ESTABLISHING, MANAGING AND EVALUATING MARINE PROTECTED AREAS WITH ARGOS

ENVIRONMENTAL MONITORING
CONTENTS
ESTABLISHING, MANAGING AND EVALUATING MARINE PROTECTED AREAS WITH ARGOS

4 | USER PROGRAM
IDENTIFYING IMPORTANT BIRD AREAS (IBAS) WITH ARGOS
By Phil Taylor
Compiling observations on a global scale

6 | USER PROGRAM
HOW SEABIRD FORAGING GROUNDS INDICATE PRIORITY AREAS FOR MPAS
By Matthieu Le Corre
Identifying sensitive areas in interaction with human activity

8 | USER PROGRAM
UNDERSTANDING FAVORABLE CONDITIONS FOR VULNERABLE SPECIES
FEATHERS AND ARGOS TRANSMITTERS
By Aurore Sterckeman, Clara Péron, Alain Pibot and David Grémillet

10 | USER PROGRAM
MIGRATORY MOVEMENTS OF SHARKS IN THE GALAPAGOS MARINE RESERVE
By César Peñaherrera, Eduardo Espinoza, Alex Hearn, James Ketchum, Pete Klimley, Yasmania Llerena, George Shillinger
Evaluating spatial effectiveness of existing marine zones

12 | USER PROGRAM
TRACKING LOGGERHEAD TURTLES
By Florence Dell’Amico and Alain Pibot
Monitoring endangered species faced with climate change
The Convention on Biological Diversity will celebrate its 20th anniversary this year. Its goal is to preserve biological diversity; one of its main priorities is to protect the marine environment. France, the second most important maritime country in the world, is a signatory of this convention and has set itself some ambitious objectives for protecting the marine environment. Above and beyond the 10% of coastal and marine areas to conserve as recommended by the treaty, France has promised to create 20% of Marine Protected Areas (MPAs) by 2020.

The French Marine Protected Areas Agency is a national public establishment set up in 2006 for the protection of the marine environment. The Agency helps implement various public maritime policies, particularly by creating and managing Marine Protected Areas (MPAs) in the waters around mainland France, in French overseas territories and, in some cases, in international contexts. It directly manages some parks and certain Natura 2000 sites and provides methodological, technical and financial support to all those managing MPAs (reserves, natural marine parks, etc.).

To carry out its missions, the Agency plays an important role in evaluating and monitoring the state of the marine environment and protective measures. In partnership with several scientific or socio-professional organizations, it collects and processes a wide range of data as input for the definition of new Marine Protected Areas, for the evaluation of the state of the marine environment and for implementing management measures, etc.

Examples of scientific campaigns that have been organized by the Agency since its creation include exploration of the deepest canyons in the Mediterranean, aerial observation of marine mammals both in mainland France and in France’s overseas territories, mapping the seabed around the Marquesas Islands and charting the marine habitats of Natura 2000 sites and natural marine parks.

As the editorialist of this special issue of ArgosForum, the French Marine Protected Areas Agency shows how the monitoring of marine species by means of satellite telemetry with Argos transmitters improves our understanding and management of the marine environment. The stars of this edition are albatrosses, Barau’s petrels, shearwaters, sharks and loggerhead turtles, protected species that exemplify marine biodiversity.
For nearly 30 years BirdLife has been identifying Important Bird Areas (IBA) and using them to inform processes of Protected Area (PA) design, regional, national and global spatial planning exercises and as indicators of ecosystem health. IBA are priority sites for conservation and are identified using a standardized and well-established set of data driven criteria and thresholds. BirdLife has identified over 10,000 IBAs to date, however, this work has been focused on the terrestrial biomes, only accounting for seabirds in designating colonies or important coastal areas. Until recently important pelagic sites (including those in international waters) have been overlooked.

Pelagic seabirds, such as albatrosses and petrels, range over vast and remote areas of ocean. They spend nearly their entire life at-sea, returning to land only for breeding. On non-breeding migrations they may travel over 40,000 km, and even during breeding, when they must return to the colony to feed their young, they may still make foraging trips of 7,000 km lasting more than two weeks. Many populations of these birds are in stark decline. Although they face threats on land, their decline can often be linked to their interactions with fishing vessels during their time at-sea. Tens of thousands of albatrosses die every year as incidental by-catch in longline and trawl fisheries, and such dramatic mortality is having a severe effect on the species status. In response, BirdLife International has developed a methodology for identifying marine «Important Bird Areas» (IBAs) for these seabird species and will be promoting protection of these sites through its global partnership and relevant policy mechanisms. As Phil Taylor, of BirdLife International explains, Argos tracking data plays an important role.

Traditional techniques for identifying and qualifying IBAs include site visits, line transects and direct observations generally. However, these are less relevant to pelagic applications; conducting line transects across entire oceans and at the temporal and spatial scale necessary is logistically and financially unfeasible. Tracking data, especially that which is remotely collected by the Argos system, offers a cost effective alternative, and as technology improves, devices are now more reliable and allow more accurate data to be collected for an increasing range of species.

By Phil Taylor

Figure 1: Some of the analytical steps in the process of marine IBA identification. From top left to bottom right, Argos satellite data is used to determine the movements of individuals, analyses identify the core use areas of each foraging trip (defined as the 50% UD), counts of overlapping core use areas, subsampling to establish representativeness values, and candidate site boundaries based on the population estimation derived from representativeness values. Argos data allows fine scale behavioral changes to be noted allowing BirdLife to determine between foraging trips and time spent on the colony, between the varying stages of breeding when the movements of the birds are subtly different, and also allows BirdLife to quantify the interannual variability in seabird movements, a key input to deciding whether an IBA is a static or dynamic site. The accuracy of Argos data also allows small scale sites, such as those shown here, to be identified, helping BirdLife be more targeted with its work.
**TRACKING ANALYSES**

In recent years, many new methods have been developed for analyzing tracking data; sophisticated approaches to improve the accuracy of locations and to better understand behavior from movements are now readily applicable.

However, a fundamental limitation when using tracking data in IBA designation is that tracking data provide information about the movement and distribution of tracked individuals only. IBA criteria ask for “regular presence” of a “significant abundance” to be proven for a site to qualify, and so an estimation of abundance must be derived. To address this BirdLife has developed a complex analytical approach using tracking data provided by a vast community of Argos users. The basic premise of the analysis is that areas used by high proportions of foraging or migratory trips are important; however, the calculation of these proportions is not straightforward and raises a number of issues. Analysis is undertaken on each unique combination of species, population and life-history stage. This ensures sites are appropriate to the specific behavior and distribution of the trigger species throughout its life-cycle, this is only possible when using high resolution data such as that provided by the Argos system. Kernel analysis and buffers are applied to each foraging/migratory trip to calculate how frequently an area is used, and by what proportion of the population. Indices of representativeness are calculated by investigating the impact of subsampling the data, and the values are used in estimating the abundance at the sites. Regularity and stability are also assessed using statistical approaches, and sites are flagged as dynamic (i.e. mobile between years) when data is shown to be significantly different across years. First passage time analysis is used to determine the average scale of Area Restricted Search behaviour (ARS; high turning rates and slow flight speeds associated with foraging) and this is used to ensure site delineations are at the an ecological appropriate scale.

The methods have been shown to work consistently well across a range of species and regions, and the resulting sites have already been approved by a number of international policy mechanisms. When complete, this work will have identified marine Important Bird Areas for around 60 seabird species and the sites will be complemented by parallel IBA work for seabird colonies and near shore areas, and will be presented as the first global marine IBA inventory planned for launch in October 2012.

**TRACKING DATABASE**

The success of this pelagic IBA work is entirely thanks to the support of those who have provided tracking data. BirdLife does not own the data itself, but instead has been allowed access to the data hosted in the Global Procellariiform Tracking Database (www.seabirdtracking.org; now hosting nearly 7000 tracks), and other data on short term agreements. These data owners are listed at right and BirdLife extends its gratitude to them, as well as accreditation for the success of this work. Over half of the tracks made available to BirdLife have been collected using the Argos satellite system. These data have been particularly important in understanding small scale behaviour over long periods, such as migratory stop off sites.

**Data Providers**

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Figure 2: The extent of the Global Procellariiform Tracking Database (www.seabirdtracking.org) in January 2012.
The western Indian Ocean is a very important habitat for cetaceans, turtles, tunas, billfish and seabirds, and yet the tropical pelagic ecosystems in this zone are increasingly at risk from human activity such as fishing and oil spills. In spite of this, Marine Protected Areas (MPAs) cover less than 1% of the oceanic and coastal surface of the region (figure derived from WIOMSA, 2010). This is why Matthieu Le Corre and his team embarked upon a large-scale study of seabird habitats, compiling eight years of data on seven species of seabirds. To identify areas where seabirds may be at risk when at sea, they also compiled spatially explicit data on industrial fisheries and on maritime trade routes, conducting an overlap analysis of these threats with their tracking data. The objective of their study is to identify “marine hotspots” in the tropical western Indian Ocean – priority locations for designation as Marine Protected Areas in the coming years, as Matthieu Le Corre explains.

WHY SEABIRDS CAN HELP IDENTIFY IMPORTANT MARINE HABITATS FOR PELAGIC ECOSYSTEMS

As seabirds are relatively easy to track at sea compared to most other marine top predators, there is a worldwide interest in using seabird telemetry data and at-sea surveys to identify potential MPAs. We propose that the foraging distributions and movements of seabirds can be used to identify oceanic areas of particular importance for the associated marine community assemblages. After all, the link between tropical seabirds and pelagic species is tight. Tropical seabirds rely on surface seizing and plunge diving (Harrison, 1990) to acquire prey, and very few are able to dive deeper than a few meters. Because epipelagic prey are distributed within the upper 50 meters of the water column, they are only accessible to seabirds when surface dwelling predators like tunas and dolphins pursue epipelagic prey and force them to flee toward the surface.

Tropical seabirds take advantage of this phenomenon by frequently foraging over schools of tunas or dolphins to catch the evading prey. Because seabirds forage mostly at places of great productivity and of important ecological processes, we propose to ultimately use these foraging areas as indicator of potential Marine Protected Areas in the tropical western Indian Ocean.

HOW TRACKING DATA MAKES IT POSSIBLE TO IDENTIFY HOTSPOTS

From September 2003 to July 2011, seven species of seabirds from 13 different populations have been tracked using Argos transmitters or archival tags (Global Positioning Systems (GPS) and Global Location Sensors also termed as “geolocators” (GLS)). This represents 222 tracked birds and 3891 days of study.

Our tracking data revealed five major oceanic areas where seabird density is particularly high (see Figure 2).
WHAT ARE THE MAIN THREATS TO PELAGIC ECOSYSTEMS IN THE INDIAN OCEAN?

Since the 1980s, surface dwelling tunas have been targeted by industrial fisheries in the tropical western Indian Ocean. Annual catches of tunas have increased 30-fold, from less than 40 thousand tons in the early 1950s, to more than 1200 thousand tons in 2007 (IOTC, 2008a). The depletion of surface dwelling tuna may reduce the foraging efficiency of many tropical seabirds, which could have cascading effects on their population dynamics.

The second major threat, which may impact marine biodiversity of the Indian Ocean, is oil pollution. Thirty-six percent of the world’s oil is produced in the Middle East, and most of it is exported via maritime routes throughout the Indian Ocean. Intensive maritime traffic increases the risk for low-level chronic pollution and potentially catastrophic oil spills (Vethamony et al., 2007; Sivadas et al., 2008).

IDENTIFYING HIGH RISK AREAS

In order to identify preferred fishing areas in the zone, we downloaded datasets (2000 to 2009) from the Indian Ocean Tuna Commission databases and compiled the total catches of long-line and purse-seine fishing separately. (http://www.iotc.org/English/data/). As for the potential risk of oil pollution, an ocean pollution index derived from commercial shipping and port activities can be downloaded from National Center for Ecological Analysis and Synthesis databases (http://www.nceas.ucsb.edu/globalmarine/impacts).

WHERE SEABIRD FORAGING SPOTS AND HIGH RISK AREAS INTERSECT

The overlap analysis between seabird density (as inferred through our tracking data) and potential threats at sea reveals that the five seabird hotspots overlap to various degrees with potential threats (Fig. 3D). The area with the highest overlap index is the Seychelles Basin, which holds both the highest seabird density and the highest human uses of the sea (substantial purse seine fishery, important long line fishery and important maritime traffic).

The Mascarene Archipelago and the south of Madagascar (including the Walters Shoals) also have a high overlap index and this is mostly due to high seabird density and high risk of pollution due to maritime traffic. Finally the southern Mozambique Channel and the central Indian Ocean have a relatively high overlap index and this is mostly due to the fact that important maritime routes cross these places of high seabird density.

CONCLUSIONS

Our tracking data revealed the main foraging hotspots of seven seabird species of the western Indian Ocean and this should help to identify major areas where specific conservation measures should be implemented. However, this is an ongoing project with still tens of equipped birds flying over the tropical Indian Ocean at the moment. The map of the seabird hotspots in this part of the world is likely to evolve in the future as research progress.

Matthieu Le Corre

Matthieu Le Corre, Ph.D., is a professor at the University of Réunion Island in Réunion, France. His research centers on tropical ecology and conservation biology with a particular focus on seabirds. Most of Le Corre's work is conducted in the tropical western Indian Ocean, a unique region for the study of seabirds. Réunion Island is the only island in the world to hold two endemic and endangered species of petrel.

On the nearby island of Madagascar there are 13 species of seabirds, most of which are locally endangered. Le Corre has been researching seabirds in the Western Indian Ocean for more than 15 years.

Le Corre was also Réunion Island’s country coordinator for the Western Indian Ocean Marine Science Associations (WIOMSA) from 2003 to 2010, an international organization dedicated to the study and conservation of marine life in the western Indian Ocean. He is the director of the Marine Ecology Laboratory (ECOMAR) and the leader of its Seabird Ecology team. Between 1993 and 2012, he organized and/or participated in more than 30 field expeditions to remote islands.

In 2003, Le Corre helped to create the Indian Ocean Seabird Group to foster greater communication among members active in the field of ecology and conservation of tropical seabirds in the Indian Ocean.

Le Corre studied biology and ecology before receiving a Ph.D. in marine ecology at the Chizé Centre for Biological Studies in 1998. Le Corre is an avid naturalist, enjoying snorkeling in the lagoon and walking in the mountains of Réunion Island.

Figure 3. Distribution of the potential threats to seabirds at sea. (A) Purse seine catches, (B) longline catches, (C) risk of maritime pollution through maritime trades, (D) overlap between seabird hotspots and potential threats. Data on purse seine and longline catches represent the total amount of catch of tunas and billfish made between 2000 and 2009 (extracted from the database of the Indian Ocean Tuna Commission). Data on risk of maritime pollution derived from Kalpern et al. (2008). See text for the calculation of the overlap index.

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The shearwaters nesting in mainland France (Cory’s, Mediterranean and Manx shearwaters) are all classified as vulnerable species in France and are listed in Annex II of the Bern Convention on the Conservation of European Wildlife and Natural Habitats. This status confirms that all three species are highly sensitive to the variability of the pelagic ecosystem they depend on, and are thus good biological indicators of the health of that environment. However, there is a real lack of knowledge about the marine ecology of these sea birds. A new project launched by French research and governmental institutions capitalize on technological improvements to increase the knowledge base about shearwaters, as Clara Péron and David Grémillet explain.

To contribute to understanding these species, several French research and governmental organizations have launched a project entitled «Marine habitat of the Shearwaters of mainland France: an approach using transmitters and isotopic analyses». This project is being led by the CNRS Centre for Functional and Evolutionary Ecology in the framework of a larger program coordinated by the French Marine Protected Areas Agency called PACOMM (Programme d’acquisition de connaissances sur les oiseaux et les mammifères marins – Program for increasing knowledge of marine birds and mammals), which combines projects using complementary observation techniques: airborne, sea platforms, telemetry or acoustics.

Using technology to increase the knowledge base

This project relies on major technological advances for its implementation, especially in terms of miniaturization, but also new statistical modelling methods. Long regarded as a minor complement to direct counting methods (from visual observations), the telemetry approach has now become a major tool for marine bird conservation at sea. Along with ‘direct’ observations, it is essential for effective analysis of the spatio-temporal distribution of species.

For the different colonies studied, the birds were fitted with transmitters to track their movements in offshore feeding areas during the breeding season (using GPS and Argos) or during their winter journey in the Atlantic (using geolocators and Argos).

The Argos transmitters, which provide near real-time positioning information by satellite relay, are currently the only way of accurately studying the marine distribution of individuals that do not need to come ashore for breeding (such as immature birds, adults that failed to reproduce, or juveniles). These categories and age groups are an important and sensitive part of the population, and their movements at sea are largely a mystery.

It is also important to include their ranges in the definition of protected areas, to confirm the importance of specific marine habitats or to identify new ones.

Given the size of the birds, the PACOMM program experts opted for solar-powered transmitters weighing 9.5g or 18g, operating on a 12h on/48h off cycle, or alternatively 12h on/24h off.

A transmitter attached to a Mediterranean shearwater from the Port Cros colony that had failed to breed revealed a spatial segregation between individuals that had successfully reproduced. The unsuccessful individual headed east towards the Italian coast, while the successful ones fed in the Gulf of Lion.
RESULTS

We tracked juvenile Cory’s shearwaters during their first sea voyage and immature birds (<5 years) that prospected in the colonies during the breeding season, before migrating to their wintering areas in the autumn. These data allowed us to track the birds as they left on their migration to the African coasts, and to highlight the importance of the Balearic Sea, off the coast of Spain, where many individuals made a stopover. This information is invaluable for obtaining a comprehensive view of the threats to seabird populations nesting in mainland France.

To learn more

This article is based on the first interim report of the project entitled «Marine habitat of the Shearwaters of mainland France: an approach using transmitters and isotopic analyses», part of the PACOMM program - Clara Peron and David Grémillet, CEFE-CNRS - November 2011.

About the PACOMM

Programme d’acquisition de connaissances sur les oiseaux et les mammifères marins - Program for increasing knowledge of marine birds and mammals

Increasing the knowledge base about the marine environment, and in particular, about pelagic seabirds, is a major challenge for the French Marine Protected Areas Agency, whose mission is to create a coherent and representative network of Marine Protected Areas. This is why the agency initiates knowledge campaigns, such as the PACOMM program. The results of the study on “Marine habitats of the shearwaters of mainland France”, combined with data from other phases of the PACOMM program, will help scientists from CNRS CEFE to determine the spatial-temporal dynamics of shearwaters’ marine habitats and identify wintering areas as well as migration corridors for different shearwater populations. In terms of management, the results of this study will respond to functional questions making it possible to strengthen the effectiveness of the Marine Protected Area network, and define relevant bio-indicators. This work makes it possible to respond to Natura 2000* requirements and help designate Natura 2000 zones off the French coasts in accordance with the European Commission’s requirements. *Natura 2000 is one of the 15 different categories of Marine Protected Areas recognized under French law.
The Eastern Tropical Pacific (ETP) is home to abundant populations of sharks and other marine predators. At some specific sites – such as the Galapagos, Cocos and Malpelo Islands – they can still be seen in high numbers, close to what would be considered pristine population states. However, unsustainable fishing practices are threatening the collapse of many shark populations in the ETP and worldwide. In order to support conservation efforts in their favor, it is essential to understand the ecology, migratory movements, and spatial dynamics of these species, as César Peñaherrera and his colleagues explain.

Marine Protected Areas (MPA) may offer considerable benefits to pelagic environments. But how do current MPA management models contribute to protection of shark and other apex pelagic species? The creation in 1998 of the Galapagos Marine Reserve (GMR) was expected to have a positive impact on all marine species. However, at the time there was limited technical information regarding the spatial dynamics of migratory species to inform related decision-making and management processes.

**THE GALAPAGOS EXAMPLE**

Since 2006, researchers in the Galapagos Islands have been working to assess the abundance trends, site fidelity and migratory pathways of sharks in the GMR. This research program began as a response to growing worldwide concern about the state of shark populations and the need to develop National Plans of Action. The project is a multi-institutional effort by the Galapagos National Park Directorate (GNPD), the Charles Darwin Foundation (CDF) and the University of California–Davis with the collaboration of Stanford University. Results obtained will provide MPA managers and stakeholders crucial biological and behavioral information to support shark management and conservation efforts in the GMR.

**USING ARGOS TO TRACK SHARKS**

To date, the satellite telemetry component of the project has tagged 15 hammerhead sharks (Sphyrna lewini; classified EN-Endangered on the IUCN Red List of Threatened Species), 11 Galapagos sharks (Carcharhinus galapagensis; classified as Near Threatened), 15 blacktip sharks (C. limbatus; Near Threatened), seven silky sharks (C. falciformis; Near Threatened) and 25 whale sharks (Rhincodon typus; Vulnerable). Satellite tags in use by the project are SPOT 5, SPLASH and PAT tags (Wildlife computers), and Sea Tags (Desert Star). Mid-size sharks (1.5 to 3.5 m in total length) are caught using a hook and line, brought onboard a research vessel with a sling, and tagged. The tags are attached to the dorsal fin of sharks with plastic bolts and stainless steel locknuts (Figure 1). Whale sharks are tagged in the water by SCUBA divers using pneumatic spear guns at half the power, and tags are placed in the musculature in the dorsal area in front of the first dorsal fin (Figure 2). All of these procedures were developed under the animal care protocol principles, in order to avoid any damage on the organism of tagged animals.
RESULTS

Preliminary results show an intense use of the GMR especially by hammerhead, silky and blacktip sharks (Figure 2). Tracked hammerhead sharks have displayed interesting movements around a central foraging area, with long excursions into the high seas. One individual went as far as 1400 km from the GMR, traveling Northwesterly when the device stopped sending signals. The longest track recorded for an individual lasted up to four months, and showed an elevated use of both the internal and near external areas of the reserve. In contrast, blacktip movements are constrained within the boundaries of the GMR, with a major use of coastal areas surrounding the islands. The individuals tracked sent signals from four days up to two months. Silky, Galapagos and whale shark data are still under analysis. It is expected that silky sharks will migrate back and forth from the GMR much like the hammerheads, as they are known to spend most of their lifetime in oceanic waters. Galapagos sharks are more coastal patrols, feeding and breeding near insular waters. Tracks observed to date for this species have shown few movements and are very restricted to near-coastal waters, similar to what has been observed for blacktipped during their movements in the first days.

Results from whale sharks are still in the first phase of filtering and analysis. Only one track is presented and showed extensive north to south movements inside the marine reserve, though its tag fell off in less than one month after application.

DOES THE MARINE RESERVE SERVE ITS PURPOSE?

As the project is in an early stage, more data is needed to properly respond to the question of whether GMR boundaries provide enough protection to the core activity areas of the shark species under assessment. We anticipate integrating movement datasets from other pelagic fish species, including yellowfin and bigeye tuna, wahoo, striped marlin, and manta rays. Our ongoing pelagic species tracking and monitoring efforts, coupled with the integration of remotely-sensed environmental datasets, will be essential for informing and improving management and conservation efforts within the Galapagos and other MPAs across the ETP.

About the Galapagos Marine Reserve (GMR)

The Galapagos Marine Reserve covers an area of approximately 133,000 km² and is one of the 10 largest marine reserve in the world. Created in 1998 by the government of Ecuador, it is home to nearly 3000 species of marine plants and animals. In 2001, the GMR added to the list of World Heritage Sites, in recognition of its enormous ecological, cultural, and economic value for the conservation and maintenance of unique species in the world.

Figure 2: Selection of shark track data collected by this project. Tracks are colored depending the species (see color guide inside).
The loggerhead turtle (*Caretta caretta*) is one of the 7 species of marine turtles found in our oceans. It is also one of those best suited to temperate or even cool waters, as it can be found in the North Sea. But this species is also one of the most endangered. It is currently considered to be subject to a high risk of extinction in the wild by the International Union for Conservation of Nature (IUCN). The loggerhead turtle is also considered to be an “indicator” species by the French Marine Protected Areas Agency because it is particularly sensitive to temperature change. This is why Florence Dell’Amico of the La Rochelle Aquarium and Alain Pibot, of the French Agency for Marine Protected Areas, were particularly interested in learning more when five juvenile turtles were found washed up on the Atlantic coast of France.

Every year, especially during the worst winter weather, young loggerhead turtles from different nesting sites (Florida, the Cape Verde Islands, etc.) are washed up on the beaches of the Bay of Biscay (off the Atlantic coast of France). They are generally victims of what the experts call “cold stunning,” a hypothermic reaction that affects the animals progressively when water temperatures drop below 10 or 11°C. As turtles are cold-blooded creatures, their metabolism can no longer compensate for the drop in temperature and they enter a lethargic state in which they will remain until the temperature rises again.

**STRANDED ON FRENCH BEACHES**

Research shows that juvenile loggerhead turtles can be delivered to locations outside their expected distribution by storm-driven surface currents, explaining how they end up in Bay of Biscay and the French coast. Generally, they migrate south again as the ocean cools. However, many of them do not manage to follow these cyclical movements, and remain trapped in colder waters, finally being stranded on French beaches.

In 2009, five young loggerhead turtles that had been found washed up on the Atlantic coast were fitted with Argos transmitters, thanks to funding from the French Marine Protected Areas. Protected Areas Agency and CNES (the French Space Agency). Two of the geolocation transmitters also had sensors for water temperature and depth.

The three turtles released in July 2009 moved northwards from the point of release and remained close to the coast. Then, at the beginning of August, two of them turned towards the west and displayed more pelagic-type behaviour (Figure 1). The two turtles released in September 2009 moved southwards from the point of release. They both remained close to the coast (Figure 2).

**VENTURING OFF TO SPAIN**

One of the turtles, tracked for 189 days, remained “blocked” in the southern Bay of Biscay, while the second entered the Mediterranean at the beginning of March.

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**Figure 1:** The three turtles released in July 2009 moved northwards from the point of release and remained close to the coast. Then, at the beginning of August, two of them turned towards the west and displayed more pelagic-type behaviour.
No more signals were received after 266 days of transmission, after the animal had been located at salt-works half-way between Valencia and Barcelona.

**RESULTS**

Due to the small number of individuals studied, no clear conclusions can be drawn until additional data (from tracking studies conducted in 2011 and 2012) can be compiled. In addition, the biases related to the chosen individuals having already been stranded once should be taken into consideration, even if research indicates that natural behavior patterns are usually maintained by rehabilitated individuals.

Nevertheless, the operation has yielded several interesting pieces of information:

That one of the turtles should have entered the Mediterranean was surprising considering the routes taken by the other individuals to which transmitters had been attached. However, migration of loggerhead turtles between the Atlantic and the Mediterranean via the Strait of Gibraltar has already been demonstrated by genetic studies and the recapture of tagged individuals. The Atlantic and Mediterranean populations therefore share the same development habitats in the western Mediterranean basin and the north-eastern Atlantic.

There is a clear correlation between surface temperatures and the distribution of young loggerheads. This hypothesis, which has been verified by several other similar experiments, provides spatial and temporal guidelines for management measures.

For example, in the Atlantic and in the Gulf of Mexico, NOAA’s National Marine Fisheries Service has taken specific measures (modification and adaptation of fishing equipment, changes to fishing practice and adaptation of legal fishing periods) to reduce the risk of turtles being captured accidentally. Such measures need to be justified in terms of the species’ ecology if they are to be accepted by fishermen.

**LEARNING MORE ABOUT ENDANGERED SPECIES**

It is obviously indispensable to know the range of a population in danger of extinction if management measures are to be effective. But we can hope to learn even more. Marine biodiversity currently lists more than 275,000 species, and it is thought that the real figure includes more than 3 million. It is obviously impossible to study all these species individually.

For this reason, the French Marine Protected Areas Agency, with several other partners, has launched a study of “indicator” species which, because of their key position in the ecosystem (apex predator, engineer species, umbrella species, etc.), provide information about more than their own evolution. This is why tracked loggerhead turtles (because they anticipate peak temperatures) could provide advance warning of plankton blooms or invasions by jellyfish in the future.

These are the kinds of observations that in the coming years can provide us with some of the knowledge we need to mitigate our impact on the marine environment and consequently manage our natural heritage sustainably.

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**Bibliography**

The St Kilda archipelago, far out in the Atlantic off the west coast of Scotland, is a World Heritage Site, renowned for its towering cliffs which during the summer are home to thousands of seabirds. However, St Kilda’s remoteness, its severe and unpredictable weather and lack of safe landing places means that studying these birds is very challenging and almost nothing is known about the biology of the approximately 60,000 pairs of northern gannets (Morus bassanus, about 20% of the east Atlantic population) that breed on the island of Boreray and its offshore stacks Stac Li and Stac an Armin. An archaeological expedition organized by the Royal Commission on the Ancient and Historical Monuments of Scotland and the National Trust for Scotland to Boreray in July 2010, provided a rare opportunity to spend time on the island and a researcher from the Centre for Ecology & Hydrology (CEH) went along to collect the first ever information on the sea areas used by gannets while they were rearing chicks.

Central to this work was the use of Argos technology to track individual birds. Sirtrack KiwiSat202 PTTs were attached with waterproof tape to the tail feathers of 22 gannets (Fig 1). The loggers provided nearly 19,000 uplinks over a total of 970 bird-days and showed that trip durations were long, typically around 24 hours but occasionally lasting several days. Distances travelled were also impressive with birds sometimes heading up past the Faeroe Islands to waters off the southeast coast of Iceland – a round trip of >1000 km (Fig 2). Scaling up these results across the gannet’s 6 week incubation period and 12 week chick rearing phase suggests that St Kilda gannets probably fly more than 30,000 km each breeding season.

In addition to providing baseline information on important feeding areas for St Kilda’s gannets, results from this work will be compared with those from other gannetries around Britain and Ireland to establish the amount of overlap in foraging areas among birds from different colonies. Such information is urgently needed given plans for large-scale offshore renewables projects and current uncertainty about what impacts this might have on internationally important seabird species.
In Portugal, a Seawatch Wavescan multi-parametric buoy manufactured by Fugro that provides real-time monitoring of waves, current profiles, water temperature and meteorological parameters uses the Argos Moored Buoy Monitoring Service (MBM) to ensure continuous uninterrupted tracking and quick retrieval in case the buoy leaves its mooring. This service, that has been very beneficial to the Portuguese Hydrographic Institute (IHPT), could also be of interest to any organization using VHF and GSM-driven oceanographic equipment in a coastal zone.

MOORED BUOY MONITORING SERVICE: A CASE STUDY

A pilot area was created off the beach of São Pedro de Moel, on the Portuguese west coast, to promote renewable energy from waves, by enhancing its technological development and its commercialization. In this framework, the IHPT was given the responsibility of conducting a multi-disciplinary study, including the deployment of a Seawatch Wavescan multi-parametric buoy (CSA87) in order to provide real time monitoring of waves, current profiles, water temperature and meteorological parameters. This buoy has been operating since December 2011, and receives regular major maintenance services every six months.

ABOUT THE PORTUGUESE HYDROGRAPHIC INSTITUTE (IHPT)

The Portuguese Hydrographic Institute (IHPT) is the Portuguese Navy’s Laboratory of Ocean Sciences. Besides its military mission, the Hydrographic Office integrates the National Network of Public Research Institutes, and plays an important role in the scientific community of sea science and technology. It has skilled human and operational resources necessary for the development of multidisciplinary research projects, in partnership with national and foreign institutions, in the fields of physical oceanography, marine geology, chemistry, hydrography, navigation and environmental protection.

WHY THE IHPT USES THE ARGOS MOORED BUOY MONITORING (MBM) SERVICE

Since the buoy is only 6 miles from land, data are transmitted by VHF instead of satellite communications. Yet, what should happen if the buoy were to drift away, out of the range of the VHF land station? We needed to find a service that provided the positioning of the buoy independently and worldwide. Since we already use Argos Subsurface Mooring Monitoring service for other deployed mooring systems since 1996, we chose the Argos MBM service, to solve this problem. In fact, we already had the proof of the service value: after a disruption in the VHF transmission due to unknown reasons, we were able to track the buoy position and be sure that it was not drifting. Being totally independent of the buoy, the system is very simple to use and a real value.

About the Moored Buoy Monitoring service

Designed for moored buoys equipped with an Argos tracker, this service will alert the user if a buoy leaves its mooring zone or has not transmitted for more than 24 hours. The mooring zone is pre-defined by the user as a circle or a polygon.

In nominal mode, the user receives a daily report by email or FTP with the buoy’s latest position.

In Alarm mode (buoy is leaving the monitoring area or stops transmitting) the MBM service provides alerts by email, SMS, FTP or fax and all positions are delivered in real-time to the buoy operator for equipment recovery.
WE WELCOME YOUR CONTRIBUTIONS!

We know your work is interesting. Let us publish it!

We are currently accepting contributions. Articles (maximum 700 words) should be submitted in French or English.

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