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Effects of surgically-implanted transmitters on survival and feeding behavior of adult English sole

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Abstract

Acoustic telemetry studies of flatfish have typically relied on an external transmitter attachment. We propose to initiate long-term monitoring of adult English sole (*Pleuronectes vetulus* Girard) movements in Puget Sound, Washington, USA. The transmitters we use have a 2-year battery life, and we are concerned that external attachment might result in increased tag loss or predation risk over the course of this study. Consequently, we conducted a laboratory study to assess the feasibility of surgically implanting the transmitters. Dummy transmitters were constructed with the exact dimensions and weight of the study transmitters (5 g in air, 9x30 mm) and coated with an epoxy resin. We collected adult English sole (≥27 cm and 200 g) from Eagle Harbor, Washington, and tested insertion of a dummy transmitter into the peritoneal cavity from either the blind or eyed sides of the fish. A total of ten fish were assigned to each treatment group: blind-side insertion, eyed-side insertion and control. Two fish from each treatment were housed in each of five 1.2-m diameter tanks for 1 month. Fish were fed three times per week, and we noted their behavior for 10 minutes during each feeding. During the experiment, only one fish died (a control) and no transmitters were expelled. In addition, we found that fish from both treatments were active and exhibited normal feeding behavior relative to controls. At the conclusion of the experiment, all fish were weighed and sacrificed. Analysis of variance indicated no significant tank or treatment effects on weight gain. Necropsy revealed greater inflammation and fibrosis of the peritoneal side of the incisions made on the blind side relative to those on the eyed side. Therefore, we concluded that surgical implantation of transmitters into the peritoneal cavity is a viable option for long-term studies of flatfish movements, and we recommend insertion from the eyed-side of the fish.

Introduction

Acoustic telemetry studies of flatfish have typically relied on external transmitter attachment. Most of these studies either used large fish or were conducted over a relatively short time period (Greer Walker *et al*., 1978; 1980; Sureau and Lagardere, 1991; Metcalfe *et al*., 1993; Szedlmayer and Able, 1993). For studies using small fish, surgical implantation of the transmitter was not an option due to inadequate body cavity size. In studies using larger fish, the external attachment has apparently not affected fish movements or mortality over periods of greater than one year (G. P. Arnold, CEFAS Lowestoft Laboratory, Suffolk, UK, personal communication).

We propose to use acoustic telemetry to conduct long-term monitoring of adult English sole (*Pleuronectes vetulus* Girard) movements in Puget Sound, Washington, USA. The transmitters we use have a 2-year battery life. We are concerned that external attachment of these transmitters on such a small flatfish for long periods of time might result in increased tag loss. Moreover, external attachment might affect fish behavior or make the tagged fish more vulnerable to predation during the course of the study. With the miniaturization of acoustic transmitters, it is now possible to surgically implant the transmitters into the body cavity of small flatfish. We therefore investigated the feasibility of surgically implanting acoustic transmitters into the peritoneal cavity of adult English sole of at least 27 cm total length.

A number of metrics have been used to assess the effects of surgically implanting transmitters in fish, including survival, growth, swimming performance, buoyancy compensation, physiological stress, dominance, predator avoidance and feeding (e.g., Mellas and Haynes, 1985; Moore *et al.*, 1990; Adams *et al.*, 1998a; 1998b; Martinelli *et al.*, 1998, Thorstad *et al.*, 2000; Jepsen *et al.*, 2001; Perry *et al.*, 2001). We felt that for English sole the most sensitive indicator of transmitter implant effects would be feeding behaviour, as the body cavity is small and the presence of the transmitter could physically affect the ability to feed to satiation. Therefore our objectives were to 1) determine whether sole would expel the transmitters as documented in other fish species (e.g., Chisholm and Hubert, 1985; Marty and Summerfelt, 1986; Lucas, 1989; Moser *et al.*, 2000) and 2) determine whether feeding activity of English sole is affected by the presence of a transmitter in the peritoneal cavity. In addition, we compared the effects of transmitter insertion from both the blind and eyed sides of the fish to establish the best protocol for surgically implanting transmitters in this, and possibly other, flatfish species.

Materials and methods

Dummy transmitters were constructed with the exact dimensions and weight of an actual transmitter (5 g in air, 9x30 mm) and coated with epoxy resin. We collected adult English sole with an otter trawl from our study location in Eagle Harbor, Washington, USA. The fish were placed in a live tank onboard the vessel and those greater than 27 cm total length and 200 g in weight were transferred to the laboratory. The sole were acclimated to laboratory conditions in 1.2-m diameter, flow-through tanks for 1 week prior to implanting the transmitters.

Each fish was anaesthetized using a sedative dose of tricaine methanesulfonate (MS-222, 25 ppm) for 15 min and then transferred to a surgery bath with a higher concentration (80 ppm) for 5 min. We weighed (nearest g) and measured (nearest mm) each fish prior to surgery. A 2-cm horizontal, antero-posterior incision was made in the body wall on either the blind side or the eyed side (Fig. 1), and a dummy transmitter was inserted into the posterior region of the peritoneal cavity so that it rested in a dorso-ventral plane just anterior to the gonad. The incision was closed using two or three simple, interrupted, non-absorbable sutures closed with a surgeon's knot. We then irrigated the incision with oxytetracycline and swabbed it with a triple antibiotic ointment. Controls were handled but not anaesthetized.

There were a total of ten fish for each of the three treatments: blind-side incision, eyed-side incision and control. Two fish from each of the three treatments were then housed in each of five 1.2-m diameter tanks with running seawater at 17 °C for 1 month. After 1 week we initiated feeding experiments. The fish were fed chopped clams three times per week at a ration of 2.5% of their starting body weight as computed for each tank. During each feeding we noted their behaviour for the first 10 min after food was introduced into the tank and we recorded each time a fish ingested some food (referred to as a "bite"). At the conclusion of the experiment, all fish were weighed and sacrificed. We examined the tag and incision for signs of inflammation, incision closure and host reaction.

Results

Only one fish died (a control) and no transmitters were expelled. During the first two weeks of the experiment, most fish did not feed much and only certain individuals fed readily, regardless of treatment (Fig. 2). As the experiment progressed, more fish fed, and we found that fish from both tagged treatments were active and exhibited normal feeding behaviour relative to controls. We tested for treatment and tank effects on percent weight change (arcsin square root transformed; Zar, 1984) using analysis of variance. Because most fish lost weight during the course of the experiment (Fig. 3), we added 0.2 to the proportional change in weight recorded for each fish. We found no significant effects of tank, treatment, or tank by treatment interaction ($p>0.05$). Therefore, we pooled the data across tanks, but still found no significant treatment effect ($df=2$, $F=0.29$, $P=0.75$).

When we necropsied the fish, we found that all but three were females. In all fish the incision had closed completely and in many cases the scar was barely visible. However, we found that 30% of the fish tagged from the blind side had intraperitoneal

Fig. 1 – Typical locations of the incision made on the eyed- (top photo) and blind-(bottom photo) side of English sole (photos taken 2 weeks after surgery).

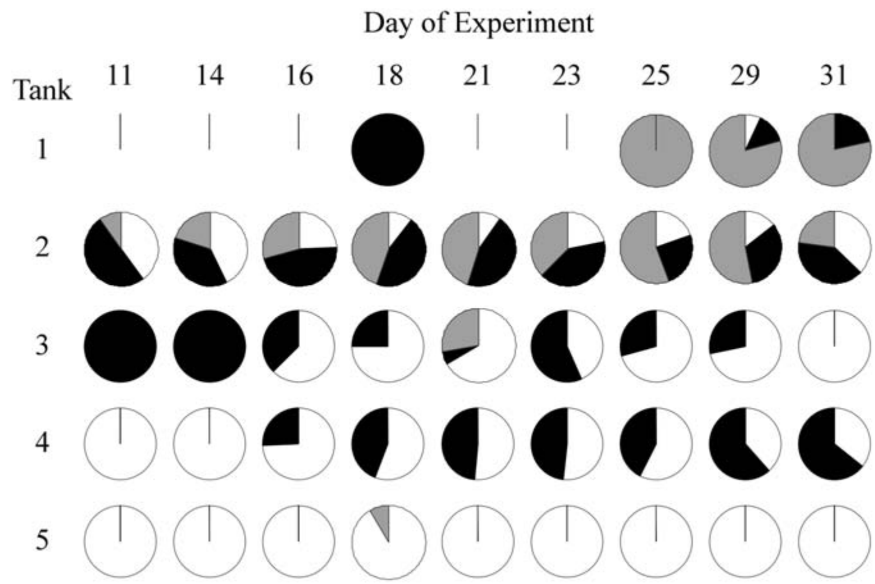

Fig. 2 – Percentage of bites made by fish of each treatment (controls in white, blind-side incision in black, and eyed-side incision hatched) in each tank during the course of the experiment. For example, on day 11 in tank 3 all bites were made by fish tagged from the blind side.

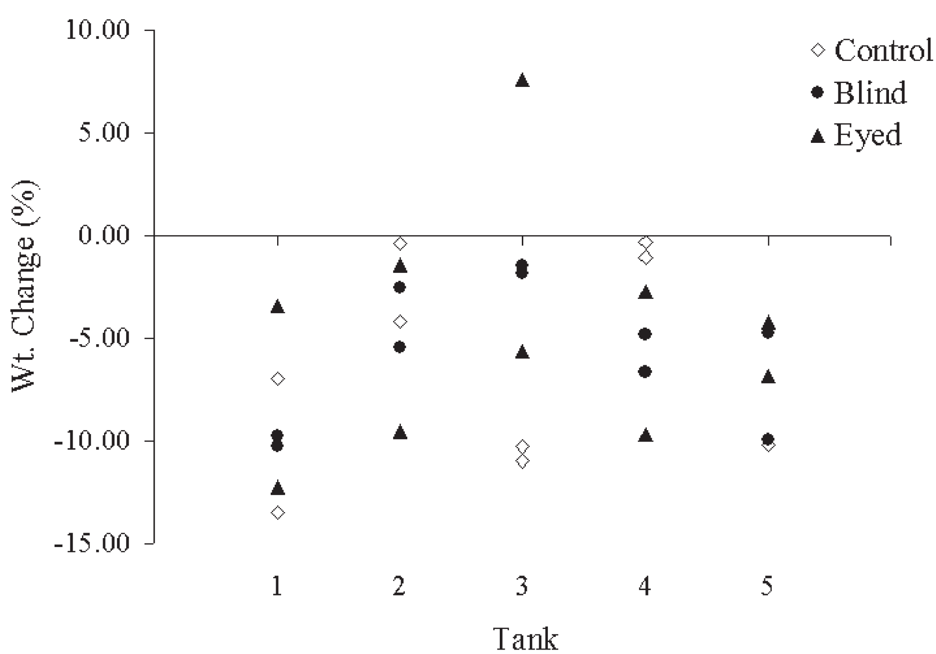

Fig. 3 – Change in weight during the course of the experiment for each treatment group: controls (open diamonds), blind-side incision (solid circles), and eyed-side incision (solid triangles).

fibrous adhesions to the incision and/or that the incision on the peritoneal side showed signs of inflammation (as opposed to 10% of the fish tagged from the eyed side). For both treatments, the tags were oriented in the same direction in the body cavity (perpendicular to the body axis and angled slightly with the ventral end of the tag more anterior than the dorsal end of the tag) and they did not appear to have shifted from their initial position at insertion. We found that opaque, fibrous tissue had started to encapsulate the tags in 30% of the fish tagged from the blind side and 40% of the fish tagged from the eyed side. However, there was no indication that the fibrous capsule was attached to the digestive tract nor evidence of muscle necrosis in the peritoneal wall adjacent to the tags in any of the fish.

Discussion

We concluded that surgical implantation of transmitters into the peritoneal cavity is a viable option for long-term studies of flatfish movements. As reported by Lucas (1989), we found some encapsulation of the tag, but there was no indication that this would result in future tag expulsion. The tags were probably too large for trans-intestinal expulsion (as in Marty and Summerfelt, 1986), and we found no evidence of muscle necrosis adjacent to the tag (a precursor of expulsion across the body wall, Lucas, 1989). Moreover, all incisions were completely closed, and in many cases the scars were barely visible after one month. There is some possibility that tag expulsion may occur as the gonads in English sole develop. However, due to the position of the tag in the body cavity, we believe that the risk of transmitter expulsion will be minimal.

While nearly all fish lost weight during the course of our study, there was no evidence that feeding was impaired by the presence of the transmitter in the body cavity. Similar studies of relatively large transmitter implants (2.3-5.5% of body weight) in juvenile chinook salmon (*Oncorhynchus tshawytscha*) also indicated that feeding was not affected by surgical implantation of the tags, while gastric implants did affect feeding (Adams *et al*., 1998a). We found leftover food in the tanks as much as 2 days after feeding, indicating that the ration was not limiting. Yet, individual variation in food intake by the English sole was high. Many fish (both tagged and controls) did not feed at all, while others consumed food regularly. This may have resulted from the relatively short time fish were allowed to acclimate to captivity prior to tag implantation. McCain *et al*. (1978) noted that adult English sole held in captivity required over 3 months to start gaining weight. Nevertheless, in our experiment some of the fish that ate most readily and took the most bites were those bearing tags, indicating that the tag did not prevent sole from feeding to satiation.

Our results suggested that inserting tags from the eyed side is preferable to blind-side insertion. This is primarily due to the fact that the incisions on the blind side were more subject to friction and abrasion during fish movements, and this could be more of a problem when the blind side of fish is exposed to sediment. Exposure of the blind-side incision to sediment not only increases the chance of abrasion, incomplete incision closure, and resultant peritoneal inflammation, but also increases the chances of opportunistic bacterial and viral infection and associated negative sequelae. In the only other pilot study that has used surgical implants of acoustic transmitters in flatfish, insertion was done on the eyed side of sole (*Solea solea*) for the same reasons (M. Begout-Anras, CREMA, L'Hommeau, France, personal communication).

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