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Effects of codend circumference and twine diameter on selection in south-eastern Australian fish trawls

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ABSTRACT

Two experiments, done in a south-eastern Australian trawl fishery targeting school whiting (*Sillago flindersi*: Sillaginidae), examined the relative efficiencies and selectivities of five codends and extension sections made from double-twine, 90-mm (inside stretched length) mesh netting. All extension sections were made from 3-mm diameter twine and were 100 meshes long and 100 meshes in circumference, while the codends were 25 meshes in length. The first experiment tested three codends made from 4-mm diameter twine: one with a circumference of 100 meshes and two of 200-mesh circumference, with one of the latter incorporating two cross-sectional joins in its extension piece. The second experiment compared two 200-mesh circumference codends, one constructed from 3-mm diameter twine and the other from 5-mm diameter twine. The codends were alternately fished with a small-meshed control. The results showed a general trend of reduced selection by the 200-mesh circumference and thicker twined codends, and especially by the industry-preferred 200-mesh circumference codend constructed from 5-mm diameter twine. Experiment 1 found that the 100-mesh codend caught significantly fewer school whiting, retained catch and total catch than did the two 200-mesh codends, and the 200-mesh codend with the modified extension section caught significantly fewer school whiting and retained catch than did the 200-mesh codend with the straight extension. In the second experiment, the 200-mesh 5-mm twine codend caught significantly more total and retained catch, school whiting, and longspine flathead (*Platycephalus longispinis*: Platycephalidae) than did the 200-mesh 3-mm twine codend. Across all codends, the smallest lengths at 50% probability of retention (L_{50}) were estimated for longspine flathead, redfish (*Centroberyx affinis*: Berycidae) and longfin gurnard (*Lepidotrigla argus*: Triglidae) in the 5-mm 200-mesh codend. The limited size range of school whiting resulted in unreliable estimation of selectivity in the 200-mesh 5-mm twine codend, but this design was the only one that retained a substantial proportion of individuals below the minimum marketable length (15 cm fork length). While the 200-mesh 5-mm twine codend retained commercial quantities of school whiting, it seems far from optimal. It is suggested that a more efficient design comprising possibly smaller, square-shaped meshes should be developed and used in conjunction with temporal, spatial and catch restrictions.

1. Introduction

To achieve the effective management and sustainability of a trawl fishery, it is important for the gear to have selectivity characteristics that optimise the harvest size of marketable species while allowing unwanted bycatch to escape. Historically, the selectivity of trawls has been controlled by prescribing minimum (and/or maximum) mesh sizes (MacLennan, 1992). While it is accepted that most selectivity occurs in the codend, it is now recognised that, in addition to mesh size, other gear design factors can affect codend selectivity. Several studies have demonstrated that increasing the diameter of codend twine decreases the selectivity (e.g. Lowry and Robertson, 1996; Herrmann and O'Neill, 2006; Sala et al., 2007), while others have quantified the changes to selectivity through altering the codend circumference in relation to the section to which it is anteriorly joined (e.g. Robertson and Ferro, 1988; Reeves et al., 1992; Broadhurst and Kennelly, 1996; Lök et al., 1997; Broadhurst et al., 2006b).

In recent years, a number of such modifications have been incorporated into the nets towed by central New South Wales (NSW) fish trawlers. These vessels are 15–24 m in length, powered by 135–450 kW main engines and tow single otter trawls with headline lengths of between 25 and 45 m; sweeps and bridles are approximately 200 m in length and most use steel vee-shaped

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otter boards. Generally, the wings and body of the trawls are constructed from light-weight netting (stretched mesh size between 90 and 110 mm) joined to an extension (100 meshes in length or normal direction—N, and 100 meshes in circumference or transverse direction—T) constructed from 3 to 4 mm diameter twine, and a codend (33 N × 100 T) made from 3 to 6 mm diameter double-twine. The size of netting in the extension and codend is 90 mm (minimum legal size). This generic trawl configuration has been used over the past 25 years to target many species of fish in depths between 25 and 600 m.

In recent years, declining catch rates of many key species on the primary offshore grounds (100–500 m) have resulted in central NSW fish trawlers directing more effort inshore where the main target has been eastern school whiting (*Sillago flindersi*: Sillaginidae) (hereon referred to as school whiting), a relatively small species mostly harvested in NSW by prawn trawlers. Because of their small size (maximum ∼28 cm fork length (FL)) and slender shape, very few school whiting are retained in conventionally rigged fish trawls with 90-mm mesh codends and so fishers have experimented with trawl arrangements to lower selectivity while still complying with the minimum allowable mesh size. A common modification is to reduce the lateral mesh openings in the codend by maximising the twine diameter and doubling the circumference to 200 meshes.

Annual landings of school whiting by central NSW fish trawlers now total more than 400 t, suggesting that such modifications have dramatically lowered overall trawl selectivity. However, no quantitative data were available so, to address this lack of information, we chartered a commercial fish trawler to assess the effects of different (i) circumferences and (ii) twine diameters on the selectivity attributes and lateral openings of 90-mm mesh codends while targeting school whiting on NSW inshore grounds.

2. Materials and methods

The objectives were addressed during two experiments done off the NSW coast between March 2005 and June 2006 with the chartered trawler towing a standard single-rigged trawl constructed from 100-mm polyethylene (PE) mesh in the wings, and 90-mm mesh in the remainder. The trawl had a general plan similar to that described by Broadhurst and Kennelly (1995), with a headline length of 33 m attached to 195 m sweeps and bridles, and 2.0 m vee-shaped boards. All hauls were for 90 min at night in depths between 40 and 80 m at between 1.4 and 1.7 m s^{-1} (2.8–3.3 knots).

2.1. Codends

A control and five treatment codend and extension sections were constructed for use with the trawl (Fig. 1). All codends and their extensions were made from dark PE netting, and were, respectively, about 2.8 and 11.0 m in length. The five treatment extensions and codends were constructed throughout from double-braided twine, 90-mm (nominal) netting made by the same manufacturer (i.e. the netting was of the same twine-type and colour, and varied only in nominal twine-diameter). All extensions were made from 3-mm diameter (Ø) twine and were 99 N × 100 T (Fig. 1a–e). The first treatment (termed 4 mm100) had a codend (4-mm Ø twine) measuring 25 N × 100 T that was joined at a ratio of 1:1 to its extension (Fig. 1a). The other four treatments (termed 4 mm200×, 4 mm200, 3 mm200, and 5 mm200) had 25 N × 200 T codends that were joined at a ratio of 2:1 to their extensions (Fig. 1b–e). The 4 mm200× codend was identical to the 4 mm200 codend, but its extension included two additional joins (at 33 and 66 N from the end), designed to restrict lateral mesh openings (Fig. 1b). The 3 mm200, 4 mm200, and 5 mm200 treatments were identical, except for different twine diameters in the codend (3, 4 and 5 mm, respectively) (Fig. 1c–e). The control consisted of a 239 N × 225 T extension made from 43-mm mesh (2-mm Ø braided twine), attached to a 61 N × 450 T codend made from 40-mm mesh (3-mm Ø twisted twine) (Fig. 1f). The control had the same fishing circumference and joining ratio as the four 200 T codends.

2.2. Experiment 1: effects of codend circumference

Experiment 1 was done over 27 nights between March and November 2005 (in depths between 42 and 79 m) using the 4 mm100, 4 mm200× and 4 mm200 treatments and control

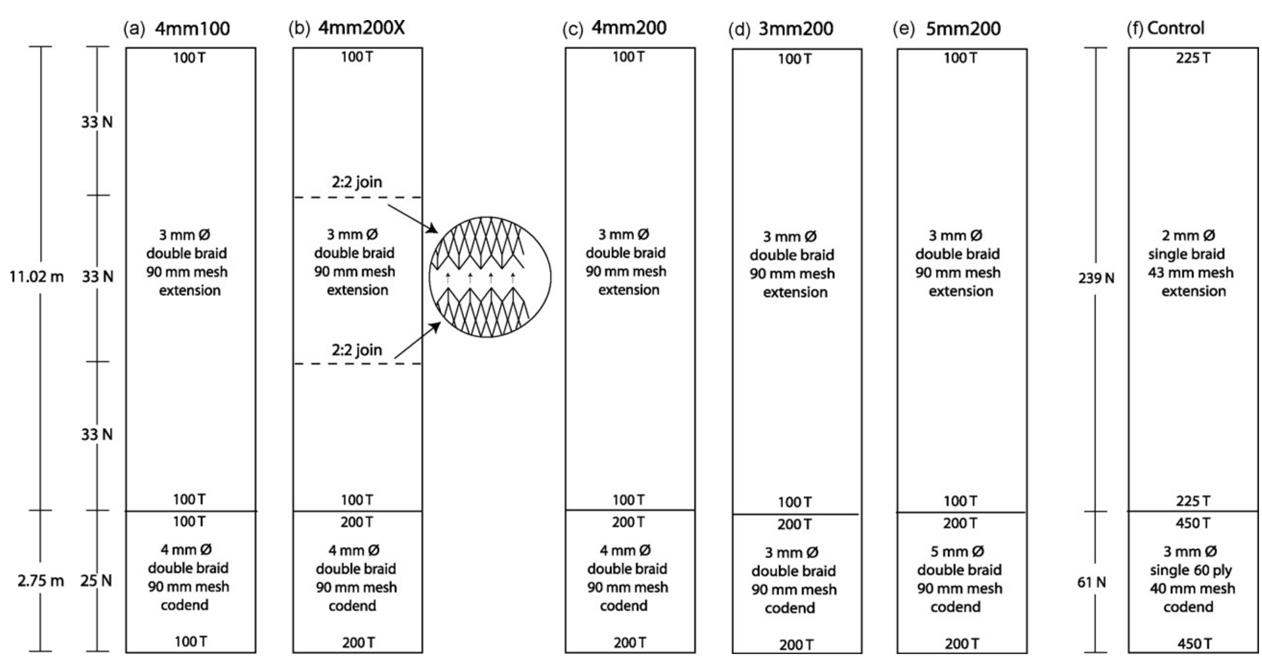

Fig. 1. Plans of the (a) 4 mm100, (b) 4 mm200×, (c) 4 mm200, (d) 3 mm200, (e) 5 mm200 treatment extension and codend arrangements, and (f) control extension and codend.