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Technical note

Feasibility of using pop-up satellite archival tags (PSATs) to monitor vertical movement of a *Sebastes*: A case study

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ABSTRACT

Pop-up satellite archival tags (PSATs) were deployed on eight blackspotted rockfish (*Sebastes melanostictus*) (37–54 cm fork length) caught in southeast Alaska at depths from 148 to 198 m. Six of these fish were tagged and released immediately after capture in a commercially available inverted, weighted crab ring, descended quickly to what was assumed to be the seafloor, and remained at that depth until the PSATs released early (after 12–14 days). The remaining two fish were held in a laboratory after capture, one for 8 months and one for 46 months, and were then released at the surface nearby the capture site. One of these two tags released after 12 days while the tag deployed on a 37 cm fish was retained for 190 days. Both fish moved to deeper depths initially and then moved back to more shallow depths, indicating that rockfish may require time to acclimate to increased pressure if the swim bladder is not currently ruptured. For the tag that was retained for 190 days, we identified six phases of vertical movement behavior. During the longest phase (122 days) the fish made rapid descents, sometimes in less than 15 min, which were deeper during the day and during high-tide, but more frequent at night. During some of the shorter phases (lasting from 8 to 28 days) the fish was more sedentary or was deeper at night. Our results show that it is possible to tag a deepwater rockfish with a PSAT.

1. Introduction

Pop-up satellite archival tags (PSATs) have been used extensively to monitor the movements of marine mammals, sea turtles, and large fish such as billfish, tuna, and sharks. These external archival tags can record data such as light levels (used to derive location), pressure (depth), and temperature. At a preprogrammed date, they detach from the animal, float to the surface, and when they arrive at the surface they transmit a subset of stored data via satellite, preventing the need to recapture the animal or recover the tag. However, if the tag is recovered, high resolution data can be obtained (data at 2 min intervals opposed to data that is transmitted via satellite at 15–30 min intervals). Recently, a significantly smaller tag has become available (Microwave Telemetry, Inc. X-tags[1]; 120 mm 32 mm diameter, 185 mm antennae; weight 40 g in air). This tag has been used on fish smaller than had been previously tagged in peer-reviewed literature, such as tropical Pacific eels (*Anguilla* spp.) (110–139 cm) (Schabetsberger et al., 2015), sablefish (*Anoplopoma fimbria*) (>84 cm) (Echave, 2016), Atlantic salmon (*Salmo salar*) (52–111 cm) (Lacroix 2013; Chittenden et al., 2013), striped bass (*Morone saxatilis*) (>93 cm) (Graves et al., 2008), Patagonian toothfish (*Dissostichus eleginoides*) (>127 cm) (Brown et al., 2013), and spiny dogfish (*Squalus acanthias*) (>67 cm) (Sulikowski et al., 2010; Carlson et al., 2014).

Rockfish (*Sebastes* spp.) are susceptible to barotrauma during capture due to trapped air expanding within the body cavity as they are brought to the surface. Although some fish appear to be severely injured or dead, there is evidence that fish can survive after recompression, but the survival rate is species specific, ranging from to 25% to 100% (Parker et al., 2006; Jarvis and Lowe 2008; Pribyl et al., 2012; Hochhalter 2012; Hannah et al., 2014). Movement and short-term survival of a few rockfish species have been observed in the wild using plastic anchor tags (Stanley et al., 1994; Hochhalter and Reed 2011) and acoustic transmitters (Pearcy 1992; Starr et al., 2001; Jorgensen et al., 2006; Mitamura et al., 2009; Hannah and Rankin 2011). Only one study has reported on movement of fish caught as deep as 200 m (Starr et al., 2001); however, these fish did not incur barotrauma because they were tagged underwater at depth by SCUBA divers. These types of tags have limitations because

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[1] Mention of trade names of commercial companies is for identification purposes only and does not imply endorsement by the National Marine Fisheries Service, NOAA.

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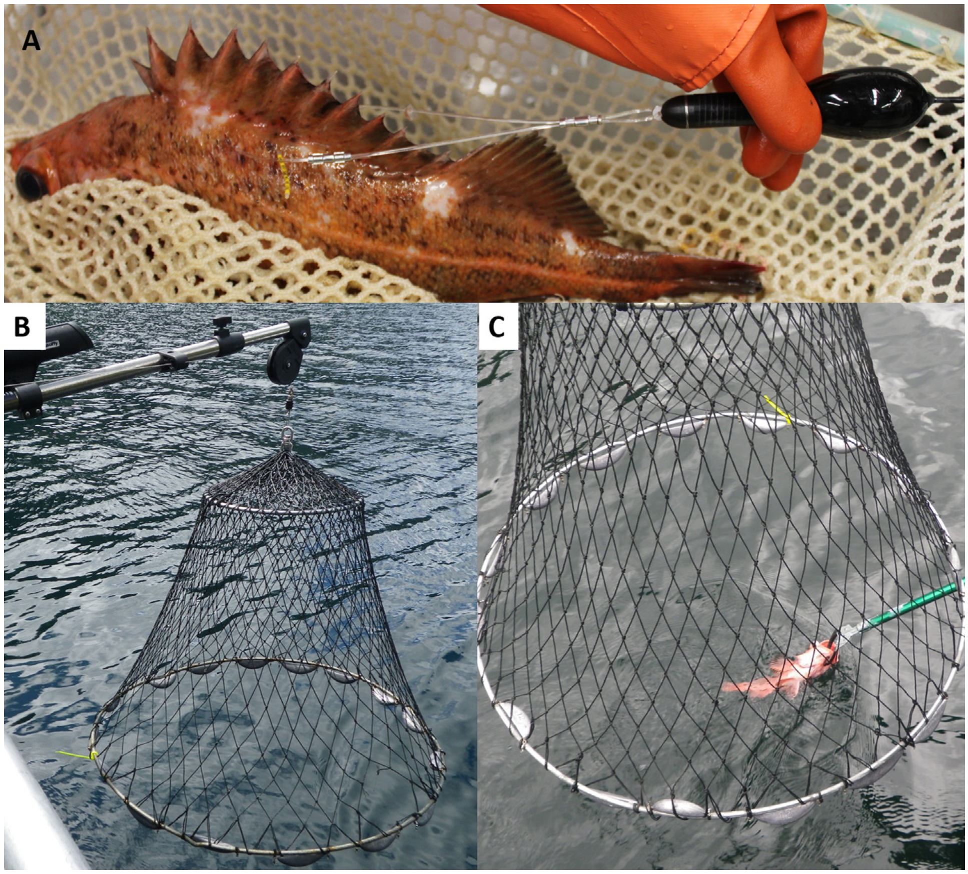

Fig. 1. (A) Pop-up archival satellite tag (PSAT) attached to a blackspotted rockfish (*Sebastes melanostictus*) by a loop of 250 lb monofilament line that was inserted through the musculature underneath the dorsal fin, and (B and C) an inverted, weighted crab ring that was used in combination with a downrigger (B) for releasing fish at depth.

either the fish have to be recaptured (plastic anchor tags) or the coverage of the animal is limited due to the detection range of receivers (acoustic tags).

PSATs have not been used on rockfish previously because the tags are costly, the survival of the animal cannot be easily predicted at capture, and fish are small relative to other species tagged with PSATs; for most Pacific rockfish the maximum length is <65 cm (Love et al., 2002). Very little is known about movement of deepwater rockfish, for which survival and behavior post-release has been minimally explored due to their susceptibility to injuries caused by abrupt changes in pressure. Data collected by PSATs can be used to improve knowledge of habitat requirements, movement, and, therefore, improve spatial resolution in rockfish stock assessments and aid in future management decisions. These data could also be used to link possible drivers of distribution changes related to climate change. As part of a larger study of post-barotrauma survival rates of a deepwater rockfish, our objectives were to (1) determine the feasibility of using PSATs on blackspotted rockfish, *Sebastes melanostictus*, and (2) describe the vertical movements of a deepwater rockfish.

2. Methods

In 2010, 2013, and 2014 eight blackspotted rockfish were collected in southeast Alaska on the southeastern side of Baranof Island in Port Herbert (56.44°N, 134.68°E) using bottom longline gear. This location was chosen because it is inshore, nearby a National Marine Fisheries Service field station, and fish were known to be present in this area (a deep fjord). All fish were measured to the nearest cm (fork length).

Fish were externally tagged with Microwave Telemetry, Inc. X-tags[2] (rated to a depth of 1296 m). The PSATs were attached by a loop of 250 lb (1.8 mm diameter) monofilament line that was inserted through the musculature underneath the dorsal fin using methods similar to those described by Lacroix (2013) and Echave (2016), which have proven successful when tagging Atlantic salmon and sablefish (Fig. 1). The monofilament loop was left large enough to not cause any pinching and so that the antennae would not be repeatedly hitting the fish's caudal fin during swimming.

Prior to tagging, the attachment method was tested by tagging a 54 cm blackspotted rockfish fish in the laboratory with a "dummy tag", one that is not functioning but is identical in size and buoyancy, for three months to ensure that the attachment method was successful. The puncture wound created during the procedure did not scar around the monofilament line, likely due to movement of the monofilament when the fish was active. This wound did not grow and the tag stayed attached to the fish. Like other blackspotted rockfish that were held in the laboratory, the fish was sedentary and was not positively buoyant. The tag did not become snagged on any of the cinder block structures in the tank during the trail. Because the tag stayed attached and did not form a larger wound, this method was used in the field project.

Tagged fish were either (1) released at depth using a weighted, commercially available crab ring (constructed of 36" diameter and 20" diameter rebar rings covered with stock polyethylene netting, which was inverted and weights were attached to the larger ring),

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