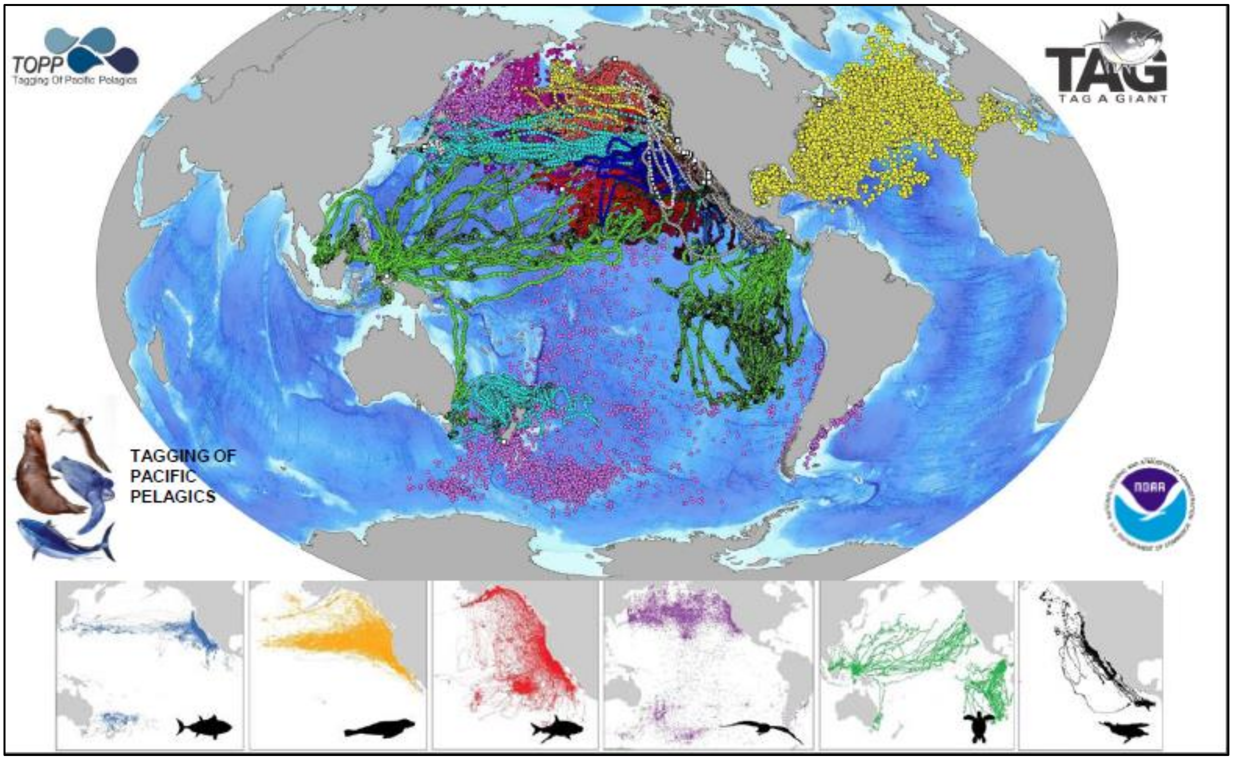

Figure 7. Tagging of Pacific Pelagics tracks from more than 6000 individual birds, fish, whales, and other animals (2000--2014), and Tag-A-Giant program Bluefin tuna tracks from more than 1,800 deployments. The tracks show areas of overlap, common habitat utilization, and biological hotspots in the Pacific Ocean[10]

A top priority of the ATN is the sustainable operations of the existing United States tagging capability and receiver arrays that have been deployed during the past 15 years, mostly in incremental pieces for coastal ocean research. In Phase II, as a component of the observations workshops described in section 2.5.2, the ATN will identify and prioritize infrastructure support to sustain ATN operations.

2.5.2 Baseline Aquatic Animal Telemetry Observations

In Phase II of ATN implementation, to be initiated in 2016, the ATN will hold a series of regional meetings and workshops with the science community, the U.S. IOOS PO, U.S. IOOS RAs, stakeholders, Federal and state agencies, and tribal entities to identify and receive input on existing assets and capability, and regional priorities for aquatic animal telemetry observations of aquatic species (e.g., pinnipeds, sharks, whales, fishes, turtles, and seabirds) that complement existing and planned efforts (See Appendix). This national planning process will be used by the IOOS PO and the SG to identify:

- Observation priorities to ensure that both national and regional needs are met;
- A concise plan for sufficient funding of the envisaged national ATN tagging program, including infrastructure and operations; and
- How the ATN national operations budget will be distributed across the eleven U.S. IOOS RAs, and how integration and coordination of these assets will be achieved.

The ATN SG, in collaboration with the NC, will work within the scope of existing participating agency budgets to support the identified priorities, explicitly accounting for ATN program observation needs and the requirements stipulated by Federal and state agencies and non-Federal entities that provide substantial funding and/or in-kind support. The voting SG membership (see Section 4, Governance) will ensure that final decisions on baseline observations are balanced fairly across the national telemetry community and the individual U.S. IOOS RAs. Although national observation priorities will need to be officially established, potential priorities may include:

- Support fishery resource and protected-species management across a range of species and environments, potentially including identification of stock boundaries and critical habitats such as spawning and foraging sites, the elucidation of animal behaviors and the impacts of anthropogenic disturbances, and the collection of movement and demographic data to enhance stock and ecosystem assessments;
- Promote the use of animals as biological sensors to monitor remote physical ocean environments to improve ocean-atmosphere modeling and forecasting;
- Promote the use of animals as sentinels of climate changes; and
- Encourage development and testing of new technologies and approaches such as smaller, less expensive, longer-lived tags; new and improved sensors; refined geolocations; improved animal capture, handling, and tagging methods; networked tags and receivers to improve data retrieval, and greater coordination of multi-species deployments.

Priority baseline observations will be of two types. The first will be consistent, long-term observations from satellites, archival tags, and acoustic systems intended as stable resources rather than responses to short-term requirements. Review and consideration of changes in these consistent, long-term priority baseline observations will occur on a regular cycle, and be initiated only after careful consideration and consultations among the SG, U.S. IOOS RAs, Federal agencies, non-Federal entities, and stakeholders.

The second type of priority baseline observation will be focused observations of animal responses to unexpected events such as warm-water anomalies (e.g., El Niños), oil spills (e.g., the Gulf of Mexico Deepwater Horizon oil spill), and natural disasters. The small and mobile nature of acoustic receivers and arrays, satellite and archival tags, and tagging equipment provides an inherent flexibility that can be used by the ATN. In limited cases or in response to an urgent national need, the ATN may request that assets held by the various regional operators and institutions be tasked with limited-duration, targeted tagging efforts. The U.S. IOOS RAs and SG will nominate targets, with scope and tasking determined by the voting members of the SG.

2.5.3 Resource Requirements for Sustained ATN Operations

Federal, tribal, state, local, and private partner organizations have a shared responsibility to support sustained, consistent aquatic animal telemetry operations and timely sharing and delivery of high-quality data and data products. This will require stable resource allocations to support ATN operations, the NC, and the DAC within the parameters of existing agency budgets using a variety of mechanisms. Interested Federal, tribal, state, and local agencies and private organizations in partnership with the U.S. IOOS PO will commit annual funds for coordinated activities through the U.S. IOOS RAs or directly with ATN individual partners in support of priorities set forth by the SG, on the basis of the coordination outlined above. U.S. IOOS RAs and individual partners will utilize funds regionally to initiate and support aquatic animal telemetry and telemetry activities that would be coordinated with the ATN.

There are several potential funding mechanisms to support ATN baseline aquatic animal telemetry observations once needs are identified and prioritized by region. For example, proposals may be solicited through the National Oceanographic Partnership Program (NOPP). NOPP research initiatives are fueled by broad science and technology goals of Federal agencies who work together to fill knowledge-needs that might fall between agency-missions or to achieve science and technology goals too large for any single agency to tackle alone. Partnerships include state and tribal governments, private sector industries, academia, and non-governmental organizations who collectively address national marine science priorities across a range of disciplines and data needs. The SG, in collaboration with the NC, could coordinate interested Federal and non-Federal partners to request proposals through NOPP for baseline animal observations and associated infrastructure on a regular 2- to 3-year cycle. Funding for baseline aquatic animal telemetry observations will leverage existing support for aquatic animal telemetry programs nationwide.

Aquatic animal tagging observations that employ or enhance existing ATN infrastructure and/or capacity (acoustic receiver arrays, tags, and associated equipment) will be encouraged by the SG in any calls for proposals. For example, the ATN will collaborate with the OTN to add permanent lines of strategically-located acoustic receivers to complement existing infrastructure in the United States Economic Exclusion Zone, maximize national benefit, and form a continental array of receivers. Additionally, the ATN will seek to integrate acoustic receivers with existing U.S. IOOS platforms (e.g., buoys and unmanned autonomous vehicles) when possible. The integration of ATN instruments with U.S. IOOS platforms will enhance the capability of ATN to transmit more data and faster volumes via the Iridium satellite system.

The ATN will explore different mechanisms for supporting existing aquatic animal telemetry studies, including in-kind support from partner Federal and non-Federal entities and equipment support for ATN related activities. For example, the ATN may opt to have a pool of mobile and stationary acoustic receivers available for loan for a period of up to 1 to 2 years. These units can be made available to help expand existing studies into new regions and to allow researchers to collect preliminary data that can be used to form the basis of funding applications to establish more permanent acoustic receiver arrays or can be used for specific events to respond to emergencies. Should a call for proposals be released, individuals or groups of scientists could submit a proposal through NOPP or through the cooperative

agreements for future studies using ATN assets. Any solicitations should support the ATN guidelines and principles.

3. ATN Data-Sharing Guidelines

ATN data management is designed to handle diverse data types and to support archival, satellite, and acoustic telemetry data from individual researchers and large programs. Archival services, QA/QC processes, data products, and dissemination to users are key components. The ATN data management system will address the needs of the ATN and fit within the DMAC guidelines of the U.S. IOOS whenever possible (ioos.noaa.gov/data/contribute-data).

Outlined below are the ATN guidelines regarding the sharing of data and products by ATN participants funded partially or entirely by Federal agencies (considered Federal data), as well as those participants funded through non-Federal mechanisms (non-Federal data).

3.1 Guidelines – Federal Data

The landscape is quickly evolving regarding the policies, procedures, and acceptable practices for public access to data and results from Federally-funded research. The principles for compliance with federal guidelines are generally described within the U.S. Open Government Initiative memo entitled *Increasing Access to the Results of Federally Funded Scientific Research* (www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf) and the Executive Order *Making Open and Machine Readable the New Default for Government Information* (www.whitehouse.gov/the-press-office/2013/05/09/executive-order-making-open-and-machine-readable-new-default-government). Federal agencies are required to provide public access to research results, and data collected are to be managed as an asset in open, machine-readable formats. Specifics regarding the implementation of these requirements are left to individual agencies.

Although the ATN strives to provide Federal participants a data management platform that is compliant with the U.S. Open Government Initiative, each ATN participant providing Federal data is ultimately responsible for ensuring that all Federal requirements are met. For example, the National Science Foundation (NSF) Division of Ocean Sciences requires that data from NSF-funded research be deposited at the Biological and Chemical Oceanography Data Management Office (www.bco-dmo.org), and the National Aeronautics and Space Administration has SeaBASS (seabass.gsfc.nasa.gov) as a data repository. The ATN will identify Federal data requirements and initiatives and develop Memoranda of Understanding or another type of formal relationship with these Federal repositories. In most cases, depositing and sharing data and metadata via the ATN should meet Federal requirements. The ATN DAC in its current version (oceanview.pfeg.noaa.gov/ATN) provides an example of a publically accessible database that satisfies some of the existing requirements.

Extramural researchers receiving Federal grants and contracts may choose to publish their data to the ATN DAC, according to the data policies of the funding agency. If the funding agency policy and/or program managers do not provide specific guidance, extramural researchers will be entitled to require that access to the data that the researchers upload to ATN DAC be initially restricted (i.e. password protected) to only individuals who are approved by that collaborator at their sole discretion These data are referred to as restricted data. The terms relating to the restricted access period will be clearly stated by the researcher and should not exceed two years from the end date of the collection period.

Extramural researchers will have the option to format their data according to ATN DAC standards and conventions (ioos.noaa.gov/data/contribute-data). The ATN SG will encourage publication of data through regional portals (ioos.noaa.gov/regions) so that ATN data can be discovered and accessed from multiple locations, thereby increasing the likelihood that it is useful to the widest possible audience. The DAC data manager will also ensure publication of ATN data through the U.S. IOOS Catalog (ioos.noaa.gov/data/catalog).

3.2 Guidelines – Non-Federal Data

Non-Federal participants have the option to send their data to the ATN DAC for archiving and publishing. Participants can require that access to the data that the participants upload to ATN DAC initially be restricted to only individuals who are approved by that collaborator at the collaborator's sole discretion. As described under the previous section on Federal data, these data are referred to as restricted data. The terms relating to the restricted access period will be clearly stated by the researcher and should not exceed two years from the end date of the collection period. Decisions to allow for a restricted access period greater than two years shall be made by an ATN Data Coordination Committee, which will likely be a sub-group of the ATN SG and include staff from the ATN DAC.

Non-Federal data collaborators also will have the option to have full control of their data. To control their data, collaborators will have to log in to ATN DAC data-sharing tools to create a new project. Data owners will have full control over who can view and download their project/data in the ATN DAC. When a user creates a project on ATN DAC data-sharing tools, he or she becomes a data manager for that project and defines the visibility of and access to their project. For example, a data manager can:

- Make the project description and data inaccessible to all others;
- Allow selected users (collaborators) to view data, with optional download access;

- Allow selected users (data managers) to upload, edit, and view and download data;
- Allow the public to view the project description and one animal track but restrict access to data and other tracks; or
- Allow the public to view the project and freely download the project data.

The data owners (data managers) for a project control access to three user groups: data managers, collaborators, and the public (all others). The user who creates a project is initially the only data manager for the project. When registered users are added as a principal investigator and contact for the project, these users will also be added as data managers. Data managers can define additional ATN DAC users as data managers or collaborators following ATN DAC data-sharing tools guidance.

Only those users who are data managers for a project are allowed to change project permissions and upload and edit data. A principal investigator who would like to have his or her dataset reviewed and permanently archived for other researchers and the public can consider publishing his or her data set in the ATN DAC.

3.3 Data Submission to ATN DAC

ATN participants who agree to submit their data to the ATN DAC are responsible for ensuring that data are uploaded in accordance with predefined ATN standards and are submitted to the ATN DAC as outlined above. Details on data upload shall be set out in a Data Use Agreement. Participants will have the option to inform ATN of any errors, inaccuracies, or necessary updates with respect to their data as soon as possible after becoming aware of such issues, or the participants can access and update their data on their own. Oceanographic observations, whether or not the observations are captured on ATN-funded equipment, can be submitted directly (in real time, if feasible) to the ATN DAC. Tag-collected oceanographic data will be quality controlled through the ATN DAC and inserted onto the World Meteorological Organization Global Telecommunication System if appropriate (see details at www.wmo.int/pages/prog/www/TEM/GTS/index_en.html).

For acoustic telemetry, there are collaborators that deploy the tags (deployment collaborators) and collaborators that collect the tracking data from the receivers (tracking collaborators). Each deployment collaborator will direct potential tracking collaborators and others seeking access to data to ATN DAC. Upon retrieval and downloading of an acoustic receiver, the following operational metadata will be made public as soon as practicable: receiver location, deployment date, download date, and the identification code of any tags detected.

ATN participants with existing services or infrastructure (e.g., OPenDAP, ESRI ArcGIS servers) for providing public access to telemetry data will be able to request that the ATN ingest data from these existing sources.

3.4 Responsibilities in Use of ATN Data

All individuals who use ATN data in a publication, product, or commercial application shall provide proper attribution to all providers of those data and/or the ATN, and shall inform the ATN of any publications, products, or commercial applications that make use of ATN data. All individuals who use ATN data will agree and acknowledge that neither ATN nor the data provider is liable for any inaccuracies in the ATN data. All users of ATN data are responsible for investigating and understanding the limitations of ATN data. The ATN will explore options to implement the Digital Object Identifier (www.doi.org) in all citations of datasets made accessible through the ATN DAC. All registered users of the ATN DAC are required to report all problems with respect to ATN data to the ATN.

3.5 Sustainability and Availability

The ATN Data Coordination Committee will be responsible for conducting periodic reviews of data management activities to ensure that the activities are consistent with the ATN data-sharing guidelines. All unrestricted data held by the ATN will be routinely copied to U.S. IOOS RA Portals, the NOAA U.S. IOOS Catalog, and international aquatic animal telemetry partners (e.g., Global Ocean Observing System), and routinely copied to the NOAA National Center for Environmental Information (NCEI) for permanent archiving.

3.6 Important Resources

The ATN data-sharing guidelines were greatly enhanced with information from the following:

- NOAA Data Sharing Policy for Grants and Cooperative Agreements Procedural Directive, www.nosc.noaa.gov/EDMC/PD.DSP.php;
- Pacific Ocean Shelf Tracking Project---Statement of Data Principles, http://www.coml.org/projects/pacific-ocean-shelf-tracking-project-post
- MoveBank Permissions and Data Sharing, www.movebank.org;
- OTN Data Policy, oceantrackingnetwork.org;
- Australian Animal Tagging and Monitoring System Data Policy, imos.org.au/aatams.html.

4. Governance

The governance of the ATN is essential to its success. A national network requires national coordination with distributed regional expertise to ensure effective network stewardship and operations. The ATN will be supported by multiple Federal agencies within their current budget structures under the U.S. Economy Act (31 U.S.C. § 1535). The U.S. IOOS PO will implement the national ATN in partnership with Federal agencies and in collaboration with the community of U.S. IOOS RAs and regional experts.

4.1 Roles and Responsibilities

The ATN NC will be the overall coordinator for the aquatic animal telemetry network. The NC, in collaboration with the ATN SG, will be responsible for coordinating resources; liaising among the data team, the U.S. IOOS PO, U.S. IOOS RAs, and Federal agencies; and serving as the national and international point of contact.

4.1.1 Interagency Ocean Observation Committee

The IOOC established a Federal Steering Group Task Team (SG-TT) responsible for designing a governance structure to ensure successful execution of this Plan. The IOOC was legislated in the Integrated Coastal and Ocean Observation System Act of 2009 (P.L. 111-11) and oversees efforts to develop the National Integrated Coastal and Ocean Observing System. Led by three Federal co-chairs, with representation from Federal agency representatives and support staff, the IOOC carries out various provisions of the Act for implementing procedural, technical, and scientific requirements to ensure full execution of U.S. IOOS.

4.1.2 ATN Steering Group

The ATN Steering Group (SG) will provide long-term technical and programmatic expertise, as well as leadership for the ATN, consistent with FACA. The SG will comprise members representing Federal agencies involved in animal telemetry, with participation from the U.S. IOOS RAs, and non-Federal entities.

The IOOS PO will convene SG meetings and Federal agency members that are providing funding to support the ATN will have voting privileges; whereas, Federal agencies not providing ATN funding and non-Federal members will be non-voting members. The IOOS PO will convene the SG meeting and will not seek consensus from the group, but seek individual input and feedback from members on matters related to the ATN. The ATN SG will create subcommittees as needed to address specific aspects of the ATN. In addition, each IOOC member agency with an interest in ATN data should identify a single point of contact for ATN issues. This individual, who may or may not sit on the SG, would provide input on ATN-related issues and be responsible for coordinating input and feedback on the ATN within his or her agency. The SG members will serve on a rotational basis, with limited terms, unless participating agencies/U.S. IOOS RAs do not have additional qualified members. The members should have experience with animal tagging and telemetry. The SG will meet three times a year for the first two years, and bi-annually thereafter, which will include one annual in-person meeting.

The SG will be responsible for the following:

- In coordination with the NC, defining the overarching ATN scientific and operational objectives on the basis of this ATN Implementation Plan;
- In coordination with the NC, leading the development of updates to the ATN Implementation Plan as needed;
- Identifying long-term strategies to meet ATN goals and objectives outlined in the ATN Implementation Plan that take into consideration Federal, tribal, non-Federal, regional, and other user needs; and
- Reviewing and providing input on ATN scientific and technical directions for U.S. IOOS, partner agencies, and the academic community.

Whereas, the SG Federal members with voting privileges will be responsible for the following:

- Annual budget review and approval among participating agencies that fund animal tagging;
- In coordination with the NC, implementing annual priorities and objectives;
- Lead the coordination of funding pathways by Federal, state, local, tribal, and industry partners, to achieve the annual operating plan goals; and
- Advising the NC on implementation issues.

4.1.3 U.S. Integrated Ocean Observing System Program Office

The U.S. IOOS PO will support ATN implementation and will pursue opportunities to advance ATN objectives through collaboration with Federal agencies on the SG and the tagging community. The U.S. IOOS PO will implement annual budget plans for implementation of the ATN. Data integration is a key element of U.S. IOOS, and U.S. IOOS PO staff will work with the ATN data management teams to ensure that the ATN develops in a way that is consistent with the larger IOOS DMAC enterprise.

4.1.4 ATN Network Coordinator

The ATN NC, located within the U.S. IOOS PO, will coordinate the overall network management, both programmatically and operationally, and serve as the central and primary point of contact for the SG, participating Federal agencies, U.S. IOOS RAs, and other regional experts. The NC will carry out the following specific tasks for the network:

- In coordination with the SG, lead the ongoing development of the overall ATN;
- In coordination with the U.S. IOOS PO, support ATN implementation and pursue opportunities to advance ATN objectives;
- Develop the annual operating plan and budget materials;
- Support the SG and the interagency funding mechanisms;
- Coordinate and ensure regular communication with the U.S. IOOS RAs and regional experts;
- Serve as a liaison between all parties involved in the ATN, including the U.S. IOOS PO, U.S. IOOS RAs, SG, Federal agencies, and regional experts;
- Ensure that the ATN activities are integrated with other ocean observing activities;
- Track network performance metrics (see Section 4.3) and report the results to the SG and to U.S. IOOS PO leadership;
- In coordination with the U.S. IOOS PO, oversee the DAC O&M, which may be contracted to a third party;
- Support data coordination and training (see Section 2.4); and
- Support outreach to the stakeholder and user communities (see Section 5).

4.1.5 U.S. IOOS Regional Associations

The U.S. IOOS RAs will assist with coordinating regional ATN efforts in those regions that have aquatic animal telemetry activities, and implementing any annual ATN work plans on a regional level as

appropriate. In regions that do not have RAs active in aquatic animal telemetry or participating in the ATN, the SG will identify regional points of contact with aquatic animal telemetry experience.

The regional points of contact may be the U.S. IOOS RA director or staff, or other individuals with appropriate aquatic animal telemetry expertise. In all cases, the regional point of contact will ensure that aquatic animal telemetry activities are coordinated with the U.S. IOOS RA activities when possible.

4.1.6 Aquatic Animal Telemetry Programs and Individual Partners

Researchers located at academic institutions and Federal and non-Federal organizations will become members of the ATN when the researchers contribute by supporting national infrastructure (through acoustic receiver lines and aquatic animal telemetry equipment), submitting historic or current datasets to the DAC, and/or deploying or recovering tags in support of baseline tagging operations.

4.2 Environmental Compliance

All ATN activities involving vertebrate animals are conducted in accordance with the rules and regulations of the NMFS and the National Environmental Policy Act. Individual researchers contributing data to or supported by the ATN are responsible for obtaining any required scientific permits for tagging specific species using recognized standard operating procedures (e.g., www.nmfs.noaa.gov/pr/permits/mmpa_permits.html).

4.3 Performance Metrics

There are many potential performance metrics available with which to gauge the performance of national ATN development. The intent of the ATN is to follow the standards set by Federal operational networks and data providers, such as the National Weather Service National Data Buoy Center. Performance of the ATN will be evaluated by the SG at different levels of organization, from the national level to regional tracking activities. Individual tracking projects may be components of regional programs (equivalent to U.S. IOOS RAs), and these regional programs may, in turn, be nested within the national ATN. It is also possible that individual projects may interact directly with the national ATN. Performance metrics should reflect these different organizational scales, but some performance metrics may be applicable to all organizational scales.

Some significant outputs from animal tracking activities may be difficult to quantify. One specific example is the use of tracking outputs for governmental or private sector planning or permitting decisions; documenting when these events occur and quantifying their impact can be problematic.

The following sections describe the types of performance metrics that may be applied at various levels of the ATN.

4.3.1 National Level

At the national level, the ATN will be evaluated by the SG on the basis of the combined productivity of individual projects, performance of the U.S. IOOS RAs on ATN-related matters, and specific national-level metrics. In more detail, evaluation may be based on the:

- Ability to secure specific, adequate, and continuing funding for regional and local activities such as deployment and maintenance of ATN infrastructure (i.e., acoustic receivers and arrays, satellite tags);
- Number of Federal agencies and non-Federal entities utilizing data from ATN sources. These include, for example, U.S. NAVY and NOAA ocean circulation operational models (e.g., Hybrid Coordinate Ocean Model) and NOAA Fisheries stock assessment models;
- Frequency or volume of data and data products uploaded to the national ATN DAC, the U.S. IOOS Catalog, and the NCEI from individual and regional ATN projects;
- Number of visits to public U.S. IOOS ATN and ATN DAC websites;
- Incorporation of data and models into national, regional, or local policy and decision-making (e.g., marine planning, Marine Protected Area design, habitat restoration, and military and energy-sector risk assessment);
- Academic excellence (e.g., published papers and reports, student support);
- Number of programs that associate themselves with the ATN; and
- Interactions with international partners.

4.3.2 Regional Organizations

U.S. IOOS RAs participating in ATN activities will be evaluated on the basis of the combined performance of individual ATN projects operating under the U.S. IOOS RA umbrella and on the performance of the U.S. IOOS RA in promoting ATN objectives. Specifically, U.S. IOOS RA evaluation may include:

- Operational success (i.e., the numbers of animals tagged, receivers deployed and downloaded), transmitted data packages received, and number and duration of successful tracks obtained by projects operating under the region’s umbrella;
- Academic excellence (e.g., papers and reports published, student support, and technical training provided);

- Management pertinence (i.e., production of information used for decision making, such as marine planning, construction permitting, and public safety policies);
- Ability to attract additional local funding partners, such as non-Federal entities;
- Outreach activity (e.g., web page hits);
- Capacity building (e.g., the number of students and technicians supported and/or trained);
- Frequency of data uploaded to GTS data base; and
- Frequency of retrieval of data supplied from regional activities funded through the ATN.

5. Communications, Outreach, and Education

5.1 Communications and Outreach

A communications and outreach strategy is critical to achieving the desired impact of the ATN in ensuring stakeholder engagement. Such a strategy will be developed both for internal and external network communications, as well as outreach to partners, data users, stakeholders, and others. The strategy should be formulated within the first few years of operation by the ATN SG and the ATN NC, in collaboration with ATN operators, partners, data users, and stakeholders

The communications and outreach strategy will describe how the ATN is coordinated with partners' outreach efforts. The strategy will list the tasks to be performed and by whom, including the necessary methods, tools, timelines, outcomes, and indicators that will help measure and evaluate the strategy's effectiveness.

5.2 Education

Animals are an accessible way to foster public understanding of the value of the ocean, coasts, and Great Lakes, and the observing systems that provide information on these systems. The ATN will develop an education strategy and plan that addresses both formal (K-12 and post-secondary) and informal education (e.g., aquaria, museums, and zoos). The strategy will work with existing education, outreach, and communications programs within the U.S. IOOS RAs, such as activities carried out under the National Sea Grant College Program. The ATN education strategy and plan will also address the potential for using aquatic animal telemetry data to build products for grades K-12 and for exposing the public to these data through informal education programs that could include exhibits on tracks of tagged animals in near-real time.

The ATN will consult the Ocean Research Advisory Panel 2013 report *Leveraging Ocean Education Opportunities* (www.nopp.org/wp-content/uploads/2010/06/Leveraging-Ocean-Education-Opportunities.pdf) in developing its education and outreach strategies and carrying out education and outreach activities.

Appendix

Tables of selected survey results and an analysis summary as well as a summary of assets, data and planned tagging efforts are available at http://www.iooc.us/atn_datasets.

Tables of Survey Results. A survey of ATN task team members and associated institutions is reflected in three Tables: (1) a sampling of the number and types of data sets that the ATN would integrate into the ATN DAC; (2) a summary of the aquatic animal telemetry assets; and (3) a summary of the planned aquatic animal telemetry tagging projects gathered by the ATN-TT during outreach to researchers currently conducting aquatic animal telemetry projects. The information is not a complete list and representation of ongoing ATN activities, but rather a subset that highlights input for the ATN at a national scale.

Summary of assets, data, and planned tagging efforts. A summary of assets, data, and planned tagging efforts are represented in seven Figures: (1) survey participants broken down by U.S. IOOS region (Figs 1,2,3); (2)a summary of assets, data, and planned tagging efforts by driver broken down by U.S. IOOS region (Figs. 4, 5, 6); and (3) a summary of scientific drivers identified by survey participants, broken down and normalized by general species categories (fig. 7)

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Abbreviations

AOOS	Alaska Ocean Observing System
ATN	Animal Telemetry Network
ATN DAC	Animal Telemetry Network Data Assembly Center
ATN-TT	Animal Telemetry Network Task Team
AUV	Autonomous Underwater Vehicles
BOEM	Bureau of Ocean Management
CeNCOOS	Central and Northern California Ocean Observing System
CEQ	Council on Environmental Quality
cm	centimeter
COL	Consortium for Ocean Leadership
CSULB	California State University, Long Beach
EOP	Executive Office of the President
GLATOS	Great Lakes Acoustic Telemetry Observation System
GCOOS	Gulf of Mexico Coastal Ocean Observing System
GLOS	Great Lakes Observing System
GSM	Global System for Mobile
GPS	Global Positioning System
GTS	Global Telecommunications System
Hydra	Pacific Northwest Sound Data Management Project
ICOOS	Integrated Coastal and Ocean Observation
IOOC	Interagency Ocean Observation Committee
Khz	Kilohertz
Km	Kilometer
m	Meter
M	Million
MARACOOS	Mid-Atlantic Regional Association Coastal Ocean Observing System
MATOS	Mid-Atlantic Acoustic Telemetry Observation System
mS	Millisiemens
NANOOS	Pacific Northwest Ocean Observing System
NC	Network Coordinator

NCEI	NOAA National Center of Environmental Information
NCEP	NOAA National Center for Environmental Prediction
NEPA	National Environmental Policy Act
NERACOOS	Northeastern Regional Association of Coastal and Ocean Observing System
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Association
NOC	National Ocean Council
NSF	National Science Foundation
NSTC	National Science and Technology Council
NOPP	National Oceanographic Partnership Program
O&M	Operations and Maintenance
OSTP	Office of Science and Technology Policy
OTN	Ocean Tracking Network
PACIOOS	Pacific Coast Ocean Observing System
QA/QC	Quality Assurance/Quality Control
R&D	Research and Development
SCCOOS	Southern California Coastal Ocean Observing System
SECOORA	Southeast Coastal Ocean Observing Regional Association
SG	Steering Group
SOST	Subcommittee on Ocean Science and Technology
STEM	Science, Technology, Engineering, and Math
TOPP	Tagging of Pelagic Predators
URL	Uniform Resource Locator
USGS	United States Geological Survey
U.S. IOOS DMAC	IOOS Data Management and Communications
U.S. IOOS	Integrated Ocean Observing System
U.S. IOOS PO	IOOS Program Office
U.S. IOOS RA	IOOS Regional Association
3D	Three dimensional