USING THE ARGOS SATELLITE SYSTEM TO PREDICT FLIGHT ALTITUDES, LOCATE CONTAMINANT SOURCES, AND RAPIDLY CONFIRM MORTALITY

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Abstract: We have worked with numerous colleagues since 1996 to use the Argos Satellite System and Platform Transmitter Terminals (PTTs) to investigate specific study objectives involving flight altitude, contaminants, and mortality, in addition to obtaining standard location estimates. We studied American white pelican (Pelecanus erythrorhynchos) flight behavior and meteorological events in the Fallon, Nevada, area as part of a program to predict bird flight and reduce risk of bird strikes by aircraft. We radio marked pelicans with satellite and conventional (VHF) telemetry to locate the birds within their large breeding season range and to track individual flights. PTTs were equipped with sensors calibrated to atmospheric pressure so we could estimate flight altitudes. Pelicans often use soaring flight and the altitude at which they fly is related to the warm thermal "updrafts" that form during the day. We are radio tracking white-faced ibis (Plegadis chihi) with PTTs to describe the annual movements of birds breeding at Carson Lake, Nevada, and to determine the source(s) of persistent DDE contamination found in breeding birds. We tracked seven individuals in 2000 - 2001 to wintering areas, in Mexico and California's Central Valley where we collected samples of invertebrates from ibis feeding habitats. The first samples have been analyzed and revealed clues to the source(s) of contaminants. We instrumented five desert bighorn sheep (Ovis canadensis nelsoni) with collars containing PTT and VHF transmitters to monitor the movements and survival of these relocated sheep. We conducted daily interpretation of PTT collar sensor data and quickly advised biologists when a potential mortality or
dropped collar was indicated. Timely notification allowed Nevada Division of Wildlife biologists to find carcasses usually within 72 hours and evaluate the cause of death.

**Introduction**

Since the earliest plans for using the Argos satellite system to study wildlife (Fuller et al. 1984, Fancy et al. 1988), the majority of use has been for obtaining location estimates and mapping the ranging or migrations of rapid moving or remotely occurring animals (Fuller et al. 1995). Examples of other applications of satellite telemetry include study of foraging behavior (Weimerskirch et al. 1993), orientation (Papi and Luschi 1996), habitat use (Mauritzen et al. 2003), and conservation (Higuchi et al. 1996). The purpose of this paper is to describe tracking and the use of sensors for research of flight behavior, mortality, and sources of environmental contaminants.

**American white pelicans - predicting bird flight**

We used the Argos satellite system (Fancy et al. 1988, Service Argos, Inc. at [http://www.argosinc.com](http://www.argosinc.com) ) to study American white pelicans (pelicans; *Pelecanus erythrorhynchos*) in the vicinity of Naval Air Station Fallon, NV where they are a threat to aircraft operated during pilot training (Yates 1999a). With colleagues from Penn State Univ. and the Univ. of Maryland-Baltimore, we studied pelican flight behavior and meteorological events in the Fallon area in 1996 - 1998. We marked pelicans from the breeding colony at Pyramid Lake and from the wetlands on the U.S. Fish and Wildlife Service Stillwater National Wildlife Refuge (SNWR) with personnel from the refuge, Naval Air Station Fallon (NASF), Nevada Division of Wildlife, and the Pyramid Lake Paiute Tribe. Biologist Bill Henry, SNWR, and others had observed pelicans regularly
making flights along a corridor between the Pyramid Lake nesting colony and the Lahontan Valley wetlands, and among the wetlands across more than a 60km radius over most of the area around the air station. To locate a sample pelican within its extensive breeding season range we radio marked pelicans with Platform Transmitter Terminals (PTTs; Microwave Telemetry, Inc., Columbia, Maryland, USA) that transmitted a radio frequency (401.65 MHz) to polar orbiting Argos satellites. We also epoxied a 216 MHz VHF transmitter (Advanced Telemetry Systems, Isanti, Minnesota, USA) to each PTT. We flew in a single engine fixed wing airplane and homed (Samuel and Fuller 1994) to the VHF transmissions to locate the birds. After we located a marked pelican we tracked and observed its flight.

Microwave Telemetry equipped the PTTs with sensors calibrated to atmospheric pressure. Shannon et al. (2002 a) used the pressure sensor data and observations of radio marked pelicans and the other birds in the flocks with which they flew to estimate flight altitudes. During our tracking and observations of individuals we received PTT data transmissions via a Gonio 400 receiver manufactured by SERPE-IESM of France. We also could track some flights or segments of flight from an automobile, receiving data from the PTTs by using a Telonics satellite uplink receiver; Telonics, Mesa, Arizona, USA.. Pelicans often use soaring and gliding flight to fly the long distances within their ranges and the altitude at which they fly is related to the height of the warm thermal "updrafts" that form during the day and to the flight biomechanics of the birds (Shannon et al. 2002 b). By integrating data collected during our observation flights with corresponding meteorological data, we established a relationship between pelican soaring-gliding flight and the strength of the forecast boundary-layer of thermals (Fig. 1).
Figure 1 The flight altitudes of one pelican for a portion of the day, plotted under the forecast boundary layer depth.

Through the application of this relationship, it was then possible to "forecast" the flight altitudes of most pelicans within the study area at a given time of day (Shannon et al. 2002 a, b). The use of PTTs and pressure sensors also have been used to study the flight of frigate birds (Fregata magnificens; Weimerskirsch et al. 2003).

After the Pyramid Lake nesting period, but before migration, some birds moved several hundred kilometers. For example, one individual left the capture area in early July, flew to northern California, then to southern Oregon, southern Idaho, and arrived at the Great Salt Lake in Utah by mid-August. In early/mid-September it returned to north central
Nevada then flew to north central Wyoming before migrating south in late September (Fig. 2).

Figure 2. Movements of one American White Pelican instrumented with PTT 5717 from 2 May 1997 through 9 November 1997.
These movements provide an example of connectivity among the wetlands of the Great Basin and adjacent regions and to migratory and wintering areas, and are representative of the useful information that can be obtained using the Argos satellite telemetry system.

**White-faced ibis movements and DDE contamination**

To date we have radio tracked ten white-faced ibis (ibis; *Plegadis chihi*) via Argos satellites. Our goal is to describe the annual movements of birds breeding at Carson Lake, NV and to determine the source(s) of persistent DDE contamination found in some of the breeding birds (Henny 1997). Dr. C.J. Henny, USGS Forest and Rangeland Ecosystem Science Center, estimates that eggshell thinning caused by DDE results in a loss of about 20% of the expected breeding colony reproduction at Carson Lake. He found no local sources of DDT/ DDE. Thus, the birds must be exposed to contaminants on the migration routes or wintering areas. In 2000, with Bill Henry and others from the Stillwater National Wildlife Refuge, and Larry Neel and others from the Nevada Division of Wildlife, we PTT marked white-faced ibis. We tracked seven individuals to wintering areas, three in Mexico and four in California's Central Valley. We visited California wintering sites and collected samples of invertebrates from areas in which ibis were feeding. In Mexico, Dr. Eduardo Santana, Instituto Manantlán de Ecología y Conservación de la Biodiversidad-DERN, Universidad de Guadalajara-CUCSUR, made corresponding collections. The samples have been analyzed and some are contaminated with DDT. During 2003 – 2004 we will PTT mark another sample of ibis and collect prey on their wintering areas to map the distribution of contaminated birds and contaminated prey.
Similarly, we are using satellite telemetry with common loons (*Gavia immer*) that migrate through Walker Lake, NV and breed in Saskatchewan (Yates 1999b). These individuals have the highest blood mercury (Hg) levels documented in U.S. loons. We are collaborating with Dr. David Evers and other loon specialists, USGS persons in water resources, Nevada fisheries staff members and USFWS biologists and contaminants specialists to determine source(s) of Hg (Fig. 3).
Figure 3. Movements of Common Loons instrumented with PTTs from 10-17 May 1998, and from 11 April - 6 May 2000.
These studies demonstrate the effective use of satellite telemetry to address questions such as where contaminants are encountered, or what breeding or wintering “populations” are affected when contamination exposure occurs in disjunct, remote locales of the annual range of migrants. These studies also show how satellite telemetry provides opportunities to team with colleagues at those locales to efficiently and effectively conduct fieldwork and address conservation issues.

**Bighorn sheep - monitoring survival**

In fall 2001 we initiated a study with the Nevada Division of Wildlife to instrument five desert bighorn sheep (*Ovis canadensis nelsoni*) with PTT collars (North Star Science and Technology, Maryland, USA) and relocate them to the Delamar Mountains in southern Nevada. Our objectives were to monitor the movements and survival of these relocated sheep with daily interpretation of PTT collar sensor data, and to quickly advise NDOW when a potential mortality or dropped collar was indicated. Daily we evaluate the data emailed from Service Argos. Specifically, we assess the PTT activity and temperature sensor data and use information from changes in an animal’s locations to decide if there is potential for a dead animal or collar that is off the animal. An example of sensor data summary from a PTT collar on a live desert bighorn sheep is shown in Table 1.
Table 1. An example of sensor data summary from a PTT collar on a live desert bighorn sheep.

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<th>time (UTC)</th>
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<td></td>
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<td>11:27:09</td>
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</table>

The count of changes in activity sensor values incremented regularly and the range of temperatures inside the PTT was normal. Thus we concluded for this period that the collar was on a live desert bighorn sheep.

Once we determined that a collar was down, we provided biologists with the coordinates of satellite telemetry location estimates, and they further homed to a VHF transmitter that was attached to each collar. Timely notification usually allowed state biologists to find a carcass within 72 hours, when it is often still possible to determine the cause of death. This use of the Argos system demonstrates how remotely occurring animals can be intensively monitored daily, without the expense of sending personnel to the field, while still providing timely relevant data.
The Raptor Research Center

The Raptor Research Center at Boise State University has utilized satellite telemetry extensively to address objectives for diverse species. In addition to studies presented herein, other projects involved peregrine falcons (*Falco peregrinus*; Henny et al. 2000), prairie falcons (*Falco mexicanus*; Bates et al. In Press), Swainson’s Hawks (*Buteo swainsoni*; Fuller et al. 1998), Steller’s sea eagles (*Haliaeetus pelagicus*; McGrady et al. 2000, McGrady et al. 2003, Ueta et al. 2003), and snowy owls (*Nyctea scandiaca*; Fuller et al. In Press). Currently, in studies funded by the Bureau of Land Management, NDOW, and the USGS, we are studying annual movements of northeastern Nevada sage grouse (*Centrocercus urophasianus*) relative to range management experiments, and the annual movements of ferruginous hawks (*Buteo regalis*).

We partner with federal, state and private individuals and organizations to design and conduct innovative studies using conventional and space-based technologies. Our involvement can include all phases of a given study or the acquisition, management and interpretation of data.

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ACKNOWLEDGMENTS

The study of American white pelicans was led by H. Shannon and G. Young of Pennsylvania State University, and assisted by W. S. Seegar, Department of Army, and B.J. Dayton and B. Henke, of the University of Maryland, Baltimore County. Funding was provided by the Department of Defense (DoD) Legacy Resource Management Program. The Legacy program also funds our research of the origin of white-faced ibis contamination, on which we work with W. S. Seegar, Department of Army, and B.J. Dayton, J. Cibor, and B. Henke, of Earthspan, and with the assistance of C.J. Henny, U.S. Geological Survey Forest and Rangeland Ecosystem Science Center, the US Fish and Wildlife Service, and Nevada Division of Wildlife. Linda Schueck, formerly with the Raptor Research Center, is a coworker on the pelican, loon and ibis research. The Nevada Division of Wildlife funds the study of big horn sheep movements and mortality, and Mike Cox is our principal colleague there with Mike Scott searching for the VHF transmissions and sheep when we provide an alert of potential mortality. We wish to thank the staff members of Service Argos for their attention to our technical and administrative questions, and Betsy Micone, Boise State University Raptor Research Center, for her administrative support.

Literature cited


