Assessment of a 35-mm square-mesh codend and composite square-mesh panel configuration in the ocean prawn-trawl fishery of northern New South Wales

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EXECUTIVE SUMMARY

Ocean prawn trawling for eastern king prawns is a significant industry in the coastal waters of northern New South Wales (NSW). The annual total catch of retained product (including prawns and other byproduct) in the Ocean Prawn Trawl (OPT) fishery is estimated to be worth approximately $A32 million. Around 58% of NSW OPT operators are based at ports north from Crowdy Head and trawl within the NRCMA marine region.

Ocean prawn trawlers primarily target eastern king prawn (*Melicertis plebejus*) and two species of whiting: eastern school (*Sillago flindersi*) and stout whiting (*S. robusta*) at depths of > 40 m. The catches of target-size whiting are usually combined and marketed as ‘school whiting’. At times, school prawn (*Metapenaeus macleayi*) is also targeted on shallower trawl grounds adjacent to the river mouths. The trawlers also retain a range of organisms other than the targeted species as marketable ‘byproduct’, including various species of flathead (*Platycephalus* spp.), octopus (*Octopus* spp.), squid (*Loligo* spp.), cuttlefish (*Sepia* spp.) and bugs (*Ibacus* spp.).

Along with retained individuals of the targeted and byproduct species, the trawlers also incidentally catch a wide range of other unwanted organisms that are subsequently discarded, collectively termed ‘bycatch’. This bycatch comprises many demersal species of no commercial interest, along with individuals of the targeted and byproduct species too small for sale.

Concerns over bycatch has, during the past couple of decades, led to a suite of research studies done by NSW Department of Primary Industries (DPI) to address the problem by examining modifications to ocean prawn trawls and trawling operations designed to reduce the capture of unwanted organisms. Research done during the 1990s ultimately resulted in legislation in 1999 to mandate the use of a range of bycatch reduction devices (BRDs) in NSW trawl fisheries designed to facilitate the escape of small whiting and other finfish. For example, the most effective square-mesh panel design developed for the OPT fishery was a ‘composite square-mesh panel’ (CSMP), which reduced bycatch by between 23.5 and 41% (by weight), without reductions in marketable catch. This and other similar square-mesh panel designs are currently in use throughout the fishery.

More recently, the capture of small, juvenile prawns and fishes in trawls and other prawn gears used in NSW has been the focus of research, owing to the potential for mortalities of juveniles of some of theses species to have a detrimental effect on yields from these stocks. Research during the 2000s has developed a gear modification – a ‘square-mesh codend’ (see below) – that was demonstrated via controlled experiments onboard selected OPT trawlers to effectively address this issue.

The diamond-mesh codends (i.e., the bag at the back of a trawl in which the catch accumulates) that are conventionally used in the OPT fishery were demonstrated to provide insufficient escapement of small prawns and fish. If codend mesh is re-oriented so that it is square-shaped (i.e., ‘hung on the bar’) throughout, the mesh openings in the codend will all be wider and of a consistent shape. Such a codend, made from 35-mm square mesh, was demonstrated to reduce the capture of small prawns and fish (compared with conventional diamond-mesh codends) without significant losses of target-size individuals of marketable species.

One of the main criticisms of this research from NSW OPT industry representatives has been that it is not representative of the entire fishery owing to the small number of vessels, short time-frames and rigid experimental protocols involved. Although these financial and scientific constraints are necessities with respect to the valid development of bycatch-mitigating technologies, it proposed that larger-scale trials with a 35-mm square-mesh codend in the OPT fishery would be a useful, complementary approach to address industry concerns.

In 2006/07, NSW DPI and the Northern Rivers Catchment Management Authority (NRCMA) formally collaborated to fund and implement a program to construct and distribute (free of charge) 35-mm square-mesh ('35S') codends (of a fixed design that included a CSMP) to north coast OPT operators on a conditional, voluntary basis. A total of 20 trawl operators accepted the offer, with codends distributed to most of those operators by November 2007. These trials provided an opportunity for NSW DPI researchers to collect detailed, observer-type catch data to assess the performance of the 35S codend across a relatively large subset of the north coast OPT fleet, under commercial fishing conditions. In 2007/08, NSW DPI and NRCMA funded a research project to realise that opportunity, culminating in this research report.

Given the above, the main objective of this research was to collect detailed catch and operational data to enable a comprehensive assessment of the performance of the 35S codend relative to that of the diamond-mesh codends currently in use throughout the fleet. Secondary catch comparisons involving the 35S codend and any codend design other than those allowed under the NSW DPI regulations were made where the opportunity arose, providing the alternative design was being used under an appropriate permit. The secondary objectives of this study were first to record data pertaining to any interactions with: 1) threatened and protected species; 2) elasmobranch (shark and ray) species; and 3) any other species of particular interest; and second, to record data identifying the location and depth of trawl grounds visited during sampled trips.

The most appropriate experimental approach to achieve the stated objectives associated with this study involves paired comparisons. The triple-gear trawl configuration used by NSW ocean prawn-trawlers allowed concurrent, parallel towing of the 35S and another codend. This configuration, in theory, eliminates, or at least minimises, the effects of factors other than differences between the two codends being towed (e.g., spatial and temporal variability in the faunal composition on trawl grounds; or operational differences among trawlers or different tows). With appropriate replication, this provides a scientifically rigorous paired comparison between the two codend types. A total of 36 sampling trips, each done onboard one of nine trawlers primarily targeting either eastern king prawns, whiting or school prawns were observed to collect catch data pertaining to these paired comparisons.

When compared with conventional diamond-mesh codends used to target eastern king prawns (or trawl whiting), the prescribed 35S codend design significantly reduced the numbers of small, discard-size prawns and/or whiting caught (by averages of up to approximately 43 and 91% respectively, depending on the conventional codend design) without significantly reducing the quantities of targeted catch and retained byproduct. Significant reductions in the discarding of non-retained bycatch species (by averages of up to 99%) were also evident. There was, however, variability in the performance of the 35S codend among vessels, with strong evidence to suggest that in the cases of some target-size animals were escaping via the composite square-mesh panel BRD. Such losses of marketable product via the BRD would probably be prevented in the case of a 35-mm square-mesh codend with a sufficiently greater circumference than the 35S codend assessed here. It is therefore recommended that such a further-modified codend be considered for mandatory use by OPT vessels targeting eastern king prawn and trawl whiting.

Although the 35S codend was very successful with respect to reducing the bycatch of the small, juvenile whiting and flathead that inhabit the school prawn trawl grounds, it also facilitated the escape of unacceptable quantities of target-size school prawns through its meshes. Such losses would probably be avoided in the case of a square-mesh codend with a sufficiently smaller mesh size (e.g., approximately 29 mm) and greater circumference (see previous point) than the 35S codend assessed here. It is therefore recommended that a square-mesh codend made from 29-mm mesh be considered for mandatory use by OPT vessels targeting school prawn.

There were few interactions with threatened and/or protected marine species (and none with marine reptiles, mammals and birds) during the ocean prawn trawl trips sampled. Therefore, this limited study provided no evidence to indicate that ocean prawn trawling is a particularly threatening activity (compared with other commercial and recreational fishing activities) with respect to such interactions in northern NSW waters. Similarly, there were few instances of interactions with non-target species of major commercial and/or recreational importance, such as snapper and mulloway, during the sampled trips.

In conclusion, this study served to: 1) validate the results of the initial research conducted to develop a 35-mm square-mesh codend (within the range of catch quantities encountered); 2) involve a greater proportion of the OPT fishers (overall) in the formal development and assessment process; and 3) provide additional insights for fisheries managers and industry regarding successful implementation of a 35-mm square-mesh codend in the OPT fishery. It is recommended that similar assessments be done prior to formal legislation of gear-based bycatch-mitigation strategies in other NSW fisheries. It is also recommended that a full-scale observer-based sampling program, spanning the entire coast and several years, be completed in the NSW OPT fishery once the appropriate square-mesh codends are made mandatory, to estimate the impacts on catches and bycatches in the fishery.

1. INTRODUCTION

1.1. The NSW Ocean Prawn Trawl (OPT) fishery

In New South Wales (NSW), Australia, demersal otter trawling for penaeid prawns is permitted in certain rivers and bays north of Sydney (Estuary Prawn Trawl – EPT – fishery) and continental shelf and oceanic waters (Ocean Prawn Trawl – OPT – fishery), with OPT activities north of Sydney permitted out to the 4,000-m depth contour (NSW DPI, 2007). The annual total retained catch in the OPT fishery is estimated to be approximately 3,400 tonnes and worth approximately $A32 million (Kennelly *et al.*, 1998; Broadhurst *et al.*, 2006a). There is a total of approximately 240 licensed fishing businesses in the OPT fishery, with the majority (i.e., over 60%) based in ports north from Crowdy Head and therefore working within the latitudinal boundaries of the Northern Rivers Catchment Management Authority (NRCMA) region (Figure 1).

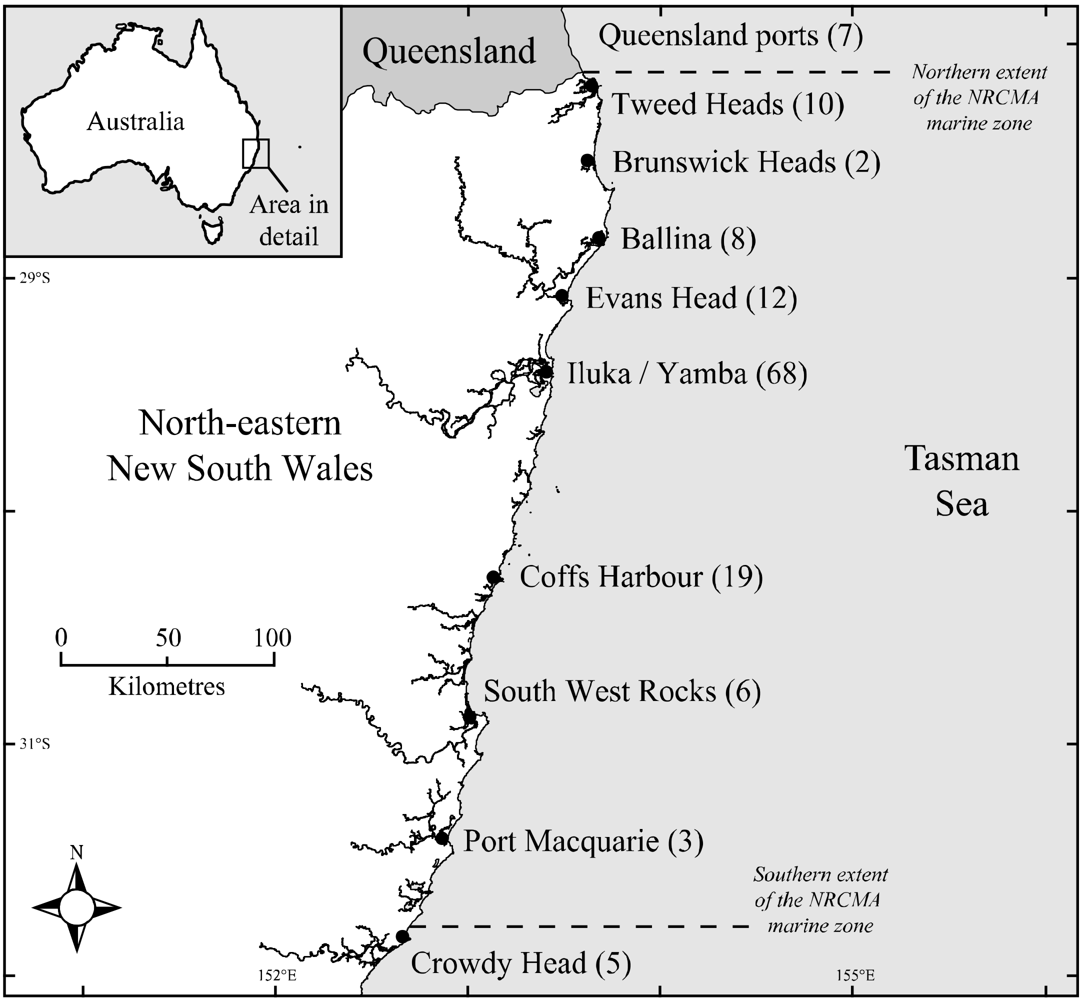

Figure 1. Map of the northern NSW coast showing the latitudinal boundaries of the marine zone of the NRCMA region and the home ports of the resident ocean prawn-trawl fleet. The figure in parentheses for each port is the number of OPT fishing businesses that list that port as their home port.

The vessels used in the OPT fishery range in size between 9 and approximately 20 m in length (Figure 2A and B), and are subject to various management regulations to control fishing capacity (NSW DPI, 2007, 2008). Triple-rigged demersal otter trawls (Figure 2C and D; refer to Andrew *et al.*, 1991, for further details) are used at night or during the day, depending on the species targeted.

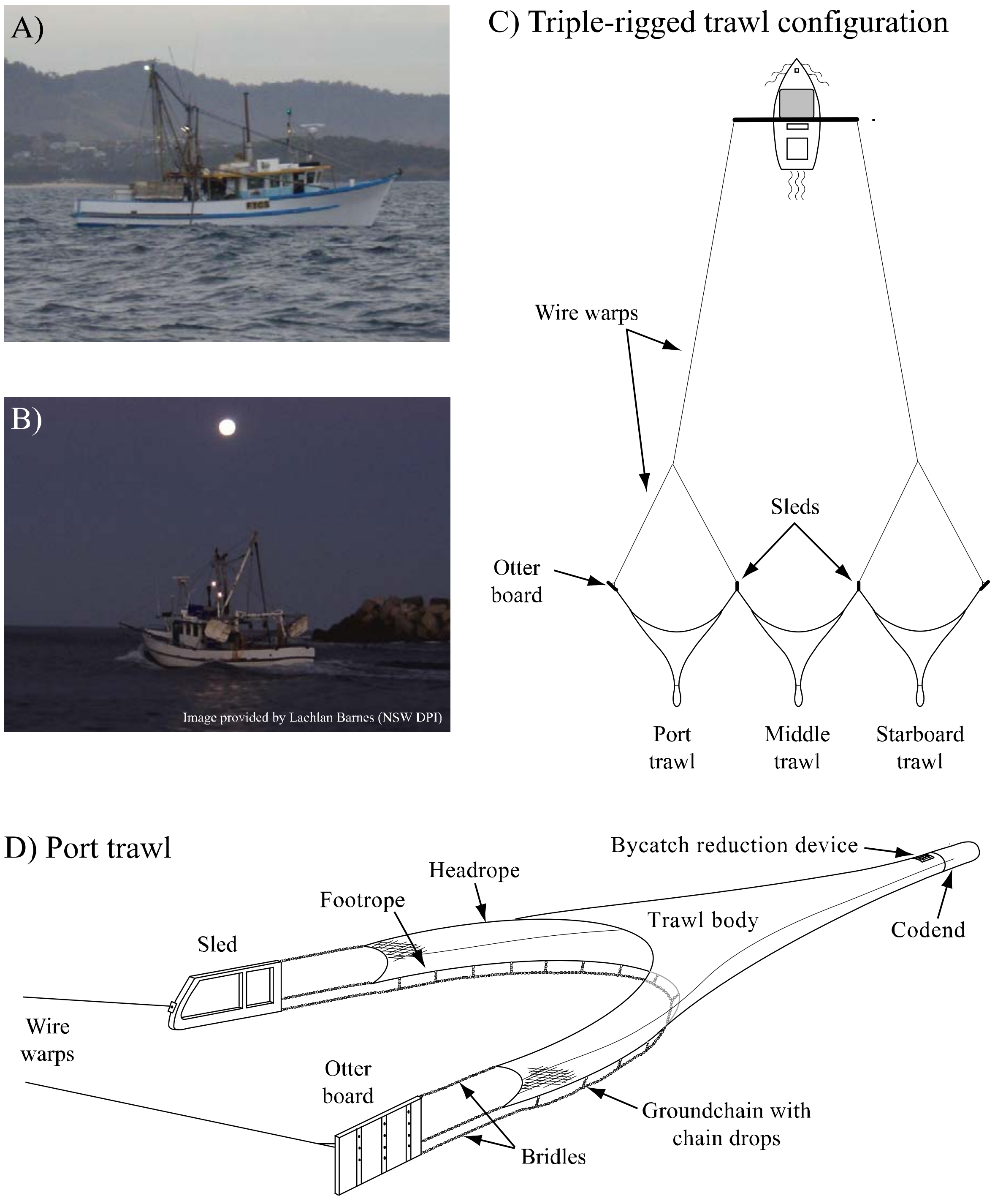

Image provided by Lachlan Barnes (NSW DPI)

Figure 2. A) and B) Typical northern NSW ocean prawn trawlers; Diagrammatic representation of a C) triple-rigged prawn trawl configuration, and D) typical port-side prawn trawl in such a configuration (Diagrams adopted from figures in Andrew *et al.*, 1991, and Broadhurst *et al.*, 2004).

In general, ocean prawn trawl configurations in NSW are restricted to a total headline length (cumulative across the three nets) of up to approximately 60 m (depending on vessel specifications) and a stretched-mesh opening (SMO – Figure 3A) of between 40 and 60 mm in the trawl body and between 40 and 50 mm in codend (i.e., the bag at the trailing end of the trawl where the catch accumulates during towing; Figure 2D) (NSW DPI, 2007). The SMO refers to the length of a mesh opening between the insides of the knots (of knotted mesh) when it is stretched to its maximum using a standard, weighted mesh-measuring instrument (Figure 3A; Ferro and Xu, 1996). In NSW, this instrument is the standard 1.585-kg mesh-size gauge used by NSW DPI Fisheries Officers (NSW Fisheries, 2003).

Note: Fractional mesh opening (FMO) = LMO / SMO

Figure 3. Diagrammatic representation of a diamond-shaped mesh demonstrating A) stretched-mesh opening (SMO), and B) lateral mesh opening (LMO). The formula for deriving the fractional mesh opening (FMO - Robertson and Stewart, 1988) is also shown.

It is important to note that most of the conventionally-used diamond-mesh codends in the fishery have SMOs ranging between 40 and 43 mm, with the mean SMO for each codend depending on the duration of time it has been working. These codends are referred to as ‘40-mm diamond-mesh codends’ throughout this report.

Historically, ocean prawn trawlers in northern NSW waters have targeted eastern king (*Melicertis plebejus*) and school (*Metapenaeus macleayi*) prawn (Figure 4), with the choice of target species at any given time subject to acceptable catch rates of the former, time of year, lunar phase and/or freshwater discharge from northern NSW rivers (Glaister, 1978; Kennelly *et al.*, 1998)[#]. At times of high river discharge, large quantities of school prawn congregate in relatively shallow waters (i.e., < approximately 40 m in depth) adjacent to the river mouths, making it financially lucrative for the trawlers to target them (usually during the day) until they disperse (Ruello, 1973; Glaister, 1978). However, the relatively greater value of eastern king prawn, which is caught in commercial quantities in deeper waters (i.e., approximately 40–200 m in depth) at night, has made it the usual first-choice target prawn species.

Ocean prawn trawlers also retain (and sometimes actively target) a range of organisms other than prawns, including various species of whiting (*Sillago* spp.), flathead (*Platycephalus* spp.), octopus (*Octopus* spp.), squid (*Loligo* spp.), cuttlefish (*Sepia* spp.) and bugs (*Ibacus* spp.), as marketable ‘byproduct’ (Kennelly *et al.*, 1998) (Figure 5). At times, this byproduct is considered to be as

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[#] Within the OPT fishery there is also a ‘deepwater’ ocean prawn-trawl fishery that targets royal red prawn (*Haliporoides sibogae*) on limited grounds in depths > 365 m off the central and northern NSW coasts (NSW DPI, 2007). The fishery is relatively small and, owing to differences between it and the king and school prawn fishery, is regarded as being outside the scope of the current research.

economically important as the targeted prawns, comprising up to 70 and 30% of total retained catches (by weight and value respectively) (Kennelly *et al.*, 1998; Broadhurst *et al.*, 2006a). In fact, since the 1990s many ocean prawn trawlers have begun specifically targeting 'school whiting' – the marketing name for the combined catch of eastern school (*Sillago flindersi*) and stout whiting (*S. robusta*) (Figure 5F) – for a significant proportion of the time (Broadhurst *et al.*, 2005, 2006a). For the purpose of this report, school whiting (i.e., eastern school and stout whiting combined) is termed 'trawl whiting'.

Image provided by Marcus Miller (NSW DPI)

Figure 4. A) A conventional diamond-mesh codend being emptied onto a sorting tray with a typical catch from eastern king prawn trawl grounds; B) eastern king prawns; and C) a typical catch from school prawn trawl grounds.

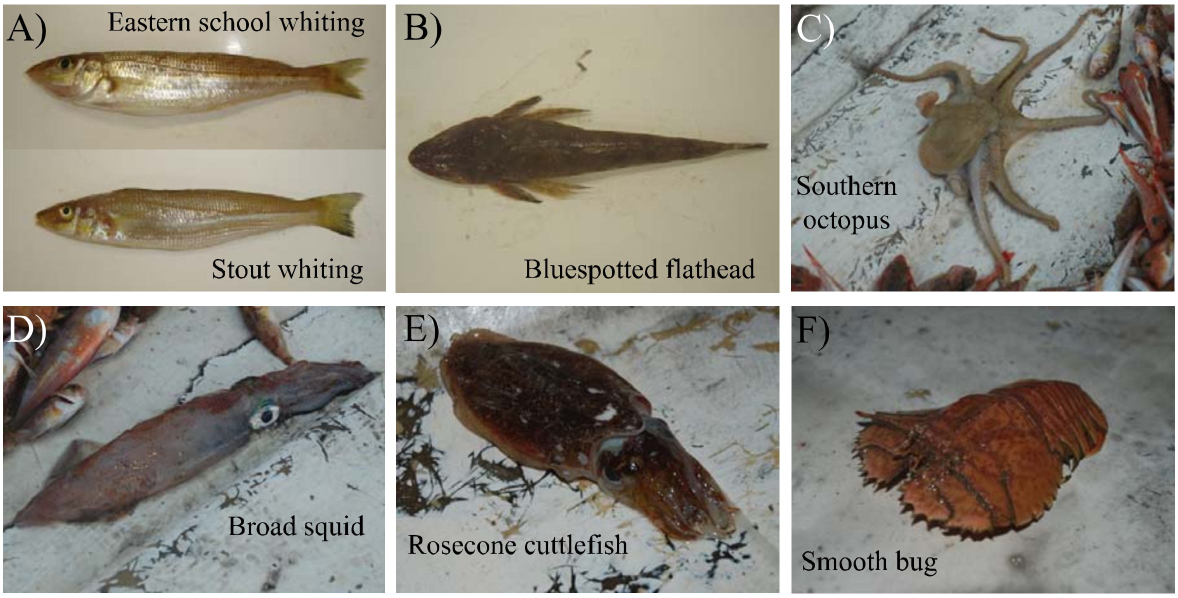

Figure 5. Byproduct from ocean prawn trawling : A) trawl whiting (comprising two species – eastern school and stout whiting), B) flathead (mostly comprising bluespotted flathead), C) octopus, D) squid, E) cuttlefish, and F) bugs.

Along with retained individuals of the targeted and byproduct species, the trawlers also catch a wide range of other unwanted organisms that are subsequently discarded, collectively termed 'bycatch' (*sensu* Saila, 1983). This bycatch comprises many demersal species of no commercial interest, along with individuals of the targeted and byproduct species that are considered too small to market (Figure 6). Concerns over bycatch led to the first of many research programs to initially the extent of the problem in the OPT fishery, and then to examine strategies for reducing bycatches.

1.2. Addressing the issue of bycatch in the NSW OPT fishery

The first step towards addressing the issue of bycatch in any given fishery is to quantify the bycatch in a formal and scientifically rigorous manner by deploying scientific observers onboard the commercial fishing vessels to record detailed data regarding the composition of catches (i.e., ‘observer-type’ studies; Kennelly and Broadhurst, 2002). This enables scientists and managers to identify problematic bycatches and collect supplementary information regarding spatial and temporal patterns in their frequency (Kennelly, 1995).

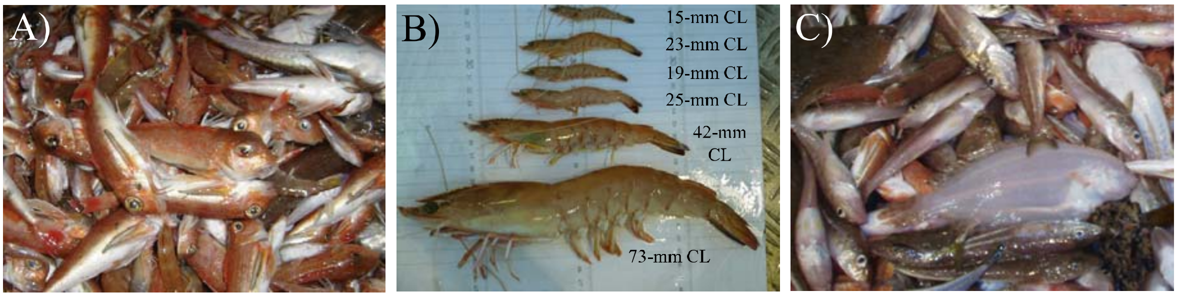

Figure 6. Bycatch from ocean prawn trawling comprises A) a wide diversity of demersal organisms of no commercial interest, along with small, juvenile B) eastern king prawns (i.e., ≤ 23-mm carapace length – CL) and C) trawl whiting (i.e., ≤ approximately 14-cm fork length – FL).

In 1990 a two-year observer program was undertaken to quantify catches and bycatches in the NSW OPT fishery (refer to Kennelly *et al.*, 1998, for full details). Sampling was done onboard vessels working from Ballina, Yamba/Iluka, Coffs Harbour and Port Stephens according to a stratified, randomised design. The ratios of retained catch (prawns and byproduct) to discarded bycatch (prawns and byproduct considered too small + unwanted species) was estimated for the three northern NSW ports to be between 1:1.60 and 1:5.14 (Kennelly *et al.*, 1998). Although these bycatch rates can be considered low-to-average compared to many other prawn-trawl fisheries around the world (see Andrew and Pepperell, 1992, for a review), large catches of juveniles of economically-important finfish led to investigations of bycatch reduction strategies.

There are two general strategies that are commonly employed to reduce the incidence and overall quantity of bycatches from commercial fishing. The first involves the implementation of management restrictions on the spatial extent of, and/or temporal access to, fishing grounds (Kennelly, 1995; Kennelly and Broadhurst, 2002). Such approaches are commonplace in many prawn fisheries, including the NSW OPT fishery (e.g., Gulland and Rothschild, 1984; NSW Fisheries, 2003; NSW DPI, 2007), and are useful in the protection of areas in which the capture of large quantities of unwanted bycatch and/or juveniles of the targeted species is known to occur (e.g., Thorsteinsson, 1992; Campos *et al.*, 2002; Gray and Kennelly, 2004). However, such closures are also likely to reduce overall catches of the targeted prawns (and/or byproduct where applicable) due to the reduction in the available extent of fishing grounds (Kennelly, 1995). Furthermore, the closure to fishing of particular areas, or during specific time periods, might simply transfer the effort to the fishing grounds that are open to fishing, causing increased fishing-related impacts to those areas (Kennelly, 1995). Although very useful in its own right as a bycatch-reduction tool, the spatial and/or temporal closure of fishing grounds is most effective when implemented in combination with the second general strategy, which involves the development of bycatch-reducing gear modifications that improve size and species selectivity, therefore reducing unwanted bycatches (Broadhurst, 2000; Kennelly and Broadhurst, 2002).

To date, most research into such modifications has centred on fish and prawn trawls owing to the extent of the bycatch problem in such fisheries throughout the world (Andrew and Pepperell, 1992; Kennelly, 1995; Broadhurst, 2000; Kennelly and Broadhurst, 2002). During the past couple of decades the prawn-trawl fisheries of NSW have been at the forefront of the development of bycatch-mitigating technologies, with many such technologies currently legislated for use. However, given that the OPT fishery is a multi-species fishery and the animals targeted and/or retained are of a variety of shapes, sizes and behavioural characteristics, the challenge of reducing unwanted bycatches without significantly impacting on retained catches has been, and is, a considerable one.

Bycatch-reducing gear modifications to trawls can be broadly categorised into three groups according to the degree of modification that is required, the types of problematic bycatch that are being addressed, and the mechanisms by which the organisms escape (Broadhurst, 2000). The first category involves perhaps the simplest modifications, whereby the lateral mesh openings (LMOs; Figure 3B) in all or part of the gear (usually the codend) are increased, usually by increasing the mesh size or changing the configuration of the meshes (e.g., Tokai and Kitahara, 1991; Thorsteinsson, 1992). The desired effect of such modifications is to facilitate the escape of those organisms smaller than the minimum size of prawns targeted. The second and third categories involve the addition of physical devices (collectively termed bycatch reduction devices (BRDs – for a detailed review refer to Broadhurst, 2000) to facilitate the escape of bycatch organisms.

The second category includes BRDs that mechanically partition the catch so that organisms larger than the targeted prawns are ejected from the gear; these are termed ‘mechanical-type BRDs’ (e.g., turtle excluder devices – ‘TEDs’). In contrast, the third category includes BRDs that facilitate the escape of bycatch organisms (usually finfish) by taking advantage of differences in their behavioural responses to encountering the trawl, and are termed ‘behavioural-type BRDs’ (e.g., square-mesh panels; Figure 7).

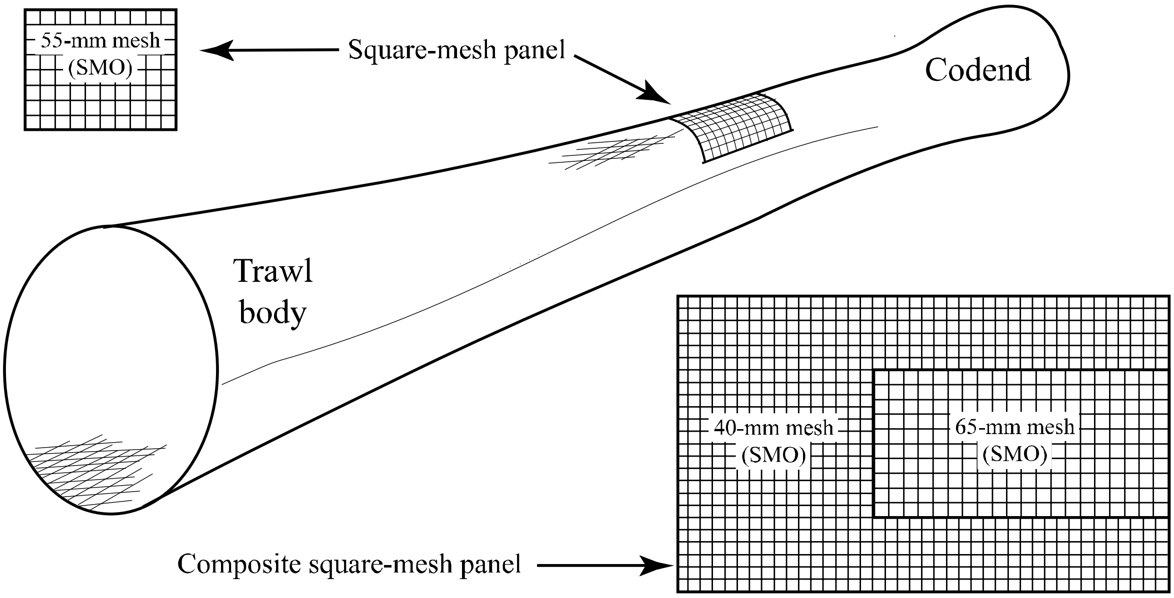

Figure 7. Schematic diagrams of a typical square-mesh panel (SMP), a typical ‘composite square-mesh panel’ (CSMP) and a square-mesh panel *in situ* in a prawn trawl.

Following the results from the observer research, a range of gear and operational modifications, designed to reduce the bycatch of small finfish without a concomitant significant reduction in catches of eastern king prawn, was tested via carefully controlled experiments in the NSW OPT fishery during the mid-1990s. These modifications included various designs and configurations of square-mesh panel (Figure 7), in combination with different codend circumferences (i.e., number of meshes around the codend) or haulback delay (Broadhurst *et al.*, 1996; Broadhurst and Kennelly, 1996, 1997). One of the main findings from this body of research was that the most effective square-mesh panel design – a 'composite square-mesh panel' (CSMP) comprising a combination of 40- and 60-mm mesh hung on the bar (Figure 7) – reduced bycatch (as per the definition given above, but excluding small, unwanted eastern king prawns) by between 23.5 and 41% (by weight). Further, there were significant, and in some cases considerable reductions in the numbers of discards for many finfish species (e.g., eye gurnard – *Lepidotrigla argus*, spotted bigeye – *Priacanthus macracanthus*, and threespine cardinalfish – *Apogonops anomalus)*, including small, juvenile individuals of some byproduct species (e.g., eastern school and stout whiting) (Broadhurst and Kennelly, 1997). These reductions were achieved while increasing the quantities of eastern king prawn caught by between 4 and 14% (by weight), and without significant loss of retained individuals for the major byproduct species (by number) (Broadhurst and Kennelly, 1997).

In 1999, the use of bycatch reduction devices (BRD) was made compulsory in the OPT fishery. The current list of eight approved BRDs comprises the composite square-mesh panel (although with 65- instead of 60-mm mesh – see Figure 7), along with a range of other designs of mechanical- (e.g., Nordmøre-grid) and behavioural-type (e.g., square-mesh panel) BRDs. Each of these BRDs has specifications with respect to its particular design and positioning, although all are designed to either eject large organisms, or provide an escape route for small fish, or both, via openings on the top surface of the codend or codend extension (Figure 7; Appendix B1.1 of NSW DPI, 2004). Anecdotal evidence suggests the most commonly used BRD in the northern NSW OPT fleet is a 'square-mesh panel' (SMP), constructed to the minimum allowable SMO (55 mm) and dimensions (surface area of 450 cm^2; width of 18 cm). Fishers perceive that the relatively small mesh-size and dimensions, along with the relatively large distance from the end of the codend that it is permitted to be positioned (compared with the composite square-mesh codend), minimizes the escape of target-size whiting (typically > 15 cm in total length – TL).

More recently, in addition to ongoing concerns over the unwanted mortality of small fish, the capture of small, juvenile prawns in trawls used in NSW was identified as an issue that could have a detrimental effect on the yield of the fishery (Broadhurst *et al.*, 2004). In many gear selectivity studies, the narrow LMOs in working, conventionally-used, diamond-mesh codends have been demonstrated to provide insufficient avenues of escape for such animals (Figure 8A; e.g., Broadhurst *et al.*, 2004, 2006a). One way of promoting the escape of individuals smaller than the targeted animals from trawls is to increase the LMO of the netting (i.e., Figure 3B). One gear modification that provides consistently wide LMOs is the full 'square-mesh codend', which involves re-orienting the meshes of the codend so that they are square-shaped (i.e., 'hung on the bar') throughout (Figure 8B).

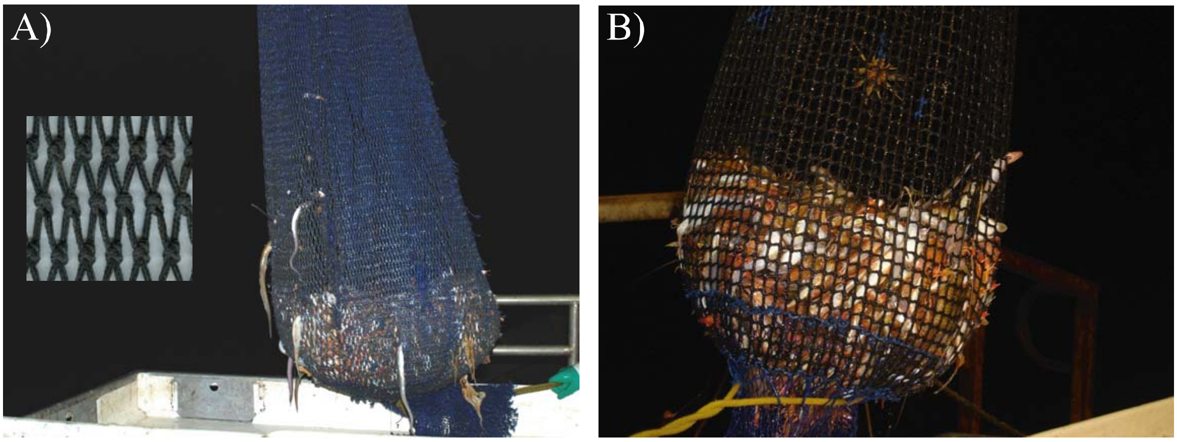

Figure 8. A) conventional diamond-mesh codend (NSW OPT fishery) partially filled with catch and (inset) typical 40-mm diamond mesh; and B) 35-mm square-mesh codend (i.e., netting hung on the bar) partially filled with catch.

Experimentation with full square-mesh codends in fish- and crustacean-trawl fisheries in Europe and North America from the 1980s through to the early-2000s provided mixed results (e.g., Robertson and Stewart, 1988; Casey *et al.*, 1992; Thorsteinsson, 1992; Walsh *et al.*, 1992; Petrakis and Stergiou, 1997; Perez-Comas *et al.*, 1998; Campos *et al.*, 2002), but confirmed the potential for such a gear modification for improving the size and species selectivity of NSW prawn trawls.

Following successful trials with full square-mesh codends in the EPT fishery (Broadhurst *et al.*, 2004), controlled experiments were done in the OPT fishery during the mid-2000s to test the effectiveness of full square-mesh codends (35- and 41-mm SMO) with respect to improving size selection for the targeted and byproduct species (i.e., reducing bycatch of small, juveniles of those species), without significant losses of retained product (Broadhurst *et al.*, 2005, 2006a, 2006b), compared with a codend representing conventionally-used diamond-mesh codends (i.e., a 41-mm diamond-mesh codend with a circumference of 150 meshes). Alternative diamond-mesh codend designs to achieve the same end were also tested, including a codend made from mesh of a larger size (i.e., 45-mm SMO at 92 meshes in circumference) than is generally conventional used, and a 40-mm mesh codend with fewer meshes comprising its circumference (i.e., 100 meshes) than is usually used (i.e., at least 150 meshes).

There were two important findings from the size-selectivity research mentioned above. First, the conventional 41-mm diamond-mesh codend was effectively non-selective for eastern king prawns and trawl whiting (Broadhurst *et al.*, 2006a, 2006b). That is, prawns and whiting of all sizes encountered were caught in the codend, including small juveniles down to approximately 10-mm CL and 4-cm FL respectively. Second, of the modified codends tested, the 35-mm square-mesh codend was the most successful with respect to reducing bycatch of small, juvenile prawns and whiting without, in most cases, significant shortfalls in larger, target-size prawns and whiting and other byproduct species (Broadhurst *et al.*, 2006a, 2006b). It is also worth noting that no significant differences between the two abovementioned codends with respect to the weight of discarded bycatch (all species combined) were detected (Broadhurst *et al.*, 2006a).

Despite the clear results and conclusions from Broadhurst *et al.* (2006a, 2006b), one of the main criticisms from NSW OPT industry representatives has been that the research was not representative of the entire fishery owing to the small number of vessels, short time-frames and rigid experimental protocols involved. Although these financial and scientific constraints are necessities with respect to the valid development of bycatch-mitigating technologies, larger-scale trials with a 35-mm square-mesh codend in the OPT fishery would be a useful, complementary approach to address the concerns of industry.

1.3. Distribution of a 35-mm square-mesh codend to OPT operators

In 2006/07, NSW DPI and NRCMA formally collaborated to fund and implement a program to construct and distribute (free of charge) 35-mm square-mesh codends, of a design comparable in dimensions to the design tested by Broadhurst *et al.* (2006a, 2006b) and including a CSMP, to north coast OPT operators on a conditional, voluntary basis (NRCMA marine projects: IS6-7-199 – 'Implementation of best-practice fishing gear technology in the ocean trawl fishery'). A total of 17 trawlers accepted the initial offer, with sets of three codends distributed to most during September 2007. A further three operators expressed belated interest in the offer and had received codends by November 2007.

This gear distribution project provided an opportunity for NSW DPI researchers to collect detailed, observer-type catch data to assess the performance of the 35-mm square-mesh codend across a larger subset of the north coast OPT fleet (relative to the experiments described above); over a relatively large time-frame; under commercial fishing protocols; and as a consequence, under a relatively wide range of fishing and catch conditions. In 2007/08, NSW DPI and NRCMA funded a research project to realise that opportunity.

1.4. Objectives

Given the above, the main objective of the current research project was to collect detailed catch and operational data to enable a comprehensive assessment of the performance of the prescribed 35-mm square-mesh codend relative to that of the diamond-mesh codends (with industry-designed BRDs) currently in use throughout the fleet. Secondary catch comparisons involving the 35-mm square-mesh codend and any codend design other than those allowed under the NSW DPI regulations were made where the opportunity arose, providing the alternative design was being used under an appropriate permit. The secondary objectives of this study were first to record data pertaining to any interactions with: 1) threatened and protected species; 2) elasmobranch (shark and ray) species; and 3) any other species of particular interest; and second, to record data identifying the location and depth of trawl grounds visited during sampled trips.

2. MATERIALS & METHODS

2.1. Study area

The marine zone of the NRCMA region extends three nautical miles (nm) directly east of the coastline along the stretch of coast bounded by the NSW/Queensland border and a point approximately 2 – 3 nm north of Crowdy Head on the mid-north coast (Figure 1). The home ports of a total of 63 ocean prawn-trawlers that are currently active in oceanic waters off the northern NSW coast are located within this stretch of coastline (Crowdy Head inclusive).

2.2. Experimental design and codends used

Given that the primary objective of the study was to quantitatively assess the performance of the 35-mm square-mesh (‘35S’) codend compared with conventionally-used diamond-mesh codends, the most appropriate experimental approach for this study involves paired comparisons. The triple-gear trawl configuration used by OPT vessels permits concurrent, parallel towing of square- and diamond-mesh codends. In theory, this configuration eliminates, or at least minimises, the effects of factors other than differences between the two codends being towed (e.g., spatial and temporal variability in the faunal composition on trawl grounds; or operational differences among trawlers or different tows) on catches during any given, replicate tow. With appropriate replication, this provides a scientifically rigorous paired comparison between the two codend types.

Paired comparisons meant that, given the volume of work required to scientifically process the catch from each codend, two researchers were required for each sampling trip. The financial resources available for this study permitted a total of approximately 36 sampling trips involving two researchers collecting paired-comparison data during each trip. All of the trawl operators who received 35S codends were contacted, although only nine were happy and/or able to host the two researchers.

An ideal experimental protocol would involve random (or regular), tow-by-tow alternating of the codends between the port and starboard trawls to eliminate the possibility of an effect on codend catches caused by differing fishing efficiencies between the two outside trawls. Owing to the commercial fishing protocols and conditions adhered to during the study alternating codends between tows was not possible. Every effort was made, however, to swap the codends over between trips done onboard any given trawler. In some cases, and for various reasons, this was not possible and so, for the results presented in this report, the general assumption must be made that there was no effect of differing fishing efficiencies between the port and starboard trawls for any of the sampled trawlers. For this reason, where sampling onboard multiple trawlers contributed to datasets analysed for specific contrasts between codend types (see Section 2.2.2), catch data pertaining to individual trawlers are only used in an illustrative capacity to complement results of the overall analyses by providing evidence for possible causes of inter-trawler and/or -tow variability in the performance of the 35S codend. It is important to reiterate that this study is a relatively broad assessment of the 35S codend rather than an attempt at definitively identifying factors causing such variability.

2.2.1. Design of the 35-mm square-mesh codend

The 35-mm square-mesh (35S) codend distributed among the cooperating trawl operators was similar, although not identical, to that tested by Broadhurst *et al.* (2006a, 2006b). The codend distributed had a square-mesh section that was 100 bars (square meshes; approximately 2.05 m) in circumference (compared with 70 bars – approximately 1.45 m), and 52 bars (approximately1.07 m) in length (compared with 54 bars – approximately 1.1 m) (Figure 9). As in the Broadhurst *et al.* (2006a, 2006b) experiments, it was attached to a diamond-mesh codend extension incorporating a CSMP positioned 1.2 m from the posterior extremity of the codend (Figure 9). In the case of each paired comparison, this configuration was attached to the relevant trawl body at a position comparable to the position of the conventional codend (and associated BRD) on the opposite trawl.

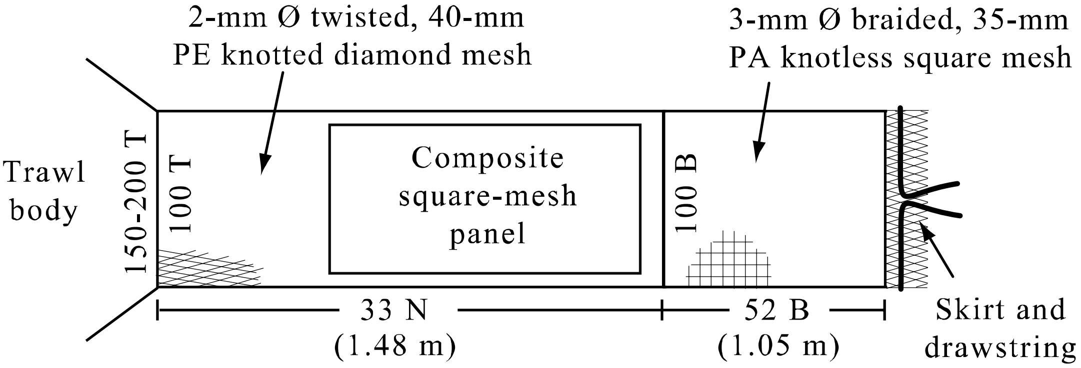

Figure 9. Schematic diagram of the 35-mm square-mesh codend (including the codend extension with composite square-mesh panel – see Figure 7) distributed to trawl operators. N, normals; T, transversals; B, bars; m, metres; Ø, twine diameter; PE, polyethylene; PA, polyamide (nylon).

Owing to most trawl operators opting to use a 55-mm SMP BRD similar in design to that shown in Figure 7, the paired comparisons must be considered as comparisons between codend configurations including BRDs (unless specified otherwise) rather than comparisons between types of codend mesh *per se*.

2.2.2. Industry codends involved in paired comparisons

A range of codend designs were being used by the trawl operators who hosted our researchers. Variables in codend design included: codend length; type of netting (i.e., knotted or knotless; twisted or braided twine; twine diameter); mesh size and configuration; and BRD design and position. However, the main purpose of this study is to broadly assess the performance of the 35S codend design relative to a subset of the conventional codends currently in use in the fishery rather than separately assessing each specific codend and/or BRD against the 35S codend configuration. Therefore, rather than describing the dimensions of each industry codend in detail, the codends (and therefore the associated replicate paired comparisons) were categorised into groups based on mesh size and configuration (Table 1). For example, six trawlers were using conventional diamond-mesh codends made from mesh of between 40 and 43 mm SMO, and of a circumference (measured as the number of diamond meshes) of approximately 150 meshes, justifying their grouping as '40D-150' codends. The same principle was applied in the cases of all of the codends that were compared with the 35S codend (Table 1).

An industry-developed, 36-mm square-mesh (36S-ind) codend, with an identical diamond-mesh codend extension and BRD to that associated with the 35S codend (i.e., CSMP; see Figure 9), was being used under special permit by one of the trawl operators (Table 1). Other than the slight difference in mesh size, this codend differed from the 35S codend in a number of ways. First, it was made from braided polyethylene, knotless mesh instead of nylon (polyamide). Second, the twine diameter was approximately 4 mm instead of 3 mm. Third, it had a circumference of approximately 2.2 m (i.e., 100 bars at 4 mm in diameter) instead of 2.05 m. Finally, it was 1.32 m long (i.e., 60 bars) instead of 1.07 m (i.e., 52 bars). This provided an ideal opportunity to compare catches from this industry-designed square-mesh codend and the 35S codend.

Table 1. Industry codends used in paired comparisons (against the 35S codend) during this study. PE, polyethylene.

Codend type	Mesh size	Codend circumference	No. vessels
40D-150 codends	40–43-mm PE diamond mesh	150 diamond meshes	6
40D-200 codends	40–43-mm PE diamond mesh	200 diamond meshes	2
45D-150 codend	45–47-mm PE diamond mesh	150 diamond meshes	1
36S-ind codend	36-mm PE square mesh	100 bars (1.32 m)	1

In the case of two of the vessels, data were necessarily collected involving some paired comparisons of the codends with their BRDs open (i.e., as per normal commercial operations), and others with their BRDs closed (i.e., BRDs rendered inoperative by sewing mesh over the escape openings). In both cases the codend configuration was altered from 'BRDs open' to 'BRDs closed' between sampling trips. This provided an opportunity to assess whether the BRD was playing some role in any differences in catches between the diamond- and square-mesh codends.

2.2.3. 29-mm square-mesh codend used during school-prawn trawling

On one trip of trawling for school-prawns, the opportunity arose to attach a 29-mm square-mesh codend, identical to the 35S codend in every way apart from the mesh size and the slightly smaller twine diameter (2.25 mm) of the square-mesh section, to the centre trawl. The only data collected from that centre trawl was the size frequency of school prawns caught.

Given the limited data collection, along with constraints associated with making comparisons between catches in the centre trawl and those in port/starboard trawls, limited viable comparisons can be made between that codend and either of the 40D-200 and 35S codends positioned on either side. Nevertheless, some catch data can be compared to a very limited degree (see subsections 3.4.1.4 for further comment).

2.3. Data collected

After each paired tow, the contents of each codend were emptied onto the sorting tray and separated by species, where the species could be readily identified. Where this was not possible during sampling trips, samples were taken back to the NSW DPI laboratory and identified to species level or, alternatively, the lowest taxanomic level possible. The total weights and numbers of each species were recorded, with the numbers of individuals estimated, where necessary, by scaling-up from a sub-sample (of 150 eastern king prawns; 250 school prawns; or 50–100 individuals for other species, depending on the time available). Species names and standard common names used throughout this report are are sourced from the Codes for Australian Aquatic Biota (CMAR, 2008).

Size-frequency data were recorded for eastern king and school prawns; eastern school and stout whiting; all flathead species; and the numerically dominant bycatch species – eye gurnard. In the case of school and eastern king prawns, the carapace length (CL) for all prawns (or a sub-sample of 150 and 250 individuals, respectively, where necessary) was measured to the nearest mm using Mitutoyo dial calipers. In the case of finfish, the fork length (FL) for all fish (or a sub-sample of 50–100 individuals where necessary) were measured to the nearest cm below the fork using laminated measuring boards. Catch components were weighed using plastic buckets (or boxes) and hand-held, Salter spring-balances (5, 10 and 25 kg) and, where sub-sampling was necessary, size-frequency distributions were appropriately scaled.

2.4. Catch variables for analysis

In general, all eastern king prawns caught during this study were retained. However, Broadhurst *et al.* (2006a, 2006b) considered eastern king prawns ≤ 23-mm CL to be smaller than the desired commercial size. Therefore, three catch variables for eastern king prawns were used for the current study: 1) weight of retained eastern king prawns; 2) weight of target-size eastern king prawns (i.e., prawns > 23-mm CL); and 3) number of discard-size eastern king prawns (i.e., prawns ≤ 23-mm CL). Note that the weights of retained catches (i.e., prawns and other byproduct) are deemed pertinent for analysis as this is the measure most relevant to the fishing industry. In contrast, the number of bycatch individuals (of targeted, byproduct or discarded species) is deemed the more appropriate measure with respect to differences in catch between codends.

As for the targeted prawns, generally all trawl whiting (except in the case of trawling for school prawns) caught during this study were retained. However, Broadhurst *et al.* (2006a, 2006b) considered trawl whiting < 15-cm TL to be smaller than commercial (target) size. This TL equates to approximate FLs of 14 and 14.5 cm for eastern school and stout whiting respectively (Broadhurst *et al.*, 2006b). Given the above, two catch variables for trawl whiting were used for the current study: 1) weight of target-size trawl whiting (i.e., whiting ≥ 14- or 14.5-cm FL, depending on species); and 2) number of discard-size trawl whiting (i.e., whiting < 14- or 14.5-cm FL, depending on species).

The flathead species retained during this study were bluespotted flathead (*Platycephalus caeruleopunctatus*), freespine flathead (*Ratabulus diversidens*; locally known as spiky flathead), marbled flathead (*P. marmoratus*), tiger flathead (*P. richardsoni*) and dusky flathead (*P. fuscus*). All but dusky flathead (36-cm TL) have a minimum legal TL of 33 cm. For the purpose of analysis in this study, all individuals of these species caught were categorised as: 1) weight of target-size marketable flathead (i.e., ≥ 33-cm FL, except for dusky flathead); and 2) number of discard-size marketable flathead (i.e., < 33-cm FL, except for dusky flathead).

The bug species retained during this study were smooth bug (*Ibacus chacei*), Balmain bug (*I. peronii*) and Bruce's bug (*I. brucei*). The minimum legal carapace width (CW) for these bugs is 10 cm. For the purpose of analysis in this study, all individuals of these species caught were categorised as: 1) weight of target-size bugs (i.e., ≥ 10-cm CW); and 2) number of discard-size bugs (i.e., < 10-cm CW).

Where fishers combined byproduct species into groups for marketing purposes, the total weights for these groups of species were analysed as individual variables. These groups were: octopus (up to six species), squid (four species) and cuttlefish (five species) (refer to Appendix A). Other byproduct species consistently caught in quantities suitable for analysis were bluestriped goatfish (*Upeneichthys lineatus*) and yellowtail scad (*Trachurus novaezelandiae*).

Bycatch individuals that were discarded (i.e., including discard-size marketable flathead and bugs – see above) were combined to provide three ‘overall’ bycatch variables: 1) weight of discarded bycatch; 2) number of discarded bycatch individuals; and 3) number of bycatch species (including whiting where appropriate). The numbers of the most abundant species in discarded bycatches were also analysed.

2.5. Analysis of data

In the case of each codend comparison examined, two-tailed, paired t-tests were used to compare catches between codend types for the relevant catch variables. Raw catch data were first converted to catch rates (kg h^{-1}) to account for variability in tow duration among tows, and then ln(x + 1) transformed to account for multiplicativity, as is appropriate for these types of commercial catch data.

Relationships between selected dependent catch variables and key explanatory trawl (catch and operational) parameters were examined for the two codend types, within certain codend comparisons, using regression analysis. The key catch and operational parameters (independent variables) investigated for regression analyses with the relevant dependent, eastern king prawn and whiting catch variables were: weight of the total catch (i.e., all catches and bycatches combined); catch rate of total catch by weight (kg h^{-1}); towing speed (knots); tow duration (min); and total headrope length (m). The dependent catch variables examined were: catch weight of target-size eastern king prawns (or whiting); number of discard-size eastern king prawns (or whiting); and catch rates for both of these variables (kg h^{-1}). All data were ln(x + 1) transformed to ensure linearity. It should also be noted that only data for the ‘BRD open’ contrasts were used for regression analyses.

Where a significant regression was detected for each of the two codend types, regressions were analysed for differences using the appropriate *F*-tests (i.e., to test for heteroscedasticity and differences in slopes and elevation).

Where one-factor analysis of variance (ANOVA) was used, raw data were ln(x + 1) transformed (to model treatment effects as approximately multiplicative) and tested for heteroscedasticity using Cochran’s test. Where necessary, significant *F*-ratios from the ANOVAs were investigated using Student-Newmans-Keuls (SNK) multiple comparisons.

Two-sample Kolmogorov-Smirnov (KS) tests were used to compare size-frequency distributions where appropriate.

3. RESULTS

3.1. Cooperation and participation by trawl operators

A total of 20 trawl operators opted to accept the specified 35S codend for use in their trawling operations. The scientific observers were able to conduct research onboard nine of those vessels. The reasons given by trawl operators who elected not to cooperate with our research are given in Table 2 below. It should be noted that some trawl operators couldn't be contacted, while others were not trawling in the study area at the time they were contacted.

Table 2. Participation in this study by trawl operators provided with 35S codends.

Reason given for non-participation (or otherwise)	No. of trawl operators
OK to take observers (on at least one trip)	9
Trawl operator couldn't be contacted	1
Not enough room on vessel or not vessel not suitably surveyed	3
Vessel not operational for an indefinite period	2
Vessel not working in NSW waters – in Qld during sampling	2
DPI contract to tow codends not finalised	3

It should also be noted that four additional trawl operators belatedly applied to receive and trial the 35S codend, with many expressing interest in hosting the researchers. However, no sampling was done onboard those trawlers because of lengthy delays in the organisation of permits.

Although during each trip every attempt was made to process catches from the two codends being compared for most tows done, the final tow on each trip was not processed so that the trawl operators could prepare their catches for market without hindrance. Further, on a few trips, a replicate tow other than the final one was not processed due to the time taken to process the previous tow.

3.2. Specific paired comparisons between codends

Sufficient replicate tows to allow an attempt at formal analysis (i.e., > 5 tows) were successfully completed for a total of five specific paired comparisons during this study (Table 3). As mentioned in the Materials & Methods section, small numbers of tows were done for a further three paired comparisons, although these numbers were deemed insufficient to allow statistical analysis.

It should be noted that data from only 34 of the 36 trips were included for the presentations and analyses below. The two excluded trips, which were the last two completed onboard one of the nine participating trawlers, and done after the trawl operator had replaced one of the outside trawls with a trawl of fundamentally different design, were unwittingly sampled by the researchers as per the necessary protocol before the substitution was revealed. Owing to the considerable differences between the designs of the outside trawls, any differences in codend performance during those two trips was confounded.

Table 3. Paired comparisons completed during this study. See Table 1 for codend definitions.

Paired codend comparison	Target species	No. trips	No. tows
35S vs. 40D-150 codend (BRDs open)	Eastern king prawns	13	30
35S vs. 40D-150 codend (BRDs closed)	Eastern king prawns	1	3
35S vs. 40D-150 codend (BRDs open)	Trawl whiting	1	2
35S vs. 40D-200 codend (BRDs closed)	Eastern king prawns	5	10
35S vs. 40D-200 codend (BRDs open)	School prawns	4	13
35S vs. 45D-150 codend (BRDs open)	Eastern king prawns	1	3
35S vs. 45D-150 codend (BRDs closed)	Eastern king prawns	3	10
35S vs. 36S-ind codend (BRDs open)	Eastern king prawns	6	12

3.3. Analysis of catches from trips targeting eastern king prawn and/or whiting

A total of 30 trips onboard 10 vessels targeting eastern king prawn and/or trawl whiting was successfully completed (Table 3). Six of these trips involved a paired comparison between the 35S codend and an industry-designed, 36-mm square-mesh codend (36S-ind), and are not included in the data analyses presented in this section (see Section 3.5 below).

The trawled grounds for the remaining 24 trips were at latitudes between 28°45’ and 30°51’S and, for the most part, were in depths between 40 and 87 m. The exception was one trip (providing one paired comparison) that involved trawling at a depth of approximately 170 m. The sampled tows ranged in speed between 1.9 and 2.8 knots (mean ± SE = 2.35 ± 0.02 knots; *n* = 115 readings) and in duration between 50 and 295 min (148 ± 7 min; *n* = 58). In summary, the 26 trips provided: 35 paired comparisons for the 35S vs. 40D-150 codend contrast (30 targeting eastern king prawns with BRDs open; 3 targeting eastern king prawns with BRDs closed; and 2 targeting trawl whiting with BRDs open); 10 paired comparisons for the 35S vs. 40D-200 codend contrast (all targeting eastern king prawns); and 13 paired comparisons for the 35S vs. 45D-150 codend contrast (3 with BRDs open and 10 with BRDs closed; all targeting eastern king prawns) (Table 3).

3.3.1. 35S vs. 40D-150 codend comparison

Owing to the low number of trips targeting whiting all paired comparisons involving a 35S vs. 40D-150 codend (BRDs open) contrast were included in the dataset, providing a total of 32 paired comparisons for that contrast. For these 32 tows the weight of total catch (i.e., retained and discarded animals combined) ranged between 19.8 and 109.8 kg (mean ± SE = 51.6 ± 4.4 kg) in the 40D-150 codend, and between 21.2 and 129.4 kg (46.5 ± 4.6 kg) in the 35S codend.

Only three replicate tows of the 35S vs. 40D-150 codend (BRDs closed) contrast were completed and so formal analyses are inappropriate. For these tows the weight of total catch ranged between 76.0 and 105.6 kg (92.0 ± 8.6 kg) in the 40D-150 codend, and between 66.1 and 136.5 kg (104.1 ± 20.5 kg) in the 35S codend. Nevertheless, some simple comparisons of length frequency distributions could be made using data from that particular contrast.

One observation that warrants mention concerns the amount of sediment throughout catches from the 35S codend for all square- vs. diamond-mesh codend comparisons done as part of this study. Catches from the 35S codend appeared to contain a greater quantity of mud and other sedimentary material than catches from the corresponding diamond-mesh codend, for the majority of such paired comparisons.

3.3.1.1. Eastern king prawn

All eastern king prawns caught during these 32 tows were retained. The mean catch rates of eastern king prawn (by weight) in the 40D-150 and 35S codend did not significantly differ; as was the case for the weight of target-size (> 23-mm CL) eastern king prawn (Table 4). In contrast, the mean catch rate of discard-size (≤ 23-mm CL) eastern king prawn (by number) was significantly lower in the 35S codend, with the reduction in the capture of these small prawns approximately 40% (Table 4).

This general result did not, however, reflect the variability in the performance of the 35S codend among vessels with respect to catches of eastern king prawns. Vessels 1 and 2 encountered relatively large numbers of discard-size prawns, for which the 35S codend clearly provided a more effective escape route than the 40D-150 codend (Figures 10A and B). In contrast, there appeared to be no difference in the numbers of discard-size prawns caught in the two codends in the case of vessel 3 (Figure 10C). In the cases of vessels 4 and 6 there was a shortfall in the capture of eastern king prawns of sizes up to 35-mm CL by the 35S codend (Figure 11A and B). However, when the BRDs of both codends were closed (in the case of vessel 6), the difference in the capture of marketable prawns appeared to be somewhat negated (Figure 11C). Note that the relatively small number of replicate tows done for paired comparisons onboard vessels 4 and 6 mean that these observations should be considered with caution.

Although specifically targeting trawl whiting, vessel 5 also caught eastern king prawns of a range of sizes (although predominantly target-size) on the whiting trawl grounds (Figure 12). In general, and contrary to results for the other trawlers, fewer target-size prawns of sizes up to 37-mm CL were caught in the 40D-150 codend than in the 35S codend (Figure 12). Interestingly, during the one deep water tow, which was done by Vessel 5 to target king prawns, the 35S codend caught over 50% more eastern king prawn (5.8 kg h^{-1}) than the 40D-150 codend (3.8 kg h^{-1}), although this statistic should not be given much consideration owing to the lack of replication with respect to deepwater tows.

Of the regression analyses done, the only ones that added further insight into the results of the paired t-tests and the size-frequency distributions for king prawn catch variables were: catch weight of target-size eastern king prawns vs. weight of the total catch; and number of discard-size eastern king prawn vs. weight of the total catch. Therefore only these plots are presented (Figure 13). In the case of the catch weight of target-size king prawns, there was not a significant regression relationship with the weight of total catch for either codend ($P > 0.05$; Figure 13A). The most important aspect of this result is that it indicates that the 35S codend with a BRD was as effective as the 40D-150 codends at catching target-size king prawns across the range of total catch weights encountered for this codend contrast. That is, there was no evidence to suggest that increases in total catch quantity *per se* affects the total catch of target-sized king prawns in the two codends any differently, across the range of weights of total catch encountered.

In contrast, there was a significant negative regression relationship between the total number of discard-size king prawns and weight of the total catch for both codends ($P < 0.01$ for both), although the regressions were not particularly strong (i.e., $r^2 < 0.35$ in both cases) and not significantly different with respect to slope and elevation ($P > 0.05$; Figure 13B). Again, it should be emphasised that the most important result here is that the two regression lines were not significantly different for the range of weights of total catch encountered.

Table 4. Mean catch rates (± SE) in the 40D-150 and 35S codends h^{-1} (n = 32 tows) for the main target and byproduct species/groups (EKP, eastern king prawns; TW, trawl whiting, MFH, marketable flathead species), total discarded bycatch (BC) variables, and the most abundant bycatch species/groups (i.e., > 1000 individuals in total) in catches (FH, flathead). Weights (Wt) are in kg. The results of two-tailed paired t-tests are shown where appropriate (ns, catches not significantly different at P = 0.05; *, significantly different at P = 0.05; **, significantly different at P = 0.01), along with the % difference where catch rates were significantly different.

Catch variable	**Mean catch h^{-1} (total n = 32 tows)**		**Result of paired t-test (n for test)**	**Decrease (-) or increase (+) from 40D-150**
	40D-150 codend	**35S codend**		
Wt retained EKP	3.39 (0.41)	3.29 (0.41)	ns (32)	
Wt target-size EKP	3.24 (0.41)	3.19 (0.40)	ns (32)	
No. discard-size EKP	36.76 (8.93)	22.10 (4.82)	** (27)	-40%
Wt target-size TW	3.62 (0.83)	3.03 (0.61)	ns (31)	
No. discard-size TW	24.43 (4.91)	2.12 (0.41)	** (27)	-91%
Wt target-size MFH	0.19 (0.05)	0.15 (0.03)	ns (22)	
No. discard-size MFH	5.02 (1.27)	4.12 (0.69)	ns (28)	
Wt target-size bugs	0.05 (0.02)	0.03 (0.01)	ns (10)	
No. discard-size bugs	16.29 (3.08)	16.44 (3.25)	ns (30)	
Wt octopus	0.83 (0.13)	0.75 (0.12)	ns (32)	
Wt squid	0.19 (0.07)	0.18 (0.06)	ns (23)	
Wt cuttlefish	0.28 (0.05)	0.32 (0.06)	ns (32)	
Wt bluestriped goatfish	0.10 (0.05)	0.08 (0.05)	ns (15)	
Wt yellowtail scad	0.47 (0.19)	0.32 (0.17)	** (27)	-32%
Wt discarded BC	12.07 (0.93)	11.99 (1.53)	ns (32)	
No. BC species	14.16 (0.86)	13.49 (0.86)	ns (32)	
No. discarded BC	585.64 (68.05)	456.18 (84.90)	** (32)	-22%
No. eye gurnard	364.87 (61.57)	260.19 (66.70)	** (32)	-29%
No. little scorpionfish	12.89 (2.92)	4.98 (2.61)	** (24)	-61%
No. non-marketed FH	46.59 (8.22)	46.72 (8.37)	ns (32)	
No. stinkfishes	7.14 (3.12)	8.59 (4.60)	ns (23)	
No. sthn rough prawn	16.23 (4.04)	4.72 (1.79)	** (27)	-71%
No. flatfishes	31.11 (5.62)	52.36 (6.21)	** (31)	+68%

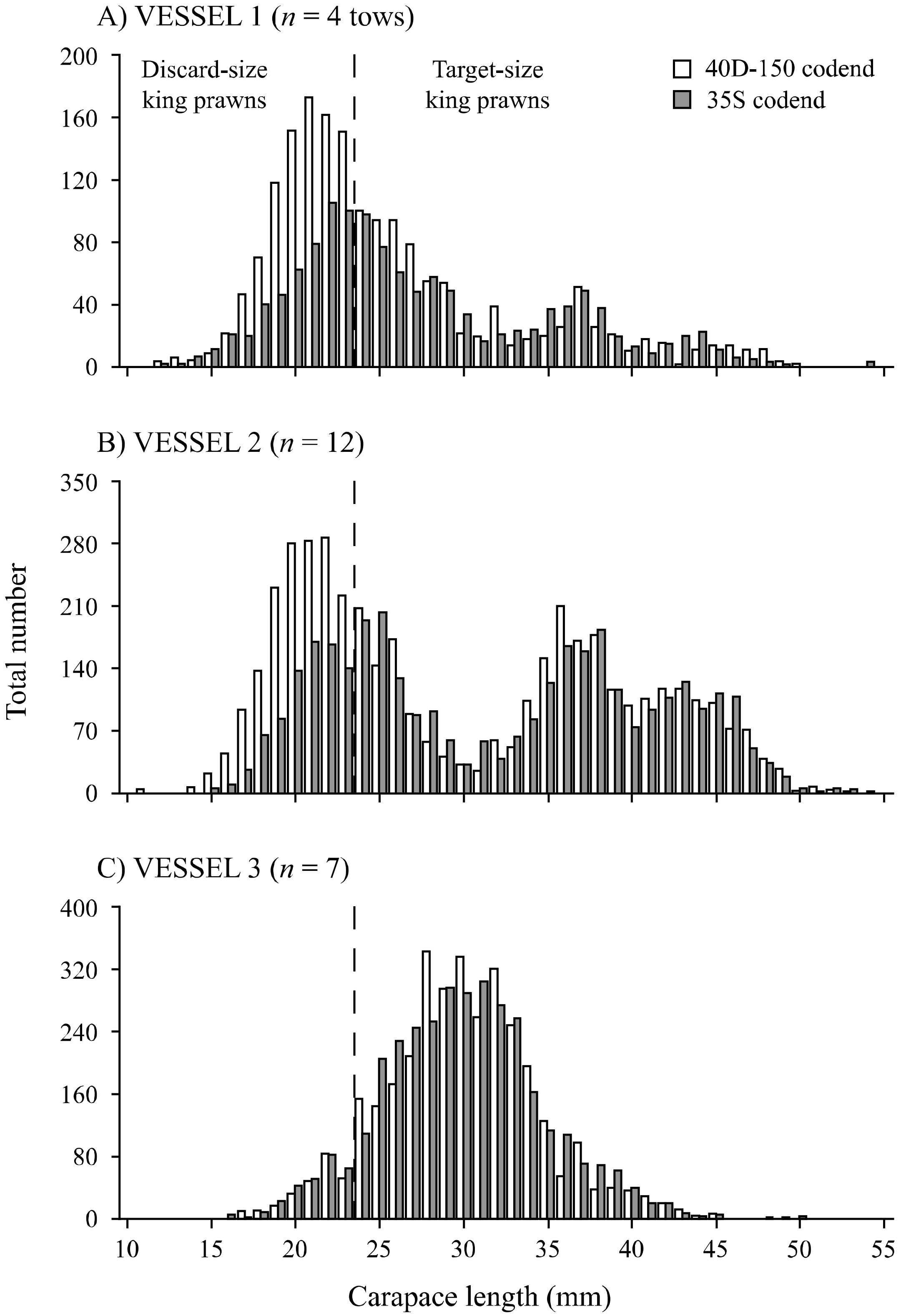

Figure 10. Size-frequency distributions of eastern king prawns caught in the 35S and 40D-150 codends onboard A) vessel 1, B) vessel 2, and C) vessel 3. The partition for target-size and discard-size prawns is shown.

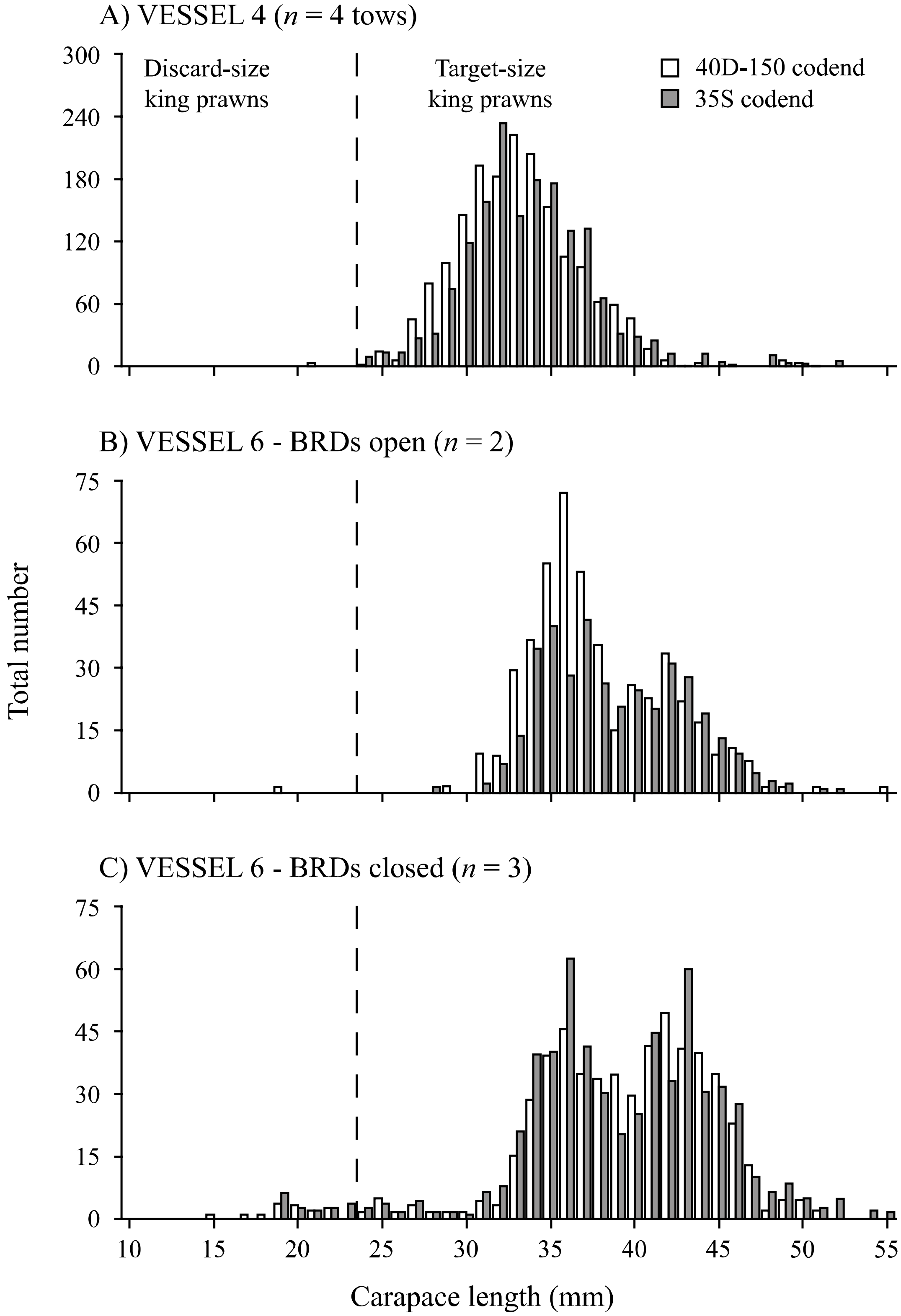

Figure 11. Size-frequency distributions of eastern king prawns caught in the 35S and 40D-150 codends onboard A) vessel 4, B) vessel 6 (BRDs open), and C) vessel 6 (BRDs closed). The partition for target-size and discard-size prawns is shown.

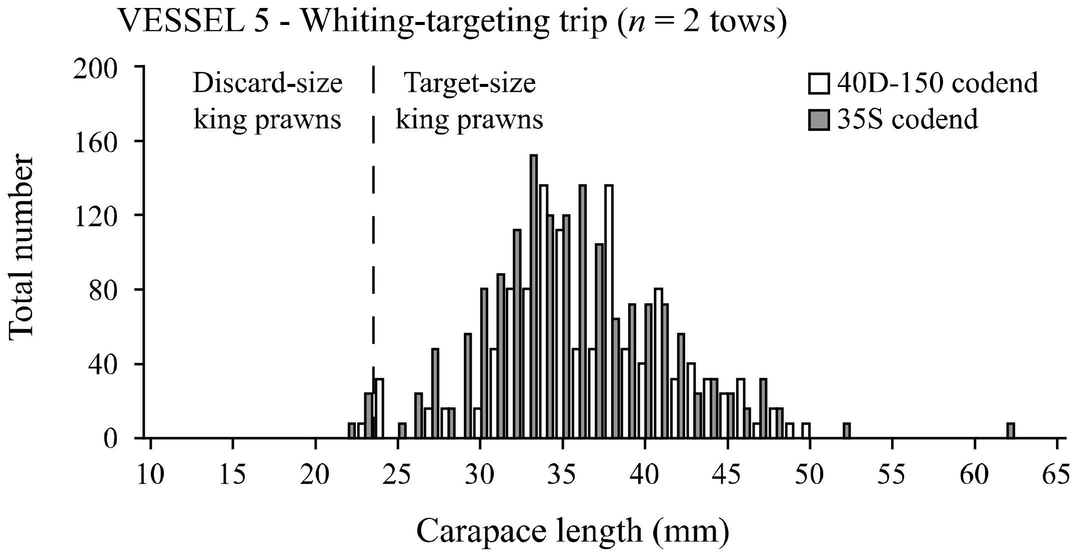

Figure 12. Size-frequency distributions of eastern king prawns caught in the 35S and 40D-150 codends onboard vessel 5 while targeting whiting. The partition for target-size and discard-size prawns is shown.

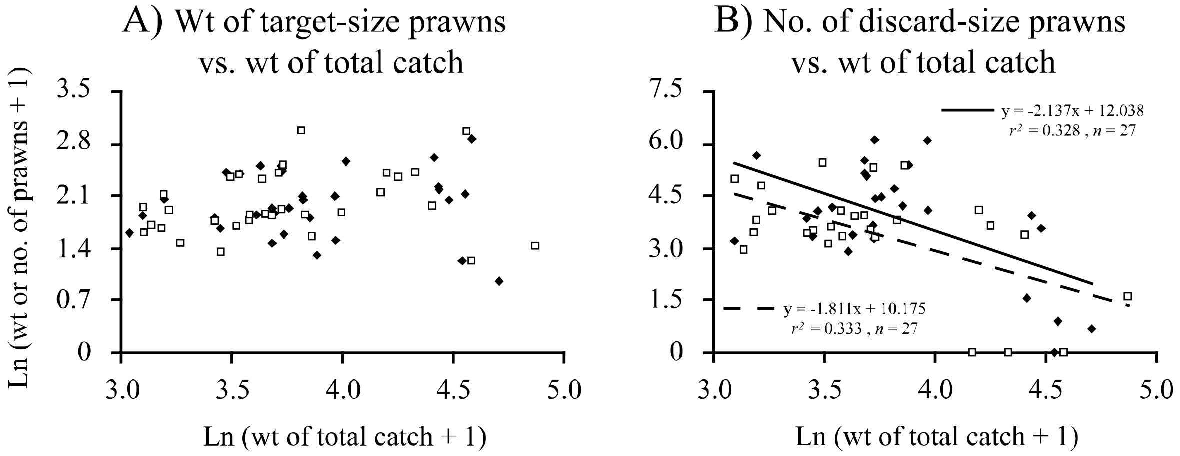

Figure 13. Plots of A) weight of target-size eastern king prawns vs. weight of the total catch (*n* = 32), and B) number of discard-size eastern king prawn vs. weight of the total catch (*n* = 27), where data are for the 35S (open squares) and 43-150 (filled diamonds) codends. ‘Total catch’ refers to retained and discarded catch of all organisms combined. Weights (wt) are in kg. All data have been ln(x + 1) transformed. Significant regression relationships are shown via a line-of-best-fit (35S – dashed line, 40D-150 – full line) along with the associated linear equation and coefficient of determination (r^2) value.

3.3.1.2. Trawl whiting

In most cases, trawl whiting of all sizes caught during the 32 tows comparing the 35S and 40D-150 codends were retained (or, at least, graded after death). The mean catch rates of target-size (≥ 14-cm FL) trawl whiting (by weight) in the two codends were not significantly different (Table 4). However, the mean catch rate of discard-size (< 14-cm FL) trawl whiting (by number) was significantly lower in the 35S codend, with the reduction in the capture of small whiting approximately 91% (Table 4).

As with catches of king prawn, there was variability in the performance of the 35S codend among vessels with respect to catches of whiting. Vessels 1, 2, 3 and 4 encountered varying numbers of discard-size trawl whiting, which mostly escaped from the 35S codend, along with some target-size whiting up to around 15-cm FL (Figure 14A – C, and Figure 15A). There was no evidence of losses of whiting larger than those sizes for those four trawlers. In contrast, there were shortfalls in the numbers of target-size whiting caught in the 35S codend across a wide range of sizes in the cases of vessels 5 (tows done to target whiting – Figure 16) and 6 (with BRDs open – Figure 15B). However, when the BRDs in both codends were closed in the case of the latter, the difference between the two codends with respect to target-size whiting caught was less (Figure 15C). Note again that the relatively small number of replicate tows done for paired comparisons onboard vessels 4 and 6 mean that these observations should be considered with caution.

As was the case for king prawns, the only regressions that added further insight into the results of the paired t-tests and the size-frequency distributions for trawl whiting variables were: catch weight of target-size trawl whiting vs. weight of the total catch; and number of discard-size whiting vs. weight of the total catch; therefore only these plots are presented (Figure 17). There were relatively clear, positive regression relationships between the catch weight of target-size trawl whiting and weight of the total catch for both codends ($P < 0.01$; Figures 17A). However, the regression relationships between codends were not significantly different with respect to slope and elevation ($P > 0.05$), indicating that increases in total catch quantity *per se* does not affect the total catch of target-sized whiting in the two codends any differently, across the range of total catch weights encountered for this codend contrast.

There was a significant positive regression relationship between the total number of discard-size trawl whiting and weight of the total catch for the 35S codend ($P < 0.05$; Figure 17B), but not for the 40D-150 codends ($P > 0.05$), preventing further analysis. However, it should be noted that these plots further demonstrate that the 35S codend consistently caught far fewer discard-size whiting than the 40D-150 codend.

3.3.1.3. Other byproduct

The mean catch rates of target-size (≥ 33-cm FL) marketable flathead (by weight) in the 40D-150 and 35S codend were not significantly different; as was the case for discard-size (< 33-cm FL) marketable flathead (Table 4). It is worth noting that the apparent difference in catches of the latter of sizes ≤ 23-cm FL between the two codend-types (Figure 18) is largely attributable to one tow – done in deep water (170 m) – during which relatively large quantities of small freespine flathead (were encountered. It is notable that no bluespotted flathead of these sizes were encountered in that tow or any of the other 31 tows. In contrast, the vast majority (approximately 90% by number) of target- and discard-size marketable flathead of sizes > 23-cm FL caught were bluespotted flathead.

The mean catch rates of target-size (≥ 10-cm CW) bugs (by weight) in the two codends did not significantly differ, with the disparity apparent in Table 4 due to an unusually large difference in the case of one tow. There was also no significant difference with respect to mean catch rates of discard-size (< 10-cm CW) bugs (by number) (Table 4).

There were no significant differences between the two codends for mean catch rates (by weight) of octopus, squid, cuttlefish and bluestriped goatfish. In contrast, mean catch rates of yellowtail scad (by weight) were significantly lower in the 35S codend, representing a consistent shortfall of approximately 32% (Table 4).

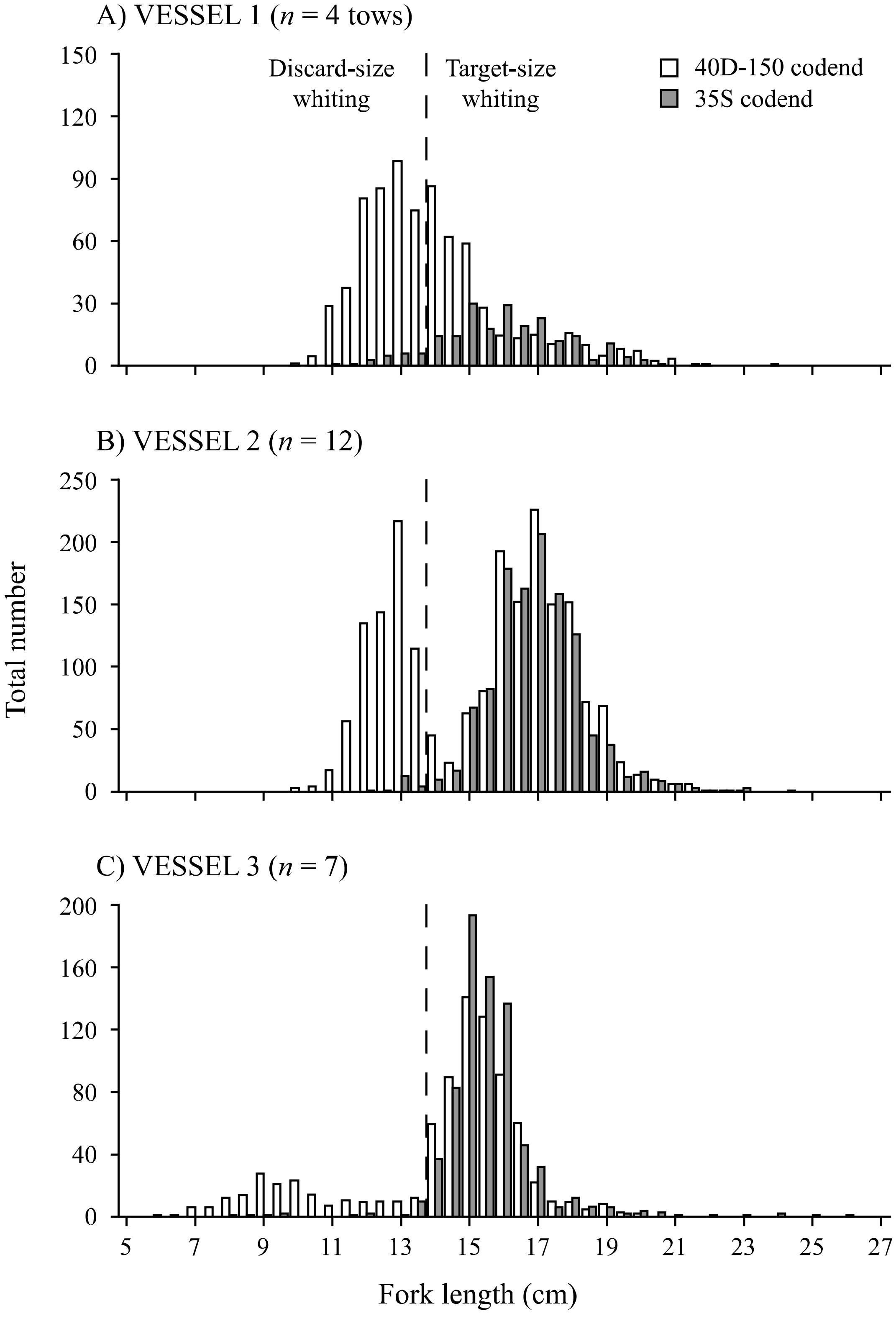

Figure 14. Size-frequency distributions of trawl whiting caught in the 35S and 40D-150 codends onboard A) vessel 1, B) vessel 2, and C) vessel 3. The partition for target-size and discard-size whiting is shown.

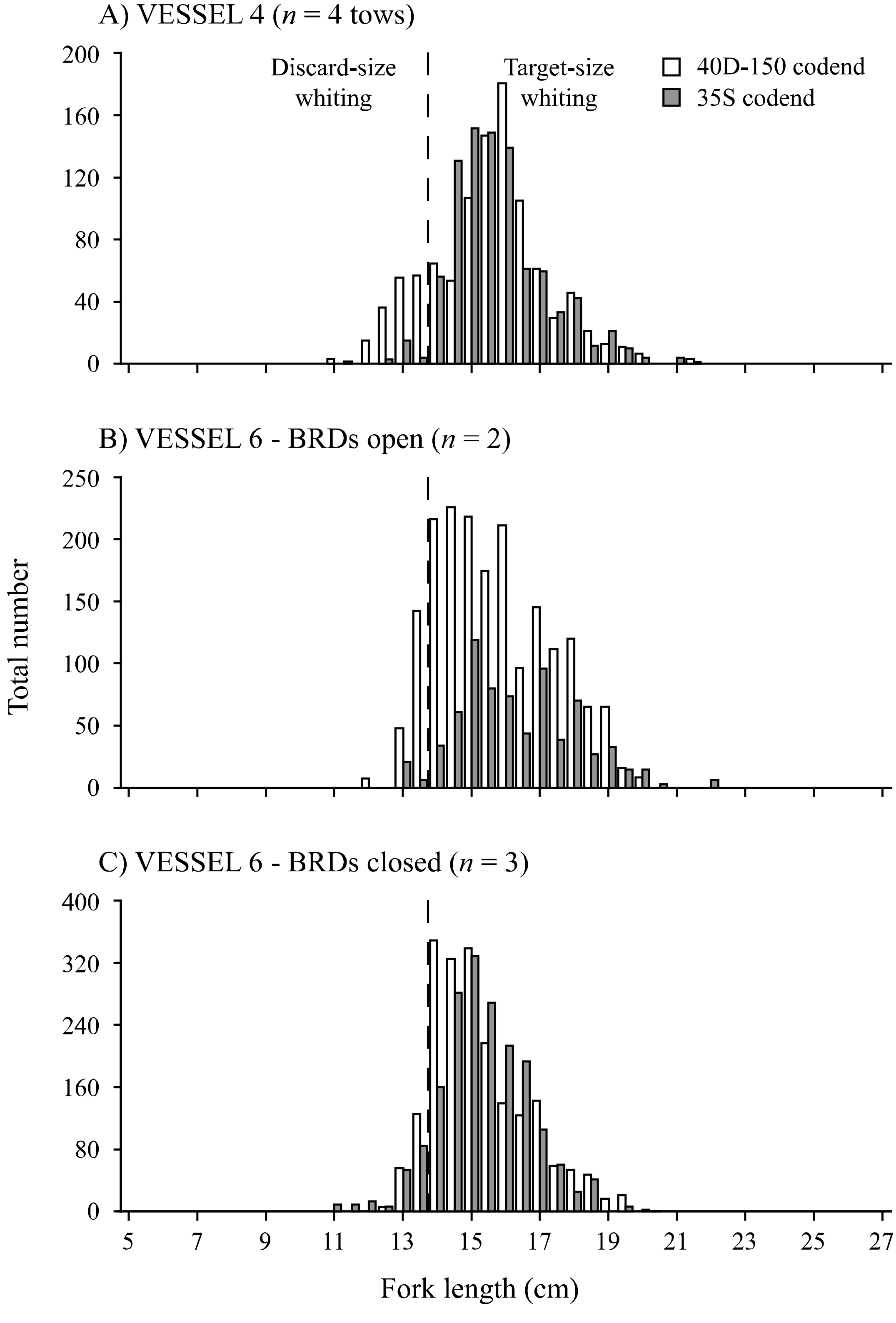

Figure 15. Size-frequency distributions of trawl whiting caught in the 35S and 40D-150 codends onboard A) vessel 4, B) vessel 6 (BRDs open), and C) vessel 6 (BRDs closed). The partition for target-size and discard-size whiting is shown.

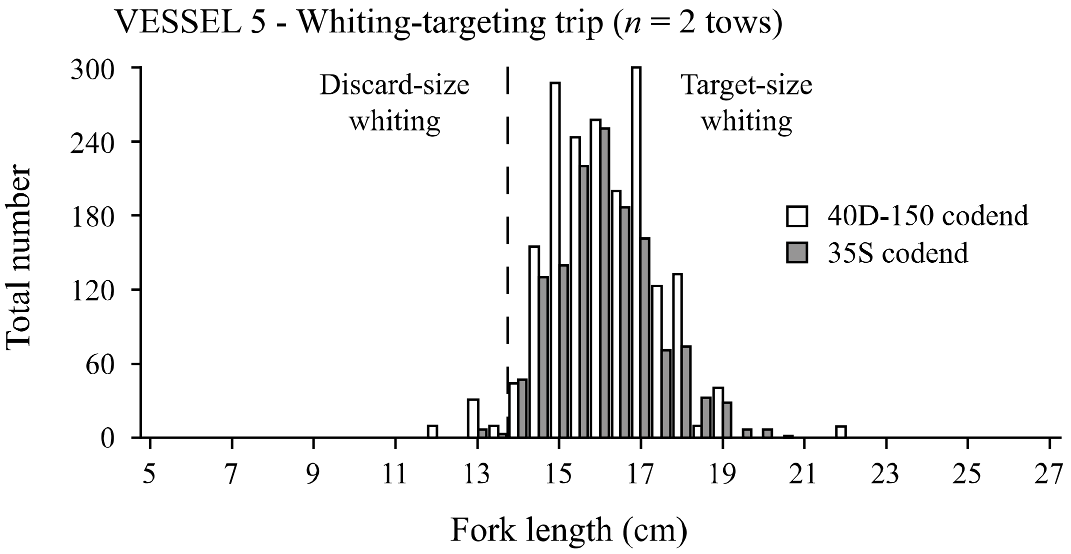

Figure 16. Size-frequency distributions of trawl whiting caught in the 35S and 40D-150 codends onboard vessel 5 while targeting whiting. The partition for target-size and discard-size whiting is shown.

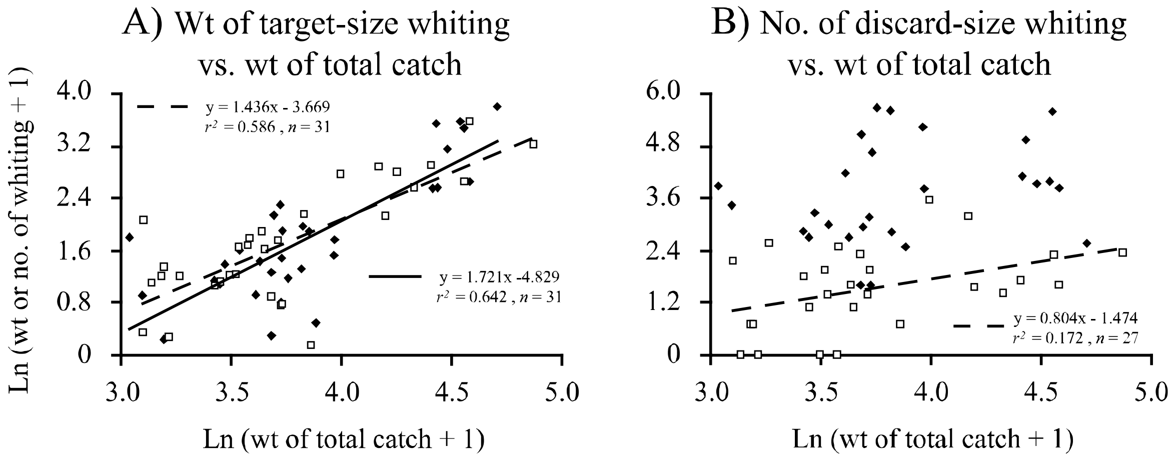

Figure 17. Plots of A) weight of target-size trawl whiting vs. weight of the total catch (*n* = 32), and B) number of discard-size trawl whiting vs. weight of the total catch (*n* = 27), where data are for the 35S (open squares) and 43-150 (filled diamonds) codends. ‘Total catch’ refers to retained and discarded catch of all organisms combined. Weights (wt) are in kg. All data have been ln(x + 1) transformed. Significant regression relationships are shown via a line-of-best-fit (35S – dashed line, 40D-150 – full line) along with the associated linear equation and coefficient of determination (r^2) value.

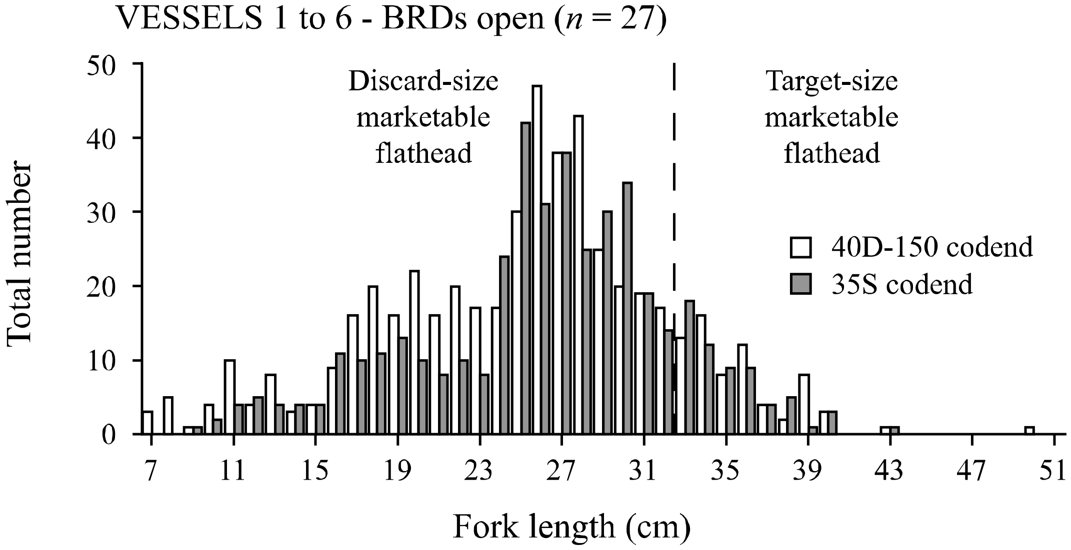

Figure 18. Size-frequency distributions of all marketable flathead species caught in the 35S and 40D-150 codends (BRDs open) for that paired comparison, combined across all vessels. The partition for target-size and discard-size marketable flathead is shown.

3.3.1.4. Discarded bycatch

Totals of 159 and 152 species (excluding eastern king prawn) were recorded from catches in the 40D-150 and 35S codend respectively (Appendix A). There were no significant differences between the two codends in mean catch rates of discarded bycatch (by weight) or bycatch species, but the mean catch rate of bycatch individuals was significantly lower in the 35S codend, with the reduction in unwanted bycatch individuals approximately 22% (Table 4).

Bycatches were numerically dominated by eye gurnard, which accounted for more than half of bycatch individuals recorded. The mean catch rate of eye gurnard was significantly lower in the 35S codend, with the reduction in the rate of their capture approximately 29% (Table 4). Further, this difference can be largely attributed to similarly lower capture rates for sizes of eye gurnard < 10-cm FL (Figure 19). Significant reductions also occurred in the cases of little scorpionfish (*Scorpaenodes smithi*) and southern rough prawn (*Trachypenaeus curvirostris*) (approximately 61 and 71% respectively). It is also worth noting that far fewer threespined cardinalfish – a small, abundant, deeper-water species – were caught in the 35S codend (350 fish) than in the 40D-150 codend (3,202 fish) during the deepwater tow.

There was no significant difference between the two codends with respect to mean catch rates of individuals of non-marketed flathead species (Table 4), with the vast majority (approximately 94%) of this catch comprising longspine flathead (*Platycephalus longispinis*) of a wide range of sizes (Figure 20). This was also the case for stinkfishes (several species combined – refer to Appendix A) (Table 4). In contrast with most other bycatch species or groups of bycatch species, flatfishes (flounders and soles of various species combined – refer to Appendix A) were caught at a significantly greater rate in the 35S codend than in the 40D-150 codend, with an increase in catch rate of approximately 68% (Table 4).

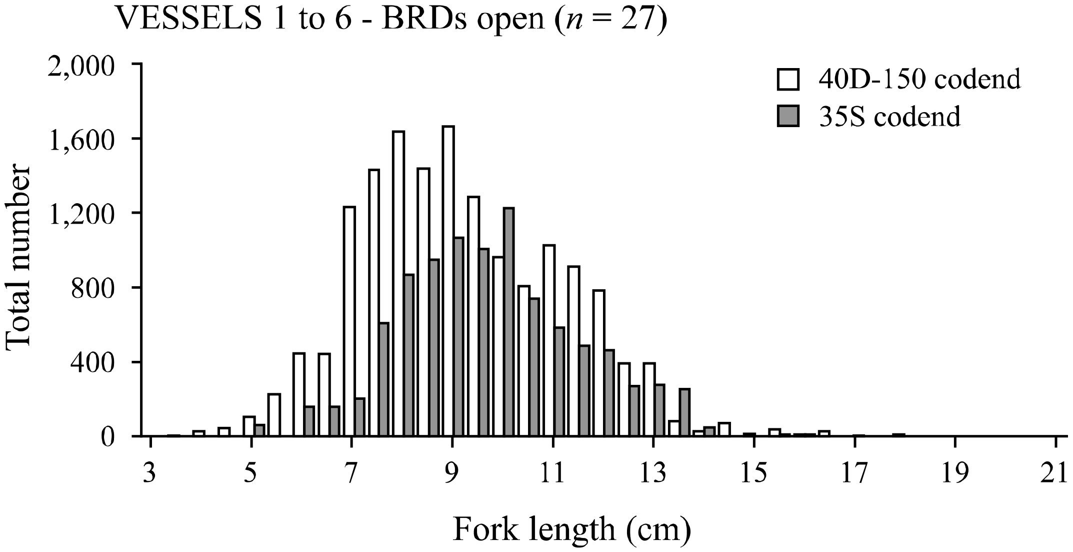

Figure 19. Size-frequency distributions of all eye gurnard caught in the 35S and 40D-150 codends (BRDs open) for that paired comparison, combined across all vessels.

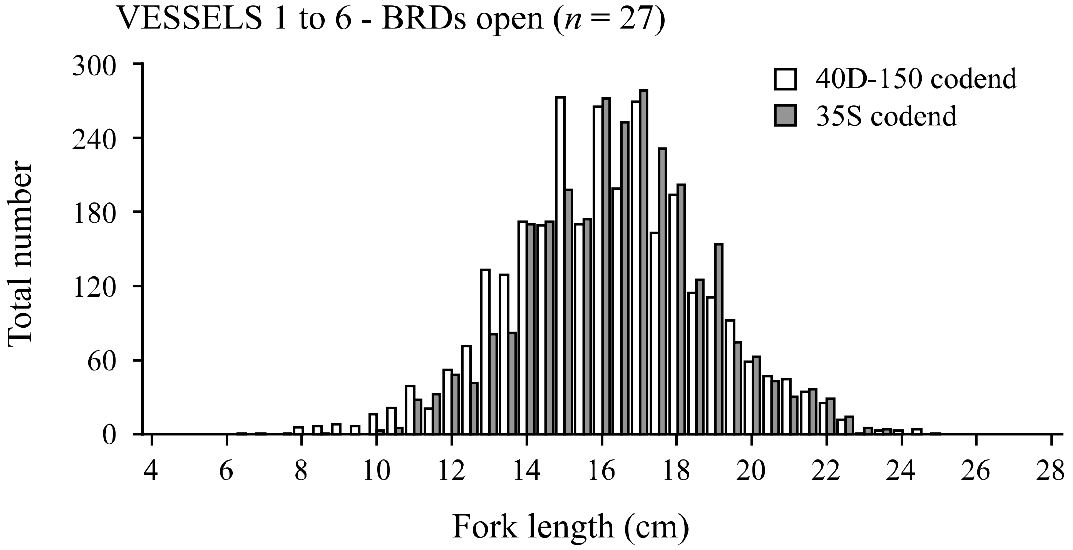

Figure 20. Size-frequency distributions of all longspine flathead caught in the 35S and 40D-150 codends (BRDs open) for that paired comparison, combined across all vessels.

3.3.2. 35S vs. 40D-200 codend comparison

The differences in catches between the 35S and 40D-200 codends, summarised in Table 5 below, were, in general, similar to those described above for the 35S vs. 40D-150 codend (BRDs open) comparison. It should be noted that BRDs were open for all 10 tows done in the case of this comparison. For these tows the weight of total catch (i.e., retained and discarded animals combined) ranged between 37.7 and 103.0 kg (mean ± SE = 67.4 ± 7.0 kg) in the 40D-200 codend, and between 31.7 and 66.9 kg (46.3 ± 3.7 kg) in the 35S codend. The catch statistics for this contrast are summarised in Table 5 below.

Table 5. Mean catch rates (± SE) in the 40D-200 and 35S codends h^{-1} (n = 10 tows) for the main target and byproduct species/groups (EKP, eastern king prawns; TW, trawl whiting, MFH, marketable flathead species), total discarded bycatch (BC) variables, and the same bycatch species/groups presented for the 35S vs. 40D-150 codend contrast (FH, flathead). Weights (Wt) are in kg. The results of two-tailed paired t-tests are shown where appropriate (ns, catches not significantly different at P = 0.05; na-1, insufficient tows for analysis; na-2, insufficient numbers caught tow^{-1} to permit meaningful analysis; *, significantly different at P = 0.05; **, significantly different at P = 0.01), along with the % difference where catch rates were significantly different.

Catch variable	**Mean catch h^{-1} (total n = 10 tows)** 40D-200 codend	35S codend	**Result of paired t-test (*n* for test)**	**Decrease (-) or increase (+) from 40D-200**
Wt retained EKP	3.26 (0.34)	2.92 (0.27)	ns (10)	
Wt target-size EKP	3.12 (0.34)	2.84 (0.28)	ns (10)	
No. discard-size EKP	32.09 (11.65)	18.43 (6.74)	* (10)	-43%
Wt target-size TW	0.94 (0.31)	0.40 (0.13)	** (6)	-57%
No. discard-size TW	0.75 (0.32)	0.04 (0.04)	na-1 (4)	
Wt target-size MFH	0.18 (0.06)	0.19 (0.08)	ns (8)	
No. discard-size MFH	2.90 (0.61)	2.89 (0.72)	ns (10)	
Wt target-size bugs	0.09 (0.04)	0.06 (0.04)	ns (7)	
No. discard-size bugs	33.98 (6.58)	33.13 (6.84)	ns (10)	
Wt octopus	0.73 (0.12)	0.55 (0.10)	ns (10)	
Wt squid	0.01 (0.01)	0.06 (0.02)	na-2 (9)	
Wt cuttlefish	0.76 (0.23)	0.74 (0.21)	ns (10)	
Wt bluestriped goatfish	0.09 (0.04)	0.11 (0.05)	ns (10)	
Wt yellowtail scad	0.03 (0.01)	0.02 (<0.01)	ns (6)	
Wt discarded BC	17.22 (2.83)	10.69 (1.57)	** (10)	-38%
No. BC species	11.56 (0.41)	10.87 (0.49)	ns (10)	
No. discarded BC	944.12 (104.43)	333.68 (46.59)	** (10)	-65%
No. eye gurnard	516.37 (90.72)	199.36 (40.49)	** (10)	-61%
No. little scorpionfish	263.45 (72.19)	3.61 (0.76)	** (8)	-99%
No. non-marketed FH	30.23 (13.31)	17.80 (6.07)	ns (10)	
No. stinkfishes	10.06 (4.26)	3.85 (1.67)	** (5)	-62%
No. sthn rough prawn	7.13 (2.84)	4.51 (0.96)	ns (8)	
No. flatfish	43.70 (6.00)	44.59 (3.46)	ns (10)	

3.3.2.1. Eastern king prawn

All eastern king prawns caught during these 10 tows were retained. The mean catch rates of retained and target-size eastern king prawn (by weight) in the 40D-200 and 35S codend did not significantly differ, while there were significantly fewer (43%) discard-size prawns caught h^{-1} in the 35S codend (Figure 21; Table 5).

The same suite of dependent and independent variables tested for regression relationships in the 35S vs. 40D-150 contrast (see subsection 3.3.1.1.) were also tested here. Perhaps not surprisingly given the similarities between the 40D-200 and 40D-150 codends, results for these analyses were very similar to those for the previous codend contrast and so are not presented in detail. In summary, there was no clear statistical evidence that variability in the weight of total catch affected the performances of the 35S and 40D-200 codends any differently from each other with respect to the capture of target-size or discard-size eastern king prawns, although this could also be due in part to the relatively small sample size (i.e., *n* = 10).

3.3.2.2. Trawl whiting

The mean catch rate of target-size trawl whiting (by weight) in the 40D-200 codend was significantly lower than that in the 35S codend, with the shortfall in their capture being approximately 57% (Table 5). This shortfall was apparent across most sizes of whiting caught (Figure 22).

Discard-size trawl whiting were caught in only four of the ten replicate tows, preventing a statistically rigorous comparison for this variable. Nevertheless, it is worth noting that the total numbers of these small whiting (i.e., sum of those four tows) in the 40D-200 and 35S codends were 19 and 1 fish respectively (Figure 22).

There were only six and four tows during which target- and discard-size trawl whiting, respectively, were caught, preventing meaningful regression analyses with respect to dependent catch variables.

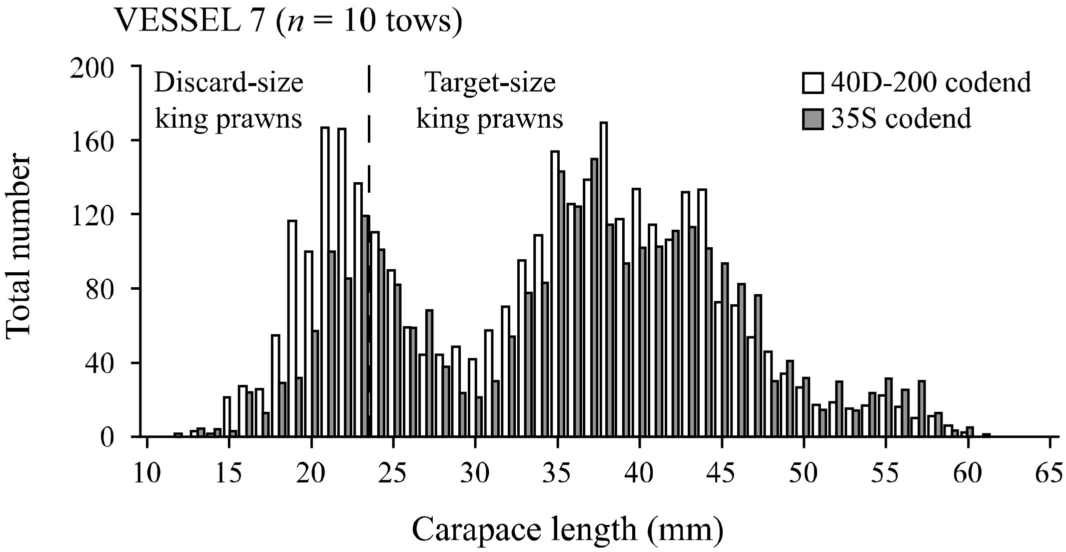

Figure 21. Size-frequency distributions of eastern king prawns caught in the 35S and 43D-200 codends done on eastern king prawn trawl grounds onboard vessel 7. The partition for target-size and discard-size prawns is shown.

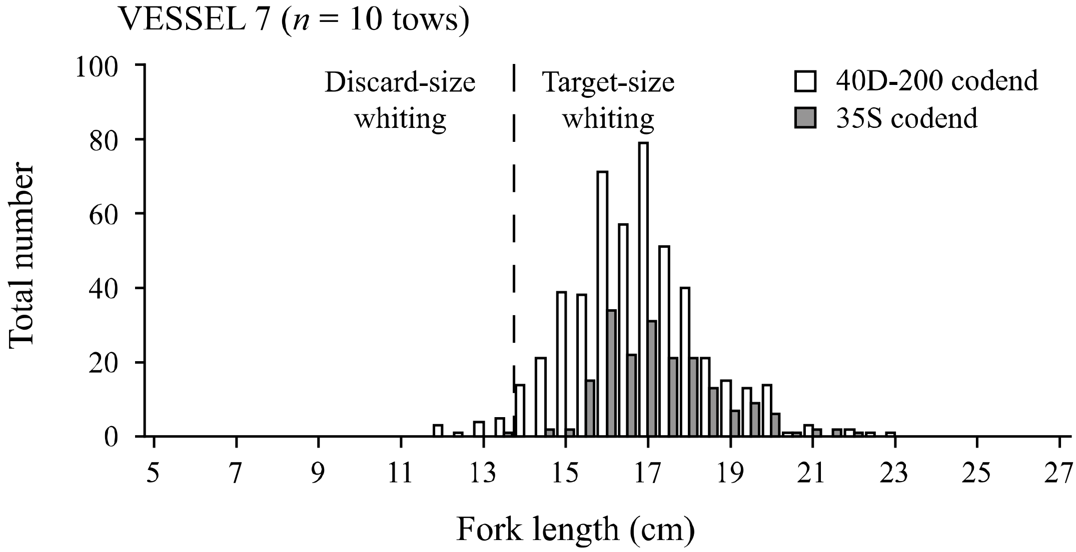

Figure 22. Size-frequency distributions of trawl whiting caught in the 35S and 43D-200 codends done on eastern king prawn trawl grounds onboard vessel 7. The partition for target-size and discard-size whiting is shown.

3.3.2.3. Other byproduct

The mean catch rates of target- and discard-size marketable flathead (by weight and number respectively) in the 40D-200 and 35S codends were not significantly different (Table 5). The same result was the case for target- and discard-size bugs (by weight and number respectively); and for weights of octopus, cuttlefish, bluestriped goatfish and yellowtail scad (Table 5). However, only one or two squid were caught during each tow, preventing meaningful analysis and interpretation of that dataset.

3.3.2.4. Discarded bycatch

Totals of 95 and 90 species (excluding eastern king prawn) were recorded from catches in the 40D-200 and 35S codend respectively (Appendix A). There were no significant differences between the two codends in the mean number of bycatch species caught h^{-1}, but mean catch rates of discarded bycatch by both weight and number did significantly differ, with catch rates in the 35S codend approximately 40% and 65% lower respectively (Table 5).

As was the case for the 35S vs. 40D-150 codend contrast, significantly fewer mean eye gurnard and little scorpionfish were caught h^{-1} in the 35S codend than in the 40D-200 codend, although the proportional sizes of the reductions (61and 99% respectively) were considerably greater in the case of the latter codend comparison (Table 5). There was also a significant reduction (62%) in mean stinkfishes caught h^{-1} in the 35S codend compared with the 40D-200 codend (Table 5). However, there was no significant difference between the two codends with respect to mean catch rates of individuals of non-marketed flathead species (combined), southern rough prawn and flatfishes (Table 5).

3.3.3. 35S vs. 45D-150 codend comparison

Of the 13 paired comparisons done onboard vessel 8 for the 35S vs. 45D-150 codend contrast, only three replicate tows (one trip) were completed with the BRDs open. The shortfalls in total catches (three tows combined) of eastern king prawns and trawl whiting in the 35S codend were 24% and

79%, which was deemed unacceptable by the trawl operator. As a consequence, the BRDs were closed up during the subsequent three trips (10 replicate tows) at the insistence of the trawl operator.

Despite the three replicate tows with BRDs open not being enough for statistically rigorous catch comparisons, some interesting observations and simple comparisons using the length frequency distributions from those tows can still be made. Further, the 10 replicate tows completed with the BRDs closed provides a direct comparison of catches between a 45-mm diamond-mesh codend and the 35S codend where, assuming the two trawls are fishing equally efficiently, the only difference between the two trawls is the size and orientation of the codend meshes. For these 10 tows the weight of total catch (i.e., retained and discarded animals combined) ranged between 21.8 and 100.7 kg (mean ± SE = 51.1 ± 7.9 kg) in the 45D-150 codend, and between 16.6 and 88.0 kg (47.6 ± 7.6 kg) in the 35S codend. The catch statistics for this contrast are summarised in Table 6 below.

3.3.3.1. Eastern king prawn

All eastern king prawns caught during the 10 tows with BRDs closed were retained. The mean catch rates of retained and target-size eastern king prawn (by weight) in the 45D-150 and 35S codend did not significantly differ, while not enough discard-size prawns were caught to allow formal analysis for that catch variable (Figure 23; Table 6).

Closing up the BRDs reduced the difference between the two codends with respect to catches of target-sized king prawns, and particularly prawns of sizes between 33- and 38-mm CL (Figure 23).

Owing to: 1) the clarity of the results presented in Figure 23; 2) the insufficient number of replicate tows done with the BRD open (i.e., n = 3); and 3) the prohibitively small numbers of discard-size eastern king prawns caught; regression analysis was either not appropriate or not necessary for this codend contrast, and therefore was not attempted. However, it is worth noting that, for the three tows done with the BRDs open (and with almost identical tow durations) the total catch weight (all organisms) in the 45D-150 codend was 21, 33 and 112 kg. During these three tows the 35S codend caught 1, 16 and 58% lower quantity of total catch (by weight) respectively, and 0, 30 and 33% lower quantitiy of target-size eastern king prawn (by weight) respectively, than the 45D-150 codend.

3.3.3.2. Trawl whiting

As was the case for eastern king prawns, the mean catch rates of target-size trawl whiting (by weight) in the two codends did not significantly differ, while not enough discard-size whiting were caught for analysis for that catch variable (Figure 24; Table 6). Further, the shortfall in catches of target-sized whiting in the 35S codend when the BRDs were open was lessened by closing the BRDs (Figure 24), although the shapes of two length frequency distributions in Figure 24B suggest the possibility of a problem with the data collection, or an extreme case of small-scale variability in whiting populations, rather than a true reflection of the differences in whiting catches between the two codends. Consequently, this observation should be considered with caution.

For similar reasons as those stated in the case of eastern king prawns, regression analyses involving trawl whiting catch variables were not done. However, again it is worth noting that during the three tows done with the BRDs open (i.e., total catch weights in the 45D-150 codend of 21, 33 and 112 kg), the 35S codend caught 52, 83 and 78 % lower quantity of target-size trawl whiting (by weight) respectively.

Table 6. Mean catch rates (± SE) in the 45D-150 and 35S codends (BRDs closed) h^{-1} (n = 10 tows) for the main target and byproduct species/groups (EKP, eastern king prawns; TW, trawl whiting, MFH, marketable flathead species), total discarded bycatch (BC) variables, and the same bycatch species/groups presented for the 35S vs. 40D-150 codend contrast (FH, flathead). Weights (Wt) are in kg. The results of two-tailed paired t-tests are shown where appropriate (ns, catches not significantly different at $P = 0.05$; na-1/2, insufficient tows and insufficient numbers caught tow^{-1} to permit meaningful analysis; *, significantly different at $P = 0.05$; **, significantly different at $P = 0.01$), along with the % difference where catch rates were significantly different.

Catch variable	**Mean catch h^{-1} (total n = 10 tows)** **45D-150 codend**	**35S codend**	**Result of paired t-test (*n* for test)**	**Decrease (-) or increase (+) from 40D-200**
Wt retained EKP	4.39 (0.70)	4.16 (0.57)	ns (10)	
Wt target-size EKP	4.39 (0.70)	4.16 (0.57)	ns (10)	
No. discard-size EKP	na	na	na-1/2 (3)	
Wt target-size TW	1.25 (0.61)	1.03 (0.58)	ns (9)	
No. discard-size TW	na	na	na-1/2 (2)	
Wt target-size MFH	0.24 (0.10)	0.14 (0.07)	* (7)	-41%
No. discard-size MFH	9.80 (2.84)	5.59 (2.14)	* (8)	-43%
Wt target-size bugs	0.08 (0.02)	0.06 (0.02)	ns (7)	
No. discard-size bugs	15.74 (2.68)	14.09 (2.90)	ns (10)	
Wt octopus	0.35 (0.19)	0.32 (0.11)	ns (8)	
Wt squid	0.06 (0.03)	0.06 (0.02)	ns (9)	
Wt cuttlefish	0.71 (0.22)	0.67 (0.18)	ns (10)	
Wt bluestriped goatfish	0.11(0.06)	0.03 (0.01)	ns (7)	
Wt yellowtail scad	2.38 (0.58)	1.60 (0.37)	ns (10)	
Wt discarded BC	15.95 (2.31)	14.30 (1.80)	ns (10)	
No. BC species	18.37 (1.85)	16.24 (2.41)	ns (10)	
No. discarded BC	587.16 (78.95)	548.11 (96.60)	ns (10)	
No. eye gurnard	448.81 (78.67)	458.99 (93.75)	ns (10)	
No. little scorpionfish	25.88 (7.62)	0.44 (0.25)	** (10)	-98%
No. non-marketed FH	5.34 (3.23)	4.87 (3.37)	ns (5)	
No. stinkfishes	na	na	na-1/2 (2)	
No. sthn rough prawn	6.39 (1.84)	0.49 (0.33)	** (10)	-92%
No. flatfish	20.40 (3.37)	31.64 (6.04)	** (10)	+55%

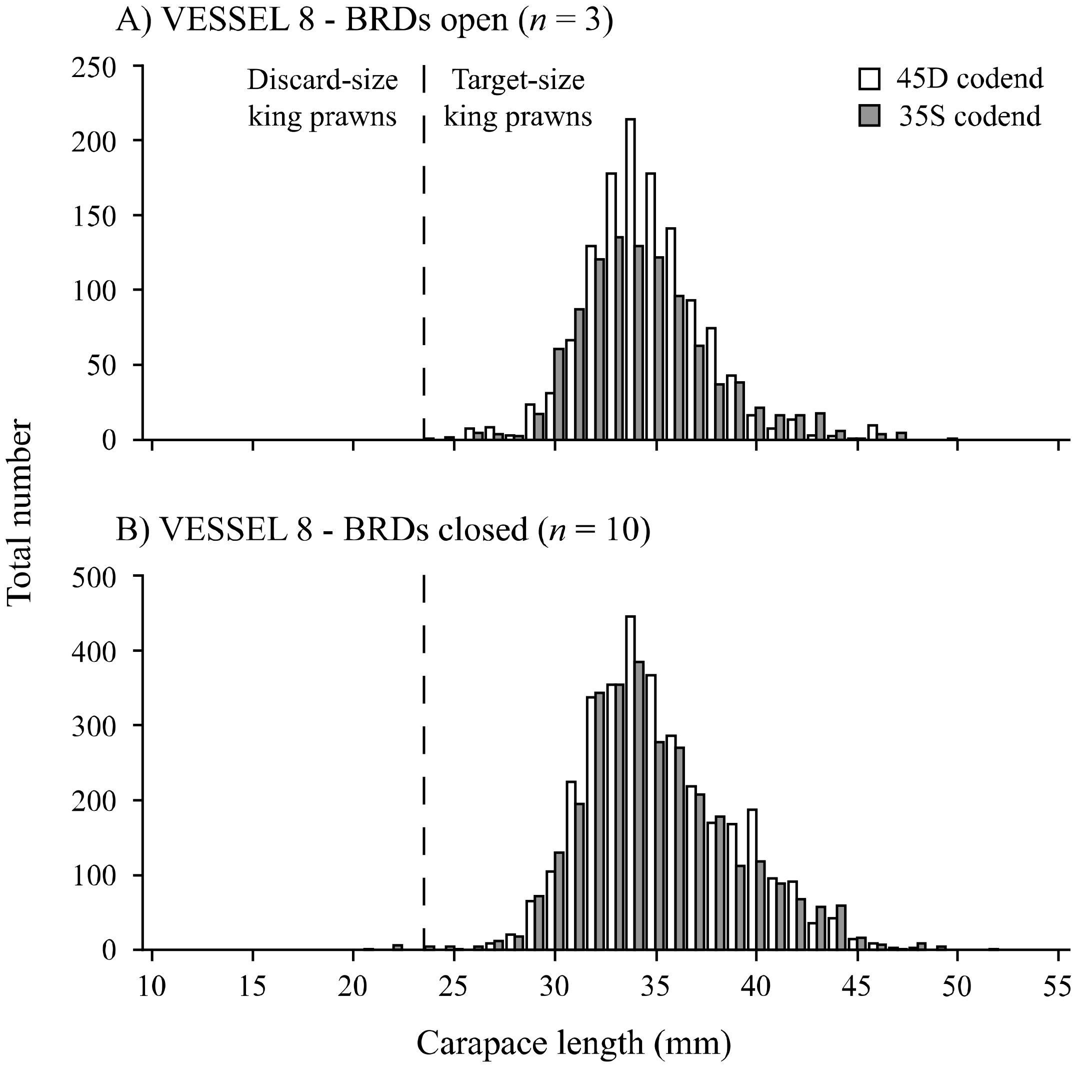

Figure 23. Size-frequency distributions of eastern king prawns caught in the 35S and 45D-150 codends onboard vessel 8 with A) BRDs open, and B) BRDs closed. The partition for target-size and discard-size prawns is shown.

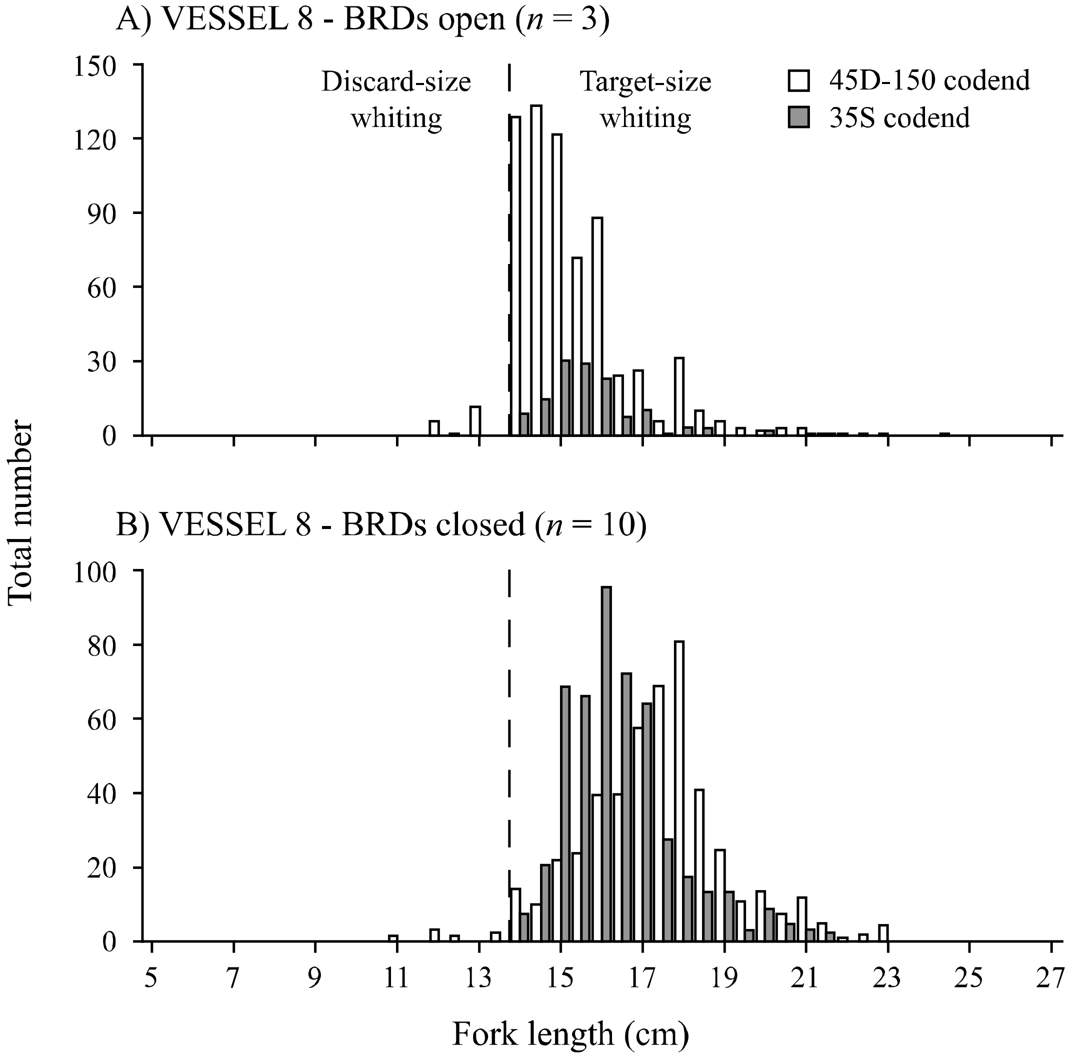

Figure 24. Size-frequency distributions of trawl whiting caught in the 35S and 45D-150 codends onboard vessel 8 with A) BRDs open, and B) BRDs closed. The partition for target-size and discard-size whiting is shown.

3.3.3.3. Other byproduct

Mean catch rates of both target- and discard-size marketable flathead (by weight and number respectively) were significantly lower in the 35S codend than in the 45D-150 codend, while mean catch rates (by weight) of octopus, squid, cuttlefish, bluestriped goatfish and yellowtail scad did not differ between the two codends (Table 6).

3.3.3.4. Discarded bycatch

A total of 84 species (excluding eastern king prawn) were recorded from catches in the both the 45D-150 and the 35S codend (BRDs closed; *n* = 10), while for the three tows done with BRDs open the totals were 57 and 46 species respectively (Appendix B). There were no significant differences between the two codends (BRDs closed) in the mean catch rates of discarded bycatch by both weight and number, nor the number of bycatch species caught h^{-1} (Table D).

Mean catch rates of eye gurnard (by number) did not significantly differ between the two codends (BRDs closed), as was the case for mean catch rates of individuals of non-marketed flathead species (Table 6). However, mean catch rates for little scorpionfish and southern rough prawn were significantly lower in the 35S codend than in the 45D-150 codend, with reductions in catches of 98 and 92% respectively (Table 6).

Catches of stinkfishes were too low and infrequent to generate means or to analyse, while flatfishes were caught at a significantly greater rate in the 35S codend than in the 45D-150 codend, with the increase in the rate of their capture in the former codend approximately 55% (Table 6).

3.4. Analysis of catches from trips targeting school prawn

A total of four trips onboard one vessel targeting school prawns was completed, comprising a total of 14 sampled tows (i.e., 14 paired comparisons). The trawled grounds were at latitudes between 29°24’ and 29°26’S and in relatively shallow water (between 6 and 10 m depth) compared with trips targeting eastern king prawn. The sampled tows ranged in speed between 1.9 and 2.2 knots (mean ± SE = 2.04 ± 0.01 knots; *n* = 28 readings) and in duration between 45 and 155 min (100 ± 8 min; *n* = 14).

3.4.1. 35S vs. 40D-200 codend comparison

The conventional diamond-mesh codend used was a 40D-200 codend, while a 35S codend was used on the opposite, outside trawl. A 29-mm square-mesh codend (29S) of identical general configuration to the 35S codend (except for twine diameter) was attached to the centre trawl to attempt a limited assessment of its suitability with respect to trawling for school prawns in the ocean (see section 3.4.2). All BRDs were open during all replicate tows. For these tows the weight of total catch (i.e., retained and discarded animals combined) ranged between 16.9 and 75.4 kg (mean ± SE = 44.8 ± 5.7 kg) in the 40D-200 codend, and between 9.3 and 45.6 kg (25.7 ± 3.2 kg) in the 35S codend. The catch statistics for this codend contrast are summarised in Table 7 below.

3.4.1.1. School prawn

The mean catch rate of school prawn was significantly greater in the 40D-200 codend than in the 35S codend, representing a mean shortfall of product in the latter of 57% (Table 7). While the numbers of prawns of sizes ≥ 22-mm CL caught in the two codends were very similar, the shortfall in catch in the 35S codend can be attributed to the considerably lower retention of target-size prawns of sizes < 22-mm CL (Figure 25). It is also worth noting that although relatively few discard-size prawns (i.e., < 15-mm CL) were caught in either codend, 92% fewer were caught in the 35S codend than in the 43-200 codend (Figure 25).

Given the efficiency of the 35S codend with respect to facilitating the escape of most sizes of school prawn, and that the maximum weight of total catch tow^{-1} in the 40D-200 codend was well below that for the 40D-150 codends (BRDs open) used on eastern king prawn trawl grounds, regression analyses for catch of school prawns vs. weight of total catch were deemed to be unnecessary.

Table 7. Mean catch rates (± SE) in the 40D-200 and 35S codends h^{-1} while targeting school prawns (n = 13 tows except in the case of school prawns, where an extra tow was processed) for the main target and byproduct species/groups (SP, school prawns; TW, trawl whiting, MFH, marketable flathead species), total discarded bycatch (BC) variables, and the most abundant bycatch species/groups (i.e., > 150 individuals in total) in catches. Weights (Wt) are in kg. The results of two-tailed paired t-tests are shown where appropriate (ns, catches not significantly different at $P = 0.05$; na-2, insufficient numbers caught tow^{-1} to permit meaningful analysis; *, significantly different at $P = 0.05$; **, significantly different at $P = 0.01$), along with the % difference where catch rates were significantly different.

Catch variable	**Mean catch h^{-1} (total n = 13/14 tows)**		**Result of paired t-test (*n* for test)**	**Decrease (-) or increase (+) from 40D-200**
	40D-200 codend	**35S codend**		
Wt retained SP (n = 14)	18.23 (2.61)	7.82 (1.65)	** (14)	-57%
Wt target-size TW	0.38 (0.32)	0.70 (0.69)	na-2 (7)	
No. discard-size TW	119.95 (54.91)	1.52 (1.06)	** (11)	-99%
No. discard-size MFH	12.11 (3.96)	2.05 (0.68)	* (12)	-83%
Wt squid	0.16 (0.07)	0.05 (0.01)	ns (13)	
Wt discarded BC	8.34 (1.95)	7.75 (2.13)	ns (13)	
No. BC species	12.02 (1.49)	8.10 (0.92)	** (13)	-33%
No. discarded BC	293.48 (85.46)	68.74 (23.93)	** (13)	-77%
No. common sand crab	51.39 (17.57)	12.38 (2.38)	* (13)	-76%
No. southern herring	10.74 (8.91)	8.06 (5.87)	ns (8)	
No. fortescue	20.79 (13.52)	0.37 (0.14)	** (13)	-98%
No. reticulated surf crab	5.07 (1.24)	4.19 (1.17)	ns (12)	
No. common stingaree	5.91 (3.00)	5.76 (2.99)	ns (13)	
No. sandy sprat	7.93 (4.31)	0.23 (0.23)	* (7)	-97%

3.4.1.2. Trawl whiting and other byproduct

The only byproduct species retained sufficiently frequently to allow statistical analysis was squid (comprising a mixture of bottle and slender squid), which was caught in mean quantities (by weight) in the two codends that were not significantly different. Other species retained included eastern shovelnose ray, largetooth flounder, bull shark and trawl (stout) whiting (Appendix C).

It is evident that considerable numbers of discard-size trawl whiting and marketable flathead species were present on the school prawn trawl grounds (Figure 26). The number of discard-size whiting caught h^{-1} in the 35S codend was significantly (99%) lower in the 35S codend than in the 40D-200 codend (Figure 26; Table 7). There was also significantly fewer (83%) discard-size marketable flathead (comprising mostly bluespotted with some dusky and northern sand flathead – Appendix C) caught h^{-1} in the 35S codend than in the 40D codend (Figure 27; Table 7).

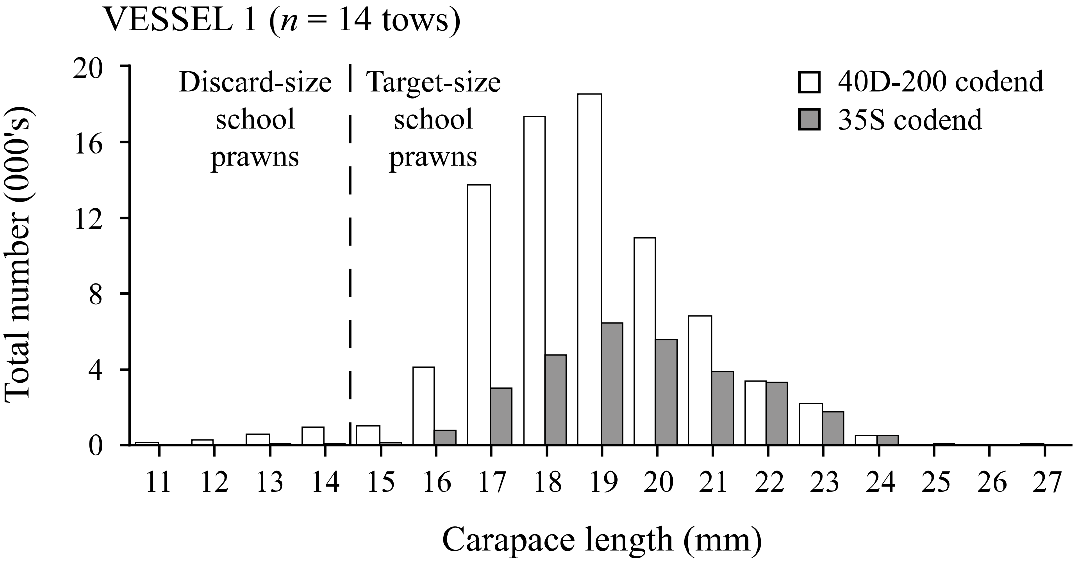

Figure 25. Size-frequency distributions of school prawns caught in the 35S and 40D-200 codends on school prawn trawl grounds onboard Vessel 1. The partition for target-size and discard-size prawns is shown.

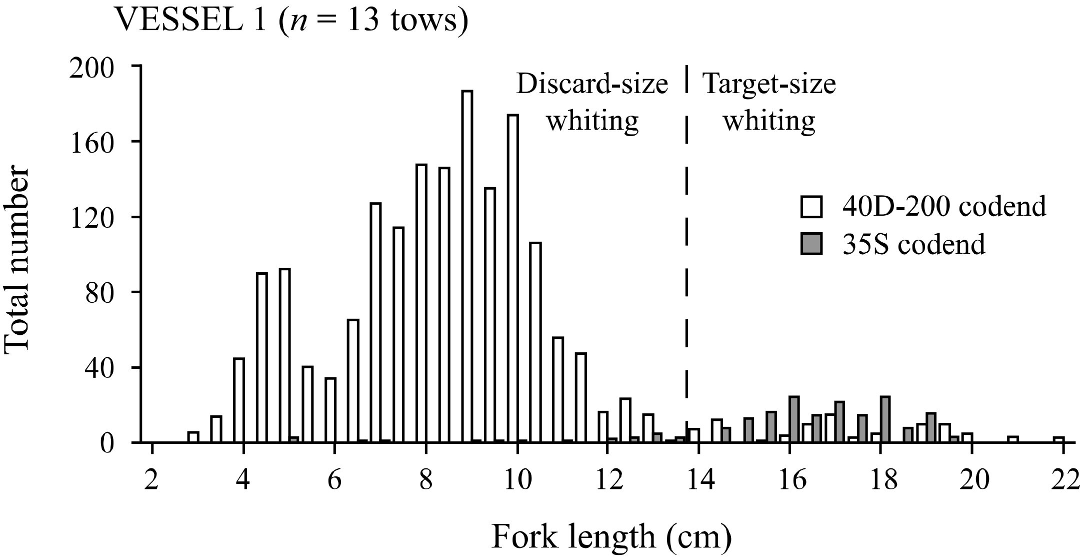

Figure 26. Size-frequency distributions of trawl whiting caught in the 35S and 40D-200 codends on school prawn trawl grounds onboard Vessel 1. The partition for target-size and discard-size whiting is shown.

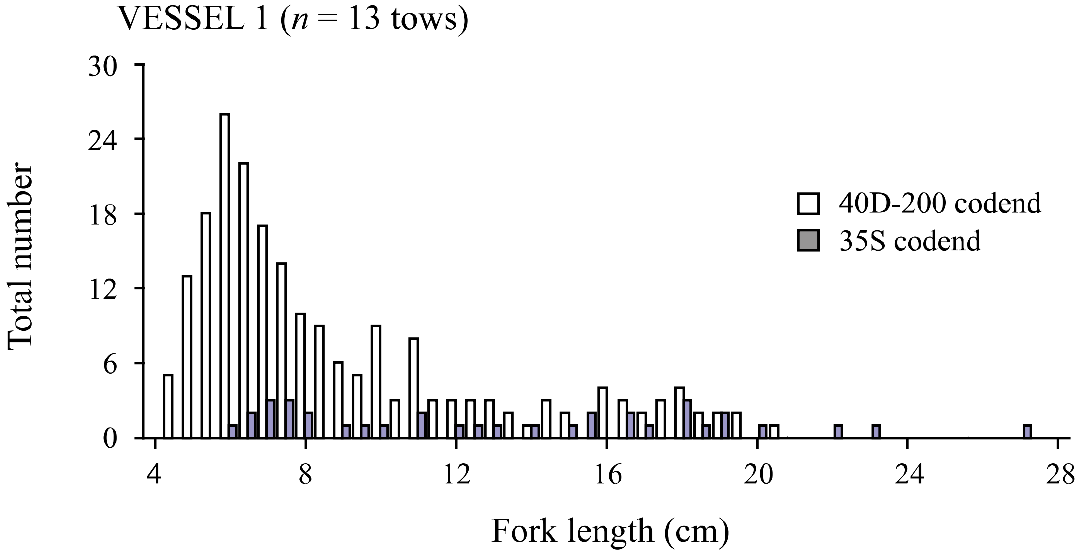

Figure 27. Size-frequency distributions of bluespotted flathead caught in the 35S and 40D-200 codends on school prawn trawl grounds onboard vessel 1.

3.4.1.3. Discarded bycatch

Totals of 53 and 46 species (excluding school prawn) were caught in the 40D-200 and 35S codend respectively (Appendix C). There was no significant difference in the mean weight of discarded bycatch h^{-1} between the 40D-200 and 35S codends, but significantly fewer mean individuals h^{-1} and species h^{-1} comprised the discarded bycatch from the 35S codend. The reduction in mean bycatch from the 40D-200 to the 35S codend with respect to these latter two variables was 77% and 33% respectively.

The most abundant bycatch species was common sand crab (*Ovalipes australiensis*), which was caught in significantly greater numbers h^{-1} in the 40D-200 codend than in the 35S codend, representing a reduction of 76% (Table 7). Other relatively abundant species to be caught in significantly fewer numbers in the 35S codend were eastern fortescue (*Centropogon australis*) and sandy sprat (*Hyperlophus vittatus*) (Table 7). In contrast, there were no significant differences in catch rates for southern herring (*Herklotsichthys castelnaui*), reticulated surf crab (*Matuta planipes*) and common stingaree (*Trygonoptera testacea*) (Table 7).

3.4.1.4. 29-mm square-mesh codend

It is important to note that, owing to inherent differences between the centre and outside (port/starboard) trawls in a triple-rigged trawl configuration, any detailed catch comparisons involving the centre-trawl configured 29S codend should be considered with extreme caution – an issue discussed in section 4. However, simple observations that can be made involve the size distributions (and hence the ‘prawn counts’ – i.e., number of school prawns $500g^{-1}$ – see below) of school prawn in codend catches among the three trawls. Although it is feasible to suspect that the size frequencies of prawns in the outside trawls might be influenced by a herding effect brought about by the otter boards, for the purposes of this simple comparison we are assuming that the fishing-efficiency of the three trawls with respect to different sizes of prawns were sufficiently similar.

The size distributions of school prawn in catches among the 40D, 35S and 29S codends (combined for each codend across tows during which all three codends were concurrently used; $n = 4$) significantly differed in the case of each of the three possible paired combinations (KS tests, $P < 0.001$; Figure 28). School prawn of sizes < 18-mm CL comprised a relatively greater proportion (by number) of the school-prawn catch in the 40D codend than in the 29S codend, which in turn comprised a greater proportion of prawns of those sizes than did the catch from the 35S codend (Figure 28).

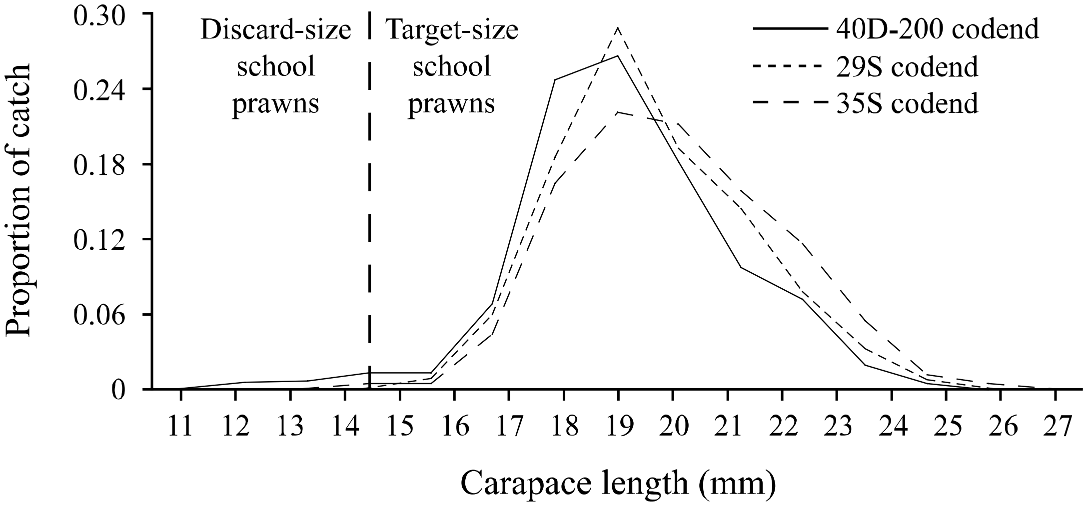

Figure 28. Size-frequency distributions of school prawn in the 40D-200, 29S and 35S codends, expressed as the proportion of the total catch of school prawns caught for that codend, and presented in continuous-line form. The partition for target-size and discard-size school prawns is shown.

There were significant differences in the mean prawn count detected among the 40D, 35S and 29S codends (1-factor ANOVA, $P < 0.01$, $n = 4$). Subsequent SNK tests revealed that the mean prawn count for the 29S codend (97.3 ± 1.4 prawns $500g^{-1}$) did not significantly differ from that for the 35S codend (95.0 ± 1.3), but both of these prawn counts were significantly lower than that for the 40D codend (104.5 ± 1.3) ($P < 0.01$).

3.5. Analysis of catches from an industry-developed square-mesh codend design

A total of four trips (12 replicate tows) was done targeting eastern king prawn using an industry-designed, 36-mm square-mesh (36S-ind) codend. The specifics relating to the construction materials and design of this codend are outlined in subsection 2.2.2.

The trawled grounds were at latitudes between 28°33’ and 29°00’S and depths of between 44 and 73 m. The sampled tows ranged in speed between 2.1 and 2.6 knots (mean ± SE = 2.37 ± 0.04 knots; $n = 24$ readings) and in duration between 125 and 235 min (171 ± 10 min; $n = 12$). For the 12 tows, the weight of total catch (i.e., retained and discarded animals combined) ranged between 35.1 and 141.2 kg (mean ± SE = 76.4 ± 9.8 kg) in the 36S-ind codend, and between 32.3 and 121.6 kg (70.8 ± 8.1 kg) in the 35S codend. The catch statistics for the 36S-ind vs. 35S codend contrast are summarised in Table 8.

With one exception, there were no significant differences between the 36S-ind and 35S codend for any of the catch variables examined (Table 8). That exception is the catch rate of cuttlefish, which was significantly greater in the 36S-ind codend than in the 35S codend (Table 8). The size-frequency distributions for eastern king prawns for the two codends were very similar (Figure 29).

Unfortunately, the low numbers of discard-size whiting in catches did not permit meaningful analyses for that variable. However, it should be noted that, although the paired t-test did not detect an overall difference between the two codends across all replicate tows (Table 8), the comparison of length-frequency distributions for the two codends suggests that there was a shortfall of target-sized whiting in the 35S codend compared with the 36S-ind codend catches (Figure 30).

Table 8. Mean catch rates (± SE) in the 36S-ind and 35S codends h^{-1} (*n* = 12 tows) for the main target and byproduct species/groups (EKP, eastern king prawns; TW, trawl whiting, MFH, marketable flathead species), total discarded bycatch (BC) variables, and the the same bycatch species/groups presented for the 35S vs. 40D-150 codend contrast (FH, flathead). Weights (Wt) are in kg. The results of two-tailed paired t-tests are shown where appropriate (ns, catches not significantly different at *P* = 0.05; na-1/2, insufficient tows and insufficient numbers caught tow^{-1} to permit meaningful analysis; *, significantly different at *P* = 0.05; **, significantly different at *P* = 0.01), along with the % difference where catch rates were significantly different.

Catch variable	**Mean catch h^{-1} (total *n* = 12 tows)**		**Result of paired t-test (*n* for test)**	**Decrease (-) or increase (+) from 40D-200**
	36S-ind codend	**35S codend**		
Wt retained EKP	3.99 (0.55)	4.04 (0.55)	ns (12)	
Wt target-size EKP	3.98 (0.55)	4.03 (0.55)	ns (12)	
No. discard-size EKP	2.24 (0.85)	2.84 (0.95)	ns (9)	
Wt target-size TW	2.08 (0.67)	1.61 (0.48)	ns (9)	
No. discard-size TW	na	na	na-1,2 (3)	
Wt target-size MFH	0.28 (0.08)	0.26 (0.06)	ns (11)	
No. discard-size MFH	2.77 (0.64)	2.38 (0.49)	ns (12)	
Wt target-size bugs	0.57 (0.13)	0.39 (0.11)	ns (11)	
No. discard-size bugs	15.28 (4.72)	11.32 (2.50)	ns (12)	
Wt octopus	0.39 (0.11)	0.39 (0.09)	ns (12)	
Wt squid	0.19 (0.05)	0.23 (0.05)	ns (12)	
Wt cuttlefish	0.32 (0.13)	0.22 (0.11)	* (12)	-32%
Wt bluestriped goatfish	0.10 (0.05)	0.15 (0.09)	ns (7)	
Wt yellowtail scad	0.09 (0.07)	0.05 (0.03)	ns (9)	
Wt discarded BC	17.39 (2.87)	16.03 (2.15)	ns (12)	
No. BC species	14.19 (0.95)	13.54 (1.00)	ns (12)	
No. discarded BC	586.23 (106.82)	593.59 (85.67)	ns (12)	
No. eye gurnard	254.23 (58.51)	298.61 (59.94)	ns (12)	
No. little scorpionfish	2.16 (1.41)	1.60 (0.39)	ns (10)	
No. non-marketed FH	155.90 (57.35)	145.48 (49.01)	ns (12)	
No. stinkfishes	6.78 (1.81)	7.03 (1.93)	ns (12)	
No. sthn rough prawn	20.17 (5.71)	21.34 (5.75)	ns (11)	
No. flatfish	73.90 (13.64)	67.10 (12.02)	ns (12)	

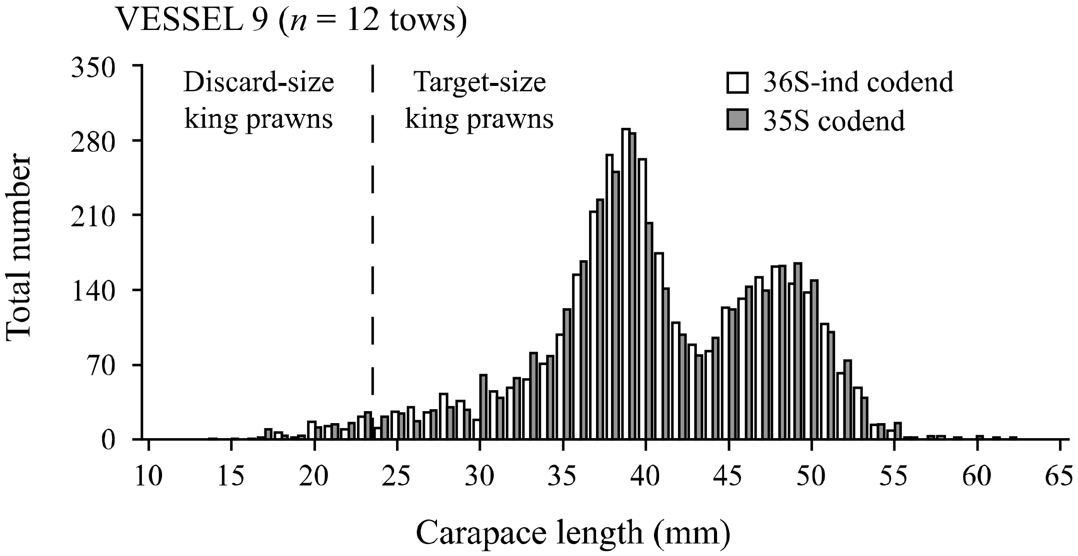

Figure 29. Size-frequency distributions of eastern king prawns caught in the 35S and 36D-ind codends on eastern king prawn trawl grounds onboard vessel 9. The partition for target-size and discard-size prawns is shown.

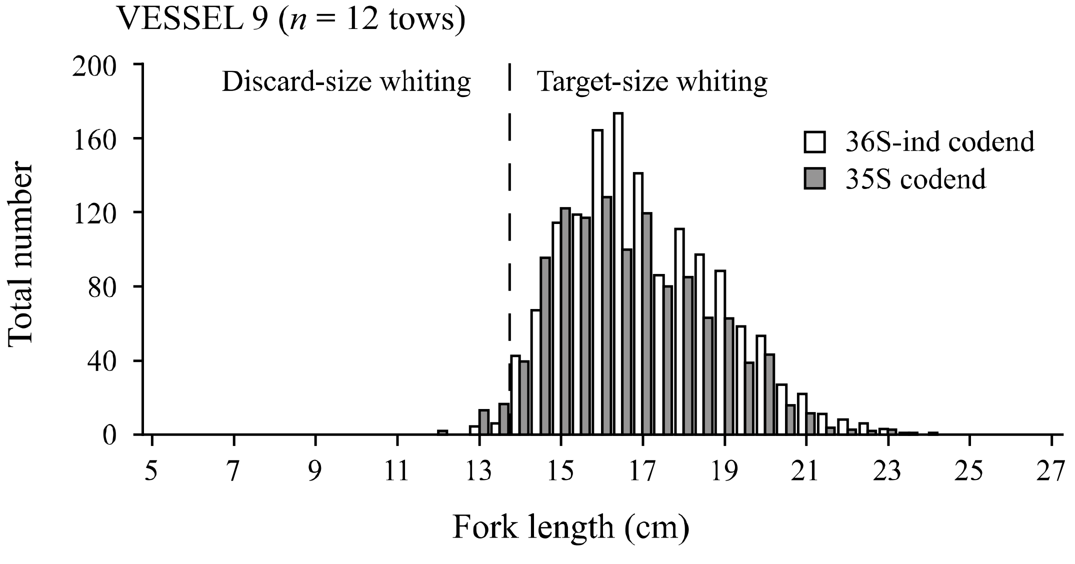

Figure 30. Size-frequency distributions of trawl whiting caught in the 35S and 36D-ind codends on eastern king prawn trawl grounds onboard vessel 9. The partition for target-size and discard-size whiting is shown.

3.6. Interactions with threatened, protected and other species of interest

Interactions with a range of species of particular interest with respect to their conservation status, importance to recreational and/or other commercial fisheries, or for other reasons, were evident during sampling operations.

3.6.1. Threatened and/or protected fish species

Although no interactions with threatened marine fish species such as grey nurse shark (*Carcharias taurus*), great white shark (*Carcharodon carcharias*), black rockcod (*Epinephelus daemelii*) and green sawfish (*Pristis zijsron*) were observed during this study, there were interactions between trawling operations and some protected species. A sandtiger shark (*Odontaspis ferox* – known locally as 'Herbst's nurse shark') was caught in the centre trawl on eastern king prawn trawl grounds in approximately 170 m of water. There were also relatively infrequent interactions with certain species of syngnathid: sad seahorse (*Hippocampus tristis* – 1 individual caught in 35 m of water); spiny pipehorse (*Solegnathus spinosissimus* – a total of 20 individuals caught over four trips and at depths of between 33 and 48 m); and Duncker's pipehorse (*Solegnathus lettiensis* – 1 individual caught in 44 m of water); which are protected in NSW. All of these animals were returned to the water apparently alive, but it is inherently impossible to provide reliable information as to their condition upon release, or their ultimate fate, within the scope and sampling protocols associated with this study (see Section 4.6 for a discussion).

3.6.2. Marine reptiles, marine mammals and seabirds

No marine reptiles (e.g., sea turtles and sea snakes), marine mammals (e.g., dolphins, porpoises, seals and whales) or sea birds (e.g., penguins, gulls, cormorants and albatrosses) were present in observed catches; nor were any of these animals observed to interact with the trawls in any way that might have caused them distress. However, it should be noted that porpoises (and/or dolphins) and seabirds of various, undetermined species were commonly observed to be opportunistically feeding on discards during onboard sorting of catches.

3.6.3. Sharks and rays

A total of 24 species of elasmobranches (sharks and rays) was recorded in catches sampled during this study (Appendices A – C), although only some were retained at any time. Eastern shovelnose ray were caught in small numbers quite frequently during the observed trawl operations and, owing to their marketability, were in most cases retained for sale. A total of 460 eastern shovelnose rays (*Aptychotrema rostrata*) was caught in the outside trawls during the 34 viable sampling trips, with 349 of these retained. Other, less-frequently caught elasmobranch species also retained at times were: southern fiddler ray (*Trygonorrhina fasciata*; 15 retained of 40 caught in total); gummy shark (*Mustelus antarcticus*; 2/6); common sawshark (*Pristiophorus cirratus*; 1/2); bull shark (*Carcharhinus leucas*; 1/1); and whitespotted guitarfish (*Rhynchobatus australiae*; 1/1).

Elasmobranches caught in notable numbers in sampled catches and always discarded included: common stingaree (371 in total); greenback stingaree (*Urolophus viridis*; 269); coffin ray (*Hypnos monopterygium*; 155); crested hornshark (*Heterodontus galeatus*; 34); and spotted wobbegong (*Orectolobus maculatus*; 20). Small total numbers of catsharks, skates and various other sharks and rays were also infrequently recorded (refer to Appendices A – C).

Although only one carcharhinid (i.e., 'requiem' or 'whaler') shark – a bull shark – was recorded in the sampled catches (Appendix C), large whaler-type sharks were commonly observed following astern of the vessel immediately following gear retrieval.

3.6.4. Non-target species of particular commercial and/or recreational importance

Only three species considered to be of importance recreationally and to other commercial fisheries were caught in frequencies and/or numbers worth highlighting – pearl perch (*Glaucosoma scapulare*), tailor (*Pomatomus saltatrix*) and blue swimmer crab (*Portunus pelagicus*). Small juvenile pearl perch (i.e., < approximately 15-cm FL) was recorded in 43 of the 140 sampled codend catches from eastern king prawn grounds during the study; usually in numbers between one and five, but sometimes up to 10 or 11 individuals (140 in total). In contrast, between one and eight juvenile tailor were recorded in 11 of the 28 sampled codend catches from school prawn grounds only (41 in total). Blue swimmer crab was recorded in a total 33 codend catches, from both eastern king and school prawn trawl grounds, with usually only one (but up to five) crab caught codend^{-1} tow^{-1} (56 in total). Approximately two-thirds of these crabs were retained for sale.

Other important species that were relatively less frequently caught included a total of 17 juvenile snapper (*Pagrus auratus*) – all on eastern king prawn trawl grounds. Two dusky flathead – one of which was of legal size – were recorded in sampled catches from eastern king prawn trawl grounds, while four small dusky flathead were caught on the school prawn trawl grounds. Finally, totals of 11 tarwhine (*Rhabdosargus sarba*), 4 silver trevally (*Pseudocaranx dentex*), 3 spanner crab (*Ranina ranina*), 1 juvenile mulloway (*Argyrosomus hololepidotus*), 1 teraglin (*Atractoscion aequidens*), 1 eastern rock lobster (*Jasus verreauxi*) and 1 sand whiting (*Sillago ciliata*) were recorded in catches sampled during the study (Appendices A – C).

4. DISCUSSION

4.1. General overview

This research project has provided valuable information with respect to assessing the potential for fleet-wide effectiveness of gear-based bycatch-mitigating measures introduced into the fishing industry. Most research into bycatch reduction in NSW commercial fisheries has centred around relatively small-scale, discrete experiments to develop gear-based modifications that reduce bycatch, with considerable success. However, commercial fishers have often been reluctant to adopt such measures owing to concerns about the applicability of the conclusions from such research across the gears and vessels in the fishery, and across the inherently variable environmental conditions they experience (i.e., catches, sea and weather conditions, etc.). Irrespective of the scientific validity of the results of the small-scale experiments involved in such cases, further scientifically-documented trials across a wider spectrum within a given fishery can serve to: 1) validate the results of the initial research conducted to develop bycatch-reduction measures (within the range of catch quantities encountered); 2) involve a greater proportion of the OPT fishers (overall) in the formal development and assessment process; and 3) provide additional insights for fisheries managers and industry regarding successful implementation in the fishery.

The effectiveness of square-mesh codends with respect to improving the size selection of prawns (or shrimps), and/or reducing bycatch in trawls targeting those species in other parts of the world has been widely documented (e.g., Thorsteinsson, 1992; Broadhurst *et al.*, 1999a; Campos *et al.*, 2002, 2003; Courtney *et al.*, 2007). In NSW, square-mesh codends have been demonstrated to reduce the capture of small prawns and/or bycatch in prawn trawls by significant amounts (Broadhurst *et al.*, 2004, 2006a; Macbeth *et al.*, 2007). Following successful experiments to identify an appropriate mesh size and codend design (Broadhurst *et al.*, 2004; Macbeth *et al.*, 2004), Macbeth *et al.* (2007) attempted a fleet-wide assessment of the effectiveness of a 27-mm square-mesh codend in the NSW estuarine school-prawn trawl fleet, and found that there was significant variability in size-selection performance among trawlers and estuaries. These studies have collectively provided sufficient information for fisheries managers to develop legislation to implement appropriately-designed square-mesh codends throughout the estuarine fleet.

The process to develop and implement a codend-mesh-based bycatch-mitigating measure in the NSW ocean prawn-trawl fishery began with successful experiments to identify and develop an appropriate 35-mm square-mesh codend design for eastern king prawns (Broadhurst *et al.*, 2005, 2006a, 2006b). The current study provides a detailed assessment of the performance of that general design across a wider subset of the north coast fleet, including, for the first time, vessels targeting school prawns. This assessment should assist fisheries managers in the implementation of appropriately-designed square-mesh codends throughout the OPT fleet.

4.2. Trawling for eastern king prawns

When compared with conventional diamond-mesh codends used to target eastern king prawns (or trawl whiting), the prescribed 35S codend design worked well with respect to significantly reducing the numbers of small prawns and/or whiting caught, without significantly reducing the quantities of targeted catch and retained byproduct – a result that correlates closely with results from earlier, small-scale studies with 35-mm square-mesh codends (Broadhurst *et al.*, 2005, 2006a, 2006b). Overall, the 35S codend caught averages of up to 43 and 91% fewer discard-size eastern king prawns and trawl whiting, respectively, than the conventional 40D-150 and -200 codends. There was, however, variability in the performance of the codend, with identical 35S codends used onboard different vessels exhibiting: 1) no clear reductions in discard-size prawns and/or whiting caught; and/or 2) shortfalls in the catches of target-sized prawns and/or whiting; compared with the diamond-mesh codends being used. Further, there was a sizable increase in the catch of target-sized prawns during the one tow done in considerably deeper water than all other tows done during the study, although little can be interpreted from this result owing to the lack of any replication. In some of the cases where shortfalls in retained catch in the 35S codend were observed, the opportunity to render the SMP and CSMP BRDs ineffective by covering up the BRDs provided evidence to confirm that the BRD was providing the escape route for the target-sized prawns and/or whiting.

It has been supposed that the most likely dominant factor in determining whether, and to what extent, marketable prawns and/or whiting escape the 35S codend via the CSMP BRD is the total quantity of animals entering the trawl during any given tow. The basis of this supposition is that, while a diamond-mesh codend can, with increasing catch quantity, expand laterally along its length and hence provide: 1) an increased volume for the catch to accumulate in; and 2) an increase in the total surface area of mesh openings to allow constancy of water flow through it; a square-mesh codend is, by design, of fixed volume and mesh-opening surface area. Consequently, and unlike the diamond-mesh codends (Herrmann, 2005), the accumulation of catch in a square-mesh codend progresses the leading surface of that catch further forward in the codend; in turn reducing the surface area of mesh openings available to maintain the flow of water through the codend. This reduction in mesh openings increases the pressure gradient (termed the ‘pressure drop’) across the mesh openings (from inside to outside the codend) and, therefore, the extent of turbulent flow generated by the water flowing past the twine, which in turn slows the net rate of increase in water flow through the remaining open meshes to less than proprtional to the net rate of water flow into the codend (Perry and Green, 1984; Mous *et al.*, 2002). It is thought that the main impact of this would be the proportional progression forward in the trawl of the ‘pressure wave’ that exists inside the trawl body forward of the opening to the codend (Dahm *et al.*, 2002; Mous *et al.*, 2002). It is noteworthy that it is the general position of this pressure wave in conventional diamond-mesh codends used in the NSW OPT fishery that determined the optimal positioning of the behavioural-type BRDs currently used (Broadhurst *et al.*, 1999b). The forward progression of the pressure wave might then result in some of the excess back-up of water exiting the gear through openings of least resistance forward of the codend, such as the BRD. This pattern of water flow within the gear might result in the escape or loss of greater quantities of marketable product through the BRD (an occurrence for which strong evidence has been presented in other studies – e.g., Macbeth, 2006) than would be the case for diamond-mesh codends, or for the same square-mesh codend containing smaller quantities of catch.

Despite the rationality of this theory, and the clear evidence of losses of target-size prawns and whiting via the BRDs for some vessels during this study, preliminary attempts at detecting differences between codend types with respect to formal regression relationships between catches of target-size prawns (or whiting) and total catch quantity (retained and discarded combined) for vessels targeting king prawns proved largely fruitless. In fact, somewhat surprisingly, the clear regression relationships between catches of target-size whiting and total catch quantity for the two codend types, which extended across comparable ranges of the latter variable, were very similar. This suggests that the influence of increases in total catch quantity *per se* on the capture of target-sized whiting does not significantly differ between the two codends within the range of total catch weights (retained and discarded catch combined) encountered during this study, and that factors other than (or in combination with) catch quantity facilitate the unwanted escape of target-size whiting via the BRD. However, attempts to detect relationships between catches of prawns or whiting and (separate) operational factors such as towing speed, tow duration and total headrope length, also proved fruitless. Therefore, attempts at more detailed, mixed-effects model-fitting to data collected during this study might be appropriate in further investigating the factors that potentially influence the fishing efficiency of the 35-mm square-mesh codend with BRD installed.

One way to address the issue of losses of target-size prawns and whiting might be via design changes to the 35S codend. The simplest solution would be to increase the volume of, and therefore the number of open meshes in, the codend via either lengthening it or increasing its circumference. It is, however, likely that lengthening the codend would introduce difficulties with respect to appropriate placement of the BRD. Recent research done with estuarine square-mesh trawl codends has indicated that the circumference of square-mesh codends is not a pivotal factor for the effectiveness of square-mesh codends in that fishery (Broadhurst *et al.*, unpublished data), and so a codend of increased circumference might be the more appropriate option. With a large enough volume, catch would accumulate in such a codend more similarly to a diamond-mesh codend and there would be far less chance of an increase in pressure drop caused by the forward build-up of catch. This would, in theory, result in the prevention of significant losses of target-size prawns and/or whiting via the BRD.

There were clear benefits via the use of the 35S codend with respect to reductions in discarded bycatch. The total number of discarded bycatch individuals was reduced by approximately 22 and 65% compared with catches in the 40D-150 and 40D-200 codend respectively. In most contrasts between the diamond-mesh codends and the 35S codend, up to 99% fewer eye gurnard and/or little scorpionfish – which are usually the most abundant of the discarded bycatch species in catches – were caught in the 35S codend. The consistent escape of many small individuals of other species, such as stinkfishes and rough prawn, through the meshes of the S35 codend was also evident. Conversely, onboard most vessels there were considerable increases in the capture of flatfishes (flounder and sole) in the 35S codend, which is consistent with results from research in other trawl fisheries that compared catches of fishes of similar, flattened transverse profile between square- and diamond-mesh codends (e.g., Petrakis and Stergiou, 1997; Macbeth *et al.*, 2004).

The trawl operators involved in this study also expressed concern over the apparent increase in mud and other sedimentary material mixed in with catches (compared with the conventional diamond-mesh codends) – referred to as ‘dirty catches’. Differences in water flow and associated forces and the resulting influence on the frequency of contact with the seabed are likely to be responsible for such observations. Considering the potential for a reduction in quality of the retained product, this issue warrants further attention.

It would not be possible to assess the bycatch-mitigating abilities of the 45D-150 codend relative to the commonly-used conventional codends using the data collected during this study primarily because the codend was not towed in a paired comparison against a conventional 40D codend. Furthermore, the majority of replicate paired tows against the 35S codend were done with the BRDs closed, which is not, technically, under normal commercial conditions. In summary, there is no clear evidence from tows done during this study to suggest that the 45D-150 codend performs as well as the 35S codend at reducing the capture of small animals. In fact, there is some evidence to show that the former performs similarly to (or only slightly better than) 40D-150 codends with respect to bycatch reduction.

The industry-designed 36-mm PE square-mesh codend generally performed similarly to the 35-mm PA square-mesh codend with respect to bycatch reduction, indicating that the specific netting material used to construct square-mesh codends is inconsequential with respect to their overall effectiveness. Therefore, if PE netting is thought by trawl operators to be superior with respect to longevity, availability, cost or other operational reasons, there is no reason for such material not to be used, providing the size of the mesh openings comply with the regulations.

4.3. Trawling for school prawns

The 35S codend allowed unacceptable quantities of target-size school prawns to escape, with a 57% shortfall in the quantity of prawns caught compared with catches in the conventional 43D-200 codend. The relatively low total catch quantities (retained and discarded catch combined) suggests that few, if any school prawns were escaping via the BRD installed in the 35S codend, although this cannot be ruled out. The comparative size-frequency distribution of school prawns caught in the 29S codend indicates that a square-mesh codend made from 29-mm mesh might be more appropriate than the 35S codend for ocean prawn trawlers targeting school prawns. Such a conclusion must, however, be considered with caution because the 29S codend was positioned on the centre trawl, which is inherently different to the two outside trawls with respect to design and, as a consequence, probably water flow and fishing efficiency. Nevertheless, it is arguable that limited comparisons between the size frequencies of prawns caught in the three codends poses no obvious problems and could be considered valid. In any case, further formal assessment of the suitability of a 29-mm square-mesh codend (or other mesh sizes smaller than 35 mm) on ocean school prawn grounds is advisable.

Despite the shortfall in catches of school prawns, the 35S codend performed very well with respect to reducing catches of discard-sized trawl whiting (99%) and discard-size individuals of marketed flathead species (83%), which were present in considerable numbers on the school prawn grounds. There were also considerable reductions in the numbers of other bycatch species, such as eastern fortescue, sandy sprat and common sand crab; with an overall reduction in discarded bycatch individuals of 77%. While a square-mesh codend made from smaller mesh would obviously be less effective at minimising the capture of such animals, its performance would be expected to be significantly better than conventional diamond-mesh codends, as has been demonstrated in the estuarine prawn-trawl fishery of NSW (Broadhurst *et al.*, 2004; Macbeth *et al.*, 2004). For example, using information provided by Broadhurst *et al.* (2006b), it would be reasonable to predict that a 29-mm square-mesh codend would allow most juvenile trawl whiting of sizes < approximately 12-cm FL to escape. This would account for the vast majority of the small trawl whiting actually caught by the 43D-200 codend on the school prawn grounds. It is also likely that some of the small bluespotted flathead caught by the 43D-200 codend would have escaped from a 29-mm square-mesh codend.

4.4. Trawling for whiting

Unfortunately, not enough replicate tows were done onboard trawlers specifically targeting whiting to allow a good comparison between the 35S codend and the conventionally-used diamond-mesh codends under the range of conditions typical for such trips. At least some additional trials to assess the suitability of such a codend for the specific targeting of trawl whiting are required.

The conclusions made regarding trips targeting eastern king prawns are also valid for trips targeting trawl whiting where total catch weights (i.e., retained and discarded catch combined) are within the ranges encountered during this study. Therefore, a 35-mm square-mesh codend of a larger circumference than that of the 35S codend might be a suitable candidate for avoiding losses of target-size whiting via the BRD during trips targeting whiting.

4.5. Interactions with threatened, protected and other species of interest

With the exception of relatively small and infrequent catches of syngnathids (seahorses and pipehorses) and one capture of a sandtiger shark (known locally as ‘Herbst’s nurse shark’), interactions with threatened and/or protected marine fish species were non-existent during the sampling done as part of this study. Similarly, there were no interactions with any marine reptile, marine mammal or seabird species that would warrant concern.

The elasmobranchs most commonly caught during this study were rays (e.g., stingarees, stingrays, coffin rays and shovelnose rays). Apart from some wobbegongs, horn sharks, catsharks and the sandtiger shark noted above, very few sharks were caught.

The only non-target species of significant commercial and/or recreational importance that were recorded in notable numbers during the study were pearl perch, tailor and blueswimmer crab. Very few individuals of all other species in this category were caught, including snapper and mulloway. Whereas relatively large numbers of these and other species are known to be caught in ocean waters in close proximity to river mouths following flood events (Miller, 2002), these species did not seem to be abundant on the trawl grounds during the current study.

4.6. Fate of discarded bycatch vs. fate of escapees during trawling

Many studies have been done to quantitatively examine the issue of mortalities associated with discarded bycatch from commercial trawling, while others have sought to estimate mortalities associated with organisms that escape through the trawl meshes or via BRDs (see Broadhurst *et al.*, 2006c for a comprehensive review). Some of the factors that influence the mortality rates of discards from trawling include the amount of time spent in the fishing gear, the quantity or type of bycatch (Kaiser and Spencer, 1995), duration of exposure to air (Hill and Wassenberg, 1990; Gamito and Cabral, 2003), and onboard handling techniques (Lancaster and Frid, 2002, Macbeth *et al.*, 2006). Alternatively, these factors may indirectly cause mortalities by rendering the surviving animals more susceptible to predation by birds and fish after being discarded (Hill and Wassenberg, 2000), owing to longer-term effects of physiological stress from emersion (Taylor and Spicer, 1987), and/or physical exertion during capture (Broadhurst *et al.*, 2002). In contrast, small prawns and fish escaping from through trawl meshes during fishing are not susceptible to the stresses associated with being brought onboard a vessel, subsequently handled, and then discarded at the surface. Therefore, their direct rates of mortality as a result of physical damage and/or physiological stress following an encounter with trawling are likely to be significantly lower than than those for discards (e.g., Macbeth *et al.*, 2006). However, the potential for higher-than-normal rates of predation upon escapees owing to, for example, their stressed, disoriented state, would still remain (Broadhurst *et al.*, 2006c).

In summary, the body of research relating to the comparative mortalities of discards and escapees from trawling activities (Broadhurst *et al.*, 2006c) suggests that, in the case of the NSW OPT fishery, the discard-size eastern king prawns, trawl whiting, flathead and other small bycatch organisms that escape through the meshes of the 35S codend would have greater rates of survival than if they were brought onboard the trawler in a conventional diamond-mesh codend. It is arguable as to whether the implementation of a 35-mm square-mesh codend throughout the fishery would ultimately provide benefits in the form of larger sustainable catches of the targeted species in the future (Ives, 2008). However, reductions in catches of all small organisms and the associated reductions in post-trawl-encounter mortalities can only be a positive result with respect to improvements in the overall environmental sustainability of the NSW OPT fishery.

5. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the above findings, the following conclusions and recommendations are made:

1. This study served to: 1) validate the results of the initial research conducted to develop a 35-mm square-mesh codend (within the range of catch quantities encountered); 2) involve a greater proportion of the OPT fishers (overall) in the formal development and assessment process; and 3) provide additional insights for fisheries managers and industry regarding successful implementation of a 35-mm square-mesh codend in the OPT fishery. It is recommended that similar assessments be done prior to formal legislation of gear-based bycatch-mitigation strategies in other NSW fisheries.

2. When compared with conventional diamond-mesh codends used to target eastern king prawns (or trawl whiting), the prescribed 35S codend design significantly reduced the numbers of discard-size prawns and/or whiting caught (i.e., by averages of up to approximately 43 and 90% respectively, depending on the conventional codend design) without significantly reducing the quantities of targeted catch and retained byproduct. Significant reductions in the discarding of non-retained bycatch species (by averages of up to 99%) were also evident. There was, however, variability in the performance of the 35S codend among vessels, with the 35S codend sometimes catching: 1) very similar quantities of small prawns and/or whiting to the conventional diamond-mesh codend; or 2) significantly smaller quantities of target-sized prawns and/or whiting than the conventional codend. In the case of the latter result, there was strong evidence to suggest that some target-size animals were escaping via the composite square-mesh panel BRD, probably as a result of an as yet undefined combination of catch and operational factors. Losses of marketable product via the BRD would probably be prevented in the case of a 35-mm square-mesh codend with a sufficiently greater circumference than the 35S codend assessed here. It is therefore recommended that such a further-modified codend be considered for mandatory use by OPT vessels targeting eastern king prawn and trawl whiting.

3. Although the 35S codend was very successful with respect to reducing the bycatch of the small, juvenile trawl whiting and flathead that inhabit the school prawn trawl grounds, it also facilitated the escape of unacceptable quantities of target-size school prawns through its meshes. Such losses would most likely be avoided in the case of a square-mesh codend with a sufficiently smaller mesh size (e.g., approximately 29 mm) and greater circumference (see previous point) than the 35S codend assessed here. It is therefore recommended that such a further-modified codend be considered for mandatory use by OPT vessels targeting school prawn.

4. There were few interactions with threatened and/or protected marine fish species (and none with marine reptiles, mammals and birds) during the ocean prawn trawl trips sampled. Similarly, there were few interactions with non-target species of major commercial and/or recreational importance, such as snapper and mulloway, during the sampled trips.

5. It is also recommended that a full-scale observer-based sampling program, spanning the entire coast and several years, be completed in the NSW OPT fishery once the appropriate square-mesh codends are made mandatory. Data from this program could be compared with the data collected in the observer program done in the fishery in the early 1990s to quantify the fishery-wide effects of the gear-based strategies introduced to reduce bycatch since that earlier research.

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7. APPENDICES

APPENDIX A: Mean catch rate (h^{-1}) (± SE) (by number) for each species recorded in sampled catches during the study. Data are for each codend type in the 35S vs. 40D-150 (BRDs open) (*n* = 32), 35S vs. 40D-150 (BRDs closed) (*n* = 3), and 35S vs. 40D-200 (BRDs open) (*n* = 10) codend contrasts done on eastern king prawn trawl grounds. Species are ordered according to 'Major group' and 'Family'. 'Unid.', unidentified.

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
BIVALVES							
Pectinidae							
Amusium balloti	Ballot's saucer scallop	1.845 (0.569)	0.673 (0.205)	0.533 (0.533)	0.241 (0.123)	0.576 (0.331)	0.076 (0.051)
Amusium sp.	Saucer scallop	1.470 (0.672)	1.278 (0.510)	-	-	2.794 (1.080)	4.422 (1.556)
Annachlamys flabellata	Fan scallop	-	-	-	-	-	-
CEPHALOPODS							
Loliginidae							
Photololigo chinensis	Broad squid	-	-	-	-	-	-
Photololigo sp.	Slender squid	1.727 (0.774)	1.477 (0.479)	1.369 (0.297)	-	0.027 (0.027)	-
Sepioteuthis australis	Southern calamari	0.137 (0.069)	0.056 (0.032)	-	-	-	0.036 (0.036)
Uroteuthis noctiluca	Bottle squid	-	-	-	-	-	-
Octopodidae							
Octopus australis	Southern octopus	6.266 (0.935)	5.350 (0.886)	6.234 (2.180)	4.265 (0.763)	6.042 (0.974)	4.975 (0.821)
Octopus sp.	Unid. octopus	-	-	-	-	-	-
Octopus sp.A	Cross-eye octopus	-	0.010 (0.010)	-	-	-	-
Octopus sp.B	Red slimy octopus	0.043 (0.025)	0.062 (0.031)	-	-	-	-
Octopus sp.C	Grey slimy octopus	0.010 (0.010)	-	0.133 (0.133)	-	0.027 (0.027)	0.052 (0.035)
Octopus tetricus	Gloomy octopus	0.447 (0.130)	0.389 (0.115)	0.108 (0.108)	-	0.083 (0.083)	0.109 (0.109)
Ommastrephidae							
Nototodarus gouldi	Gould's arrow squid	0.539 (0.252)	0.229 (0.128)	-	0.533 (0.533)	0.190 (0.065)	0.327 (0.092)
Sepiadariidae							
Sepioloidea lineolata	Pinstripe bottle-tailed squid	0.128 (0.088)	0.038 (0.030)	0.588 (0.436)	-	0.169 (0.081)	0.025 (0.025)
Sepiidae							
Sepia hedleyi	King cuttlefish	-	0.274 (0.132)	-	4.622 (2.262)	4.687 (2.824)	2.366 (0.929)
Sepia limata	Pink cuttlefish	-	0.009 (0.009)	-	-	-	-
Sepia opipara	Staregaze cuttlefish	-	-	-	-	-	-
Sepia plangon	Mourning cuttlefish	3.756 (0.572)	3.807 (0.561)	10.057 (1.747)	-	0.509 (0.339)	0.691 (0.461)
Sepia rozella	Rosecone cuttlefish	1.942 (0.390)	2.036 (0.478)	0.533 (0.533)	1.290 (0.673)	8.617 (2.428)	10.936 (2.904)

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
CRUSTACEANS							
Calappidae							
Calappa lophos	Red-streaked box crab	0.045 (0.027)	0.044 (0.025)	-	-	0.027 (0.027)	-
Calappa philargius	Red-spotted box crab	0.016 (0.016)	-	-	-	-	-
Mursia curtispina	Spiny box crab	-	-	-	-	-	-
Cassidae							
Semicassis bisulcata	Un-named helmet crab	-	0.016 (0.016)	-	-	-	-
Corystidae							
Jonas luteanus	Un-named Corystid crab	0.030 (0.030)	-	-	-	-	-
Diogenidae							
Dardanus arrosor	Smooth-legged hermit crab	-	-	-	-	-	-
Dardanus crassimanus	Northern hairy hermit crab	-	-	-	-	-	-
Strigopagurus strigimanus	Hairy-legged hermit crab	0.267 (0.221)	0.182 (0.182)	-	-	0.026 (0.026)	0.053 (0.036)
Goneplacidae							
Ommatocarcinus macgillivrayi	Long-armed crab	0.081 (0.063)	0.043 (0.030)	0.133 (0.133)	-	-	-
Leucosiidae							
Arcania undecimspinosa	Rough pebble crab	0.015 (0.015)	-	-	-	-	-
Bellidilia undecinspinosa	Large pebble crab		0.018 (0.018)	-	-	-	-
Leucosia anatum	Painted pebble crab	0.031 (0.031)	-	-	-	-	-
Leucosiidae sp.	Small-spined pebble crab	0.031 (0.031)	-	-	-	-	-
Majidae							
Hyastenus elatus	Dwarf spider crab	-	0.033 (0.023)	-	-	-	0.027 (0.027)
Leptomithrax tuberculatus	Pygmy spider crab	-	-	0.133 (0.133)	-	-	
Naxioides robillardi	Longhorn spider crab	-	-	-	-	-	0.027 (0.027)
Phalangipus australiensis	Daddy longlegs spider crab	-	0.014 (0.014)	-	-	-	-
Teratomaia richardsoni	long-armed spider crab	-	-	-	-	-	-
Unid. Majid	Unid. spider crab	-	-	-	-	-	-
Matutidae							
Matuta planipes	Reticulated surf crab	-	-	-	-	-	-
Palinuridae							
Jasus verreauxi	Eastern rock lobster	-	-	-	-	-	-
Pandalidae							
Plesionika martia	Unid. Carid shrimp	0.015 (0.015)	-	-	-	-	-

MAJOR GROUP **Family / *Species***	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
		40D-150	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Plesionika spinipes	Striped carid	0.030 (0.030)	0.092 (0.069)	-	-	0.052 (0.052)	0.027 (0.027)
Paralichthyidae							
Bellidilia laevis	Smooth pebble crab	-	0.016 (0.016)	-	-	-	-
Penaeidae							
Melicertis plebejus	Eastern king prawn	184.183 (26.245)	168.640 (24.933)	71.931 (5.582)	76.369 (11.378)	125.197 (21.043)	103.451 (15.960)
Metapenaeopsis palmensis	Southern velvet prawn	0.034 (0.020)	0.267 (0.147)	-	-	-	0.025 (0.025)
Metapenaeus bennettae	Greentail (greasyback) prawn	0.063 (0.063)					
Metapenaeus macleayi	School prawn	-	0.059 (0.046)	-	-	-	-
Penaeus esculentus	Brown tiger prawn	0.102 (0.068)	0.180 (0.097)	1.333 (1.333)	1.441 (1.283)	-	-
Trachypenaeus curvirostris	Southern rough prawn	16.232 (4.044)	4.719 (1.791)	19.680 (17.795)	10.032 (3.829)	7.126 (2.841)	4.511 (0.962)
Unid. Parapenaeid	Unid. Parapenaeid prawn	0.010 (0.010)					
Portunidae							
Charybdis bimaculata	Un-named swimmer crab	0.098 (0.038)	0.069 (0.037)	0.160 (0.160)	0.241 (0.123)	1.957 (0.851)	1.559 (0.648)
Charybdis feriata	Coral crab	0.462 (0.159)	0.401 (0.103)	-	-	0.040 (0.040)	0.081 (0.054)
Charybdis miles	Common trawl crab	0.593 (0.156)	0.712 (0.266)	-	-	0.164 (0.090)	0.423 (0.351)
Charybdis natator	Hairyback crab	0.217 (0.063)	0.241 (0.087)	0.133 (0.133)	0.160 (0.160)	0.122 (0.089)	0.081 (0.054)
Lupocyclus sp.	Longlegs swimmer crab	-	0.019 (0.019)	-	-	-	-
Ovalipes australiensis	Common sand crab	0.018 (0.018)	0.029 (0.029)	-	-	-	-
Portunus pelagicus	Blue swimmer crab	0.260 (0.075)	0.295 (0.096)	0.427 (0.232)	0.376 (0.194)	-	0.043 (0.043)
Portunus rubromarginatus	Northern pink swimmer crab	3.715 (1.127)	3.196 (0.991)	16.995 (6.204)	12.632 (5.183)	3.949 (1.579)	4.484 (1.652)
Portunus sanguinolentus	Threespot sand crab	0.014 (0.014)	0.031 (0.031)	-	-	-	-
Raninidae							
Lyreidus tridentatus	Frog crab	0.014 (0.014)	0.013 (0.013)	-	-	0.052 (0.035)	0.052 (0.035)
Ranina ranina	Spanner crab	-	0.008 (0.008)	0.108 (0.108)	-	-	-
Scyllaridae							
Biarctus sordidus	Pygmy slipper lobster	0.038 (0.038)	-	-	-	0.027 (0.027)	0.136 (0.109)
Ibacus brucei	Bruce's bug	0.020 (0.020)	-	-	-	-	-
Ibacus chacei	Smooth bug	16.528 (3.051)	16.580 (3.251)	15.585 (11.645)	8.680 (6.262)	34.686 (6.469)	33.588 (6.753)
Ibacus peronii	Balmain bug	0.067 (0.054)	0.035 (0.020)	-	-	0.027 (0.027)	-
Solenoceridae							
Solenocera choprai	Ridgeback prawn	0.058 (0.050)	0.020 (0.020)	-	-	-	-
Squillidae							
Belosquilla laevis	Common mantis	3.447 (1.536)	3.032 (1.228)	-	-	0.672 (0.427)	0.270 (0.191)
Harpiosquilla melanoura	Black-tailed mantis	0.094 (0.094)	-	-	-	-	-
Quollastria capricornae	Pink mantis shrimp	0.092 (0.056)	0.101 (0.059)	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Quollastria gonypetes	Red-spined mantis	0.023 (0.023)	0.056 (0.056)	-	-	-	-
ECHINODERMS							
Unid. sand dollars	Unid. sand dollars	-	-	-	-	-	-
Unid. starfishes	Unid. starfishes	0.535 (0.147)	0.763 (0.221)	0.480 (0.480)	0.160 (0.160)	0.150 (0.064)	-
Unid. sea tulips	Unid. sea tulips	-	0.009 (0.009)	0.133 (0.133)	-	-	-
Unid. urchins	Unid. urchins	0.309 (0.159)	0.741 (0.324)	1.227 (0.858)	-	0.025 (0.025)	0.100 (0.100)
ELASMOBRANCHES							
Brachaeluridae							
Brachaelurus colcloughi	Colclough's shark	-	-	-	-	-	-
Carcharhinidae							
Carcharhinus leucas	Bull shark	-	-	-	-	-	-
Chimaeridae							
Hydrolagus sp.	Unid. ghostshark	-	0.010 (0.010)	-	-	-	-
Hydrologus ogilbyi	Ogilby's ghost shark	0.010 (0.010)	-	-	-	-	-
Dasyatidae							
Dasyatis kuhlii	Bluespotted maskray	0.021 (0.014)	-	-	-	-	-
Dasyatis thetidis	Black stingray	-	0.018 (0.018)	-	-	-	-
Heterodontidae							
Heterodontus galeatus	Crested hornshark	0.113 (0.057)	0.069 (0.037)	-	-	0.129 (0.093)	-
Heterodontus portusjacksoni	Port Jackson shark	0.038 (0.038)	0.019 (0.019)	-	-	-	-
Myliobatidae							
Aetobatus narinari	Whitespotted eagle ray	-	-	-	-	-	-
Rhinoptera neglecta	Australian cownose ray	-	-	-	-	-	-
Orectolobidae							
Orectolobus maculatus	Spotted wobbegong	0.024 (0.017)	0.108 (0.036)	-	-	0.141 (0.080)	0.114 (0.058)
Pristiophoridae							
Pristiophorus cirratus	Common sawshark	-	-	-	-	-	-
Rajidae							
Dipturus australis	Sydney skate	-	0.010 (0.010)	-	-	-	-
Dipturus polyommata	Argus skate	-	-	-	-	-	-
Rhinidae							
Rhynchobatus australiae	Whitespotted guitarfish	-	0.016 (0.016)	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Rhinobatidae							
Aptychotrema rostrata	Eastern shovelnose ray	0.658 (0.172)	0.667 (0.212)	3.617 (1.461)	5.645 (2.789)	0.497 (0.193)	0.334 (0.200)
Trygonorrhina fasciata	Southern fiddler ray	0.209 (0.089)	0.114 (0.049)	0.108 (0.108)	0.267 (0.267)	0.204 (0.161)	0.209 (0.141)
Scyliorhinidae							
Asymbolus sp.	Unid. spotted catshark	0.030 (0.030)	0.025 (0.017)	-	-	-	-
Galeus boardmani	Sawtail catshark	0.020 (0.020)	0.039 (0.039)	-	-	-	-
Torpedinidae							
Hypnos monopterygium	Coffin ray	0.235 (0.058)	0.231 (0.083)	0.480 (0.480)	2.080 (1.120)	0.415 (0.177)	0.134 (0.092)
Triakidae							
Mustelus antarcticus	Gummy shark	0.020 (0.020)	-	-	-	0.036 (0.036)	-
Urolophidae							
Trygonoptera testacea	Common stingaree	0.259 (0.119)	0.254 (0.122)	1.023 (0.665)	-	2.573 (1.840)	2.973 (2.204)
Urolophus bucculentus	Sandyback stingaree	0.026 (0.026)	-	-	-	-	-
Urolophus viridis	Greenback stingaree	1.255 (1.061)	0.862 (0.586)	-	-	-	-
TELEOSTS							
Acropomatidae							
Apogonops anomalus	Threespine cardinalfish	31.599 (31.599)	3.454 (3.454)	-	-	-	-
Antennariidae							
Antennarius striatus	Striate anglerfish	0.010 (0.010)	-	-	-	-	-
Kuiterichthys furcipilis	Rough anglerfish	0.010 (0.010)	0.028 (0.028)	-	-	-	-
Apogonidae							
Apogon nigripinnis	Two-eyed cardinalfish	0.033 (0.025)	0.009 (0.009)	-	-	-	-
Apogon quadrifasciatus	Bar-striped cardinalfish	0.034 (0.024)	-	-	-	-	-
Apogon truncatus	Flagfin cardinalfish	0.012 (0.012)	0.009 (0.009)	-	-	-	-
Ariidae							
Arius graeffei	Blue catfish	-	-	-	-	-	-
Ariommatidae							
Ariomma luridum	Slope driftfish	-	0.020 (0.020)	-	-	-	-
Aulopidae							
Aulopus purpurissatus	Sergeant baker	0.015 (0.015)	0.022 (0.016)	-	-	-	-
Hime curtirostris	Shortsnout threadsail	0.030 (0.030)	-	-	-	-	-
Batrachoididae							
Batrachomeus dubius	Eastern frogfish	-	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Bembridae							
Bembras macrolepis	Bigscale flathead	0.010 (0.010)	-	-	-	-	-
Berycidae							
Centroberyx affinis	Redfish	0.528 (0.336)	0.536 (0.403)	-	-	0.027 (0.027)	0.052 (0.052)
Bothidae							
Asterorhombus bleekeri	Bleeker's flounder	-	-	-	-	-	-
Crossorhombus valderostratus	Broadbrow flounder	2.912 (0.602)	4.587 (0.873)	3.136 (0.881)	3.785 (1.015)	8.184 (2.727)	8.087 (2.561)
Engyprosopon maldivensis	Olive wide-eye flounder	0.016 (0.016)	-	-	-	-	-
Lophonectes gallus	Crested flounder	12.283 (2.150)	28.171 (3.841)	73.312 (45.790)	138.636 (45.898)	29.171 (6.027)	31.905 (4.790)
Bregmacerotidae							
Bregmaceros sp.	Unid. codlet	-	-	-	-	0.025 (0.025)	-
Callionymidae							
Bathycallionymus moretonensis	Ocellate dragonet	-	0.020 (0.020)	-	-	-	-
Callionymidae sp.	Unid. stinkfish	-	-	-	-	-	0.306 (0.204)
Calliurichthys scaber	Japanese stinkfish	0.185 (0.154)	0.066 (0.043)	-	-	9.295 (4.209)	3.083 (1.338)
Dactylopus dactylopus	Finger dragonet	-	-	-	-	-	-
Foetorepus calauropomus	Common stinkfish	6.955 (3.130)	8.505 (4.610)	-	0.160 (0.160)	0.382 (0.302)	0.464 (0.325)
Repomucenus calcaratus	Spotted dragonet	-	-	-	-	0.382 (0.255)	-
Repomucenus macdonaldi	Greyspotted dragonet	-	-	-	-	-	-
Caproidae							
Antigonia rhomboidea	Rhomboid deepsea boarfish	-	-	-	-	-	0.027 (0.027)
Antigonia rubicunda	Rosy deepsea boarfish	-	0.016 (0.012)	-	-	0.027 (0.027)	0.027 (0.027)
Carangidae							
Carangoides caeruleopinnatus	Onion trevally	-	-	-	-	0.027 (0.027)	0.027 (0.027)
Carangoides chrysophrys	Longnose trevally	-	-	-	-	0.027 (0.027)	-
Carangoides equula	Whitefin trevally	-	-	-	-	-	-
Pseudocaranx dentex	Silver trevally	-	0.029 (0.029)	-	-	-	-
Trachurus novaezelandiae	Yellowtail scad	7.790 (2.559)	4.697 (1.849)	-	0.267 (0.267)	1.512 (0.505)	0.577 (0.248)
Chaetodontidae							
Chaetodon guentheri	Gunther's butterflyfish	-	0.126 (0.103)	-	-	-	-
Cheilodactylidae							
Cheilodactylus gibbosus	Magpie morwong	-	-	-	-	-	-
Clupeidae							
Herklotsichthys castelnaui	Southern herring	-	-	-	-	-	-
Hyperlophus vittatus	Sandy sprat	-	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Sardinops neopilchardus	Australian sardine	0.019 (0.019)	-	-	-	-	-
Congridae							
Gnathophis grahami	Graham's conger	0.067 (0.054)	-	-	-	-	-
Gnathophis longicaudus	Little conger	0.615 (0.352)	0.039 (0.030)	0.160 (0.160)	-	1.090 (0.517)	0.298 (0.108)
Cynoglossidae							
Cynoglossus bilineatus	Fourline tongue sole	-	-	-	-	-	-
Cynoglossus maculipinnis	Spotfin tongue sole	0.124 (0.055)	0.170 (0.055)	0.267 (0.267)	1.957 (1.051)	0.120 (0.051)	0.219 (0.102)
Paraplagusia bilineata	Lemon tongue sole	0.012 (0.012)	-	-	-	-	-
Dactylopteridae							
Dactyloptena papilio	Largespot flying gurnard	0.048 (0.034)	0.106 (0.066)	0.480 (0.480)	0.693 (0.474)	0.106 (0.059)	0.051 (0.034)
Dinolestidae							
Dinolestes lewini	Longfin pike	-	-	-	-	-	-
Diodontidae							
Dicotylichthys punctulatus	Threebar porcupinefish	0.018 (0.018)	-	-	-	0.036 (0.036)	0.127 (0.089)
Emmelichthyidae							
Emmelichthys struhsakeri	Golden redbait	-	0.010 (0.010)	-	-	-	-
Engraulidae							
Engraulis australis	Australian anchovy	0.009 (0.009)	-	-	-	-	-
Enoplosidae							
Enoplosus armatus	Old wife	-	-	-	-	-	-
Fistulariidae							
Fistularia commersonii	Smooth flutemouth	0.022 (0.022)	-	-	-	-	-
Fistularia petimba	Rough flutemouth	-	-	-	-	0.079 (0.041)	0.053 (0.036)
Gempylidae							
Rexea solandri	Gemfish	-	0.010 (0.010)	-	-	-	-
Gerreidae							
Gerres subfasciatus	Common silver biddy	-	0.014 (0.014)	0.160 (0.160)	0.160 (0.160)	-	-
Glaucosomatidae							
Glaucosoma scapulare	Pearl perch	0.507 (0.180)	0.296 (0.153)	0.827 (0.603)	-	0.240 (0.115)	0.665 (0.382)
Gonorynchidae							
Gonorynchus greyi	Beaked salmon	0.022 (0.015)	0.030 (0.030)	-	-	0.621 (0.299)	-
Hemiramphidae							
Hyporhamphus australis	Eastern sea garfish	-	-	-	-	-	-
Hyporhamphus regularis	River garfish	-	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Kyphosidae							
Atypichthys strigatus	Mado	0.041 (0.030)	-	-	-	-	0.027 (0.027)
Microcanthus strigatus	Stripey	0.026 (0.026)	0.022 (0.022)	-	-	0.027 (0.027)	-
Scorpis lineolata	Silver sweep	0.013 (0.013)	-	-	-	-	-
Labridae							
Choerodon frenatus	Bridled tuskfish	-	-	-	-	-	-
Choerodon venustus	Venus tuskfish	-	-	-	-	0.025 (0.025)	-
Leiognathidae							
Leiognathus equulus	Common ponyfish	2.553 (1.024)	0.571 (0.271)	-	-	-	-
Lophidae							
Lophiomus setigerus	Broadhead goosefish	0.439 (0.171)	1.613 (0.809)	-	-	0.106 (0.080)	0.050 (0.050)
Macrouridae							
Caelorinchus mirus	Gargoyle fish	0.730 (0.730)	1.914 (1.914)	-	-	-	-
Monacanthidae							
Nelusetta ayraudi	Ocean jacket	0.099 (0.062)	0.140 (0.079)	-	-	0.043 (0.043)	-
Paramonacanthus lowei	Lowe's leatherjacket	0.040 (0.026)	0.023 (0.016)	-	-	0.077 (0.054)	0.027 (0.027)
Monocentrididae							
Cleidopus gloriamaris	Australian pineapplefish	0.065 (0.031)	0.046 (0.029)	0.160 (0.160)	-	0.036 (0.036)	-
Monodactylidae							
Schuettea scalaripinnis	Eastern pomfred	-	-	-	-	-	-
Moridae							
Lotella rhacina	Largetooth beardie	-	-	-	-	-	-
Pseudophycis breviuscula	Bastard red cod	0.445 (0.230)	0.077 (0.053)	-	-	0.260 (0.133)	0.027 (0.027)
Mullidae							
Parupeneus rubescens	Blackspot goatfish	-	-	-	-	-	-
Upeneichthys lineatus	Bluestriped goatfish	1.080 (0.549)	0.966 (0.485)	0.160 (0.160)	0.133 (0.133)	1.145 (0.377)	1.243 (0.599)
Upeneus moluccensis	Goldband goatfish	-	-	-	-	0.040 (0.040)	-
Upeneus tragula	Bartail goatfish	0.020 (0.014)	-	-	-	-	-
Myctophidae							
Myctophidae sp.	Unid. lanternfish	0.020 (0.020)	-	-	-	-	-
Nemipteridae							
Nemipterus theodorei	Theodore's threadfin bream	1.574 (0.513)	0.706 (0.350)	0.293 (0.148)	0.400 (0.400)	3.988 (1.261)	2.323 (1.045)
Neosebastidae							
Neosebastes thetidis	Thetis fish	0.060 (0.045)	0.110 (0.080)	-	-	1.127 (0.621)	0.243 (0.188)

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Nomeidae							
Unid. *Nomeid*	Unid. driftfish	0.020 (0.020)	-	-	-	-	-
Ogcocephalidae							
Halieutaea sp.	Unid. seabat	-	0.010 (0.010)	-	-	-	-
Ophidiidae							
Neobythites nigriventris	Blackbelly cusk	0.010 (0.010)	0.010 (0.010)	-	-	-	-
Ophidion sp.	Unid. cusk	0.013 (0.013)	0.130 (0.086)	-	-	0.160 (0.072)	0.052 (0.035)
Sirembo metachroma	Chameleon cusk	-	-	-	-	-	-
Ostraciidae							
Anoplocapros inermis	Eastern smooth boxfish	1.735 (0.401)	1.650 (0.399)	0.724 (0.368)	0.776 (0.217)	1.287 (0.464)	1.984 (0.580)
Tetrosomus reipublicae	Smallspine turretfish	0.153 (0.057)	0.052 (0.023)	0.960 (0.733)	1.467 (1.467)	0.686 (0.195)	0.689 (0.103)
Paralichthyidae							
Pseudorhombus arsius	Largetooth flounder	-	-	-	-	-	-
Pseudorhombus jenynsii	Smalltooth flounder	-	-	-	-	-	-
Pseudorhombus tenuirastrum	Slender flounder	14.322 (4.853)	15.418 (4.642)	17.966 (2.791)	13.485 (2.521)	4.679 (1.079)	3.502 (0.533)
Paraulopidae							
Paraulopus melanogrammus	Cucumberfish	0.010 (0.010)	-	-	-	-	-
Pataecidae							
Pataecus fronto	Red Indian fish	-	-	-	-	0.026 (0.026)	-
Pempheridae							
Pempheris analis	Bronze bullseye	-	-	-	-	-	-
Pempheris compressa	Smallscale bullseye	-	-	-	-	-	-
Pentacerotidae							
Paristiopterus labiosus	Giant boarfish	-	-	-	-	-	-
Zanclistius elevatus	Blackspot boarfish	0.019 (0.019)	-	-	-	-	-
Pinguipedidae							
Parapercis allporti	Barred grubfish	0.192 (0.071)	0.109 (0.054)	0.133 (0.133)	-	0.331 (0.331)	0.177 (0.111)
Parapercis binivirgata	Redbanded grubfish	-	-	-	-	-	-
Parapercis nebulosa	Pinkbanded grubfish	0.008 (0.008)	-	-	-	-	-
Parapercis ramsayi	Spotted grubfish	0.041 (0.026)	-	-	-	-	-
Simipercis trispinosa	Un-named grubfish	-	-	-	-	-	-
Platycephalidae							
Ambiserrula jugosa	Mud flathead	0.138 (0.138)	0.109 (0.109)	-	-	0.027 (0.027)	0.027 (0.027)
Platycephalus arenarius	Northern sand flathead	-	0.092 (0.092)	-	-	-	-
Platycephalus caeruleopunctatus	Bluespotted flathead	3.724 (0.551)	3.489 (0.471)	8.852 (4.259)	11.857 (5.768)	2.585 (1.024)	2.958 (1.174)

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Platycephalus fuscus	Dusky flathead	0.032 (0.023)	-	-	-	-	-
Platycephalus longispinis	Longspine flathead	44.840 (8.012)	46.048 (8.239)	134.920 (24.273)	105.862 (42.897)	29.654 (13.189)	17.721 (6.070)
Platycephalus marmoratus	Marbled flathead	0.095 (0.038)	0.085 (0.046)	-	-	0.240 (0.173)	0.104 (0.070)
Platycephalus richardsoni	Tiger flathead	-	-	-	-	-	-
Ratabulus diversidens	Freespine flathead	2.403 (1.360)	1.251 (0.719)	-	-	0.937 (0.356)	0.666 (0.33)
Pleuronectidae							
Samaris cristatus	Cockatoo flounder	-	-	-	-	-	-
Plotosidae							
Cnidoglanis macrocephalus	Estuary catfish	-	-	-	-	-	-
Plotosus lineatus	Striped catfish	-	-	-	-	-	-
Pomatomidae							
Pomatomus saltatrix	Tailor	-	-	-	-	-	-
Priacanthidae							
Priacanthus macracanthus	Spotted bigeye	0.841 (0.185)	1.186 (0.321)	-	-	3.018 (0.869)	1.856 (0.757)
Pristigenys niphonia	Whiteband bigeye	-	-	-	-	0.026 (0.026)	-
Samaridae							
Plagiopsetta glossa	Tongue flatfish	-	0.020 (0.020)	-	-	-	-
Sciaenidae							
Argyrosomus hololepidotus	Mulloway	-	-	-	-	-	-
Atractoscion aequidens	Teraglin	-	-	-	-	-	0.036 (0.036)
Scombridae							
Scomber australasicus	Blue mackerel	0.032 (0.018)	-	-	-	0.027 (0.027)	0.027 (0.027)
Scorpaenidae							
Pterois volitans	Common lionfish	-	0.029 (0.029)	-	-	-	-
Scorpaena cardinalis	Eastern red scorpionfish	0.014 (0.014)	0.034 (0.027)	-	-	0.161 (0.066)	0.055 (0.055)
Scorpaenodes smithi	Little scorpionfish	12.893 (2.922)	4.984 (2.615)	6.347 (4.563)	1.147 (0.596)	263.445 (72.193)	3.609 (0.756)
Scorpaenopsis diabolus	False stonefish	0.020 (0.014)	-	-	-	0.052 (0.035)	0.027 (0.027)
Serranidae							
Epinephelus ergastularius	Banded rockcod	0.027 (0.020)	0.046 (0.023)	-	-	-	0.026 (0.026)
Lepidoperca brochata	Fangtooth perch	-	0.010 (0.010)	-	-	-	-
Siganidae							
Siganus fuscescens	Black rabbitfish	0.012 (0.012)	-	-	-	-	-
Sillaginidae							
Sillago ciliata	Sand whiting	-	-	-	-	-	-
Sillago flindersi	Eastern school whiting	81.905 (17.238)	57.967 (13.329)	53.433 (27.041)	61.367 (30.653)	9.338 (3.327)	5.803 (2.080)

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Sillago robusta	Stout whiting	24.924 (9.720)	13.454 (4.063)	227.034 (128.803)	183.022 (56.934)	10.513 (3.635)	1.835 (0.783)
Soleidae							
Aseraggodes macleayanus	Narrow-banded sole	1.262 (0.507)	1.915 (0.605)	3.536 (1.570)	5.617 (2.509)	1.549 (0.693)	0.826 (0.327)
Brachirus nigra	Black sole	-	-	-	-	-	-
Pardachirus hedleyi	Southern peacock sole	-	0.024 (0.017)	-	0.160 (0.160)	-	-
Zebrias scalaris	Many-banded sole	0.178 (0.074)	2.072 (1.453)	2.284 (0.858)	0.911 (0.056)	-	0.050 (0.050)
Sparidae							
Dentex tumifrons	Yellowback bream	0.143 (0.078)	0.172 (0.108)	-	-	-	-
Pagrus auratus	Snapper	0.035 (0.027)	0.154 (0.143)	-	-	-	0.036 (0.036)
Rhabdosargus sarba	Tarwhine	0.039 (0.039)	0.121 (0.085)	-	-	-	-
Sphyraenidae							
Sphyraena acutipinnis	Sharpfin barracuda	-	0.015 (0.015)	-	-	-	-
Sphyraena barracuda	Great barracuda	0.036 (0.020)	0.015 (0.015)	-	-	-	-
Synanceiidae							
Erosa erosa	Pacific monkeyfish	-	-	-	-	-	-
Syngnathidae							
Hippocampus tristis	Sad seahorse	-	-	-	-	-	-
Solegnathus dunckeri	Duncker's pipehorse	-	-	-	-	-	-
Solegnathus spinosissimus	Spiny pipehorse	-	-	-	-	-	0.027 (0.027)
Synodontidae							
Saurida filamentosa	Threadfin saury	0.010 (0.010)	0.019 (0.019)	-	-	-	-
Saurida undosquamis	Largescale saury	1.296 (0.338)	1.303 (0.443)	1.280 (1.280)	2.720 (2.720)	0.143 (0.062)	0.238 (0.082)
Synodus indicus	Indian lizardfish	-	-	-	-	-	-
Trachinocephalus myops	Painted grinner	0.008 (0.008)	-	-	-	-	-
Terapontidae							
Pelates quadrilineatus	Fourline striped grunter	0.037 (0.021)	-	9.067 (9.067)	6.400 (6.400)	0.036 (0.036)	0.073 (0.073)
Tetraodontidae							
Arothron firmamentum	Starry toadfish	-	0.029 (0.029)	-	-	-	-
Canthigaster callisterna	Clown toby	-	0.029 (0.021)	-	-	-	-
Lagocephalus cheesemanii	Cheeseman's puffer	0.076 (0.044)	0.103 (0.056)	-	-	0.103 (0.056)	-
Lagocephalus sceleratus	Silver toadfish	-	-	-	-	-	-
Reicheltia halsteadi	Halstead's toadfish	-	-	-	-	0.027 (0.027)	-
Tetractenos glaber	Smooth toadfish	1.088 (0.758)	2.639 (2.305)	-	2.213 (1.147)	-	-
Tetractenos hamiltoni	Common toadfish	-	0.063 (0.063)	-	-	5.455 (5.455)	-
Tetraodontidae sp.	Unid. toadfish	0.122 (0.122)	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 40D-150 (BRDs open)**		**35S vs. 40D-150 (BRDs closed)**		**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**40D-150**	**35S**	**40D-150**	**35S**	**43D-200**	**35S**
Torquegenia tuberculiferus	Fringe-gill toadfish	0.365 (0.365)	0.354 (0.354)	-	-	-	-
Torquigener altipinnis	Highfin toadfish	0.320 (0.210)	0.103 (0.072)	2.747 (2.069)	-	-	-
Torquigener pleurogramma	Weeping toadfish	-	-	-	-	-	0.081 (0.058)
Torquigener squamicauda	Scalytail toadfish	0.008 (0.008)	-	-	-	-	-
Tetrarogidae							
Centropogon australis	Eastern fortescue	-	-	-	-	-	-
Trachichthyidae							
Aulotrachichthys novaezelandicus	New Zealand roughy	0.079 (0.079)	0.266 (0.266)	-	-	0.025 (0.025)	-
Optivus agastos	Violet roughy	1.281 (0.811)	0.393 (0.241)	2.533 (2.533)	0.800 (0.800)	1.576 (0.650)	0.544 (0.268)
Trachichthys australis	Southern roughy	-	0.029 (0.029)	-	-	-	-
Macrorhamphosodes uradoi	Common trumpetsnout	0.976 (0.697)	0.153 (0.079)	-	-	0.811 (0.357)	0.179 (0.130)
Trigildae							
Chelidonichthys kumu	Red gurnard	0.020 (0.015)	0.112 (0.063)	-	-	0.077 (0.054)	-
Lepidotrigla argus	Eye gurnard	364.869 (61.567)	260.194 (66.696)	313.138 (62.843)	553.890 (129.720)	516.371 (90.724)	199.365 (40.494)
Lepidotrigla grandis	Little red gurnard	0.167 (0.144)	3.270 (3.072)	-	-	-	-
Lepidotrigla umbrosa	Blackspot gurnard	0.061 (0.053)	0.063 (0.063)	-	-	-	-
Pterygotrigla andertoni	Painted latchet	0.010 (0.010)	0.010 (0.010)	-	-	-	-
Satyrichthys rieffeli	Spotted armour gurnard	-	0.010 (0.010)	-	-	-	-
Uranoscopidae							
Ichthyscopus nigripinnis	Blackfin stargazer	-	-	-	-	-	-
Ichthyscopus sannio	Spotted stargazer	-	-	-	-	-	-
Kathetostoma laeve	Common stargazer	-	-	-	-	-	0.027 (0.027)
Uranoscopidae sp.	Unid. stargazer	0.052 (0.040)	-	-	-	-	-
Uranoscopus terraereginae	Queensland stargazer	-	0.013 (0.013)	-	-	-	-
Veliferidae							
Metavelifer multiradiatus	Common veilfin	-	-	-	-	-	-
GASTROPODS							
Conidae							
Conus sanguinolentus	Un-named cone shell	-	0.029 (0.029)	-	-	-	-
Ficidae							
Ficus subintermedius	Fig shell	0.015 (0.015)	0.047 (0.033)	-	-	-	-
Olividae							
Ancillista velesiana	Olive shell	0.041 (0.031)	0.045 (0.033)	-	-	0.027 (0.027)	0.078 (0.040)

MAJOR GROUP **Family / *Species***	**Standard common name**	**35S vs. 40D-150 (BRDs open)** **40D-150**	 **35S**	**35S vs. 40D-150 (BRDs closed)** **40D-150**	 **35S**	**35S vs. 40D-200 (BRDs open)** **43D-200**	 **35S**
Tonnidae							
Tonna chinensis	Un-named tun shell	-	0.016 (0.016)	-	-	-	-
Tonna variegata	Tun shell	-	0.133 (0.104)	-	-	-	0.025 (0.025)
Volutidae							
Cymbiolista hunteri	Un-named volute shell	-	-	-	-	-	-
Livonia mamilla	Bailer shell	0.040 (0.023)	0.014 (0.014)	-	-	0.086 (0.086)	0.064 (0.043)
PORIFORANS							
Unid. sponges	Unid. sponges	0.008 (0.008)	-	-	-	-	-

APPENDIX B: Mean catch rate (h^{-1}) (± SE) (by number) for each species recorded in sampled catches during the study. Data are for each codend type in the 35S vs. 45D-150 (BRDs open) ($n = 3$), 35S vs. 45D-150 (BRDs closed) ($n = 10$), and 35S vs. 36-ind (BRDs open) ($n = 12$) codend contrasts done on eastern king prawn trawl grounds. Species are ordered according to 'Major group' and 'Family'. 'Unid.', unidentified.

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
BIVALVES							
Pectinidae							
Amusium balloti	Ballot's saucer scallop	-	-	0.234 (0.183)	0.173 (0.117)	0.366 (0.220)	0.165 (0.119)
Amusium sp.	Saucer scallop	4.116 (1.493)	3.958 (1.635)	3.180 (1.236)	1.441 (0.579)	1.503 (0.659)	0.588 (0.201)
Annachlamys flabellata	Fan scallop	-	-	-	-	-	0.027 (0.02)
CEPHALOPODS							
Loliginidae							
Photololigo chinensis	Broad squid	0.982 (0.726)	-	-	-	0.111 (0.085)	-
Photololigo sp.	Slender squid	-	0.372 (0.186)	0.432 (0.135)	0.694 (0.144)	0.540 (0.288)	0.823 (0.348)
Sepioteuthis australis	Southern calamari	-	-	-	-	0.358 (0.091)	0.165 (0.094)
Uroteuthis noctiluca	Bottle squid	-	-	-	-	-	-
Octopodidae							
Octopus australis	Southern octopus	1.545 (0.867)	1.572 (1.014)	1.682 (0.650)	1.677 (0.660)	2.537 (0.635)	2.945 (0.965)
Octopus sp.	Unid. octopus	-	-	-	-	0.021 (0.021)	-
Octopus sp.A	Cross-eye octopus	0.190 (0.190)	-	-	-	-	-
Octopus sp.B	Red slimy octopus	-	-	0.043 (0.043)	0.033 (0.033)	0.123 (0.087)	0.203 (0.162)
Octopus sp.C	Grey slimy octopus	-	-	-	-	-	-
Octopus tetricus	Gloomy octopus	-	0.400 (0.400)	0.242 (0.170)	-	0.225 (0.101)	0.090 (0.049)
Ommastrephidae							
Nototodarus gouldi	Gould's arrow squid	0.200 (0.200)	-	-	-	1.125 (0.589)	1.686 (0.722)
Sepiadariidae							
Sepioloidea lineolata	Pinstripe bottle-tailed squid	-	-	-	-	0.589 (0.193)	0.543 (0.173)
Sepiidae							
Sepia hedleyi	King cuttlefish	-	12.000 (12.000)	7.617 (3.223)	0.120 (0.120)	5.047 (2.133)	4.150 (1.856)
Sepia limata	Pink cuttlefish	-	-	-	-	-	0.040 (0.040)
Sepia opipara	Staregaze cuttlefish	0.400 (0.400)	-	-	0.289 (0.196)	-	-
Sepia plangon	Mourning cuttlefish	-	0.364 (0.364)	2.671 (1.266)	3.844 (1.463)	0.929 (0.405)	1.010 (0.427)

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Sepia rozella	Rosecone cuttlefish	22.261 (2.340)	8.073 (4.248)	6.083 (2.356)	6.616 (3.182)	2.177 (1.433)	1.436 (0.726)
CRUSTACEANS							
Calappidae							
Calappa lophos	Red-streaked box crab	-	-	-	0.036 (0.036)	-	-
Calappa philargius	Red-spotted box crab	-	-	-	-	-	-
Mursia curtispina	Spiny box crab	-	-	-	-	-	-
Cassidae							
Semicassis bisulcata	Un-named helmet crab	-	-	-	-	-	-
Corystidae							
Jonas luteanus	Un-named Corystid crab	-	-	-	0.089 (0.089)	-	-
Diogenidae							
Dardanus arrosor	Smooth-legged hermit crab	-	-	-	-	0.191 (0.191)	0.040 (0.040)
Dardanus crassimanus	Northern hairy hermit crab	-	-	-	-	0.027 (0.027)	
Strigopagurus strigimanus	Hairy-legged hermit crab	0.600 (0.600)	0.190 (0.190)	0.193 (0.157)	0.328 (0.259)	-	0.021 (0.021)
Goneplacidae							
Ommatocarcinus macgillivrayi	Long-armed crab	0.190 (0.190)	-	-	-	-	-
Leucosiidae							
Arcania undecimspinosa	Rough pebble crab	-	-	-	-	-	-
Bellidilia undecinspinosa	Large pebble crab	-	-	-	-	-	-
Leucosia anatum	Painted pebble crab	-	-	-	-	-	-
Leucosiidae sp.	Small-spined pebble crab	-	-	-	-	-	-
Majidae							
Hyastenus elatus	Dwarf spider crab	-	-	-	-	-	-
Leptomithrax tuberculatus	Pygmy spider crab	-	0.400 (0.400)	-	-	0.021 (0.021)	0.049 (0.033)
Naxioides robillardi	Longhorn spider crab	-	-	-	-	-	-
Phalangipus australiensis	Daddy longlegs spider crab	-	-	-	-	0.029 (0.029)	-
Teratomaia richardsoni	long-armed spider crab	-	-	-	-	-	0.029 (0.029)
Unid. Majid	Unid. spider crab	-	-	-	-	0.027 (0.027)	-
Matutidae							
Matuta planipes	Reticulated surf crab	-	-	-	-	-	-
Palinuridae							
Jasus verreauxi	Eastern rock lobster	-	-	-	0.036 (0.036)	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Pandalidae							
Plesionika martia	Unid. Carid shrimp	-	-	-	-	-	-
Plesionika spinipes	Striped carid	-	-	0.141 (0.141)	-	0.040 (0.040)	-
Paralichthyidae							
Bellidilia laevis	Smooth pebble crab	-	-	-	-	-	-
Penaeidae							
Melicertis plebejus	Eastern king prawn	236.246 (126.085)	189.196 (83.950)	170.560 (28.942)	156.836 (24.101)	97.878 (10.922)	100.740 (11.011)
Metapenaeopsis palmensis	Southern velvet prawn	-	-	-	-	-	-
Metapenaeus bennettae	Greentail prawn	-	-	-	-	-	-
Metapenaeus macleayi	School prawn	-	-	-	-	-	-
Penaeus esculentus	Brown tiger prawn	-	-	-	-	-	-
Trachypenaeus curvirostris	Southern rough prawn	-	-	6.386 (1.841)	0.494 (0.327)	20.174 (5.708)	21.341 (5.750)
Unid. Parapenaeid	Unid. Parapenaeid prawn	-	-	-	-	-	-
Portunidae							
Charybdis bimaculata	Un-named swimmer crab	1.273 (1.273)	1.697 (1.194)	2.504 (0.787)	1.141 (0.378)	3.538 (2.358)	1.686 (1.226)
Charybdis feriata	Coral crab	-	-	0.052 (0.052)	-	-	-
Charybdis miles	Common trawl crab	-	0.745 (0.478)	0.285 (0.175)	0.216 (0.113)	-	-
Charybdis natator	Hairyback crab	-	-	-	-	0.105 (0.061)	0.029 (0.029)
Lupocyclus sp.	Longlegs swimmer crab	-	-	-	-	0.029 (0.029)	0.021 (0.021)
Ovalipes australiensis	Common sand crab	-	-	-	-	0.271 (0.217)	0.137 (0.095)
Portunus pelagicus	Blue swimmer crab	-	-	-	-	0.023 (0.023)	0.023 (0.023)
Portunus rubromarginatus	Northern pink swimmer crab	-	-	-	0.205 (0.139)	12.918 (3.156)	10.005 (1.550)
Portunus sanguinolentus	Threespot sand crab	-	-	-	-	0.040 (0.040)	-
Raninidae							
Lyreidus tridentatus	Frog crab	-	-	-	0.075 (0.075)	-	-
Ranina ranina	Spanner crab	-	-	-	-	0.029 (0.029)	-
Scyllaridae							
Biarctus sordidus	Pygmy slipper lobster	0.190 (0.190)	-	-	-	-	-
Ibacus brucei	Bruce's bug	-	-	-	-	-	-
Ibacus chacei	Smooth bug	21.251 (9.185)	21.069 (9.078)	16.394 (2.766)	14.573 (2.976)	19.086 (5.143)	14.130 (2.840)
Ibacus peronii	Balmain bug	-	-	-	-	0.057 (0.039)	0.082 (0.059)
Solenoceridae							
Solenocera choprai	Ridgeback prawn	-	-	-	-	0.085 (0.085)	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Squillidae							
Belosquilla laevis	Common mantis	-	0.200 (0.200)	0.238 (0.127)	0.036 (0.036)	0.028 (0.028)	0.065 (0.045)
Harpiosquilla melanoura	Black-tailed mantis	-	-	-	-	-	-
Quollastria capricornae	Pink mantis shrimp	0.182 (0.182)	-	-	0.316 (0.237)	0.021 (0.021)	-
Quollastria gonypetes	Red-spined mantis	0.190 (0.190)	-	-	0.035 (0.035)	0.061 (0.044)	-
ECHINODERMS							
Unid. sand dollars	Unid. sand dollars	-	-	-	-	0.027 (0.027)	-
Unid. starfishes	Unid. starfishes	0.182 (0.182)	0.372 (0.186)	1.120 (0.669)	1.459 (0.700)	-	-
Unid. sea tulips	Unid. sea tulips	-	-	-	-	-	-
Unid. urchins	Unid. urchins	-	0.190 (0.190)	0.075 (0.075)	-	1.651 (0.780)	0.086 (0.062)
ELASMOBRANCHES							
Brachaeluridae							
Brachaelurus colcloughi	Colclough's shark	-	-	-	-	0.160 (0.160)	0.200 (0.200)
Carcharhinidae							
Carcharhinus leucas	Bull shark	-	-	-	-	-	-
Chimaeridae							
Hydrolagus sp.	Unid. ghostshark	-	-	-	-	-	-
Hydrologus ogilbyi	Ogilby's ghost shark	-	-	-	-	-	-
Dasyatidae							
Dasyatis kuhlii	Bluespotted maskray	-	-	-	-	-	0.021 (0.021)
Dasyatis thetidis	Black stingray	-	-	-	-	-	-
Heterodontidae							
Heterodontus galeatus	Crested hornshark	0.182 (0.182)	0.926 (0.485)	0.453 (0.235)	0.151 (0.084)	-	-
Heterodontus portusjacksoni	Port Jackson shark	-	-	-	-	-	-
Myliobatidae							
Aetobatus narinari	Whitespotted eagle ray	-	-	-	-	-	0.023 (0.023)
Rhinoptera neglecta	Australian cownose ray	-	-	-	-	-	-
Orectolobidae							
Orectolobus maculatus	Spotted wobbegong	-	-	-	0.033 (0.033)	-	0.023 (0.023)
Pristiophoridae							
Pristiophorus cirratus	Common sawshark	-	0.190 (0.190)	0.043 (0.043)	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Rajidae							
Dipturus australis	Sydney skate	0.182 (0.182)	-	-	-	-	-
Dipturus polyommata	Argus skate						
Rhinidae							
Rhynchobatus australiae	Whitespotted guitarfish	-	-	-	-	-	-
Rhinobatidae							
Aptychotrema rostrata	Eastern shovelnose ray	3.443 (0.397)	2.317 (0.642)	0.974 (0.359)	1.245 (0.355)	2.824 (0.571)	2.081 (0.404)
Trygonorrhina fasciata	Southern fiddler ray	-	-	-	-	0.036 (0.036)	0.080 (0.080)
Scyliorhinidae							
Asymbolus sp.	Unid. spotted catshark	-	-	0.291 (0.179)	0.043 (0.043)	-	-
Galeus boardmani	Sawtail catshark	-	-	-	-	-	-
Torpedinidae							
Hypnos monopterygium	Coffin ray	-	0.182 (0.182)	-	0.085 (0.085)	0.353 (0.133)	0.398 (0.123)
Triakidae							
Mustelus antarcticus	Gummy shark	-	-	0.075 (0.075)	-	-	0.043 (0.043)
Urolophidae							
Trygonoptera testacea	Common stingaree	-	-	0.145 (0.145)	0.033 (0.033)	0.027 (0.027)	0.054 (0.037)
Urolophus bucculentus	Sandyback stingaree	-	-	-	-	-	-
Urolophus viridis	Greenback stingaree	-	0.381 (0.381)	0.454 (0.381)	0.272 (0.119)	0.862 (0.476)	0.619 (0.384)
TELOSTS							
Acropomatidae							
Apogonops anomalus	Threespine cardinalfish	-	-	-	-	-	-
Antennariidae							
Antennarius striatus	Striate anglerfish	-	-	-	-	0.095 (0.051)	0.056 (0.038)
Kuiterichthys furcipilis	Rough anglerfish	0.190 (0.190)	-	-	-	-	-
Apogonidae							
Apogon nigripinnis	Two-eyed cardinalfish	-	-	-	-	-	-
Apogon quadrifasciatus	Bar-striped cardinalfish	-	-	-	-	-	
Apogon truncatus	Flagfin cardinalfish	-	-	-	0.240 (0.240)	-	-
Ariidae							
Arius graeffei	Blue catfish	-	-	-	-	-	-
Ariommatidae							
Ariomma luridum	Slope driftfish	-	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Aulopidae							
Aulopus purpurissatus	Sergeant baker	0.190 (0.190)	-	0.043 (0.043)	-	-	-
Hime curtirostris	Shortsnout threadsail	-	-	-	-	-	-
Batrachoididae							
Batrachomeus dubius	Eastern frogfish	-	-	-	-	-	0.027 (0.027)
Bembridae							
Bembras macrolepis	Bigscale flathead	-	-	-	-	-	-
Berycidae							
Centroberyx affinis	Redfish	0.400 (0.400)	0.909 (0.909)	1.705 (0.701)	0.347 (0.234)	-	-
Bothidae							
Asterorhombus bleekeri	Bleeker's flounder	-	0.200 (0.200)	-	-	-	1.404 (1.404)
Crossorhombus valderostratus	Broadbrow flounder	-	-	6.043 (2.908)	4.702 (2.190)	-	-
Engyprosopon maldivensis	Olive wide-eye flounder	-	-	-	0.167 (0.167)	-	0.080 (0.080)
Lophonectes gallus	Crested flounder	30.633 (14.993)	28.810 (14.591)	11.842 (3.172)	22.594 (3.995)	28.248 (5.120)	27.029 (4.601)
Bregmacerotidae							
Bregmaceros sp.	Unid. codlet	-	-	-	-	-	-
Callionymidae							
Bathycallionymus moretonensis	Ocellate dragonet	-	-	-	-	-	-
Callionymidae sp.	Unid. stinkfish	-	-	-	-	-	-
Calliurichthys scaber	Japanese stinkfish	-	-	0.147 (0.098)	-	0.803 (0.757)	0.909 (0.761)
Dactylopus dactylopus	Finger dragonet	-	-	-	-	0.457 (0.231)	0.117 (0.064)
Foetorepus calauropomus	Common stinkfish	-	-	-	0.167 (0.167)	5.791 (1.929)	6.079 (2.029)
Repomucenus calcaratus	Spotted dragonet	-	-	-	-	-	-
Repomucenus macdonaldi	Greyspotted dragonet	-	-	-	-	-	-
Caproidae							
Antigonia rhomboidea	Rhomboid deepsea boarfish	-	-	-	-	-	-
Antigonia rubicunda	Rosy deepsea boarfish	-	-	-	-	-	-
Carangidae							
Carangoides caeruleopinnatus	Onion trevally	-	-	-	-	-	-
Carangoides chrysophrys	Longnose trevally	-	-	-	-	-	-
Carangoides equula	Whitefin trevally	-	-	0.035 (0.035)	0.085 (0.085)	-	-
Pseudocaranx dentex	Silver trevally	-	-	-	0.120 (0.120)	-	0.028 (0.028)
Trachurus novaezelandiae	Yellowtail scad	2.352 (1.238)	1.325 (1.064)	34.435 (8.946)	24.235 (5.973)	1.597 (1.194)	0.284 (0.161)
Chaetodontidae							
Chaetodon guentheri	Gunther's butterflyfish	-	-	-	-	0.029 (0.029)	0.057 (0.038)

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Cheilodactylidae							
Cheilodactylus gibbosus	Magpie morwong	-	-	-	-	0.045 (0.045)	-
Clupeidae							
Herklotsichthys castelnaui	Southern herring	-	-	-	-	-	-
Hyperlophus vittatus	Sandy sprat	-	-	-	-	-	-
Sardinops neopilchardus	Australian sardine	-	-	-	-	-	-
Congridae							
Gnathophis grahami	Graham's conger	-	-	0.043 (0.043)	-	-	-
Gnathophis longicaudus	Little conger	2.853 (0.294)	-	1.688 (0.923)	0.120 (0.120)	0.169 (0.097)	0.111 (0.085)
Cynoglossidae							
Cynoglossus bilineatus	Fourline tongue sole	-	-	-	-	-	0.027 (0.027)
Cynoglossus maculipinnis	Spotfin tongue sole	-	-	0.080 (0.080)	0.570 (0.322)	-	-
Paraplagusia bilineata	Lemon tongue sole	-	-	-	-	-	-
Dactylopteridae							
Dactyloptena papilio	Largespot flying gurnard	-	0.182 (0.182)	0.155 (0.104)	0.036 (0.036)	0.051 (0.034)	0.197 (0.061)
Dinolestidae							
Dinolestes lewini	Longfin pike	-	-	0.035 (0.035)	0.129 (0.129)	-	-
Diodontidae							
Dicotylichthys punctulatus	Threebar porcupinefish	0.182 (0.182)	0.190 (0.190)	-	-	0.021 (0.021)	-
Emmelichthyidae							
Emmelichthys struhsakeri	Golden redbait	-	-	-	-	-	-
Engraulidae							
Engraulis australis	Australian anchovy	-	-	-	-	-	-
Enoplosidae							
Enoplosus armatus	Old wife	-	-	-	-	-	-
Fistulariidae							
Fistularia commersonii	Smooth flutemouth	-	-	-	-	-	-
Fistularia petimba	Rough flutemouth	-	-	-	-	-	-
Gempylidae							
Rexea solandri	Gemfish	-	-	-	-	-	-
Gerreidae							
Gerres subfasciatus	Common silver biddy	-	-	-	-	0.197 (0.137)	0.195 (0.134)
Glaucosomatidae							
Glaucosoma scapulare	Pearl perch	0.200 (0.200)	0.182 (0.182)	0.359 (0.190)	0.809 (0.713)	0.300 (0.173)	0.131 (0.109)

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Gonorynchidae							
Gonorynchus greyi	Beaked salmon	0.745 (0.373)	-	0.043 (0.043)	-	0.297 (0.215)	0.287 (0.096)
Hemiramphidae							
Hyporhamphus australis	Eastern sea garfish	-	-	-	-	-	-
Hyporhamphus regularis	River garfish	-	-	-	-	0.101 (0.081)	-
Kyphosidae							
Atypichthys strigatus	Mado	-	-	0.104 (0.104)	0.052 (0.052)	-	-
Microcanthus strigatus	Stripey	-	-	0.033 (0.033)	-	0.038 (0.038)	-
Scorpis lineolata	Silver sweep	-	-	-	-	-	-
Labridae							
Choerodon frenatus	Bridled tuskfish	-	-	-	-	0.231 (0.192)	0.203 (0.162)
Choerodon venustus	Venus tuskfish	-	-	-	-	-	-
Leiognathidae							
Leiognathus equulus	Common ponyfish	-	-	-	-	-	-
Lophidae							
Lophiomus setigerus	Broadhead goosefish	-	-	-	-	-	-
Macrouridae							
Caelorinchus mirus	Gargoyle fish	-	-	-	-	-	-
Monacanthidae							
Nelusetta ayraudi	Ocean jacket	2.487 (1.625)	2.906 (0.935)	0.162 (0.129)	0.426 (0.258)	0.028 (0.028)	
Paramonacanthus lowei	Lowe's leatherjacket	-	-	-	-	0.156 (0.094)	0.021 (0.021)
Monocentrididae							
Cleidopus gloriamaris	Australian pineapplefish	-	0.182 (0.182)	0.076 (0.051)	0.035 (0.035)	0.111 (0.079)	0.056 (0.056)
Monodactylidae							
Schuettea scalaripinnis	Eastern pomfred	-	-	-	-	-	-
Moridae							
Lotella rhacina	Largetooth beardie	-	-	1.387 (1.314)	0.212 (0.170)	-	-
Pseudophycis breviuscula	Bastard red cod	0.545 (0.545)	-	0.791 (0.260)	0.147 (0.098)	0.021 (0.021)	0.040 (0.040)
Mullidae							
Parupeneus rubescens	Blackspot goatfish	-	-	-	-	0.021 (0.021)	-
Upeneichthys lineatus	Bluestriped goatfish	0.600 (0.600)	0.600 (0.600)	0.560 (0.173)	0.454 (0.264)	1.634 (0.879)	1.677 (0.849)
Upeneus moluccensis	Goldband goatfish	-	-	-	-	-	-
Upeneus tragula	Bartail goatfish	-	-	-	0.033 (0.033)	0.040 (0.040)	-
Myctophidae							
Myctophidae sp.	Unid. lanternfish	-	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Nemipteridae							
Nemipterus theodorei	Theodore's threadfin bream	5.205 (2.331)	0.382 (0.192)	4.632 (1.252)	0.613 (0.229)	1.037 (0.620)	1.215 (0.918)
Neosebastidae							
Neosebastes thetidis	Thetis fish	-	-	0.123 (0.086)	0.035 (0.035)	-	0.061 (0.044)
Nomeidae							
Unid. Nomeid	Unid. driftfish	-	-	-	-	-	-
Ogcocephalidae							
Halieutaea sp.	Unid. seabat	-	-	-	-	-	-
Ophidiidae							
Neobythites nigriventris	Blackbelly cusk	-	-	-	-	-	-
Ophidion sp.	Unid. cusk	1.463 (1.189)	-	0.044 (0.044)	0.080 (0.080)	0.021 (0.021)	0.040 (0.040)
Sirembo metachroma	Chameleon cusk	-	-	-	-	0.021 (0.021)	-
Ostraciidae							
Anoplocapros inermis	Eastern smooth boxfish	1.135 (0.322)	0.754 (0.169)	1.046 (0.382)	0.790 (0.254)	1.687 (0.480)	1.550 (0.448)
Tetrosomus reipublicae	Smallspine turretfish	-	-	0.036 (0.036)	0.043 (0.043)	2.214 (1.448)	1.781 (0.938)
Paralichthyidae							
Pseudorhombus arsius	Largetooth flounder	-	-	-	-	-	-
Pseudorhombus jenynsii	Smalltooth flounder	-	-	-	-	-	-
Pseudorhombus tenuirastrum	Slender flounder	2.335 (0.950)	4.926 (1.407)	2.348 (0.604)	3.506 (0.968)	24.764 (7.465)	26.907 (8.079)
Paraulopidae							
Paraulopus melanogrammus	Cucumberfish	-	-	-	-	-	-
Pataecidae							
Pataecus fronto	Red Indian fish	-	-	-	-	-	-
Pempheridae							
Pempheris analis	Bronze bullseye	-	-	-	-	-	-
Pempheris compressa	Smallscale bullseye	-	-	-	-	0.028 (0.028)	0.027 (0.027)
Pentacerotidae							
Paristiopterus labiosus	Giant boarfish	0.190 (0.190)	-	-	-	-	-
Zanclistius elevatus	Blackspot boarfish						
Pinguipedidae							
Parapercis allporti	Barred grubfish	1.143 (1.143)	-	0.812 (0.509)	0.071 (0.071)	-	-
Parapercis binivirgata	Redbanded grubfish	-	-	0.152 (0.103)	-	-	-
Parapercis nebulosa	Pinkbanded grubfish	-	-	-	-	-	0.240 (0.240)
Parapercis ramsayi	Spotted grubfish	-	-	-	-	-	-
Simipercis trispinosa	Un-named grubfish	2.286 (2.286)	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Platycephalidae							
Ambiserrula jugosa	Mud flathead	0.381 (0.381)	-	1.330 (0.562)	0.637 (0.297)	-	-
Platycephalus arenarius	Northern sand flathead	-	-	-	-	-	-
Platycephalus caeruleopunctatus	Bluespotted flathead	2.953 (1.854)	4.200 (4.200)	1.168 (0.459)	2.530 (1.327)	2.681 (0.968)	2.362 (0.677)
Platycephalus fuscus	Dusky flathead	-	-	-	-	-	-
Platycephalus longispinis	Longspine flathead	26.582 (26.310)	16.011 (11.140)	5.106 (3.104)	4.697 (3.367)	155.536 (57.263)	145.315 (48.909)
Platycephalus marmoratus	Marbled flathead	-	-	-	-	0.634 (0.240)	0.506 (0.191)
Platycephalus richardsoni	Tiger flathead	0.381 (0.381)	-	0.120 (0.120)	-	-	-
Ratabulus diversidens	Freespine flathead	9.379 (4.008)	3.491 (2.912)	13.557 (3.196)	7.082 (2.171)	0.711 (0.497)	0.631 (0.464)
Pleuronectidae							
Samaris cristatus	Cockatoo flounder	-	-	-	-	0.146 (0.110)	0.133 (0.074)
Plotosidae							
Cnidoglanis macrocephalus	Estuary catfish	-	-	-	-	-	-
Plotosus lineatus	Striped catfish	-	-	-	-	-	-
Pomatomidae							
Pomatomus saltatrix	Tailor	-	-	-	-	-	-
Priacanthidae							
Priacanthus macracanthus	Spotted bigeye	2.254 (0.805)	2.144 (0.885)	4.345 (1.063)	3.549 (1.220)	1.053 (0.392)	0.916 (0.294)
Pristigenys niphonia	Whiteband bigeye	-	-	-	-	-	-
Samaridae							
Plagiopsetta glossa	Tongue flatfish	-	-	-	-	-	-
Sciaenidae							
Argyrosomus hololepidotus	Mulloway	-	-	-	-	-	-
Atractoscion aequidens	Teraglin	-	-	-	-	-	-
Scombridae							
Scomber australasicus	Blue mackerel	-	-	0.205 (0.139)	-	0.091 (0.091)	0.387 (0.224)
Scorpaenidae							
Pterois volitans	Common lionfish	-	-	-	0.120 (0.120)	-	-
Scorpaena cardinalis	Eastern red scorpionfish	0.182 (0.182)	-	0.073 (0.073)	-	-	-
Scorpaenodes smithi	Little scorpionfish	9.177 (5.124)	0.545 (0.545)	25.878 (7.616)	0.445 (0.251)	2.164 (1.407)	1.598 (0.394)
Scorpaenopsis diabolus	False stonefish	-	-	-	-	0.115 (0.062)	0.123 (0.064)
Serranidae							
Epinephelus ergastularius	Banded rockcod	-	-	0.085 (0.085)	0.198 (0.105)	-	0.027 (0.027)
Lepidoperca brochata	Fangtooth perch	-	-	-	-	-	-

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Siganidae							
Siganus fuscescens	Black rabbitfish	-	-	-	-	-	-
Sillaginidae							
Sillago ciliata	Sand whiting	-	-	-	-	-	-
Sillago flindersi	Eastern school whiting	135.204 (118.964)	26.660 (23.292)	22.459 (11.219)	21.934 (12.729)	14.993 (9.033)	10.592 (5.811)
Sillago robusta	Stout whiting	0.600 (0.600)	0.200 (0.200)	0.522 (0.522)	1.983 (1.983)	29.876 (7.754)	25.813 (7.128)
Soleidae							
Aseraggodes macleayanus	Narrow-banded sole	0.200 (0.200)	-	0.086 (0.059)	0.104 (0.104)	5.766 (2.558)	5.140 (1.605)
Brachirus nigra	Black sole	-	-	-	-	-	-
Pardachirus hedleyi	Southern peacock sole	-	-	-	-	0.023 (0.023)	-
Zebrias scalaris	Many-banded sole	-	-	-	-	1.385 (0.462)	1.050 (0.375)
Sparidae							
Dentex tumifrons	Yellowback bream	-	-	0.127 (0.090)	0.187 (0.131)	-	-
Pagrus auratus	Snapper	-	-	-	-	-	0.028 (0.028)
Rhabdosargus sarba	Tarwhine	-	-	-	-	-	-
Sphyraenidae							
Sphyraena acutipinnis	Sharpfin barracuda	-	-	-	-	-	-
Sphyraena barracuda	Great barracuda	-	-	0.086 (0.086)	0.043 (0.043)	0.027 (0.027)	-
Synanceiidae							
Erosa erosa	Pacific monkeyfish	-	-	-	-	-	0.028 (0.028)
Syngnathidae							
Hippocampus tristis	Sad seahorse	-	0.200 (0.200)	-	-	-	-
Solegnathus dunckeri	Duncker's pipehorse	0.190 (0.190)	-	-	-	-	-
Solegnathus spinosissimus	Spiny pipehorse	-	-	0.302 (0.256)	0.478 (0.343)	-	-
Synodontidae							
Saurida filamentosa	Threadfin saury	-	-	-	-	-	-
Saurida undosquamis	Largescale saury	3.600 (3.600)	2.000 (2.000)	3.733 (1.076)	2.490 (0.702)	3.735 (0.921)	3.425 (0.828)
Synodus indicus	Indian lizardfish	-	-	-	-	0.021 (0.021)	-
Trachinocephalus myops	Painted grinner	-	-	-	-	0.409 (0.145)	0.494 (0.175)
Terapontidae							
Pelates quadrilineatus	Fourline striped grunter	-	-	-	-	0.057 (0.039)	0.134 (0.058)
Tetraodontidae							
Arothron firmamentum	Starry toadfish	-	-	-	-	0.085 (0.058)	-
Canthigaster callisterna	Clown toby						

MAJOR GROUP	**Standard common name**	**35S vs. 45D-150 (BRDs open)**		**35S vs. 45D-150 (BRDs closed)**		**35S vs. 36-ind (BRDs open)**	
Family / *Species*		45D-150	35S	45D-150	35S	36S-ind	35S
Lagocephalus cheesemanii	Cheeseman's puffer	-	-	0.445 (0.205)	0.519 (0.201)	4.272 (1.633)	4.254 (1.708)
Lagocephalus sceleratus	Silver toadfish	-	-	-	0.146 (0.097)	-	-
Reicheltia halsteadi	Halstead's toadfish	-	-	-	0.167 (0.167)	-	-
Tetractenos glaber	Smooth toadfish	-	-	-	-	0.333 (0.225)	0.222 (0.150)
Tetractenos hamiltoni	Common toadfish	-	-	0.292 (0.218)	1.082 (0.818)	5.343 (1.738)	2.110 (0.716)
Tetraodontidae sp.	Unid. toadfish	-	-	-	-	-	-
Torquegenia tuberculiferus	Fringe-gill toadfish	-	-	-	-	-	-
Torquigener altipinnis	Highfin toadfish	0.571 (0.571)	-	-	0.033 (0.033)	0.240 (0.240)	0.120 (0.120)
Torquigener pleurogramma	Weeping toadfish	-	-	-	-	-	-
Torquigener squamicauda	Scalytail toadfish	-	-	0.165 (0.110)	-	-	-
Tetrarogidae							
Centropogon australis	Eastern fortescue	-	-	-	-	0.442 (0.228)	0.194 (0.110)
Trachichthyidae							
Aulotrachichthys novaezelandicus	New Zealand roughy	1.333 (1.333)	-	0.171 (0.171)	1.406 (1.313)	-	-
Optivus agastos	Violet roughy	14.773 (5.264)	1.509 (0.801)	15.734 (5.771)	6.313 (3.426)	1.640 (1.151)	1.525 (1.123)
Trachichthys australis	Southern roughy	-	-	-	-	-	-
Macrorhamphosodes uradoi	Common trumpetsnout	-	0.200 (0.200)	0.043 (0.043)	-	-	-
Trigildae							
Chelidonichthys kumu	Red gurnard	0.200 (0.200)	-	0.036 (0.036)	0.043 (0.043)	0.143 (0.052)	0.397 (0.120)
Lepidotrigla argus	Eye gurnard	684.906 (449.274)	378.340 (251.153)	448.813 (78.674)	458.986 (93.749)	254.232 (58.514)	298.605 (59.934)
Lepidotrigla grandis	Little red gurnard	-	-	-	-	-	-
Lepidotrigla umbrosa	Blackspot gurnard	-	-	-	-	-	-
Pterygotrigla andertoni	Painted latchet	-	-	-	-	-	-
Satyrichthys rieffeli	Spotted armour gurnard	-	-	-	-	-	-
Uranoscopidae							
Ichthyscopus nigripinnis	Blackfin stargazer	-	-	-	-	0.029 (0.029)	-
Ichthyscopus sannio	Spotted stargazer	-	-	-	-	-	0.021 (0.021)
Kathetostoma laeve	Common stargazer	-	-	0.104 (0.104)	-	-	-
Uranoscopidae sp.	Unid. stargazer	-	-	-	-	-	-
Uranoscopus terraereginae	Queensland stargazer	0.200 (0.200)	-	0.085 (0.085)	0.085 (0.085)	-	-
Veliferidae							
Metavelifer multiradiatus	Common veilfin	-	-	-	-	0.040 (0.040)	0.080 (0.080)
GASTROPODS							

MAJOR GROUP **Family / *Species***	**Standard common name**	**35S vs. 45D-150 (BRDs open)** 45D-150	 35S	**35S vs. 45D-150 (BRDs closed)** 45D-150	 35S	**35S vs. 36-ind (BRDs open)** 36S-ind	 35S
Conidae							
Conus sanguinolentus	Un-named cone shell	-	-	-	-	-	-
Ficidae							
Ficus subintermedius	Fig shell	-	-	-	-	-	-
Olividae							
Ancillista velesiana	Olive shell	-	-	-	-	0.172 (0.125)	0.029 (0.029)
Tonnidae							
Tonna chinensis	Un-named tun shell	-	-	-	-	-	-
Tonna variegata	Tun shell	-	-	-	-	0.217 (0.159)	0.027 (0.027)
Volutidae							
Cymbiolista hunteri	Un-named volute shell	-	0.200 (0.200)	-	-	13.519 (8.032)	5.160 (3.400)
Livonia mamilla	Bailer shell	-	-	0.035 (0.035)	0.036 (0.036)	0.027 (0.027)	-
PORIFORANS							
Unid. sponges	Unid. sponges	0.182 (0.182)	-	-	-	-	-

APPENDIX C: Mean catch rate (h^{-1}) (± SE) (by number) for each species recorded in sampled catches during the study. Data are for each codend type in the 35S vs. 40D-200 (BRDs open) (*n* = 13 except for school prawns, where *n* = 14) codend contrast done on school prawn trawl grounds. Species are ordered according to 'Major group' and 'Family'. 'Unid.', unidentified.

MAJOR GROUP Family / *Species*	Standard common name	35S vs. 40D-200 (BRDs open) 43D-200	 35S
BIVALVES			
Pectinidae			
Amusium balloti	Ballot's saucer scallop	-	-
Amusium sp.	Saucer scallop	-	-
Annachlamys flabellata	Fan scallop	-	-
CEPHALOPODS			
Loliginidae			
Photololigo chinensis	Broad squid	-	-
Photololigo sp.	Slender squid	-	0.042 (0.042)
Sepioteuthis australis	Southern calamari	-	-
Uroteuthis noctiluca	Bottle squid	23.495 (14.221)	8.685 (3.682)
Octopodidae			
Octopus australis	Southern octopus	-	-
Octopus sp.	Unid. octopus	-	-
Octopus sp.A	Cross-eye octopus	-	-
Octopus sp.B	Red slimy octopus	-	-
Octopus sp.C	Grey slimy octopus	-	0.051 (0.051)
Octopus tetricus	Gloomy octopus	-	-
Ommastrephidae			
Nototodarus gouldi	Gould's arrow squid	-	-
Sepiadariidae			
Sepioloidea lineolata	Pinstripe bottle-tailed squid	-	-
Sepiidae			
Sepia hedleyi	King cuttlefish	-	-
Sepia limata	Pink cuttlefish	-	-
Sepia opipara	Staregaze cuttlefish	-	-
Sepia plangon	Mourning cuttlefish	-	-
Sepia rozella	Rosecone cuttlefish	-	-
CRUSTACEANS			
Calappidae			
Calappa lophos	Red-streaked box crab	-	-
Calappa philargius	Red-spotted box crab	-	-
Mursia curtispina	Spiny box crab	0.030 (0.030)	-
Cassidae			
Semicassis bisulcata	Un-named helmet crab	-	-
Corystidae			
Jonas luteanus	Un-named Corystid crab	-	-
Diogenidae			
Dardanus arrosor	Smooth-legged hermit crab	-	-

		35S vs. 40D-200 (BRDs open)	
MAJOR GROUP **Family / *Species***	**Standard common name**	**43D-200**	**35S**
Dardanus crassimanus	Northern hairy hermit crab	-	-
Strigopagurus strigimanus	Hairy-legged hermit crab	-	-
Goneplacidae			
Ommatocarcinus macgillivrayi	Long-armed crab	-	-
Leucosiidae			
Arcania undecimspinosa	Rough pebble crab	-	-
Bellidilia undecinspinosa	Large pebble crab	-	-
Leucosia anatum	Painted pebble crab	-	-
Leucosiidae sp.	Small-spined pebble crab	-	-
Majidae			
Hyastenus elatus	Dwarf spider crab	-	-
Leptomithrax tuberculatus	Pygmy spider crab	-	-
Naxioides robillardi	Longhorn spider crab	-	-
Phalangipus australiensis	Daddy longlegs spider crab	-	-
Teratomaia richardsoni	long-armed spider crab	-	-
Unid. Majid	Unid. spider crab	-	-
Matutidae			
Matuta planipes	Reticulated surf crab	5.066 (1.236)	4.187 (1.169)
Palinuridae			
Jasus verreauxi	Eastern rock lobster	-	-
Pandalidae			
Plesionika martia	Unid. Carid shrimp	-	-
Plesionika spinipes	Striped carid	-	-
Paralichthyidae			
Bellidilia laevis	Smooth pebble crab	-	-
Penaeidae			
Metapenaeopsis palmensis	Southern velvet prawn	-	-
Metapenaeus bennettae	Greentail prawn	-	-
Metapenaeus macleayi	School prawn	3493.867 (483.266)	1339.339 (260.430)
Penaeus esculentus	Brown tiger prawn	-	-
Trachypenaeus curvirostris	Southern rough prawn	-	-
Unid. Parapenaeid	Unid. Parapenaeid prawn	-	-
Portunidae			
Charybdis bimaculata	Un-named swimmer crab	-	-
Charybdis feriata	Coral crab	-	-
Charybdis miles	Common trawl crab	-	-
Charybdis natator	Hairyback crab	-	-
Lupocyclus sp.	Longlegs swimmer crab	-	-
Ovalipes australiensis	Common sand crab	51.393 (17.567)	12.380 (2.384)
Portunus pelagicus	Blue swimmer crab	0.141 (0.101)	0.112 (0.060)
Portunus rubromarginatus	Northern pink swimmer crab	-	-
Portunus sanguinolentus	Threespot sand crab	0.147 (0.077)	0.303 (0.159)
Raninidae			
Lyreidus tridentatus	Frog crab	-	-
Ranina ranina	Spanner crab	-	-
Scyllaridae			
Biarctus sordidus	Pygmy slipper lobster	-	-
Ibacus brucei	Bruce's bug	-	-
Ibacus chacei	Smooth bug	0.051 (0.051)	-

MAJOR GROUP **Family** / ***Species***	**Standard common name**	**35S vs. 40D-200 (BRDs open)** **43D-200**	 **35S**
Ibacus peronii	Balmain bug	-	-
Solenoceridae			
Solenocera choprai	Ridgeback prawn	-	-
Squillidae			
Belosquilla laevis	Common mantis	-	-
Harpiosquilla melanoura	Black-tailed mantis	-	-
Quollastria capricornae	Pink mantis shrimp	-	-
Quollastria gonypetes	Red-spined mantis	-	-
ECHINODERMS			
Unid. sand dollars	Unid. sand dollars	-	-
Unid. starfishes	Unid. starfishes	-	-
Unid. sea tulips	Unid. sea tulips	-	-
Unid. urchins	Unid. urchins	-	-
ELASMOBRANCHES			
Brachaeluridae			
Brachaelurus colcloughi	Colclough's shark	-	-
Carcharhinidae			
Carcharhinus leucas	Bull shark	-	0.038 (0.038)
Chimaeridae			
Hydrolagus sp.	Unid. ghostshark	-	-
Hydrologus ogilbyi	Ogilby's ghost shark	-	-
Dasyatidae			
Dasyatis kuhlii	Bluespotted maskray	0.081 (0.057)	0.051 (0.051)
Dasyatis thetidis	Black stingray	-	-
Heterodontidae			
Heterodontus galeatus	Crested hornshark	-	-
Heterodontus portusjacksoni	Port Jackson shark	-	-
Myliobatidae			
Aetobatus narinari	Whitespotted eagle ray	-	0.038 (0.038)
Rhinoptera neglecta	Australian cownose ray	0.038 (0.038)	-
Orectolobidae			
Orectolobus maculatus	Spotted wobbegong	-	-
Pristiophoridae			
Pristiophorus cirratus	Common sawshark	-	-
Rajidae			
Dipturus australis	Sydney skate	-	-
Dipturus polyommata	Argus skate	-	-
Rhinidae			
Rhynchobatus australiae	Whitespotted guitarfish	-	-
Rhinobatidae			
Aptychotrema rostrata	Eastern shovelnose ray	0.782 (0.283)	0.325 (0.211)
Trygonorrhina fasciata	Southern fiddler ray	-	-
Scyliorhinidae			
Asymbolus sp.	Unid. spotted catshark	-	-
Galeus boardmani	Sawtail catshark	-	-
Torpedinidae			

		<u>**35S vs. 40D-200 (BRDs open)**</u>	
MAJOR GROUP **Family / *Species***	**Standard common name**	**43D-200**	**35S**
Hypnos monopterygium	Coffin ray	1.203 (0.434)	1.494 (0.347)
Triakidae			
Mustelus antarcticus	Gummy shark	-	-
Urolophidae			
Trygonoptera testacea	Common stingaree	5.908 (3.003)	5.759 (2.993)
Urolophus bucculentus	Sandyback stingaree	-	-
Urolophus viridis	Greenback stingaree	-	-
TELOSTS			
Acropomatidae			
Apogonops anomalus	Threespine cardinalfish	-	-
Antennariidae			
Antennarius striatus	Striate anglerfish	-	-
Kuiterichthys furcipilis	Rough anglerfish	-	-
Apogonidae			
Apogon nigripinnis	Two-eyed cardinalfish	0.103 (0.103)	-
Apogon quadrifasciatus	Bar-striped cardinalfish	-	-
Apogon truncatus	Flagfin cardinalfish	-	-
Ariidae			
Arius graeffei	Blue catfish	0.038 (0.038)	-
Ariommatidae			
Ariomma luridum	Slope driftfish	-	-
Aulopidae			
Aulopus purpurissatus	Sergeant baker	-	-
Hime curtirostris	Shortsnout threadsail	-	-
Batrachoididae			
Batrachomeus dubius	Eastern frogfish	-	-
Bembridae			
Bembras macrolepis	Bigscale flathead	-	-
Berycidae			
Centroberyx affinis	Redfish	-	-
Bothidae			
Asterorhombus bleekeri	Bleeker's flounder	-	-
Crossorhombus valderostratus	Broadbrow flounder	-	-
Engyprosopon maldivensis	Olive wide-eye flounder	-	-
Lophonectes gallus	Crested flounder	-	0.051 (0.051)
Bregmacerotidae			
Bregmaceros sp.	Unid. codlet	-	-
Callionymidae			
Bathycallionymus moretonensis	Ocellate dragonet	-	-
Callionymidae sp.	Unid. stinkfish	-	-
Calliurichthys scaber	Japanese stinkfish	-	-
Dactylopus dactylopus	Finger dragonet	-	-
Foetorepus calauropomus	Common stinkfish	1.400 (0.741)	0.202 (0.157)
Repomucenus calcaratus	Spotted dragonet	-	-
Repomucenus macdonaldi	Greyspotted dragonet	2.297 (0.808)	0.275 (0.167)
Caproidae			

MAJOR GROUP **Family** / ***Species***	**Standard common name**	**35S vs. 40D-200 (BRDs open)** **43D-200**	 **35S**
Antigonia rhomboidea	Rhomboid deepsea boarfish	-	-
Antigonia rubicunda	Rosy deepsea boarfish	-	-
Carangidae			
Carangoides caeruleopinnatus	Onion trevally	-	-
Carangoides chrysophrys	Longnose trevally	-	-
Carangoides equula	Whitefin trevally	-	-
Pseudocaranx dentex	Silver trevally	-	0.049 (0.049)
Trachurus novaezelandiae	Yellowtail scad	3.594 (1.720)	-
Chaetodontidae			
Chaetodon guentheri	Gunther's butterflyfish	-	-
Cheilodactylidae			
Cheilodactylus gibbosus	Magpie morwong	-	-
Clupeidae			
Herklotsichthys castelnaui	Southern herring	10.743 (8.911)	8.058 (5.873)
Hyperlophus vittatus	Sandy sprat	7.931 (4.310)	0.231 (0.231)
Sardinops neopilchardus	Australian sardine	-	-
Congridae			
Gnathophis grahami	Graham's conger	-	-
Gnathophis longicaudus	Little conger	-	-
Cynoglossidae			
Cynoglossus bilineatus	Fourline tongue sole	-	0.051 (0.051)
Cynoglossus maculipinnis	Spotfin tongue sole	-	0.051 (0.051)
Paraplagusia bilineata	Lemon tongue sole	-	-
Dactylopteridae			
Dactyloptena papilio	Largespot flying gurnard	-	-
Dinolestidae			
Dinolestes lewini	Longfin pike	0.103 (0.103)	-
Diodontidae			
Dicotylichthys punctulatus	Threebar porcupinefish	-	-
Emmelichthyidae			
Emmelichthys struhsakeri	Golden redbait	-	-
Engraulidae			
Engraulis australis	Australian anchovy	-	0.051 (0.051)
Enoplosidae			
Enoplosus armatus	Old wife	0.049 (0.049)	-
Fistulariidae			
Fistularia commersonii	Smooth flutemouth	-	-
Fistularia petimba	Rough flutemouth	-	-
Gempylidae			
Rexea solandri	Gemfish	-	-
Gerreidae			
Gerres subfasciatus	Common silver biddy	0.433 (0.236)	0.404 (0.275)
Glaucosomatidae			
Glaucosoma scapulare	Pearl perch	-	-
Gonorynchidae			
Gonorynchus greyi	Beaked salmon	-	-
Hemiramphidae			
Hyporhamphus australis	Eastern sea garfish	0.092 (0.092)	-
Hyporhamphus regularis	River garfish	-	0.051 (0.051)

MAJOR GROUP Family / *Species*	Standard common name	35S vs. 40D-200 (BRDs open) 43D-200	 35S
Kyphosidae			
Atypichthys strigatus	Mado	0.460 (0.265)	-
Microcanthus strigatus	Stripey	0.195 (0.132)	-
Scorpis lineolata	Silver sweep	0.044 (0.044)	-
Labridae			
Choerodon frenatus	Bridled tuskfish	-	-
Choerodon venustus	Venus tuskfish	-	-
Leiognathidae			
Leiognathus equulus	Common ponyfish	-	-
Lophidae			
Lophiomus setigerus	Broadhead goosefish	-	-
Macrouridae			
Caelorinchus mirus	Gargoyle fish	-	-
Monacanthidae			
Nelusetta ayraudi	Ocean jacket	0.044 (0.044)	-
Paramonacanthus lowei	Lowe's leatherjacket	-	-
Monocentrididae			
Cleidopus gloriamaris	Australian pineapplefish	-	-
Monodactylidae			
Schuettea scalaripinnis	Eastern pomfred	0.030 (0.030)	-
Moridae			
Lotella rhacina	Largetooth beardie	-	-
Pseudophycis breviuscula	Bastard red cod	-	-
Mullidae			
Parupeneus rubescens	Blackspot goatfish	-	-
Upeneichthys lineatus	Bluestriped goatfish	-	-
Upeneus moluccensis	Goldband goatfish	-	-
Upeneus tragula	Bartail goatfish	-	-
Myctophidae			
Myctophidae sp.	Unid. lanternfish	-	-
Nemipteridae			
Nemipterus theodorei	Theodore's threadfin bream	-	-
Neosebastidae			
Neosebastes thetidis	Thetis fish	-	-
Nomeidae			
Unid. Nomeid	Unid. driftfish	-	-
Ogcocephalidae			
Halieutaea sp.	Unid. seabat	-	-
Ophidiidae			
Neobythites nigriventris	Blackbelly cusk	-	-
Ophidion sp.	Unid. cusk	-	-
Sirembo metachroma	Chameleon cusk	-	-
Ostraciidae			
Anoplocapros inermis	Eastern smooth boxfish	-	-
Tetrosomus reipublicae	Smallspine turretfish	-	-
Paralichthyidae			
Pseudorhombus arsius	Largetooth flounder	1.260 (0.672)	1.622 (1.375)
Pseudorhombus jenynsii	Smalltooth flounder	0.209 (0.120)	0.147 (0.108)
Pseudorhombus tenuirastrum	Slender flounder	-	-

MAJOR GROUP **Family /** ***Species***	**Standard common name**	**35S vs. 40D-200 (BRDs open)** **43D-200**	 **35S**
Paraulopidae			
Paraulopus melanogrammus	Cucumberfish	-	-
Pataecidae			
Pataecus fronto	Red Indian fish	-	-
Pempheridae			
Pempheris analis	Bronze bullseye	0.030 (0.030)	-
Pempheris compressa	Smallscale bullseye	0.359 (0.359)	0.044 (0.044)
Pentacerotidae			
Paristiopterus labiosus	Giant boarfish	-	-
Zanclistius elevatus	Blackspot boarfish	-	-
Pinguipedidae			
Parapercis allporti	Barred grubfish	-	-
Parapercis binivirgata	Redbanded grubfish	-	-
Parapercis nebulosa	Pinkbanded grubfish	-	-
Parapercis ramsayi	Spotted grubfish	-	-
Simipercis trispinosa	Un-named grubfish	-	-
Platycephalidae			
Ambiserrula jugosa	Mud flathead	-	-
Platycephalus arenarius	Northern sand flathead	0.202 (0.091)	0.276 (0.134)
Platycephalus caeruleopunctatus	Bluespotted flathead	11.824 (3.952)	1.707 (0.659)
Platycephalus fuscus	Dusky flathead	0.082 (0.056)	0.068 (0.068)
Platycephalus longispinis	Longspine flathead	-	-
Platycephalus marmoratus	Marbled flathead	-	-
Platycephalus richardsoni	Tiger flathead	-	-
Ratabulus diversidens	Freespine flathead	-	-
Pleuronectidae			
Samaris cristatus	Cockatoo flounder	-	-
Plotosidae			
Cnidoglanis macrocephalus	Estuary catfish	-	0.049 (0.049)
Plotosus lineatus	Striped catfish	0.967 (0.967)	-
Pomatomidae			
Pomatomus saltatrix	Tailor	1.083 (0.345)	0.864 (0.435)
Priacanthidae			
Priacanthus macracanthus	Spotted bigeye	0.049 (0.049)	0.051 (0.051)
Pristigenys niphonia	Whiteband bigeye	-	-
Samaridae			
Plagiopsetta glossa	Tongue flatfish	-	-
Sciaenidae			
Argyrosomus hololepidotus	Mulloway	0.037 (0.037)	-
Atractoscion aequidens	Teraglin	-	-
Scombridae			
Scomber australasicus	Blue mackerel	-	-
Scorpaenidae			
Pterois volitans	Common lionfish	-	-
Scorpaena cardinalis	Eastern red scorpionfish	-	-
Scorpaenodes smithi	Little scorpionfish	-	-
Scorpaenopsis diabolus	False stonefish	-	-
Serranidae			

MAJOR GROUP	**Standard common name**	**35S vs. 40D-200 (BRDs open)**	
Family / *Species*		**43D-200**	**35S**
Epinephelus ergastularius	Banded rockcod	-	-
Lepidoperca brochata	Fangtooth perch	-	-
Siganidae			
Siganus fuscescens	Black rabbitfish	-	-
Sillaginidae			
Sillago ciliata	Sand whiting	0.038 (0.038)	-
Sillago flindersi	Eastern school whiting	48.416 (23.852)	0.508 (0.365)
Sillago robusta	Stout whiting	79.337 (36.874)	15.683 (14.500)
Soleidae			
Aseraggodes macleayanus	Narrow-banded sole	-	0.142 (0.077)
Brachirus nigra	Black sole	0.185 (0.185)	0.180 (0.122)
Pardachirus hedleyi	Southern peacock sole	-	-
Zebrias scalaris	Many-banded sole	1.418 (0.700)	1.577 (1.173)
Sparidae			
Dentex tumifrons	Yellowback bream	-	-
Pagrus auratus	Snapper	-	-
Rhabdosargus sarba	Tarwhine	-	-
Sphyraenidae			
Sphyraena acutipinnis	Sharpfin barracuda	-	-
Sphyraena barracuda	Great barracuda	6.307 (4.105)	0.038 (0.038)
Synanceiidae			
Erosa erosa	Pacific monkeyfish	-	-
Syngnathidae			
Hippocampus tristis	Sad seahorse	-	-
Solegnathus dunckeri	Duncker's pipehorse	-	-
Solegnathus spinosissimus	Spiny pipehorse	-	-
Synodontidae			
Saurida filamentosa	Threadfin saury	-	-
Saurida undosquamis	Largescale saury	0.092 (0.092)	-
Synodus indicus	Indian lizardfish	-	-
Trachinocephalus myops	Painted grinner	-	-
Terapontidae			
Pelates quadrilineatus	Fourline striped grunter	-	0.129 (0.068)
Tetraodontidae			
Arothron firmamentum	Starry toadfish	-	-
Canthigaster callisterna	Clown toby	-	-
Lagocephalus cheesemanii	Cheeseman's puffer	0.178 (0.104)	-
Lagocephalus sceleratus	Silver toadfish	-	-
Reicheltia halsteadi	Halstead's toadfish	2.088 (1.003)	0.872 (0.388)
Tetractenos glaber	Smooth toadfish	-	-
Tetractenos hamiltoni	Common toadfish	0.034 (0.034)	-
Tetraodontidae sp.	Unid. toadfish	-	-
Torquegenia tuberculiferus	Fringe-gill toadfish	-	-
Torquigener altipinnis	Highfin toadfish	-	0.034 (0.034)
Torquigener pleurogramma	Weeping toadfish	0.419 (0.214)	0.318 (0.270)
Torquigener squamicauda	Scalytail toadfish	-	-
Tetrarogidae			
Centropogon australis	Eastern fortescue	20.788 (13.523)	0.365 (0.138)
Trachichthyidae			

MAJOR GROUP **Family / *Species***	**Standard common name**	**35S vs. 40D-200 (BRDs open)** **43D-200**	 **35S**
Aulotrachichthys novaezelandicus	New Zealand roughy	-	-
Optivus agastos	Violet roughy	-	-
Trachichthys australis	Southern roughy	-	-
Macrorhamphosodes uradoi	Common trumpetsnout	-	-
Trigildae			
Chelidonichthys kumu	Red gurnard	2.191 (1.061)	1.120 (0.668)
Lepidotrigla argus	Eye gurnard	-	-
Lepidotrigla grandis	Little red gurnard	-	-
Lepidotrigla umbrosa	Blackspot gurnard	-	-
Pterygotrigla andertoni	Painted latchet	-	-
Satyrichthys rieffeli	Spotted armour gurnard	-	-
Uranoscopidae			
Ichthyscopus nigripinnis	Blackfin stargazer	-	-
Ichthyscopus sannio	Spotted stargazer	-	-
Kathetostoma laeve	Common stargazer	-	-
Uranoscopidae sp.	Unid. stargazer	-	-
Uranoscopus terraereginae	Queensland stargazer	-	-
Veliferidae			
Metavelifer multiradiatus	Common veilfin	-	-
GASTROPODS			
Conidae			
Conus sanguinolentus	Un-named cone shell	-	-
Ficidae			
Ficus subintermedius	Fig shell	-	-
Olividae			
Ancillista velesiana	Olive shell	-	-
Tonnidae			
Tonna chinensis	Un-named tun shell	-	-
Tonna variegata	Tun shell	-	-
Volutidae			
Cymbiolista hunteri	Un-named volute shell	-	-
Livonia mamilla	Bailer shell	-	-
PORIFORANS			
Unid. sponges	Unid. sponges	-	-

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