ELSEVIER

Journal of Experimental Marine Biology and Ecology 351 (2007) 243 – 254

Journal of EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY

www.elsevier.com/locate/jembe

Long-term effects and recovery from surgical implantation of dummy transmitters in two marine fishes

Mary C. Fabrizio *, Jeffrey P. Pessutti

NOAA-National Marine Fisheries Service, Northeast Fisheries Science Center, 74 Magruder Road, Highlands, NJ 07732 USA

Received 11 May 2006; received in revised form 1 February 2007; accepted 30 June 2007

Abstract

We surgically implanted black sea bass and summer flounder with dummy transmitters and monitored recovery, survival, and growth during an 11-month post-operative period. We also examined transmitter retention rates as neither species had been previously implanted with transmitters. Recovery time from surgery and anesthesia was significantly greater than recovery time from anesthesia alone for black sea bass, but this relation was not observed for summer flounder. Summer flounder recovery times were highly variable, but in general, smaller fish had longer recovery times. All black sea bass and summer flounder retained their surgically implanted transmitter at least 11 months and had high survival rates in laboratory trials (black sea bass survival, 97.9%; summer flounder survival, 94.6%). Nonparametric analyses of covariance using initial size as the covariate indicated that black sea bass exhibited no significant detrimental growth effects after 11 months, but significantly slower growth was observed for summer flounder (this was especially pronounced in the larger [>800 g] fish). Surgical implantation of acoustic transmitters in these species can be used to conduct long-term field studies of habitat use and movements because fish exhibited high survival rates and 100% retention of transmitters.

Keywords: Acoustic transmitters; Black sea bass; Clove oil; Growth; Summer flounder; Surgical implantation

1. Introduction

Monitoring the behavior of individual fish in the wild can enhance our understanding of fish-habitat relations. Such individualized information may be obtained from tagging studies with acoustic tags (i.e., transmitters) that permit simultaneous tracking of multiple fish. In the marine environment, ultrasonic tagging experiments have been used to study movements, habitat use, and home range of a variety of fish species (Hooge and Taggart, 1998; Arendt et al., 2001; Cote et al., 2003; Lowe et al., 2003; Parsons et al., 2003; Heupel et al., 2004).

In studies that track individuals over substantial periods of time, transmitter retention must be assured, and retention rates should be known prior to conducting experiments in the field. Transmitter expulsion occurs when fish encyst and eject transmitters implanted in the peritoneal cavity either through the incision, the abdominal body wall, or via the intestines (Summerfelt and Mosier, 1984; Chisholm and Hubert, 1985; Helm and Tyus, 1992; Baras and Westerloppe, 1999; Walsh et al., 2000; Lacroix et al., 2004; Gosset and Rives, 2005). In general, larger transmitters are associated with significantly increased transmitter expulsion rates (Marty and Summerfelt, 1986; Lacroix et al., 2004) and higher

* Corresponding author. Current address: Department of Fisheries Science, Virginia Institute of Marine Science, PO Box 1346, Gloucester Point, VA 23062 USA.

E-mail address: mfabrizio@vims.edu (M.C. Fabrizio).

0022-0981/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.jembe.2007.06.031

mortality rates (Lacroix et al., 2004). Winter (1996) recommended that transmitter weight should not exceed 2% of the fish's weight in air, but this commonly used guidance is not well supported by empirical data (Mulcahy, 2003; Zale et al., 2005). Appropriate transmitter size is best determined by considering the objectives of the study, the attachment or implantation method, and the species under study, as well as other factors (Jepsen et al., 2005). Transmitter retention rates can be improved by ensuring proper transmitter characteristics (weight, shape, volume, roughness), appropriate implantation methods, and proficiency of the surgeon. For compressiform fishes, transmitter shape may be an important determinant of retention rates. Although commercially available ultrasonic transmitters are cylindrical, flat elongated transmitters have been suggested for peritoneal implantation in laterally compressed fish (Jepsen et al., 2002). Because transmitter retention, mortality rates, and behavioral effects vary by species and with size of fish, such rates and effects must be determined experimentally prior to conducting ultrasonic tagging experiments in the field.

In this study, we examined the long-term effects and recovery from transmitter implantation in black sea bass *Centropristis striata* and summer flounder *Paralichthys dentatus.* We selected these species because we planned to conduct a field study of habitat associations of black sea bass and summer flounder in coastal waters using ultrasonic transmitters. Both species support commercial and recreational fisheries in the mid-Atlantic region and are locally abundant. Black sea bass and summer flounder are demersal species, but they differ in body shape: black sea bass exhibit a typical fusiform body, whereas summer flounder are compressiform fishes. Both species were to receive peritoneal implantation of transmitters involving anesthesia, surgery, and resuscitation.

We conducted a series of laboratory experiments to ascertain the effects of transmitter implantation and clove oil[1] anesthesia in black sea bass and summer flounder. We examined short-term recovery from surgical implantation as well as long-term growth and mortality, and long-term effects of clove oil anesthesia alone. To our knowledge, no studies have been published on the effects of clove oil anesthesia on black sea bass or summer flounder, and only three studies reported the results of clove oil as an anesthetic with strictly marine fishes (coral reef species, Munday and Wilson, 1997; intertidal rockpool fishes of Australia, Griffiths, 2000; black sea bass, King et al., 2005). Because surgical implantation may require that fish remain anesthetized (and therefore, exposed to the anesthetic) for periods greater than 5 min, and because fish exposed to clove oil for periods greater than 5 min may have higher mortality (Woody et al., 2002), we conducted overexposure trials with black sea bass and monitored long-term growth and mortality effects. Thus, our three treatment groups included: fish anesthetized with clove oil and surgically implanted with dummy transmitters, fish anesthetized with clove oil and exposed for varying lengths of time after full induction, and control fish which were neither exposed to clove oil nor surgically altered. The overexposure trials with black sea bass provided an indication of how much longer we could expose fish without incurring mortalities or prolonging recovery from anesthesia. In addition, we examined transmitter retention rates among the surgically altered fish, as neither species had been previously implanted with ultrasonic transmitters.

2. Field collections

Adult black sea bass were collected during May and June 2002 from fish traps deployed at 21-25 m and using hook and line techniques in 7–9 m waters off the coast of New Jersey. Most of the trap-captured fish had inflated swim bladders, and some exhibited stomach evulsion. We deflated swim bladders by puncturing the abdominal wall with a hollow needle and exerting gentle pressure on the abdominal area (Collins et al., 1999). Fish captured by hook and line did not exhibit decompression trauma because they were taken from shallower water. Fish that survived handling and transport to the laboratory (size range: 224–445 mm total length [TL] and 192–1044 g) were used in subsequent experiments.

We collected adult summer flounder (size range: 281–509 mm TL and 197–1618 g) from NJ coastal waters from June to August 2002 using hook and line techniques, and held fish in the laboratory for later work. In November 2002, we acquired 18 summer flounder (size range: 313–509 mm TL and 330–1318 g) from an aquaculture facility and transported the fish to the laboratory; hereafter these fish are referred to as the 'hatchery' fish. We began experimental trials on hatchery fish after all surviving hatchery fish ($N=17$) had begun feeding.

[1] Although clove oil is "generally recognized as safe" when used as a direct food additive, it is not approved for use as a fish anesthetic by the USDA Center for Veterinary Medicine (FDA, 2002). Nevertheless, researchers have experimented with clove oil as a fish anesthetic (e.g., Peake, 1998; Taylor and Roberts 1999; Schreer et al., 2001; Woody et al., 2002). Our laboratory work with clove oil was performed in anticipation of the availability of a zero-withdrawal fish anesthetic based on isoeugenol, an active compound in clove oil; such a product is currently under investigation and testing (Schnick, 2006).