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30 years of WILDLIFE TRACKING WITH ARGOS

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TRACKING MARINE MAMMALS
OVER THE SEAS AND UNDER THE WAVES

By
Dr. Russel D. Andrews

Figure 1. Steller sea lion equipped with Argos-GPS stomach temperature tag.

The year 2009 is full of celebratory occasions for a marine biologist in Alaska. This year we are celebrating the 50th anniversary of Alaskan statehood, the 300th anniversary of the birth of Georg Steller, Alaska's first naturalist, and of course, the 30th anniversary of the Argos satellite data and tracking system. With more miles of coastline than the rest of the United States combined, the Argos system has been a valuable tool for marine biologists in Alaska.

In Argos's first operational year, some of the very first animals to be tracked with the Argos system were polar bears off the coast of Alaska. Although polar bears are classified as marine mammals, they differ from most other marine mammals by possessing a neck that is suitable for a collar attachment. Tag attachment for other marine mammals such as seals and whales is more of a challenge and successful tracking of some of these species did not occur until the mid-1980's. As a late-comer to the field of satellite telemetry, I missed out on some of those early developments, but over the last 17 years I have been fortunate to observe a steady improvement in the system and its application to studies of the behavior of marine mammals. Key advances have occurred in at least 3 areas: methods for analyzing the movement data collected by the Argos system, proliferation in the type of sensors and therefore the variety of data types capable of being sent by an animal-borne transmitter, and miniaturization of transmitters.

New sensors and analysis methods

Once researchers discovered that epoxy could be used to glue telemetry tags to the fur of pinnipeds such as seals and sea lions (Fedak et al., 1983), Argos satellite tags gained widespread use in marine mammalogy. To progress beyond simply describing the movement path of marine mammals, we have relied on innovations in the sensors that satellite transmitters include as well as advances in the ways that we analyze the movement data. Recently there has been much progress in developing and applying new movement analysis methods such as fractal analysis, Lévy flights, first passage time, and state-space models (reviewed in Schick et al., 2008). A novel method that was recently applied to some of our northern fur seal tracking data offers promise for picking out behavioral change points from the Argos data, even when it suffers from the common problem of irregular sampling intervals and uncertain location error (Gurarie et al., 2009).

Many of these methods, however, attempt to infer the behavioral mechanisms or the animal-environment interactions that have led to observed movement patterns when it would be preferable to directly collect and transmit relevant behavioral and environmental data. With the advent of stable, miniature sensors for temperature and conductivity, Argos satellite tags carried by marine mammals are now being used to collect information on important oceanographic variables, as reported in recent Argos Forum articles (Fedak, 2003; Guinet, 2004).

Figure 2. Location-only Argos tag for attachment to cetacean dorsal fins.

Until recently, the behavioral data that we could collect from marine mammals using Argos tags have been limited to water immersion and dive depth. For many years we have used archival (non-transmitting) tags equipped with additional sensors for direct measurement of variables such as prey ingestion, flipper stroking, and even physiological parameters like heart rate. Although bandwidth limitations had previously discouraged us from attempting to telemeter this data via satellite, we've recently begun using Argos satellite tags with sensors for stomach temperature because this is a signal that is relatively easy to compress into an Argos message with enough resolution to identify drops in stomach temperature that indicate prey ingestion of colder ectothermic prey by warmer endothermic marine mammals.

These new tags have facilitated a recent study of Steller sea lions in far eastern Russia. Adult Steller sea lions can be captured by darting them with a tranquilizer during the breeding season, but their wariness makes it very difficult to do this a second time to retrieve archival data loggers,

necessitating telemetry. In past studies, however, we obtained poor temporal and spatial resolution from Argos tracking during the short, over-night foraging trips of Steller sea lions. Traditional GPS receivers didn't work due to the very short surfacings of sea lions, but with the new "Fastloc" technology from Wild Track Telemetry Systems that requires less than 100 ms to take a "snapshot" of the GPS constellation, GPS locations can now be obtained for marine mammals using Argos satellite transmitters to relay data.

We worked with Wildlife Computers to obtain a tag (Fig. 1) that included Fastloc GPS as well as stomach temperature telemetry and dive depth so that we could pin-point the location and timing of feeding by sea lions in an area (Fig. 3) where their populations had undergone a marked decline over the last few decades. Although many of us bemoan the low bandwidth of the Argos system, the inclusion of novel behavioral and environmental sensors in Argos satellite transmitters will expand research opportunities and the data is bound to be coming in faster than we can keep up with it.

tags being remotely implanted into large whales like blue and humpback whales. The solution was to design a very small tag (Fig. 2, 4) that flies through the air nearly as well as it flies through the water. These tags are launched onto the fin with a crossbow or air-gun and held to the fin with 2 small barbed titanium darts. The tags typically transmit for 1-3 months, but up to 6 months depending upon species, before the darts pull back out the same holes they created upon attachment.

These new miniature tags have rapidly expanded the number of cetacean species that can now be tracked via Argos. Some of these are whales whose movement patterns were poorly known, if at all, such as false killer, pygmy killer, melon-headed, and Blainville's and Cuvier's beaked whales. Thanks to Argos, it is finally possible to closely monitor their behavior and to develop recommendations for the protection of their habitat. ■

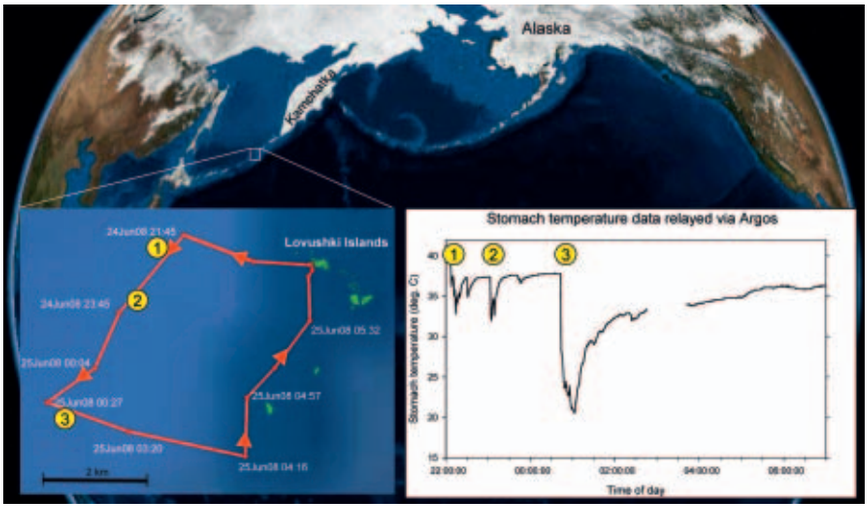

Figure 3. Illustration of the GPS locations and stomach temperature data collected by the tag in Fig. 1 during a 9 hour foraging trip and relayed via the Argos system. Left panel: locations along the track where drops in stomach temperature indicative of prey ingestion occurred are marked with numbers in yellow circles that correspond to the same numbers on the stomach temperature graph in the right panel. Gaps in the stomach temperature record reflect periods when no data was relayed via satellite.

More species tracked thanks to very small tag design

Another important advancement has been the dramatic reduction in the size of the transmitters. Marine mammals are relatively large animals, so the energetic consequences of carrying a satellite tag are not likely to be significant, but when attempting to attach a tag to marine mammals that lack fur, miniaturization is critical for being able to keep the tag attached. We were interested in tracking some of the medium-sized cetaceans that were too large to be captured for surgical attachment of a tag but too small for the larger

To learn more

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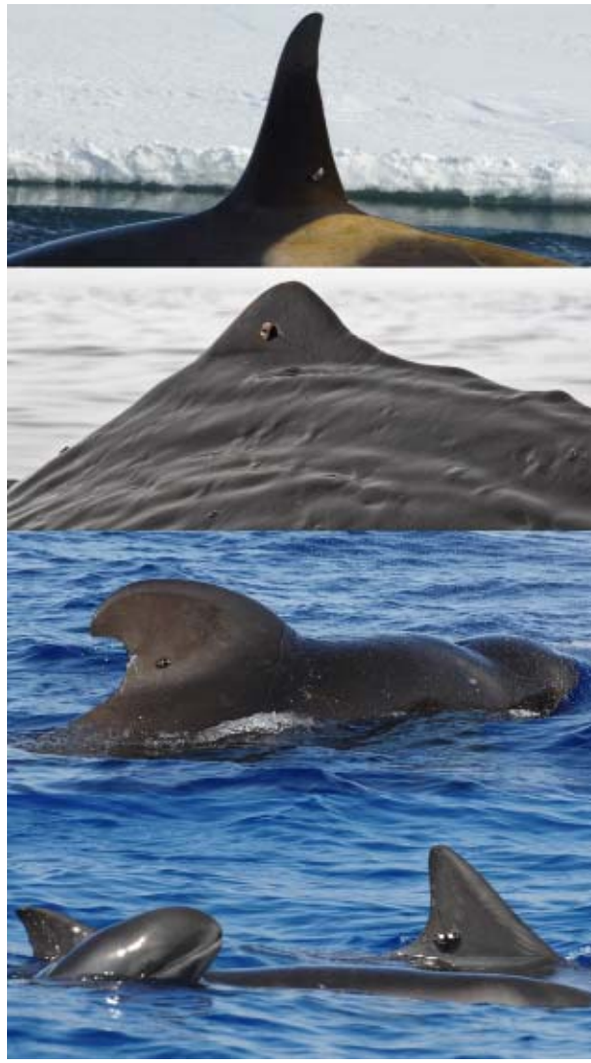

Figure 4. Four species of whales with the tag in Fig. 2 attached to their dorsal fin or hump. From top: killer, sperm, short-finned pilot, and pygmy killer whale.

Figure 5. Dr. Andrews launching an Argos cetacean tag mounted on the end of a crossbow bolt.

Dr. Russel D. Andrews

Dr. Andrews is an Alaska SeaLife Center scientist and a Research Professor for the School of Fisheries and Ocean Sciences at the University of Alaska, Fairbanks. Using remote-monitoring instruments, many of which he has designed and built himself, he has studied the physiology, behavior and conservation biology of marine mammals, sea birds and sea turtles from the Arctic to the Antarctic.