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NOTE

FIRST SUCCESSFUL SURGICAL INTERNAL IMPLANTATION OF ELECTRONIC TAGS IN MARLIN

Kim N. Holland, David G. Itano, and Michael Domeier

A major goal of marlin behavioral studies is to discover if billfish follow predictable migratory pathways as they move throughout the world's oceans or whether they simply move haphazardly in response to feeding opportunities or general oceanographic influences. Does the same individual marlin repeatedly re-visit predictable locations within a home range? Answers to these questions could have significant management implications such as indicating if there are migration "corridors' that could be protected on a seasonal basis. Getting these answers requires obtaining long-term (multi-year) tracks of the movements of individual billfish and to date, this has not happened. One of the main reasons for this failure is the fact that billfishes do not reliably carry externally attached "pop-up" satellite tags for longer than a few months.

By contrast, long-term retention of tags has been achieved by implanting electronic tags in the gut cavity of several fish species. The results obtained from internally implanted tags have made significant contributions to our understanding of long-term movement patterns and habitat preferences of various shark and tuna species (Teo et al., 2004; Schaefer and Fuller, 2005 inter alia). However, for marlin, internal implantation of electronic tags has not previously been attempted. Here we describe the successful testing of an articulated, adjustable cradle that allowed us to capture and restrain sub-adult striped marlin, *Tetrapturus audax* (Philippi, 1887), and intraperitoneally implant acoustic transmitters. In this case, acoustic transmitters were used because in an unrelated experiment, acoustic data loggers had been attached to all the fish aggregating devices (FADs) around the island of Oahu, Hawaii, and implanting acoustic transmitters in marlin offered the possibility of elucidating their behavior around FADs. However, successful restraint of the animals and implantation of acoustic tags in our case would indicate that future experiments could use surgical implantation for a variety of tag types including archival tags.

Methods

To determine whether the marlin survived the implantation surgery and behaved normally after release, we double-tagged each marlin carrying an internal tag with an external "pop-up" satellite tag. Four of these were made available to this project by the Pfleger Institute for Environmental Research. Data from the satellite tags allowed insight into the post-release behavior of the marlin and indicated whether or not they survived the implant surgery. Pop-up tags have been previously used in this way to determine post-release survival of marlin (Graves et al., 2002; Kerstetter et al., 2003; Horodysky and Graves, 2005).

Cradle Design.—The tagging cradle is a modified "V" shaped trough with a hinge along the entire lower margin of the outer wall to allow it to squeeze and "sandwich" the captured fish against the stationary inner wall. Rapid squeezing and immobilization of the fish is achieved by pulling on two ropes attached to the exterior surface of the outer wall. Once the fish is sandwiched, the walls can be rapidly locked in position by jamming the ropes into the jaws of fast locking "open-jaw" cleats fixed to the outside surface of the inside (fixed) cradle

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Figure 1. Cradle locked in place on gunwale with cradle wall in open position.

wall. The cradle is lined with a foam pad covered with a plasticized fabric to reduce mucus loss and allow the fish to slide easily into the cradle (Fig. 1).

The cradle has two stanchions that fit into pole holders on the gunwale. The aft cradle stanchion can be lifted out of its holder and the forward stanchion has an "L" shaped extension that rotates and swivels to allow the cradle to pivot downward from the boat's gunwale such that the trailing end of the cradle just penetrates the ocean surface adjacent to the vessel (Fig. 2). Marlin captured with trolling gear were leadered into the trailing end of the cradle and pulled up the length of the cradle (leaving the caudal fin protruding). The ropes and cleats were then used to rapidly lock the outer wall tight against the fish (Fig. 3). When the fish was sandwiched in place, the trailing end of the cradle was lifted up to deck height and re-anchored in the pole holders thereby providing easy access to the fish (Fig. 1). This capture procedure means the marlin were lifted and restrained without experiencing any "dead weight" and without being able to thrash and bruise. The hook can be carefully removed without causing further damage. The restrained animals were irrigated with running seawater from a hose inserted in the mouth. Once subdued, the fish can be repositioned (inverted) in the cradle by temporarily releasing and then re-locking the outer wall. This allows access to both dorsal and ventral surfaces of the fish. After tagging and measurement, the hinged wall was

Figure 2. Cradle deployed with trailing edge in water, wall in open position.

Figure 3. Striped marlin upside down in cradle. Outside wall is in the closed (sandwich) position but the cradle is still in the trailing configuration (not retracted onto gunwale).

unlocked and the marlin allowed to spill back into the water where further resuscitation was performed if necessary.

Implantation Surgery and Tag Attachment.—With the marlin in an inverted orientation, the acoustic transmitters (model V16, Vemco, Nova Scotia) were implanted through a 3 cm long incision in the ventral midline that was closed with three interrupted dissolvable sutures. The cradle was then briefly loosened to allow repositioning of the fish and the pop-up tag (Mk4 PAT, Wildlife Computers, Redmond, Washington) attached with a titanium anchor placed through the dorsal musculature and pterygiophores. The fish was then released.

Results

We successfully tested the prototype cradle and double tagged four striped marlin (120–180 cm lower jaw fork length) with internally implanted acoustic transmitters and externally attached pop-up tags. The pop-up tag data showed that three of the four fish survived the restraining/tagging procedure and behaved normally until the external tags detached after 36, 37, and 52 d. These three fish spent 81.5%, 81%, and 76.6% of their time < 90 m below the surface and all three showed maximum swim depths of about 220 m. The fourth fish was apparently attacked by a shark immediately after release. The tag was apparently regurgitated after 45 d when it floated to the surface and downloaded data showing average depths of over 500 m. None of the acoustic tags was detected by the data loggers on the FADs but this is not surprising since the tracks produced by the pop-up tags indicated that the marlin quickly moved away from Oahu.

Discussion

We believe that capture and restraining methods such as those we have developed will expedite surgical implantation of tags in marlin with commensurate advances in our understanding of their long-term movement patterns. Our results indicate that marlin can be captured, immobilized, and restrained for successful tag implantation surgery. The dimensions of the cradle used in our work could be increased to accommodate larger marlin—possibly by deploying the cradle through the transom fish door found on many fishing vessels.

Literature Cited

Graves, J. E., B. E. Luckhurst, and E. D. Prince. 2002. An evaluation of pop-up satellite tags for estimating postrelease survival of blue marlin (*Makaira nigricans*) from a recreational fishery. Fish. Bull. 100: 134–142.

Horodysky, A. Z. and J. E. Graves. 2005. Application of pop-up satellite archival tag technology to estimate post release survival of white marlin (*Tetrapturus albidus*) caught on circle and straight-shank ("J") hooks in the western North Atlantic recreational fishery. Fish. Bull. 103: 84–96.

Kerstetter, D. W., B. E. Luckhurst, E. D. Prince, and J. E. Graves. 2003. Use of pop-up satellite archival tags to demonstrate survival of blue marlin (*Makaira nigricans*) released from pelagic longline gear. Fish. Bull. 101: 939–948.

Schaefer, K. M. and D. Fuller. 2005. Behavior of bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*) tunas within aggregations associated with floating objects in the equatorial eastern Pacific. Mar. Biol. 146: 781–792.

Teo, S. L. H., A. Boustany, S. Blackwell, A. Walli, K. C. Weng, and B. A. Block. 2004. Validation of geolocation estimates based on light level and sea surface temperature from electronic tags. Mar. Ecol. Prog. Ser. 283: 81–98.

Addresses: (K.N.H.) *Hawaii Institute of Marine Biology, Coconut Island, PO Box 1346, Kaneohe, Hawaii 96744.* (D.G.I.) *Pelagic Fisheries Research Program, SOEST, University of Hawaii, Honolulu, Hawaii 96822.* (M.D.) *Pfleger Institute for Environmental Research, 901-B Pier View Way, Oceanside, California 92054.* Corresponding Author: (K.N.H.) *E-mail: <kholland@hawaii.edu>.*