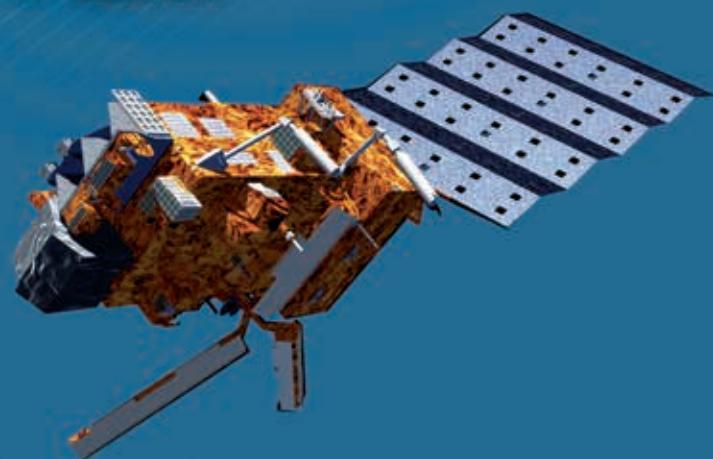


# ARGOS FORUM # 79

11 / 2014



THE SCIENCE  
THE SUCCESS  
THE SYSTEM



## SPECIAL EDITION

Highlighting the remarkable research showcased at the International User Conference on Argos Wildlife Applications, National Aquarium, Baltimore, MD, USA



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## The Science, The Success, The System

A tribute to the International Argos User's Conference on Wildlife Applications, National Aquarium, Baltimore, USA, November 18-20, 2014



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### KEYNOTE ADDRESS

## WALLACE J. NICHOLS



Dr. Wallace «J.» Nichols is a scientist, wild water advocate, movement-maker, New York Times bestselling author, and dad.

He takes a slow, collaborative approach with leaders in businesses, government, non-profits, and academia to inspire a deeper connection with nature and inventive solutions to pressing issues.

J. knows that inspiration comes sometimes through adventures, or simply by walking and talking. Other times through writing, images, and art. Science and knowledge can also stoke our fires. But he also

knows that what really moves people is feeling part of and touching something bigger than ourselves.

His research and expeditions have taken him to coasts and waterways across North, Central and South America, to Asia, Africa, Australia, and Europe where he continually finds that the emotional connection to waters of all kinds—rather than force of financial gain—is what keeps his colleagues and collaborators working hard to understand and restore our blue planet.



## The System: A successful international cooperation since 1978



The **National Oceanic and Atmospheric Administration (NOAA)** is a scientific agency within the United States Department of Commerce focused on the conditions of the oceans and the atmosphere. NOAA warns of dangerous weather, charts seas and skies, guides the use and protection of ocean and coastal resources, and conducts research to improve understanding and stewardship of the environment.



CENTRE NATIONAL D'ÉTUDES SPATIALES

Founded in 1961, the **Centre National d'Études Spatiales (CNES)** is the government agency responsible for shaping and implementing France's space policy in Europe.

Its task is to invent the space systems of the future, bring space technologies to maturity and guarantee France's independent access to space. CNES is a pivotal player in Europe's space program, and a major source of initiatives and proposals that aim to maintain France and Europe's competitive edge.



EUMETSAT is the **European operational satellite agency for monitoring weather, climate and the environment**. It operates a system of meteorological satellites that observe the atmosphere and ocean and land surfaces. This data is supplied to the National Meteorological Services of the organization's Member and Cooperating States in Europe, as well as other users worldwide.



The **Indian Space Research Organisation (ISRO)** is the primary space agency of India. ISRO is one of the largest government space agencies in the world. Its primary objective is to advance space technology and use its applications for national benefit.



**CLS** is a subsidiary of **CNES**, **IFREMER** and the investment company **ARDIAN**. It has been operating satellite systems, including the Argos system, and providing high value-added products and services since 1986.

# EDITORIAL

**Bill Woodward, CLS America**

**Eric Schwaab, National Aquarium**



**Bill Woodward**, Vice President,  
Environmental Monitoring, CLS America



**Eric Schwaab**, Chief Conservation  
Officer, National Aquarium

In the late 1970's the Argos Data Collection and Location System was conceived by engineers at the French Space Agency after their successful operation of a similar experimental data relay satellite for acquiring and relaying telemetered data from meteorological balloons. Dedicated to the environment and begun as a cooperative program among CNES, NOAA and NASA, (joined later with JAXA and now with EUMETSAT and ISRO as well), the Argos success story has spanned more than three decades and has had an enormous positive impact on our ever evolving capabilities for earth-based biological and physical sciences research.

In particular, Argos has enabled the wildlife community to continuously rewrite their textbooks on the migration patterns and habits of an increasingly wide variety of land, marine and avian animal species thus providing the essential science-based data needed to guide global conservation policy-making through informed management, economic and political decisions. At a time when field scientists were able to, at best, track animals at distances only marginally greater than line-of-sight, Argos allowed visionary biologists to begin dreaming beyond the horizon and to think about wildlife tracking on global scales. As Argos capabilities have grown, the vital simplicity and very low power of the system essential for wildlife tracking has remained.

The spirit of Argos is captured in the innovative and breathtaking scientific efforts of the global wildlife community, a large portion of which is captured in the following pages and showcased in November 2014 at the International User Conference on Argos Wildlife Applications at the National Aquarium in Baltimore, United States. Please explore the brilliant scientific efforts that are outlined in this publication and allow them to inspire you to celebrate the Science, the Success and the System, and assist the community in shaping the future of wildlife tracking with Argos.

All ARGOS publications are available at:  
**[www.argos-system.org](http://www.argos-system.org)**



# DIVERSITY AND ECOLOGY OF SPECIES TRACKED BY ARGOS

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## THE WIRED OCEAN: USING BIOLOGGING TECHNOLOGY TO TRACK WILDLIFE AND PREDICT THE IMPACTS OF CLIMATE CHANGE

| Dr. Barbara Block, Professor, Hopkins Marine Station, Dept. of Biological Sciences, Stanford

Biologging science with animal-borne tags is revolutionizing our view of how animals use the ocean. When free-ranging animals are tagged with a satellite tag that either pops up and delivers data, or broadcasts data continuously from the surface of the animal's body, these devices provide information about ocean basin scale movements, oceanographic preferences, physiology and behaviors of many pelagic species. The tracks and their underlying biology can be studied in relationship to the ocean environment, providing a new means for understanding how animals use the blue planet. Miniaturization of tags, and increased sensor capacity, combined with mobile glider technologies are creating an ecosystem of environmental animal intelligence in a "Wired Ocean." Electronic tags provide the capacity to track animal behaviors and physiology within the physical environment through which the animals are moving. Diving animals themselves become oceanographers as they probe the depths and take data of high resolution from the sea. Animal-derived data are being made available to the general

oceanographic community through data systems previously reserved for ship-based oceanographic data. Autonomous vehicles called Wave Gliders, instrumented with sensors for receiving tagged animal data; as well as passive and active buoys instrumented with data receivers, are contributing to our new capacity to observe free swimming animals in their environment. Detailed observations of animal movements in their aquatic environment have significantly improved our understanding of population structure and individual behaviors, fisheries management, and physiological constraints of species. These data are critical for conservation biology, preventing extinctions, preserving biodiversity and implementing ecosystem-based management of living resources, particularly in the face of a rapidly changing ocean environment.



Dr. Block's research is focused on the physiology of tunas, sharks and billfishes and studies how large pelagic fishes utilize the open ocean environment. Dr. Block is Co-director of the Tuna Research and Conservation Center the only facility in North America holding bluefin tuna for captive research. Her team has worked with engineers to develop and deploy electronic tags on ocean fish and sharks. The combination of lab and field work has led to a rapid increase in the understanding of movement patterns, population structure, physiology and behaviors of pelagic fish. Dr. Block leads a bluefin tuna tagging program called TAG-A-Giant that has placed almost 2000 electronic tags on northern bluefin in the Atlantic and Pacific oceans to better understand their ecology, physiology and conservation.

## 21 YEARS' SATELLITE TRACKING OF RAPTORS - SOME HIGHLIGHTS

| Bernd Meyburg, World Working Group on Birds of Prey (WWGBP)

Since 1992 scientists from the World Working Group on Birds of Prey have studied 16 species of raptors and tracked up to 100 individuals (Lesser Spotted Eagle) per species. The biggest species tracked has been the huge Steller's Sea Eagle and the smallest the tiny Amur Falcon. At the International User Conference, Bernd Meyburg shall report on a few highlights of his telemetry work especially the tracking of Amur Falcons from South Africa to NE China and back. This included five-day

non-stop flights of up to 6,000 kilometers and regular crossings of the Indian Ocean of all the birds tracked. His research has also revealed links between rainfall and migration paths. Prior knowledge and the site fidelity exhibited by this eagle suggests that temporal variability of resources may have a greater impact on the movements of this species than the spatial variability.



## USE OF PROTECTED AREAS BY MARINE TURTLES TAGGED IN DRY TORTUGAS NATIONAL PARK, FL, USA

| Kristen M. Hart, USGS



Use of existing marine protected areas by marine turtles can be determined using Argos satellite telemetry. Because of a lack of information on protected area use by marine turtles in the Gulf of Mexico, scientists at the USGS used satellite transmitters in 2008-2013 to track movements of 84 marine turtles tagged in Dry Tortugas National Park (DRTN), south

Florida, USA. Throughout the study period, loggerheads, green turtles, and hawksbills spent disproportionate numbers of tracking days within US protected areas, the closest of which is the Florida Keys National Marine Sanctuary. Many loggerheads and hawksbills, in particular, traveled into international waters, away from protected zones.

# DIVERSITY AND ECOLOGY OF SPECIES TRACKED BY ARGOS

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## HOW ARGOS SATELLITE TRACKING PROVIDES KEY DATA FOR CONSERVATION

| Dave Douglas, Research Wildlife Biologist at the U.S. Geological Survey Alaska Science Center

Exponential growth of Argos animal tracking studies over the past 30 years is testimony to the system's efficacy for obtaining unique and relevant insights into the movement ecology of migratory animals. Emphasis is typically placed on species of special concern, either because their populations are threatened or potentially threatened, or because they are subject to managed harvest. Knowing where individuals go at daily, seasonal, and annual time scales is fundamental to robust and effective conservation practices. Research biologists at the U.S. Geological Survey (USGS) have used the Argos System since 1985 to advance scientific understanding of many species of concern to management agencies in the U.S. Department of Interior; notably the U.S. Fish and Wildlife Service, Bureau of Land Management, National Park Service, and Bureau of Ocean Energy Management. Although USGS studies



Mr. Douglas has been involved with numerous assessments of Argos location accuracy and transmitter performance. His main scientific interests fall broadly under the topic of "habitat dynamics", in which he exploits satellite remote sensing and reanalysis data to investigate how variations in climate affect the quality and availability of wildlife habitats, and how variations in weather affect the timing and routes of wildlife migrations.

comprise but a small fraction of the Argos animal-tracking applications worldwide, they offer a diverse portfolio from which to highlight how satellite tracking has provided key information to management decisions and strategic conservation planning. USGS studies that have utilized the Argos System have allowed scientists to acquire new knowledge about the movements

of waterfowl, raptors, shorebirds and sea ducks. The studies have proven instrumental in not only defining important use areas across international borders, but also in documenting remarkable capabilities of navigation and physical endurance.

## TRACKING TROPICAL MANATEES: USE OF ARGOS TAGS ON ANTILLEAN MANATEES FROM THE BAHAMAS TO BRAZIL

| James Reid, USGS



For nearly 10 years, researchers in Brazil, Belize, Mexico and Puerto Rico have been working together to understand the migratory movements of the Antillean manatees (*Trichechus manatus*). Unlike the migratory Florida manatees (*Trichechus manatus latirostris*) of the temperate southeastern United States, Antillean manatees (*Trichechus manatus manatus*) occupy tropical coastal habitats in the Western Atlantic from Mexico to Brazil and also in the Greater Antilles. Argos

satellite tracking has proven to be a key tool to understand local movement patterns and develop management strategies. These collaborative efforts have all involved contributions from various nations and agencies assisting in developing tracking technology, research strategies and management strategies. These collaborative efforts have all involved contributions from various nations and agencies assisting in developing tracking technology, research strategies and management goals.

## USE OF SOLAR-POWERED SATELLITE TRANSMITTERS IN ASSESSING MIGRATION PATTERNS OF BURROWING OWLS IN WESTERN NORTH AMERICA

| David H. Johnson, Idaho Cooperative Fish and Wildlife Research Unit

During 2013 and 2014, scientists at Idaho Cooperative Fish and Wildlife Research Unit and Environment Canada placed backpack-mounted, solar-powered satellite transmitters (PTTs) onto 37 adult female Burrowing Owls (*Athene cunicularia*) in Oregon, Washington, Montana, South Dakota, Colorado, Nebraska, Utah, Alberta and Saskatchewan. PTTs were enhanced by adding 9 mm tall epoxy 'lift kits' to the underside of the units to elevate the solar panel arrays so they would not be covered by the owls' neck and back feathers. They used nylon-coated stainless steel cable (in 2013) and 4.8 mm-diameter Teflon

tubing (in 2014) as the harness materials. The Argos satellite system was used to document owl migration phenology, migration pathways, overwintering sites, movement rates, and extent of breeding site fidelity. At the International Argos User Conference, the use and recovery of PTTs, accuracy of satellite fixes, data acquired from and cost effectiveness of two PTT duty cycles, effectiveness of the two harness materials, and the migration patterns of Burrowing Owls in western North America will be explored.







Greater flamingoes wearing Argos satellite transmitters, in the United Arab Emirates. Photo courtesy of Salim Javed.



## SATELLITE TRACKING MIGRATORY BIRDS FROM THE UNITED ARAB EMIRATES OPPORTUNITIES FOR SPECIES AND SITE CONSERVATION

| Dr. Salim Javed, Manager, Terrestrial Assessment and Conservation Section at Environment Agency - Abu Dhabi

Important migratory birds have been tracked using satellite telemetry in the United Arab Emirates (UAE) since 2005 to determine migration routes, stopover sites and local habitat use patterns. Satellite tracking of eight different waterbirds and migratory raptors undertaken by the Environment Agency-Abu Dhabi has provided highly useful information on migration routes and stopover sites for the tracked species, some for the very first time. The Argos satellite tracking work on the Greater Flamingos (*Phoenicopterus roseus*) led to the discovery of the breeding colony of the species in the coastal Abu Dhabi and the site has been proposed as one of the protected areas in the Emirate. The work of the Terrestrial Assessment and Conservation Unit has also been instrumental in providing timely recommendations to promote development of key bird and biodiversity areas in the Emirate. As the UAE continues to develop rapidly with major developments planned along the coast and islands, Dr. Javed's work on migratory waterbirds and raptors

would continue to provide information to mitigate threats from such projects locally but will also have conservation implications for species along their migratory routes regionally and globally.



Dr. Salim Javed has undertaken and completed several important projects on birds including satellite tracking of Eurasian Cranes and Bar-headed geese in India and has successfully satellite tracked many important species in the UAE including some for the very first time such as the Sooty Falcon. His work focuses on using satellite telemetry and other modern technologies in decision making to help the local government in protecting key species and sites. He used Argos for nearly 15 years and first tracked Eurasian Cranes from India in 1999. He has tracked 12 species so far.



*“Wildlife tracking using Argos is the most efficient way to track long distance migrants. The technology provides enormous opportunities to understand migration ecology of birds both at coarse (long-distance migration) and fine resolutions (habitat use etc.). I have used this technology for nearly 15 years and I continue to be fascinated by it even today. The technology has huge conservation implications, both locally and regionally and can be a very effective education awareness and outreach tool!”*

Salim Javed, Argos user since 1999

## LEARNING THE SPATIAL DISTRIBUTION OF SEA TURTLES IN THE GULF OF MEXICO FOR CONSERVATION AND MANAGEMENT STRATEGIES

| Eduardo Cuevas, Pronatura Península de Yucatán, A. C. and Centro de Investigación y de Estudios Avanzados del I.P.N., Unidad Mérida

The Southern Gulf of Mexico harbors the largest hawksbill (*Eretmochelys imbricata*) turtle nesting populations, and one of the top five most important green (*Chelonia mydas*) turtle nesting populations in the Caribbean. The comprehension of their spatial distribution and usage of the marine habitats is key to define the most pertinent conservation and management strategies both for their populations and their habitats. Argos satellite telemetry has become an indispensable tool to locate interesting areas, migratory corridors and feeding grounds for adult and juvenile individuals from Southern Gulf of Mexico.

Since 2006, 39 turtles of both species have been tracked with Argos, and their critical habitats located. This information has led to a better ecological understanding of sea turtles, and brought out the urgent theme on international conservation to protect and preserve critical habitats shared by sea turtle populations in the Gulf of Mexico. Satellite telemetry will continue to be a key tool for sea turtle conservation in this region, and there are plans for increasing the number of tracked individuals for a more complete panorama.





# WILDLIFE TRACKING CONSERVATION APPLICATIONS

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Photo courtesy of Gerardo Ceballos



## FROM JAGUARS TO BISON: ECOLOGY AND CONSERVATION SCIENCE IN MEXICO

| Dr. Gerardo Ceballos, Professor, National Autonomous University of Mexico

The current loss of biological diversity is one of the most severe global environmental problems and probably is the only one that is truly irreversible. Anthropogenic factors are causing increasing rates of extinctions of both populations and species. Indeed it is estimated that more than 50% of all wildlife populations have been lost in the last 40 years. Mexico, considered one of the top 5 more biologically diverse countries, is not an exception with many species at risk of extinction because of human activities. At the International Argos Users Conference, Dr. Ceballos will describe two successful projects of the use of Argos wildlife satellite tracking for evaluating the ecology and conservation of key species in Mexico. First, he describes his studies with jaguar ecology and conservation in southern Mexico. At a regional level he and his colleagues have

been able to assess jaguars' home ranges, habitat availability and selection, and population densities. At a national level they have conducted the first jaguar census at a country level and have estimated a 4000-jaguar population in Mexico. The second project is about the interaction of prairie dogs, bison, and cattle in the arid grasslands of northern Mexico. Using radio-collars they evaluated bison and cattle habitat use and found out that cattle can be used to mimic bison foraging activities. They also found that cattle and prairie dogs do not compete for forage a major assumption that is used to exterminate prairie dogs in the United States. In both cases, the projects have been successful because of the use of technological advances such as wildlife tracking.



Dr. Ceballos is a major figure in global conservation science, carrying out strenuous field work testing ideas in countryside biogeography and doing important theoretical/practical work on the global distributions of mammals and their significance for mammal conservation as well as on global rates of extinction as humanity triggers the sixth great extinction event. Ceballos also has been responsible for enormous direct contributions to the preservation of the biodiversity of Mexico -- a global «hotspot.»

### GERARDO CEBALLOS, TOP 6 FINALIST 2014 INDIANAPOLIS PRIZE



Champion for jaguars in Mexico, conducting the first country-level jaguar census and the most comprehensive jaguar study to date, Dr. Ceballos' work was recognized with the prestigious Indianapolis Prize, a biennial award given to individuals for «extraordinary contributions to conservation efforts» affecting one or more animal species by the Indianapolis Zoo. It is considered to be the world's leading award for animal conservation by members of the professional wildlife conservation community.





Adult male bottlenose dolphin in Sarasota Bay, Florida, with Wildlife Computers Splash tag, May 2012.  
Photo by Sarasota Dolphin Research Program, taken under NMFS Scientific Research Permit No. 15543.



## SATELLITE-LINKED TAGGING OF SMALL CETACEANS: A CRUCIAL TOOL FOR CONSERVATION

| Randall Wells, Director, Sarasota Dolphin Research Program

Small cetaceans are inherently difficult to study, because they are at the water's surface for only very brief periods of time to breathe. Thanks to advances in telemetry and the advent of the Argos system, these brief surfacings provide opportunities to obtain crucial data for conservation, from satellite-linked tags on cetacean dorsal fins. Over the past 20 years, such tags have evolved to be sufficiently small for use on even the smallest cetaceans for months, with little risk. Hands-on attachments have been reduced to a single pin through the fin's trailing edge, and for some species, remote attachment techniques exist. Tag data on ranging, diving, and habitat use patterns have aided the conservation of poorly studied species, such as Franciscanas in South

America, which face serious threats from fishing nets and development. In the United States, tag data help to define stocks, and identify habitat use related to exposure to such activities as fishing or oil spills, that can affect mitigation and restoration. Tags on stranded-rehabilitated cetaceans provide opportunities post-release to evaluate rehab success, and open windows into the lives of little-studied species. With changing climates, tagging will be important for identifying changes in cetacean behavior. These data will be needed for reducing cumulative impacts on the animals, for identifying and mitigating the more controllable anthropogenic threats, increasing their survival chances in the changing environment.

## USE OF ARGOS-LINKED GPS TECHNOLOGY TO STUDY FLORIDA MANATEE ECOLOGY AND BEHAVIOR: DISCOVERIES FROM THE PAST 12 YEARS OF TRACKING FOR CONSERVATION

| Charles J. Deutsch, Florida Fish and Wildlife Conservation Commission

Management decisions involving the endangered Florida manatee often require fine-scale information on their use of waterways and how that interacts with human activities. Over the course of 3 multi-year studies conducted since 2002, Dr. Chip Deutsch and his colleagues deployed GPS-PTT tags on 101 manatees and obtained near-real-time and accurate movement tracks and behavioral data through the Argos System. This technology has opened up new windows into manatee ecology and behavior, including a greater understanding of their foraging behavior and use of warm water refuges in winter, identification of high-use areas and hotspots, and variations in movements and habitat use among individuals. Detailed 3D travel paths were delineated in relation to habitat features and boat activity in conjunction with TDRs and DTAGs.



Dr. Wells has been using Argos to track dolphins and small whales since 1997. His involvement includes the tagging and/or tracking of more than 100 small cetaceans of 8 species, ranging in size from franciscanas up to pilot whales. His current research program uses a collaborative approach to examine the behavior, social structure, life history, ecology, health, and population biology of bottlenose dolphins along the central west coast of Florida, with studies focusing on five concurrent generations of a locally resident 160-member dolphin community. Recent research topics include the effects of human activities on coastal dolphins, such as boat traffic, fishing activities, human feeding of wild dolphins, and environmental contaminants.

2014 INDIANAPOLIS  
PRIZE NOMINEE

### Dr WELLS, NOMINEE - 2014 INDIANAPOLIS PRIZE

Program director of the Sarasota Dolphin Research Program, the world's longest-running study of a wild dolphin population. Dr. Wells' work was nominated for the prestigious Indianapolis Prize, a biennial award given to individuals for «extraordinary contributions to conservation efforts» affecting one or more animal species by the Indianapolis Zoo. It is considered to be the world's leading award for animal conservation by members of the professional wildlife conservation community.



## THE MONITORING OF THE LONG-TERM MOVEMENTS AND DIVING BEHAVIOR OF RELEASED REHABILITATED MARINE TURTLES IN NEW ZEALAND WATERS

| Chris Andrews, SEA LIFE US, Merlin Entertainments

Since 1991 Kelly Tarltons SEA LIFE aquarium in Auckland, NZ, has rehabilitated and released 33 marine turtles (including 26 green turtles) into the wild. Until recently, it was impossible to ensure that the released turtles were not compromised from the outset because the temperate New Zealand waters are considered to be a sub-optimal habitat for release. With the evolution of autonomous tracking systems, it has become possible to monitor the long-term survival and migratory be-

havior of these cryptic species across a vast marine landscape. Since 2004, eight green turtles (*Chelonia mydas*) recovered in New Zealand and released after rehabilitation at Kelly Tarltons SEA LIFE Aquarium have been satellite tracked via the Argos system. At the International Argos Users Conference, the Sea Life team will share some insights to the post-release survival, movement, and behavior of marine turtles in New Zealand waters.



## TRACKING PACIFIC BARROW'S GOLDENEYES IN THE PACIFIC NORTHWEST TO EVALUATE BREEDING, MOLTING AND WINTERING SITES FOR CONSERVATION

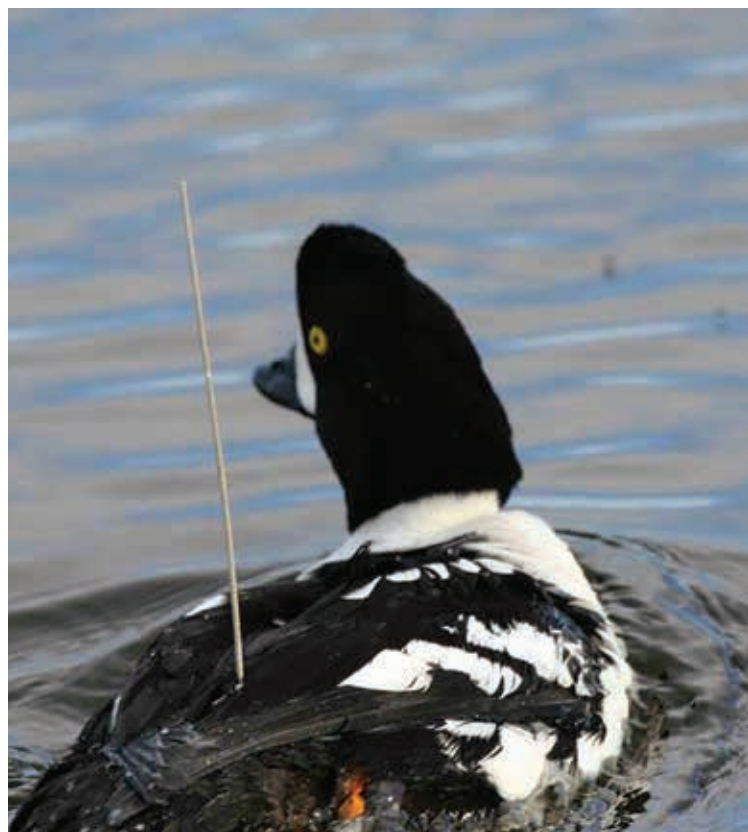
| Walter S. Boyd, Environment Canada

Scientists at Environment Canada implanted more than 300 Pacific Barrow's Goldeneyes (*Bucephala islandica*) with Argos satellite transmitters to describe migration routes, seasonal habitat affiliations, and degree of site fidelity within and across years. The migration data come from cohorts of birds captured during breeding, molting, and wintering periods to describe population structure and delineate appropriate

units for management. Adult birds showed high levels of site fidelity in all periods of the annual cycle, and this finding has important management and conservation implications. In addition, tracking data lead to the discovery of an important molting lake for adult males in Alberta; this, in turn, led to estimates of 5-6,000 males using the lake and an assessment of goldeneye molt ecology.



Photo of Grey-belly Brant with a percutaneous antenna. Photo courtesy of Walter Boyd.



Barrow's goldeneye with percutaneous antennae. Photo courtesy of Walter Boyd.

# USING ARGOS TO UNDERSTAND PROTECTED HABITATS AND SPECIES



## USING ARGOS TO UNDERSTAND PROTECTED HABITATS AND SPECIES FROM SINGLE ANIMALS TO ANIMAL TELEMETRY NETWORKS

| Dr. Richard Merrick, Chief Science Advisor and Director of Scientific Programs, NOAA Fisheries

In the early 1980s, when Service-Argos first began offering service for wildlife telemetry, there were only a few, very basic instruments available to use. The taxa instrumented were largely limited to large terrestrial mammals (e.g., bears) and a few marine species (e.g., grey whales). At that time, scientists were satisfied to receive a few locations a day. Over that next decade, incredible advances were made partly due to cooperative efforts between a few manufacturers and biologists but also because of advances in information processing and hardware provided through Argos. By the end of the decade, scientists were not only receiving numerous locations a day, but also data associated with the animals at those locations. On the marine side, the incorporation of time-depth dive data was a major advance forward, but it was also found that high

resolution physical oceanographic data could be captured and delivered at relatively low costs. Since then there has been a continued reduction in instrument size, an expansion of the suite of sensor data, inclusion of GPS technologies, and refinements in processing/analyses of uplinked data. Through the use of these instruments researchers have achieved a profound insight into the lives of many vertebrate species, and the habitats they individually exploit. These observations are critical for sustaining populations, conserving biodiversity and developing the kinds of data required to implement ecosystem-based management. These animals are particularly adept at helping scientists identify critical habitats, spawning locations, and important oceanographic features (e.g., fronts, eddies and upwelling areas). This provides important insights into regions of the

oceans that are difficult and expensive to monitor (e.g., offshore environments, Arctic) that may not be available from more expensive ship, aircraft, and satellite platforms. To further this approach, NOAA is implementing a national Animal Telemetry Network (ATN) through its U.S. Integrated Ocean Observing System to implement a range of operational telemetry technologies, (some of which absolutely require Argos support) that enable monitoring of a host of aquatic life over multiple temporal and spatial scales. A national ATN will enhance fisheries and ecosystem-based management, fill oceanographic knowledge gaps, improve ocean modeling and forecasting, and advance many of the U.S. National Ocean Policy's priority objectives.



Richard Merrick began serving as Director, Scientific Programs and Chief Science Advisor for NOAA Fisheries in September 2011. In this capacity, he leads NOAA Fisheries' efforts to provide the science needed to support sustainable fisheries and ecosystems and to continue our country's progress in ending overfishing, rebuilding fish populations, saving critical species, and preserving vital habitats. As the head of NOAA Fisheries' scientific operations, Dr. Merrick directs NOAA's six regional Fisheries Science Centers, including 30 NOAA Fisheries laboratories.

## IDENTIFICATION OF WHALE MIGRATORY ROUTES AND HIGH-USE AREAS FROM ARGOS SATELLITE TELEMETRY DATA

| Dr. Helen Bailey, Research Assistant Professor at the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science

Management of protected species, such as whales, requires spatially-explicit information on their distribution, and how this varies over time. Argos satellite telemetry data are a valuable source of information for this because, unlike many survey methods, it can provide a continuous time series of locations and this has greatly increased our understanding of animal movements. In this study Dr. Helen Bailey and her colleagues analyzed the movements of four whale species (blue, fin, hump- back and gray whales) that were tracked using Argos satellite telemetry in the California Current System. These species are protected under the U.S. Marine Mammal Protection Act and the former three species are also listed as Endangered. A state-space model was applied to all of the

satellite tracks ( $n=156$ ) from 1994 to 2009 to account for errors in the locations and to infer their behavior. The whales' movement patterns and behavioral states were analyzed to identify high-use areas, migration routes and foraging grounds. Habitat modeling was also used to provide further insight into the processes driving these spatial distributions. Mortality and injuries caused by ship strikes in U.S. waters are a cause of concern for large whales. The scientists suggested possible modifications to existing shipping lanes to reduce the likelihood of collisions with vessels. Improved understanding of the movements and spatio-temporal distribution of whales will help to inform how management policies could be adapted to most effectively protect these species.



Helen Bailey is a Research Assistant Professor at the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science. Prior to that, she studied the environmental impacts of offshore wind turbines on marine mammals as well as the migration pathways and hot spots of marine predators at the National Oceanic and Atmospheric Administration (NOAA) as part of the Census of Marine Life's Tagging of Pacific Predators project. She joined the University of Maryland in 2010 where her research focuses on studying patterns of habitat use, migration and species, and its application to management and conservation.



# USING ARGOS TO UNDERSTAND PROTECTED HABITATS AND SPECIES



## BROAD AND FINE-SCALE MOVEMENTS OF WHITE SHARKS IN THE WESTERN NORTH ATLANTIC DERIVED FROM MULTIPLE TECHNOLOGIES

| Dr. Gregory Skomal, Senior fisheries biologist with Massachusetts Marine Fisheries

Despite its well-established presence in the North Atlantic, the white shark, (*Carcharodon carcharias*), is not considered an abundant species and efforts to study its life history and ecology have been hampered by the inability of researchers to predictably encounter these sharks. However, increasing pinniped populations are now attracting white sharks to the shores of Cape Cod, MA, thereby providing research opportunities. From 2009-2013, Gregory Skomal and his team tagged 39 white sharks off the eastern coast of Cape Cod, MA to examine fine- and broad-scale movements, habitat use, site fidelity, residency, and feeding behavior. The sharks, which ranged from 2.4-5.5m

total length (mean = 4.0 m), were tagged with pop-up Argos satellite tags, smart positioning satellite tags, passive acoustic transmitters, and/or conventional tags. To date, they have found that some white sharks exhibit seasonal site-fidelity to the coastal waters of Cape Cod, returning over multiple years. Broad-scale movements have varied from a relatively restricted coastal seasonal migratory pattern to deep diving behavior and expansive use of offshore regions from the Sargasso Sea to the Mid-Atlantic Ridge. As demonstrated elsewhere, white sharks in the North Atlantic appear to have a complex migratory pattern likely linked to reproductive biology.



*“Our ability to track fish with the Argos satellite system has dramatically changed the way we think about these amazing animals.”*

Gregory Skomal, Argos user since 1994

## THE USE OF ARGOS TAGS AS A TOOL FOR UNDERSTANDING LARGE WHALE ECOLOGY AND MANAGEMENT

| Amy Kennedy, National Marine Mammal Laboratory (Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration)



Over the past decade, the National Marine Mammal Laboratory (NMML) has partnered with local and international organizations to conduct satellite telemetry research on large whales in order to describe their fine-scale movement and habitat use. In addition to ecological studies, projects detailing the physical and physiological effects of tagging on individuals and populations have been conducted.

North Pacific right whales, humpbacks, and gray whales were tagged. Results from these projects show that Argos satellite telemetry is a powerful tool for collecting fine-scale movement data (particularly in remote areas) that cannot be obtained or predicted in any other manner. The scientists found that while whales aggregate in well-known areas, there can be substantial individual movement variation within seasons. Results also show that whales are routinely crossing international borders, reinforcing the need for multinational collaboration when managing these endangered animals.



Dr. Gregory Skomal is an accomplished marine biologist, underwater explorer, photographer, aquarist, and author. He has been a senior fisheries biologist with Massachusetts Marine Fisheries since 1987 and currently heads up the Massachusetts Shark Research Program. He is also adjunct faculty at the University of Massachusetts School of Marine Science and Technology in New Bedford, MA, and an adjunct scientist at the Woods Hole Oceanographic Institution in Woods Hole, MA. Over the last 20 years, Dr. Skomal has used hundreds of Argos-linked tags on more than a dozen species of highly migratory fishes, including sharks, tunas, and swordfish, to study their natural history and ecology.

Using Argos to track great white sharks in the Western North Atlantic



The great white sharks are captured and an Argos satellite tag is attached to the dorsal fin. Photo courtesy of Gregory Skomal.



# ARGOS AS A TOOL TO ADVANCE GLOBAL CONSERVATION AND IMPROVE ENVIRONMENTAL POLICY, ECONOMICS AND SOCIETY

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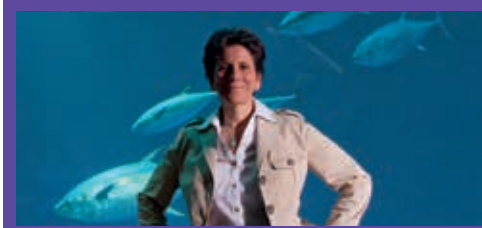
## SUSHI & SATELLITES: USING SATELLITE TECHNOLOGY AS A CONSERVATION TOOL FOR PROTECTING MARINE FISHES AND ECOSYSTEMS

| Dr. Barbara Block, Professor, Hopkins Marine Station, Dept. of Biological Sciences, Stanford

Atlantic bluefin tuna are among the largest and most valuable fish in the ocean. They are currently managed by ICCAT as separate western and eastern populations. The western Atlantic population is primarily accessed by North American fishers and is more severely depleted than the eastern population. Gulf of Mexico bluefin have only been fished for less than sixty years. In contrast, Mediterranean fishers have accessed the bluefin tuna plying these waters for over 2500 years. Electronic tagging

using the Argos data collection system has provided new long term movement data on bluefin, providing new information on how these large pelagic fish use the North Atlantic Ocean, the Mediterranean Sea and the Gulf of Mexico. Tagging data demonstrate that extensive trans-oceanic movements occur in short durations and provide evidence for site-directed fidelity to known breeding areas that maintains distinct populations. New management models built with electronic tagging data

indicate that improved biological knowledge advances our understanding of how bluefin use their environment and how many remain in the sea. The tagging science has led to recent designations of new protected areas for spawning bluefin tuna in the Gulf of Mexico, and identifies zones in international waters where overfishing on mixed stock fisheries occurs and impedes recovery of the western population of tuna that spawns in the Gulf of Mexico.



Dr. Block's research is focused on the physiology of tunas, sharks and billfishes and studies how large pelagic fishes utilize the open ocean environment. Dr. Block is Co-director of the Tuna Research and Conservation Center the only facility in North America holding bluefin tuna for captive research. Her team has worked with engineers to develop and deploy electronic tags on ocean fish and sharks. The combination of lab and field work has led to a rapid increase in the understanding of movement patterns, population structure, physiology and behaviors of pelagic fish. Dr. Block leads a bluefin tuna tagging program called TAG -A-Giant that has placed almost 2000 electronic tags on northern bluefin in the Atlantic and Pacific oceans to better understand their ecology, physiology and conservation.

## SATELLITE TRACKING RED-BREASTED GEESE

| Meenakshi Nagendran, United States Fish and Wildlife Service

The Red-breasted Goose (*Branta rufficollis*) is one of the most threatened goose species in the world. They breed in the Arctic Tundra, in Taimyr, Gydan, and Yamal peninsulas, and winter primarily in Bulgaria and Romania at the current time. The Bulgaria-US Redbreasted Goose Project, a collaboration among Bulgarian and American conservationists and collaborators from Holland, Romania, Belgium, and Russia, deployed Argos GPS-Platform Transmitter Terminals on 8 red-breasted geese from 2012-2014 on their wintering ground in Bulgaria.

The enormous value of this wide-ranging collaborative effort where satellite tracking can be crucial to the conservation of long distance migrants will be presented at the International Argos Users conference, including the fate of each bird as well as the important stopover sites for the populations, the challenges of using satellite tracking technology, its incredible value for natural resource conservation, and the challenges that lie ahead.



## SATELLITE TELEMETRY AND THE CONSERVATION ECOLOGY OF IMPERILED RAPTORS AND WATER BIRDS

| Kenneth D. Meyer, Avian Research and Conservation Institute

Sound data on habitat and foraging needs, seasonal movements, survivorship, exposure to contaminants, and the locations of critical areas are essential for conservation planning and management of imperiled species. Since 1996, Avian Research and Conservation Institute has used Argos satellite telemetry to test related hypotheses for nine species birds in need of protection. Some examples illustrate how this technology can provide information unobtainable with any other

method, or at least with greater volume, accuracy, economy, and less observer bias than by any other approach. Species tracked include Swallow-tailed Kites (*Elanoides forficatus*), Snail Kites (*Rostrhamus sociabilis*), the Reddish Egret (*Egretta rufescens*), Great White Herons (*Ardea alba*), White-crowned Pigeon (*Patagioenas leucocephala*), and Magnificent Frigatebirds (*Fregata magnificens*).





# ARGOS AS A TOOL TO ADVANCE GLOBAL CONSERVATION AND IMPROVE ENVIRONMENTAL POLICY, ECONOMICS AND SOCIETY

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Photo courtesy of Matt Witt



## HOW SATELLITE TRACKING HAS HELPED ADVANCE MARINE VERTEBRATE CONSERVATION

| Dr. Matt Witt, Scientist, Marine Sea Turtle Research Group

Since the launch of the first satellites hosting Argos receivers, the Argos System has revealed the once unknown movements of terrestrial and aquatic organisms alike. The technology has profoundly changed the ways in which scientists perceive the complex lives of animals, providing insight into habitat use, foraging behavior and mating ecology, to name but a few advancements. In more recent years, with increasing understanding of human activities, particularly at sea, data from the Argos System are being used to address applied issues in conservation science, such as spatio-temporal efficacy of protected areas, overlap of protected species with small scale

and industrial fisheries and site selection of large engineering projects on land and sea. It is increasingly evident that Argos data are crucial in developing the evidence base around which management and policy decisions for protected species might be made. At the International Argos User's Conference, Dr. Witt will present recent conservation advances using the Argos System, and reflect on the future role it has in helping conservation and environmental scientists to improve knowledge for the future. He will also feature two case studies where Argos tracking has lead to real conservation change.



Dr. Witt's research focuses on marine ecology, looking specifically at the distribution and behavior of mobile marine species, including turtles, sharks and seabirds. He uses a wide range of technologies, including satellite tracking, acoustic detection and videography. He is especially interested in integrating satellite-derived environmental datasets with information on marine species distribution and knowledge on man's behavior to determine likely areas of conflict. His current research projects include the satellite tracking of basking sharks in the northeast Atlantic, assessing the effects of marine energy generation on host ecosystems and the development of acoustic based methods to describe marine biodiversity.

## SATELLITE TELEMETRY OF INTRA-AMAZONIAN MIGRANT BIRDS: WHAT WE KNOW AND WHERE WE ARE GOING

| Lisa Davenport, Duke University Center for Tropical Conservation

Since 2010 we have tracked intra-Amazonian migrant birds, primarily the Orinoco Goose (*Neochen jubata*), a rare and declining species that is Critically Endangered in Peru and Near Threatened globally. Our main fieldsite in Manu National Park, hosts the last known breeding population for Peru. Combining data from 3 birds tagged in Manu with 2 birds tracked from the Rio Jurua, Brazil, we demonstrate strong migratory connectivity between breeding populations in

both Peru and Brazil with the Llanos de Moxos, Bolivia, an extensive wetland-savanna habitat rich in waterfowl which is currently 98% in private hands. Birds from both Peru and Brazil showed high site fidelity to their respective breeding beaches and Peru birds repeatedly visited individual lakes in Bolivia that we consider likely staging areas. In addition to work with the Orinoco Goose, we also report on a new tracking program of additional beach-dependent

birds in Manu National Park, including the Black Skimmer (*Rynchops niger*) and Large-Billed terns (*Phaetusa simplex*). Being piscivorous, they are not expected to follow similar wet- season migrations as the herbivorous geese, but they may indicate important movement strategies for birds dealing with the complex flooding regime in Amazonia. Data from birds to be tagged in September 2014 are forthcoming and will be compared to work from the Orinoco Goose.



## GOLDEN EAGLES USE OF THE NORTH AMERICAN LANDSCAPE FROM NATAL TO ADULT BREEDING TERRITORIES

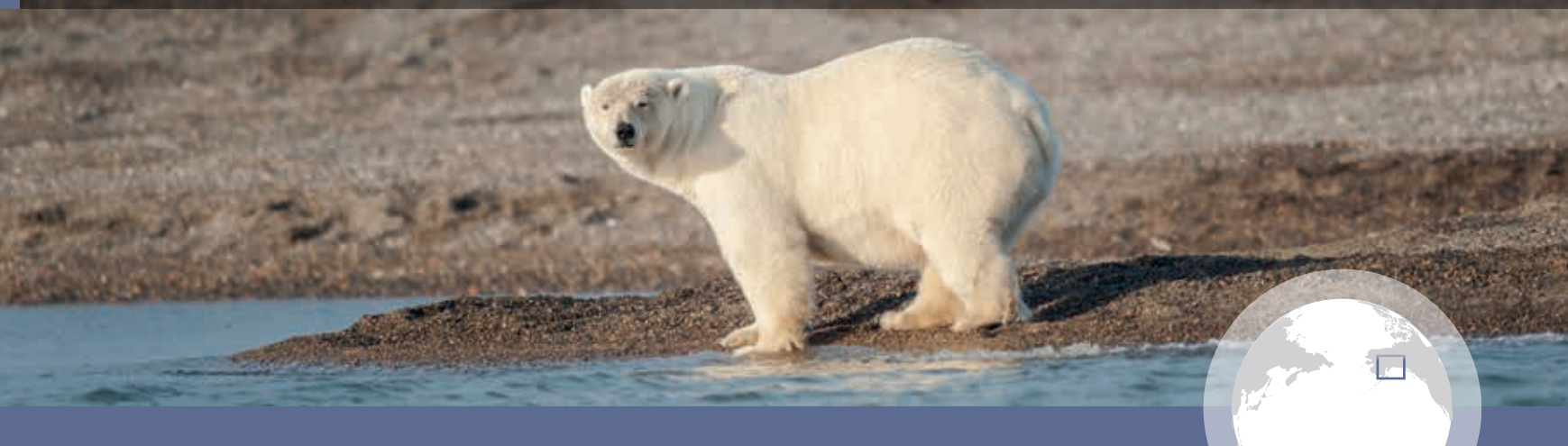
| Dave Bittner, Wildlife Research Institute, Inc.

Scientists at the Wildlife Research Institute, Inc., have tracked 63 golden eagles using Argos since 2007. In Montana, 23 birds were tracked to monitor movements of the migratory populations from Alaska and Canada as they winter in the continental Western United States. Adult breeding

pairs were also tracked to study use of the landscape and territorial boundaries. In Southern California and Nevada, natal dispersal, survival and mortality of young and return to natal areas were monitored for 40 eagles. In 2010, due to new concerns by the U.S. Fish and Wildlife Service, the Wildlife Research

Institute began evaluating the dispersal and migration of golden eagles in relationship to proposed wind and solar development. The findings of 8 years of satellite tracking for these 63 golden eagles will be presented at the International Wildlife User's Conference.





## USING ARGOS TO ASSESS THE RESPONSE OF POLAR BEARS AND PACIFIC WALRUSES TO ARCTIC SEA ICE LOSS

| Dr. George Durner, USGS, Alaska Polar Bear Research Center

Polar bears (*Ursus maritimus*) and Pacific walruses (*Odobenus rosmarus divergens*) are of conservation concern because their dependence on sea ice makes them vulnerable to its loss from climate warming. Radio tag data processed through the Argos Data Collection and Location System have allowed the U.S. Geological Survey to remotely observe both species and develop an understanding of their response to sea ice declines. Since 1985, more than 104,000 tracking days of data from more than 500 polar bears and more than 18,000 tracking days from over 580 walruses have been collected in United States, Russian, and Canadian Arctic marine waters. Links between Argos and

environmental data have played a pivotal role in developing projections of polar bear and walrus populations through the 21st century. Precipitous summertime loss of sea ice during the past 15 years has displaced polar bears from continental shelf waters where their seal prey are most abundant, and increasingly into deep-water pack ice or land. Retreat of sea ice north of the continental shelf has resulted in walruses hauling out on land where nearshore prey is believed to be inferior, and where hundreds (U.S.) to thousands (Russia) of young walruses have been found trampled to death after disturbances. Polar bears have made energetically expensive long-distance swims

in their search for sea ice or land – an effort that can take several days and hundreds of kilometers, and entails risk of drowning. Argos data have shed light on polar bear maternal denning ecology and revealed changes in denning in response to loss of sea ice. Future data collection from subadult and adult male polar bears and walruses will benefit from miniaturized Argos-compatible radio tags. Continued tracking data will improve our understanding of how polar bears and walruses are responding to environmental change, and allow for more effective adaptive conservation strategies for both species.



George Durner is a research zoologist with the US Geological Survey, Alaska Science Center polar bear research program. He entered this position in 1991 and currently works with a team of USGS scientists to identify and describe the mechanisms that drive the response of polar bears to a changing Arctic ecosystem. His research focus is on polar bear habitat relationships, particularly on how polar bears have and will respond to declines in sea ice. Hence, his research has been reliant on a 29 year history of polar bear location data gained through the Argos Data Collection and Location System. Much of his research results were used to inform the United States Secretary of the Interior's decision in 2008 to list polar bears as a threatened species under the Endangered Species Act.

## PENGUINS AND CLIMATIC VARIABILITY: FORAGING RESPONSES OF KING PENGUINS IN THE SOUTH INDIAN OCEAN NEXT STEPS WITH THE EARLY LIFE PROJECT

| Dr. Charles-André Bost, CEBC-CNRS

Understanding how climate variability affects the foraging ecology of marine key predators at a short and long-term scale is a key issue in the studies of oceanic food webs. Dr. Charles-André Bost and his team extensively used Argos satellite tracking in a long-term project on the foraging areas and behavior of king penguins in two localities of the South Indian ocean, Crozet (since 1993) and Kerguelen Islands (since 1998). The aim of the project is i) to study how the change in penguins foraging parameters and success reflect the impact of oceanographic conditions on key food webs of the Indian Ocean; ii) to investigate the role of frontal zones as a driving key force for penguins populations; iii) to model the foraging habitat in different climatic scenarios. At the International Argos User Conference, Dr. Bost will

discuss the results of the change in penguins at-sea trajectories, diving behavior, foraging success and effort in relation to the inter-year changes in the hydrographic structure. He will explore the potential impact of the predicted warming of the water masses in the Southern frontal zones by the end of the century, according to the proximity of the colonies to the polar front, a major oceanographic boundary. The southward shift of the frontal zones could represent a major challenge for top predators especially flightless species such as penguins. In the framework of the Early Life project, he will present the input of new Argos transmitters to investigate the foraging behavior of young penguins during the first year of life at sea after independence, which remains a real challenge.



Charles-André Bost is a leader in the study of the foraging ecology of marine top-predators, conducting research for 25 years in the Southern Ocean with special emphasis on the impact of the climatic variability on sub-Antarctic marine food webs. He has also developed the approaches using marine predators borne as autonomous platforms to investigate physical changes in the Southern environment and monitor resource availability.



# USING ARGOS TRACKING TO ASSESS IMPACTS OF CLIMATE CHANGE ON WILDLIFE

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Photo courtesy of Dee Boersma



## USE OF ARGOS DATA TO DESIGN A MARINE PROTECTED AREA FOR THE LARGEST MAGELLANIC PENGUIN COLONY IN THE WORLD

| Dr. Dee Boersma, Professor, University of Washington, Founder and Editor, Conservation Magazine

The Magellanic penguin (*Spheniscus magellanicus*) is listed as Near Threatened by the International Union for the Conservation of Nature (IUCN) because of rapid population decline in some breeding areas. At their largest colony in Punta Tombo, Argentina, active nests declined by more than 30% in the last 30 years. What is causing the decline of this colony? As with many other species of penguins, oil pollution, overfishing, and climate change are major contributors to their decline. Penguin reproductive success is low at Punta Tombo with starvation being the major cause of chick death as many adult penguins must forage far from the colony. Although a terrestrial Provincial Reserve protects some

of the breeding colony, there is no Marine Protected Area (MPA) in the waters around Punta Tombo. Protecting their foraging area could help mitigate chick starvation which on average kills 40% of chicks. Dr. Dee Boersma and her team sought to determine the minimum size of an MPA to protect waters where adults forage when they have young chicks. Using Argos, they satellite-tracked breeding penguins foraging for young chicks (less than 20 days of age) in 1997-2001 and 2006-2009. Core foraging areas for penguins whose chicks did not starve (successful) and those whose chicks starved (unsuccessful) partially overlapped. Unsuccessful penguins however, foraged farther from the colony

( $59 \pm 27$  km,  $N = 39$  penguins, 115 trips) and had a larger core foraging area (877 km<sup>2</sup>) than successful penguins ( $46 \pm 19$  km,  $N = 23$  penguins, 78 trips,  $P = 0.002$ ; core foraging area = 580 km<sup>2</sup>). The extra travel distance for unsuccessful parents requires more energy and takes penguins almost 10 hours to return to shore, long enough to result in their small chicks starving. An important conservation tool missing at Punta Tombo is an MPA encompassing the core foraging areas during November-January when chicks are under 30 days of age. An MPA would likely reduce chick starvation, increase reproductive success and could protect adult penguins from fishing gear.



Dr. Dee Boersma has been dubbed the “Jane Goodall of penguins” by the New York Times. Seabirds are her passion. She has shown that even a small oil spill over a hundred kilometers from their nest can cause fork-tailed storm-petrels to feed contaminated food to their offspring, and that climate variation can cause Galapagos penguins to desert their eggs and chicks. Dr. Boersma considers penguins «marine sentinels,» sounding the alarm on environmental threats to ocean ecosystems. Dr. Boersma and her students follow the lives of individual penguins, monitor the colony, and develop the data needed to plan effective conservation efforts at Punta Tombo, Argentina.



*“Being able to track penguins at sea using Argos technology has opened new insights into the natural history and breeding biology of penguins. From our satellite tracking, we know that Magellanic penguins can swim 176 km per day and some individuals swim at the same speed day and night, presumably because they are so anxious to return to the colony to feed their chicks.”*

Dee Boersma, Argos user since 1996

## FISH FUTURES: OBSERVATION, ADAPTATION AND RESPONSE TO CLIMATE CHANGE

| Kevin C. Weng, Assistant Professor, Virginia Institute for Marine Science, College of William & Mary



In the future, marine fishes are likely to get squeezed by warming, stratification, deoxygenation at depth, and acidification. Some species may be pre-adapted to habitats that will likely expand in the future, while others may experience a contraction of suitable habitat. Scientists at Virginia Institute for Marine Science and University of Hawaii have used Argos data to compare the behavior of high trophic level species

that have contrasting adaptations to hypoxia, and look at adaptations to their respective habitats. The tunas are ‘energy speculators’ that require high oxygen environments, and have a range of adaptations to high metabolic rate. In contrast, species inhabiting the oxygen minimum layer, such as the bluntnose sixgill shark, have adaptations to energy conservation and low metabolic rate. Future ocean conditions may favor energy

conserving adaptations across large regions. Since hypoxia interacts with temperature and pH in its physiological impact, the scientists developed a model to predict performance under a range of present and future scenarios. This model could potentially be used to incorporate the effects of pH into existing ecosystem models that are driven by temperature, oxygen and productivity.

# ARGOS TRACKING BEST PRACTICES AND LESSONS LEARNED

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Photo courtesy of Oregon State University Marine Mammal Institute, photographer Craig Hayslip.

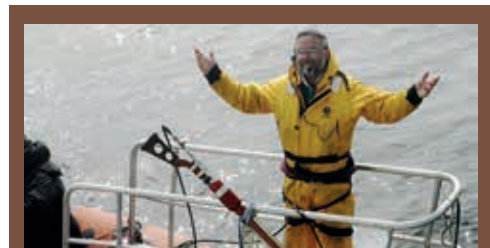


## SATELLITE TELEMETRY GIVES ENDANGERED WHALES A VOICE TO SOLVE CONSERVATION CHALLENGES AND MITIGATE ANTHROPOGENIC RISKS

| Bruce Mate, Professor, Oregon State University

Argos satellite-monitored tags have provided many new insights into the fundamentals of whale biology, as well as some very advanced and unexpected details. Historically, humpback whales photographed in the winter breeding area off Hawaii were matched to South East Alaska for the summer feeding season. However, when Bruce Mate and his team tracked their first humpback whale from Hawaii to a Russian feeding destination, it surprised many folks. Since then they have tracked other humpback whales to areas with no history of photo matches. His recent tags were designed to identify forging efforts of deep diving sperm whales in the Gulf of Mexico as a follow-up to the Macondo oil spill. In contrast, he and his team tagged shallower-diving blue

whales in the eastern North Pacific for a decade to reveal that their areas of most concentrated use coincided with shipping lanes into Los Angeles and San Francisco, California. Tagged gray whales foraging during summers in the Pacific North West revealed a migration to Mexican breeding areas that was not in unison. The resulting turnover demonstrated that it would not be possible to estimate the total population during any winter survey. The future of Argos tags, providing a better understanding of natural variability, is bright and will ultimately make it possible to better gage the true effects of anthropogenic activities, such as vessel noise, seismic surveys, and fisheries exploitation.



Bruce Mate has pioneered the development of Argos satellite-monitored radio tag technology for large whales with Office of Naval Research (ONR) support. His research on the migration routes and seasonal distributions of 17 populations of seven different endangered species has been conducted in every ocean. As an early adopter of the Argos system, his teams have helped miniaturize tags and develop best practices for trans-cutaneous tags. He has personally tagged over 600 whales and says every project has changed a long-held conventional "wisdom" for each species.

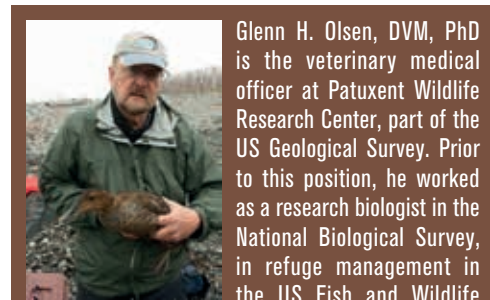
## TECHNIQUES FOR IMPLANT SURGERY OF ARGOS SATELLITE TRANSMITTERS IN SEADUCKS

| Dr. Glen Olsen, USGS Patuxent Wildlife Research Center

Satellite transmitters with percutaneous antennas are surgically implanted in seaducks and diving ducks in general. Dr. Olsen and his team have been improving the techniques to increase the comfort and survival of the seaduck patients. After a review of procedures at the 4th International Sea Duck Conference, times between surgery and release and total time in captivity have been greatly reduced to improve post release survival. They use nylon mesh hand-stitched around the transmitter package to give the veterinary surgeons places to anchor the transmitter in the coelomic cavity. They have tested various agents used to keep the feathers away from the edge of the skin incision in order to improve visualization of the surgery site without removing feathers. All agents tested, whether mechanical (various

types of tape products) or chemical (chlorhexidine, alcohol, surgical jelly) produce some feather wetting as compared to control sea ducks. Anesthetic agents, analgesic and tranquilizing medications vary depending on practice, and location. More remote locations have required the use of injectable anesthetic agents such as propofol. Where oxygen is available in tanks or from oxygen generators, gaseous anesthetic agents such as isoflurane are used. They have performed studies on diving ducks to compare oxygen saturation using oxygen from tanks versus generators. Other analgesic and tranquilizing medications are used to improve patient comfort and increase the survival post-surgery, as explained further at the International Argos User's Conference.

(Mention of specific products does not imply U.S. Government endorsement.)



Glenn H. Olsen, DVM, PhD is the veterinary medical officer at Patuxent Wildlife Research Center, part of the US Geological Survey. Prior to this position, he worked as a research biologist in the National Biological Survey, in refuge management in the US Fish and Wildlife Service, and as an assistant professor at Louisiana State University. In addition to working with ducks, Dr. Olsen also does research on whooping crane reintroductions.



# ARGOS TRACKING BEST PRACTICES AND LESSONS LEARNED

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Photo courtesy of Neil Hammerschlag.



## CONSIDERING THE FATE OF SATELLITE TAGS: INTERACTIONS WITH STAKEHOLDERS AND USER RESPONSIBILITY WHEN ENCOUNTERING TAGGED ANIMALS

| Dr. Neil Hammerschlag, Research Assistant Professor, University of Miami

The use of wildlife telemetry and Argos to study the behavior and ecology of animals has increased dramatically over the past decade. As scientists continue to use these tools, it is inevitable that other researchers and the public at-large will encounter animals carrying such tags with increasing frequency. If the animals appear burdened or injured by the tag (e.g. showing signs of trauma), or if the tag is non-functional,

these encounters have the potential to generate conflict with various wildlife stakeholders (e.g. tourists/operators, hunters) that can negatively affect research efforts and undermine conservation work. Yet, these encounters also present an unparalleled opportunity to advance the field of wildlife tracking by improving animal welfare, tagging technology and practices, while also gaining the trust and

support of wildlife stakeholders. Therefore, as scientists, it is important to consider the fate of our electronic tags, interactions with stakeholders and our responsibilities when encountering tagged animals. The framework in which these issues are discussed is novel and failure to address them can significantly impede advances in the development and use of biotelemetry and even one's ability to conduct research.



Dr. Hammerschlag's research centers broadly on the behavioral ecology and conservation physiology of marine predators. His current and future research has three primary foci: (1) understanding how predator-prey interactions structure marine communities (2) determining the habitat use and migratory patterns of large coastal sharks using biotelemetry and (3) understanding the underlying behavioral, physiological, morphological and biological mechanisms driving the movement decisions of marine predators. Dr. Hammerschlag has been an Argos user since 2010 and tracked over 150 sharks including tigers, bulls, hammerheads, Makos and blacktips. One of the tiger sharks covered an area of over 1 billion football fields.

## THE WAY FORWARD FOR TAGGING MARINE PELAGIC ANIMALS WITH POPUP SATELLITE ARCHIVAL TAGS - LESSONS LEARNT AND PERSPECTIVES FOR FUTURE STUDIES

| Chi Hin Lam, Large Pelagics Research Center, University of Massachusetts, Amherst



Since the late 1990s, the Large Pelagics Research Center (LPRC) has been involved in the development and use of pop-up satellite archival tags (PSATs) on marine pelagic species. To date, research conducted and sponsored by LPRC have developed over 700 PSATs on 8 species. Valuable lessons were learnt through the many field campaigns, from the animals that were studied to the

hardware and human dimensions involved in the process. The research team presents a recent update on tag performance and usage issues after the seminal paper of Musyl et al. 2011 (doi:10.3354/meps09202), with a focus on tuna species which routinely subject PSATs to the toughest challenges, such as repetitive drastic pressure and temperature changes.

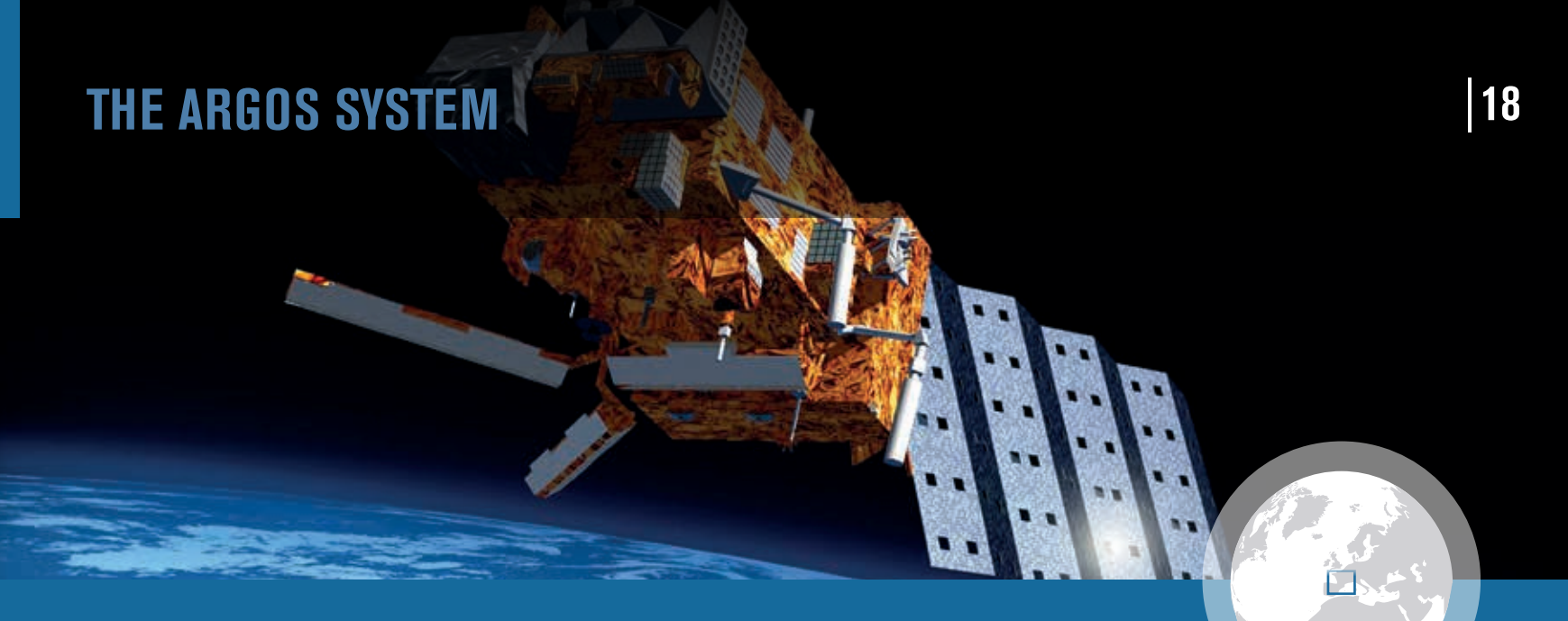
## DEFINING LOGGERHEAD SEA TURTLE (CARETTA CARETTA) INTENSIVE USE AREAS : A CUMULATIVE ANALYSIS OF SEASONAL UTILIZATION DISTRIBUTIONS

| Gwen G. Lockhart, Virginia Aquarium and Marine Science Center

Scientists at the Virginia Aquarium and Marine Science Center have developed a method for leveraging robust data and using them to inform space-based management decisions with a seasonal dimension. They applied this method to conduct a cumulative home-range analysis on 23 loggerheads tracked since 2011. Of the 23 - 17 were rehabilitated and 6 were wild caught. All animals were released in Virginia or North Carolina waters, off the mid-Atlantic Coast of the United States, between June

2011 and October 2013. Fourteen Sea Mammal Research Unit and 9 Wildlife Computers tags were deployed. Their findings show that while intensive relative cumulative use (RCU) shifted, 53%-86% of the Chesapeake Bay had moderate use through all three seasons. This method offers a practical way to leverage robust data collections and use them to inform space-based management decisions.





## ARGOS: A ROBUST AND CONSTANTLY EVOLVING SYSTEM

| Michel Guigue, Data Collection Missions Manager, CLS Group

Argos is a global satellite-based location and data collection system dedicated to studying and protecting our planet's environment. CLS is the operator of the Argos system on behalf of the Argos intergovernmental partners, NOAA, CNES, EUMETSAT and ISRO, and continues to maintain and improve operational capabilities and services for all Argos users.

The Argos system is currently composed of a space segment of 6 operational satellites with 3 NOAA Polar Satellites (NOAA-15, NOAA-18, NOAA-19), 2 EUMETSAT spacecrafts (Metop-A & Metop-B) and 1 ISRO (Indian Space Research Organization

satellite) called SARAL. The Argos ground segment for data retrieval includes 7 global receiving stations (6 in the northern hemisphere and 1 in Antarctica) and 65 local, real-time receiving stations worldwide.

Michel Guigue presentation will provide a brief overview of the Argos system, its capabilities and how they have evolved, especially in support of wildlife tracking applications, since 1978. The newest Argos features will be emphasized and how the wildlife tracking community can benefit from them now and in the future.



Michel Guigue is the Data Collection Missions Manager for the CLS Group. In collaboration with CLS Technical Direction, Michel works to define specifications for satellite-based systems.

## IMPROVING ARGOS LOCATION AND DATA COLLECTION FOR LOW POWER PLATFORMS

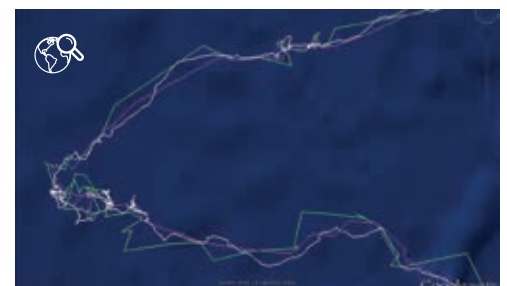
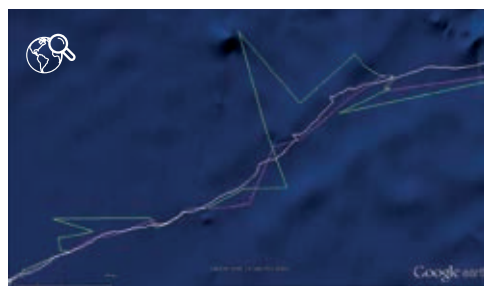
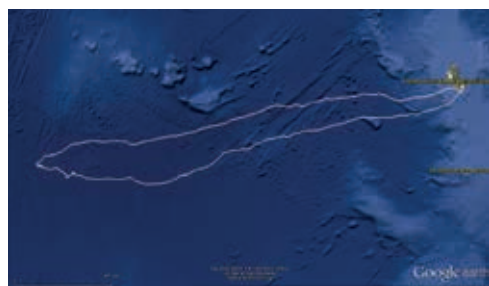
| Rémy Lopez, CLS



Collecte Localisation Satellite (CLS) is continuously improving the data collection and localization capabilities of the Argos System for low power platforms. Rémy Lopez and his colleagues present two major improvements of Argos that will be available for users and manufacturers.

1) New off-line location reprocessing service. This value added processing achieves an error reduction of about one third for locations computed with two or three messages per pass. For 1-message locations, the error is typically divided by two. It targets harsh Argos applications, such as wildlife tracking, for which obtaining more accurate locations is more important than obtaining locations in real-time.

2) New message correction capability of wrong bits in Argos messages. Erroneous bits can be corrected using Bose, Ray-Chaudhuri and Hocquenghem (BCH) codes. An extension is added to the Argos message and is used in the Argos processing center to detect and correct wrong bits in the messages received by the satellites. With an extension of 32 bits for example, it is possible to correct up to four errors in the messages.



Elephant seal tracking off the Kerguelen Islands. . The GPS tracks are white, while green tracks represent real-time Argos positions processed with the Kalman filter algorithm. The purple tracks represent the deferred time Argos positions, using a new smoothing algorithm. The positions are much closer to GPS positions. Data courtesy of Christophe Guinet from Centre d'Etudes Biologique de Chizé.



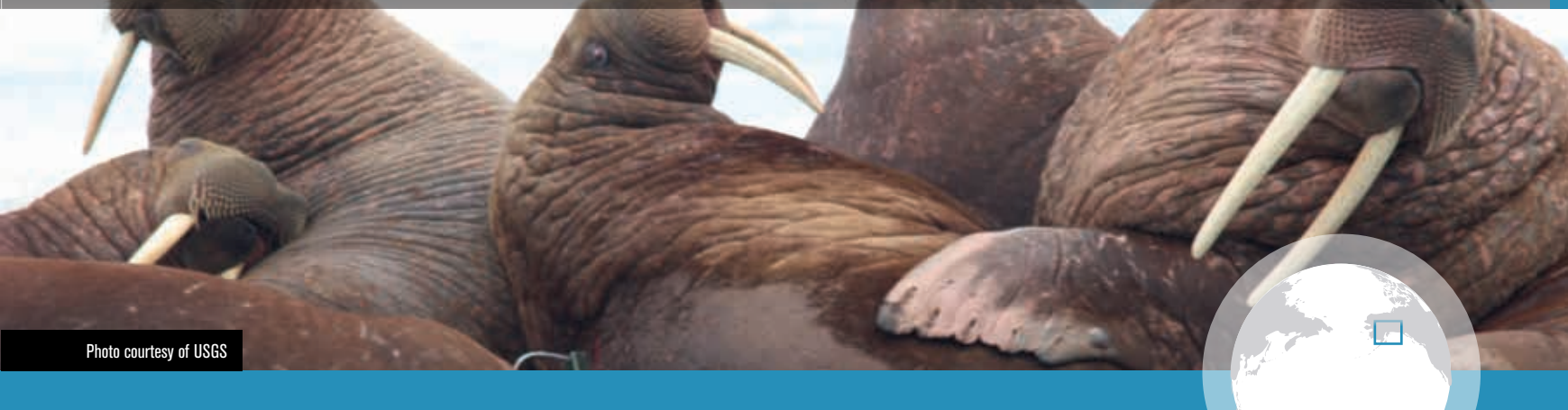


Photo courtesy of USGS

## HOW MUST ARGOS EVOLVE TO KEEP PACE WITH THE INCREASINGLY COMPLEX WILDLIFE TRACKING REQUIREMENTS

| Dave Douglas, Research Wildlife Biologist at the U.S. Geological Survey Alaska Science Center

Prosperity of the Argos System for animal tracking has been cultivated by an informal yet effective partnership between the users, transmitter manufacturers, and CLS. Users define the breadth of tracking requirements from which manufacturers balance economic and technological constraints in a manner to best utilize the Argos Data Collection and Location System. Success of this partnership has been realized, in part, by a common passion to pioneer new discoveries about animal migration. In the future, the Argos System for animal tracking will attain its highest potential if the synergism of this partnership is sustained by common visions and goals. At the International User Conference, Dave Douglas explores topics and strategies that might underlie such goals, with the simple intent of fostering more ideas

and dialog. It is clear that attractive alternatives to Argos now exist for some wildlife tracking requirements; however the Argos System will likely remain the best solution in the foreseeable future for animal tracking with small transmitters in remote areas. Power supply continues to be a dominant limitation to animal tracking, especially for small transmitters. Reducing, conserving, and generating power are mutually compatible strategies that could offer partial solution to this long-standing limitation. Further, reducing the costs of animal tracking would stimulate more research effort. More studies with larger sample sizes and longer transmitter life will lead to more robust population inferences and contribute new insights into how animal movements evolve and adapt over many years as individuals age or their environments change.



Mr. Douglas has been involved with numerous assessments of Argos location accuracy and transmitter performance. His main scientific interests fall broadly under the topic of “habitat dynamics”, in which he exploits satellite remote sensing and reanalysis data to investigate how variations in climate affect the quality and availability of wildlife habitats, and how variations in weather affect the timing and routes of wildlife migrations.



*“Almost 30 years ago, my education in biology and computer science fortuitously prepared me to join a team of scientists in Alaska who were preparing to evaluate an emerging technology – tracking wildlife by satellite with the Argos System. I have since had the pleasure of collaborating on scores of telemetry studies, developing methodologies for data analysis and mentoring new users of the Argos System. Since 1985, my colleagues at the USGS Alaska Science Center have deployed over 3000 transmitters on over 40 species, with a research emphasis on polar bears, walruses, sea ducks, waterfowl, and shorebirds. I have witnessed satellite tracking evolve from an experimental application to a powerful tool for wildlife science and conservation.”*

Dave Douglas, Argos user since 1985



Scientists prepare to radio-tag walruses in the Chukchi sea to track movements as sea ice is reduced in the region. Image courtesy of USGS.



Photo courtesy of USGS

# PANEL DISCUSSION: A SUCCESS STORY - CONSERVATION AND POLICY APPLICATIONS OF THE ARGOS SYSTEM

| 20



## DETERMINING OFFSHORE USE OF SEADUCK SPECIES IN FEDERAL WATERS OF THE MID-ATLANTIC UNITED STATES USING ARGOS SATELLITE TRACKING

| Dr. James Woehr, United States Department of the Interior, Bureau of Ocean Energy Management,  
Division of Environmental Sciences



The United States Department of the Interior's Bureau of Ocean Energy Management (BOEM) has a legal and societal mandate to facilitate the orderly development of energy and mineral resources from the United States Outer Continental Shelf (OCS) in compliance with the National Environmental Policy Act, the Endangered Species Act, and other relevant environmental laws. To accomplish this BOEM maintains a vigorous Environmental Studies Program within the Division of Environmental

Sciences. Studies include various research and survey activities from Alaska to the Pacific coast, to the Gulf of Mexico, and the Atlantic coast. When information needed for compliance with environmental laws is scant or nonexistent, BOEM sponsors the necessary research to fill the information gaps. One such study will be featured at the International User Conference on Argos Wildlife Applications, as a success story of how Argos tracking can be used for Conservation and Policy Applications. BOEM needed to know the winter concentration areas and migration pathways of three wide-ranging species of mid-to-large diving birds that use the Atlantic OCS of the United States. These are the Northern Gannet (*Morus*

*bassanus*), the Red-throated Loon (*Gavia stellata*) and the Surf Scoter (*Melanitta perspicillata*). All three species spend much of the winter in U.S. Atlantic waters but nest farther north from western Canada to Greenland. Knowledge of their movements and concentration areas was needed to allow site selection for potential wind energy developments in locations least likely to negatively affect these species, so it was decided to track these species with Argos satellite transmitters. Panelists Alicia Berlin, Iain Stenhouse, and Bill Montevecchi each describe how the study was carried out and what has been learned to date about each of these species.

## ARGOS SATELLITE TRACKING OF SURF SCOTERS IN FEDERAL WATERS OF THE MID-ATLANTIC UNITED STATES

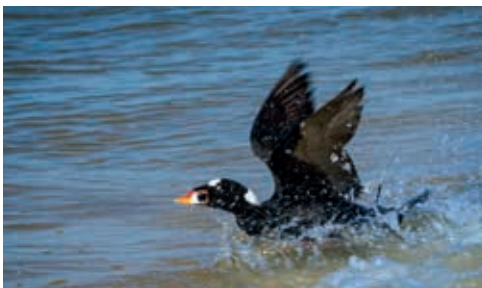
| Dr. Alicia Berlin, USGS Patuxent Wildlife Research Center (PWRC)



Offshore wind energy is one of the fastest-growing segments of the world energy market, offering a clean and abundant source of electricity to meet growing demands. However, offshore wind facilities may have detrimental impacts on many bird species, exposing them to

increased mortality through turbine collisions, and altering behavior and flight pathways. To evaluate the potential for detrimental effects to marine birds posed by wind turbines in Federal waters, there is a need to collect information on the distribution and behavior (e.g., flight pathways, seasonal use timing, etc.) of a broad suite of birds in these areas. A total of 185 Surf Scoter (76 males, 109 females) have been tagged with Argos platform terminal transmitter satellite tracking tags (PTTs). Surf Scoter exhibit strong site fidelity to their

wintering grounds and their migration pathways. Preliminary data suggest they stay within 10 nm of the coastline and may not be influenced by the proposed wind energy areas controlled under BOEM jurisdiction, but the state plans may have an impact on this species. There is some indication that this species moves quite a bit within a wintering area, such as the Chesapeake Bay, and some move between wintering areas, such as between Delaware and Chesapeake Bays.



A Surf Scoter wearing an Argos PTT.  
Image courtesy of Jonathan Fiely.



Image courtesy of Ian Johnson.



Image courtesy of Ian Johnson.



## DETERMINING WINTERING AREAS AND MIGRATION ROUTES OF RED-THROATED LOONS IN ATLANTIC OFFSHORE WATERS USING ARGOS SATELLITE TRACKING

| Dr. Iain Stenhouse, Biodiversity Research Institute, Portland, Maine



The Red-throated Loon is listed by the U.S. Fish & Wildlife Service (USFWS) as a species of conservation concern in much of its Arctic breeding range and wintering grounds along the Atlantic Flyway. Large data gaps exist, however, regarding wintering distributions, including concentration and timing of use, migratory routes, and

stopover areas. This study aims to determine the fine-scale occurrence and local movements of Red-throated Loons in Federal waters of the mid-Atlantic United States during migration and winter, using Argos platform termi-

nal transmitter satellite tracking tags (PTTs). In 2012-14, as part of this BOEM project focused on offshore wind energy development and diving birds, the Biodiversity Research Institute (BRI) captured Red-throated Loons at sea on their wintering grounds in the Mid-Atlantic region and implanted them with Argos PTTs. They calculated composite kernel density (KDE) maps using GIS from movement data for each loon. Kernel density rasters were generated for each animal during one year for each period and all KDE rasters were aggregated and usage was averaged over all animals for the entire utilization area. The results identify key wintering areas, as well as important migration habitats and stopover areas for Red-throated Loons along the Atlantic Flyway.



A red-throated loon with percutaneous Argos PTT. Image courtesy of Ian Johnson.



Image courtesy of Jonathan Fiely.

## SATELLITE TRACKING OF NORTHERN GANNET ACTIVITY IN U.S. MID-ATLANTIC WATERS

| Dr. Bill Montevecchi, Professor, Memorial University of Newfoundland



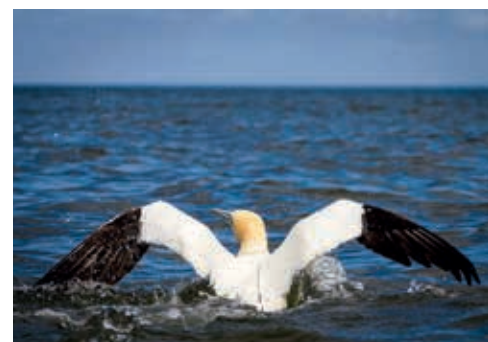
Dr. Bill Montevecchi reports on the results of the first 2 years of a longer-term study of Northern Gannet activity in mid-Atlantic U.S. waters.

During 2012 and 2013, 35 birds were captured in mid-Atlantic waters. Twenty-six birds were captured in winter and nine were captured in autumn from the species' southernmost breeding colony at Cape St. Mary's, Newfoundland, Canada. In addition, 19 juvenile birds are included to document initial migratory movements. Gannets concentrated in the mid-Atlantic region, exhibited regional-scale movements along the coast during winter. About mid-April they began a northward migration to their colonies in eastern Canada. During return fall migration, both colony and winter caught gannets moved from shelf to

coastal waters, as they travelled to the mid-Atlantic region or through it on their way to the South Atlantic Bight or Gulf of Mexico. By October-November, the mid-Atlantic region and Gulf of Mexico are "hotspots" for Northern Gannet activity throughout winter and into spring. The use of coastal waters appears to be more pronounced among females. Unlike adults, juveniles did not frequent the Chesapeake and Delaware bays and remained in offshore shelf waters. Results to date indicate that Northern Gannets from major breeding areas in eastern Canada make extensive use of marine waters along the U.S. mid-Atlantic coast from autumn through spring.



A Northern Gannet with percutaneous Argos PTT. Images courtesy of Jonathan Fiely.



# PANEL DISCUSSION: ADVANCES IN ARGOS WILDLIFE TRACKING TOOLS

## MOVEBANK AS A FREE AND FLEXIBLE WEB-BASED INTERFACE FOR ANALYZING ARGOS WILDLIFE TRACKING DATA

| John W. Wilson, Department of Civil, Environmental and Geodetic Engineering, Ohio State University



Animal movements tracked using Argos represent innovative ecological research, novel conservation applications, and unique observations of life on earth. Robust and low-cost tools for managing, analyzing, and archiving these data help maximize the quality and

amount of information obtained from them. The animal tracking database Movebank (movebank.org) offers free web-based resources for working with Argos wildlife tracking data while maintaining users' ownership of their data and control over access. As of May 2014, the database contains over 80 million locations representing movements of nearly 400 taxa contained in 1200 user-created studies. Movebank's "Argos live feed" option, which automatically transfers and stores Argos data in Movebank, is now used by nearly 200 users within 175 studies. In addition, older data can be archived using raw DIAG/DS or custom-format text files. As data are imported to Movebank, the Douglas Argos Filter allows flexible filtering of Doppler-based

locations based on species and objectives. Additional features include tools for data visualization and management, an API for data access by other applications, annotation of external environmental data using the Env-DATA System, and data publication (DOIs) to meet data-sharing requirements. Upcoming developments include integration of new environmental datasets and analysis tools as part of Env-DATA, near-live data feeds for GSM tags, and advances in visualizing and managing very large datasets.



## STAT: BUILDING CAPACITY TO MANAGE, ANALYZE AND SHARE ANIMAL TRACKING DATA

| Michael Coyne, SEATURTLE.ORG



Many biologists interested in tracking large vertebrates using the Argos system find it difficult to store, manipulate, analyze and successfully share their data. The Satellite Tracking and Analysis Tool (STAT), a freely available web-based resource, is a complete package designed specifically for managing

animal-based satellite telemetry data. This presentation outlines the utility of the available features and products, how they benefit the wider animal tracking community, and how they can be used to maximize outreach and education efforts and help build capacity within small and large projects around the world. The STAT system provides a user-friendly interface for sharing tracking projects with the public. The public web site allows visitors (more than 25 million visits) to follow individual projects through daily e-mail updates and provide financial support to these projects through an animal adoption program. To date more than \$275K has been raised through the

public adoption program. Michael Coyne's presentation further reviews the progress made since the last Argos User Conference and highlights what has been learned from the more than 12,000 animals and 9.2 million data points collected in cooperation with 170 partners and 500 satellite tracking projects in more than 140 countries around the world.



## ARGOS DATA ACCESS

| Debbie Stakem, CLS America



The Argos System is the satellite telemetry system of choice for biologists worldwide. In fact, species monitoring and Argos technology have grown together, and biology applications are the fastest growing of all the monitoring and protection programs in the Argos System. System enhancements have provided a number of advantages to biologists, such as increased

sensitivity, improved location calculation, new low-power modulation, and broadening of the bandwidth. All of these improvements can benefit those involved in wildlife tracking and management. This presentation will provide an overview of the methods available for scientists to access their Argos data.



## PANEL DISCUSSION: HOW RESULTS AND CONCLUSIONS ARE EFFECTIVELY COMMUNICATED TO THE GENERAL PUBLIC



### RICHARD MERRICK

Director, Scientific Programs and Chief Science Advisor, NOAA Fisheries

Richard Merrick began serving as Director, Scientific Programs and Chief Science Advisor for NOAA Fisheries in September 2011. In this capacity, he leads NOAA Fisheries' efforts to provide the science needed to support sustainable fisheries and ecosystems and to continue our country's progress in ending overfishing, rebuilding fish populations, saving critical species, and preserving vital habitats. As the head of NOAA Fisheries' scientific operations, Dr. Merrick directs NOAA's six regional Fisheries Science Centers, including 30 NOAA Fisheries laboratories.



### WALLACE J. NICHOLS

Scientist, wild water advocate, community organizer, author, and dad

Wallace J. Nichols' research and expeditions have taken him to coasts and waterways across North, Central and South America, to Asia, Africa, Australia, and Europe where he continually finds that the emotional connection to waters of all kinds—rather than force of financial gain—is what keeps his colleagues and collaborators working hard to understand and restore our blue planet.



### ERIC SCHWAAB

Chief Conservation Officer, National Aquarium

As Chief Conservation Officer of the National Aquarium, Baltimore, Eric Schwaab provides strategic vision and leadership for the aquarium's Conservation and Science Division, a team of 130 professionals, engaging in initiatives ranging from field conservation and biological programs to legislative advocacy and animal rescue.

## SUSTAINING THE FUTURE OF ARGOS WILDLIFE TRACKING



### JEREMY WEIRICH

Clerk, Subcommittee Staff Director, U.S. Senate Committee on Appropriations

Jeremy Weirich serves as the Clerk and Subcommittee Staff Director for the Commerce, Justice, Science, and Related Agencies Subcommittee on the U.S. Senate's Committee on Appropriations under the leadership of Senator Barbara A. Mikulski. Jeremy has been with the Committee since 2008 and has directly managed the committee's science accounts including NASA, NOAA, NIST, NSF, and NTIA.



### RICHARD SPINRAD

Chief Scientist, NOAA

Dr. Richard W. Spinrad is the National Oceanic and Atmospheric Administration (NOAA)'s Chief Scientist. An internationally recognized scientist and executive with more than 30 years of experience, Dr. Spinrad is the senior scientist for the agency, driving policy and program direction for science and technology priorities. Until this appointment, Dr. Spinrad served as vice president for research at Oregon State University (OSU) in Corvallis, Oregon, and from 2005 until 2010, was the head of NOAA's Office of Oceanic and Atmospheric Research and the head of the National Ocean Service.



### PHILIPPE GASPAR

Scientific Coordinator of the CLS Satellite Oceanography Division

In 1990, Dr. Gaspar joined CLS to develop and lead the CLS Satellite Oceanography Division. Satellite altimetry and the use of altimeter data to monitor ocean circulation then became his main topics of interest. In 2000, he got involved in a leatherback turtles' tracking program, trying to understand how ocean currents impact their migration routes. Dr. Gaspar then progressively focused his research work on the synergistic use of satellite oceanography, satellite telemetry and numerical modeling to help understand how the oceanic variability influences the life history and population dynamics of marine animals.

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