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An improved technique for estimating short-term survival of released line-caught fish, and an application comparing barotrauma-relief methods in red emperor (*Lutjanus sebae* Cuvier 1816)

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ABSTRACT

Promotion of better procedures for releasing undersize fish, advocacy of catch-and-release angling, and changing minimum legal sizes are increasingly being used as tools for sustainable management of fish stocks. However without knowing the proportion of released fish that survive, the conservation value of any of these measures is uncertain. We developed a floating vertical enclosure to estimate short-term survival of released line-caught tropical and subtropical reef-associated species, and used it to compare the effectiveness of two barotrauma-relief procedures (venting and shotline releasing) on red emperor (*Lutjanus sebae*). Barotrauma signs varied with capture depth, but not with the size of the fish. Fish from the greatest depths (40–52 m) exhibited extreme signs less frequently than did those from intermediate depths (30–40 m), possibly as a result of swim bladder gas being vented externally through a rupture in the body wall. All but two fish survived the experiment, and as neither release technique significantly improved short-term survival of the red emperor over non-treatment we see little benefit in promoting either venting or shotline releasing for this comparatively resilient species. Floating vertical enclosures can improve short-term post-release mortality estimates as they overcome many problems encountered when constraining fish in submerged cages.

1. Introduction

Fish caught by hook and line may sustain injury from poor handling practices (Diodati and Richards, 1996; Meka, 2004; Bartholomew and Bohnsack, 2005; Grixti et al., 2007), hook damage (Muoneke and Childress, 1994; Cooke et al., 2003) or the effects of pressure reduction as they are brought to the surface (Feathers and Knable, 1983; Rummer and Bennett, 2005; Rogers et al., 2008). These injuries may lead to reduced physiological fitness or reproductive potential, or in extreme cases to acute or delayed mortality.

The signs and effects of capture depth on pressure-related injury or barotrauma in fish have been well documented (e.g. Bruesewitz et al., 1993; St John and Syers, 2005; Gravel and Cooke, 2008; Hannah et al., 2008). One consistent and obvious external sign of barotrauma is an enlargement of the body cavity due to distension of the swim bladder, causing the fish to become positively buoyant and experience difficulty in submerging when released, thus increasing its vulnerability to near-surface predators (Collins, 1991; Bruesewitz et al., 1993). Signs of more serious barotrauma include gut eversion, with part of the alimentary canal protruding from the mouth, vent or gill cavity; exophthalmia (bulging eyes); and external haemorrhaging around the vent. These visible signs constitute part of an extensive suite of external and internal symptoms described by Rummer and Bennett (2005).

Two principal methods of relieving the effects of barotrauma – venting and shotline releasing – are presently used by anglers. Recommended for some years by the angling industry in the U.S. (Florida Sea Grant, 2005) and more recently in Australia by the national Recfishing Research programme[2], venting involves deflating the distended swim bladder by puncturing the body wall with a hollow needle. The less-publicised shotline or release-weight releasing method involves compressing the swim bladder to its original

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volume by forcing the fish back down to its capture depth. This is achieved by attaching the fish to a barbless hook embedded in a lead weight, lowering it to its capture depth where it is assumed to become neutrally buoyant, then releasing it by jerking the line (Bartholomew and Bohnsack, 2005).

Studies examining the effectiveness of venting as a barotrauma-mitigation procedure have yielded inconsistent results. Venting improved the survival rate of released black sea bass and vermilion snapper (Collins et al., 1999), groupers (Wilson and Burns, 1996) and yellow perch (Keniry et al., 1996), but had no positive effect on the survival of rockfish (Gotshall, 1964), burbot (Bruesewitz et al., 1993), or red snapper (Render and Wilson, 1994). A meta-analysis of 17 published and unpublished studies concluded that venting may actually be detrimental as a conservation measure (Wilde, 2009). The release-weight technique has been promoted by some agencies as a preferred alternative to venting, but its effectiveness for mitigating the effects of barotrauma has yet to be formally evaluated (Bartholomew and Bohnsack, 2005).

Enclosed submerged cages have often been used in studies of short-term post-release survival of barotrauma-affected fish (Collins, 1991; Wilson and Burns, 1996; Collins et al., 1999; St John and Syers, 2005; Jarvis and Lowe, 2008; Stewart, 2008). However in experiments testing the effects of barotrauma remediation procedures, submerged cages are inappropriate, as they do not provide for untreated controls — *i.e.* fish that have received no other remediation treatment. Forcing non-vented fish to the bottom in a cage does not constitute 'non-treatment', but is itself a treatment which partially approximates the shotline release, an issue recognised by St John and Syers (2005). The cage option is also a poor simulation of reality in that it fails to reflect the sequence of events typically experienced by fish released after being caught and brought to the surface. Untreated release occurs frequently in reality, and may result in bloated fish either recovering to the extent that they are able to swim down to equilibrium depth, or alternatively being preyed upon by one of a number of potential predators (Keniry et al., 1996). Submerged cages do not allow these possibilities to be examined, even qualitatively (Pollock and Pine, 2007). This was recognised by Hannah et al. (2008), who used bottomless floating enclosures to examine the effect of size and capture depth on the ability of rockfish to resubmerge after capture. Once a fish is caught and vented (or not, according to the experimental design) it should be released as soon as practicable to avoid exposure to unduly long and variable surface intervals (*i.e.* the time between capture and release). When the time between successive captures exceeds 10–15 min, it is not possible to place more than a few fish in a cage without seriously extending the surface interval.

As submerged cages cannot be used to test the relative effectiveness of the two release methods, we designed a vertical enclosure to contain the treated fish. The advantages of this system are that (a) it allows untreated controls to be included in the experimental design (*i.e.* the apparatus itself does not constitute a treatment, as it does in the case of the cages); (b) it provides an environment into which fish can be released with the aid of a shotline or release weight; (c) it provides some insights into the situation where a released fish may drift on the surface after release, during which time (in its natural environment) it could be at risk of predatory mortality; (d) it can reduce the surface interval by allowing marked fish to be introduced into the apparatus at any time; and (e) it improves the efficiency of the experiment by enabling more fish (up to 30 or 40) to be held in the apparatus at any given time.

Henry and Lyle (2003) estimated that about half of the Australian recreational catch of line-caught fish (by number) is discarded or released. The application of increasingly stringent minimum legal size (MLS) and bag limits as management mechanisms for maintaining effective spawning stock sizes and limiting catches is likely to increase the releasing rate in many of these fisheries. For example, the change in MLS for red emperor (*Lutjanus sebae*) from 45 to 55 cm in 2003 (Sumpton et al., 2008) resulted in an increase in the discarding rate of this species in both the commercial and recreational sectors. Recreational releasing of red emperor increased from 69% in 2002 to 83% in 2005, and the retained catch dropped correspondingly from 393 t to 232 t over the same period (Coastal Habitat Resources Information System, Department of Employment, Economic Development and Innovation). Commercial landings of red emperor in Queensland also decreased from annual averages of 163 t over the four year period 2000–2003 to 37 t over the four years from 2004 to 2007 (Commercial Fisheries Catch and Effort Database, DEEDI). Such high levels of releasing have raised concerns about the extent of associated cryptic post-release mortality, a potentially important but unquantified component of fishing mortality.

In this study we first evaluated the vertical enclosures by comparing the survival rates of red emperor held in submerged cages and enclosures. We investigated whether fish could equilibrate at a shallower depth than that from which they were caught, as (from Boyle's Law) the effects of pressure differences on swim bladder volume are proportionately greater in shallower than deeper water. We then used the vertical enclosures to test the effectiveness of two barotrauma-relief procedures (venting and shotline releasing) on the short-term survival of this popular angling species.

2. Materials and methods

2.1. Experimental site selection

An area north of Double Island Point, Queensland, Australia (25° 55′S, 153° 11′E; Fig. 1) was chosen as the main site of this experiment because of its proximity to reefs supporting populations of red emperor. Additional data on a small number of red emperor were collected from a site off the north-east corner of Heron Island Reef (23° 25′S, 151° 59′E; Fig. 1) during subsequent survival experiments on other reef fish species.

2.2. Apparatus design

Cages were slightly larger than those used successfully by St John and Syers (2005), and of similar design to the collapsible pots used in the Queensland blue swimmer crab fishery (Campbell and Sumpton, 2008). They consisted of two 1 m diameter metal hoops separated by four 350 mm high tubular PVC risers and were covered with either 50 mm × 36 ply orange nylon mesh or 25 mm × 9 ply blue nylon mesh. Fish were placed into the cage via a drawstring-constrained opening in the upper surface. Cages were deployed in strings of four. The first cage was suspended (at 15 or 30 m depth) from a surface float which was moored by a 10 kg anchor on 60 m of rope, and trailed a dan-buoy with radar reflector, flag and night-light. The second cage, with its own surface float, was attached to the first cage's float line via a 15 m line with a stainless steel clip-ring which slid down the first float line to the top of the first cage. This arrangement allowed each successive cage to be deployed and retrieved with minimal disturbance to the previous one.

Vertical enclosures were cylinders 1.9 m in diameter and 15 m in depth. Eight horizontal steel hoops were separated by 2.5 m of 101 mm × 36 ply brown mesh, except for the top two hoops which were held 0.5 m apart by solid welded rods (Fig. 2). Four inflatable plastic floats were attached to the inside of the second metal ring to give the apparatus positive buoyancy at the surface. The eighth (bottom) ring was 15 m below the surface and weighted with three 13 kg lead blocks to keep the net vertical in a current. A 20 m × 12 mm retrieval rope was connected to a 1.2 m 4-arm 'spider' chain, which was in turn attached to the seventh spacer ring 2.5 m from the bottom of the apparatus. The retrieval rope was held centrally inside the top ring by a 50 mm stainless steel locating ring. On retrieval by crane, the apparatus collapsed in concertina-fashion except for the bottom-most compartment holding the fish, which could then be released from the cod end of the enclosure. Each enclosure was moored by two in-line