Design and Field Testing of an Internal Helix Antenna Satellite Transmitter for Sea Turtles

Barbara A. Schroeder[1] **and George H. Balazs**[2]
[1]*N.M.F.S., Office of Protected Resources, 1315 East West Highway, Silver Spring, Maryland 20910 USA*
[2]*N.M.F.S., Southwest Fisheries Science Center, Honolulu Lab., 2570 Dole St., Honolulu, Hawaii 96822-2396 USA*

The use of satellite telemetry to study the migrations of marine turtles opened up a new avenue of investigation during the 1980's. Technological improvements have reduced transmitter size and increased the sophistication of satellite transmitters to enable the collection of data including geographic position and even dive profiles. Although the specific objectives of satellite telemetry research vary, the desire for regular and long-term, high quality locational data are universal. We have been studying the post-nesting movements of Hawaiian and Floridian green turtles (*Chelonia mydas*), respectively, since 1992 and 1994. While the results of our work, using Telonics ST-14 backpack-style transmitters, are considered highly successful and have elucidated the migratory pathways and identified the resident foraging grounds, we began to see a similar pattern of satellite transmitter performance and transmitter life. Locational data transmitted along the migratory routes were generally frequent and of good quality, but this was followed by a drop in quality once the turtles arrived at their foraging habitat, and rapidly degraded thereafter until locational data ceased.

Conventional satellite transmitters used on sea turtles for the past two decades have been built with an external vertical wire antenna. When used on sea turtles in benthic (non-pelagic) habitats, we suspected vulnerability of the antenna, resulting in signal attenuation or loss. The conclusions most frequently drawn when a satellite transmitter is no longer sending data are that either the unit has fallen off or the batteries have been depleted. Our evidence, working with post-nesting green turtles, indicates that these reasons are unlikely when transmitter models with a proven track record are used and when proven attachment techniques are used. In studying our results over a several year period, and encountering turtles in subsequent nesting seasons that had been previously outfitted with satellite transmitters, we concluded that the antenna was the weakest link of the system. In all cases where transmitters were recovered, the antenna was sheared off at the insertion point of the housing, while the transmitter itself was intact. These recoveries, in both the Atlantic and Pacific, corroborate our suspicion that the external antenna, in contrast to battery capacity, is the primary limiting factor in the duration and quality of successful transmissions.

We met with the manufacturer of our satellite tags, Telonics, Inc. (Mesa, Arizona, USA), in late 1997, to discuss the problem of antenna damage and how it might be overcome. During that visit with Boyd Hansen, Brenda Burger, and Stan Tomkiewicz, we sketched out a satellite transmitter housing that would encase a helix antenna and would be more streamlined than the boxy standard ST-14 unit, in order to provide improved hydrodynamic performance (see Watson and Granger, 1998). Over the next few months, Telonics used these to design and build a prototype ST-14 unit with an internal helix antenna. In 1998, we tested four prototype units, two in Florida and two in Hawaii and, at the same time, deployed three standard ST-14 units, one in Florida and two in Hawaii. The duty cycle (time in hours that the units cycle on and off) was identical within study sites but differed between study sites. The testing of the prototypes was not designed as a comparative study between Hawaii and Florida, but was integrated into our respective, ongoing studies and was intended to compare standard vs. prototype transmitter performance at each location. The attachment technique consisted of an initial layer of silicone elastomer as a base for the transmitter, followed by three applications of polyester resin and fiberglass cloth strips (Balazs *et al*., 1996). The standard ST-14 units were attached with the antenna posterior and a cylinder of fiberglass cloth with an outside layer of kevlar cloth resined in directly in front of the antenna to provide increased protection to the base of the antenna. The prototype units were attached in the same manner, except that the internal antenna was placed anterior and no cylinder was needed.

Results from Hawaii

Data resulting from the prototype units used in the Hawaii component of the study are depicted in **Fig. 1.** The location class codes indicate the relative accuracy of the calculated positions. Codes 1,2,3 have estimated accuracies of less than 1000 m; code 0 has an estimated accuracy of greater than 1000 m; and no accuracy estimates are defined for codes A or B, however these locations can be highly accurate and the researcher must interpret these locations judiciously. The standard external antenna units resulted in twice as many transmissions overall (1835 vs. 767) and about twice as many transmission that resulted in calculated locations. Seventy percent of the transmissions from the prototype did not result in a calculated position ("Z" class data). Despite the reduction in the number of locations calculated from the prototype units, there were enough valid locations to provide a clear definition of the migratory track to the resident foraging habitat.

Results from Florida

Data from the Florida turtles were dissimilar to the Hawaii results in that many fewer overall transmissions were received from both the standard and prototype units (**Fig. 2**). The migratory track and residential endpoint at the

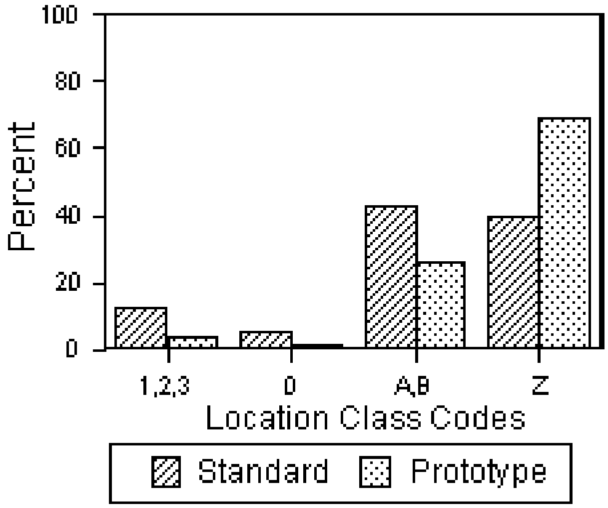

Figure 1. Results from Hawaii, combined standard units vs. combined prototype units.

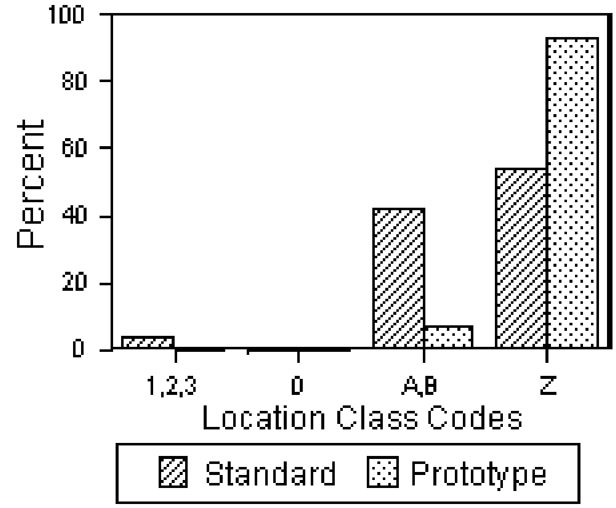

Figure 2. Results from Florida, standard unit vs. combined prototype units.

foraging ground were clearly defined by the data resulting from the standard unit. In contrast, so few data points were received from the two prototype units that neither a clear definition of the migratory track nor confirmation of taking up residence on the foraging grounds could be demonstrated. The standard and prototype units performed similarly with regard to location class codes 1,2,3 and 0, but the standard unit generated a greater percentage of location class A and B positions than the prototype units, which enabled definition of the migratory pathway and confirmation of residence at the foraging site. Ninety-three percent of the prototype unit transmissions were location class code "Z" and no positions could be calculated.

Conclusions

The external antenna outperformed the internal helix antenna with regard to the number and quality of transmissions yielding locational data, six months post-deployment.

As of March 1999, of the three external antenna units, only one (a Hawaii unit) is still transmitting.

As of March 1999, of the four prototype units, all are continuing to transmit regularly, however, only the Hawaii units are currently transmitting location data.

We recommend the standard external antenna ST-14 over the prototype unit when migration routes and resident foraging habitats are unknown for post-nesting green turtles. The rolled cylinder and reverse antenna orientation (antenna posterior) are recommended for improved performance.

Under certain conditions, and for certain applications, the prototype internal antenna unit may be useful for collecting longer-term data. Additional testing on other sea turtle species or under different conditions may be warranted. Telonics, Inc. will build the prototype unit on a cost-order basis. This project has resulted in the mold being available at no additional cost.

Acknowledgments

We thank Denise Ellis, Marc Rice, Randy Miller, Skippy Hau, Shawn Murakawa, the U.S. Fish and Wildlife Service Refuge Division, the University of Central Florida Marine Turtle Group, Dean Bagley, Lew Ehrhart, Andrea Mosier, Steve Morreale, and Michael Coyne for their assistance with various aspects of the studies. Special thanks to Brenda Burger, Stan Tomkiewicz, and Boyd Hansen of Telonics, Inc. for their expertise and collaboration on the prototype design.

Literature Cited

Balazs, G.H., R.K. Miya, and S.C. Beavers. 1996. Procedures to attach a satellite transmitter to the carapace of an adult green turtle, *Chelonia mydas*. Proc. 15th Ann. Symp. Sea Turtle Biol. Conserv. NOAA Tech. Memo. NMFS-SEFSC-387, 355pp.

Watson, K.P. and R.A. Granger. 1998. Hydrodynamic effect of a satellite transmitter on a juvenile green turtle (*Chelonia mydas*). J. Exp. Biol. 210: 2497-2505.