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NOTE

Archival Tagging Methods for Monkfish

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Abstract

The purpose of this study was to develop archival tagging methods for goosefish *Lophius americanus* (more commonly known as monkfish), a species thought to be highly susceptible to capture and tagging mortality and very difficult to maintain in captivity. Archival tags were implanted subcutaneously near the second dorsal fin using sanitary surgical methods. A streamer attached to the tag extended through the skin and provided an externally visible tag. Mortality of both tagged and control fish was high (39–44%) in laboratory experiments but did not differ significantly; thus, tagging did not increase mortality. Tag retention was 100% through 6 weeks, but 38% of the incisions on tagged fish showed possible signs of opening. Two of four tagged fish held for up to 6 months expelled their tags. We hypothesize that the streamer prevented complete healing of the incision and led to tag loss. We conclude that archival tagging of monkfish could be successful but recommend that archival tags be completely enclosed if implanted subcutaneously.

Seven *Lophius* species support high-value fisheries around the world, yet fundamental aspects of their life history remain poorly understood, including stock structure, migratory patterns, and spawning locations (Fariña et al. 2008). These information gaps would best be addressed by tagging with data-recording tags, as *Lophius* spp. habitat extends to waters deeper than the range of fisheries or surveys. Yet, *Lophius* spp. have been considered poor subjects for tagging because they lack scales and have a large unprotected abdomen, which may make them especially susceptible to infection and injury. They are also notoriously difficult to maintain in captivity, raising concerns that postrelease survival might be poor. For these reasons, there has been very little tagging of goosefish *Lophius americanus* (more commonly known as monkfish) in the Northwest Atlantic Ocean.

Our interest was in developing methods for the archival tagging of monkfish because fine-scale information is needed to fill the gaps in our understanding of their biology (Richards et al. 2008), such as size-specific seasonal migrations between management areas and residence periods in deepwater habitat. We developed procedures for implanting archival tags (data storage tags [DSTs]) and held tagged monkfish in the laboratory to determine their survival and tag retention rates as a basis for using DSTs in the field.

METHODS

The study was conducted in two phases: (1) development of tagging approaches and implantation techniques and (2) experimental studies to test monkfish survival and tag retention. The tags used were dummy Star-Oddi DST Centi-TD Loggers fitted with a 2-mm-diameter polyolefin streamer (~8 cm long; Figure 1). The tags were cylindrical (15 mm in diameter × 46 mm long), weighed 19 g (approximately 0.6% of an individual fish's weight), and had a ceramic-based biologically inert housing. The streamer was attached to the tag by a monofilament bridle that was threaded through holes at one end of the tag casing.

Using dead monkfish, we explored options for tag placement and developed surgical techniques for subcutaneous tag implantation. Several additional marking or tagging techniques were considered to provide ancillary marks that would increase the detection probability of an internally implanted archival tag (Petersen discs, T-bar tags, and injection of visco-elastic polymer on the white ventral surface of the jaw; McFarlane et al. 1990; Nielsen 1992). We concluded that the additional handling required for the visco-elastic injections was not justified and that Peterson tags might entangle algae or other objects or lead to infection. We chose to use T-bar tags because they were fast and easy to insert securely into the pterygiophores of the second dorsal fin, and appeared to be suitable as secondary marks.

The second phase of the project was a controlled experiment to test the effects of tagging on the survival of monkfish and to investigate tag retention. Thirty-eight monkfish ranging in size from 40 to 78 cm (mean, 58 cm) were captured in gill nets

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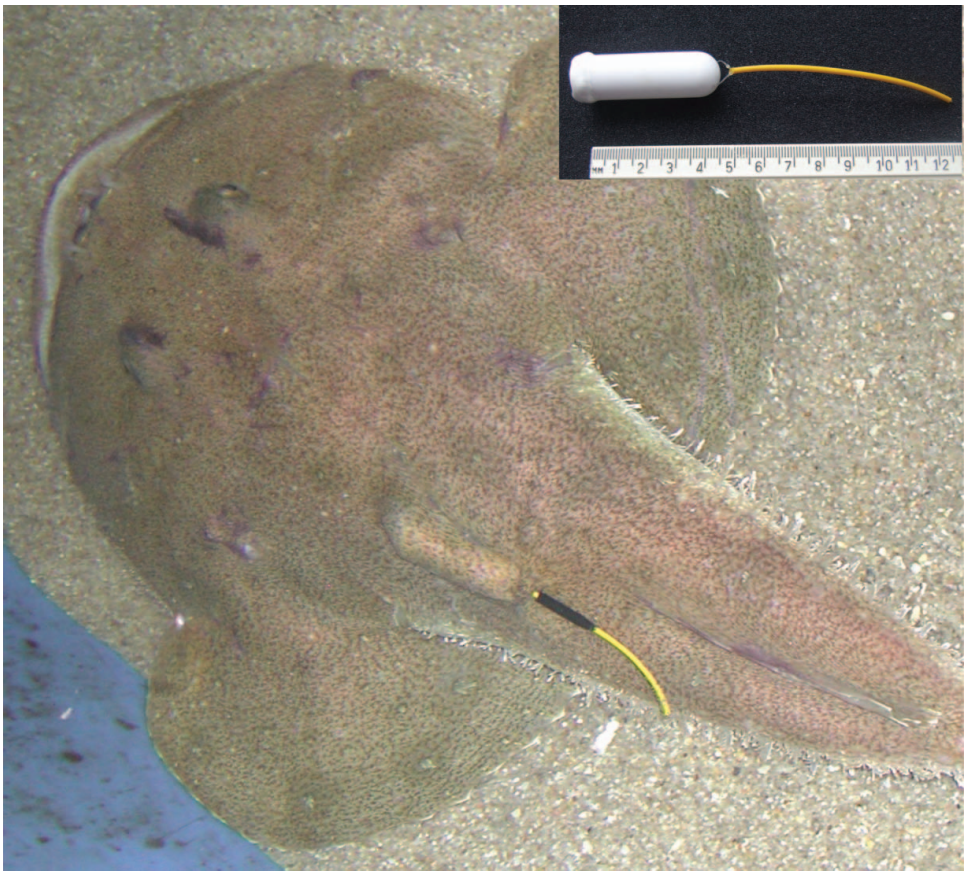

FIGURE 1. Monkfish (52 cm total length) with implanted archival tag. Inset: archival tag used in experiments (Star-Oddi DST Centi-TD Logger). (Figure available online in color.)

set at approximately 100 m depth for about 48 h during 11–15 December 2006. Upon removal from the gill net, monkfish were placed in a holding tank on the boat's deck with a constant flow of seawater (~6–8°C) and held for a maximum of 10 h before return to port, where they were transferred to 38-L coolers equipped with chillers and air stones. The water in the coolers was treated at recommended dosages with Amquel to control NH_3^+ and Slime Coat to help maintain the mucus coating of the monkfish. Transport time from port to laboratory was approximately 1 h. Upon arrival at the laboratory, the cooler water was equilibrated with the tank temperature (~7°C) over a period of about 1 h. The fish were held in two 9.8-m^3 tanks supplied with ambient running seawater, which ranged from 5°C to 8°C during the course of the experiment. Four monkfish died before the experiment began on 19 December.

Eighteen monkfish were tagged 4–10 d after their arrival in the laboratory; the remaining 16 fish were left untagged to serve as controls. Control fish were not handled and thus represent a control for the combined effects of handling and tagging during the experiment. Nine tagged fish and eight control fish were held in each tank. We subjectively matched pairs of fish based on size and perceived condition, then randomly chose which of the pair to tag. Tag streamers were color-coded for easy recognition of individual monkfish. Food (opalescent inshore squid *Loligo opalescens* or capelin *Mallotus villosus* chunks) was offered daily; however, the food was rarely taken. Observations of mortality, qualitative condition (skin color, skin lesions, and incision condition), and tag retention or loss were recorded on a daily basis without handling the fish. The experiment was terminated 40 d after the final batch of monkfish was tagged. The remaining monkfish were euthanized or held for longer-term observation.

Eight fish retained for long-term observation were transferred to two 1.1-m^3 tanks, each holding two tagged fish and two control fish. These fish were maintained for up to 6 months after tagging. The experiment ended when all fish died due to a pump malfunction 179 d after tagging was completed.

Survival curves of tagged and control fish were estimated using the Kaplan–Meier method and compared using the generalized Wilcoxon test in Proc Lifetest (SAS 9.1, SAS Institute, Cary, North Carolina; Allison 1995).

RESULTS

Tagging Approach

External tag attachment sites, including the dorsal or ventral surface of the pectoral fin, the caudal fin, and the dorsal fin, were rejected as either too obstructive (e.g., pectoral fins are

used for "walking" and "digging" [Laurenson et al. 2004] and the gill opening is directly beneath them) or inadequate (the tag could become entangled or fouled or work itself free [Thorstad et al. 2001; Rikardsen and Thorstad 2006]). Subcutaneous implantation on the dorsal surface of the tail was chosen because it appeared that this location would minimize interference with the fish's functioning. Further, if the tag was not detected and the tail processed for market, the tag would probably be recovered in the consumer chain. The dorsal surface on monkfish has sufficient loose skin to easily accommodate a tag of the size we used.

Captive monkfish often develop skin lesions very rapidly; therefore, sanitary tagging protocols were developed to minimize the transfer of pathogens. These protocols included cold-sterilizing instruments between surgeries, cold-sterilizing tags, using surgical gloves and a sterile drape over the fish, and cleaning the incision site with antiseptic before and after the surgery. The antiseptic used was chlorhexidine gluconate (ChlorHexiderm). Instruments and tags were rinsed with fresh tap water before use.

The fish to be tagged were placed on a towel wetted with a solution of Slime Coat and the gills irrigated with either a large hand syringe or a constant flow of seawater. The incision site was gently wiped with antiseptic, and a 1–1.5-cm incision was made through the skin using surgical scissors. The scissors were then used to bluntly separate the skin from the underlying muscle, creating a tunnel to house the tag. The tag was inserted parallel to the dorsoventral axis of the fish and tacked to the muscle through a "bridle" that attached the streamer to the tag. The incision was closed with a purse-string suture using dissolvable monofilament (Monocryl [poliglecaprone 25], swaged onto a 3–0 gauge cutting cuticular needle) and knotted using a surgeon's knot. The purse-string suture was made by taking running stitches around the perimeter of the incision; the stitches were then drawn up to close the wound. The duration of surgery averaged 6.5 min (minimum, 4.3 min; maximum, 10.3 min). No anesthesia was used, and most fish did not react visibly to the procedure, though some were more active than others.

Tagging Experiments

During our 6-week controlled experiment, seven tagged fish (39%) had died by day 22 and seven control fish (44%) had died by day 12. No further mortalities occurred during the remainder of the experiment (Figure 2). The survival curves of tagged and control fish did not differ significantly (Wilcoxon test: $n = 34$, $P > 0.05$; Allison 1995). The fish that died earliest had been judged to be in poorer condition at the time of tagging (Figure 3; analysis of covariance [ANCOVA]: $P < 0.05$). The number of days that tagged fish survived was not related to the duration of surgery, fish length, or interaction between these factors (Figure 3; ANCOVA: $P > 0.05$). There were no differences in mean survival duration between tanks or taggers (t-tests: $P > 0.05$). One of the seven tagged fish that died by day 22 showed signs of stress around the tag site (change in coloration of the skin); the tag site appeared healthy in the remaining fish that died by day 22. However, of 11 tagged fish that were held at least 36 d, 4 (36%) showed possible signs of the tag site opening (typically a small opening ventral to the streamer). However, this was not noticeable until we euthanized the fish and examined the tagging site closely.

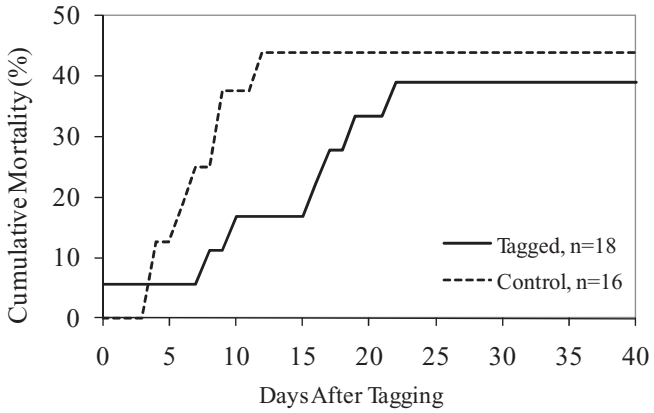

FIGURE 2. Cumulative mortality of tagged and control fish during the 6-week controlled archival tagging experiment.

During the long-term holding study (four controls and four tagged fish held up to 179 d), two fish lost their tags (after 76 and 133 d). A third tagged fish died 92 d after DST-tagging and showed a small (~2-mm) opening below the streamer at the site of the incision. The tag site was clean and did not appear to be related to the cause of death. The fourth tag remained implanted without signs of deterioration at the tag site.

DISCUSSION

Our study of the survival of tagged monkfish indicates that archival tagging studies of this species are feasible if tag retention can be improved. Tagging did not significantly increase the mortality of monkfish held in captivity for up to 40 d relative to that of control fish; however, as anticipated, both control and tagged fish experienced high mortality during the holding study. This high mortality is a concern because postcapture mortality in the field might occur at similar rates. Conventional tagging studies of trawl-caught European monkfish (black anglerfish *Lophius budegassa* and white anglerfish *Lophius piscatorius*) seemed to confirm poor survival, as they obtained relatively low tag return rates (0.6–1.1% [Landa et al. 2008] and 4.5% [Laurenson et al. 2005]). However, return rates of monkfish tagged after capture in gill nets were 6.8–9.0%, suggesting that survival can be relatively high if the capture method is less traumatic (Landa et al. 2008).

The reasons for the high mortality rates of captive monkfish are not well understood, but they are probably related to stress due to capture, transportation, and holding, coupled with disruption of the mucus coat during handling. Pickering et al. (1989) found that elevated levels of the stress hormone cortisol lowered immunity in salmonids, led to bacterial and fungal infections, and increased mortality. Similar processes may be responsible for skin lesions in monkfish, as such lesions often appear in the

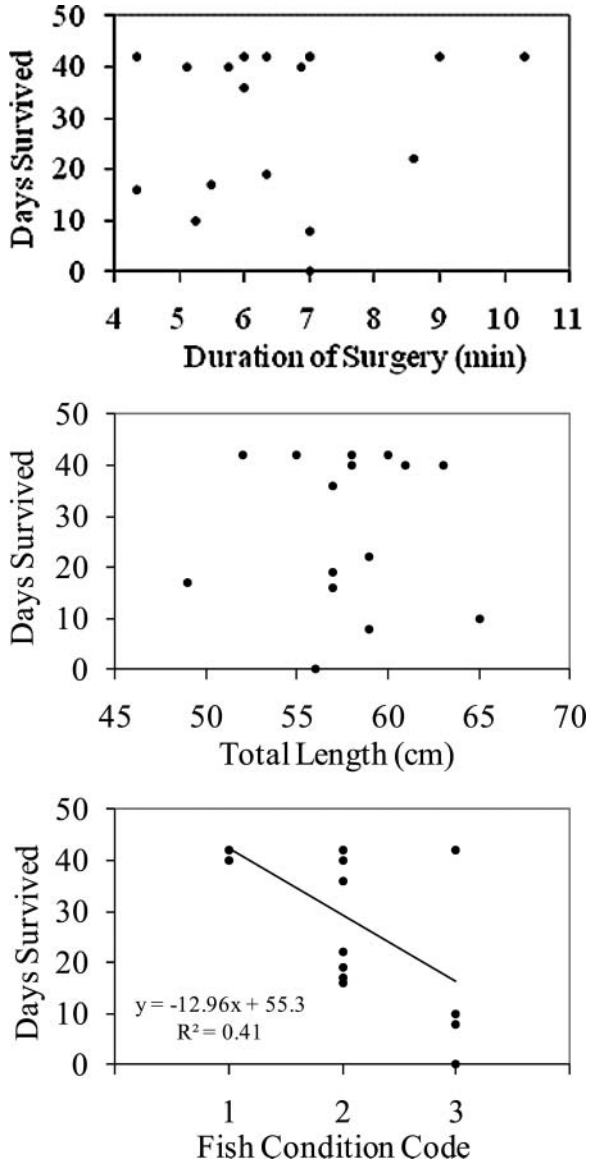

FIGURE 3. Survival of 18 tagged fish during the 6-week controlled experiment as a function of duration of surgery (top), fish length (middle), and fish relative condition (1 = best, 3 = worst) at time of tagging (bottom).

absence of an obvious wound. The failure of captive monkfish to feed probably also compromised their condition.

Tag loss occurred during our study, and modifications to the tagging method will be required to reduce it. The appearance of small openings beneath the tag streamers suggests that the protruding streamers either prevented complete wound healing or caused erosion of the healed wounds, which then led to tag loss. Further, the streamers probably interfered with complete apposition of the wound edges, which is critical to good wound healing (Wagner et al. 2000). Anchoring the archival tag in the muscle apparently did not prevent tag loss, so we would discontinue this practice.

It is unclear whether antiseptic preparation of incision sites in fish is beneficial or not. Surgical preparation (antiseptic) had no effect on wound healing in rainbow trout *Oncorhynchus mykiss* (Wagner et al. 1999) and could even cause harm by disrupting mucus layers, the constituents of which inhibit colonization and infiltration by pathogenic bacteria. However, pathogenic bacteria may also reside in the mucus (Austin and Austin 1987); if so, preparing the incision site may reduce the chance of infection. In a scaleless fish such as monkfish, the incision site is relatively easy to prepare, so disruption of the mucus coat can be minimized. Surgical preparation appears to have caused no harm in our experiments. Despite the presence of lesions on the tagged monkfish, we did not observe lesions or signs of infection at the incision sites.

The results of this study, along with pilot DST field studies (Thangstad et al. 2006; Rountree et al. 2008), indicate that archival tagging of monkfish could be successful. Our recommendations, therefore, are to (1) tag monkfish caught in gill nets fished on a short soak time, (2) implant tags subcutaneously rather than attaching them externally and completely enclose the implanted tags (no streamers), (3) use sanitary techniques, including cold-sterilization of tags and instruments and treatment of the incision site, and (4) use conventional tags (e.g., T-bar tags) to increase the chances of detection of archival-tagged fish.

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