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Short communication

Finding their way in the world: Using acoustic telemetry to evaluate relative movement patterns of hatchery-reared fish in the period following release

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ABSTRACT

Patterns in space use and activity were compared for wild and hatchery-reared Mulloway (*Argyrosomus japonicus*) using acoustic telemetry. Acoustic tags were implanted in four wild (42 ± 2 cm; mean ± SE), and four hatchery-reared (42 ± 1 cm; mean ± SE) Mulloway, and movements were simultaneously monitored for up to 288 h in an 11 km section of river. Across all fish, space utilisation contours developed from weighted kernel density estimates ranged between 2–51 ha (90% or total area) and 1–28 ha (50% or core area), and contained up to 99% optimal habitat area. Hatchery-reared fish used significantly larger total and core areas, and activity rates of hatchery-reared fish were consistently higher than wild fish. A period of settlement or acclimation appeared to occur during the first 5 days following release for hatchery-reared fish, and their movement tended to contract back to within the habitat patch into which they were released from the 6–12th day following release. The movement ranges of wild fish were largely invariant between the two periods. The relevance of this research to understanding broader ecological processes is discussed. Acoustic telemetry presents a useful approach for studying post-release dynamics of hatchery-reared fish and their wild counterparts.

1. Introduction

Fish stocking is a progressive management approach aimed at dealing with several fisheries issues, usually relating to increasing fisheries yield or restoring populations (Bell et al., 2005). Recent developments in the field have resulted in scientific and ecological approaches to both developing release strategies, and understanding the dynamics of released species (e.g. Smith et al., 2012). This modern approach to fish stock enhancement and sea ranching has led to a resurgence in interest in the practice, and widespread application in estuaries and coastal areas across the globe (Bell et al., 2008). This has in turn led to a large amount of ecological research into exploited species which has far-reaching benefits for our overall understanding of both species and ecosystem dynamics.

Acoustic telemetry is a useful technique for studying the movements and behaviour of a range of aquatic species (Hussey et al., 2015; Payne et al., 2014; Taylor and Ko, 2011). In recent years, acoustic tags have been used as a viable marking technique for the evaluation of stocking trials (Liao et al., 2003; Lino et al., 2009; Molony et al., 2003; Pursche et al., 2013; Pursche et al., 2014; Taylor et al., 2013), but their value in stocking programs goes far beyond this. Application of the technique also provides an opportunity to conduct comparative studies between stocked individuals and their wild counterparts, investigate behavioural responses in wild populations exposed to stocking, and monitor concomitant changes in fish density and competition. Of principal interest in the study of stock enhancement is the relative performance of hatchery-reared individuals post-release, and evaluation of the period of acclimation to wild conditions.

Mulloway, *Argyrosomus japonicus* (Sciaenidae), is a top-level predator in the coastal ecosystems of southern Australia, South Africa and China. This species uses estuaries as juveniles, and is thought to undertake coastal migrations as adults (West, 1992). Specifically, juveniles utilise deep-holes within the brackish regions of estuaries and reside almost exclusively within these habitats as they provide both predation refuge and preferred prey (Taylor et al., 2006a; Taylor et al., 2006b; Taylor et al., 2014). Mulloway have been stocked into New South Wales waters intermittently since 1997 primarily to enhance recreational fisheries

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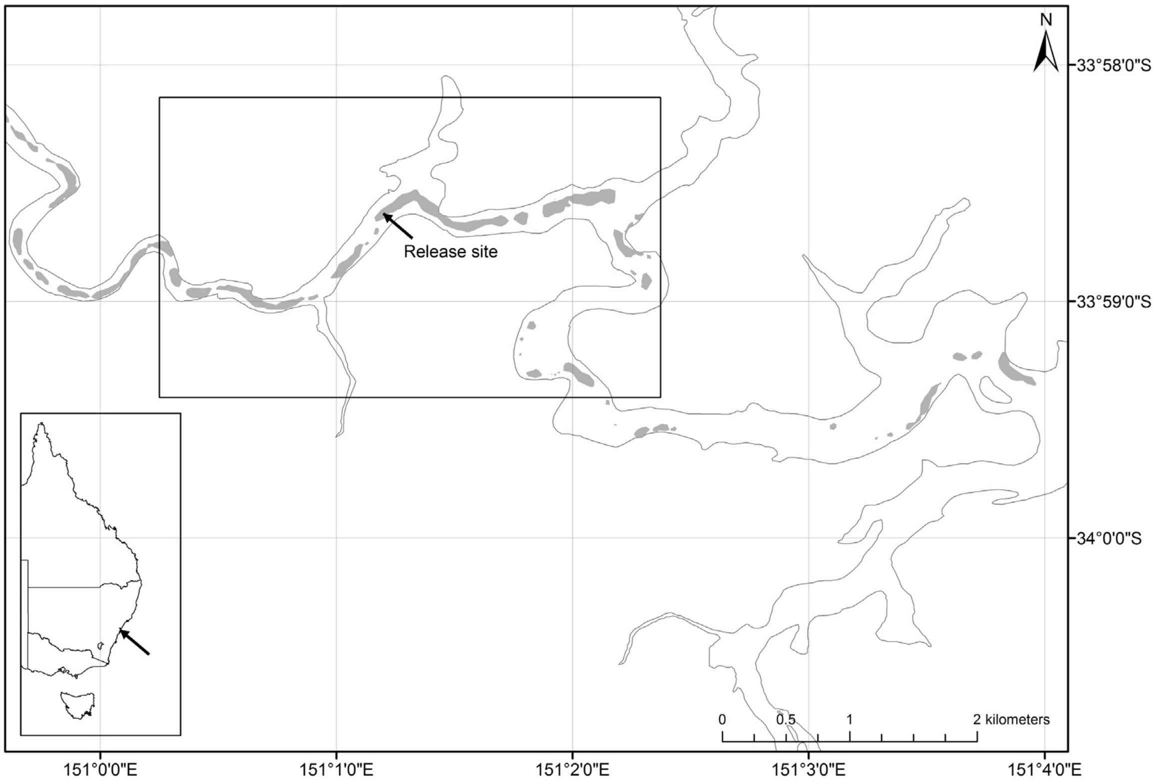

Fig. 1. Study area showing the entire tracking region, patches of juvenile Mulloway habitat (shaded light grey), and the site-of-release for both wild and hatchery-reared *A. japonicus*. The inset indicates the area of river that is presented in Fig. 3.

(Taylor and Piola, 2008) where there is a perceived recruitment limitation, but now several programs are expanding Mulloway stocking into other estuaries both in Australia and abroad (Kramer, 2009; Palmer, 2008; Stagles, 2011). This study reports a small-scale, comparative study aimed to further our knowledge of post-release behaviour and space use in a top-level predator (Mulloway, *Argyrosomus japonicus*), relative to behaviour of wild conspecifics monitored simultaneously.

2. Materials and methods

2.1. Study area and design

The Georges River is a riverine estuary located in the southern Sydney metropolitan area (33.976°S, 151.023°E), New South Wales, Australia (Fig. 1). The estuary has a catchment area of around 800 km^2 which discharges an average of $\approx 3.2 \times 10^8$ m^3 of water annually into Botany Bay (Bell and Edwards 1980). The study area included approximately 11 km of the river, although most fish activity was concentrated in the area surrounding the site of release (the tracking area is shown in its entirety in Fig. 1).

The study monitored the movements of hatchery-reared fish post-release, relative to wild fish, using acoustic telemetry. Wild fish were used as an indicator of normal wild Mulloway behaviour in the study estuary, against which to compare the behaviour of hatchery-reared fish post-release, and any changes in behaviour that occur. Both wild and hatchery-reared fish (4 per group) were tagged on the 16th November 2007. Wild fish (42 ± 2 cm; mean ± SE) were captured using a short (20 min) deployment of a 2.5 inch monofilament gill net, and the initial deployment yielded enough fish for tagging. Following capture, fish were briefly held in a makeshift boat-based flow-thru aquarium, before surgery to implant the tag (described below). Wild fish were released back into the water at the site of capture 0.5–1 h following surgery. Hatchery-reared juvenile Mulloway (42 ± 1 cm; mean ± SE) were tagged in captivity and allowed to recover from surgery for 7 days, before release into the wild on the 22nd November 2007, at the location where wild fish were tagged. Active tracking of both wild and hatchery-reared cohorts commenced on this day, meaning that both cohorts had 7 days to recover from surgery before data collection commenced. Tracking of both groups continued simultaneously for 12 days (24 h per day). A longer tracking period was not possible due to the limited battery life of the small tags.

2.2. Tagging and tracking of fish

Mulloway were tagged using conventional methods (Pursche et al., 2014; Taylor et al., 2013). Fish were immersed in an anaesthetic bath containing 60 mg L^{-1} of AQUI-S® in seawater, and a 1.5 cm incision was made in the anterior to posterior direction ≈0.5–1 cm above the ventral midline. A Sonotronics IBT-96-1 tag was inserted (25 mm length, 8 mm diameter, 1.5 g, 21 d battery life; Table 1), and the wound was closed with two dissolving sutures. Fish were handled and released as described in 2.1.

A manual or active tracking approach was employed in this study to give positions of tagged fish at a high spatial resolution. Fish were continually searched for using a boat-based Sonotronics USR-96 ultrasonic receiver and DH-4 hydrophone. Where a signal was located, an individual fish could be identified through interpretation of an audible code (these codes are presented in Table 1). The minimum transmitter range was 324 ± 12 m (mean ± SE) and repeated tracking studies have shown the location error to be 4.8 ± 0.7 m (mean ± SE, Taylor et al., 2006b). The tracking area (Fig. 1) was continually monitored for signals by repeatedly travelling along the river, scanning all relevant frequencies for signals. Each time a fish was located, a GPS waypoint, time and depth were recorded.

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