The Sydney inshore trawl-whiting fishery: codend selectivity and fishery characteristics

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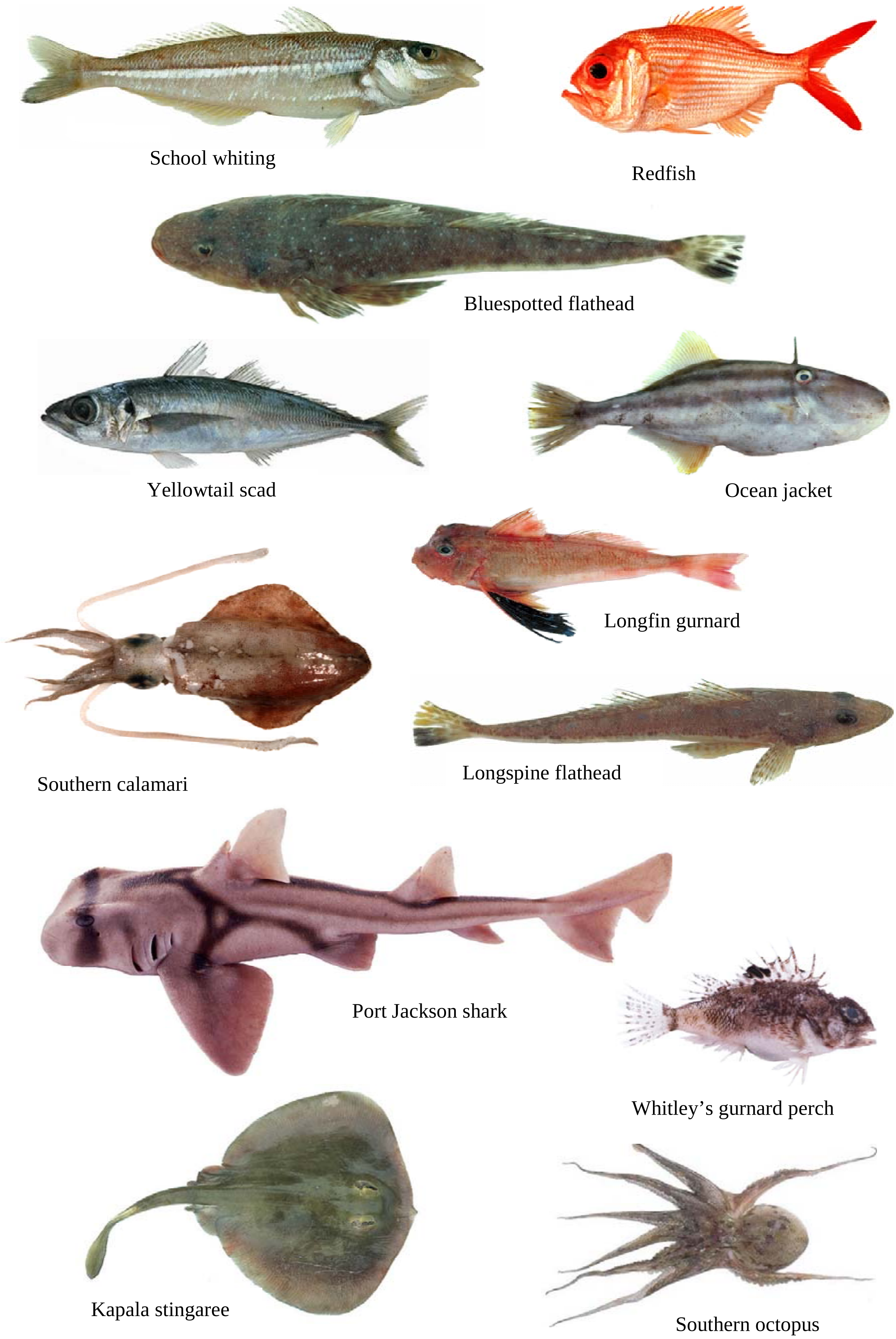
Landing the ‘whiting’ codend on FV *Kirrawa*, August 2004.

Sorting a school whiting catch on FV *Kirrawa*, May 2005.



Species commonly caught on central NSW school whiting grounds.

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ACKNOWLEDGEMENTS

I thank Richard Bagnato for making the *Kirrawa* and *May Bell II* available for the project, and for his continuous co-operation and professional advice. I also thank his crews for their willing help on the deck. The late Domenic Bagnato constructed the trial codends and I greatly appreciated his generosity in freely contributing his knowledge from long experience in the fishery.

Matt Broadhurst oversaw the design of project and, with Russell Millar (University of Auckland, New Zealand), formally analysed the selectivity data. I thank Will Macbeth for helpful discussions, and Matt Broadhurst, Kevin Rowling and Veronica Silberschneider for reviewing the report and suggesting improvements.

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NON-TECHNICAL SUMMARY

The Sydney inshore trawl-whiting fishery: codend selectivity and fishery characteristics.

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OBJECTIVES:

1) To test the effects of codend circumference on the efficiency and selectivity of 90 mm mesh fish-trawl codends when targeting eastern school whiting.

2) To test the effects of codend-mesh twine diameter on the efficiency and mesh selectivity of 90 mm mesh fish-trawl codends when targeting school whiting.

3) To document the size composition of the main commercial and non-commercial species caught in each gear treatment.

4) To compare catch rates and size compositions from tows in depths shallower and deeper than 55 m (30 fathoms).

5) To document the fish and invertebrate fauna on the central NSW inshore trawl grounds.

NON-TECHNICAL SUMMARY:

Historically, most eastern school whiting (*Sillago flindersi*) in NSW were harvested as byproduct of prawn trawling. However, declining catches of many offshore trawl species have resulted in central NSW fish trawlers directing more effort onto inshore grounds with school whiting the main target. To retain school whiting in the large meshed (90-mm) fish-trawl codends, fishers have modified their nets, typically by doubling the codend circumference from 100 to 200 meshes and then joining it to a 100-mesh circumference extension section. Combined with heavy (5 mm diameter double twine) mesh, this arrangement effectively reduces the lateral opening of the codend meshes sufficiently to retain commercial quantities of whiting.

The implications of these gear changes and a proposal to limit the use of trawls rigged for school whiting to depths less than 55 m were canvassed during the preparation of the Fishery Management Strategy for the NSW Ocean Trawl Fishery. To provide current information on the fishery and gear, a research project was done on a chartered Sydney trawler during 2005 and 2006 to assess the effects of different codend circumferences and twine diameters on the selectivity attributes of 90-mm mesh fish trawl codends when targeting school whiting. Specifically, two experiments examined the relative efficiencies and selectivities of five codends made from 90-mm, double-twine mesh, but with different circumferences (100 and 200 meshes) and twine diameters (3, 4, and 5 mm). The codends were interchanged with a small-meshed control codend in alternate-haul comparisons. Length composition data were collected from those species with size ranges likely to provide selectivity parameters, including two non-commercial species. In addition to the selectivity results, the report describes comparative catch composition data from depths shallower and deeper

than 55 m, and data on the relative abundances of the fishes, molluscs and crustaceans taken in over 150 tows.

The results showed a general trend of reduced selection by the 200-mesh circumference and thicker-twined codends, particularly by the industry-preferred codend of 200 meshes constructed from 5 mm diameter twine. Compared to the more lightly constructed codends, significantly greater numbers of total-catch, retained-catch, and school whiting were caught by the 200 mesh, 4- and 5-mm twined codends, and also significantly more longspine flathead (*Platycephalus longispinis*) in the latter. Across all codends, the smallest sizes at 50% probability of retention (L_{50}) were estimated for school whiting, longspine flathead, redfish (*Centroberyx affinis*) and longfin gurnard (*Lepidotrigla argus*) in the industry preferred 5-mm 200-mesh codend. The total number and weight of catch taken by this codend were respectively about one half and one third of the catch taken by its corresponding control, and the results clearly demonstrated that the 5-mm 200-mesh codend configuration was the least selective and, as a consequence, most effective in retaining commercial quantities of school whiting.

In the five treatment (90-mm mesh) codends, retained catch weights were between 47 and 67% of the total-catch, with school whiting about half of the retained catches in the 200-mesh, 4- and 5-mm diameter twine codends but only 33% of retained-catch in the 3-mm 200-mesh codend and 9% in the 100-mesh codend. Catch rates of most other commercial species were similar for all codends, irrespective of construction and including the 100-mesh circumference codend designated by the Ocean Trawl Fishery Management Strategy for use by the fish-trawl sector. School whiting were shown to be similarly abundant in depths of 40 – 55 m and 55 – 80 m, and few below marketable size (~15 cm TL) were caught in either depth range. The proportion of discarded commercial species (below minimum legal or acceptable market length) was 15 – 20% of total-catch weight, and comprised mainly ocean jackets (*Nelusetta ayraudi*) in depths shallower than 55 m and redfish in greater depths; relatively few undersized flathead (Platycephalidae) or snapper (*Pagrus auratus*) were caught across all depths.

A total of 173 species of fishes and invertebrates were recorded but a high proportion of the catch consisted of a small number of species, with more than 80% of the total catch number and 60% of catch weight consisting of the commercial school whiting, ocean jacket and redfish, and the non-commercial longfin gurnard and longspine flathead. Over the whole study, elasmobranchs were 1% of total catch number but 16% of catch weight, while teleosts were 95% by number and 76% by weight. Molluscs, mainly cephalopods such as southern calamari (*Sepioteuthis australis*) and cuttlefish (*Sepia* spp.), were respectively about 3% and 7% of total catch number and weight, but the few crustaceans (mostly Balmain bugs and blue-swimmer crabs) contributed less than 1% of the catch.

Although used for targeting school whiting, the industry codend was only about 50% as efficient at retaining school whiting as the small-meshed control codend, suggesting that the heavily constructed 90-mm diamond mesh codend used by industry may not be the most appropriate for the fishery. As there appeared to be minimal numbers of legally undersized or unmarketably small fish on the grounds fished (particularly in depths less than about 60 m), it is suggested that a more efficient codend, possibly constructed of smaller, square-shaped meshes, could be developed and used in conjunction with temporal, spatial, and catch restrictions for the targeting of school whiting by the fish-trawl sector of the NSW Ocean Trawl Fishery. However, the impact on non-commercial species and overall biodiversity would need to be appraised in conjunction with such a development.

KEYWORDS: trawl fishery, fishery management, codend selectivity, codend circumference, species selection, school whiting.

1. INTRODUCTION

Through the 1990 Offshore Constitutional Settlement (OCS) agreement, New South Wales (NSW) has jurisdiction over trawling in depths less than 4000 m (to ca. 80 nautical miles from the coast) in waters between Barrenjoey Point (Broken Bay) and the Queensland border; NSW also holds jurisdiction over waters within 3 nautical miles of the coastline south from Barrenjoey Point to the Victorian border (DPI 2004).

The NSW Ocean Trawl Fishery (OTF), which operates in these State waters, has two components: i) ocean prawn trawlers operating mainly off central and northern NSW (between Newcastle and Tweed Heads) and ii) fish trawlers working grounds south of Crowdy Head. In 2000, about 100 NSW fishing businesses held an entitlement to operate in the fish-trawl sector but many of these either fished predominantly in Commonwealth waters south of Sydney, or also had prawn-trawl endorsements and participated in the NSW fishery wholly for prawns; in addition, a proportion of fish-trawling licences were inactive. In 2006, there was a major buy-out of entitlements in a number of Commonwealth Government managed fisheries, including from the trawl-sector of the South East Scalefish and Shark Fishery (SESSF), resulting in an overall 50% reduction in trawl-concessions in the SESSF (Larcombe & McLoughlin 2007). A significant proportion of NSW trawler operators sold their endorsements with an end result that approximately 20 trawlers remained operating in Commonwealth waters from NSW ports south from Sydney. While most Sydney trawler owners also tendered their Commonwealth concessions back to the government, they have continued operating in State waters inside three nautical miles south of Barrenjoey Point, and across all depths to the north of Barrenjoey Point.

Currently, 10 – 15 vessels work principally as fish trawlers in NSW state waters from Sydney, Newcastle and Port Stephens. The trawlers are between 13 and 24 m in length and are powered by 135 – 450 kW (180 – 600 hp) main engines. Otter trawls are between 25 and 50 m headline length with chain or rubber disc (max 100 mm diameter) ground-ropes, and are constructed generally of light-weight netting in the wings and body and heavier double-twine mesh in the extension section and codend. Regulations prescribe a minimum mesh size of 90 mm (inside stretched length). Steel vee-doors or super-vee doors are the most common style of otter board, and sweep wires are usually 180 m (100 fathoms) of 24 – 28 mm diameter combination rope (see Figure 1.1 for general arrangement of demersal trawl gear). The main trawling grounds range in depth between 25 and 600 m although the larger trawlers occasionally fish down to 1000 m.

Since 2000, reported total landings from NSW waters by fish trawlers averaged almost 1600 t per annum with the highest total of 1860 t in 2005-06 (NSW DPI Commercial Catch data). Although the fishery lands over 100 species (DPI 2004), more than 50% of the 2005-06 catch comprised just four species: eastern school (red-spot) whiting (*Sillago flindersi*) contributed 24% (445 t) of the landings, tiger flathead (*Platycephalus richardsoni*) and silver trevally (*Pseudocaranx georgianus*) were each 14% (260 t), and the deepwater mirror dory (*Zenopsis nebulosus*) 5.5% (102 t). Only five other taxa exceeded 50 t for the year: shovelnose ray (*Aptychotrema rostrata*) (68 t), eastern bluespotted (sand) flathead (*Platycephalus caeruleopunctatus*) (64 t), leatherjackets (mostly ocean jackets, *Nelusetta ayraudi*) (62 t), redfish (*Centroberyx affinis*) (58 t) and southern calamari (*Sepioteuthis australis*) (51 t). Most of this catch was taken from depths less than 100 m, and mainly by central coast (Sydney-Port Stephens) trawlers.

To achieve effective management and sustainability of the fish-trawl sector of the NSW OTF, it is important for the gear to have selectivity characteristics appropriate for the targeted and bycatch species. Gear parameters that affect selectivity include codend-extension length, codend circumference, mesh size and construction (single or double twine), and twine thickness. At present the only legally prescribed restrictions on fish-trawling gear in NSW waters are a minimum allowable mesh size of 90 mm (inside stretched length) and a maximum allowable diameter of 100 mm for bobbins on trawl groundropes. The minimum mesh size of 90 mm was introduced into NSW in the 1950s to reduce the catch of juvenile flathead (Houston 1955), and was based on the 33 cm minimum legal length (MLL) of tiger flathead. At that time, and through to the 1970s, codend netting used in the NSW trawl and Danish seine fishery was constructed of 3 – 5 mm diameter single twine. The universal change from Danish seining to trawling in the 1970s saw the introduction of more heavily constructed codends, particularly in the developing upper slope fishery for gemfish (*Rexea solandri*), where the light-weight codends were easily damaged by the sharp teeth of the gemfish. Some fishers reportedly hand-knitted codends from 6-mm diameter trap-rope in an attempt to alleviate damage by the gemfish. By the 1980s, double-twine codend material was readily available and, depending on the size of the vessel, codends made from double 4-, 5- or 6-mm diameter braided twine were universally adopted. From that time, the conventional arrangement of fish trawls used off south-eastern Australia included a heavy-meshed codend of 100 meshes in circumference and 25 or 33 meshes in length, joined to an extension section or lengthener of 100 meshes (long) by 100 meshes (circumference) constructed from 3 – 4 mm diameter twine (K. Graham, unpublished data). In 1999, a Fisheries Research & Development Corporation (FRDC) funded study (unpublished) investigated the selectivity of 4 mm double twine 100-mesh circumference codends fished in outer shelf and upper slope depths off southern NSW and western Victoria, and determined that the 50% selection sizes of species such as tiger flathead, redfish, pink ling and gemfish were well below appropriate minimum capture sizes.

In recent years, declining catches of many trawl species in outer shelf and upper slope depths (100 – 500 m) resulted in central NSW fish trawlers directing more effort onto inshore grounds where eastern school whiting (hereafter referred to as school whiting), a relatively small species usually harvested as a by-product of prawn trawling, has been the main target. But as the retention of school whiting in conventionally rigged fish trawls with 90-mm mesh codends was very low, local fishers experimented with their trawl designs to facilitate commercial catch rates of whiting while still complying with the minimum mesh size specified for the fishery. A common modification has been to make the 100-mesh circumference extension section from double 3- or 4-mm diameter twine netting and join to it a 200-mesh circumference codend made from double 5-mm diameter braided twine. Some larger trawlers have operated with a 200-mesh circumference extension section and codend constructed totally from 5-mm diameter twine, and there have also been instances of ropes being illegally fixed around the codends. These arrangements were designed to sufficiently reduce the lateral openings of codend meshes and enable the retention of commercially viable catches of school whiting.

Trawlers operating from Sydney target school whiting mainly on grounds between Broken Bay and Norah Head but occasionally work as far north as Newcastle (Figure 1.2). Most of the trawling is at night in the 45 – 55 m (25 – 30 fathom) depth range but school whiting are sometimes targeted as deep as 80 m (45 fm) in winter or in daytime, and at times when ocean jacket concentrations exclude trawling in the more-favoured shallower depths. However, the development of this target fishery for school whiting has raised management issues mainly around the selectivity of the modified codend arrangements. The change to double-twine codends with increasing twine diameter has progressively decreased the inherent selectivity of fish trawl, and the adoption of 200-mesh circumference codends to catch school whiting has further exacerbated the trend. However, there has been no recent study done in NSW waters to establish the selectivity characteristics of 90-mm mesh codends or to determine whether the various net and codend configurations used in the fishery are consistent with the aims of the Fishery Management Strategy (FMS) for the OT (DPI 2007).

While there are no current concerns about the status of the NSW school whiting stocks, species of particular concern in the OTF are silver trevally and redfish, both of which can be caught in the same depths as school whiting. In the OTF Environmental Impact Statement (DPI 2004), these species were assessed as being growth overfished and the ensuing FMS suggests that an improvement in the selectivity characteristics of trawl codends will aid their recovery (DPI 2007). One of the stated objectives of the FMS is to restrict fish trawl codends to a maximum circumference of 100 meshes with a joining ratio of 1:1 to the next forward section of the net, and for codends to be constructed of single twine (max. 6-mm diameter) 90-mm mesh netting. However, recognising that such regulations would eliminate the trawl-whiting fishery in its current form, an interim arrangement was proposed whereby fish-trawl endorsement holders could continue using codends made from double-braided twine in depths less than 55 m (30 fathoms), subject to a commitment to implement the results of future research into the development of appropriately selective codends.

This report describes experiments done in 2005 and 2006 that were designed to investigate the selectivity attributes of codends with either different circumferences to the extension-section of the codend, or different twine diameters. The study was done on two chartered Sydney trawlers on the regular whiting grounds and provided, in addition to the codend selectivity data, an opportunity to profile the inshore trawl fishery for school whiting. Chapters 4 – 6 give detailed results of the two experiments, and a draft of a submitted journal paper describing the formal analyses and results of the catch and selectivity data is in Appendix 7. Chapter 7 compares the composition of catches from depths shallower and deeper than 55 m, and Chapter 8 describes the diversity and relative abundances of the fauna on the school whiting grounds. Detailed size composition data for important commercial and selected non-commercial species from each of the codend types are included, and Appendices 3 – 6 list the frequency of capture and relative abundances of all fishes, molluscs and crustaceans recorded during the study.

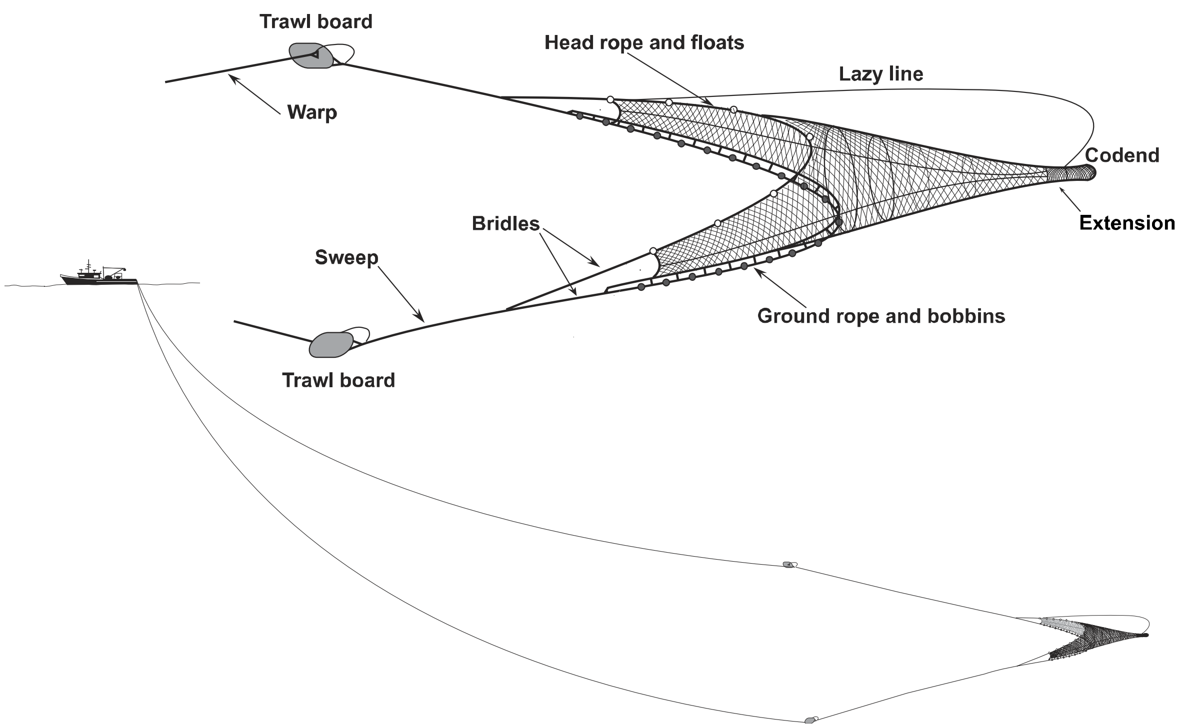

Figure 1.1. General arrangement of demersal trawling gear showing principal components (drawing by J. Matthews).

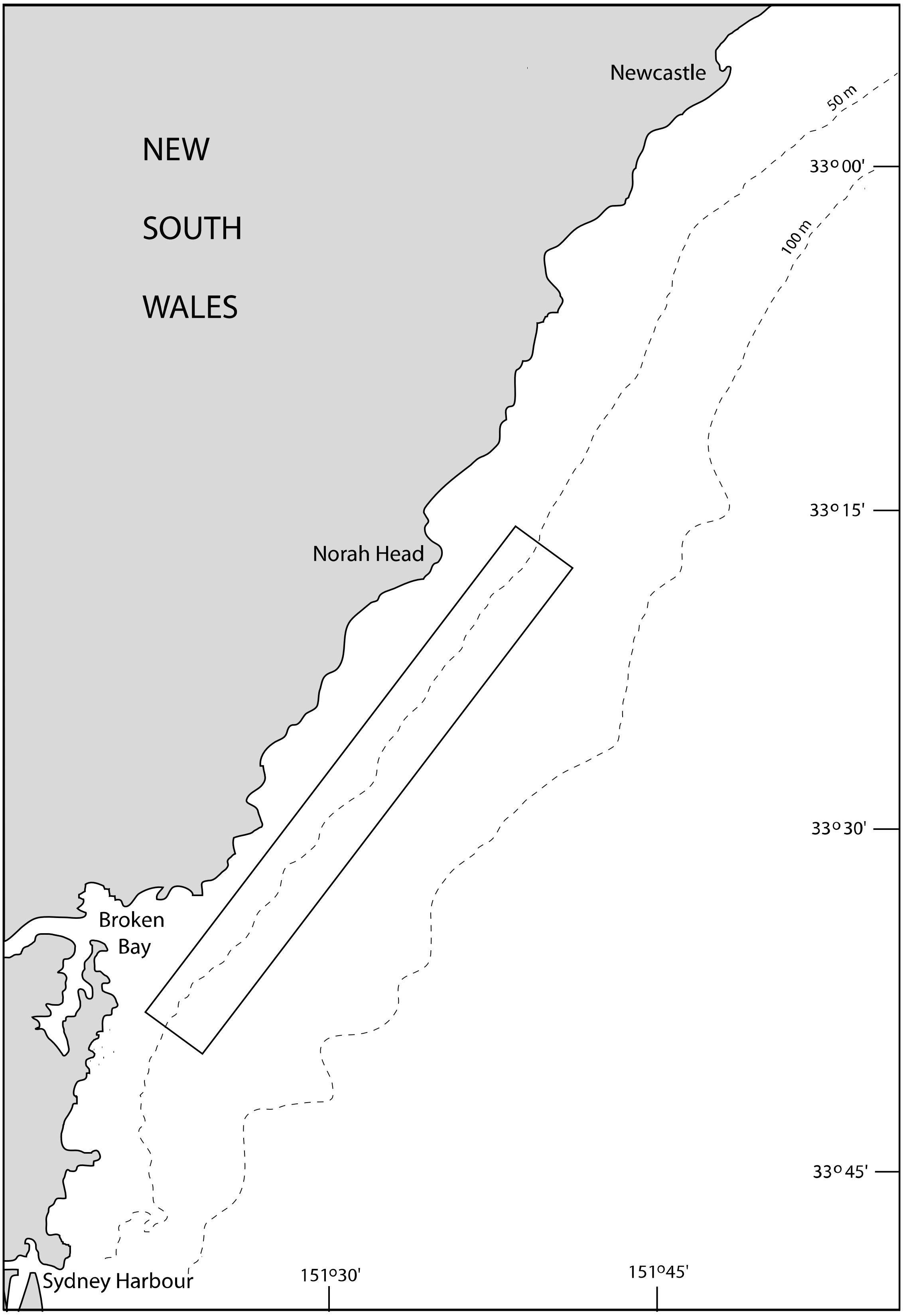

Figure 1.2. Map of coastline between Sydney and Newcastle showing main school whiting trawl ground (dotted lines are the 50 m and 100 m depth contours).

2. OBJECTIVES

1) To test the effects of codend circumference on the efficiency and selectivity of 90 mm mesh fish-trawl codends when targeting eastern school whiting.

2) To assess the effects of twine diameter on the efficiency and mesh selectivity of 90 mm mesh fish-trawl codends while targeting school whiting.

3) To document the size composition of the main commercial and non-commercial species caught in each gear treatment.

4) To compare catch rates and size compositions from tows in depths shallower and deeper than 55 m (30 fathoms).

5) To document the fish and invertebrate fauna on the central NSW inshore trawl grounds.

3. METHODS

3.1. Vessels and fishing gear

3.1.1. FV *Kirrawa*

L.O.A. 17.4 m
Main engine 300 kW
Doors: Super-Vee

3.1.2. FV *May Bell II*

L.O.A. 19.4 m
Main engine 350 kW
Doors: 2.0 m Vee

3.1.3. Fishing gear

Sweeps:	2 x 180 m x 24 mm diameter combination wire rope (CWR)
Bridles:	15 m – upper 10 mm diam. steel wire-rope, lower 24 mm diam CWR
Net:	design – local
	headline length – 33 m
	groundrope – chain or 6 cm diameter rubber discs
	mesh size – 90-mm throughout

3.2. Experimental gear and methods

Experiment 1 in 2005 tested for the effect of codend circumference on catch: three different 90-mm mesh extension-section/codend arrangements were fished alternately with a small-mesh control extension/codend. During 2006 (Experiment 2), the effect of different codend twine diameters on catch was tested: two 90-mm mesh codends with netting made from 3- and 5-mm diameter twine were fished alternately with the small-mesh control.

3.2.1. *Experiment 1 codends*

- Treatment T4mm200: 200 mesh (circ.) x 25 mesh (length) codend joined 2:1 onto 100 mesh (circ.) x 100 mesh (length) extension section (Figure 3.1a).
- Treatment T4mm200X: 200 mesh (circ.) x 25 mesh (length) codend joined 2:1 onto 100 mesh (circ.) x 100 mesh (length) extension section; extension section cut into 3 sections and rejoined 2 meshes to 2 meshes (Figure 3.1b).
- Treatment T4mm100: 100 mesh (circ.) x 25 mesh (long) codend joined 1:1 onto 100 mesh (circ.) x 100 mesh (length) extension section (Figure 3.1c).
- The extension-section for all treatments was made from 90-mm mesh x double 3-mm diameter braided polyethylene (PE) twine, and the codends from 90-mm mesh x double 4-mm diameter braided PE twine.
- Control: the codend was 450 meshes (circ.) x 61 meshes (length) x 40-mm mesh-size made from 3-mm diameter 60 ply single twine; the extension section was 225 meshes (circ.) x 240 meshes (long) x 43-mm mesh-size made from 2-mm diameter single braided twine (Figure 3.1f). The design length and circumference of the control extension and codend were equal to the treatment extension and 200-mesh codends.

3.2.2. *Experiment 2 codends*

- Treatment T5mm200: 200 mesh (circ.) x 25 mesh (length) x 90-mm mesh-size; codend netting made from 5-mm diameter double braided twine (Figure 3.1d).
- Treatment T3mm200: 200 mesh (circ.) x 25 mesh (length) x 90-mm mesh-size; codend netting made from 3-mm diameter double braided twine (Figure 3.1e).
- In turn, each codend was joined 2:1 onto 100 mesh (circ.) x 100 mesh (length) x 3-mm diameter double-twine extension section.
- Control: as for Experiment 1.

3.2.3. *Trawling methods*

Experiment 1 tows were initially done on the Sydney based trawler *Kirrawa* (21 nights) and completed on *May Bell II* (6 nights) after the trawler operator changed vessels. All trawling for Experiment 2 (2006) was on *May Bell II*. Design trawling (ground) speed was 2.8 knots as measured by GPS and, apart from shorter tow duration, normal commercial trawling procedures when targeting whiting were followed. For each tow, the treatment or control codend and extension was attached to the end of the tapered body-section of a standard net normally used by the chartered trawler for targeting whiting; over the duration of the experiments, two nets were used but both were of the same design and the forward gear (sweeps and bridles) did not change.

Tows were done at night on established school whiting grounds between Sydney and Newcastle with all but four tows between Broken Bay and Norah Head (Figure 1.2) using the standard “alternate haul” method. On most nights, four 90 minute hauls were completed with a trial codend and the control codend, the two being alternately fished twice. On some occasions, only one pair of trawls (treatment and control) was completed. During Experiment 1, the three trial codends were each tested in turn over consecutive fishing nights, before the sequence was repeated, while in Experiment 2, the two treatment codends were fished on alternate nights

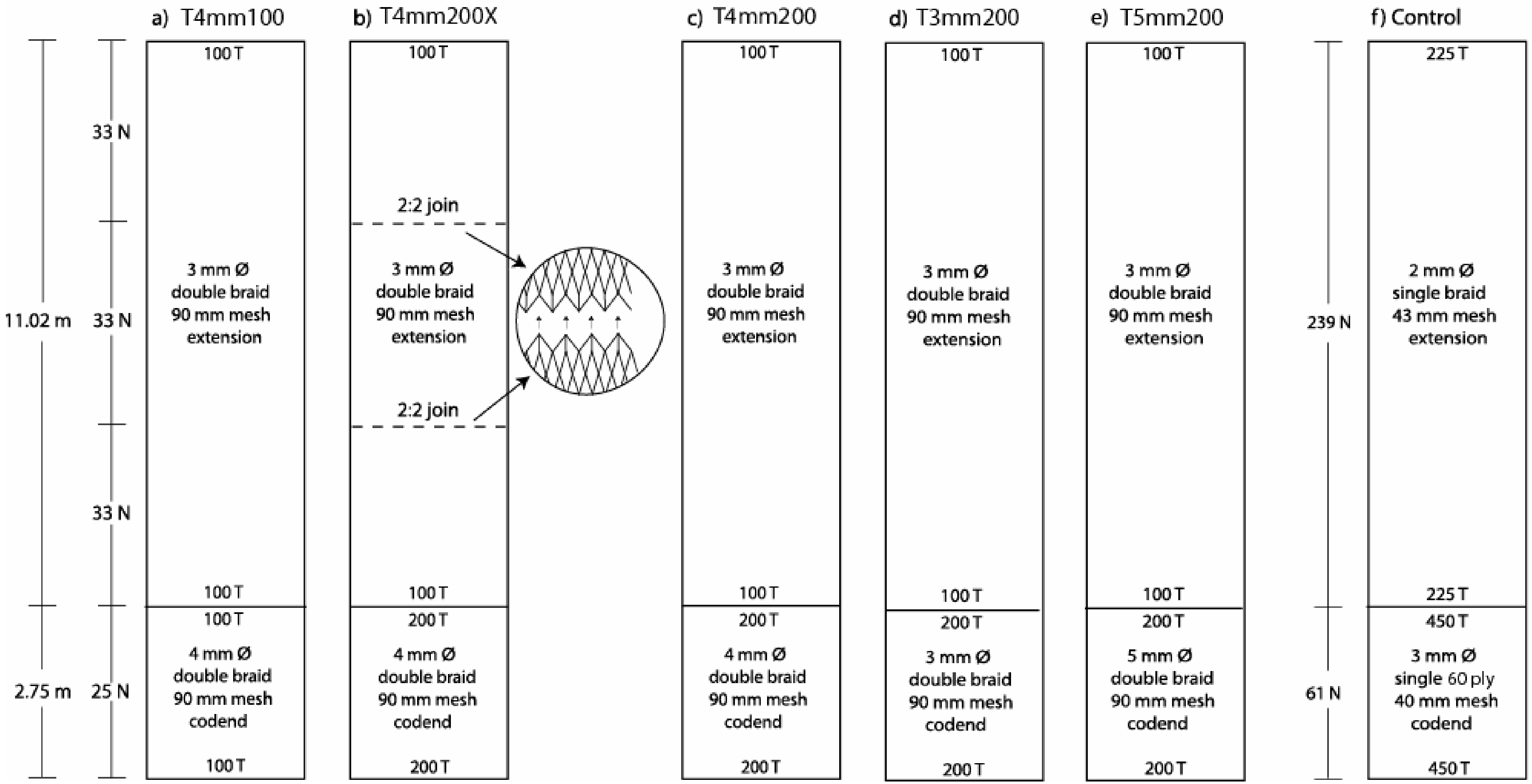

Figure 3.1. Net plans for experimental extension-sections and codends used during Experiment 1(a-c) and Experiment 2 (d-e), and plan for the control extension-codend (f).

3.2.4. *Sampling and catch analyses*

Catch weights (whole fish) and numbers of all fishes, crustaceans, cephalopods and gastropod molluscs were recorded. Each catch was sorted into commercial (those marketed in NSW from any fishery) and non-commercial (discarded) components; commercial species were further divided into retained and discarded (legally undersized or below marketable size) categories. In Experiment 1, the weights of retained and discarded components of some commercial species were not separated *in situ* but were subsequently estimated from length-weight relationships derived by Graham (1999) and Broadhurst *et al.* (2006a). The two components were separated and weighed *in situ* during Experiment 2.

Analyses of variance (ANOVA) was used to examine differences in the total, retained and discarded catches from the treatment codends, and differences in the numbers and weights of retained and discarded key species where there were sufficient data (defined as at least 1 individual in each of 10 hauls). To provide balanced analyses, data were only considered from the nights for which there were two replicate pairs of hauls for each treatment: six nights in Experiment 1 and seven nights in Experiment 2 (see Appendices 1 & 2). For both experiments, data were $ln(x+1)$ transformed (so that effects would be on the multiplicative scale), tested for heterogeneous variances and analysed by one-nested factor ANOVA (nights and treatment codend were considered random and fixed factors, respectively). To increase power for the main effect of treatment codend, where the nested term (nights) was non-significant at $p < 0.25$, it was pooled with the residual. All significant effects of treatment codend were investigated using Student-Newman-Keuls (SNK) multiple comparisons. A formal presentation of methods and results is in Appendix 7.

From the data used for the ANOVA, mean catch rates (weight and number per 1.5 hour tow, $\pm$ SE) were determined for the retained (marketed), discarded commercial, and discarded non-commercial species and species-groups for each of the treatment codends; for comparison, data from the alternate control tows were similarly pooled. Results are discussed in Chapters 4 – 5.

For all species, frequency of capture and mean catch numbers ($\pm$ SE) were calculated for each treatment codend, and for the control trawls associated with each treatment (Appendices 3, 5 & 6). These calculations included data from all trawls excluding those catches where ocean jacket numbers and weights exceeded 1000 and 400 kg (six in Experiment 1 and two in Experiment 2) because of difficulties of sorting and/or subsampling such large catches; data for all ocean jacket catches are presented separately. Catch weights of some small non-commercial species taken in low numbers were usually not recorded individually but incorporated into ‘miscellaneous species’ totals; for later relative abundance/biomass analyses (Chapter 8), relevant small species were allocated approximate weights to complete the data.

3.2.5. *Length-frequency data*

All, or subsamples of, key commercial and two non-commercial species were measured. Fishes with forked: school whiting, redfish, snapper (*Pagrus auratus*), or emarginated: bluespotted and tiger flatheads, red gurnard (*Chelidonichthys kumu*) caudal fins were measured to the centre of the fork or fin margin (FL) while those with truncated or rounded fins: marble flathead (*P. marmoratus*), longspine flathead (*P. longispinus*), longfin gurnard (*Lepidotrigla argus*) and ocean jacket were recorded as total length (TL); southern calamari measurements were dorsal mantle length (ML). All measurements were to the nearest 0.5 cm below actual length.

Length distributions of the main species were pooled for each treatment codend, and its corresponding control, and graphed. Where catches were sub-sampled, total numbers were calculated by simple proportioning. The size distributions from the treatment and control codends were compared with two-sample Kolmogorov-Smirnov tests (P = 0.05); pooled length-frequency data were not compared for species with fewer than 50 individuals.

3.2.6. Mesh selectivity analyses

For those species with sufficient data, size frequencies were combined across all tows for the treatment codends and their associated controls within each experiment. Logistic selection curves were then fitted to these data by Russell Millar, Department of Statistics, University of Auckland, New Zealand, using maximum likelihood and REP corrected for overdispersion arising from between-haul variation (Millar *et al.* 2004). These fits used the SELECT methodology and were done with both equal and estimated-split models (Millar and Walsh 1992), which were assessed for goodness-of-fit by comparing model deviances and through inspection of residuals. Chapter 6 summarises the results; a formal presentation of methods and results is in Appendix 7.

3.2.7. Comparison of catches shallower and deeper than 55 m (30 fathoms)

There were sufficient tows done during Experiment 1 to provide comparative information between depths shallower and depths deeper than 30 fathoms (55 m). Catch-data from the T4mm200 and T4mm200X treatment codends (i.e., codends of similar construction, netting material and mesh size) were pooled, as were data from the alternate hauls with the control codend, and analysed for each of the two depth categories in the same manner as for the overall data (see above). Length-frequency data for the main species were also pooled for the treatment codends and control codends for each of the depth categories, and compared. For large species not affected by mesh size (bluespotted flathead, ocean jackets), data from all codends were pooled for each depth. Differences in size distributions between depths and codends were tested with two-sample Kolmogorov-Smirnov tests (P = 0.05).

3.2.8. Faunal composition and relative abundance

Scientific names and common names for fish species follow Yearsley *et al.* (2006) and Catalogue of Australian Aquatic Biota (CAAB) numbers are included in the Appendix 3 list; CAAB numbers and names (where available) are also used for invertebrates. When possible, taxa were identified to species level, and catch number of each species and catch weights of all but very small species were recorded for each tow (small species were combined and recorded as a composite miscellaneous species weight). Up to three species of small congers (*Gnathophis* spp.) were present in some catches but these could not be separated to species level in the field, so are presented as composite data for the genus.

To assess faunal diversity, the overall total number of species caught during the project was determined, and the mean number of species within the main taxonomic groups, and in total, were compared and tested for differences (two-sample t-tests, p = 0.05) among the codends. To describe the relative abundances and biomass of individual species across the grounds, numbers and weights of each species were separately pooled for all treatment and control catches (excluding tows with large ocean jacket catches), converted to percentages of total-catch number and weight, and then ranked according the their relative importance by number or weight. Species data from the most selective (T4mm100) and least selective (T5mm200) codends were collated in a similar manner and compared with their respective control.

4. EXPERIMENT 1: TO TEST THE EFFECTS OF CODEND CIRCUMFERENCE

4.1. Method summary

Experiment 1 compared the catch compositions of three 90 mm mesh treatment codends, each with the same codend twine diameter (4 mm) but one with a circumference of 100 meshes (T4mm100), and two with 200 mesh circumferences (T4mm200 & T4mm200X); the T4mm200X treatment had two inbuilt constrictions in the extension section (see Figure 3.1). Each treatment was fished alternately with the small meshed (40 mm) control codend which, for each pairing with the three treatments, are respectively referred to as C100, C200 and C200X. Six nights with replicate trawls with each treatment codend were selected for catch analyses (ANOVA), and catches from the alternate control tows were compared.

4.2. Results

All operational data are presented in Appendix 1. Most tows were done between Broken Bay and Norah Head (Figure 1.2) with an overall latitudinal range of 33^{o}15’ to 33^{o}41’ and trawling depth range of 41 m to 82 m. Good sea conditions (calm or slight seas) were experienced on most nights; nights with winds stronger than 20 knots were avoided when possible as head seas affected trawl performance and made efficient catch sampling and processing on deck difficult.

Following two nights of preliminary testing of procedures, 48 pairs (alternate treatment and control) of tows were completed over 25 nights. Twenty-one nights were as planned with two pairs of alternate tows with one treatment done each night; the remaining 6 pairs of alternate tows with various treatments were completed over four nights because of interruptions by bad weather and other logistic constraints. Overall, the T4mm200 and T4mm100 treatment codends, each alternated with the control, were fished 16 times, and the T4mm200X treatment and alternate-control were each fished 15 times. One C200X control-codend catch of about 2 t of ocean jackets was not landed, and data from six other tows with large ocean jacket catches were excluded from the overall mean catch-rate calculations presented in Appendix 5 [tows: 704 (T4mm200X), 1004 (C200), 1102 (T4mm100), 1602 (C200X), 2001 (C200X), 2002 (T4mm200X)]. Tows excluded from the treatment codend catch analyses (ANOVA), and the calculations of mean catch rates by the associated control codend, are indicated in Appendix 1.

4.2.1. Experiment 1 catches

All species caught during Experiment 1, with frequency of capture and mean catch number for each treatment codend and associated control, are listed in Appendices 3 and 5. There were 57 commercial species including 8 elasmobranchs (sharks and rays), 34 teleosts and 15 invertebrates. These included species such as blue mackerel (*Scomber australasicus*) and yellowtail scad (*Trachurus novaezelandiae*) which are usually discarded from trawl catches but are important in other NSW fishery sectors. Some other commercial species e.g. eagle ray (*Myliobatus australis*) and latchet (*Pterygotrigla polyommata*) were always discarded as no marketable sized individuals were caught. The 89 non-commercial species comprised 15 elasmobranchs, 43 teleosts and 29 invertebrates.

Figures 4.1 – 4.4 summarise the main features of the catch data and Tables 4.1 – 4.6 list the mean catch rates (kg and no. per 90 minute tow), standard error (s.e.) and percentage of total catch for the main species, species groups and totals for each of the treatment codends and its alternate control. ANOVA results are indicated in Figures 4.1 and 4.2, and presented fully in Appendix 7.

4.2.1.1. Total-catches

Average total-catch weights were between 179 (T4mm100) and 277 kg (T4mm200X) for the treatment codends but none was significantly different from each other (Figure 4.1). However, the mean total-catch number (998) in the T4mm100 codend was significantly less than mean catch-numbers in both the T4mm200 (2694) and T4mm200X (1917) codends. In the associated controls, mean total-catch was between 332 and 460 kg (i.e., 30 – 80% higher than in the alternate treatments), and mean total-catch numbers were 2.5 – 4.5 times greater than the corresponding treatment codends.

The mean weight of all organisms in each of the T4mm200, T4mm200X and T4mm100 codends was respectively 107, 127 and 187 g, and in the control for each, between 71 and 75 g (Figure 4.5).

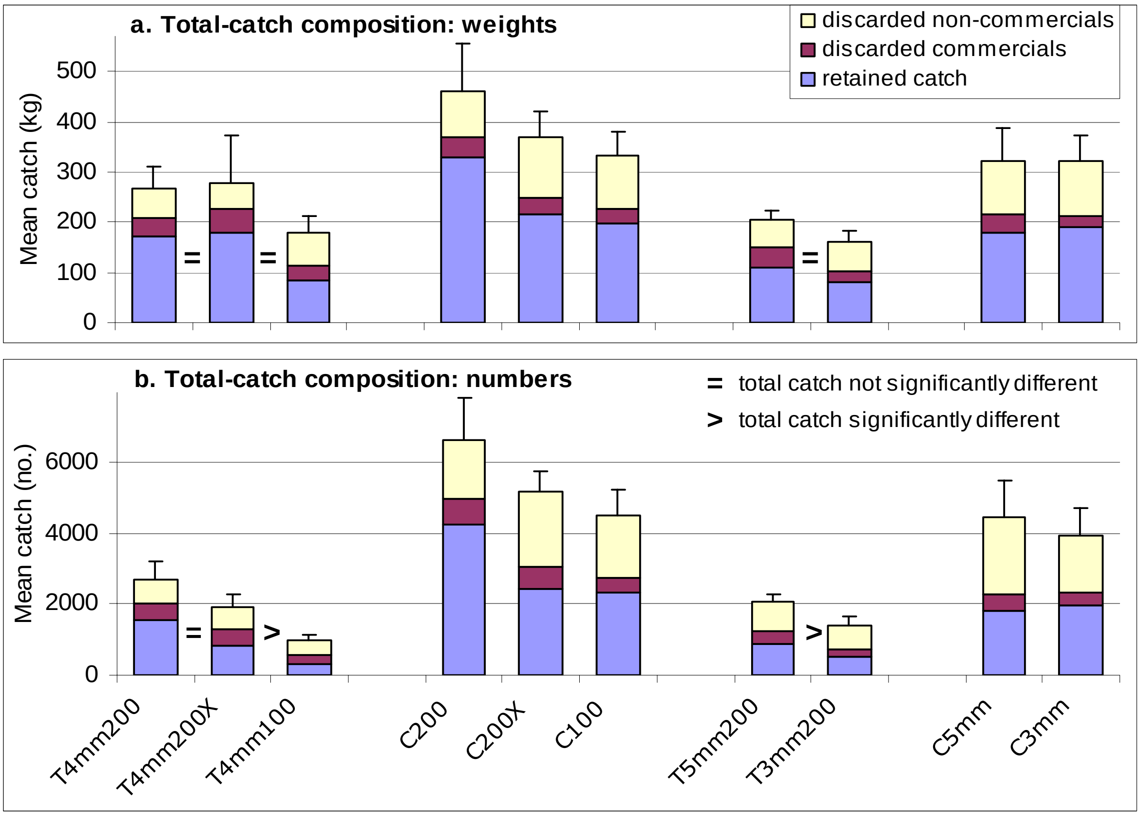

Figure 4.1. Experiments 1 and 2 mean catch rates (+ 1 s.e. for total) of the main catch components in the treatment (T) codends and the control (C) when alternated with each treatment: a. kg/90 min. tow; b. no./90 min. tow.

4.2.1.2. Catch composition – retained

Mean total retained-catch weights in the treatment codends (85 – 180 kg/tow) were between 47% (T4mm100) and 65% (T4mm200 & T4mm200X) of their respective total-catches. In the T4mm200 and T4mm200X codends, total retained-catch numbers were 58% and 45% of their respective total-catches but only 30% in T4mm100. The ANOVA showed no significant differences between the mean total retained-catch weights but mean total retained-catch numbers among the three treatment codends were significantly different (Figure 4.2; Appendix 7).

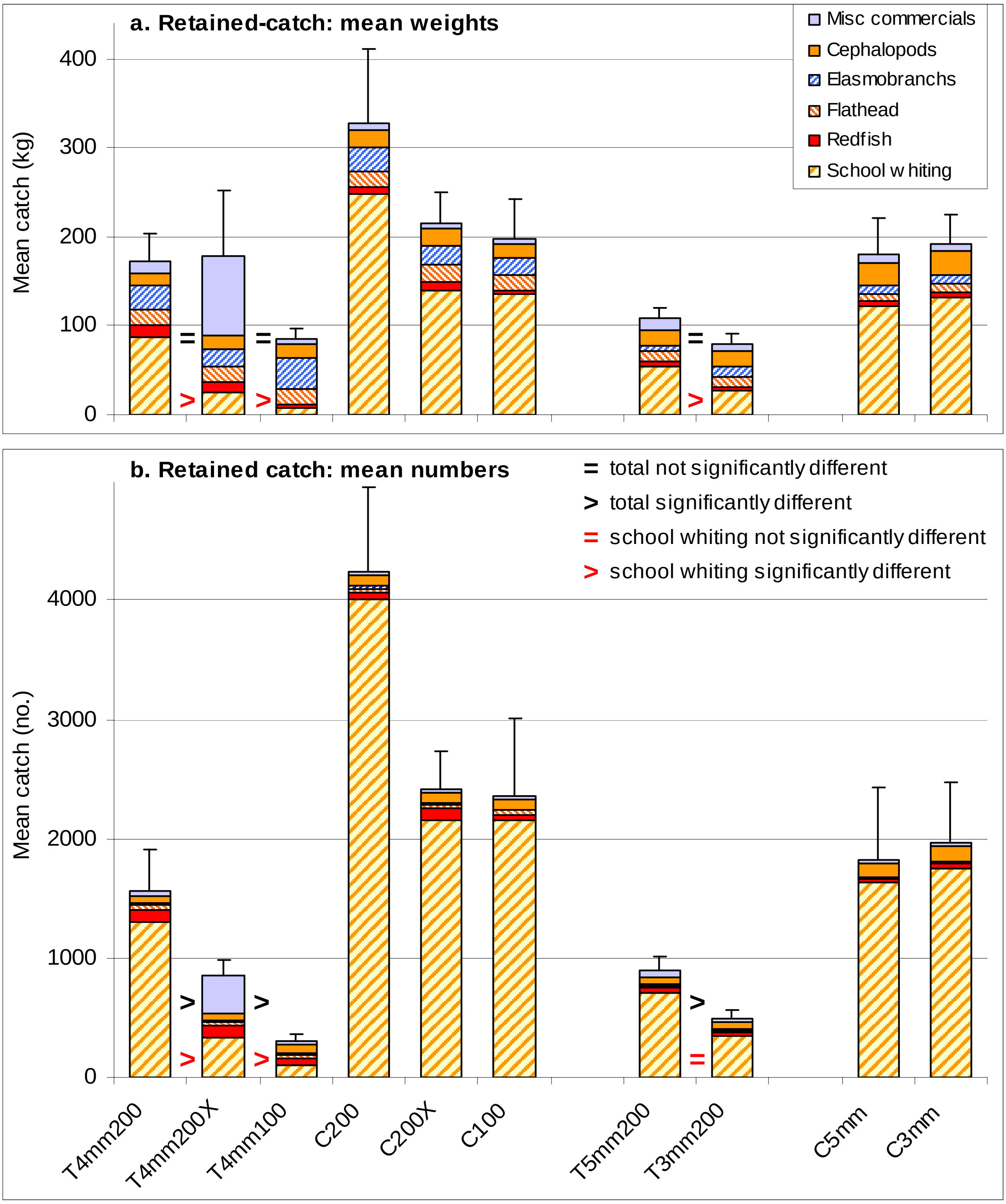

Figure 4.2. Experiment 1 and 2 mean catch rates (+ 1 s.e. for total) of the main retained species or species groups in the treatment (T) codends and the control (C) when alternated with each treatment: a) kg/90 min. tow; b) no./90 min. tow.

School whiting (87 kg/tow) contributed about half of the retained-catch in the T4mm200 codend whereas in the T4mm200X (26 kg/tow) and T4mm100 (7 kg/tow) codends, whiting were only about 15% and 9% of the total retained-catch. Both by weight and number, mean school whiting catches in each treatment codend were significantly different from each other (Figure 4.2; Appendix 7). The relatively large 'miscellaneous commercials' component of the T4mm200X

retained-catch (Figure 4.2) was mainly attributable to a single 1000 kg catch of ocean jackets; all other retained-catches of ocean jackets were less than 70 kg.
In the alternated control for each treatment, mean retained-catch weights were substantially greater (198 – 328 kg/tow) than for the corresponding treatment, and were between 58% (C200X) and 71% (C200) of their respective total-catches; mean retained-catch numbers were between 46% (C200X) and 64% (C200) of the total-catch number (Figure 4.2). School whiting mean catch rates were 249 kg/tow in C200 and 136 – 140 kg/tow in C100 and C200X (Figure 4.2); when two exceptionally large school whiting catches of 700 kg and 750 kg taken in C200 near Newcastle are discounted, the mean for C200 is 143 kg/tow, almost identical to the C100 and C200X means. Overall, school whiting were 38 – 54% by weight and 42 – 60% by number of the total-catches, and around 70% (weight) and 90% (number) of the retained control catches. The mean school whiting catch-weight and number) for the T4mm200 were approximately 35% of their control catches and for the T4mm100 codend, about 5% of its control (see Figure 4.7).

Catch rates of other retained fish and invertebrates (species other than school whiting and ocean jackets) did not vary greatly among the codends averaging, in total, between 68 and 79 kg/tow in the treatments and 61 – 77 kg/tow in the associated control catches. Mean catches of bluespotted flathead were between 27 and 32 fish or 15 – 17 kg per tow, whereas only small quantities of tiger, dusky (*Platycephalus fuscus*) and marble flathead, averaging in total less than 2.5 kg (6 fish) per tow, were taken in any codend (see Appendix 5). Overall, commercial-sized flatheads caught in the treatment codends contributed around 12% of the retained-catch weight and 4% of the numbers. Most redfish were too small to market (see below) with mean retained catches between 4.5 and 14 kg per tow. Average catch rates of commercial elasmobranchs (all species combined) ranged between 19 and 34 kg per tow (12 – 24 fish/tow) and, in the treatment codends, accounted for 18% of the total-catch weight although less than 2% of the total-catch numbers. The most commonly caught species were shovelnose ray (*Aptychotrema rostrata*), banjo ray (*Trygonorrhina* sp.) and gummy shark (*Mustelus antarcticus*) (Appendix 5).

Apart from small numbers of southern calamari smaller than about 12 cm ML, all commercial cephalopods were retained. Total cephalopod catches were between 14 and 20 kg per tow (8.3% of the retained catch) with over half consisting of southern calamari. Rose-cone (*Sepia rozella*) and giant (*S. apama*) cuttlefishes were regularly caught in all codends, while octopuses (principally southern octopus, *O. australis*) were mainly taken in the small-meshed control codend (Appendix 5). Retained crustaceans consisted of relatively small numbers of Balmain bugs (*Ibacus peronii*), smooth bugs (*I. chacei*) and blue-swimmer crabs (*Portunus pelagicus*).

4.2.1.3. Catch composition – discarded commercials

Discarded commercial species consisted almost totally of fish, either legally under-sized or too small to market; the few invertebrate commercial-discards were undersized or berried bugs and blue-swimmer crabs, and small numbers of juvenile king prawns. In the treatment codends, total weights of commercial-discards ranged between 28 and 45 kg/tow representing 13 – 16% of the total-catches and 29 – 47% of all discards. Total commercial-discards in the control catches averaged 27 – 40 kg/tow (8 – 9% of total-catch).

In the three treatment codends, small redfish (means 7 – 14 kg/tow) accounted for 4 – 5% of the total-catch weights (10 – 12% by number), representing 31% of the weight and 51% of the number of commercial-discards; slightly higher catch rates of discarded redfish (10 – 18 kg/tow) were taken in the associated control tows. In contrast, school whiting discards from the treatment codends were negligible (< 1% of commercial-discards by weight) although in the control catches they were about 8% of the commercial-discard weight with most being caught in depths greater than 55 m (see Chapter 7). Catches of yellowtail scad, which were all discarded, were irregular in the treatment codends (means 0.8 – 11.3 kg/tow) although they contributed about 15% of the total commercial-discard weight (~18% by number); in the control tows, mean catch rates were similar (2.5 – 8.6 kg/tow). Across all tows, the total number and weight of undersized snapper were less than 1% of the total catch and in more than 70% of tows, none was caught. The relatively large mean-catch of discarded snapper in T4mm200 (5.5 kg/tow) was mainly due to two catches of 27 and 30 kg, and the 5.8 kg/tow in T4mm100 resulted from a single catch of 70 kg. Almost no undersized bluespotted flathead were caught with the small quantities of flathead discards comprising mostly marble and tiger flathead; almost 90% of undersized tiger flathead were caught between July and October.

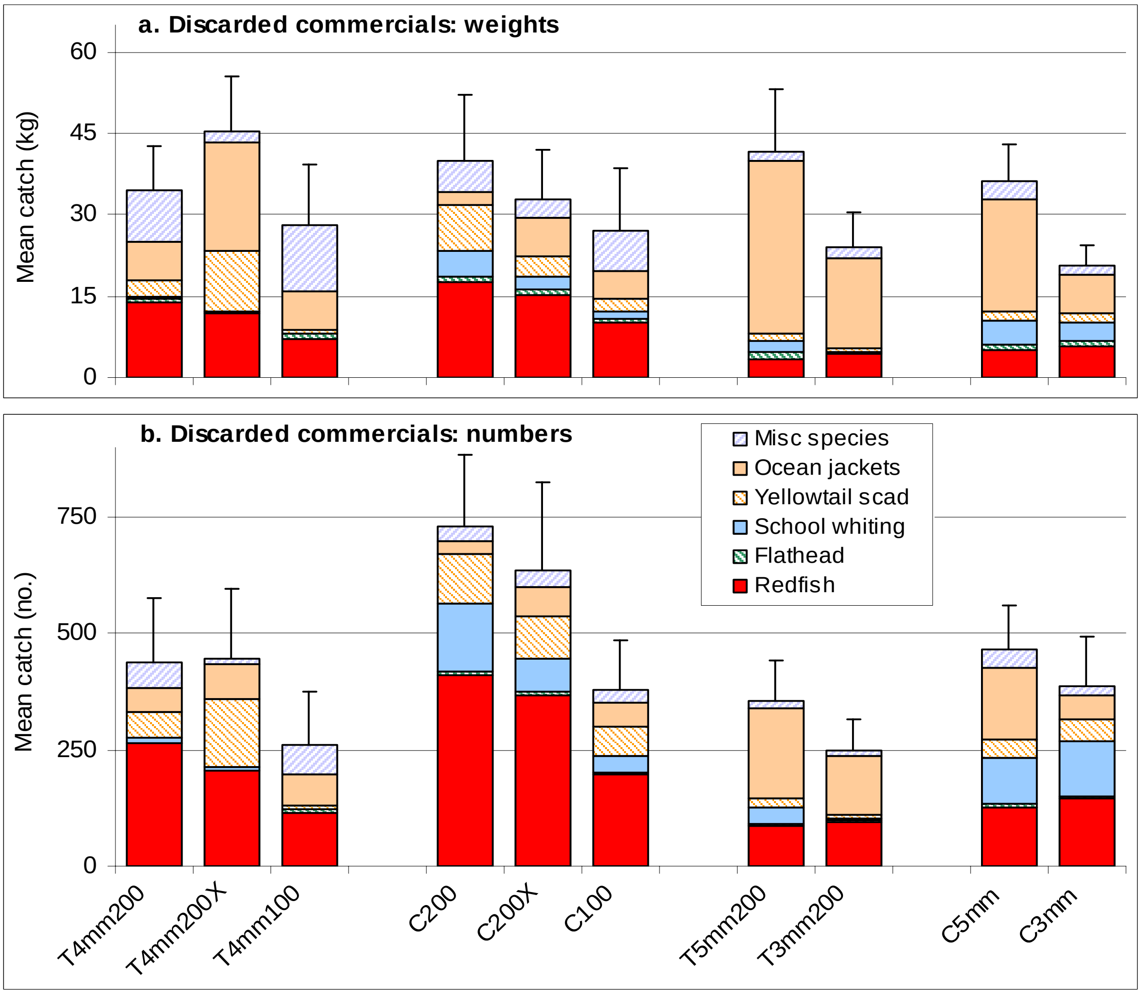

Figure 4.3. Experiment 1 and 2 mean catch rates (kg/tow + 1 s.e. for total) for the main discarded commercial species in the treatment codends (T) and control (C) when alternated with each treatment: a) kg/90 min. tow; b) no./90 min. tow.

4.2.1.4. Catch composition – discarded non-commercials

Mean total weights of discarded non-commercial species did not vary greatly among the treatment codends: 52 – 66 kg/tow (19 – 37% of total catch), or in the corresponding control catches: 93 – 122 kg/tow (20 – 33% of total catch). However, the proportions of several species within the discarded catch varied substantially by weight and/or number according to codend (Figure 4.4).

By weight, the non-commercial discards in the treatment codends consisted mainly of elasmobranchs (28 – 57% of non-commercial discards) and longfin gurnard (28 – 46%), with smaller quantities of longspine flathead (13 – 15% in T4mm200 & T4mm200X, and 5% in

T4mm100). Because discarded elasmobranchs were mainly large Port Jackson sharks (*Heterodontus portusjacksoni*) and various species of stingaree (fam. Urolophidae), they represented less than 4% of the total number of non-commercial discards in the three codends. In contrast, longfin gurnard made up 70 – 74% and longspine flathead 9 – 16% of the non-commercial discard numbers. In the associated control catches, the most abundant species were longspine flathead (25 – 43% of non-commercial discard weights and numbers) and longfin gurnard (27 – 39%); elasmobranchs were 13 – 17% of non-commercial discard weight but equal to or less than 1% of discard numbers.

When individual codends were compared, the T4mm100 codend retained less than half the quantities of longspine flathead (weight and number) than the T4mm200 and T4mm200X codends. Also of note was the capture of many small congers (*Gnathophis* spp.) in the control codend (~5% by weight and number) whereas almost none was retained in any of the larger-meshed treatments. The ANOVA for number and weight of total discarded-catch (commercial and non-commercial species combined) found no significant differences among the three treatment codends (Appendix 7).

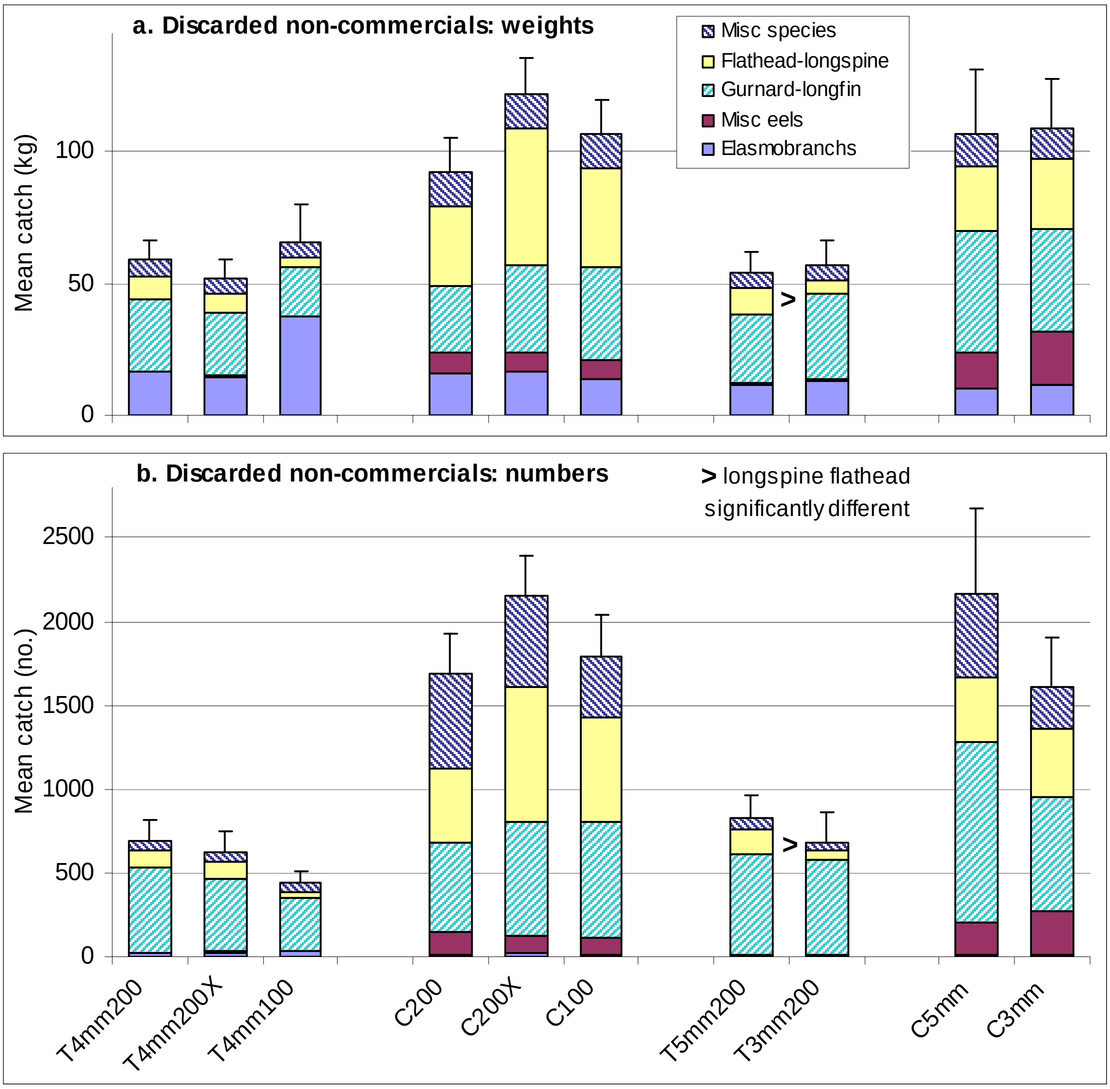

Figure 4.4. Experiment 1 and 2 mean catch rates (+ 1 s.e. for total) for main discarded non-commercial species in the treatment codends (T) and control (C) when alternated with each treatment: a) kg/90 min. tow; b) no./90 min. tow.

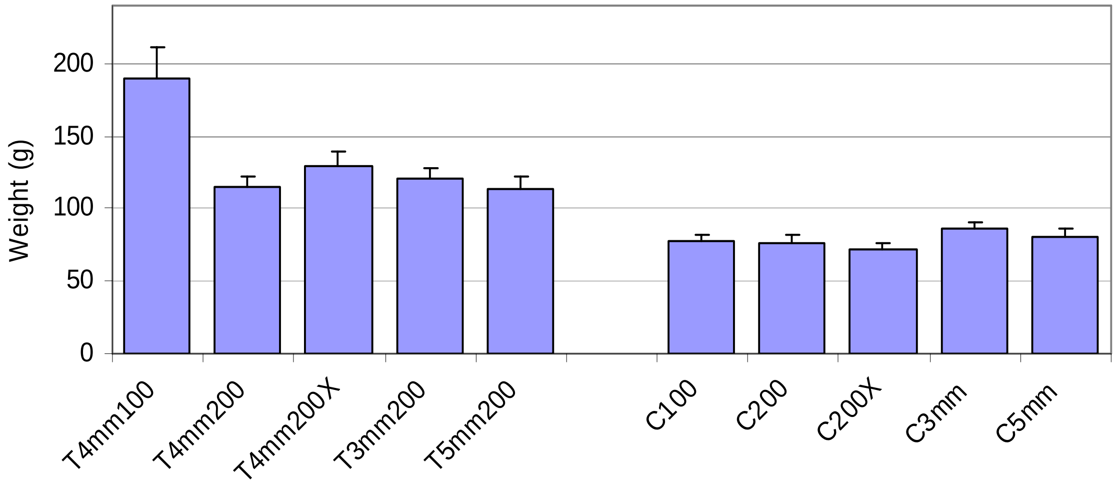

Figure 4.5. Mean weight (+ 1 s.e.) of organisms in each of the treatment codends and their respective control codend during Experiments 1 and 2.

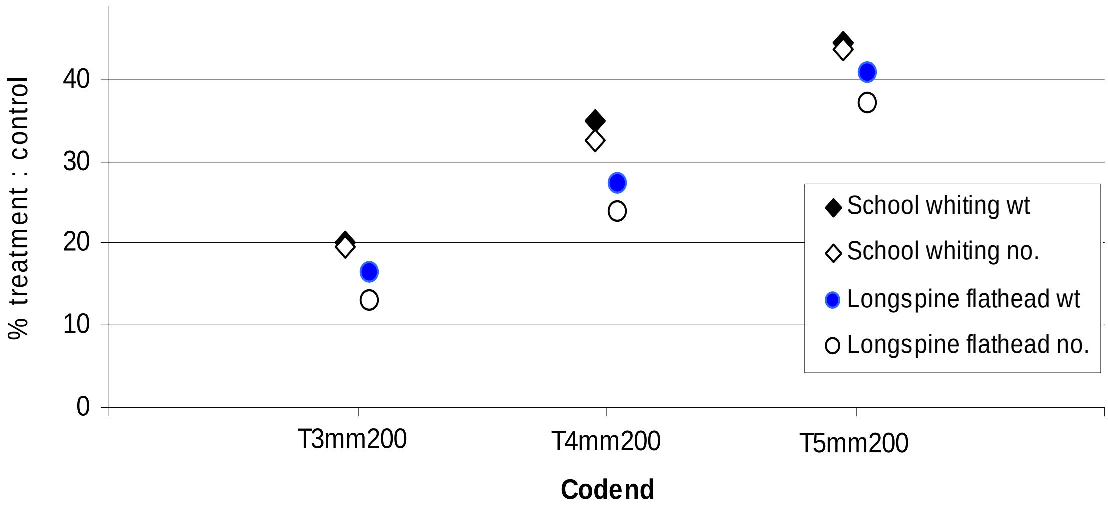

Figure 4.6. School whiting and longspine flathead mean catches in the 3-, 4- and 5-mm twine, 200-mesh circumference codends as a percentage of their respective mean control-codend catches.

4.2.1.5. Ocean jacket catches

In all but one of the tows used for catch analyses (above), incidental catches of ocean jackets were less than 5% of the total catch, averaging less than 6 kg/tow (retained) and 10 kg/tow (discarded). Mean total-catches of retained and discarded ocean jackets from all 47 landed catches ranged between 14 and 112 kg/tow in the treatment codends, and 6 – 98 kg/tow in the controls (Figure 4.7). Individually large catches in T4mm200X (1200 kg), T4mm100 (840 kg), C200 (1500 kg) and C200X (375 kg) tows resulted large standard errors around the means. Marketable-sized ocean jackets (> 28 cm TL) dominated the large catches in the T4mm200X and C200 codends, whereas the catch in T4mm100 consisted almost totally of smaller fish (see Figure 4.14). Overall, about 50% of the total-catch weight (all codends) and 19% of the total number were of marketable size.

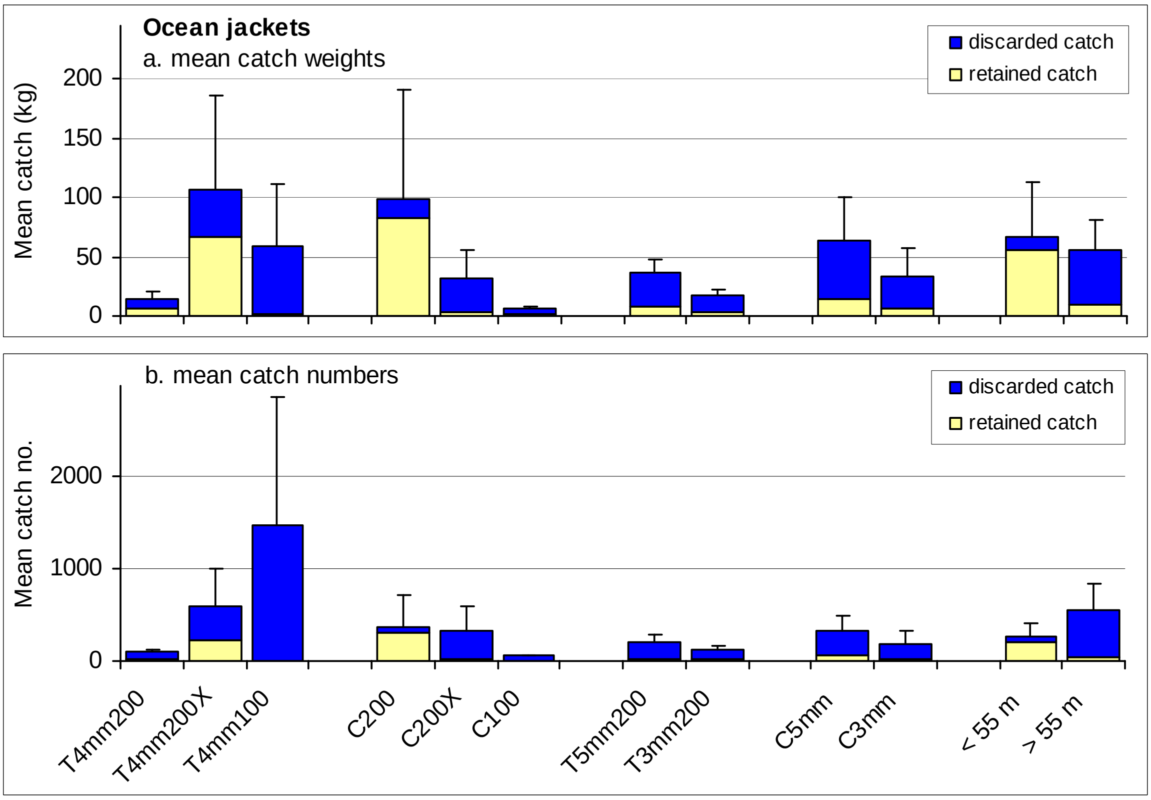

Figure 4.7. Mean catch rates (+ 1 s.e. for total) of ocean jackets caught during Experiments 1 and 2, and for Experiment 1 tows in depths greater or less than 55 m.: a. kg/90 min. tow; b. no./90 min. tow.

4.2.2. *Experiment 1 length-frequency data*

Length distributions of nine commercial and two non-commercial species are shown in Figures 4.8 – 4.18. Results comparing length-distributions between codends (Kolmogorov-Smirnov tests) are summarised in Table 4.7.

4.2.2.1. Commercial species

The mean lengths of school whiting caught in the three treatment codends (18.5 – 19.3 cm FL) were each greater than in the corresponding control (17.9 – 18.4 cm FL) and when compared, the length-distributions were significantly different from each other (Table 4.7; Figure 4.8). Few school whiting (~1%) smaller than the minimum marketable length (MML) of ~15 cm were retained by the 90-mm mesh treatment codends although about 5% of the whiting caught in the small-mesh control codend were smaller than 15 cm (Figure 4.8c).

All bluespotted flathead were between 27 and 64 cm FL and the size compositions of catches in all codends were similar (Figure 4.9). The average sizes of bluespotted flathead in the treatment and control codends were 42.5 cm and 42.0 cm, with only about 1% of fish in the treatments and 3% in the controls smaller than the minimum legal length (MLL) of 33 cm TL. About 55% of tiger and marble flathead in the treatment codends were smaller than 33 cm (Figures 4.10, 4.11a) whereas in the control, 75 – 80% of these species were less than 33 cm. The comparative data suggest that a relatively high proportion of flathead smaller than 25 cm escaped from the 90-mm mesh treatment codends (Figures 4.10c, 4.11a).

Over 70% of red gurnard exceeded 28 cm TL (MML) in the treatment codends but, overall, there were no significant differences in the size distributions of the catches pooled for the treatment and control codends (Figure 4.11b). All but two of the relatively small number of snapper were smaller than the MLL of ~25 cm FL (30 cm TL) (Figure 4.11c).

Redfish larger than about 15 cm FL were marketed but, as shown by Figure 4.12, more than 70% of redfish from the treatment codends and about 80% from the controls were smaller than 15 cm and consequently discarded. Although the size-composition comparisons were all statistically different, the mean sizes of redfish from each of the three treatment codends were very similar (13.4 – 13.7 cm FL). Compared to the treatments, the control codend retained a higher proportion of redfish smaller than 10 cm (Figure 4.12c) suggesting that only very small redfish escaped through the treatment (90 mm) codend meshes.

The overall size range of southern calamari was between 4 and 34 cm mantle length and no size class dominated the distribution from any codend (Figure 4.13). The calamari size distribution in the T4mm100 codend was significantly different from its equivalent control codend ($p > 0.001$), with a mean size of 17.7 cm compared to 14.7 cm in the C100 codend; Figures 4.13a & b indicate that a substantial proportion of calamari less than 10 cm were able to escape from the T4mm100 codend.

4.2.2.2. Ocean jackets

The individually large catches (N > 1000) of ocean jackets in Experiment 1 were each dominated by single size classes around 14, 19 or 27 – 33 cm TL (Figure 4.14). The catch of 14 cm jackets taken in May and the two catches of 19 cm fish in August belong to the 0+ year class, while the 27 – 33 cm jackets in the April catches are 1+ year olds (M. Miller 2007). Modes of similar size classes were also apparent when data from all catches were amalgamated (Figure 4.15), and when pooled for the treatment and control codend catches from which large catches were excluded (Figure 4.16c).

4.2.2.3. Non-commercial species

Longspine flathead and longfin gurnard were caught in large numbers throughout the project and provided comparable size data for all codends. In addition to marked differences in catch numbers between the codends, the size distributions of both species from all treatment codends were significantly different ($p > 0.001$) from their respective control catches. Overall, the mean size of longspine flathead in the treatment codends was 22.5 cm, about 1.5 cm greater than from the combined control catches (Figure 4.17). Similarly, the average size of longfin gurnard in the treatment codends was almost 1 cm longer than the average size from the control (Figure 4.18).

4.3. Discussion

As used in the fishery, 200-mesh circumference codends are designed to minimise the lateral spread of the codend meshes thereby increasing the retention of small fish such as school whiting. The insertion of two joining rows in the extension section of T4mm200X was an additional device designed (by the chartered trawler operator) to enhance this goal. However, comparisons between the T4mm200 and T4mm200X catch data did not support such an effect as, contrary to expectations, the T4mm200X codend caught significantly less school whiting than the T4mm200 codend. There were no significant differences in the catch rates of any other species and, among those small species that may have been expected to have increased catch rates, only the mean catches of southern calamari and yellowtail scad in T4mm200X were a little greater than in the T4mm200 codend. It seems possible that instead of enhancing the whiting catch, the constrictions in the extension-section inadvertently created slack or more-open meshes at the joins, and allowed whiting of all sizes to escape at these junctures. Subsequently to this experiment, the fisher ceased using this modification after independently concluding that it gave no catch benefits.

Nonetheless, when compared to the T4mm100 codend, the T4mm200 and T4mm200X treatments did retain significantly greater quantities of small fish and invertebrates. By weight and number, the mean school whiting catches in the 200-mesh codends were several times greater than in the 100-mesh codend and, of the small bycatch species, longspine flathead catches were more than double. However, despite this apparently high level of retention, the mean whiting catch in the 200-mesh T4mm200 codend was only about 34% (by number and weight) of that taken in its corresponding small-meshed control, suggesting that a high proportion of school whiting entering the net subsequently escaped through the 90-mm codend meshes. Consistent with this, the retention rate of whiting in the T4mm100 codend was proportionally more than six-fold lower, with its average catch only 5% of its control. Similarly, the mean catch of longspine flathead in the T4mm200 codend was more than double that of the 100-mesh treatment but only 27% of the catch in its control; in the T4mm100 codend, the mean longspine flathead catch was just 9% of its alternate control. That the proportion of longspine flathead retained in the T4mm200X codend was only 14% of its control (cf. 27% for T4mm200) suggests that, as for school whiting, the modification (joins) in the codend extension-section may have fascilitated the escape of many longspine flathead. The small southern octopus was the only other frequently-caught species that showed marked reductions in numbers between the 200- and 100-mesh codends, although the data suggest that octopuses readily escaped through the 90-mm codend meshes in both codend types as many fewer were retained in any of the treatment codends compared to their corresponding control.

Most longfin gurnard ranged in size between 10 and 20 cm TL, and this species' mean length of about 15 cm was considerably smaller than the mean lengths of school whiting (18 – 19 cm FL) and longspine flathead (21 – 23 cm TL). However, in contrast to those species, there were relatively small differences in the mean weights and numbers of longfin gurnard retained by the 200-mesh treatment codends and their alternate control catches, and the mean catch in the 100-mesh treatment codend was more than half that taken in its associated control. Although the data indicates that many longfin gurnard escaped through the 90-mm mesh, particularly from the T4mm100 codend, the numbers were very much smaller than for school whiting and flathead. This difference in retention rates between the species can be explained by their respective cross-sectional shape or height-width ratios (see Broadhurst *et al.* 2006a). Species of whiting and flathead have height-width ratios of about 1.5 and 0.5, and relatively streamlined head shapes, which allow them to more readily push through a diamond mesh than can a gurnard with its almost square cross-section (ratio ~1.0) and rough head.

Overall, the results demonstrated that the T4mm100 codend was the most selective of the treatment codends in that it retained significantly lower numbers of total catch, retained catch, and school whiting than did the 200-mesh T4mm200 and/or T4mm200X codends. The T4mm100 codend is similar in construction to the codend preferred for the fish-trawl sector of the NSW Offshore Trawl Fishery (OTF) i.e., maximum 100-mesh circumference codend of single twine (maximum 6-mm diameter) joined 1:1 to the section immediately forward of the codend (see OTF Fishery Management Strategy (DPI 2007)). The results here supported the proposal for mandatory adoption of a 100-mesh circumference codend for use on all OTF grounds outside any designated school whiting areas, as catch rates of commercial species other than school whiting were not significantly different to those from the 200-mesh codends while numbers of unwanted catch were substantially reduced. The results indicated that substantially greater numbers of small and/or slender fish and invertebrates escaped from the 100-mesh codend than from the 200-mesh circumference codends, although this did not result in greatly different mean sizes between the two codend types. This suggested that most sizes of species such as school whiting and longspine flathead escaped from the 90-mm mesh of all three treatment codends but they did so at a greater rate from the 100-mesh codend. The overall mean size of organisms in each of the codends (Figure 4.5) was consistent with their relative selectivity characteristics, with the values for the 200-mesh codends (115 and 130 g) considerably smaller than the 190 g mean weight for organisms in the more selective 100-mesh codend, and all were greater than 72 – 78 g mean weights for the catches in the small-mesh control.

4.4. Summary

- The T4mm100 codend caught significantly less numbers of total-catch, retained-catch and school whiting than the T4mm200 and T4mm200X codends; mean weight of school whiting in T4mm100 was also significantly smaller than in the two 200-mesh codends.
- There were no significant differences in total-catch weight and number between the T4mm200 and T4mm200X codends but, contrary to expectations for the design, mean number of retained-catch, and number and weight of school whiting, in the T4mm200X codend were significantly less than in the T4mm200 codend.
- Mean catches of school whiting in the T4mm200 and T4mm100 codends were about 35% and 5% of the catch rates in their corresponding control.
- There was a (non-significant) trend for lower mean total-catch weight, retained-catch weight, and numbers of discarded-catch, redfish, longfin gurnard, longspine flathead and octopus in the 100-mesh codend compared to the 200-mesh codends.
- Discarded commercial species (below minimum legal or marketable length) were 13 – 16% of total-catch in the treatment codends and comprised mainly redfish and ocean jackets. Relatively few undersized bluespotted or tiger flathead and snapper were caught in any codend.
- Elasmobranchs (15 – 38% of total-catch weight) and longfin gurnard (19 – 28%) were the main components of the non-commercial discards.
- Occasional large catches of ocean jackets were each dominated by either 0+ (14 or 19 cm TL) or 1+ (27 – 33 cm TL) size classes; most ocean jackets were discarded.

Table 4.1. Summary of catches (mean, standard error, and % of total catch; n = 12) taken in the T4mm200 treatment codend during Experiment 1.

	T4mm200 treatment codend					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	26.5	4.3	9.9	16.1	2.1	0.6
Redfish	13.4	9.9	5.0	99.0	74.0	3.7
Flathead-bluespotted	17.3	2.9	6.5	32.4	6.4	1.2
Flathead-other	1.2	0.3	0.4	2.9	0.7	0.1
School whiting	86.9	29.9	32.6	13.6.9	425.5	48.5
Ocean jackets	7.4	5.8	2.8	22.6	16.8	0.8
Misc. fish	5.4	1.4	2.0	22.8	8.4	0.8
Total retained fish	**158.0**	**33.3**	**59.2**	**1502.6**	**424.4**	**55.8**
Calamari	7.1	1.3	2.6	25.9	4.3	1.0
Cuttlefish	6.2	2.5	2.3	24.7	11.8	0.9
Octopus	0.3	0.2	0.1	1.5	0.4	0.1
Total retained molluscs	**14.2**	**3.6**	**5.3**	**55.9**	**16.8**	**2.1**
Bugs & crabs	0.7	0.1	0.2	4.4	0.8	0.2
Total retained catch	**172.9**	**35.5**	**64.8**	**1563.0**	**435.4**	**58.0**
Discarded commercials						
Redfish	13.9	6.7	5.2	263.0	110.5	9.8
Flathead-bluespotted	0.2	0.1	0.1	0.9	0.4	0.0
Flathead-other	0.3	0.1	0.1	1.8	0.6	0.1
School whiting	0.4	0.2	0.2	12.3	7.0	0.5
Yellowtail scad	4.0	3.3	1.5	52.2	43.2	1.9
Snapper	5.5	3.2	2.1	32.8	18.7	1.2
Ocean jackets	6.2	3.4	2.3	51.7	23.8	1.9
Misc. commercial fish	3.6	1.0	1.3	18.4	5.9	0.7
Total discarded commercial fish	**34.1**	**10.2**	**12.8**	**433.0**	**138.2**	**16.1**
Discard crabs & bugs	0.5	0.1	0.2	4.2	0.7	0.1
Total discarded commercials	**34.7**	**10.2**	**13.0**	**437.2**	**138.2**	**16.2**
Discarded non-commercials						
Elasmobranchs	16.3	6.7	6.1	19.4	8.9	0.7
Misc eels	0.4	0.2	0.1	5.3	2.4	0.2
Gurnard-longfin	27.5	5.6	10.3	509.6	110.2	18.9
Flathead-longspine	8.2	2.1	3.1	104.5	26.3	3.9
Misc. fish	5.9	1.3	2.2	43.4	10.8	1.6
Total discarded non-commercial fish	**58.3**	**7.0**	**21.8**	**682.2**	**122.7**	**25.3**
Misc. invertebrates	0.9	0.2	0.3	11.6	2.8	0.4
Total discarded non-commercials	**59.3**	**7.0**	**22.2**	**693.8**	**123.3**	**25.8**
Total discarded fish	92.4	14.1	34.6	1115.2	150.6	41.4
Total discarded invertebrates	1.5	0.3	0.6	15.8	2.8	0.6
Total discarded catch	**93.9**	**14.1**	**35.2**	**1130.9**	**150.5**	**42.0**
Total catch	**266.8**	**44.2**	**100.0**	**2693.9**	**499.8**	**100.0**

Table 4.2. Summary of catches (mean, standard error, and % of total catch; n = 12) taken in the T4mm200X treatment codend during Experiment 1.

	T4mm200X treatment codend					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	s.e.	%	mean	s.e.	%
Retained commercial species						
Elasmobranchs	19.2	3.3	7.0	13.2	1.7	0.7
Redfish	11.3	6.1	4.1	92.8	43.8	4.8
Flathead-bluespotted	14.7	3.3	5.3	25.8	5.8	1.3
Flathead-other	1.7	0.7	0.6	3.5	1.4	0.2
School whiting	26.1	6.9	9.4	337.6	73.9	17.6
Ocean jackets	85.8	83.1	31.0	287.6	255.5	15.0
Misc. fish	4.2	1.2	1.5	20.4	6.2	1.1
Total retained fish	**163.0**	**81.2**	**58.9**	**780.9**	**256.8**	**40.7**
Calamari	10.9	2.2	3.9	32.6	7.5	1.7
Cuttlefish	4.0	1.6	1.4	28.7	10.8	1.5
Octopus	0.4	0.1	0.1	2.6	0.8	0.1
Total retained molluscs	**15.9**	**3.4**	**5.7**	**66.3**	**15.7**	**3.5**
Bugs & crabs	0.8	0.3	0.3	6.0	2.0	0.3
Total retained catch	**179.7**	**79.9**	**65.0**	**853.2**	**252.7**	**44.5**
Discarded commercial species						
Redfish	11.7	4.2	4.2	203.4	62.8	10.6
Flathead-bluespotted	0.1	0.0	0.1	0.3	0.1	0.1
Flathead-other	0.3	0.2	0.3	2.0	0.8	0.1
School whiting	0.1	0.1	0.0	5.5	2.2	0.3
Yellowtail scad	11.3	9.9	4.1	147.2	119.3	7.7
Snapper	0.3	0.2	0.1	1.7	0.8	0.1
Ocean jackets	19.8	16.5	7.2	74.3	48.7	3.9
Misc. commercial fish	1.1	0.2	0.4	5.6	1.1	0.3
Total discarded commercial fish	**44.7**	**18.4**	**16.1**	**439.8**	**149.0**	**22.9**
Discard crabs & bugs	0.6	0.2	0.2	5.6	1.7	0.3
Total discarded commercials	**45.3**	**18.4**	**16.4**	**445.4**	**149.5**	**23.2**
Discarded non-commercial species						
Elasmobranchs	14.5	4.3	5.3	21.3	7.7	1.1
Misc eels	0.8	0.5	0.3	7.9	4.9	0.4
Gurnard-longfin	23.6	5.7	8.5	437.9	104.7	22.8
Flathead-longspine	7.5	2.2	2.7	94.4	26.0	4.9
Misc. fish	4.2	0.9	1.5	47.8	14.8	2.5
Total discarded non-commercial fish	**50.7**	**7.4**	**18.3**	**609.3**	**125.2**	**31.8**
Misc. invertebrates	1.0	0.2	0.4	8.7	1.7	0.5
Total discarded non-commercials	**51.7**	**7.4**	**18.7**	**617.9**	**125.2**	**32.2**
Total discarded fish	95.4	21.4	34.5	1049.1	188.1	54.7
Total discarded invertebrates	1.6	0.3	0.6	14.3	2.9	0.7
Total discarded catch	**97.0**	**21.4**	**35.0**	**1063.3**	**187.8**	**55.5**
Total catch	**276.7**	**97.3**	**100.0**	**1916.6**	**363.6**	**100.0**

Table 4.3. Summary of catches (mean, standard error, and % of total catch; n = 12) taken in the T4mm100 treatment codend during Experiment 1.

	T4mm100 treatment codend					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	34.0	8.7	19.0	23.6	5.9	2.4
Redfish	4.6	2.9	2.6	51.0	35.3	5.1
Flathead-bluespotted	15.3	2.1	8.6	27.4	4.2	2.7
Flathead-other	2.2	0.9	1.2	5.3	2.3	0.5
School whiting	7.4	1.7	4.1	102.1	25.1	10.2
Ocean jackets	0.9	0.3	0.5	2.8	0.9	0.3
Misc. fish	4.3	1.0	2.4	16.7	5.4	1.7
Total retained fish	**68.6**	**12.6**	**38.4**	**228.8**	**59.8**	**22.9**
Calamari	8.4	2.1	4.7	26.6	6.7	2.7
Cuttlefish	6.4	1.9	3.6	35.8	13.7	3.6
Octopus	0.0	0.0	0.0	0.3	0.2	0.0
Total retained molluscs	**15.2**	**2.2**	**8.5**	**64.5**	**12.8**	**6.5**
Bugs & crabs	1.0	0.2	0.5	5.8	1.2	0.6
Total retained catch	**84.8**	**14.0**	**47.5**	**299.1**	**66.9**	**30.0**
Discarded commercials						
Redfish	7.2	3.9	4.0	116.3	62.2	11.7
Flathead-bluespotted	0.0	0.0	0.0	0.2	0.1	0.0
Flathead-other	0.9	0.5	0.5	5.5	3.4	0.6
School whiting	0.1	0.0	0.0	1.7	0.9	0.2
Yellowtail scad	0.8	0.4	0.4	6.6	2.7	0.7
Snapper	5.8	5.2	3.3	38.8	34.7	3.9
Ocean jackets	6.8	4.4	3.8	67.9	44.4	6.8
Misc. commercial fish	5.5	2.3	3.1	15.8	5.4	1.6
Total discarded commercial fish	**27.1**	**11.4**	**15.2**	**252.8**	**115.9**	**25.3**
Discard crabs & bugs	0.9	0.2	0.5	5.9	1.3	0.6
Total discarded commercials	**28.0**	**11.3**	**15.7**	**258.8**	**115.3**	**25.9**
Discarded non-commercials						
Elasmobranchs	37.8	15.1	21.1	29.0	16.5	2.9
Misc eels	0.0	0.0	0.0	0.1	0.1	0.0
Gurnard-longfin	18.5	4.0	10.4	318.4	66.3	31.9
Flathead-longspine	3.4	0.7	1.9	40.1	8.2	4.0
Misc. fish	5.0	1.5	2.8	42.1	18.2	4.2
Total discarded non-commercial fish	**64.8**	**14.6**	**36.3**	**429.7**	**67.7**	**43.0**
Misc. invertebrates	1.0	0.2	0.6	10.9	2.2	1.1
Total discarded non-commercials	**65.8**	**14.5**	**36.8**	**440.6**	**66.6**	**44.1**
Total discarded fish	91.9	23.1	51.5	682.5	111.4	68.4
Total discarded invertebrates	1.9	0.3	1.1	16.8	3.1	1.7
Total discarded catch	**93.8**	**22.9**	**52.5**	**699.3**	**109.2**	**70.0**
Total catch	**178.6**	**34.9**	**100.0**	**998.4**	**157.1**	**100.0**

Table 4.4. Summary of catches (mean, standard error, and % of total catch; n = 11) taken in the control codend (C200) when fished alternately with the T4mm200 codend during Experiment 1.

	Control codend (C200)					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	28.2	9.0	6.1	17.5	5.1	0.3
Redfish	7.7	3.6	1.7	67.4	36.4	1.0
Flathead-bluespotted	15.5	3.0	3.4	26.5	6.0	0.4
Flathead-other	0.9	0.3	0.2	2.9	1.2	0.1
School whiting	248.5	73.5	54.0	4002.0	1040.6	60.1
Ocean jackets	2.1	1.8	0.5	6.0	4.5	0.1
Misc. fish	4.2	1.0	0.9	22.3	7.2	0.3
Total retained fish	**307.2**	**80.0**	**66.8**	**4144.6**	**1043.9**	**62.2**
Calamari	8.8	1.3	1.9	29.8	5.8	0.4
Cuttlefish	7.9	3.6	1.7	40.7	21.3	0.6
Octopus	1.9	0.2	0.4	15.1	2.4	0.2
Total retained molluscs	**19.4**	**4.4**	**4.2**	**92.7**	**26.7**	**1.4**
Bugs & crabs	0.9	0.3	0.2	6.9	2.4	0.1
Total retained catch	**327.5**	**84.0**	**71.2**	**4244.2**	**1068.9**	**63.7**
Discarded commercials						
Redfish	17.7	7.5	3.8	412.2	144.5	6.2
Flathead-bluespotted	0.1	0.0	0.0	0.4	0.2	0.0
Flathead-other	0.8	0.3	0.2	7.6	3.1	0.1
School whiting	4.7	2.2	1.0	145.2	71.4	2.2
Yellowtail scad	8.6	3.8	1.9	107.5	34.0	1.6
Snapper	1.3	0.9	0.3	6.9	4.1	0.1
Ocean jackets	2.4	0.8	0.5	26.2	11.2	0.4
Misc. commercial fish	3.8	2.6	0.8	10.5	4.8	0.2
Total discarded commercial fish	**39.4**	**12.1**	**8.6**	**716.6**	**190.9**	**10.8**
Discard crabs & bugs	0.7	0.2	0.1	11.9	3.6	0.2
Total discarded commercials	**40.1**	**12.1**	**8.7**	**728.5**	**190.8**	**10.9**
Discarded non-commercials						
Elasmobranchs	15.6	5.0	3.4	16.5	5.6	0.2
Misc eels	8.0	2.0	1.7	126.9	28.1	1.9
Gurnard-longfin	25.5	5.3	5.5	542.3	113.9	8.1
Flathead-longspine	30.0	6.5	6.5	437.6	97.7	6.6
Misc. fish	12.8	3.0	2.8	554.3	84.5	8.3
Total discarded non-commercial fish	**91.8**	**12.4**	**20.0**	**1677.6**	**239.8**	**25.2**
Misc. invertebrates	0.7	0.2	0.1	13.2	3.8	0.2
Total discarded non-commercials	**92.6**	**12.4**	**20.1**	**1690.8**	**239.9**	**25.4**
Total discarded fish	131.2	16.7	28.5	2394.3	275.8	35.9
Total discarded invertebrates	1.5	0.3	0.3	25.1	6.7	0.4
Total discarded catch	**132.7**	16.7	**28.8**	**2419.3**	275.1	**36.3**
Total catch	**460.2**	**95.5**	**100.0**	**6663.6**	**1158.8**	**100.0**

Table 4.5. Summary of catches (mean, standard error, and % of total catch; n = 11) taken in the control codend (C200X) when fished alternately with the T4mm200X codend during Experiment 1.

	Control codend (C200X)					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	21.9	5.2	5.9	13.9	2.4	0.3
Redfish	9.9	6.4	2.7	93.1	58.6	1.8
Flathead-bluespotted	16.4	4.3	4.4	29.4	7.5	0.6
Flathead-other	1.8	0.8	0.5	4.8	2.2	0.1
School whiting	139.9	28.6	37.8	2159.1	371.6	41.5
Ocean jackets	0.9	0.9	0.3	4.1	4.0	0.1
Misc. fish	4.0	1.1	1.1	15.7	5.9	0.3
Total retained fish	**194.8**	**33.0**	**52.7**	**2320.1**	**382.4**	**44.6**
Calamari	11.0	2.2	3.0	41.6	9.5	0.8
Cuttlefish	5.7	1.9	1.5	24.3	12.2	0.5
Octopus	2.1	0.3	0.6	18.9	3.1	0.4
Total retained molluscs	**19.5**	**3.1**	**5.3**	**90.0**	**19.2**	**1.7**
Bugs & crabs	0.7	0.2	0.2	4.8	1.1	0.1
Total retained catch	**215.0**	**34.9**	**58.2**	**2414.9**	**394.2**	**46.5**
Discarded commercials						
Redfish	15.1	6.0	4.1	366.8	155.3	7.1
Flathead-bluespotted	0.6	0.2	0.2	3.0	1.0	0.1
Flathead-other	0.6	0.1	0.1	4.2	1.0	0.1
School whiting	2.4	1.2	0.6	73.2	36.8	1.4
Yellowtail scad	3.7	1.4	1.0	91.0	32.5	1.8
Snapper	0.8	0.7	0.2	6.0	5.3	0.1
Ocean jackets	7.0	4.4	1.9	62.8	31.9	1.2
Misc. commercial fish	2.1	0.9	0.6	15.5	8.7	0.3
Total discarded commercial fish	**32.3**	**9.108.7**	**10.7**	**622.6**	**189.7**	**12.0**
Discard crabs & bugs	0.6	0.1	0.2	12.7	2.3	0.2
Total discarded commercials	**32.9**	**9.1**	**8.9**	**635.3**	**189.0**	**12.2**
Discarded non-commercials						
Elasmobranchs	16.8	11.7	4.5	18.7	10.1	0.4
Misc eels	6.8	1.3	1.8	107.9	21.5	2.1
Gurnard-longfin	33.1	6.8	8.9	674.3	148.4	13.0
Flathead-longspine	52.2	10.8	14.1	811.7	132.4	15.6
Misc. fish	11.8	2.1	3.2	516.4	73.3	9.9
Total discarded non-commercial fish	**120.7**	**13.9**	**32.6**	**2129.0**	**246.3**	**41.0**
Misc. invertebrates	1.2	0.3	0.4	19.5	3.2	0.4
Total discarded non-commercials	**121.9**	**14.0**	**33.0**	**2148.5**	**247.5**	**41.4**
Total discarded fish	153.0	16.0	41.4	2751.6	254.9	52.9
Total discarded invertebrates	1.8	0.3	0.4	32.2	4.0	0.6
Total discarded catch	**154.8**	**16.1**	**41.8**	**2783.8**	**257.5**	**53.5**
Total catch	**369.8**	**49.8**	**100.0**	**5198.7**	**570.1**	**100.0**

Table 4.6. Summary of catches (mean, standard error, and % of total catch; n = 12) taken in the control codend (C100) when fished alternately with the T4mm100 codend during Experiment 1.

	Control codend (C100)					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	20.5	5.4	6.2	12.5	3.2	0.3
Redfish	4.5	2.8	1.3	43.2	27.2	1.0
Flathead-bluespotted	14.7	2.5	4.4	27.5	4.9	0.6
Flathead-other	1.4	0.6	0.4	3.7	1.3	0.1
School whiting	135.7	40.6	40.8	2161.4	619.9	47.8
Ocean jackets	2.2	2.1	0.7	6.7	6.2	0.1
Misc. fish	3.8	1.3	1.1	18.4	7.1	0.4
Total retained fish	**182.7**	**41.5**	**55.0**	**2273.3**	**629.5**	**50.2**
Calamari	5.9	0.9	1.8	29.0	6.7	0.6
Cuttlefish	7.2	2.5	2.2	36.4	17.5	0.8
Octopus	1.2	0.2	0.4	9.9	1.9	0.2
Total retained molluscs	**14.8**	**2.7**	**4.5**	**80.9**	**17.9**	**1.8**
Bugs & crabs	0.9	0.3	0.3	5.8	1.7	0.1
Total retained catch	**198.4**	**43.1**	**59.7**	**2360.1**	**643.8**	**52.2**
Discarded commercials						
Redfish	10.2	5.7	3.1	199.3	75.9	4.4
Flathead-bluespotted	0.1	0.0	0.0	0.3	0.2	0.0
Flathead-other	0.6	0.3	0.2	1.7	0.6	0.0
School whiting	1.2	0.8	0.4	36.0	23.9	0.8
Yellowtail scad	2.5	0.8	0.7	63.8	21.3	1.4
Snapper	0.1	0.0	0.0	0.4	0.3	0.0
Ocean jackets	4.9	2.1	1.5	51.0	17.2	1.1
Misc. commercial fish	6.8	4.1	2.0	15.0	8.1	0.3
Total discarded commercial fish	**26.2**	**11.7**	**7.9**	**367.5**	**109.4**	**8.1**
Discard crabs & bugs	0.8	0.2	0.2	10.9	2.3	0.2
Total discarded commercials	**27.0**	**11.6**	**8.1**	**378.4**	**108.1**	**8.4**
Discarded non-commercials						
Elasmobranchs	13.8	5.1	4.2	8.8	2.3	0.2
Misc eels	6.8	2.5	2.0	102.7	38.7	2.3
Gurnard-longfin	35.4	7.2	10.6	696.3	141.0	15.4
Flathead-longspine	37.8	6.0	11.4	617.8	93.8	13.7
Misc. fish	12.1	1.9	3.6	331.0	45.1	7.3
Total discarded non-commercial fish	**105.8**	**12.5**	**31.8**	**1756.5**	**260.4**	**38.8**
Misc. invertebrates	1.1	0.3	0.3	30.2	8.6	0.7
Total discarded non-commercials	**106.9**	**12.6**	**32.2**	**1786.7**	**257.2**	**39.5**
Total discarded fish	132.0	10.4	39.7	2124.0	219.4	46.9
Total discarded invertebrates	1.9	0.4	0.6	41.1	9.1	0.9
Total discarded catch	**133.9**	**10.5**	**40.3**	**2165.0**	**217.8**	**47.8**
Total catch	**332.3**	**48.0**	**100.0**	**4525.1**	**714.1**	**100.0**

Table 4.7. Results of K-S tests comparing length distributions of important species in treatment and control codends during Experiment 1 (T = treatment, TT = pooled data for treatments; C = control, CC = pooled data for control; ns = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

Codend comparisons:	**T4mm200 – C200**	**T4mm200X – C200X**	**T4mm100 – C100**	**TT – CC**
School whiting	***	***	***	***
Flathead-bluespotted	ns	ns	*	ns
Flathead-tiger	***	ns	***	ns
Flathead-marble	***	-	-	**
Flathead-longspine	***	***	***	***
Redfish	***	***	***	***
Gurnard-red	ns	ns	ns	ns
Gurnard-longfin	***	***	***	***
Southern calamari	ns	ns	***	ns

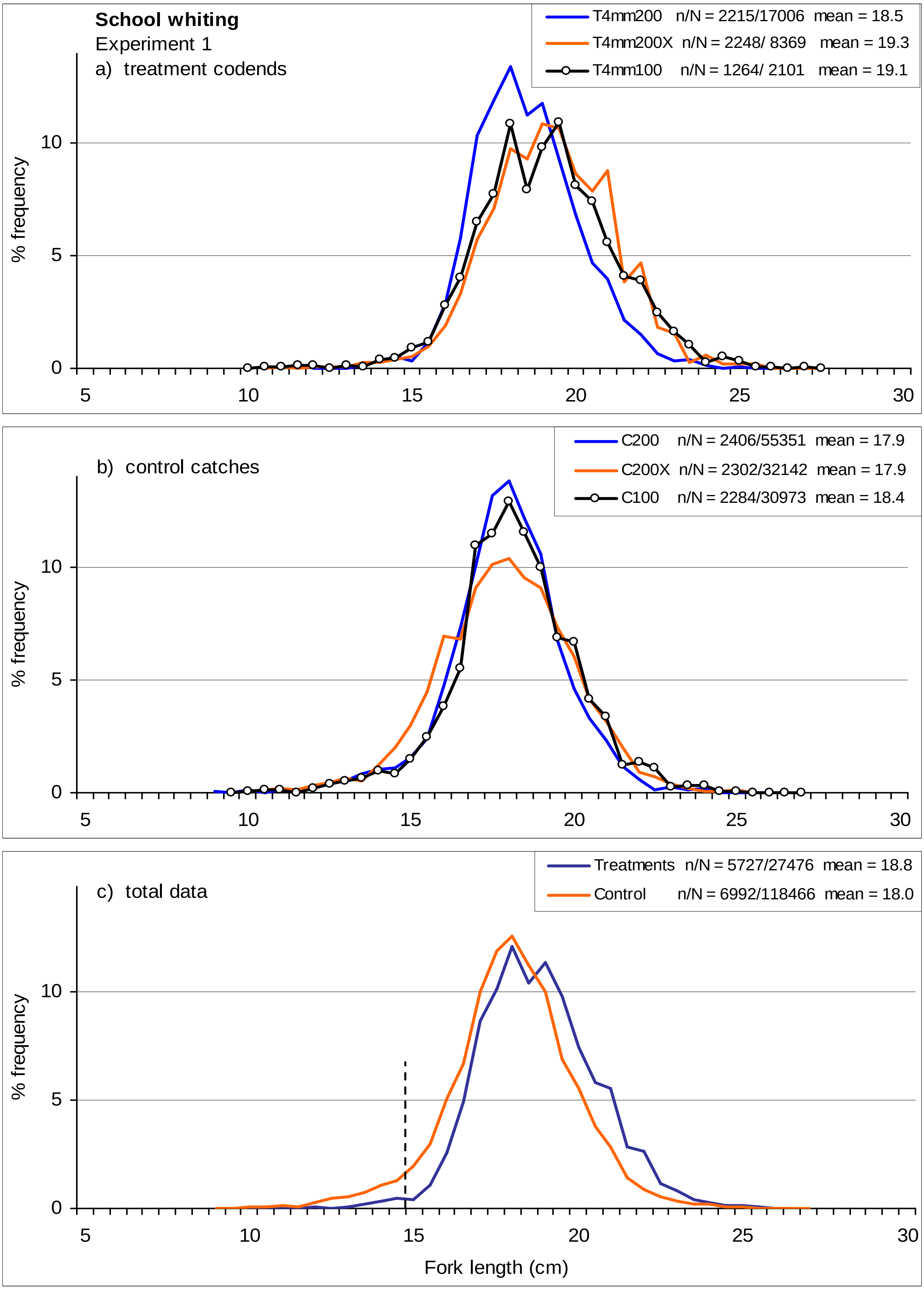

Figure 4.8. Length distributions of school whiting from the treatment codends and their associated control during Experiment 1 (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length.

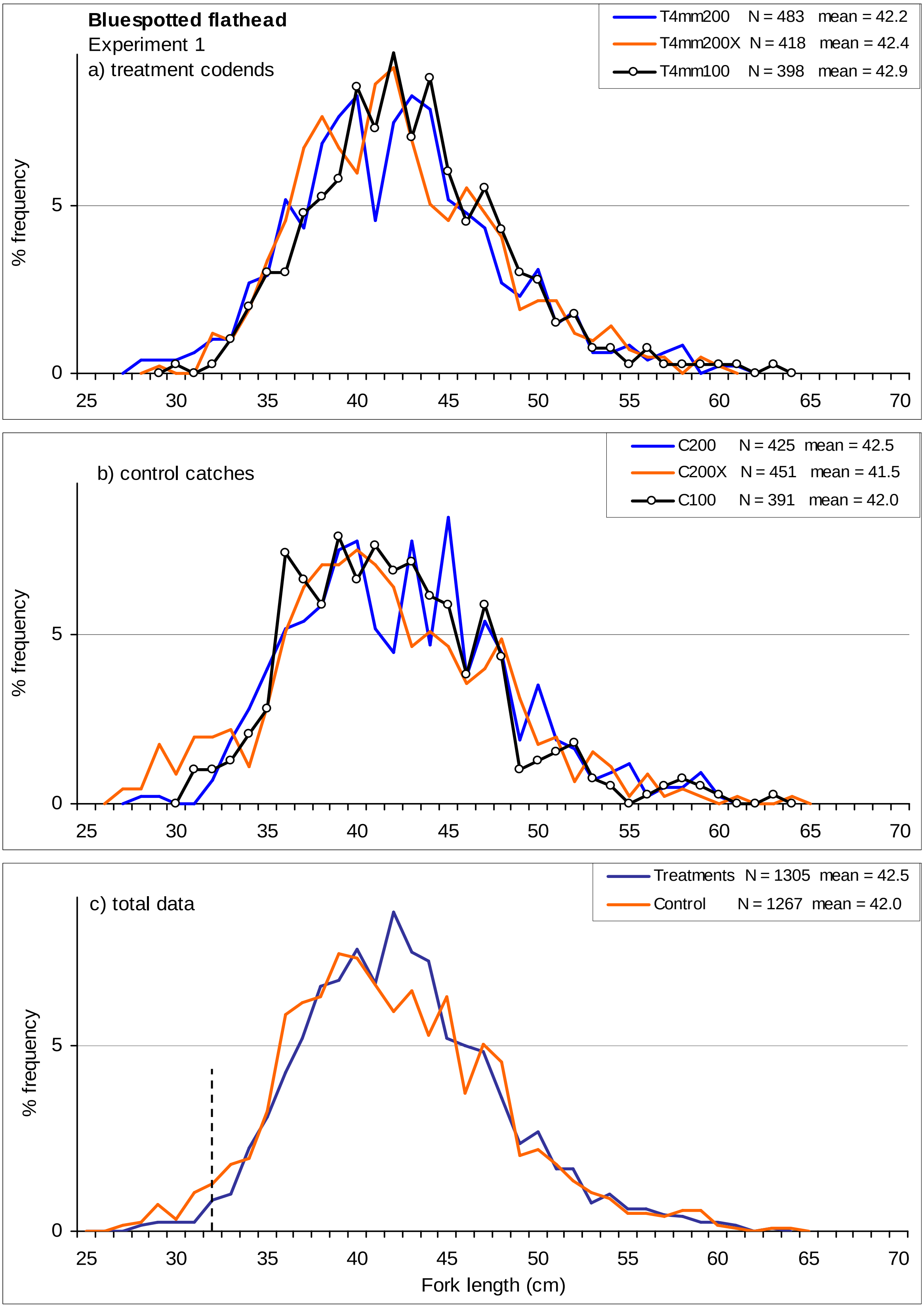

Figure 4.9. Length distributions of bluespotted flathead from the treatment codends and their associated control during Experiment 1 (N = total catch); the dotted line indicates minimum legal length (32.5 cm FL = 33.0 cm TL).

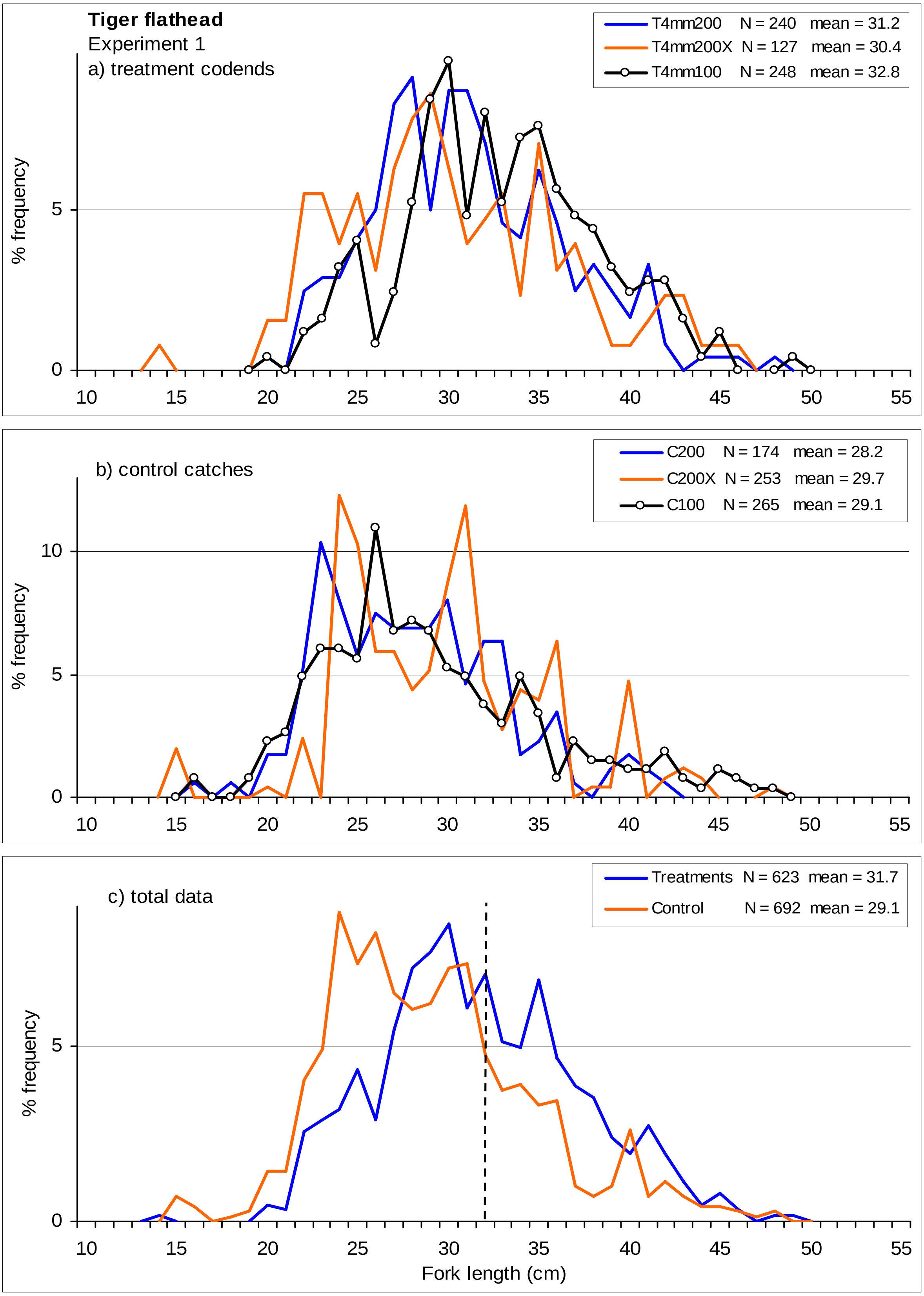

Figure 4.10. Length distributions of tiger flathead from the treatment codends and their associated control during Experiment 1 (N = total catch); the dotted line indicates minimum legal length (32.5 cm FL = 33.0 cm TL).

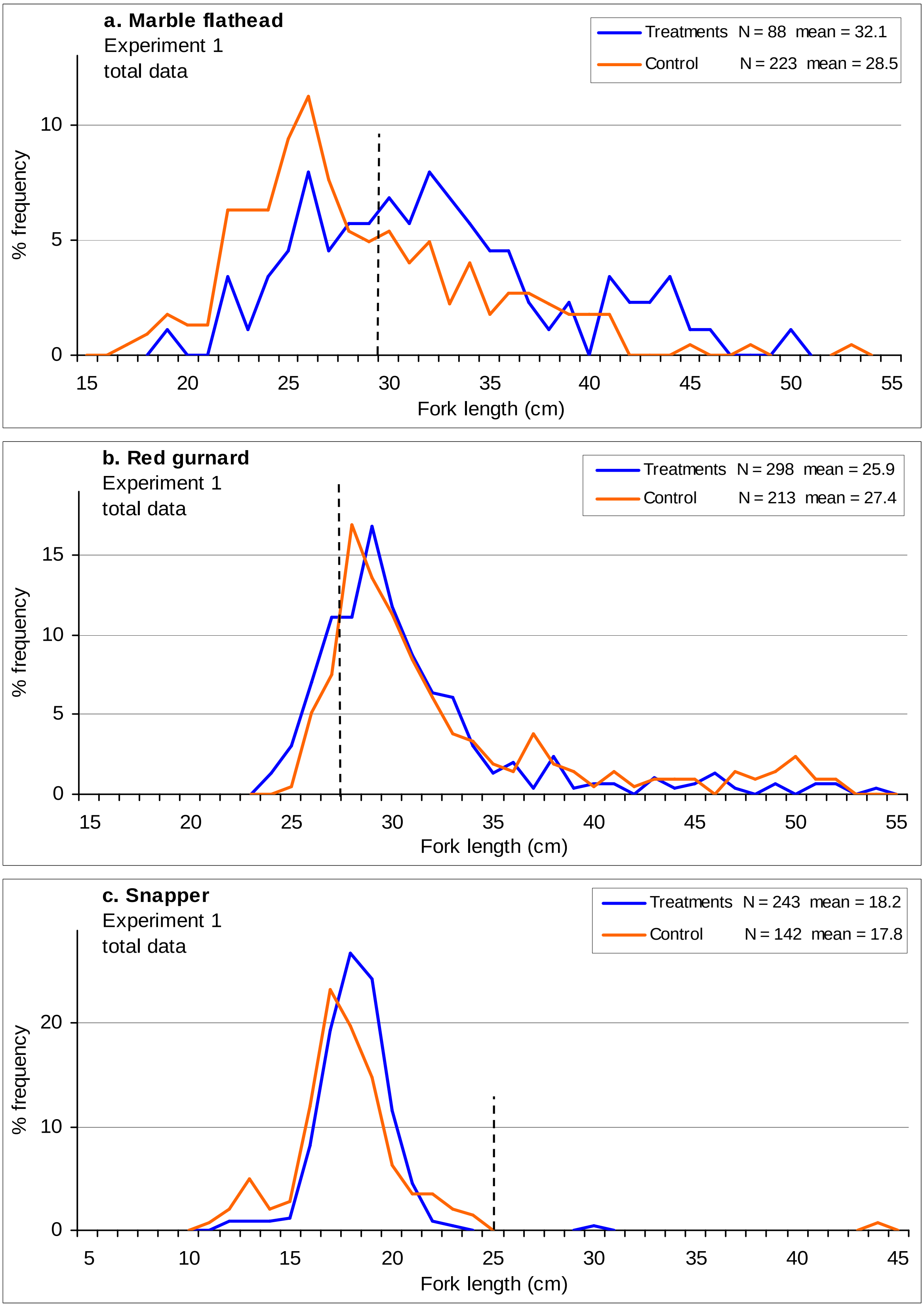

Figure 4.11. Length distributions of a) marble flathead, b) red gurnard and c) snapper from the treatment and control codends during Experiment 1 (N = total catch); the dotted line indicates approximate minimum marketable (marble flathead, red gurnard) or legal length (snapper: 25.5 cm FL = 30.0 cm TL).

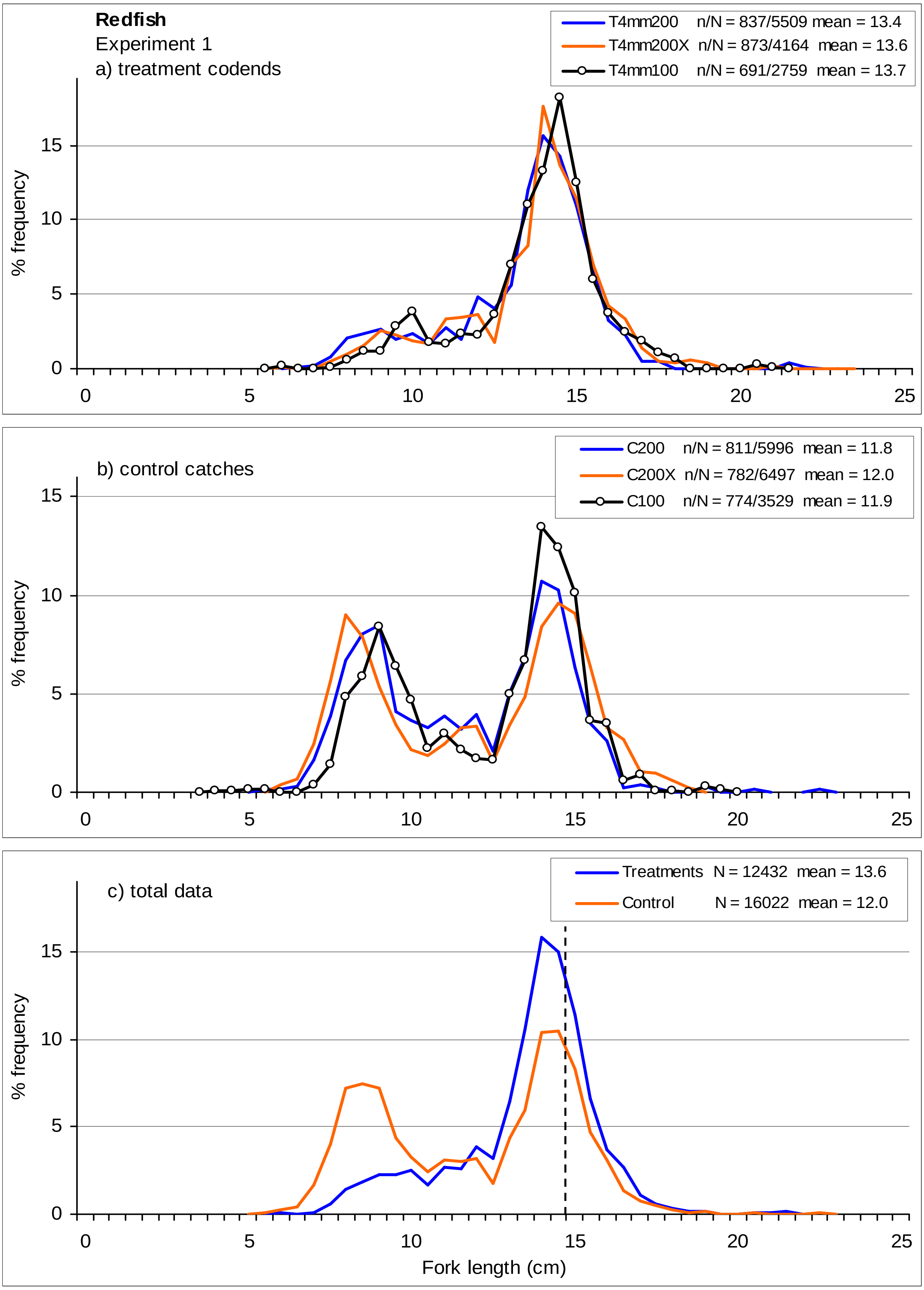

Figure 4.12. Length distributions of redfish from the treatment codends and their associated control during Experiment 1 (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length (15 cm FL = 18 cm TL).

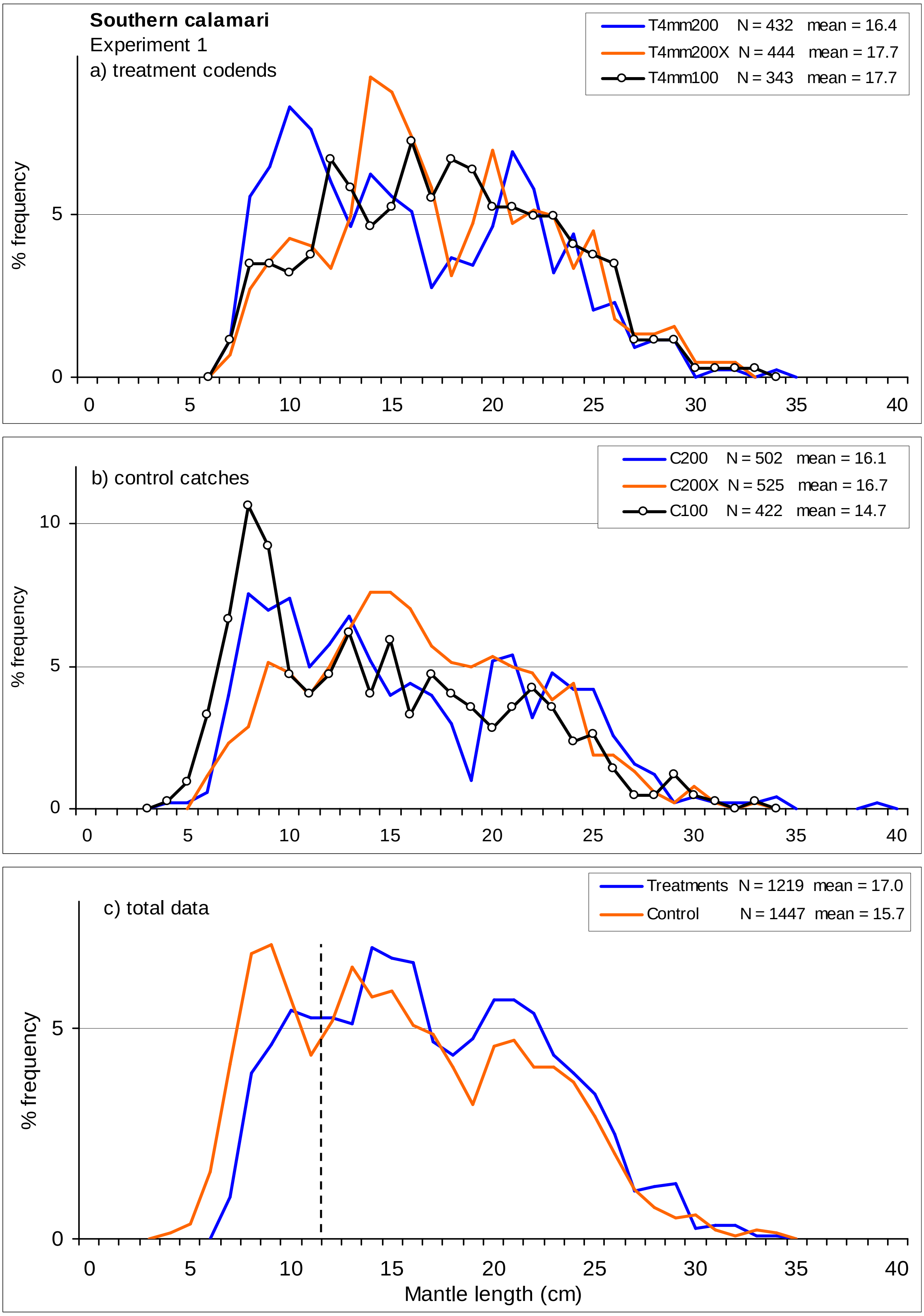

Figure 4.13. Length distributions of southern calamari from the treatment codends and their associated control during Experiment 1 (N = total catch); the dotted line indicates approximate minimum marketable length (12 cm ML).

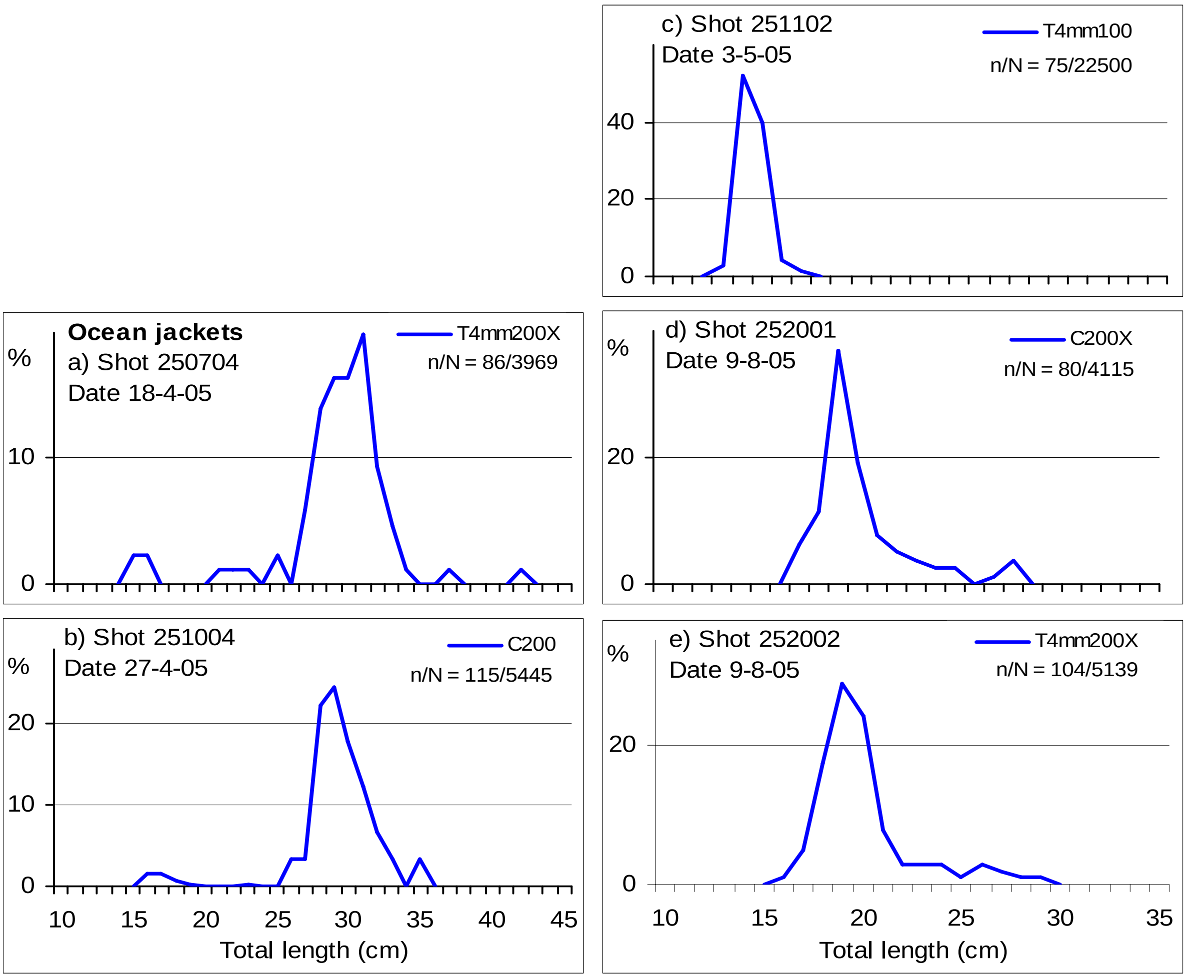

Figure 4.14. Length distributions of ocean jackets from individually large catches taken in the treatment (T) and control (C) codends during Experiment 1 (n = sample, N = total catch).

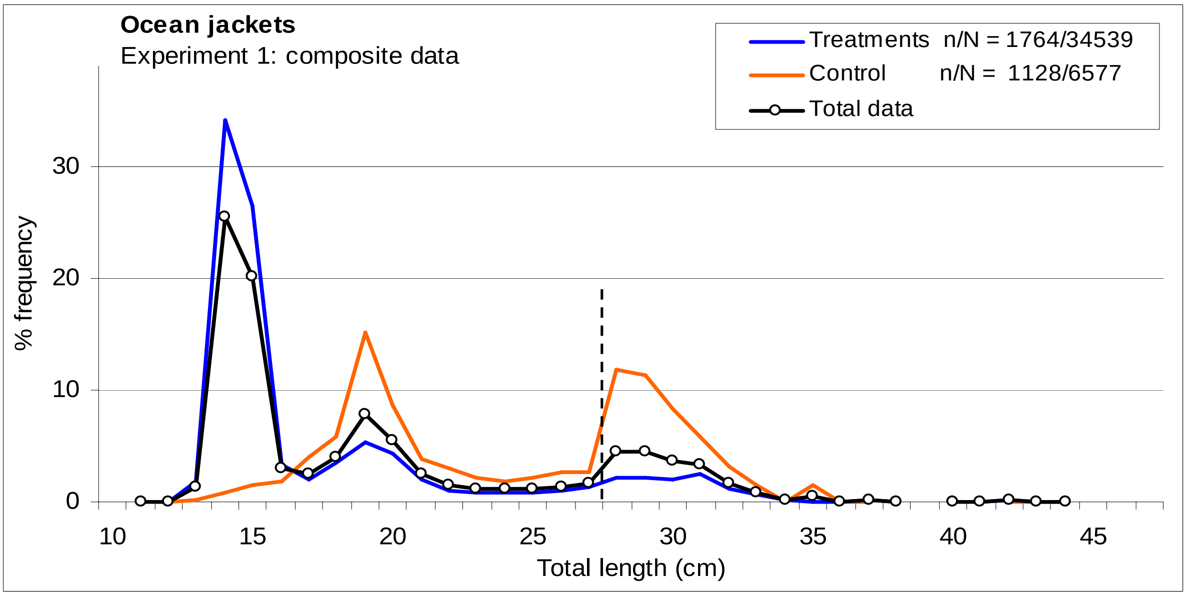

Figure 4.15. Length distributions of ocean jackets (pooled from all catches) from the treatment and control codends during Experiment 1 (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length (28 cm TL).

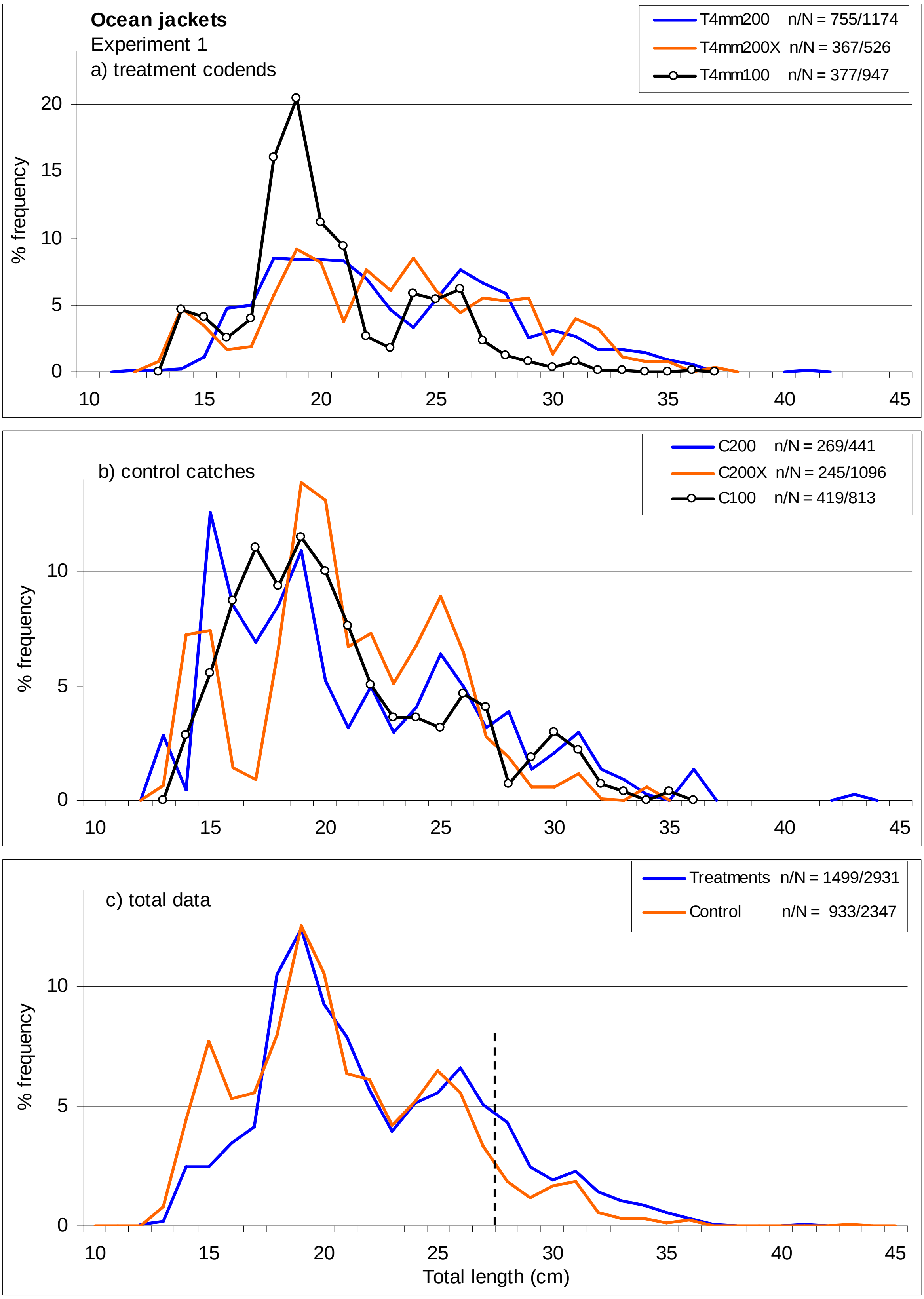

Figure 4.16. Length distributions of ocean jackets from the treatment codends and their associated control during Experiment 1, excluding very large catches (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length (28 cm TL).

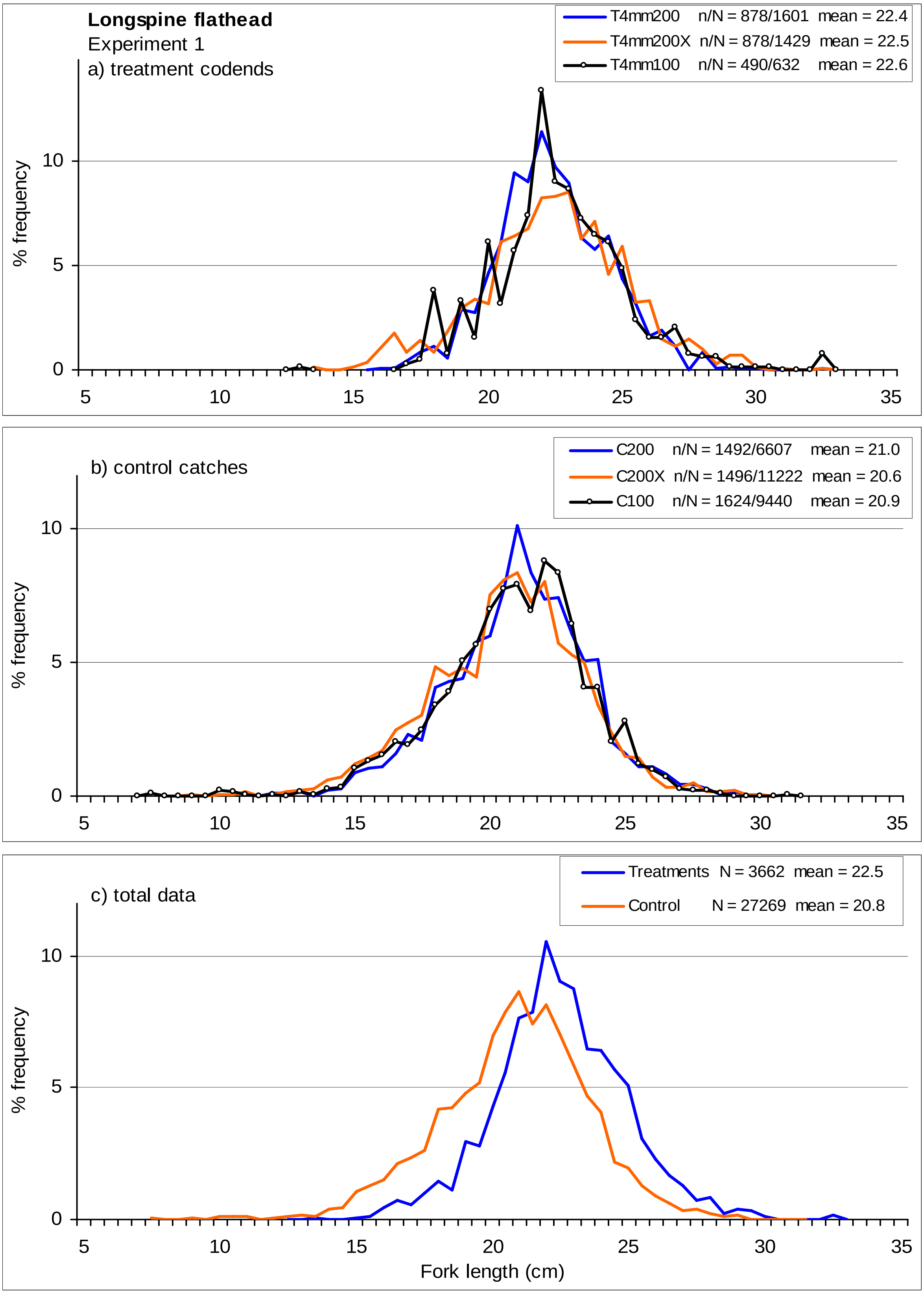

Figure 4.17. Length distributions of longspine flathead from the treatment codends and their associated control during Experiment 1 (n = sample, N = total catch).

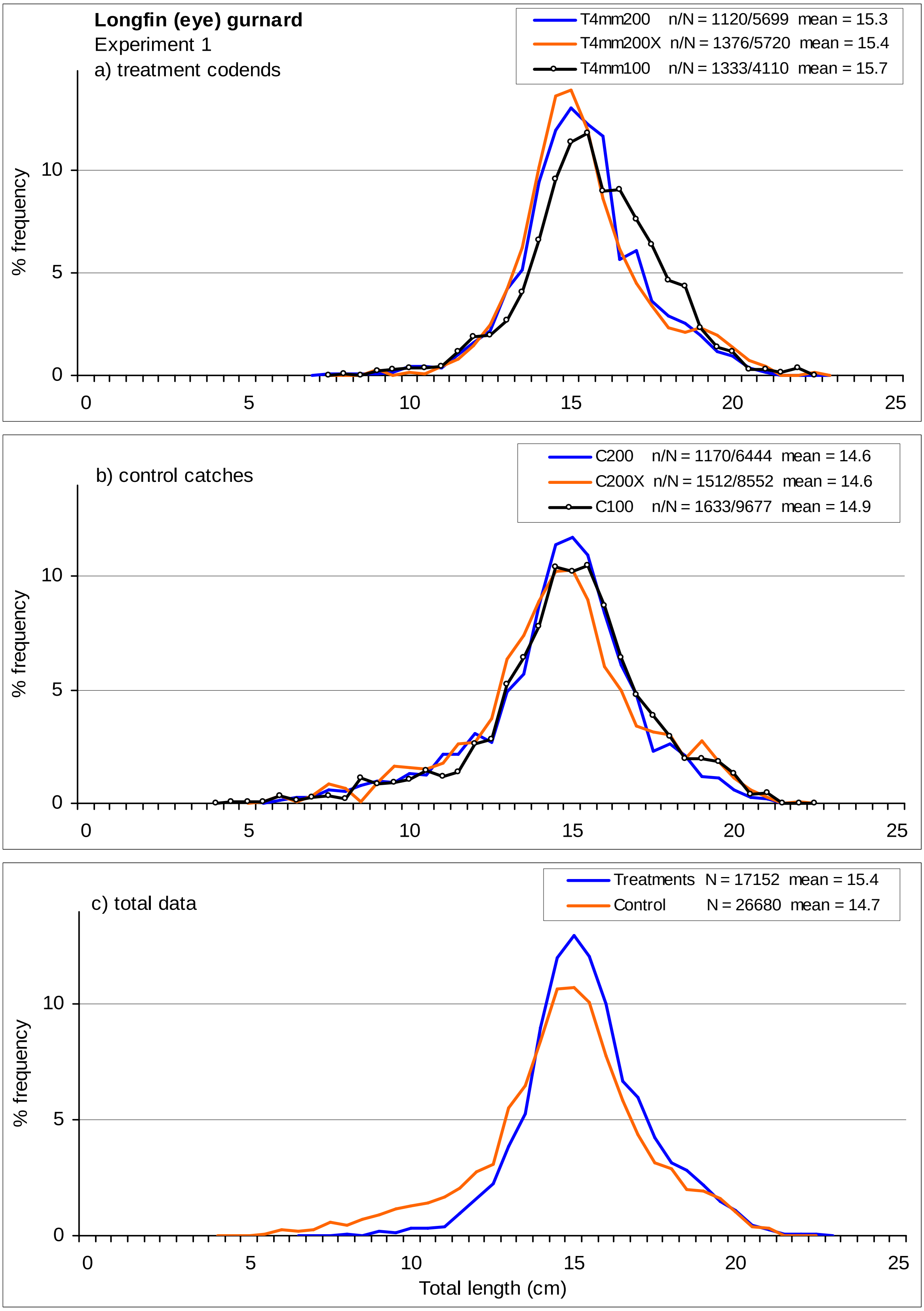

Figure 4.18. Length distributions of longfin gurnard from the treatment codends and their associated control during Experiment 1.

5. EXPERIMENT 2: TO TEST THE EFFECTS OF TWINE SIZE

5.1. Method summary

Experiment 2 compared the catch compositions of two 200-mesh circumference x 90 mm mesh treatment codends, one constructed from 5-mm diameter double-twine (T5mm200) and the other from 3-mm diameter double-twine (T3mm200) (Figure 3.1). Each was fished alternately with the small-meshed (40 mm) control codend (referred to respectively as C5mm and C3mm). Seven nights with replicate trawls with each treatment codend were selected for catch analyses (ANOVA), and catches from the alternate control tows were compared.

5.2. Results

Trawling was done during the period March-June 2006 mainly between Broken Bay and Norah Head but with an overall latitudinal range of 33°04’ to 33°40’ (Figure 1.2); trawling depths were between 41 and 66 m. The 64 tows (32 sets of alternate treatment and control tows) planned for Experiment 2 were completed over 16 nights, with two sets of tows with either the T5mm200 or T3mm200 codend fished with the control each night. All operational data are in Appendix 2.

Because no school whiting were caught in one tow (trawl 261204), ANOVA was done on data from seven nights for each treatment codend; the two nights excluded are indicated in Appendix 2. Data for two control tows (260501: C3mm, and 261203: C5mm) were also excluded from the calculations of mean-catch in the associated control because of ocean jacket catches in excess of 400 kg/2000 individuals. Most banjo rays were discarded during this experiment but, to be consistent with Experiment 1 catch data, are included in the retained-catch. The main features of the catch data for the treatment and control codends are shown in Figures 4.1 – 4.4, and summarised in Tables 5.1 – 5.4. The mean catch-number and standard error for all taxa caught during Experiment 2 are listed in Appendix 6.

5.2.1. Experiment 2 catches

5.2.1.1. Total-catches

In total, 138 species were recorded during Experiment 2 including 25 elasmobranchs, 77 teleosts, 24 molluscs and 12 crustaceans. Fifty-nine were commercially harvested species (Appendix 3a) but some such as the southern eagle ray, yellowtail scad, snapper, blue mackerel and king prawns were always discarded because of their small size or the insignificant commercial value of the small quantities caught.

By weight, the mean total-catch rates of the two treatment codends were 205 kg/tow (T5mm200) and 160 kg/tow (T3mm200), substantially less than the 322 and 321 kg/tow of their respective controls (Figure 4.1). In both treatments, about half of the total-catch weight was marketable (retained-catch) although the proportion by number was lower: 43% in T5mm200 and 35% in T3mm200. Discarded commercial species from the two treatment codends were 15 – 20% of total-catch weight and number, while non-commercial discards were respectively 26 – 37% and 40 – 48% of total-catch weights and numbers. The results of the ANOVA showed that the mean total, retained and discarded-catch weights, and discarded-catch numbers, in the treatment codends were not statistically different from each other. However, the mean number of total-catch and retained-catch in the T3mm200 codend were significantly less than those of the T5mm400 codend (Figures 4.1, 4.2; Appendix 7).

The mean weight of all organisms in each of the T5mm200 and T3mm200 codends was respectively 113 and 121 g, and in the controls 87 and 80 g (Figure 4.5).

5.2.1.2. Catch composition- retained

By weight, half of the mean total of retained-catch in the T5mm200 codend was school whiting (54 kg/tow) whereas the T3mm200 whiting catch of 26 kg/tow was significantly smaller (ANOVA results: see Appendix 7) and only 35% of its total retained-catch. The respective alternate-control catches of school whiting averaged around 125 kg/tow or about 70% of total retained-catch weights (Figure 4.2). The mean number of school whiting in all codends was between 70 and 90% of the total retained-catch numbers. Overall, average school whiting catches in the T5mm200 and T3mm200 codends (weight and number) were about 45% and 21% of their respective control catches (Figure 4.6).

Mean catch rates of the other main components of retained-catch were similar for all codends e.g., elasmobranchs (7 – 12 kg/tow), redfish (4 – 7 kg/tow), flathead (8 – 11 kg/tow), and calamari (14 – 19 kg/tow). Greater numbers of octopus retained by the small-mesh control was the main contributing difference in total-cephalopod catch rates between the control codend (24 – 27 kg/tow) and the treatments (17 – 18 kg/tow).

5.2.1.3. Catch composition – discarded commercials

As in Experiment 1, discarded commercial species consisted almost totally of small fish, principally ocean jackets (Figure 4.3). In the treatment codends, small ocean jackets averaged 17 kg/tow (T3mm200) and 32 kg/tow (T5mm200), 10 – 16% of total-catch weights. All other commercial discards caught in the treatment codends totalled less than 10 kg/tow and 5% of total-catch. For all codends, the mean number of commercial-discards (excluding ocean jackets) was less than 10% of the total-catch numbers. Relatively few small school whiting (2.1 kg/tow) were discarded from the T5mm200 codend and almost none from the T3mm200 treatment; whiting discards were 3 – 5 kg/tow from the control although these amounts were little more than 1% of total-catch. Similarly, relatively small quantities of redfish were discarded (4 – 7 kg/tow), less than about 3% of total-catch weights.

5.2.1.4. Catch composition – discarded non-commercials

Mean weight of non-commercial discards in the two treatment codends was 54 kg/tow (T5mm200) and 57 kg/tow (T3mm200), representing 27 and 36% of the total-catch weights; numbers of non-commercial discards were 40 – 48% of the total-catch numbers. In the alternate control tows, mean catches of non-commercials were 107 – 109 kg/tow or 33 – 34% of the respective total catches. Elasmobranchs made up over 20% of the non-commercial discard-catch weight in the treatment codends and about 10% of the discarded control catches but were less than 2% of the numbers. Longfin gurnard was the main non-commercial catch in all codends (Figure 4.4) with mean weights between 25 and 43 kg/tow or 12 – 21% of the the total-catch. By number, longfin gurnard were 72 – 83% of non-commercial discard numbers in the treatment codends and 42-49% in the controls. Longspine flathead catches in the control tows (25-27 kg/tow) were almost equal to the longfin gurnard catch rates. However, relatively few longspine flathead were retained by the large-meshed treatment codends although the 10 kg/tow caught in the T5mm200 codend was significantly greater than the 4.5 kg/tow taken by the T3mm200 treatment (ANOVA results; see Appendix 7). In addition to longspine flathead, the control codend also retained much greater quantities of small congers (*Gnathophis* spp.) (14-21 kg/tow) than did the treatment codends (< 1.0 kg/tow).

5.2.1.5. Ocean jackets

During Experiment 2, ocean jacket catch rates were less variable than during Experiment 1 (Figure 4.7) with only two catches, both taken in the control codend, exceeding 150 kg (600 and 400 kg in C5mm and C3mm tows). Across the treatment codends, the average catch for all tows was about 27 kg/tow and in the controls, 48 kg/tow; the proportions of retained ocean jackets were about 20% of the total weight and 14% of the total number of jackets taken.

5.2.2. Experiment 2 length-frequency data

5.2.2.1. Commercial species

The size compositions and mean lengths of school whiting from the T5mm200 codend and its control were very similar (19.1 & 18.8 cm FL). Compared to its control, the T3mm200 catch retained substantially fewer whiting smaller than about 17 cm FL (Figure 5.1) resulting in a mean length of 19.8 cm FL which was 0.9 cm larger than that of the control. However, the Kolmogorov-Smirnov tests indicated that the school whiting distributions from both treatments and their respective control catches were statistically different from each other (Table 5.5).

There were no significant differences in the size compositions of bluespotted or tiger flathead between each of the codends (Table 5.5). The overall size range of bluespotted flathead from all codends was 32 to 67 cm (mean ~42 cm) and only three individuals were under the minimum legal length of 33 cm (Figure 5.2). In contrast, the mean size of tiger flathead was 33 – 35 cm and, in total, more than half were smaller than 33 cm; only the small catch in the T3mm200 codend had a majority of fish (60%) larger than 33 cm (Figure 5.3). In total, about 75% of marble flathead were smaller than 33 cm (Figure 5.4a) although more larger fish were caught in the treatment codends resulting in a mean size (~32 cm), more than 4 cm greater than in the control.

Red gurnard size compositions and mean sizes (23.8 – 25.8 cm) were similar for all codends and, from both treatment and control codends, about 80% were smaller than the marketable size of ~28 cm (Figure 5.4b). The few snapper were all less than 25 cm (Figure 5.4c). The redfish size distributions were strongly bi-modal with peaks at 10 – 11 cm and 15 cm. About 70% of redfish from the treatments and 76% from the control were smaller than the marketable size of ~15 cm (Figure 5.5). The mean sizes from each of the treatment codends were almost identical (12.9 and 13.1 cm) and less than 1 cm greater than those from their associated control catches. The size distributions of ocean jackets from all codends were similar, with most fish 20 – 30 cm in length, and the means around 24 – 25 cm (Figure 5.6).

Southern calamari ranged in size between 7 and 39 cm (mantle length) with the pooled data showing a close to normal distribution of size classes (Figure 5.7). There were no statistical differences between the codends (Table 5.5) reflecting the very similar mean sizes (17.0 – 17.9 cm ML).

5.2.2.2. Non-commercial species

For both longspine flathead and longfin gurnard, the T5mm200 and T3mm200 size distributions were significantly different from their respective control catches, as were the distributions between treatments (Table 5.5). The mean size of the relatively few longspine flathead retained in the T3mm200 codend was 1.6 cm greater than its control, and 1.2 cm larger than the mean size in the T5mm200 codend (Figure 5.8). The longfin gurnard size data from each treatment and its control were similar to each other (Figure 5.9a, b) but a comparison of the size distributions and means from the two treatments (Figure 5.9c) indicated that the T5mm200 codend (mean size 14.4. cm TL) retained greater numbers of small longfin gurnard than did the T3mm200 codend (mean 15.9 cm TL).

5.3. Discussion

The results of this experiment quantified the differences in catch composition between two codends made from 5-mm (T5mm200) and 3-mm (T3mm200) diameter double-twine, and were comparable to the results from Experiment 1 for the T4mm200 codend (4-mm double-twine) which also had a circumference of 200 meshes and the same codend-extension section. The T5mm200 codend was near new and belonged to the chartered trawler for commercially targeting whiting. Through trials and experience, 200-mesh circumference codends constructed from 5-mm diameter double twine were adopted by most trawlers in the Sydney trawl-whiting fishery as they were of a size and weight that took a fishing shape (i.e., relatively closed meshes) that retained viable catches of whiting while still being practical to use and compliant with minimum mesh-size regulations. The resulting catch rates and size compositions recorded from the T5mm200 codend are therefore considered indicative of the commercial fishery, although with one possible qualification: the normal tow duration in the fishery is around three hours compared to the 90 minutes employed for the experimental tows. Fishers believe that, because of the apparently clumped distribution of school whiting on the grounds, a longer towing time is necessary to give the trawl a greater opportunity to encounter the whiting aggregations and short tow durations result in lower catch rates (R. Bagnato, personal communication). In theory this should not be the case if a sufficient number of trawls are done to lower this uncertainty. However, as catch accumulates through the tow, tension increases in the codend and the meshes close (Anon 1991), further reducing the avenue of escape for whiting (and other small fish); this effect, in turn, possibly results in an increasing rate of accumulation of small species such as school whiting as the tow progresses.

As the control codends were fished alternately with the treatments, it can be assumed that each pair of trawls sampled similar populations, and catches by the treatment codends were proportional to their respective controls. It follows, therefore, that the ratios of mean treatment-catch to control-catch for the 200-mesh circumference codends of each twine diameter (T3mm200, T4mm200 and T5mm200 codends) can be compared. For school whiting, the ratios of both catch weight and catch numbers increased almost linearly ($R^2 > 0.98$) with increasing twine diameter, with mean catches by the T3mm200, T4mm200 and T5mm200 codends being respectively about 20, 34 and 44% of their controls (Figure 4.6). Similarly, the respective proportions of longspine flathead retained by the three codends were approximately 15, 26 and 39%. There were only small differences between the ratios for school whiting number and weight for each codend (0.2 – 2.3%) and relatively small but consistent differences in the longspine flathead ratios (3.5 – 3.8%). This supported the validity of these comparisons as it demonstrated that the number-weight relationships within species did not vary greatly among the codends and any differences between codends were not influenced by different size-compositions. The results suggest that school whiting and longspine flathead of almost all sizes escaped from all three 90-mm mesh codends but the rates of escape, at least for these codends, were directly proportional to the twine diameter.

In Experiment 1, school whiting was the only species that had significantly higher catch rates in the more heavily constructed treatment codends (T4mm200 & T4mm200X) compared with the more selective T4mm100 codend; longspine flathead catches were also much larger in the 200-mesh codends while catch rates of larger fishes such as elasmobranchs, flatheads, redfish and others were similar across the three codends. Likewise in Experiment 2, catch rates of the larger, non-selective species did not vary greatly between the T5mm200 and T3mm200 treatments but catches of both school whiting and longspine flathead in the thinner-twined T3mm200 codend were significantly smaller than in the T5mm200 codend. Consequently, because school whiting contributed 70 – 80% of the retained-catch numbers to each of the two codends, the mean number of retained-catch was also significantly less in the 3-mm twine codend. Similarly, the combination of the smaller school whiting and longspine flathead catches, along with species such as yellowtail scad, ocean jackets and *Gnathophis* eels that also showed the same trend (Tables 5.1 – 5.2), resulted in a significantly smaller total-catch number in the T3mm200 codend.

Overall, the mean size of organisms retained in each of the five treatment codends was smallest for the T5mm200 codend (Figure 4.6) confirming that the commercially favoured codend, constructed from the thickest twine, was the least selective of the codends tested. The mean catch of discarded school whiting (< 15 cm FL) in the T5mm200 codend (2.1 kg/tow) was much higher than for any of the other four treatments (0.1 – 0.4 kg/tow) but this represented less than 2% of the mean whiting catch-weight in that codend. This was consistent with the size composition data from the control codend in Experiments 1 and 2 (Figures 4.8, 5.1) that indicated that there were relatively few whiting smaller than marketable size on the grounds. Although the T5mm200 treatment was the only codend that selected for school whiting less than market size (see Chapter 6), the length data suggests that the commercial use of such codends on the Sydney school-whiting ground does not lead to large quantities of discarded whiting.

The length-frequency distributions and mean sizes for the other main species were similar to those recorded during Experiment 1 in 2005. The redfish data clearly showed three distinct size modes around 5 cm, 10 cm and 15 cm that, with spawning in late summer-autumn (Rowling 1994), corresponded to age classes of one, two and three years (K. Rowling pers. comm.). The size composition of ocean jacket catches were less defined than in Experiment 1 with most in the 20 – 30 cm size range corresponding to 1 – 2 year old fish (Miller 2007).

5.4. Summary

- The T5mm200 codend caught significantly greater numbers of retained-catch and total-catch than did the T3mm200 codend; however, there were no significant differences in the weights of retained-catch and total-catch between the two codends.

- The weight of retained school whiting, and number and weight of longspine flathead, were significantly greater in the T5mm200 codend compared to the T3mm200 codend.

- Mean catch rate of school whiting in the T5mm200 codend was about double that of the T3mm200 codend, and about 45% and 21% of the catch rate in their corresponding control; catch rates of other commercial species were similar for the both treatment and control codends.

- Retained-catch weights in the T5mm200 and T3mm200 codends were about 50% of total-catch weight and consisted mainly of school whiting (27 and 16% of total-catch) and cephalopods (9 and 11% of total-catch). Mean catch rates of other commercial species were similar in both treatment codends.

- Mean weights and numbers of commercial-discards from the T5mm200 and T3mm200 codends were 15 – 20% of total catch; ocean jackets were more than 50% of commercial discard weights and numbers in both codends.

- Discarded redfish, flathead and school whiting totalled less than 7 kg/tow in both codends.

- Only three undersized bluespotted flathead were caught but about half of the relatively small numbers of tiger and marble flathead, and all snapper, were smaller than legal or marketable size.

Table 5.1. Summary of catches (mean, standard error, and % of total catch; n = 14) taken in the T5mm200 treatment codend during Experiment 2.

	T5mm200 treatment codend					
	Kg / 90 min. tow			**No. / 90 min. tow**		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	7.0	2.0	3.4	3.9	1.3	0.2
Redfish	6.4	2.9	2.9	41.1	21.0	2.0
Flathead-bluespotted	7.0	1.0	3.4	13.5	2.4	0.7
Flathead-other	3.1	1.5	1.5	6.4	3.4	0.3
School whiting	54.3	8.6	26.5	711.4	109.3	34.3
Ocean jackets	7.3	3.5	3.6	29.1	14.5	1.4
Misc. fish	4.6	1.3	2.2	17.4	7.2	0.8
Total retained fish	**89.6**	**9.8**	**43.8**	**822.8**	**114.0**	**39.6**
Calamari	14.1	2.8	6.9	44.9	5.6	2.2
Cuttlefish	1.1	0.4	0.5	5.1	0.6	0.2
Octopus	1.2	0.3	0.6	16.6	2.7	0.8
Total retained molluscs	**18.1**	**3.1**	**8.8**	**66.9**	**6.2**	**3.2**
Bugs & crabs	1.2	0.3	0.6	6.2	1.1	0.3
Total retained catch	**108.9**	**11.0**	**53.2**	**895.9**	**115.8**	**43.1**
Discarded commercials						
Redfish	3.5	1.0	1.7	85.1	26.7	4.1
Flathead-bluespotted	0.0	0.0	0.0	0.1	0.1	0.0
Flathead-other	1.3	0.7	0.6	7.2	4.3	0.3
School whiting	2.1	1.5	1.0	32.9	24.5	1.6
Yellowtail scad	1.2	0.4	0.6	18.9	6.4	0.9
Snapper	0.1	0.0	0.1	0.6	0.2	0.0
Ocean jackets	31.9	10.7	15.6	196.1	65.0	9.4
Misc. commercial fish	1.1	0.4	0.5	5.7	1.2	0.3
Total discarded commercial fish	**41.2**	**11.5**	**20.1**	**346.5**	**89.3**	**16.7**
Discard crabs & bugs	0.4	0.1	0.2	8.1	3.9	0.4
Total discarded commercials	**41.6**	**11.5**	**20.3**	**354.6**	**88.1**	**17.1**
Discarded non-commercials						
Elasmobranchs	11.4	3.9	5.6	6.7	2.7	0.3
Misc eels	0.8	0.3	0.4	10.3	2.5	0.5
Gurnard-longfin	26.3	6.6	12.8	599.0	120.6	28.8
Flathead-longspine	10.1	1.4	4.9	145.1	23.7	7.0
Misc. fish	4.4	1.9	2.2	52.3	6.5	2.5
Total discarded non-commercial fish	**53.0**	**7.9**	**25.9**	**813.4**	**138.8**	**39.2**
Misc. invertebrates	1.3	0.2	0.6	12.6	2.3	0.6
Total discarded non-commercials	**54.3**	**7.9**	**26.5**	**826.1**	**139.2**	**39.8**
Total discarded fish	94.2	13.8	46.0	1159.9	139.3	55.9
Total discarded invertebrates	1.6	0.3	0.8	20.8	5.3	1.0
Total discarded catch	**95.8**	**13.8**	**46.8**	**1180.7**	**138.6**	**56.9**
Total catch	**204.8**	**19.9**	**100.0**	**2076.6**	**206.1**	**100.0**

Table 5.2. Summary of catches (mean, standard error, and % of total catch; n = 16) taken in the T3mm200 treatment codend during Experiment 2.

	T3mm200 treatment codend					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	11.7	5.2	7.3	4.8	1.3	0.3
Redfish	4.4	1.0	2.8	34.5	8.7	2.4
Flathead-bluespotted	9.9	2.9	6.2	16.6	4.9	1.2
Flathead-other	1.2	0.6	0.7	2.3	1.4	0.2
School whiting	26.3	5.4	16.4	344.1	78.0	24.2
Ocean jackets	3.0	1.0	1.9	13.0	4.6	0.9
Misc. fish	3.1	0.7	1.9	8.7	2.4	0.6
Total retained fish	**59.6**	**8.8**	**37.1**	**424.0**	**75.1**	**29.8**
Calamari	15.7	3.0	9.8	50.7	9.5	3.6
Cuttlefish	1.4	0.7	0.9	4.6	2.4	0.6
Octopus	1.1	0.3	0.7	7.5	1.4	0.5
Total retained molluscs	**18.3**	**3.5**	**11.4**	**63.1**	**11.0**	**4.4**
Bugs & crabs	0.8	0.3	0.5	6.1	1.0	0.4
Total retained catch	**79.2**	**10.3**	**49.4**	**493.2**	**74.4**	**34.7**
Discarded commercials						
Redfish	4.5	1.5	2.8	96.7	34.6	6.8
Flathead-bluespotted	0.0			0.0		
Flathead-other	0.2	0.2	0.2	1.2	1.0	0.1
School whiting	0.1	0.0	0.0	2.9	2.0	0.2
Yellowtail scad	0.7	0.3	0.4	10.5	5.0	0.7
Snapper	0.1	0.0	0.0	0.7	0.5	0.1
Ocean jackets	16.5	5.2	10.3	123.9	41.1	8.7
Misc. commercial fish	1.5	0.3	0.9	7.6	1.3	0.5
Total discarded commercial fish	**23.5**	**6.1**	**14.6**	**243.5**	**68.8**	**17.1**
Discard crabs & bugs	0.7	0.2	0.4	3.9	0.8	0.3
Total discarded commercials	**24.2**	**6.1**	**15.1**	**247.9**	**68.6**	**17.4**
Discarded non-commercials						
Elasmobranchs	13.3	3.9	8.3	9.5	3.8	0.7
Misc eels	0.1	0.0	0.1	1.2	0.4	0.1
Gurnard-longfin	33.0	9.5	20.6	566.3	170.4	39.8
Flathead-longspine	4.5	0.9	2.8	52.4	11.3	3.7
Misc. fish	5.1	1.2	3.2	45.2	20.7	3.2
Total discarded non-commercial fish	**56.0**	**9.8**	**34.9**	**674.6**	**181.0**	**47.4**
Misc. invertebrates	1.0	0.2	0.6	7.3	1.7	0.5
Total discarded non-commercials	**57.0**	**9.7**	**35.6**	**681.9**	**180.5**	**47.9**
Total discarded fish	79.5	13.3	49.6	918.1	214.2	64.5
Total discarded invertebrates	1.7	0.3	1.1	11.7	2.2	0.8
Total discarded catch	**81.2**	**13.2**	**50.6**	**929.9**	**213.2**	**65.3**
Total catch	**160.4**	**22.0**	**100.0**	**1423.1**	**241.0**	**100.0**

Table 5.3. Summary of catches (mean, standard error, and % of total catch; n = 14) taken in the control codend (C5mm) when fished alternately with the T5mm200 codend during Experiment 2.

	Control codend (C5mm)					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	s.e.	%	mean	s.e.	%
Retained commercials						
Elasmobranchs	9.2	2.0	2.8	5.5	1.1	0.1
Redfish	5.5	1.9	1.7	35.6	12.8	0.8
Flathead-bluespotted	6.5	1.1	2.0	10.9	2.0	0.2
Flathead-other	2.2	1.4	0.7	4.5	2.8	0.1
School whiting	122.0	42.4	37.8	1627.9	608.6	36.5
Ocean jackets	4.0	1.5	1.2	14.5	5.6	0.3
Misc. fish	4.0	0.9	1.2	12.1	3.0	0.3
Total retained fish	**153.4**	**42.1**	**47.6**	**1711.0**	**6.6.5**	**38.4**
Calamari	18.2	3.6	5.6	54.5	10.2	1.2
Cuttlefish	1.0	0.4	0.3	6.7	4.0	0.2
Octopus	5.3	0.7	1.6	46.9	7.4	1.1
Total retained molluscs	**24.9**	**3.9**	**7.7**	**109.0**	**13.4**	**2.4**
Bugs & crabs	1.1	0.3	0.3	5.9	1.6	0.1
Total retained catch	**179.4**	**43.2**	**55.6**	**1825.9**	**608.0**	**40.9**
Discarded commercials						
Redfish	5.1	1.9	1.6	127.5	41.5	2.9
Flathead-bluespotted	0.0	0.0	0.0	0.1	0.1	0.0
Flathead-other	1.0	0.5	0.3	7.0	3.6	0.2
School whiting	4.3	3.1	1.3	96.8	78.1	2.2
Yellowtail scad	1.7	0.3	0.5	42.2	7.2	0.9
Snapper	0.3	0.2	0.1	1.6	0.7	0.0
Ocean jackets	20.9	6.8	6.5	153.6	49.7	3.4
Misc. commercial fish	2.2	0.7	0.7	8.8	2.3	0.2
Total discarded commercial fish	**35.5**	**6.7**	**11.0**	**437.6**	**92.2**	**9.8**
Discard crabs & bugs	0.8	0.2	0.2	26.6	14.5	0.6
Total discarded commercials	**36.3**	**6.8**	**11.2**	**464.2**	**95.0**	**10.4**
Discarded non-commercials						
Elasmobranchs	9.9	3.1	3.1	9.7	3.4	0.2
Misc eels	14.0	3.6	4.3	199.9	54.5	4.5
Gurnard-longfin	45.9	22.4	14.2	1069.1	456.9	24.0
Flathead-longspine	24.7	4.8	7.7	391.6	79.6	8.8
Misc. fish	12.3	1.9	3.8	469.9	134.3	10.5
Total discarded non-commercial fish	**106.8**	**24.2**	**33.1**	**2140.1**	**501.9**	**48.0**
Misc. invertebrates	0.1	0.0	0.0	30.5	11.1	0.7
Total discarded non-commercials	**106.8**	**24.2**	**33.1**	**2170.6**	**503.8**	**48.7**
Total discarded fish	142.3	24.0	44.1	2577.8	484.6	57.8
Total discarded invertebrates	0.8	0.3	0.3	57.1	17.4	1.3
Total discarded catch	**143.1**	**24.1**	**44.4**	**2634.9**	**490.1**	**59.1**
Total catch	**322.4**	**65.9**	**100.0**	**4460.8**	**1052.2**	**100.0**

Table 5.4. Summary of catches (mean, standard error, and % of total catch; n = 15) taken in the control codend (C3mm) when fished alternately with the T3mm200 codend Experiment 2.

	Control codend (C3mm)					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
Elasmobranchs	10.0	2.9	3.1	5.5	1.8	0.1
Redfish	5.0	1.4	1.5	40.2	12.4	1.0
Flathead-bluespotted	7.0	1.2	2.2	12.0	2.0	0.3
Flathead-other	2.3	1.4	0.7	4.8	3.2	0.1
School whiting	132.4	41.2	41.3	1747.5	529.7	44.2
Ocean jackets	1.9	0.9	0.6	7.3	3.9	0.2
Misc. fish	4.3	0.9	1.4	17.4	4.9	0.4
Total retained fish	**162.9**	**39.8**	**50.8**	**1834.8**	**524.0**	**46.4**
Calamari	18.3	4.2	5.7	58.6	14.0	1.5
Cuttlefish	1.3	0.7	0.4	6.9	3.3	0.2
Octopus	6.9	1.3	2.1	55.6	10.8	1.4
Total retained molluscs	**26.7**	**5.3**	**8.3**	**121.8**	**22.8**	**3.1**
Bugs & crabs	1.5	0.3	0.5	6.6	1.2	0.2
Total retained catch	**191.0**	**38.3**	**59.5**	**1963.2**	**516.4**	**49.6**
Discarded commercials						
Redfish	5.9	1.9	1.8	144.1	49.1	3.6
Flathead-bluespotted	0.0			0.0		
Flathead-other	0.9	0.5	0.3	5.7	3.2	0.1
School whiting	3.5	3.1	1.1	119.1	105.0	3.0
Yellowtail scad	1.7	0.5	0.5	47.5	9.6	1.2
Snapper	0.1	0.1	0.0	0.3	0.1	0.0
Ocean jackets	6.9	2.0	2.1	52.5	12.6	1.3
Misc. commercial fish	1.4	0.3	0.4	7.8	1.4	0.2
Total discarded commercial fish	**20.3**	**3.8**	**6.3**	**376.8**	**107.2**	**9.5**
Discard crabs & bugs	0.4	0.1	0.1	8.2	2.3	0.2
Total discarded commercials	**20.7**	**3.8**	**6.5**	**385.0**	**107.1**	**9.7**
Discarded non-commercials						
Elasmobranchs	11.5	4.6	3.6	9.4	2.7	0.2
Misc eels	20.5	5.4	6.4	259.4	75.0	6.6
Gurnard-longfin	38.5	12.7	12.0	681.3	210.7	17.2
Flathead-longspine	27.2	4.3	8.5	407.8	65.5	10.3
Misc. fish	10.6	1.9	3.3	225.9	36.4	5.7
Total discarded non-commercial fish	**108.3**	**18.3**	**33.7**	**1583.8**	**292.8**	**40.0**
Misc. invertebrates	0.8	0.2	0.3	26.2	7.7	0.7
Total discarded non-commercials	**109.1**	**18.3**	**34.0**	**1609.9**	**290.0**	**40.7**
Total discarded fish	128.6	16.8	40.1	1960.6	273.4	49.5
Total discarded invertebrates	1.3	0.2	0.4	34.3	8.0	0.9
Total discarded catch	**129.8**	**16.9**	**40.5**	**1994.9**	**272.1**	**50.4**
Total catch	**320.9**	**52.0**	**100.0**	**3958.2**	**743.0**	**100.0**

Table 5.5. Results of K-S tests comparing length distributions of important species in treatment and control codends during Experiment 2 (T = treatment, TT = pooled data for treatments; C = control, CC = pooled data for controls; ns = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

Codends compared	**T5mm200–C5mm**	**T3mm200–C3mm**	**TT–CC**
School whiting	***	***	***
Flathead-bluespotted	ns	ns	ns
Flathead-tiger	-	ns	ns
Flathead-marble	-	-	**
Flathead-longspine	***	***	***
Redfish	***	***	***
Gurnard-red	ns	ns	ns
Gurnard-longfin	***	***	***
Southern calamari	ns	ns	ns

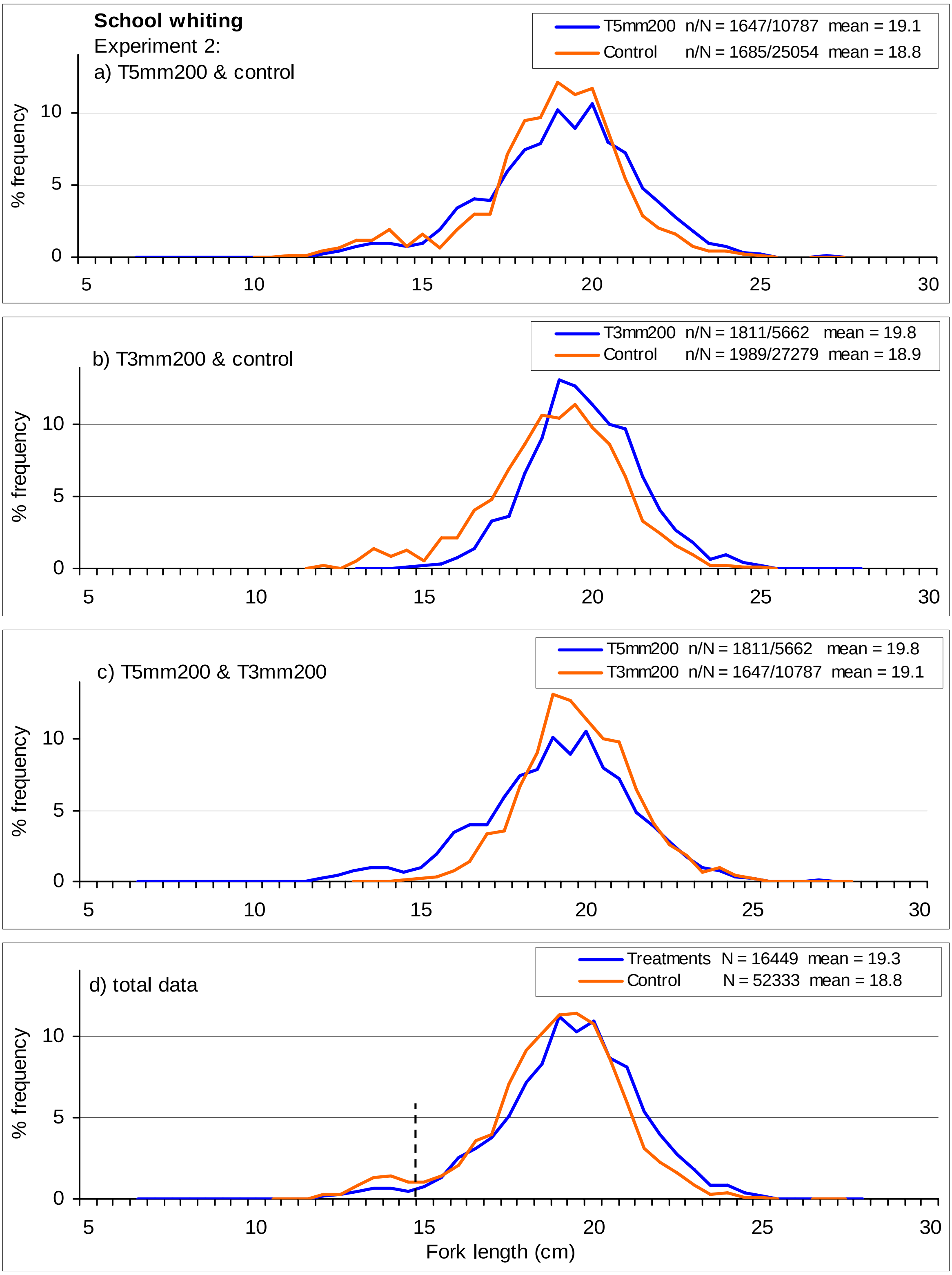

Figure 5.1. Length distributions of school whiting from the treatment codends and their alternated control during Experiment 2 (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length.

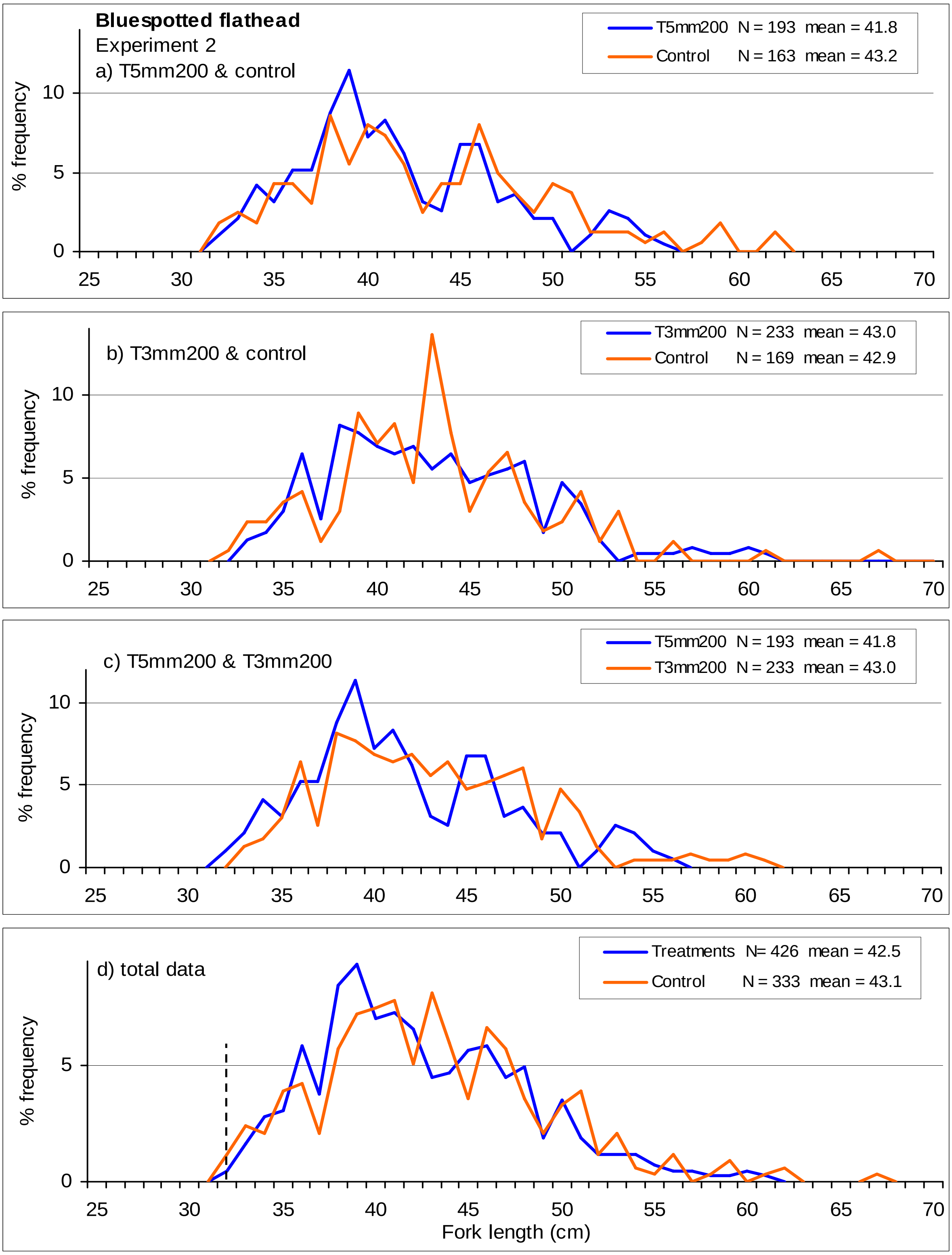

Figure 5.2. Length distributions of bluespotted flathead from the treatment codends and their alternated control during Experiment 2 (N = total catch); the dotted line indicates minimum legal length (32.5 cm FL = 33.0 cm TL).

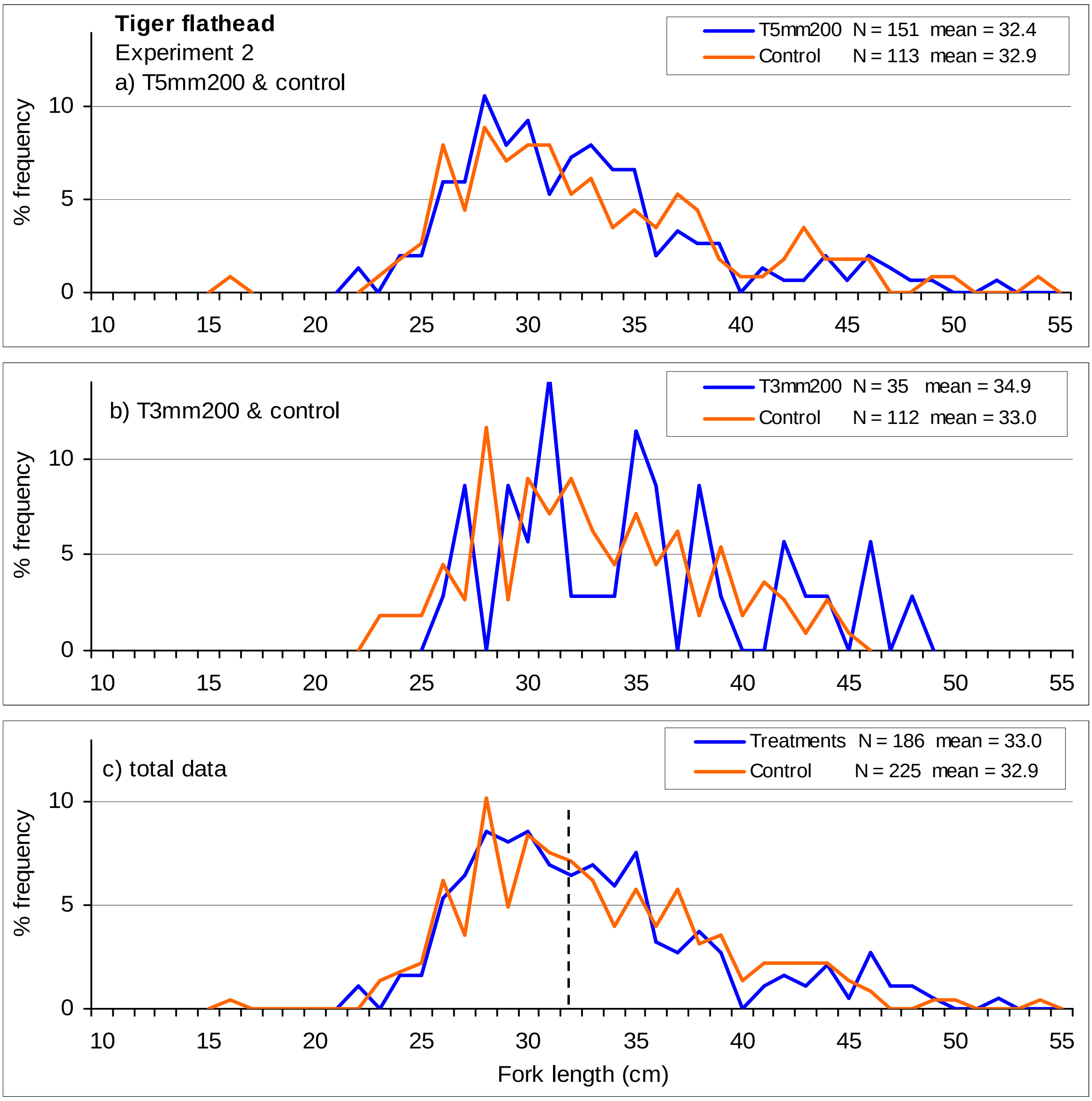

Figure 5.3. Length distributions of tiger flathead from the treatment codends and their alternated control during Experiment 2 (N = total catch); the dotted line indicates minimum legal length (32.5 cm FL = 33.0 cm TL).

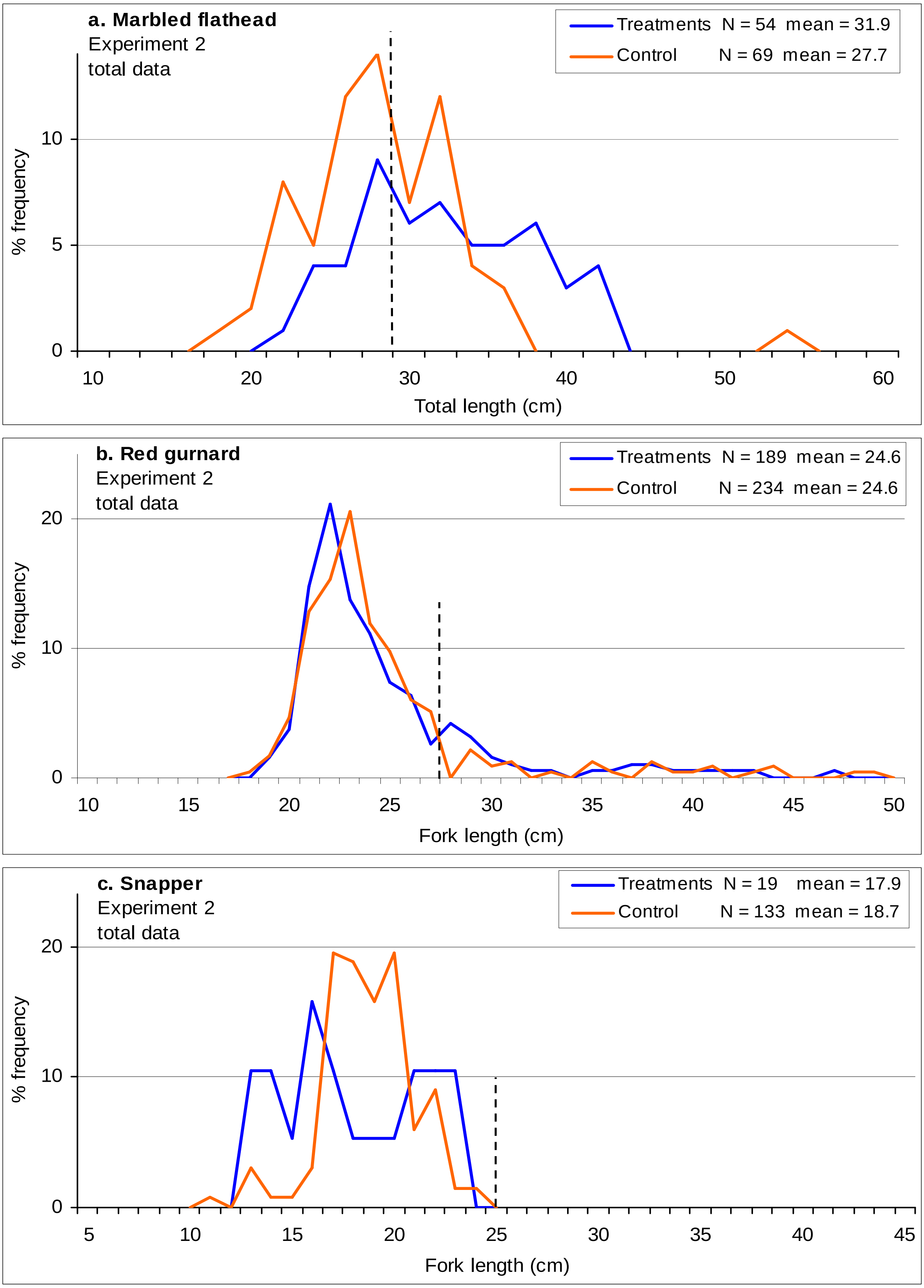

Figure 5.4. Length distributions of a) marbled flathead, b) red gurnard and c) snapper from the treatment and control codends during Experiment 2 (N = total catch); the dotted line indicates approximate minimum marketable length (marble flathead, red gurnard) or legal length (snapper: 25.5 cm FL = 30.0 cm TL).

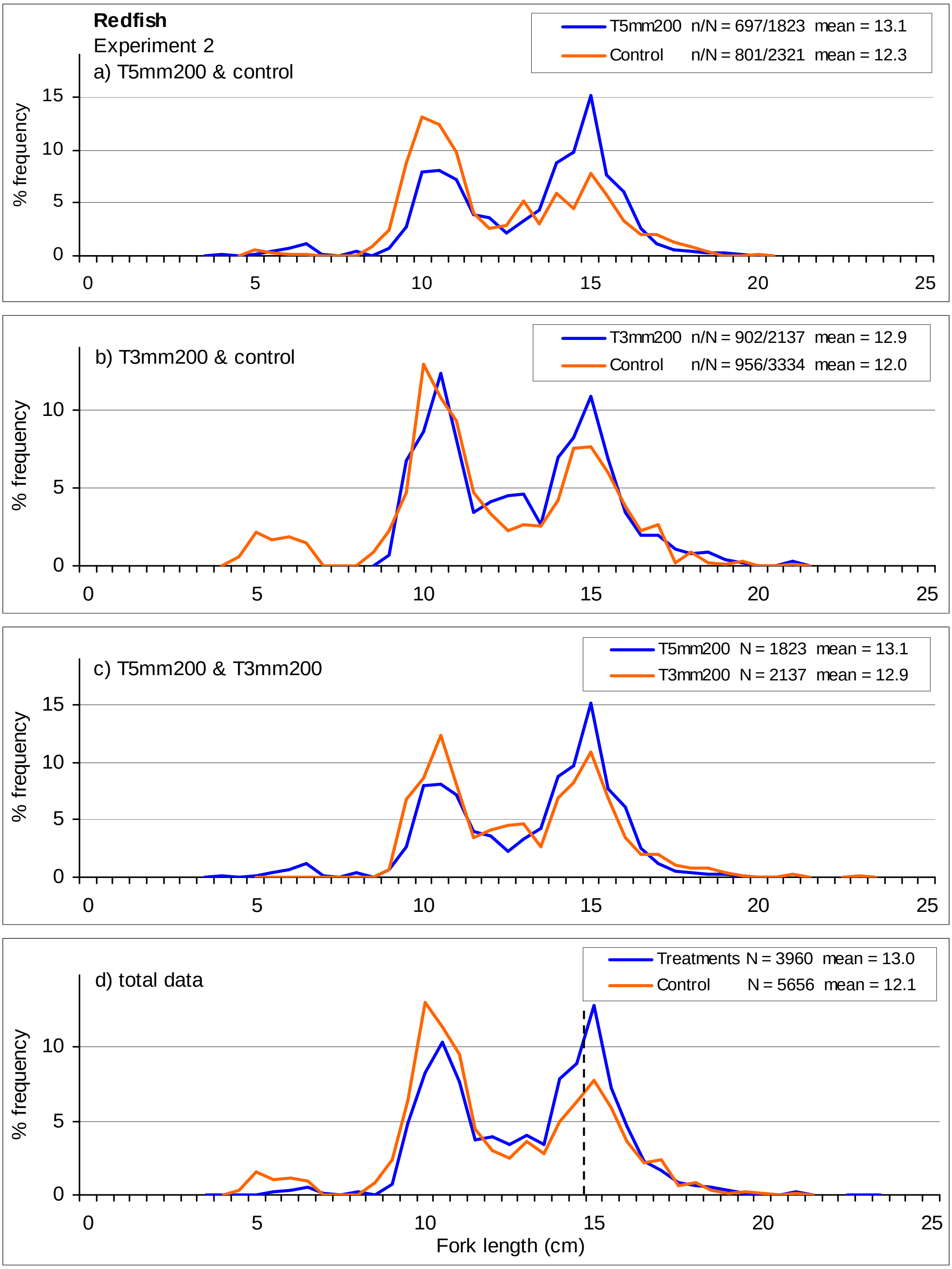

Figure 5.5. Length distributions of redfish from the treatment codends and their alternated control during Experiment 2 (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length (15 cm FL = 18 cm TL).

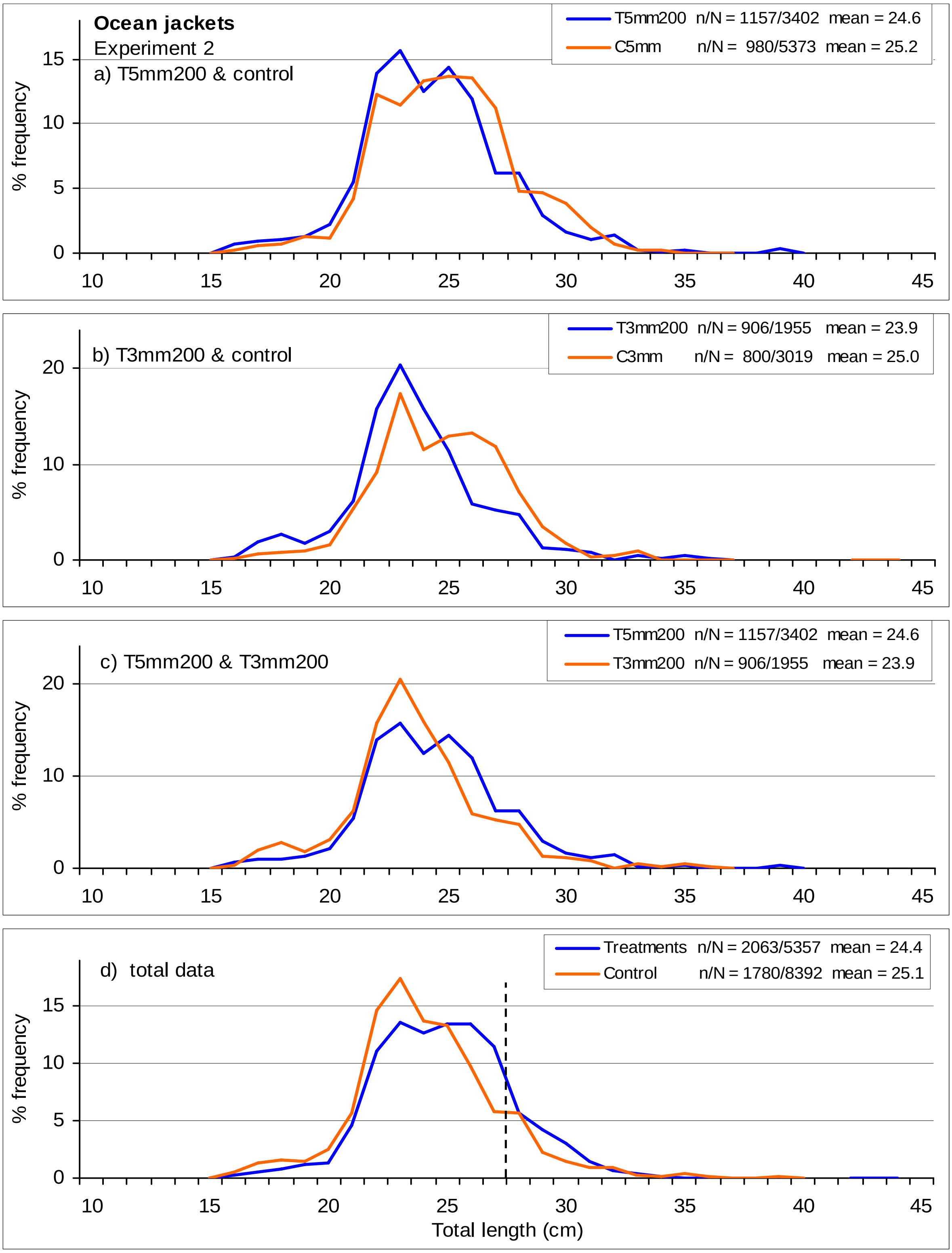

Figure 5.6. Length distributions of ocean jackets from the treatment codends and their alternated control during Experiment 2 (n = sample, N = total catch); the dotted line indicates approximate minimum marketable length (28 cm TL).

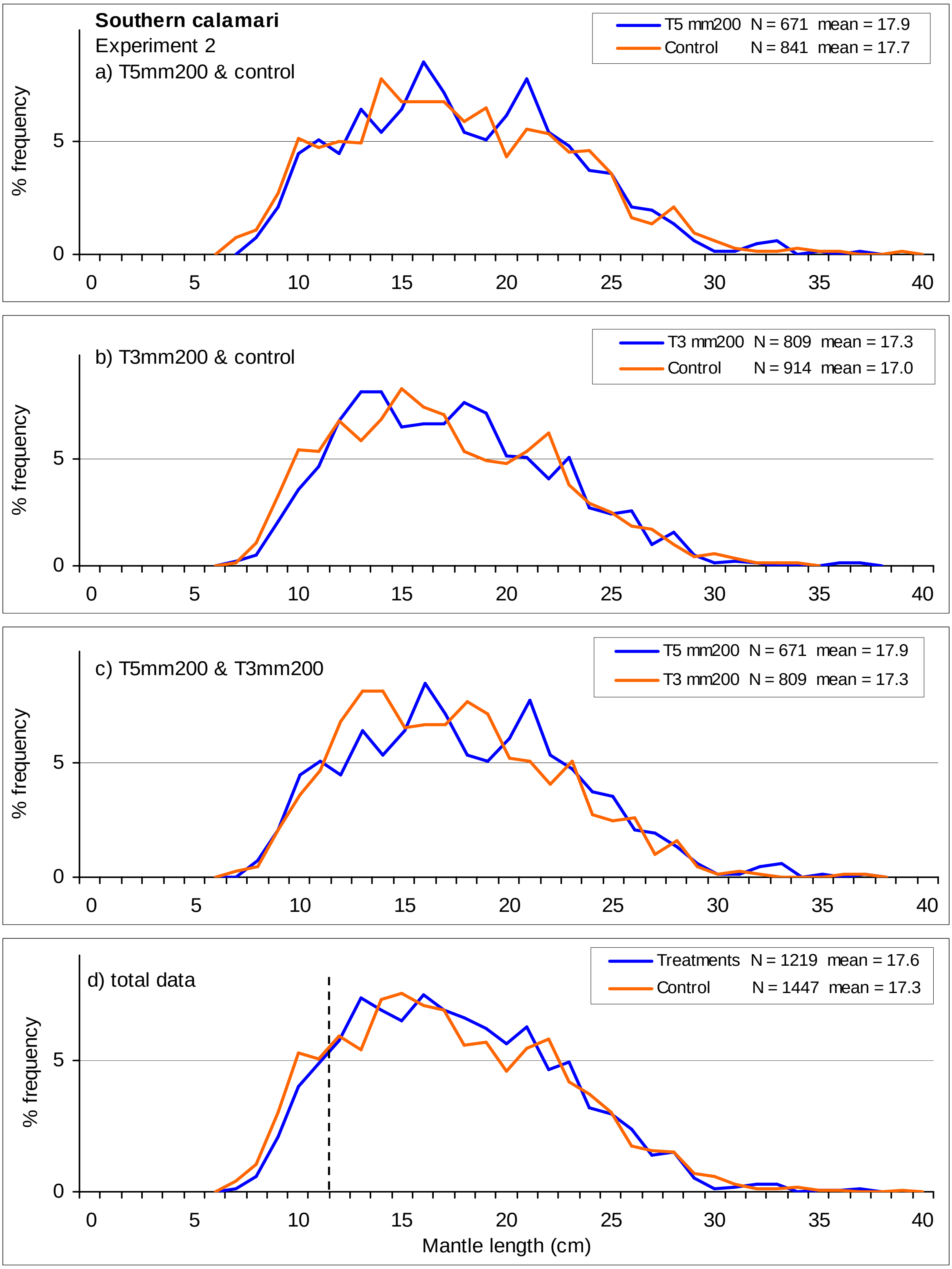

Figure 5.7. Length distributions of southern calamari from the treatment codends and their alternated control during Experiment 2 (N = total catch); the dotted line indicates approximate minimum marketable length (12 cm ML).

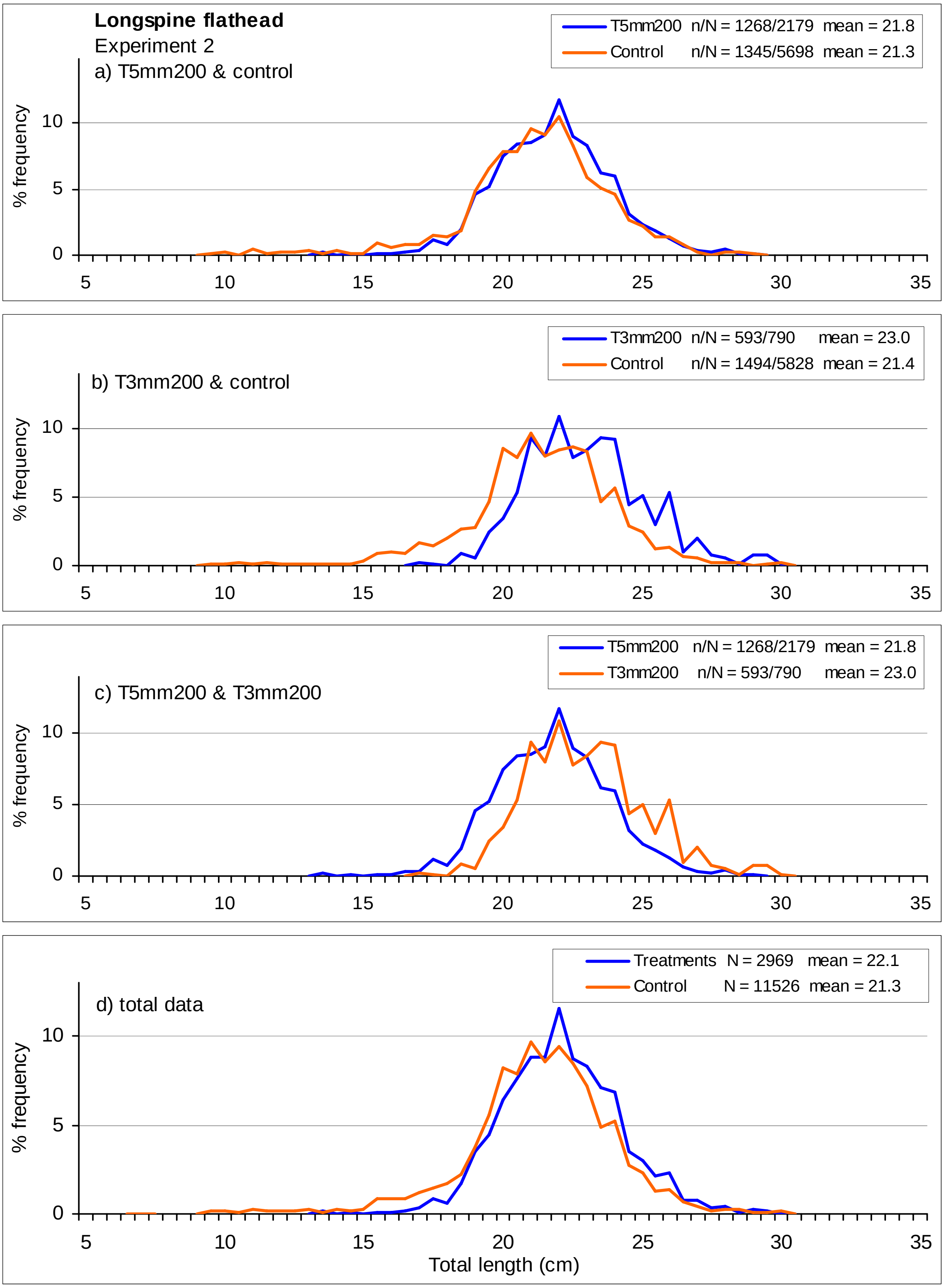

Figure 5.8. Length distributions of longspine flathead the treatment codends and their alternated control during Experiment 2 (n = sample, N = total catch).

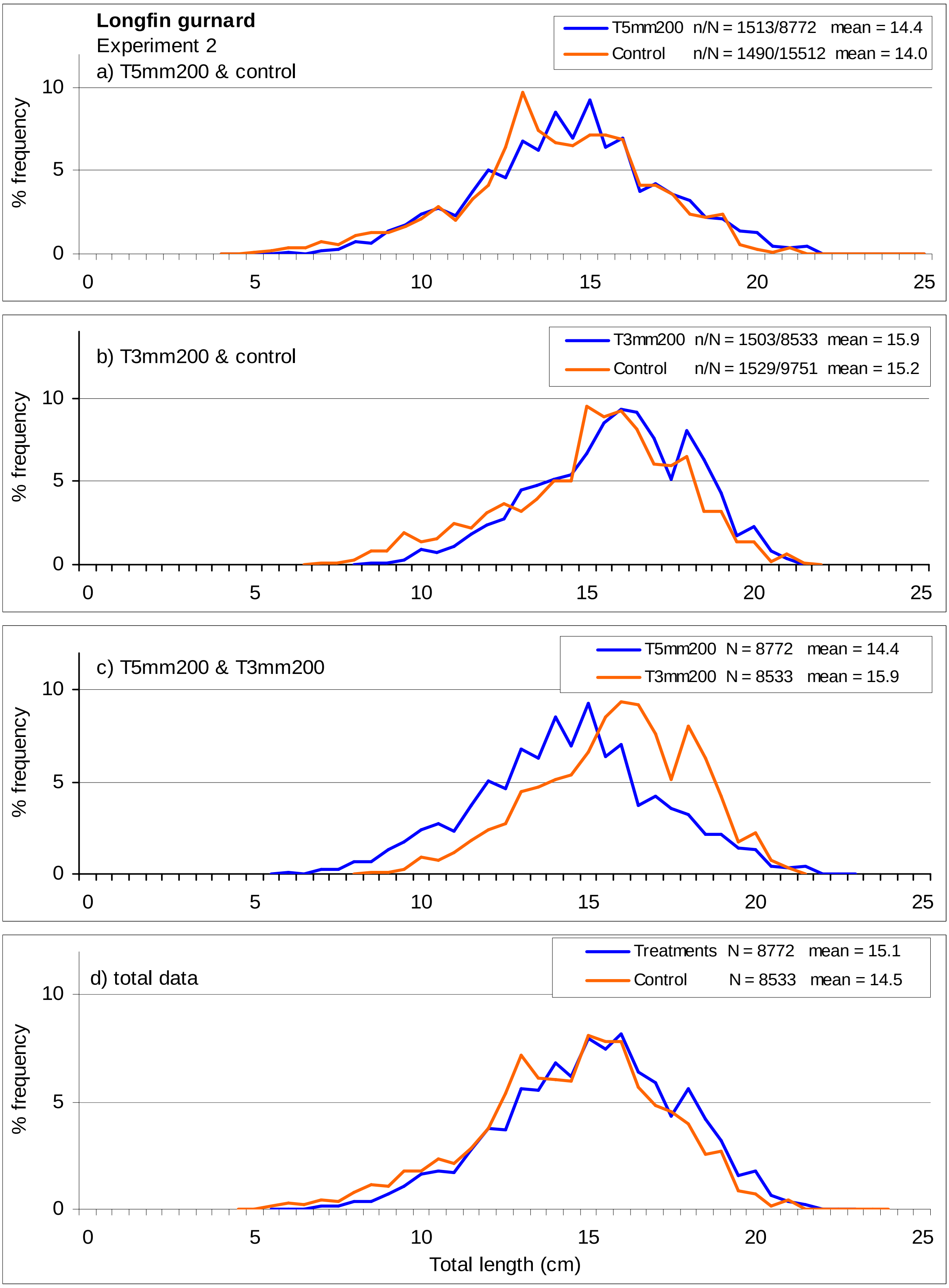

Figure 5.9. Length distributions of longfin gurnard from the treatment codends and their alternated control during Experiment 2 (n = sample, N = total catch).

6. SUMMARY OF SELECTIVITY ANALYSES

6.1. Method summary

The size frequencies of key species were combined across all tows with each of the treatment codends and their associated controls and, where there were sufficient data, logistic selection curves fitted. See Appendix 7 for details of methodology, analyses and results (including selection curves). An L_{50} selection size for tiger flathead was independently estimated from pooled data from the T4mm100 codend and its associated control.

6.2. Results

Table 6.1 summarises the size ranges, mean sizes and selectivity parameters for the nine species analysed, and Figures 6.1 – 6.9 show their length distributions with estimated L_{50} values (where calculated) indicated.

6.2.1. Experiment 1

The 50% probability of retention lengths (L_{50}) of 18.7 and 20.5 cm FL calculated for school whiting in the T4mm200 and T4mm200X codends were both appreciably larger than the minimum marketable length of ~15 cm; the L_{50} of 28.2 cm modelled for the T4mm100 codend was unrealistic as no whiting as large as this were caught (see Figure 6.1a). Despite the small number of blue-spotted flathead smaller than 33 cm (see Figure 6.2), a relatively precise L_{50} of 32.9 cm (selection range 2.4 cm) was generated for the T4mm200X codend whereas the data for the T4mm100 codend was more variable, resulting in an L_{50} of 35.0 cm with a large selection range (9.6) and high standard error (see Appendix 7). The L_{50} estimate for tiger flathead of 30.0 cm was less than the minimum legal length (MLL) of 32.5 cm FL (33.0 cm TL). Only very small redfish and southern calamari escaped from any of the treatment codends resulting in L_{50} values between 10.2 cm (T4mm200X) and 12.4 cm (T4mm200) for redfish (Figure 6.4), and 7.5 – 10.5 cm ML for calamari (Figure 6.5), all smaller than acceptable marketable size for both species. Selectivity curves could not be fitted to the red gurnard or ocean jacket data (Figures 6.6 & 6.7) and, of the two discard species, the L_{50}s for longfin gurnard (12.2 – 12.5 cm) were similar for all three codends while for longspine flathead, the L_{50} for the T4mm100 codend of 24.8 cm was 3.6 cm greater than for the T4mm200 codend (Figures 6.8 & 6.9).

6.2.2. Experiment 2

Selection curves were modelled for eight species but the fits for red gurnard, ocean jacket and bluespotted flathead did not indicate any selectivity (see Appendix 7). School whiting of all sizes escaped from the T3mm200 codend and the L_{50} of 19.0 cm FL was well above the minimum marketable size for whiting; in contrast, the T5mm200 codend retained most size classes of whiting with a resulting L_{50} of 12.2 cm. As in Experiment 1, only very small redfish and southern calamari escaped from the treatment codends. The redfish L_{50} of 9.2 cm for the T3mm200 codend was only 0.6 cm greater than the T5mm200 result, and both were much smaller than the preferred minimum marketing size of about 15 cm. Similarly, the L_{50} for southern calamari in both codends was around 8.0 cm and also well below an acceptable marketing size; however, the lack of small size classes in the data resulted in relatively imprecise L_{50} values for calamari (as indicated by the high standard errors around the selection ranges: see Appendix 7). The results for longspine flathead and longfin gurnard were consistent for the two codends in that the 50% selection sizes for both species from the T3mm200 codend (24.5 & 10.9 cm) were substantially greater than the T5mm200 L_{50} values of 21.8 and 8.5 cm.

6.3. Discussion

The treatment codends of differing circumferences and twine diameters were expected to show selectivity differences for species such as school whiting and the various flatheads. However, in the case of bluespotted flathead, there were too few small size classes in the catches to give definitive selectivity estimates (see Figure 6.2), while for tiger and marble flatheads, there were insufficient data to develop selectivity models. For species such as red gurnard and ocean jacket, their shape and size prevented any escape from the T3mm200 or T5mm200 treatment codends and selectivity parameters could not be determined.

The selectivity analyses confirmed that the codend used by industry (T5mm200) was the least selective and, conversely, the most effective at retaining school whiting. Most sizes of school whiting escaped through the 90-mm mesh of the treatment codends but the T5mm200 codend was the only one to select for whiting at sizes below the minimum market size of about 15 cm. The results suggest that if the industry-preferred codends were fished on grounds where juveniles were abundant, discard rates of school whiting would be relatively high. FRV *Kapala* prawn-trawl survey data from the Newcastle-Port Stephens inshore king prawn grounds (i.e.,< 80 m depth) showed a high proportion of school whiting smaller than 15 cm FL present in some depth strata (Graham *et al.* 1993a, b, 1997). However, the size composition of whiting caught by *Kapala* with a fish trawl fitted with a 42 mm-mesh codend liner (similar to the control trawl in these experiments) on grounds south of Newcastle was consistent with the size of whiting taken in this study, in that few were below 15 cm FL (Graham *et al.* 1995, 1996). It is possible that some small whiting escape through the large meshes in front of the extension and codend sections of fish trawls. However, size distributions of school whiting caught off Broken Bay in 1991 with prawn nets also contained few small fish (unpublished *Kapala* data) indicating that whiting on the grounds south of Newcastle, where there is relatively little prawn-trawling activity, are predominantly of a marketable size (i.e., > 15 cm).

The lack of small (< 30 cm) size classes for bluespotted flathead, and the sporadic nature of the data for tiger flathead, resulted in L_{50} retention estimates for only two of the codends, and those estimates may not be very reliable. While 50% selection values were calculated for bluespotted flathead in the T4mm200X and T4mm100 codends, and for tiger flathead in T4mm100, the L_{50}s for the similarly-shaped longspine flathead in the T4mm200 (same codend as the T4mm200X) and T4mm100 codends were substantially smaller. The 15 – 30 cm TL size range of longspine flathead was well represented in most length classes (Figure 6.9) and gave selectivity values that were consistent with the tiger flathead L_{50} estimate of 23.4 cm TL for a 100-mesh circumference codend made from double 4-mm diameter twine, tested at Bermagui in 1999 (unpublished FRDC study). This suggests that if there had been greater numbers of smaller bluespotted and tiger flathead in the catches, the L_{50} estimates would have been substantially smaller. The Bermagui study also estimated an L_{50} of 13.1 cm FL for redfish, a value larger than the 10.5 cm FL for the equivalent codend (T4mm100) here, but similarly well below marketable size for the species.

The results demonstrated that the only benefit to fish trawlers from the use of the heavy 5-mm 200-mesh codends was the retention of school whiting, as mean catches of all other commercial species (apart from the relatively small numbers of southern octopus) were not significantly different to the other 90-mm treatment codends. These findings reinforce the argument that 100-mesh circumference codends of lighter and/or larger mesh are required for greater selectivity of almost all other species in the fishery – particularly for redfish and trevally, as canvassed in the Fishery Management Strategy for the Ocean Trawl Fishery (DPI 2007). In addition, the selectivity data showed that whiting of all sizes escaped from all the 90-mm codends, including the heavy

T5mm200 codend. This suggests that, although the T5mm200 codend retains commercial catch-rates of school whiting while still complying with fishery regulations for fish trawls, it may not the most appropriate trawl arrangement for the efficient harvesting of school whiting. Previous studies by NSW DPI (see Broadhurst *et al.* 2005, 2006b) have shown that codends made from between 35 and 40-mm mesh hung square selects school whiting at L_{50}s between ~14 and 18 cm TL. The development of such trawl gear with codend selectivity characteristics specific to school whiting would provide a better way of efficiently and optimally harvesting school whiting. However, any introduction of small-meshed codends for whiting could not be universal but would require complementary spatial, temporal and other appropriate management controls. It can also be argued that the inherent inefficiencies of the currently used 90-mm mesh codends result in less fishing pressure on the school whiting stocks than would the adoption of a specifically-designed square-mesh codend, albeit with better selectivity characteristics.

6.4. Summary

- The 100-mesh circumference codend (T4mm100) was more selective than the 200-mesh codends (T4mm200 & T4mm200X) with L_{50} selection values for school whiting, bluespotted flathead, longspine flathead and southern calamari in the T4mm100 codend greater than for either of the 200-mesh codends.

- The thinner-twined T3mm200 codend was more selective than the thick-twined T5mm200 with the L_{50} selection sizes for school whiting, longspine flathead, redfish, longfin gurnard and southern calamari from the T3mm200 codend greater than for the T5mm200.

- School whiting was the only commercial species that was significantly impacted by the heavier codends with the greatest mean catch rates in the 200-mesh, 4-mm and 5-mm twine diameter codends.

- The L_{50} selection size for school whiting in the T5mm200 codend was 12.2 cm, well below the whiting minimum market size of 15 cm; however, whiting smaller than 15 cm were less than 2% of the catch weight and number.

- In all codends, the L_{50} selection values for redfish and southern calamari were at sizes well below their minimum marketable sizes of ~15 cm FL and ~12 cm ML respectively; for red gurnard and ocean jackets, all codends were non-selective for the sizes caught.

- Because only large bluespotted flathead were caught, and catches of tiger flathead were relatively low, estimated selectivity parameters for flatheads were not reliable; however, L_{50} selection sizes for the smaller but similarly shaped longspine flathead were between 17 and 25 cm TL, much smaller than the MLL of 33 cm for commercial flatheads.

- Overall, most of the generated selection values were consistent with selectivity decreasing with increased codend circumference and/or twine diameter. It was clear that the T5mm200 codend (favoured by industry) was the least selective, generating the highest catch rates of whiting, and lowest L_{50} estimates for all species with sufficient data.

Table 6.1. Size ranges, mean sizes and L_{50} retention sizes (s.e.) for key species in each of the treatment codends; ns: non-selective for sizes caught; for commercial species, MLL: minimum legal length, MML: approximate minimum marketable length.

Species	Treatment	Size range (cm)		Mean size (cm)			MLL/
		Treat.	Control	Treat.	Control	L_{50} cm	MML* (cm)
School whiting	T4mm100	10.0-26.5	10.5-27.0	19.1	18.4	28.2 (1.0)	15.0*
	T4mm200	9.0-24.0	12.5-25.5	18.5	17.9	18.7 (3.3)	
	T4mm200X	10.0-25.0	11.0-26.0	19.3	17.9	20.5 (0.2)	
	T3mm200	12.0-25.0	13.5-27.5	19.8	18.9	19.0 (0.6)	
	T5mm200	11.0-27.0	7.0-27.0	19.1	18.8	12.2 (1.5)	
Bluespotted flathead	T4mm100	31.0-63.0	30.0-63.0	42.9	42.0	35.0 (2.2)	32.5
	T4mm200	28.0-60.0	28.0-61.0	42.2	42.5	ns	
	T4mm200X	27.0-64.0	29.0-60.0	42.4	41.5	32.9 (0.7)	
	T3mm200	33.0-61.0	32.5-67.0	43.0	42.9	ns	
	T5mm200	32.0-56.0	32.0-62.0	41.8	43.2	ns	
Tiger flathead	T4mm100	20.0-49.0	16.0-48.0	32.8	29.1	30.0 (1.8)	32.5
	T4mm200	22.5-48.5	16.0-42.0	31.2	28.2	-	
	T4mm200X	14.5-46.5	20.5-48.5	30.4	29.7	-	
	T3mm200	26.5-48.0	23.0-45.0	34.9	33.0	-	
	T5mm200	22.5-52.0	16.0-54.0	32.4	32.9	-	
Longspine flathead	T4mm100	7.5-32.5	13.0-31.0	22.6	20.9	24.8 (2.3)	-
	T4mm200	12.0-32.5	16.0-29.0	22.4	21.0	21.2 (0.6)	
	T4mm200X	9.0-32.5	13.5-30.0	22.5	20.6	-	
	T3mm200	9.5-30.0	17.0-30.0	23.0	21.4	24.5 (1.2)	
	T5mm200	9.5-29.0	13.5-29.0	21.8	21.3	17.5 (0.4)	
Redfish	T4mm100	4.0-19.5	6.0-21.0	13.7	11.9	10.5 (0.5)	15.0*
	T4mm200	5.5-22.5	6.5-22.0	13.4	11.8	12.4 (0.8)	
	T4mm200X	6.0-18.5	6.0-23.0	13.6	12.0	10.2 (0.4)	
	T3mm200	4.5-21.0	9.0-21.0	12.9	12.0	9.2 (0.4)	
	T5mm200	5.0-20.0	4.0-20.0	13.1	12.3	8.6 (1.2)	
Red gurnard	T4mm100	19.5-47.0	21.0-47.0	25.3	27.2	-	25.0*
	T4mm200	18.0-48.0	21.0-46.0	26.1	27.1	-	
	T4mm200X	19.0-44.5	20.0-46.0	25.5	27.5	-	
	T3mm200	19.0-47.0	18.0-49.0	23.8	25.0	ns	
	T5mm200	20.0-43.0	19.5-44.0	25.8	24.1	ns	
Longfin gurnard	T4mm100	4.0-22.0	8.0-22.0	15.7	14.9	12.4 (0.8)	-
	T4mm200	6.0-21.0	7.5-22.5	15.3	14.6	12.2 (0.3)	
	T4mm200X	5.5-21.0	8.0-22.5	15.4	14.6	12.5 (0.2)	
	T3mm200	7.0-21.5	8.5-21.0	15.9	15.2	10.9 (0.4)	
	T5mm200	5.0-22.0	6.0-22.5	14.4	14.0	7.7 (0.8)	
Ocean jacket	T4mm100	14.0-35.5	14.0-36.0	20.6	20.9	-	28.0*
	T4mm200	12.5-41.0	13.0-43.0	23.4	21.3	-	
	T4mm200X	13.0-37.5	13.5-34.5	23.4	21.2	-	
	T3mm200	16.0-36.5	16.0-43.0	23.9	25.0	ns	
	T5mm200	16.0-39.0	16.5-36.5	24.6	25.2	ns	
Southern calamari	T4mm100	4.5-33.0	7.0-33.0	17.7	14.7	10.5 (0.5)	12.0*
	T4mm200	4.5-39.0	7.0-34.5	16.4	16.1	7.9 (0.5)	
	T4mm200X	6.0-36.0	7.5-32.0	17.7	16.7	7.5 (0.0)	
	T3mm200	7.0-34.0	7.0-37.0	17.3	17.0	7.7 (1.7)	
	T5mm200	7.0-39.0	8.0-37.0	17.9	17.7	8.5 (0.6)	

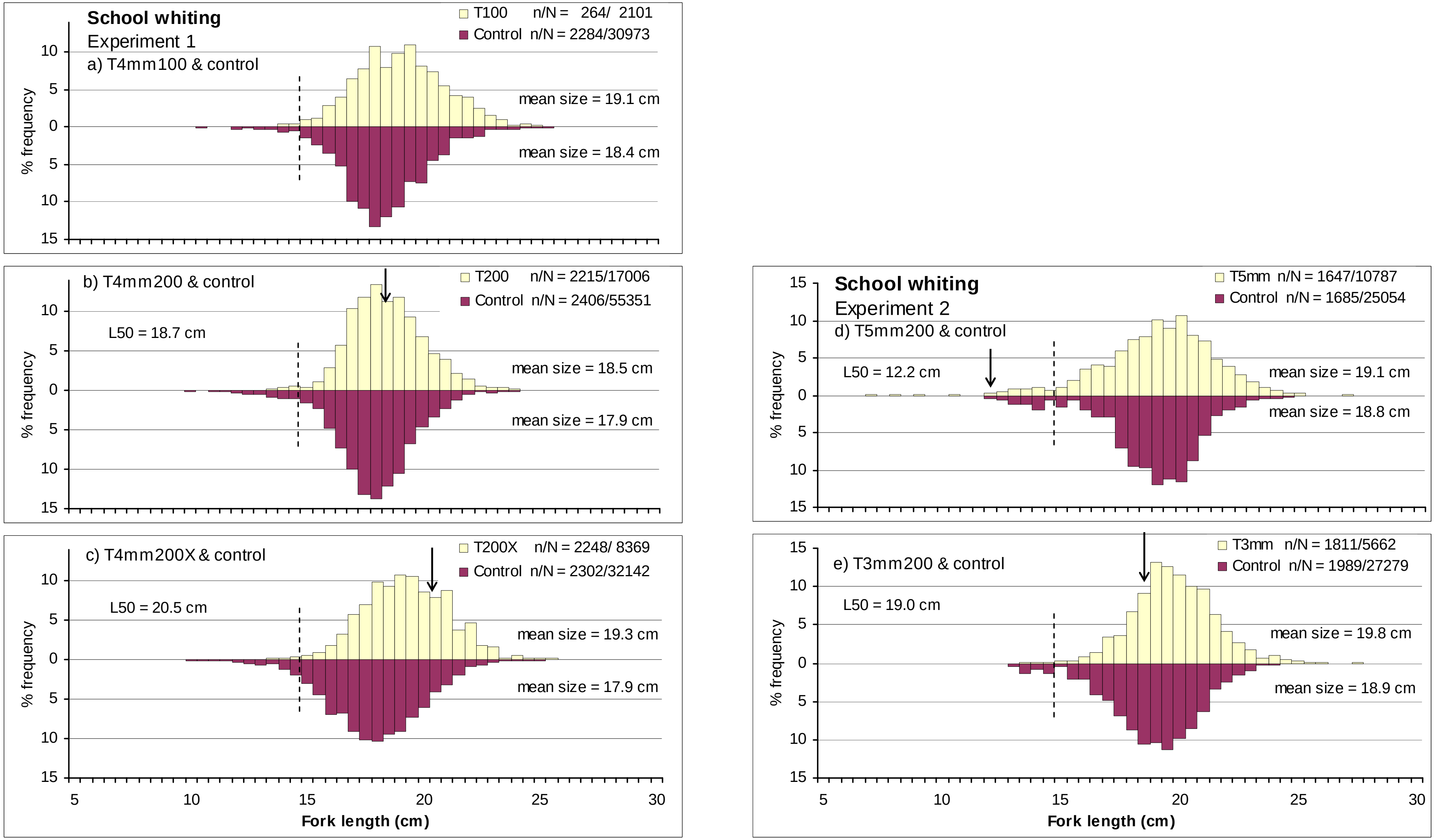

Figure 6.1. Comparative length distributions of school whiting from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e) showing estimated L_{50} selection values (arrow); dotted line is approximate minimum marketable length (15 cm FL).

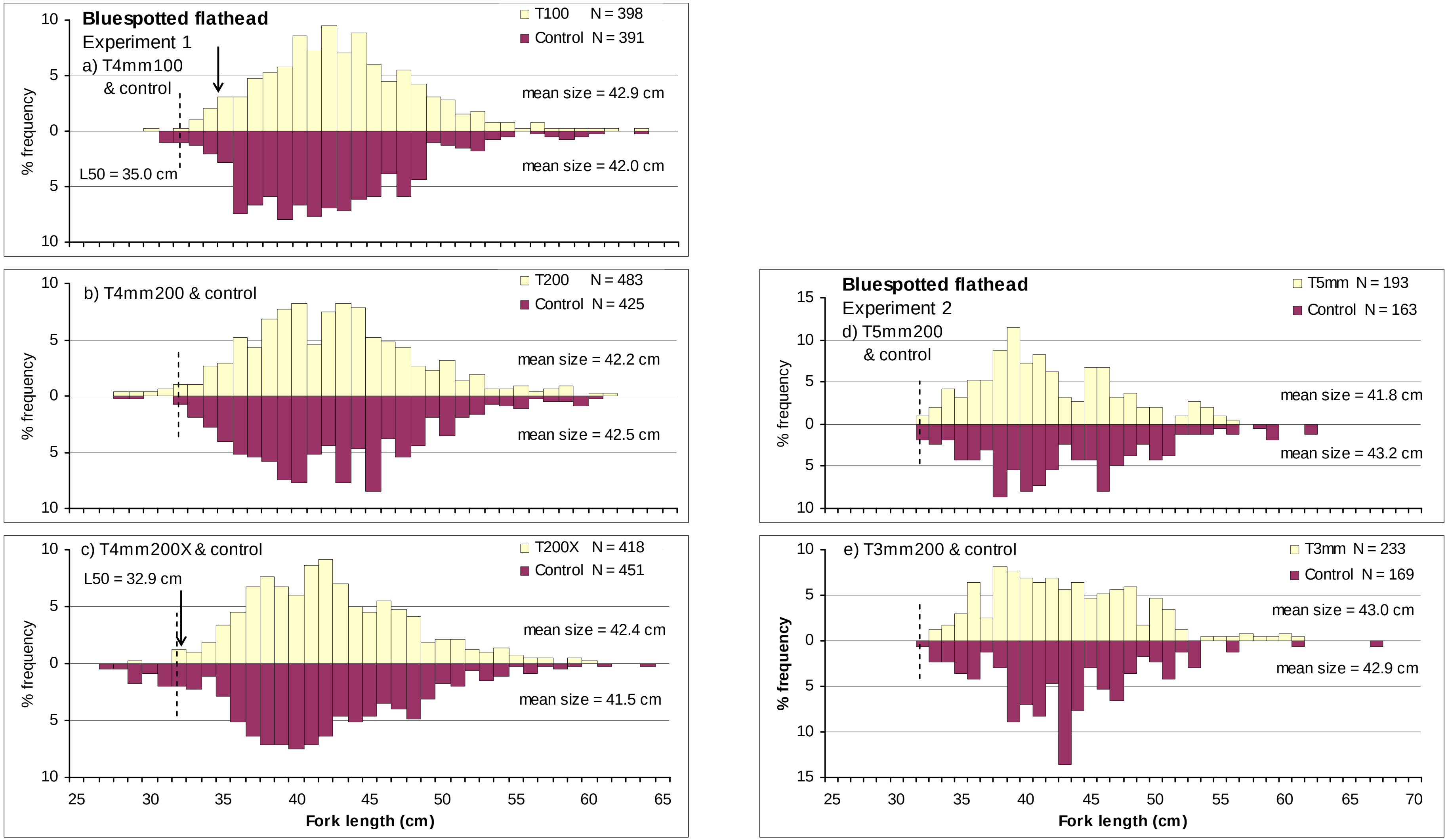

Figure 6.2. Comparative length distributions of bluespotted flathead from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e) showing estimated L_{50} selection values (arrow) for T4mm200X and T4mm100 codends; no selectivity occurred in the other codends; dotted line is minimum legal length (32.5 cm FL).

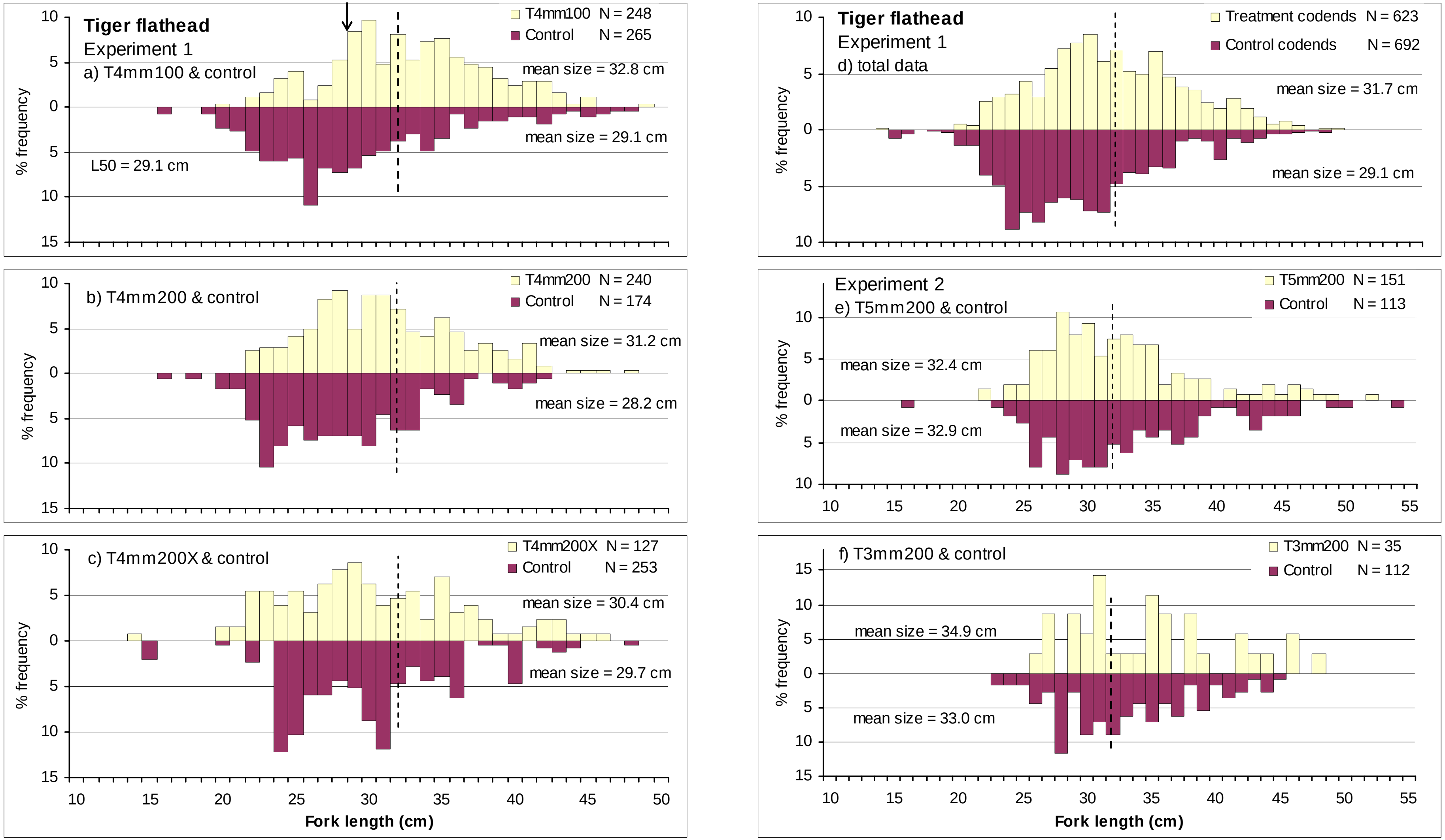

Figure 6.3. Comparative length distributions of tiger flathead from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e); estimated L_{50} selection value (arrow) for the T4mm100 codend derived from few data; dotted line is minimum legal length (32.5 cm FL).

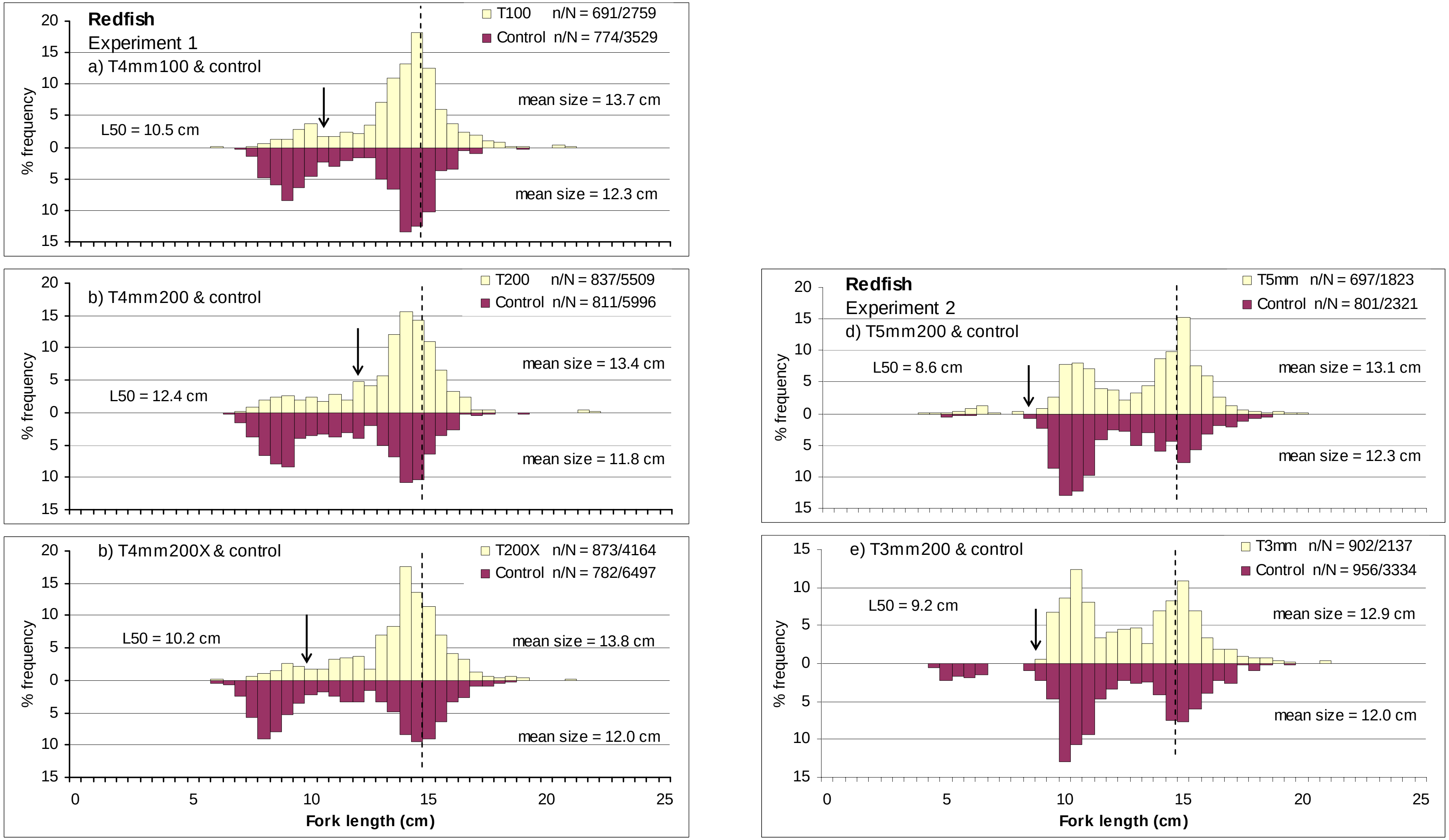

Figure 6.4. Comparative length distributions of redfish from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e) showing estimated L_{50} selection values (arrow); dotted line is approximate minimum market length (15 cm FL).

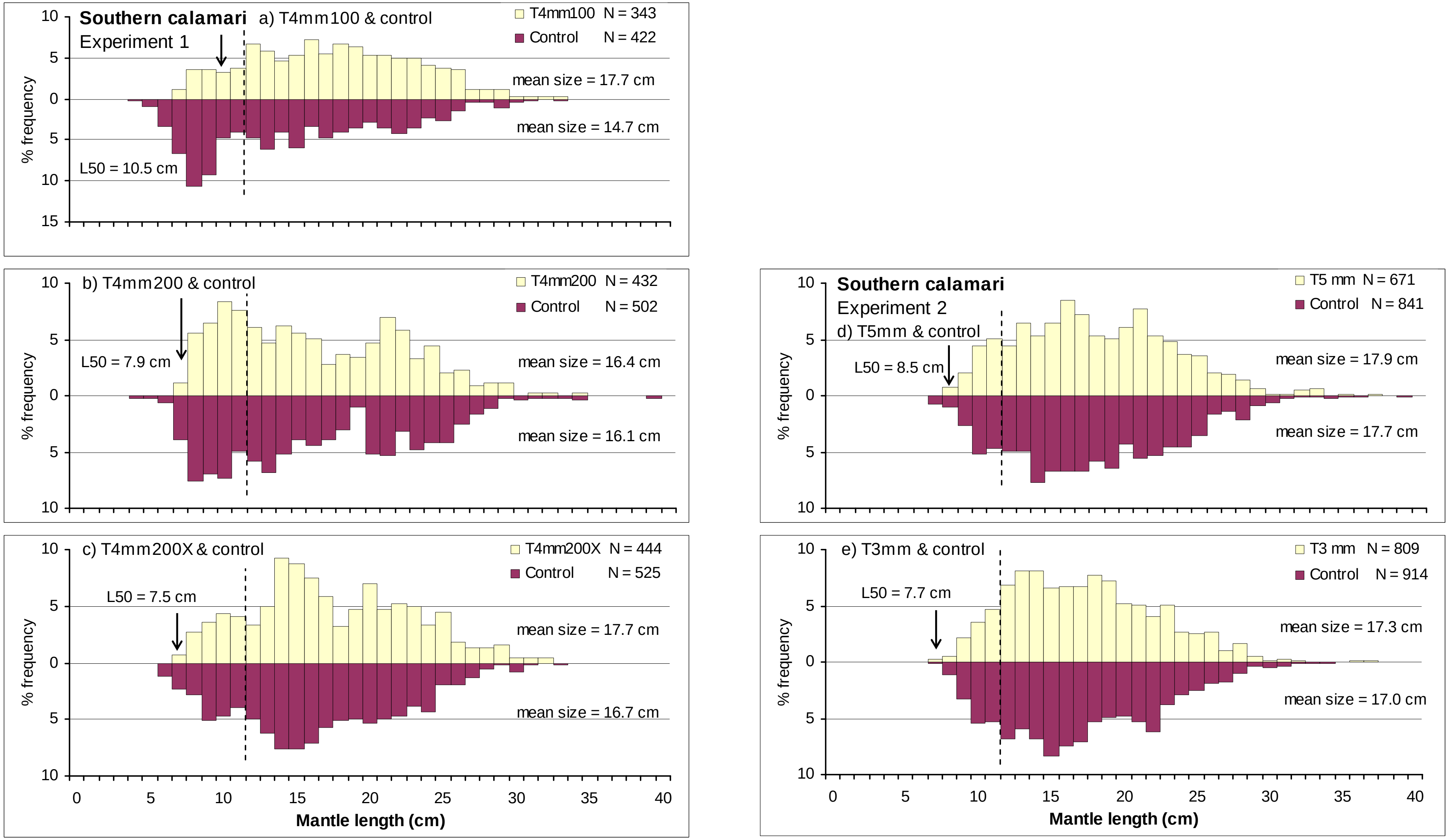

Figure 6.5. Comparative length distributions of southern calamari from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e) showing estimated L_{50} selection values (arrow); dotted line is approximate minimum market length (12 cm ML).

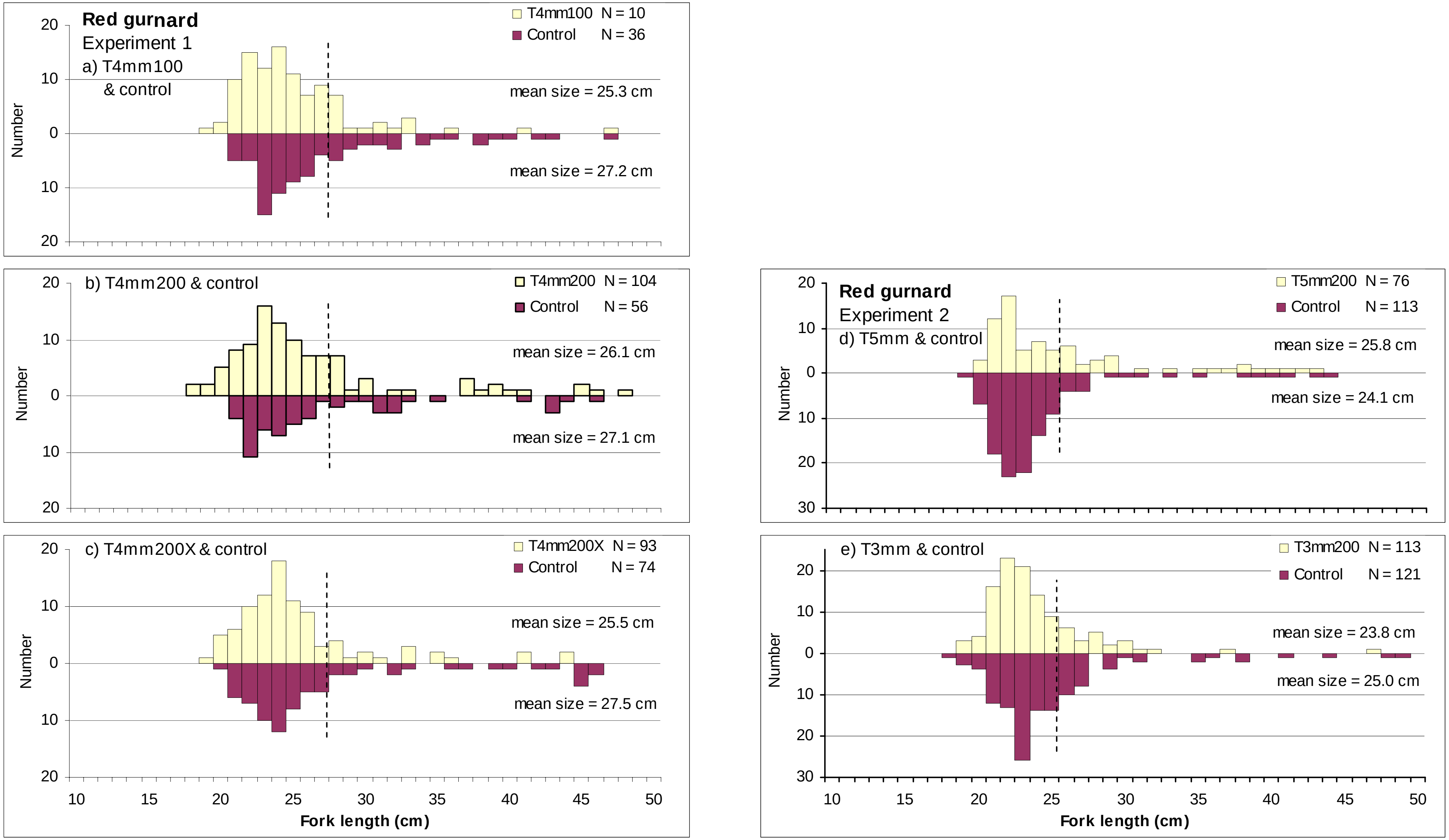

Figure 6.6. Comparative length distributions of red gurnard from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e); no selectivity occurred for red gurnard in any codend; dotted line is approximate minimum market length (28 cm FL).

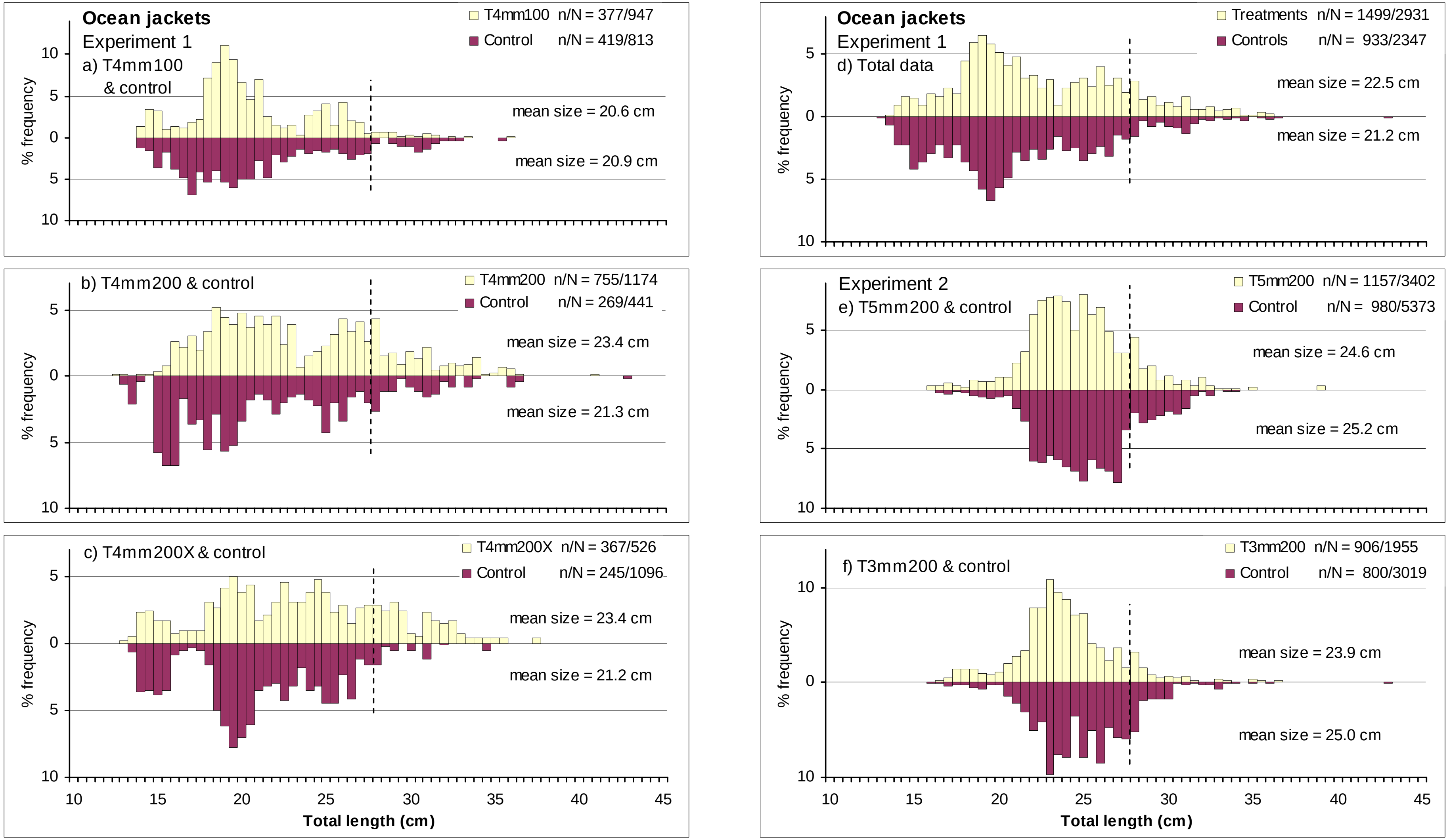

Figure 6.7. Comparative length distributions of ocean jackets from treatment and control codends in Experiment 1 (a-d) & Experiment 2 (e-f); no selectivity occurred for ocean jackets in any codend; dotted line is approximate minimum market length (28 cm TL).

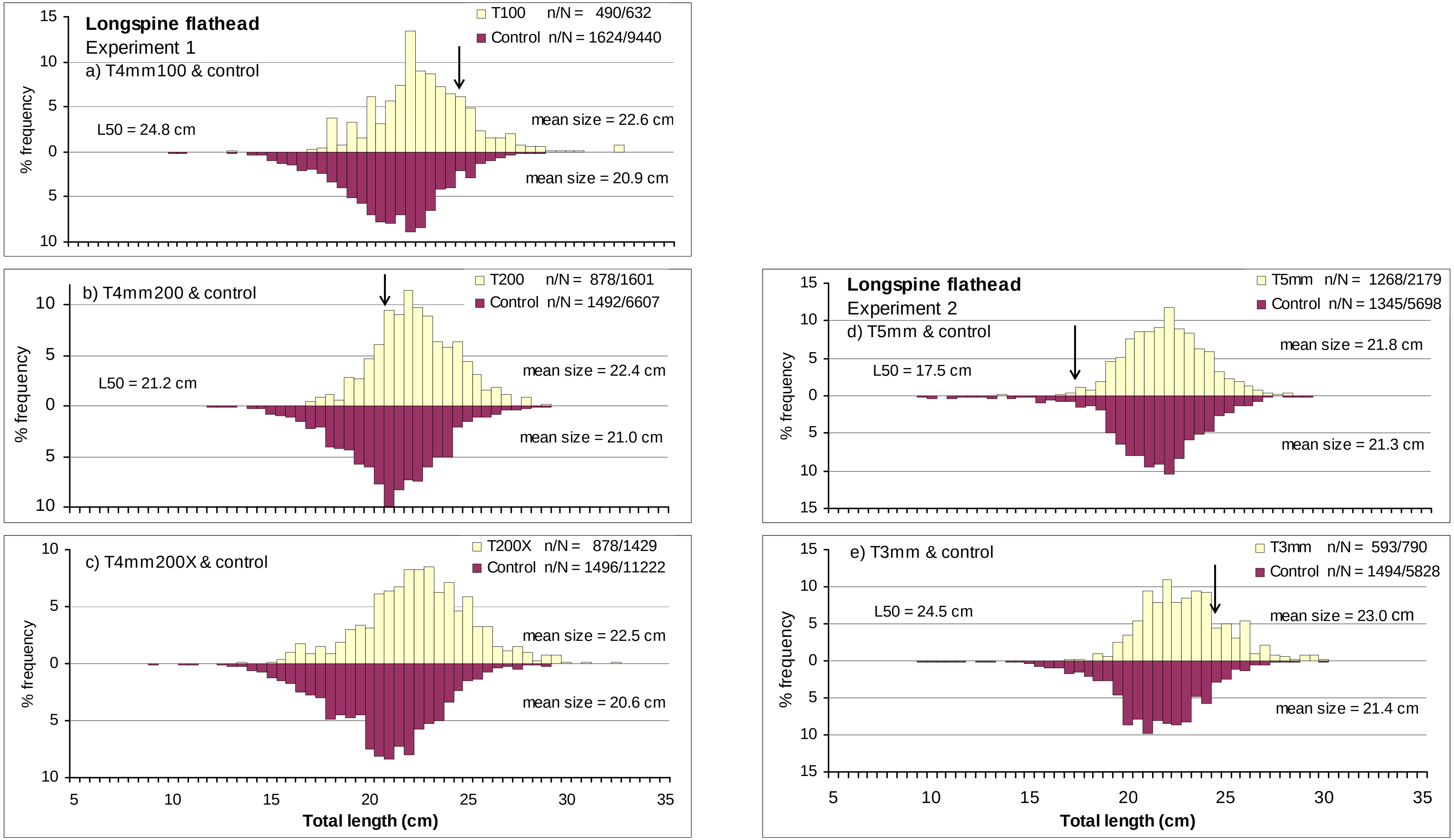

Figure 6.8. Comparative length distributions of longspine flathead from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e) showing estimated L_{50} selection values (arrow).

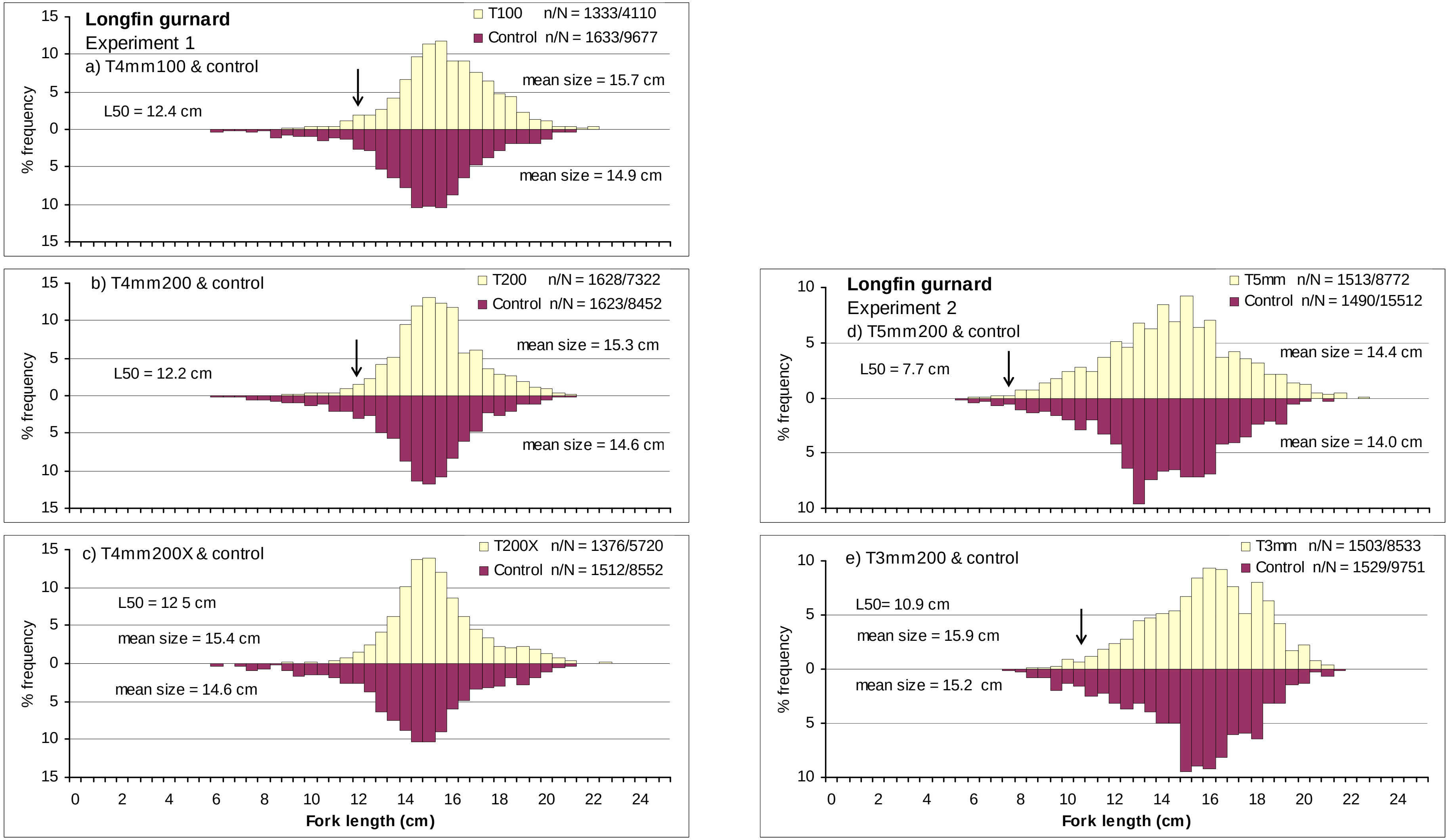

Figure 6.9. Comparative length distributions of longfin gurnard from treatment and control codends in Experiment 1 (a-c) & Experiment 2 (d-e) showing estimated L_{50} selection values (arrow).

7. COMPARISON OF CATCHES FROM DEPTHS LESS AND GREATER THAN 55 M

7.1. Method summary

During 2005, 20 tows with each of the 200-mesh circumference 90-mm mesh treatment codends (T4mm200 and T4mm200X) and 20 with the 40-mm mesh control codend (when alternated with the treatments) were done in depths shallower than 55 m, while in depths between 55 and 85 m, 10 tows with the same two treatment codends and 9 with the control were completed. Data from the 90-mm and 40-mm codends were each were pooled and mean catch rates (weight and numbers) for the main species, species groups and totals calculated for each of the two depth zones. Length data for the main species are also presented for the two depths and, where appropriate, for the 90-mm and 40-mm codends in each depth.

7.2. Results

7.2.1. Catches

Total-catches in the shallow depths averaged 219 and 396 kg/tow in the 90-mm (treatment) and 40-mm (control) codends respectively, compared to 263 and 389 kg/tow in the deeper water. Across all codends in both depths, retained-catch (by weight and number) was 49 – 64% of the total catches (Tables 7.1 – 7.4; Figure 7.1a, b). In the shallow depths, the mean catch-weight of retained school whiting in the 90-mm codend was more than double, and the 40-mm codend catch more than 30% greater, than the respective catches in depths over 55 m (Figures 7.1c, 7.2). The total numbers of school whiting (‘retained’ plus ‘discarded’) taken in the control codends were, however, almost identical for both depths (Figure 7.3) indicating that the difference in catch weight was because of their smaller mean size in the deeper tows (see below). Few marketable redfish were caught in the shallow tows by either codend (< 1 kg/tow) whereas the mean catch of retained-redfish in the deeper tows was 27 – 37 kg/tow (Figure 7.2). The 90-mm trawls in the shallow depths caught a significantly greater number and weight of retained flathead but, for both codends, average retained-catch weights and numbers of elasmobranchs (sharks and rays), cephalopods, and total retained-catch from the two depths were not significantly different (Table 7.5; Figure 7.2).

Mean total-weights of commercial-discards from the 90-mm and 40-mm codends in depths over 55 m were 56 and 76 kg/tow compared to 23 kg/tow in both codends in the shallow depths. The main components of commercial-discards from the shallow tows were redfish (3 – 6 kg/tow) and yellowtail scad (5 – 9 kg/tow). Redfish (33 kg/tow) was also the main discarded commercial fish in the deeper catches, contributing 60% of the total commercial-discard weight and 76% of numbers from the 90-mm codends (Figures 7.1e, 7.1f). Trawls with the 90-mm codend in both depth ranges caught negligible quantities (< 1% of total catch) of discarded whiting and flathead although the smaller size-composition of whiting from the deeper tows resulted in almost 13 kg/tow being discarded from the 40-mm codend (Figure 7.2). Overall, mean total commercial-discard weights and numbers were 6 – 13% of total catch in the shallow tows, significantly less than the 19 – 39% of total-catch in tows deeper than 55 m (Table 7.5).

In depths less than 55 m, non-commercial discards in the 90-mm (65 kg/tow) and 40-mm (122 kg/tow) codends were both approximately 30% of total-catch weight. In comparison, mean non-commercial discards taken deeper than 55 m were 60 kg/tow (90-mm codend) and 85 kg/tow (40-mm codend), each around 22% of total-catch. There were significant differences in the mean catches

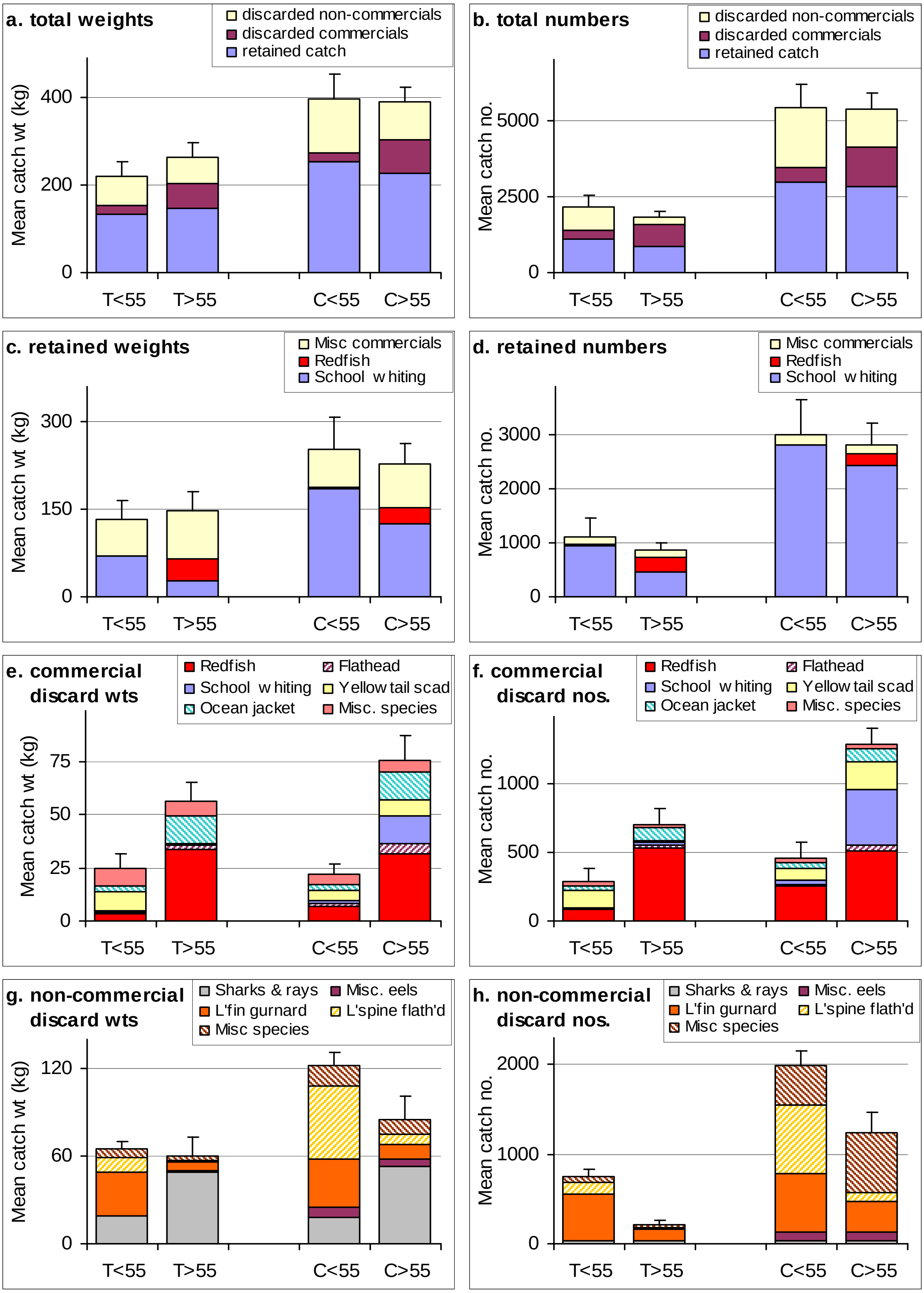

Figure 7.1. Mean catch rates (no. or kg / 90 min. tow, + 1 s.e. for total catch) of main species or species groups taken in depths less (<) or greater (>) than 55 m (30 fathoms) in the 90-mm (T) and 40-mm (C) codends during 2005.

between the two depths for longfin gurnard and longspine flathead, and for overall non-commercial catch numbers (Table 7.5). In the shallow depths, 61 – 68% of the non-commercial weights consisted of longfin gurnard and longspine flathead, and 15 – 30% of elasmobranchs. In contrast, the non-commercial discard component in the deeper tows was dominated by elasmobranchs, principally large Port Jackson sharks, which made up 82% of the discard weight in the 90-mm codend and 62% in the 40-mm codend. The mean catch rates of longfin gurnard and longspine flathead in depths less than 55 m were respectively about three and eight times greater than those recorded from the deeper tows.

7.2.2. Length-frequency data

School whiting size data from catches in the 90-mm and the 40-mm codends were each pooled and compared for the two depths; all length distributions showed that whiting from depths less than 55 m were, on average, significantly larger ($p < 0.01$) than those from deeper water (Figure 7.4). Mean sizes in the 40-mm codend were 18.4 cm in shallow depths and around 17.0 cm from deeper than 55 m compared to 19.0 cm and 18.1 cm in the 90-mm codend.

In contrast, bluespotted flathead (codends combined) were significantly larger ($p < 0.01$) in the deeper tows (mean 44.0 cm) than in the shallower depths (mean 41.5 cm); few undersize (< 33 cm) bluespotted flathead were caught in either depth (Figure 7.5). The average size of tiger flathead from the two depths, however, was almost the same within each codend although there were differences between the codends (Figure 7.6). The mean sizes of tiger flathead for the two depths in the 90-mm codend (~31 cm) were significantly larger ($p < 0.01$) than those from the 40-mm codend (~29 cm), reflecting the greater selectivity of the larger-meshed codend. Small numbers of marble flathead, most less than 30 cm in length, were caught in both depth ranges (Figure 7.7).

The size distributions of redfish were clearly differentiated by depth with the shallow tows catching a predominance of fish smaller than 10 cm while redfish from depths greater than 55 m were mostly 12 – 17 cm in length (Figure 7.8). The ocean jacket size data was influenced by a few very large catches each with a dominant size class. Overall, about 80% of ocean jackets from depths shallower than 55 m were between 27 and 33 cm in length while more than 75% of those from the deeper tows were in the 17 – 22 cm size range (Figure 7.9). The mean sizes of southern calamari from the two depths were similar (~16 cm ML), although the size distributions were significantly different ($p < 0.01$) mainly because of a higher proportion of small (< 15 cm ML) calamari in the deeper catches (Figure 7.10).

7.3. Discussion

The preferred target depth for whiting by the Sydney trawlers is 40 – 55 m but greater depths are sometimes fished for a variety of reasons. Mainly during the autumn-winter months, there are periodic influxes of large masses of small ocean jackets onto the whiting ground making trawling untenable. There are also times when viable quantities of whiting are available in depths around 60 – 80 m during daylight hours. However, the OT FMS proposes to restrict use of any trawl-gear modified for the capture of school whiting to depths less than 55 m. The analyses presented here provide comparative information on the catch rates and compositions of trawls done shallower and deeper than 55 m and, although this component was not an initial objective of the study, there were sufficient tows in each depth zone to quantify any differences. Depths greater than 55 m were fished during May-August, primarily because of the presence of ocean jackets in the shallower depths, while trawling in depths less than 55 m occurred during March-May and August-October. Consequently, some of the differences found between the two depth ranges may have been seasonally influenced.

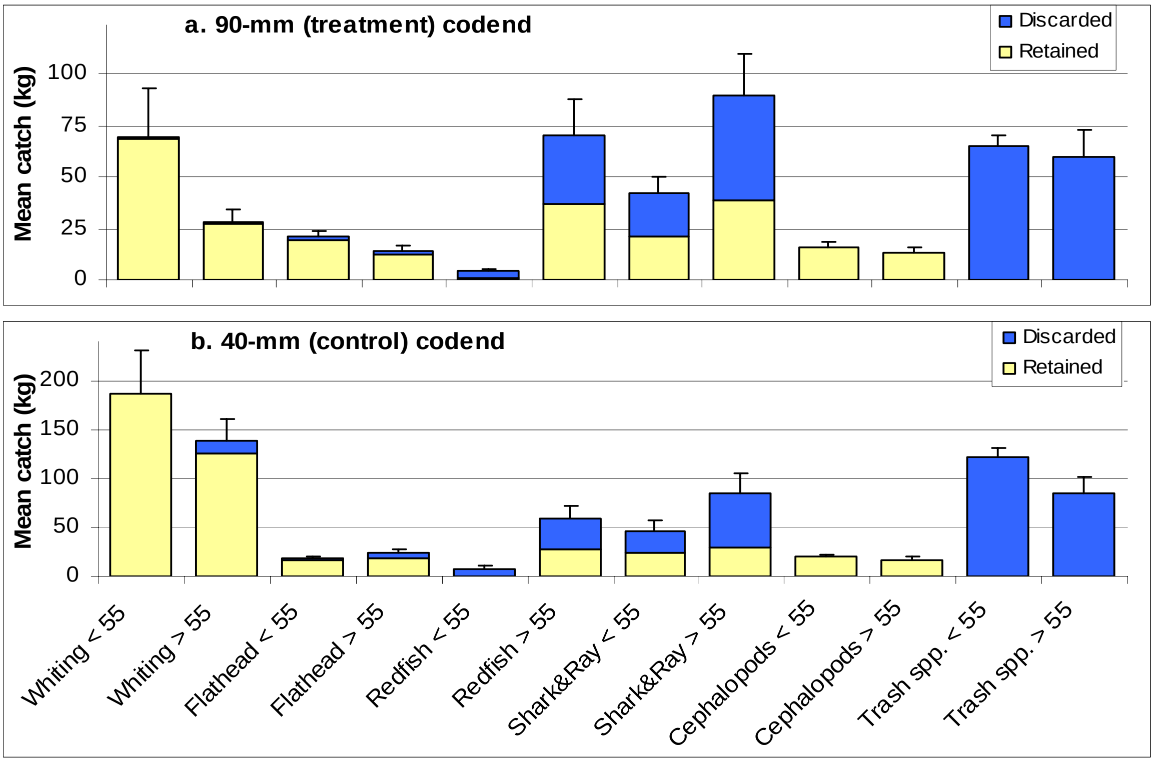

Figure 7.2. Summary of mean catch weights (kg/90 min. tow + 1 s.e. for total catch) of main species or species groups taken in depths less or greater than 55 m in (a) 90-mm and (b) 40-mm codends during 2005.

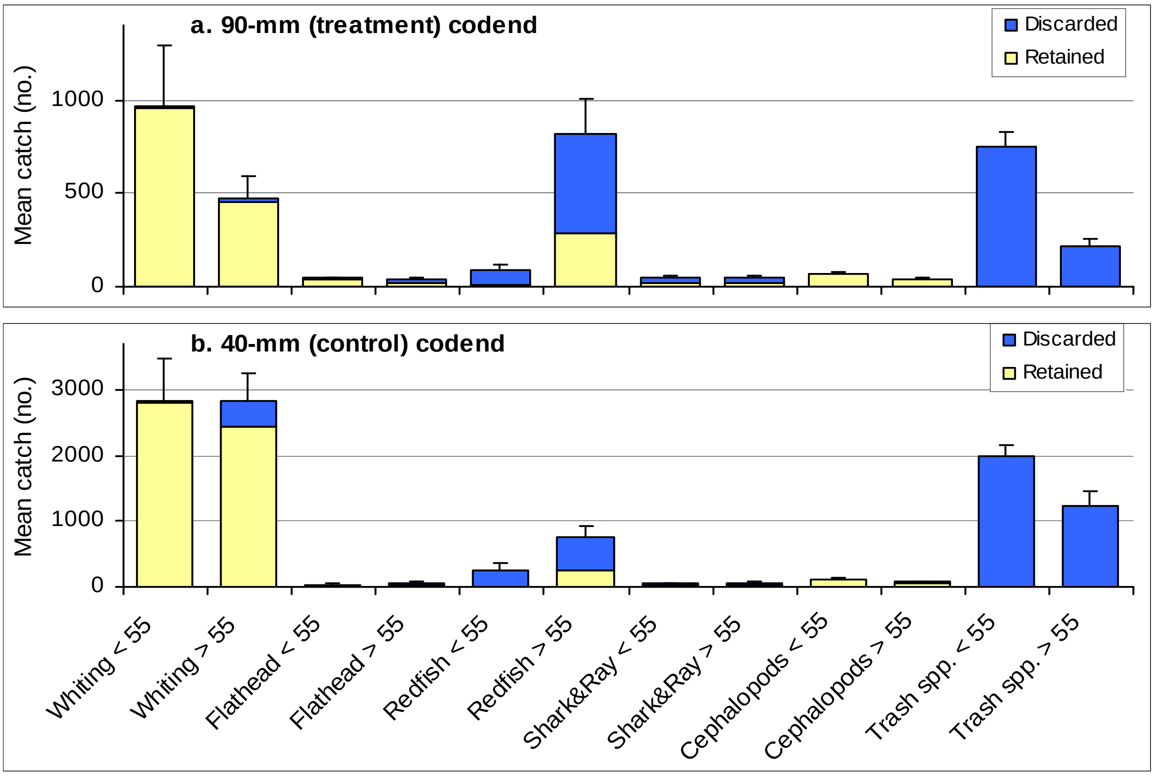

Figure 7.3. Summary of mean catch numbers (no./90 min tow + 1 s.e. for total catch) of main species or species groups taken in depths less or greater than 55 m in (a) 90-mm and (b) 40-mm codends during 2005.

To compare catch rates between the two depth zones, data from the 40-mm (control) codend (with its minimal selectivity characteristics) can be taken as a measure of available harvest on the grounds. The 90-mm (treatment) codend made from 4-mm diameter twine (T4mm200) was similar in size and construction to those normally used in the commercial fishery but, as shown by Experiments 1 and 2, has a lower retention rate of small fish and invertebrates compared to the 5-mm twine diameter commercial codends. In particular, the school whiting catch rate with a commercial codend is likely to be substantially greater than that taken by the T4mm200 codend. However, catch rates of other market species in the 90-mm codend are probably comparable to commercial-trawl catch rates.

In the 40-mm codend, school whiting was the major catch in both depths. The average whiting catch number (retained and discarded combined) was almost identical for each depth and comprised 52 – 53% of the total-catch number for all species. By weight, almost half (47%) of the total-catch in the shallow tows was whiting but this proportion was only about 36% of total-catch in depths over 55 m because of the smaller mean size of whiting and the presence of large elasmobranchs in the catch, both of which affected the whiting-weight to total-weight ratio. With similar numbers of school whiting available in each of the depth ranges, the substantially lower catches with the 90-mm codend (compared to the 40-mm codend catches) can be attributed to the larger codend mesh size. In depths less than 55 m, the whiting catch-rate in the treatment codend was 35% of the control mean catch (see Chapter 5) whereas, in depths greater than 55 m, the treatment whiting catch rate was only 20% of the control, reflecting the smaller size of the whiting and, because of their relatively small size, a greater ability to escape through the 90-mm codend mesh. This selectivity effect also resulted in a mean size almost 1.5 cm longer than the school whiting caught in the 40-mm codend. Discarded whiting contributed only about 2% by weight and 4% by number of the total whiting catch in the 90-mm codend compared to 9 – 14% of total whiting in the small-meshed codend (see Figure 7.2, 7.3). Although commercial codends constructed of 5-mm diameter twine would retain a higher proportion of small school whiting than was observed for the 4-mm twine 90-mm codend, it is likely that the quantities of unmarketable whiting (i.e., < 15 cm FL) in catches from depths over 55 m would be relatively small and somewhat less than was observed in the control codends.

The most obvious differences in the catches between the two depths were the greater abundance and larger mean size of redfish in the deeper tows. Redfish were a very small fraction (< 2%) of the catch weights in the shallow depths although relatively large numbers of very small fish (< 10 cm) were retained by the 40-mm codend during tows in September-October. This size class (1+ year old) was almost totally absent in the 90-mm codend in the shallow tows suggesting these small fish could escape through the 90-mm mesh. Very few redfish smaller than 10 cm were caught deeper than 55 m although the dominant size class in the deeper tows (12 – 17 cm; 2+ years) still comprised mostly unmarketably small fish with about 70% (by number) being discarded. The capture of larger redfish in the tows deeper than 55 m was consistent with the correlation between redfish size and capture depth previously modelled by Chen *et al.* (1997). This behaviour of redfish is contrary to what appears to be happening with school whiting which, despite the apparently greater fishing pressure in depths less than 55 m, were of a larger mean-size in the shallower depths. Past prawn-trawl surveys of inshore grounds off Newcastle by FRV *Kapala* recorded the majority of small (5 – 15 cm FL) school whiting in depths less than 20 m (e.g., Graham *et al.* 1993b) and it is possible that the larger mature whiting concentrate in the shallower (30 – 60 m) depths for spawning with most juveniles initially inhabiting waters even closer inshore.

The occurrence of tiger flathead on the school whiting ground appeared to be seasonal with most being caught during winter (July-September). Although their size distributions were similar across both depth ranges, over 70% of tiger flathead were below the minimum legal length (MLL) of 33 cm. The size distributions of southern calamari, a typically fast growing squid, were probably influenced by the seasonal nature of sampling in the two depths. The depths greater than 55 m were sampled over a relatively short time (four months) and the data suggest the presence of two cohorts of calamari around 10 cm and 20 – 25 cm mantle length. The size data for the shallower depths do not appear to show these discreet size classes but, as data were pooled from most months between March-May and August-October, it is unlikely that individual cohorts would remain evident. The data, therefore, cannot be interpreted to indicate that the two size classes were less abundant in the shallower depths. The data did show, however, that juvenile calamari were relatively abundant in depths greater than 55 m.

Although the total-catch rates of non-commercial (trash) species in the treatment codends were similar for the two depths, the depth-dependent distributions of several species resulted in very different catch compositions. The relatively common capture in the depths over 55 m of large Port Jackson sharks, along with numerous stingaree and the occasional black stingray, resulted in elasmobranchs being the dominant trash component by weight although their numbers were relatively low. It should be noted that most Port Jackson sharks and stingrays are alive when landed on deck, and will survive if quickly returned to the sea.

7.4. Summary

- In the 90-mm codend, the mean school whiting catch in < 55 m (69 kg/tow) was more than douple that in depths > 55 m (27 kg/tow); in the 40-mm codend, mean catches were 186 and 125 kg/tow, respectively. However, catch-numbers in the 40-mm (control) codend indicated that school whiting were numerically equally abundant in both depths but had a larger average size in depths shallower than 55 m.

- Redfish were mostly very small in size and mean catch-weights low (8 kg/tow in the 90-mm codend) in depths < 55 m; in depths > 55 m, the mean redfish catch was 70 kg/tow although about 70% by number and over 50% by weight were below marketable size.

- Few undersized bluespotted flathead were caught in either depth range. Tiger flathead were mainly caught during winter-spring across all depths; about 65% of those caught in the 90 mm codend were undersized but tiger flathead were less than 0.5% of the total catch.

- Catch rates of other commercial species (retained and discarded) were similar for both depth ranges; the commercial-discard component for all species other than redfish was small.

- Ocean jackets, when encountered in large numbers in any depth, were mostly too small to market.

- Weights of non-commercial discards were similar for the two depths; a relatively high proportion of the discard weight in depths shallower than 55 m comprised longfin gurnard and longspine flathead, whereas in depths deeper than 55 m, the main components were elasmobranchs, principally large Port Jackson sharks and several species of stingarees.

Table 7.1. Summary of catches (mean, standard error, and % of total catch; n=20) taken in the 90-mm (T4mm200 & T4mm200X) codends in depths less than 55 m during Experiment 1.

	Treatment codends					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
School whiting	69.0	23.8	31.5	959.9	335.9	44.5
Elasmobranchs	21.4	3.5	9.8	16.5	2.7	0.8
Flathead-bluespotted	17.9	2.2	8.2	34.3	4.3	1.6
Flathead-other	1.8	0.8	0.8	4.3	2.2	0.2
Redfish	1.0	0.4	0.4	8.3	3.9	0.4
Ocean jackets	0.8	0.3	0.3	3.0	1.3	0.1
Misc. fish	3.7	1.0	1.7	20.4	6.6	0.9
Total retained fish	**115.5**	**26.8**	**52.7**	**1046.4**	**340.7**	**48.5**
Calamari	9.5	1.5	4.3	30.0	4.9	1.4
Cuttlefish	5.3	1.6	2.4	33.2	10.0	1.5
Octopus	0.4	0.1	0.2	2.2	0.5	0.1
Total retained cephalopods	**15.4**	**2.7**	**7.0**	**69.7**	**13.8**	**3.2**
Bugs & crabs	0.9	0.2	0.4	6.4	1.2	0.3
Total retained catch	**131.9**	**28.5**	**60.1**	**1122.5**	**348.6**	**52.0**
Discarded commercials						
School whiting	0.1	0.1	0.1	3.4	2.1	0.2
Flathead-bluespotted	0.1	0.1	0.1	0.6	0.3	0.0
Flathead-other	1.0	0.8	0.5	6.0	5.0	0.3
Redfish	3.3	1.0	1.5	84.9	27.8	3.9
Yellowtail scad	9.2	5.8	4.2	127.1	75.1	5.9
Snapper	2.9	2.2	1.3	17.0	12.7	0.8
Ocean jackets	2.9	1.5	1.3	30.6	12.3	1.4
Misc. commercial fish	3.0	1.0	1.4	12.1	2.8	0.6
Total discarded commercial fish	**22.5**	**7.2**	**10.3**	**281.5**	**99.0**	**13.0**
Discard crabs & bugs	0.3	0.1	0.2	5.5	1.1	0.3
Total discarded commercials	**22.8**	**7.2**	**10.4**	**287.0**	**99.4**	**13.3**
Discarded non-commercials						
Elasmobranchs	19.0	5.9	8.7	26.7	9.4	1.2
Misc eels	0.5	0.3	0.2	6.2	3.0	0.3
Gurnard-longfin	29.2	3.7	13.3	529.3	77.0	24.5
Flathead-longspine	10.4	1.5	4.7	130.3	17.6	6.0
Misc. fish	5.3	0.9	2.4	46.1	10.9	2.1
Total discarded non-commercial fish	**64.5**	**5.8**	**29.4**	**738.4**	**78.7**	**34.2**
Misc. invertebrates	0.2	0.0	0.1	11.3	1.8	0.5
Total discarded non-commercials	**64.7**	**5.8**	**29.5**	**749.7**	**79.0**	**34.7**
Total discarded fish	87.0	10.6	39.6	1019.9	130.8	47.2
Total discarded invertebrates	0.5	0.1	0.2	16.8	2.2	0.8
Total discarded catch	**87.5**	**10.6**	**39.9**	**1036.7**	**130.9**	**48.0**
Total catch	**219.4**	**33.5**	**100.0**	**2159.2**	**393.6**	**100.0**

Table 7.2. Summary of catches (mean, standard error, and % of total catch; n=20) taken in the 40-mm (control) codend in depths less than 55 m during Experiment 1.

	Control codends					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	s.e.	%	mean	s.e.	%
Retained commercials						
School whiting	185.9	44.7	46.9	2805.3	637.9	51.6
Elasmobranchs	23.2	5.3	5.9	15.3	3.2	0.3
Flathead-bluespotted	15.6	2.8	3.9	29.4	4.9	0.5
Flathead-other	1.2	0.5	0.3	3.1	1.2	0.1
Redfish	0.9	0.5	0.2	8.5	5.3	0.2
Ocean jackets	0.1	0.1	0.0	0.5	0.3	0.0
Misc. fish	3.7	0.8	0.9	20.0	5.4	0.4
Total retained fish	**230.6**	**49.3**	**58.2**	**2882.2**	**644.0**	**53.0**
Calamari	9.9	1.4	2.5	35.0	6.0	0.6
Cuttlefish	8.0	2.1	2.0	45.1	13.2	0.8
Octopus	1.7	0.2	0.4	15.6	2.3	0.3
Total retained cephalopods	**20.1**	**2.8**	**5.1**	**104.8**	**16.3**	**1.9**
Bugs & crabs	0.9	0.2	0.2	6.5	1.3	0.1
Total retained catch	**251.7**	**51.5**	**63.5**	**2993.4**	**657.9**	**55.1**
Discarded commercials						
School whiting	1.1	0.7	0.3	34.9	21.1	0.6
Flathead-bluespotted	0.4	0.1	0.1	1.9	0.6	0.0
Flathead-other	1.0	0.6	0.2	6.8	3.9	0.1
Redfish	6.9	2.4	1.7	255.8	101.1	4.7
Yellowtail scad	4.8	1.9	1.2	87.2	25.7	1.6
Snapper	0.5	0.4	0.1	3.8	2.9	0.1
Ocean jackets	2.8	0.8	0.7	34.3	10.9	0.6
Misc. commercial fish	4.7	1.8	1.2	18.2	5.7	0.3
Total discarded commercial fish	**22.1**	**4.9**	**5.6**	**442.8**	**118.7**	**8.1**
Discard crabs & bugs	0.7	0.1	0.2	11.3	1.8	0.2
Total discarded commercials	**22.8**	**4.9**	**5.8**	**454.0**	**118.4**	**8.4**
Discarded non-commercials						
Elasmobranchs	18.5	6.7	4.7	24.6	8.3	0.5
Misc eels	6.7	1.3	1.7	99.0	19.1	1.8
Gurnard-longfin	32.7	3.9	8.3	658.7	86.4	12.1
Flathead-longspine	50.6	5.3	12.8	771.9	64.1	14.2
Misc. fish	13.1	1.9	3.3	413.3	46.5	7.6
Total discarded non-commercial fish	**121.6**	**8.7**	**30.7**	**1967.5**	**162.1**	**36.2**
Misc. invertebrates	0.3	0.0	0.1	20.4	3.7	0.4
Total discarded non-commercials	**121.9**	**8.7**	**30.7**	**1987.8**	**162.2**	**36.6**
Total discarded fish	143.7	12.3	36.2	2410.2	195.9	44.3
Total discarded invertebrates	1.0	0.1	0.3	31.6	4.5	0.6
Total discarded catch	**144.7**	**12.3**	**36.5**	**2441.8**	**196.8**	**44.9**
Total catch	**396.4**	**58.9**	**100.0**	**5435.2**	**738.7**	**100.0**

Table 7.3. Summary of catches (mean, standard error, and % of total catch; n = 10) taken in the 90-mm (T4mm200 & T4mm200X) codends in depths greater than 55 m during Experiment 1.

	Treatment codends					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	**s.e.**	**%**	**mean**	**s.e.**	**%**
Retained commercials						
School whiting	27.3	6.5	10.4	454.8	112.0	25.3
Elasmobranchs	39.1	13.9	14.9	17.7	5.1	1.0
Flathead-bluespotted	8.3	1.3	3.2	12.4	2.2	0.7
Flathead-other	3.9	1.0	1.5	10.5	2.6	0.6
Redfish	36.9	11.6	14.0	281.5	89.5	15.7
Ocean jackets	11.2	6.8	4.3	37.4	19.9	2.1
Misc. fish	6.2	1.2	2.4	17.6	4.2	**1.0**
Total retained fish	**132.9**	**21.2**	**51.0**	**831.9**	**133.5**	**46.3**
Calamari	7.5	1.5	2.8	26.5	5.9	1.5
Cuttlefish	4.9	2.3	1.8	14.8	4.3	0.8
Octopus	0.2	0.1	0.1	1.5	0.6	0.1
Total retained cephalopods	**13.1**	**2.7**	**5.0**	**44.1**	**8.4**	**2.5**
Bugs & crabs	0.2	0.1	0.1	2.2	0.7	0.1
Total retained catch	**147.3**	**21.9**	**56.0**	**878.2**	**133.4**	**48.8**
Discarded commercials						
School whiting	0.6	0.3	0.2	20.6	7.8	1.1
Flathead-bluespotted	0.0	0.0	0.0	0.2	0.2	0.0
Flathead-other	2.0	0.9	0.8	14.1	6.7	0.8
Redfish	33.4	6.2	12.7	537.1	103.4	29.9
Yellowtail scad	0.6	0.3	0.2	8.9	2.9	0.5
Snapper	1.2	0.8	0.4	7.1	4.6	0.4
Ocean jackets	12.9	4.0	4.9	99.4	32.4	5.5
Misc. commercial fish	3.6	1.1	1.4	14.5	6.2	0.8
Total discarded commercial fish	**55.8**	**8.5**	**21.2**	**701.9**	**113.6**	**39.0**
Discard crabs & bugs	0.1	0.0	0.0	2.8	0.7	0.2
Total discarded commercials	**55.8**	**8.5**	**21.2**	**704.7**	**113.7**	**39.2**
Discarded non-commercials						
Elasmobranchs	49.5	12.9	18.8	29.6	10.5	1.6
Misc eels	0.1	0.0	0.0	0.6	0.2	0.0
Gurnard-longfin	6.2	2.1	2.4	136.9	42.0	7.6
Flathead-longspine	0.9	0.3	0.3	10.6	3.6	0.6
Misc. fish	3.3	0.7	1.3	31.1	10.2	1.7
Total discarded non-commercial fish	**59.9**	**13.0**	**22.7**	**208.8**	**45.2**	**11.6**
Misc. invertebrates	0.2	0.0	0.1	6.9	1.4	0.4
Total discarded non-commercials	**60.0**	**13.0**	**22.8**	**215.7**	**45.2**	**12.0**
Total discarded fish	115.6	17.3	43.9	910.7	129.0	50.6
Total discarded invertebrates	0.2	0.0	0.1	9.7	1.4	0.5
Total discarded catch	**115.9**	**17.3**	**44.0**	**920.4**	**128.7**	**51.2**
Total catch	**263.1**	**34.0**	**100.0**	**1798.6**	**238.3**	**100.0**

Table 7.4. Summary of catches (mean, standard error, and % of total catch; n = 9) taken in the 40-mm (control) codend in depths greater than 55 m during Experiment 1.

	Control codends					
	Kg / 90 min. tow			No. / 90 min. tow		
	mean	s.e.	%	mean	s.e.	%
Retained commercials						
School whiting	125.4	22.7	32.2	2424.9	414.4	45.3
Elasmobranchs	29.4	6.2	7.6	19.1	3.7	0.4
Flathead-bluespotted	13.9	2.5	3.6	20.9	4.4	0.4
Flathead-other	4.1	1.5	1.0	11.7	2.9	0.2
Redfish	27.2	7.5	7.0	239.6	71.1	4.5
Ocean jackets	3.8	2.3	1.0	12.5	6.6	0.2
Misc. fish	7.2	1.6	1.8	27.1	6.6	0.5
Total retained fish	**211.0**	**25.2**	**54.2**	**2755.8**	**410.7**	**51.4**
Calamari	9.8	2.2	2.5	36.2	11.4	0.7
Cuttlefish	4.9	1.8	1.3	15.4	6.5	0.3
Octopus	1.7	0.3	0.4	13.3	2.9	0.2
Total retained cephalopods	**17.0**	**2.9**	**4.4**	**67.4**	**15.3**	**1.3**
Bugs & crabs	0.3	0.2	0.1	3.0	1.6	0.1
Total retained catch	**228.3**	**25.8**	**58.6**	**2826.2**	**406.9**	**52.8**
Discarded commercials						
School whiting	12.9	2.9	3.3	409.1	97.6	7.6
Flathead-bluespotted	0.0	0.0	0.0	0.0	0.0	0.0
Flathead-other	5.2	3.1	1.3	37.1	19.9	0.7
Redfish	31.4	8.3	8.1	515.0	121.3	9.6
Yellowtail scad	7.5	3.0	1.9	195.0	42.7	3.6
Snapper	1.5	1.1	0.4	7.3	5.0	0.1
Ocean jackets	13.4	6.4	3.4	102.3	46.9	1.9
Misc. commercial fish	3.9	2.2	1.0	12.3	4.8	0.2
Total discarded commercial fish	**75.8**	**11.7**	**19.5**	**1278.2**	**123.6**	**23.9**
Discard crabs & bugs	0.3	0.2	0.1	8.9	4.0	0.2
Total discarded commercials	**76.2**	**11.7**	**19.6**	**1287.1**	**122.6**	**24.0**
Discarded non-commercials						
Elasmobranchs	52.7	15.4	13.5	33.8	12.0	0.6
Misc eels	5.3	1.2	1.4	96.6	23.8	1.8
Gurnard-longfin	10.3	4.0	2.7	335.8	121.4	6.3
Flathead-longspine	6.4	3.1	1.6	100.3	47.3	1.9
Misc. fish	9.9	1.4	2.5	655.3	100.5	12.2
Total discarded non-commercial fish	**84.6**	**16.1**	**21.7**	**1221.8**	**221.2**	**22.8**
Misc. invertebrates	0.3	0.0	0.1	21.2	7.0	0.4
Total discarded non-commercials	**84.9**	**16.1**	**21.8**	**1243.0**	**220.6**	**23.2**
Total discarded fish	160.4	18.7	41.2	2500.0	309.9	46.7
Total discarded invertebrates	0.6	0.2	0.2	30.1	8.1	0.6
Total discarded catch	**161.1**	**18.6**	**41.4**	**2530.1**	**306.9**	**47.2**
Total catch	**389.4**	**37.1**	**100.0**	**5356.3**	**561.8**	**100.0**

Table 7.5. Results of t-test comparisons of mean catch weights and numbers from 90-mm (T) and 40-mm (C) codends between tows in depths shallower (<) and deeper (>) than 55 m during Experiment 1 (ns = not significant; * $p < 0.05$; ** $p < 0.01$).

Comparison	Mean catch weight T < 55 – T > 55	Mean catch weight C < 55 – C > 55	Mean catch number T < 55 – T > 55	Mean catch number C < 55 – C > 55
School whiting-*retained*	ns	ns	ns	ns
School whiting-*discarded*	ns	**	ns	**
School whiting-total	ns	ns	ns	ns
Flathead-*retained*	*	ns	*	ns
Flathead-*discarded*	ns	ns	ns	ns
Flathead-total	ns	ns	ns	ns
Redfish-*retained*	*	**	*	*
Redfish-*discarded*	**	*	**	ns
Redfish-total	**	**	**	*
Elasmobranchs-*retained*	ns	ns	ns	ns
Elasmobranchs-*discarded*	ns	ns	ns	ns
Elasmobranchs-total	*	ns	ns	ns
Calamari-*retained*	ns	ns	ns	ns
Cuttlefish-*retained*	ns	ns	ns	ns
Octopus-*retained*	ns	ns	ns	ns
Cephalopods-total	ns	ns	ns	ns
Longfin gurnard	**	**	**	*
Longspine flathead	**	**	**	**
Total retained fish	ns	ns	ns	ns
Total retained catch	ns	ns	ns	ns
Total discarded commercials	**	**	*	**
Total trash fish	ns	ns	**	**
Total discarded fish	ns	ns	ns	ns
Total catch	ns	ns	ns	ns

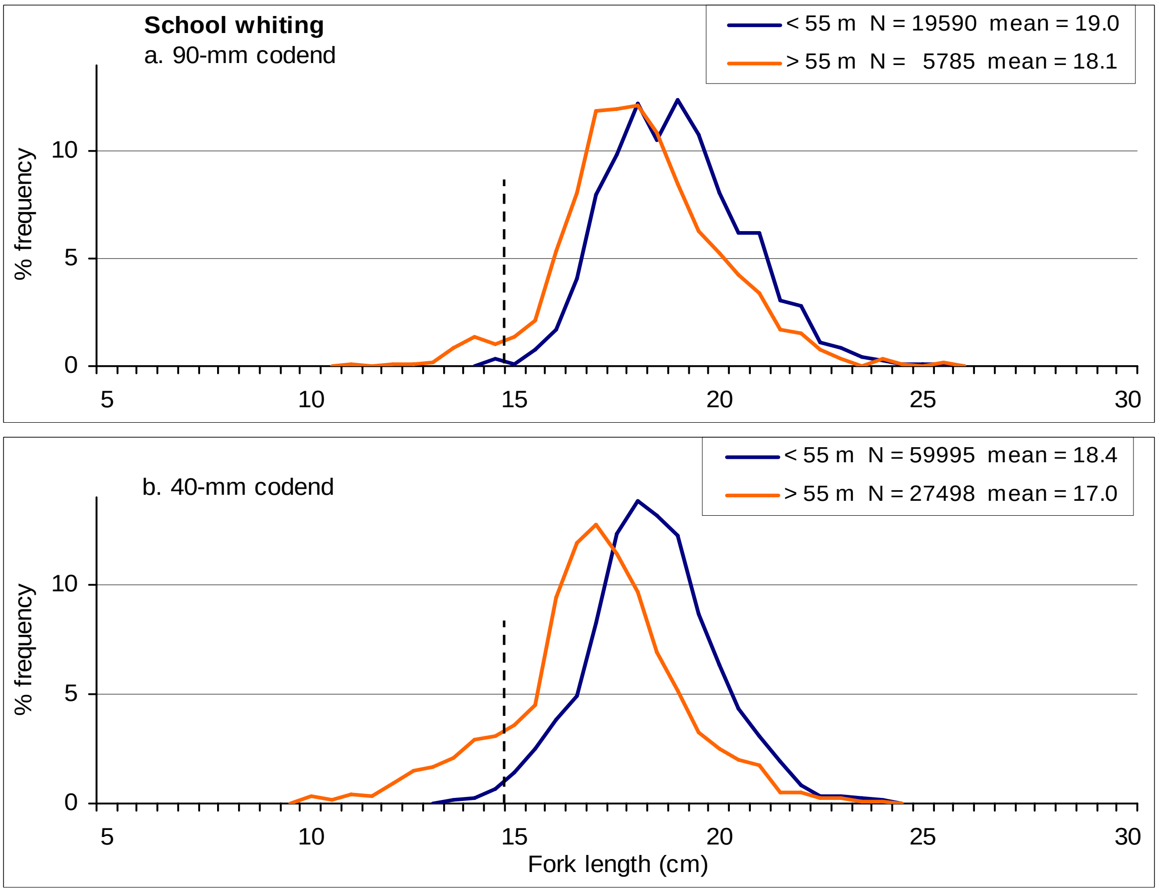

Figure 7.4. Length distributions of school whiting taken in (a) 90-mm and (b) 40-mm codends in depths less and greater than 55 m during 2005; the dotted line indicates approximate minimum marketable size.

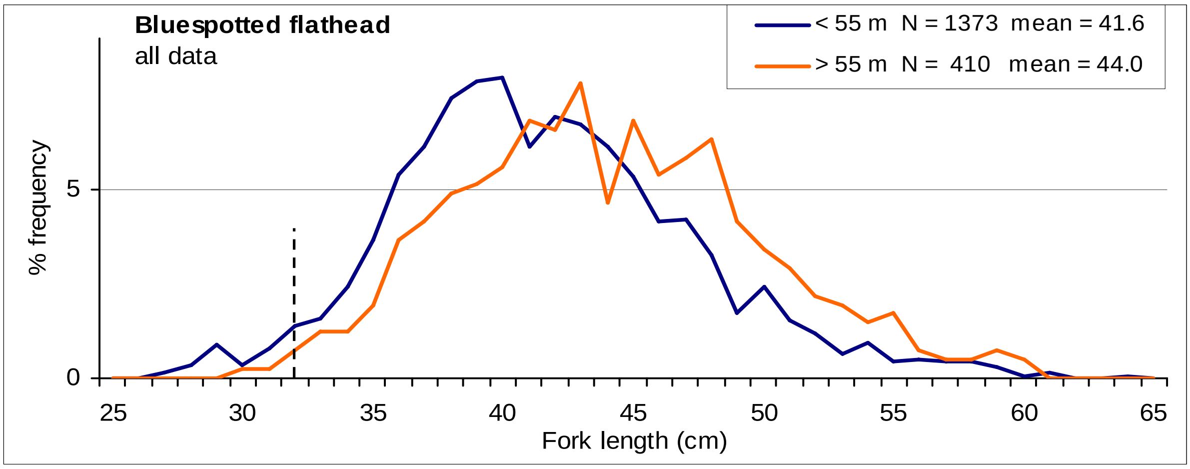

Figure 7.5. Length distributions of bluespotted flathead taken in depths less and greater than 55 m during 2005; the dotted line indicates minimum legal length.

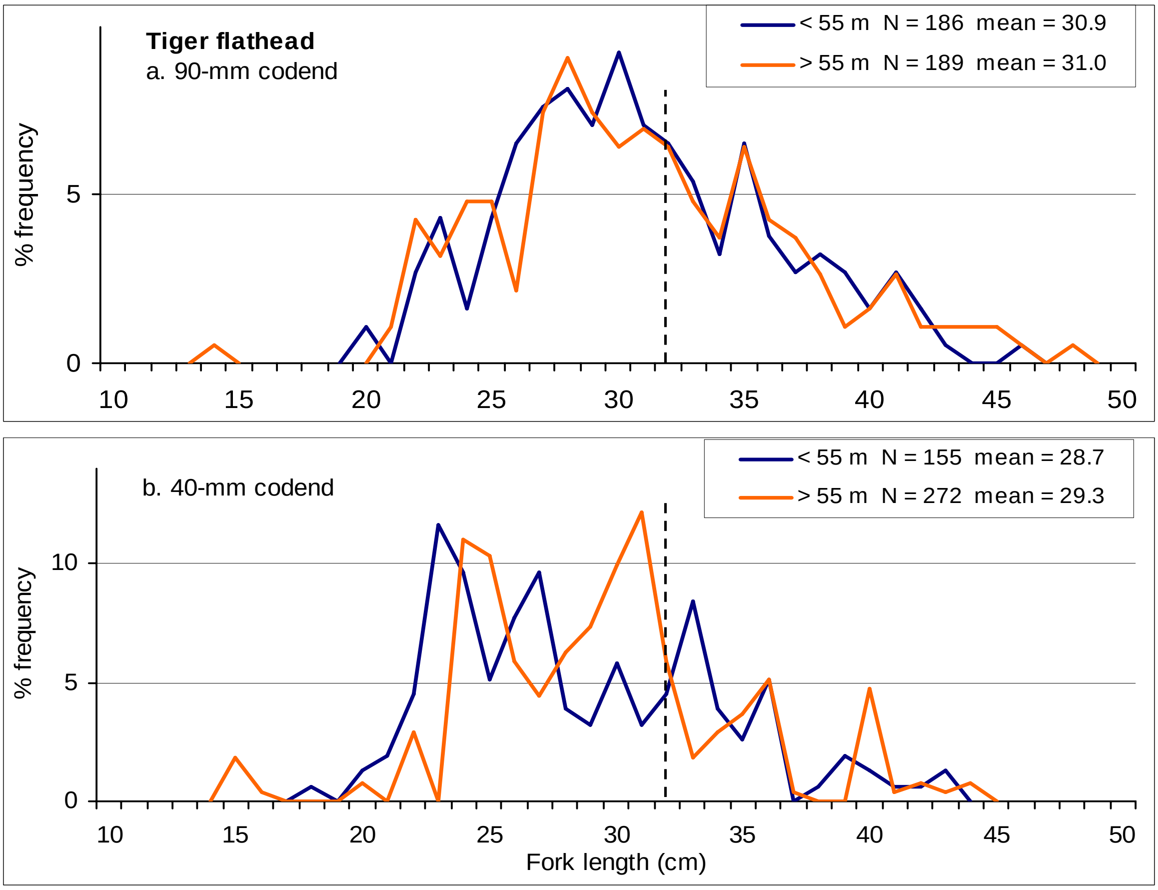

Figure 7.6. Length distributions of tiger flathead taken in (a) 90-mm and (b) 40-mm codends in depths less and greater than 55 m during 2005; the dotted line indicates minimum legal length.

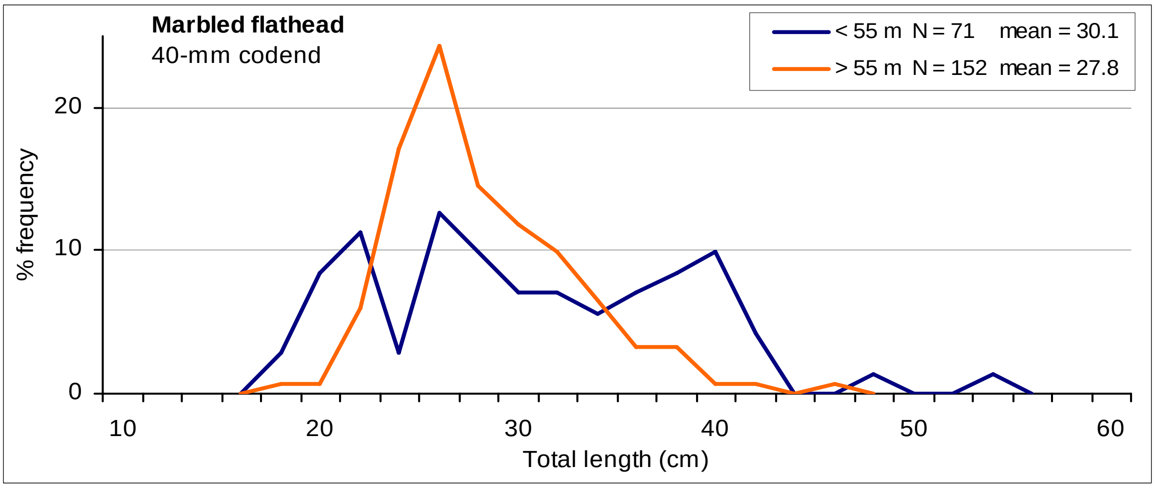

Figure 7.7. Length distributions of marbled flathead taken in the 40-mm codend in depths less and greater than 55 m during 2005.

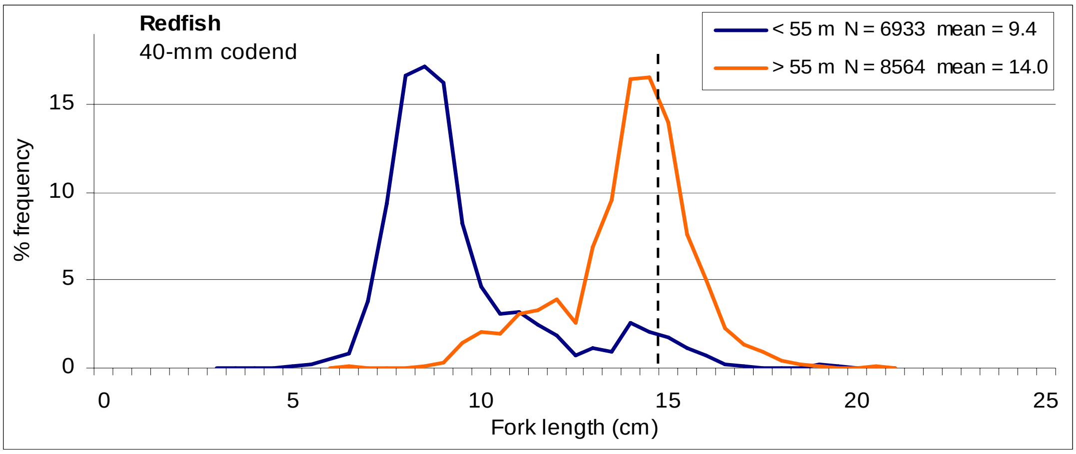

Figure 7.8. Length distributions of redfish taken by the control codend in depths less and greater than 55 m during 2005; the dotted line indicates approximate minimum market size.

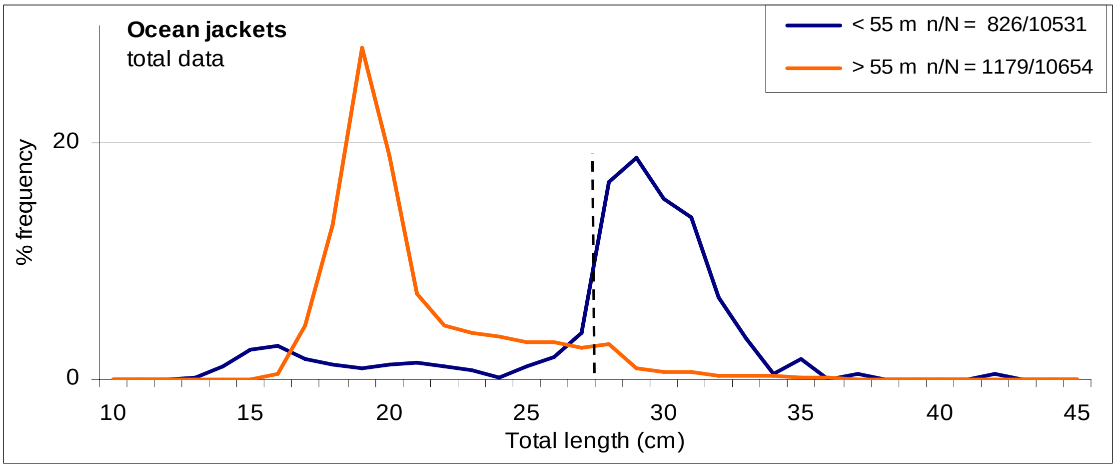

Figure 7.9. Length distributions of ocean jackets taken in depths less and greater than 55 m during 2005; the dotted line indicates approximate minimum market size.

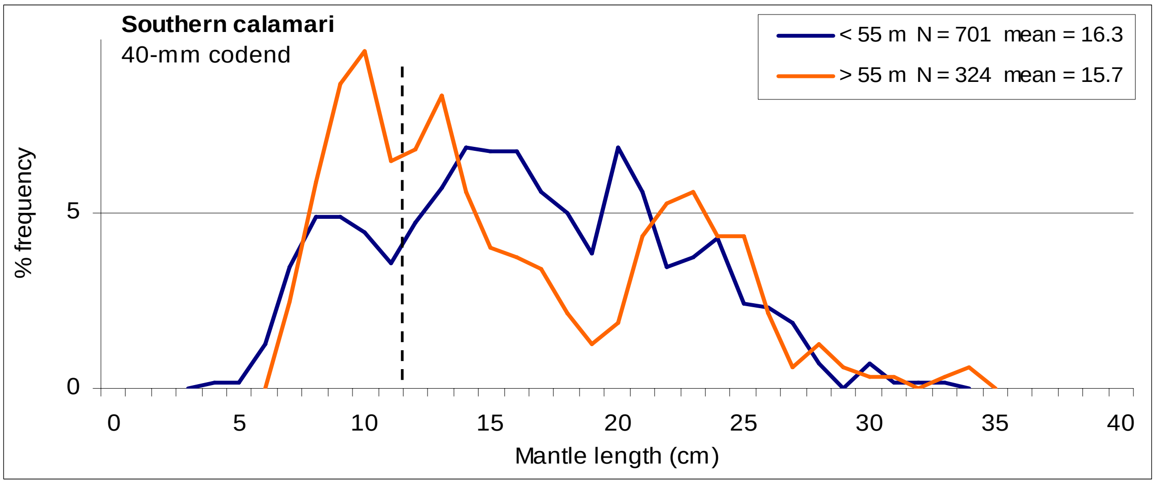

Figure 7.10. Length distributions of southern calamari taken in depths less and greater than 55 m during 2005; the dotted line indicates approximate minimum market size.

8. FAUNAL COMPOSITION AND RELATIVE ABUNDANCES

8.1. Method summary

Fishes, molluscs, and crustaceans (decapods and stomatopods) were identified to species level; the catch number and weight of each species were recorded for each tow. The total number of species and the mean numbers of species within the major taxonomic groupings were compared across codends. Catch numbers and weights for individual species, pooled for treatment and control codends, were compared, and species data from the most selective (T4mm100) and least selective (T5mm200) codends were compared with their respective control.

8.2. Results

8.2.1. Number of species and frequency of capture

The total catch from 152 tows completed during Experiments 1 and 2 weighed 40 907 kg and comprised 482 380 organisms. The 173 species recorded from this catch included 27 elasmobranchs, 94 teleosts, 26 molluscs (including 16 cephalopods) and 26 crustaceans; 67 were species marketed in NSW (Appendix 3). A total of 126 species were recorded from the treatment codends with a mean number per tow of 32.6 ± 0.7 while the control catches contained 127 species and averaged 39.8 ± 0.7 species per tow, and these overall means for the two gears did not vary within each of the two experiments (Table 8.1).

For individual codends, the total numbers of species caught by the T4mm100 and T3mm200 codends were 91 and 92 respectively, while the other treatment codends and the corresponding control each captured between 100 and 113 species (Table 8.1). For the 90-mm mesh treatment codends, the mean number of species per tow was between 30.7 and 35.1 compared with their small-mesh control which averaged 38.9 – 42.9 species (Table 8.1, Figure 8.2a). When compared, all the associated control catches comprised significantly more species of teleosts and, for the C200 and C100 controls, more molluscs (t-test: $p < 0.05$) than their respective treatments (Table 8.1). However, the proportions of species from each of the four taxonomic groups were similar across all codends: 53 – 61% teleosts, 11 – 19% elasmobranchs, 17 – 22% molluscs and 8 – 10% crustaceans (Figure 8.3a).

The frequency of capture for most individual species was relatively low. Southern calamari and longfin gurnard were caught in every tow, and school whiting was taken in all but one. Only four further species: bluespotted flathead, longspine flathead, ocean jacket and redfish were captured in more than 90% of tows. Overall, just 26 species (15%) were caught in more than half of the 152 tows while 50% of the 173 species were present in fewer than 10 tows including 35 species (21%) captured only once (see Appendix 3). This pattern of a core-group of species being caught relatively often while most are infrequently caught is reflected in the species-cumulative catch curves (Figure 8.3). The curves show similar trends for the two codend types in each experiment, with 50 – 60% of total species taken by each codend after only 4 – 6 tows, followed by a much slower, albeit steady, accumulation of additional taxa throughout the remainder of the trawling.

All but one of the 21 species present in the treatment codends but absent in the control catches were caught only once or twice, suggesting that their absence from the control tows was because of low abundance and was not gear related. Similarly, about one third of the 25 species captured only in one or two of the control catches were relatively large species that could also have been retained

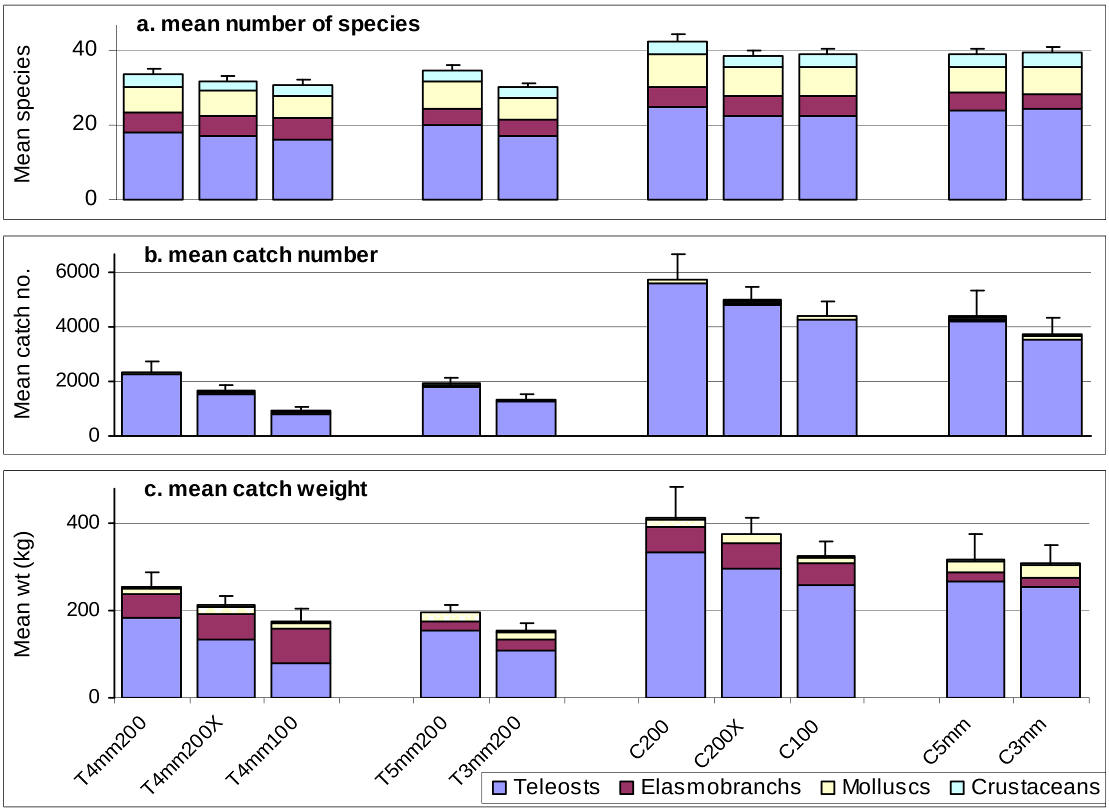

Figure 8.1. Mean catches of main taxonomic groups taken by each codend: a. number of species, b. catch number, c. catch weight (+1 s.e. for total).

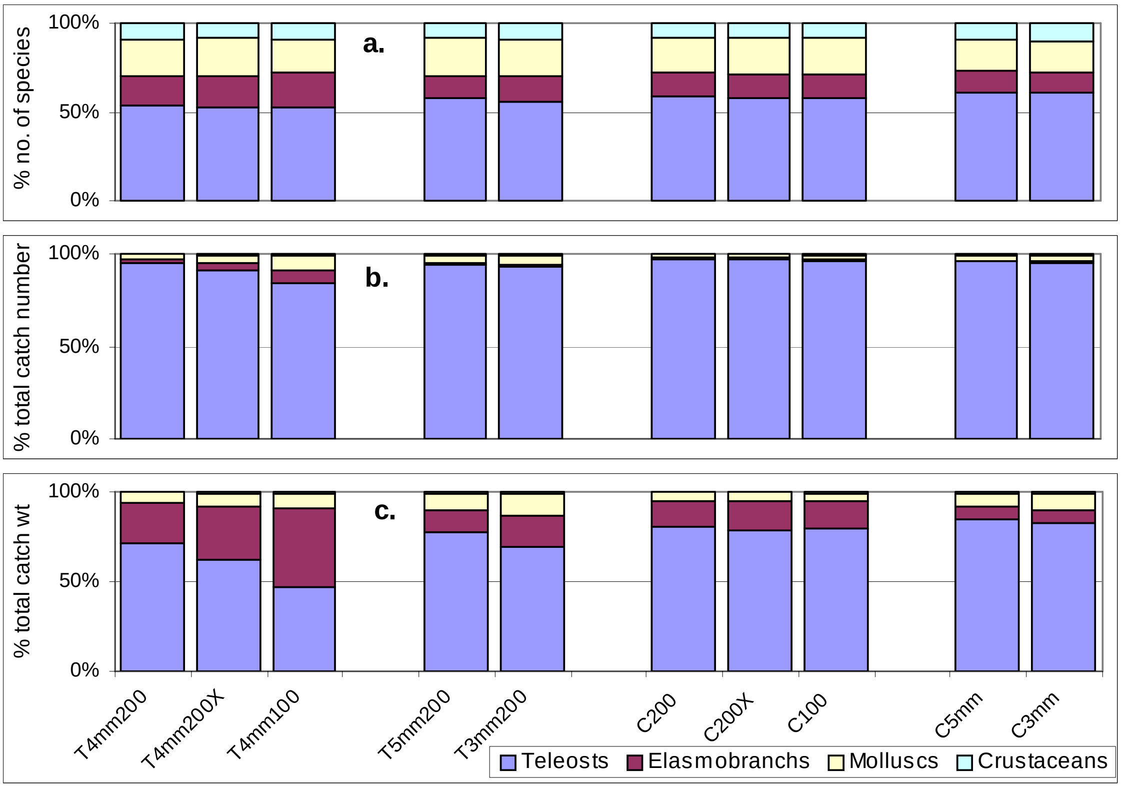

Figure 8.2. Proportions of main taxonomic groups retained by each codend: a. mean number of species, b. mean catch number, c. mean catch weight.

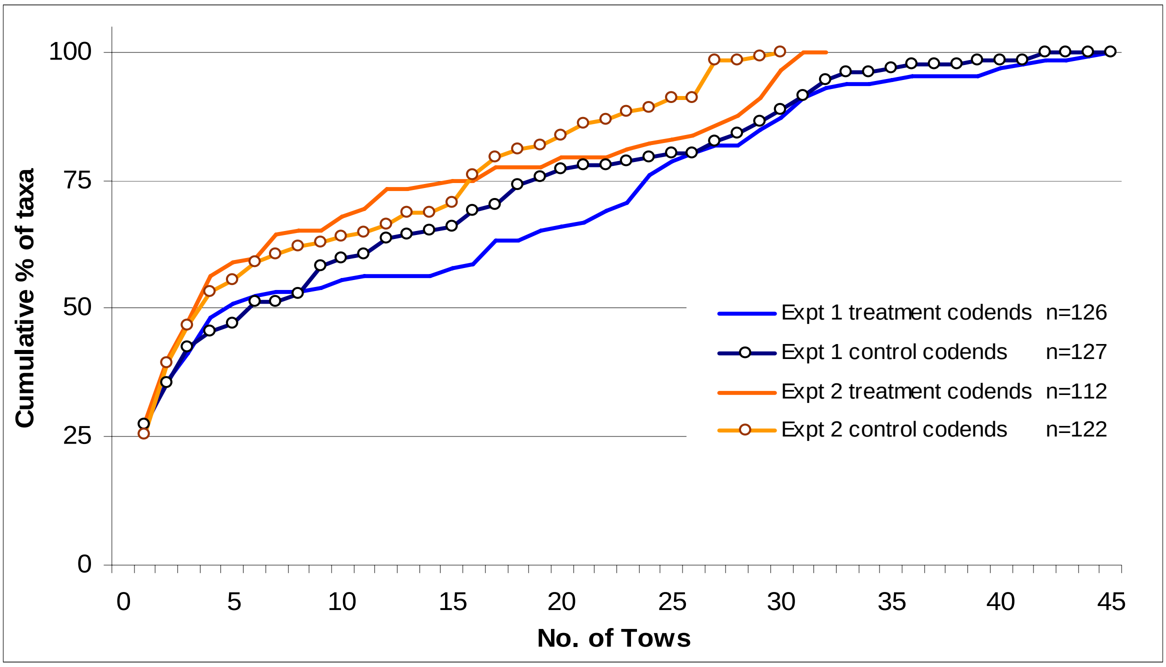

Figure 8.3. Cumulative percentage of taxa plotted against the number of sequential tows with treatment (T) and control (C) codends during Experiments 1 (T & C, each 45 tows) and 2 (T: 32 & C: 30 tows); n = total no. of species taken in each gear type.

by any of the treatment codends. However, many of the species caught exclusively in the small-meshed control codend were small and/or slender species unlikely to be retained by treatment codends e.g., bigeye pike eel (*Oxyconger leptognathus*), mottled conger (*Poeciloconger kapala*) and sharpfin barracuda (*Sphyraena acutipinnis*) that were each captured in 6 – 9 control tows. The effect of mesh size on capture rate was also evident for other similarly shaped or small species that were recorded from both codend types. These included species such as *Gnathophis* eels, beaked salmon (*Gonorynchus greyi*), Whitley's gurnard perch (*Maxillicosta whitleyi*), crested flounder (*Lophonectes gallus*), manyband sole (*Zebrias scalaris*), striped dumpling-squid (*Sepioloidea lineolata*) and southern octopus (*Octopus australis*) that were captured 40 – 60% more often, and in substantially greater numbers (see below), in the 40-mm mesh control than in the 90-mm treatments.

Most trawls during Experiment 1 and all during Experiment 2 were in depths less than 65 m and consequently the majority of species were typically representative of the inner-shelf fauna. Catches from tows deeper than 65 m included species such as the Sydney skate (*Dipturus australis*), yellowback (*Urolophus sufflavus*), greenback (*U. viridis*), and sandyback (*U. bucculentus*) stingarees, three-spined cardinalfish (*Apogonops anomalus*) and Gould's squid (*Nototodarus gouldi*) more commonly found in mid to outer shelf depths. Large Port Jackson sharks (*Heterodontus portusjacksoni*) were also more abundant in the deeper tows, contributing substantially to the relatively high (discarded) elasmobranch catch rates during Experiment 1 (see Chapter 7). Although catches of small congers (*Gnathophis* spp.) were not identified to species level for most catches, samples indicated that catches from shallower than 55 m comprised almost totally *G. longicaudus* with small numbers of *G. grahami*; those from greater depths were mainly *G. grahami* and *G. umbrellabius*, with few *G. longicaudus*.

8.2.2. *Proportions of main taxonomic groups and species in catches*

By number, teleost fishes dominated catches in all codends (Figures 8.1b, 8.2b). Teleosts contributed 91 – 95% of the total number of organisms caught in all treatment codends except for the more selective T4mm100 (85%); in the small-mesh control codend, teleosts were 95 – 97% of total catch numbers. By weight, however, the catch proportions of teleosts were lower although they still contributed more than 60% of catch in most treatment codends and about 80% or more in the controls (Figures 8.1c, 8.2c). Elasmobranchs were less than 2% of catch numbers in all codends except T4mm200X (3.6%) and T4mm100 (6.8%), but were frequently of large size (e.g., Port Jackson shark) and their catch weights contributed more than 12% of total weight across all treatment codends, with a high of 44% in the T4mm100 codend. The contributions of molluscs (5 – 12% of total catch weights), which comprised mainly cephalopods, were also relatively high whereas crustaceans were mostly few in number and insignificant in weight.

When data were pooled across all treatment and control tows with species ranked by catch number and weight, school whiting was the dominant species in both codends, particularly in the controls where it contributed 47% of the total catch number and 41% of catch weight (Table 8.2; Appendix 4). When combined, four of the most abundant species (school whiting, longfin gurnard, longspine flathead and redfish) contributed more than 75% of total catch number in both codends, and over 40% of total weight in the treatment codends and almost 65% of weight in the controls. Small species such as the crested flounder, violet sawbelly (*Optivus agastos*) and Whitley's gurnard perch were numerically abundant in the controls but were ranked relatively lowly by weight. In contrast, the catch numbers of several elasmobranchs including Port Jackson shark, eastern shovelnose ray (*Aptychotrema rostrata*), banjo ray (*Trygonorrhina* sp. A) and southern eagle ray (*Myliobatis australis*) were small, but their catch weights were significant (Table 8.2). Overall, more than 90% of the total catch numbers in the treatment and control codends were comprised of teleosts whereas elasmobranchs were only 2.4% and 0.7% of total catch numbers in the respective codends; by weight, however, elasmobranchs together made up 24% of the treatment catch and 12% of the control catch.

The invertebrate catch, 3 – 5% of total catch numbers and less than 10% by weight (Table 8.2), was mainly composed of molluscs, principally cephalopods. Southern calamari alone contributed about half the mollusc number and more than half the weight in the treatment codends; calamari, southern octopus and rosecone cuttlefish (*Sepia rozella*) were the main contributors to mollusc catches in the small-meshed control codend. Although less abundant, gastropod molluscs were frequently caught and included moderate numbers of Hunter's volute (*Cymbiolista hunteri*), Thomson's helmetshell (*Phalium thomsoni*) and the variegated cask shell (*Tonna cerevisina*); the only bivalves taken were two specimens of the saucer scallop (*Amusium balloti*) (see Appendices 3 – 5). Crustaceans regularly taken in the treatment codends were mostly large species such as the Balmain bug (*Ibacus peronii*) and blue-swimmer crab (*Portunus pelagicus*) while in the control codend, the smaller hardback (*Trachypenaeus curvirostris*) and king (*Melicertus plebejus*) prawns were also relatively numerous.

8.2.3. *Species relative abundance and biomass in T4mm100 and control*

Almost 85% of the T4mm100 catch number were teleosts with nearly 70% comprising longfin gurnard, redfish, school whiting, ocean jacket and longspine flathead; elasmobranchs contributed only about 7% and invertebrates 9% of the total number (Table 8.3). By weight, however, four (shovelnose ray, Port Jackson shark, common stingaree *Trygonoptera testacea* and banjo shark) of the top seven species were elasmobranchs and, in total, formed about 35% of total-catch weight; the five most numerous teleosts (above) totalled just 26% of the weight. Overall, catch-weight proportions of teleosts (46%) and elasmobranchs (44%) in the T4mm100 codend were almost equal.

The total catch number in the 40-mm control codend was about five times greater than in the T4mm100 codend and, in contrast, was dominated by teleosts both by number (96%) and weight (80%). This resulted from the high retention of relatively small teleosts such as school whiting, longfin gurnard, longspine gurnard and yellowtail scad (*Trachurus novaezelandiae*) which together totalled 80% of the catch number and over 60% of catch weight (Table 8.3). Other small teleosts like the crested flounder, *Gnathophis* congers, Whitley's gurnard perch and violet roughy were also abundant in the control codend although they were few in number in the treatment catches. Elasmobranchs made up less than 1% of catch number but contributed about 15% of catch weight.

Invertebrates were less than 10% of total number and weight in both the T4mm100 and control codends. The few crustaceans caught (< 1.5% of number or weight in either codend) were mostly Balmain bugs (*Ibacus peronii*) and blue-swimmer crabs whereas molluscs, mainly rosecone cuttlefish and southern calamari, supplied about 9% and 5% respectively of the T4mm100 and control total catch weights (Table 8.3).

8.2.4. *Species relative abundance and biomass in T5mm200 and control*

In the T5mm200 codend, more than 80% of the total catch number and 60% of total weight were comprised of school whiting, longfin gurnard, ocean jackets and longspine flathead (Table 8.4). These same four species accounted for over 70% of the total catch number and weight in the control catches. Other relatively small species such as yellowtail scad and violet roughy were also prominent in catches from both codends whereas very small and/or more slender fishes such as *Gnathophis* congers, crested flounder, Whitley's gurnard perch, ravenous cusk (*Ophidion genyopus*) and beaked salmon (*G. greyi*) were relatively abundant only in the control catches. Elasmobranchs contributed about 1% of the total catch number in the T5mm200 with the Kapala stingaree (*U. kapalensis*) the only species ranked numerically in the top 20 species; however by weight, it and six other elasmobranchs were ranked between 8 and 17 and, combined, contributed 11% of the total weight (Table 8.4). The control catches followed a similar pattern with total elasmobranchs only 0.4% of the total number (no species ranked higher than 30) but 6.3% of the total weight, including six species ranked between 10 and 20.

8.3. Discussion

The diversity of fauna on the Sydney trawl-whiting grounds was measured by the number of species of fishes, molluscs and crustaceans recorded from 152 trawls done between Broken Bay and Newcastle across a depth range of 40 – 85 m. Several species of echinoderms and sessile organisms such as sponges and hydroids were also captured but were not recorded. Apart from gastropod molluscs and some crabs, all recorded taxa were relatively mobile in habit and capable of some reactive response to the oncoming trawl. During trawling, some individuals may escape the net through the larger meshes near the front of the trawl but most, after passing over the groundrope, remain swimming in the water column and move readily down the net to the codend where their retention is dependent on the selectivity characteristics of the codend i.e., mesh size, twine diameter and codend construction, as discussed above. The differences in catch proportions among the taxonomic groups (Table 8.1), and at a species level (Tables 8.2 – 8.4), were largely related to size and/or shape, and ultimately reflected the selectivity attributes of the codends.

The trawl gear used throughout the experiments was operated with long sweeps and bridles (~ 200 m) designed to herd fish into the path of the net. As sweeps do not effectively herd invertebrates, it was consistent that more than 90% of the resulting catches (by number and weight) were comprised of fish, particularly teleosts (Tables 8.2). The groundrope of the trawl used for almost all tows was constructed of 24-mm combination wire-rope served with looped chain, and was designed to maintain close contact with the smooth seabed characteristic of the school whiting ground. This style of groundrope, similar (although heavier) to most prawn-trawl arrangements used in NSW, facilitates the capture of benthic fishes such as sole and flounder, as well as gastropods, crabs, bugs (*Ibacus* spp) and echinoderms. However, the invertebrates that were retained in the codends were mostly of a large size suggesting that small species and specimens with little or no swimming ability dropped through the more open meshes near the front of the net. It was also observed that on the few occasions that a trawl with a rubber-disc (6-cm diameter) groundrope was deployed, the catch appeared cleaner and contained fewer benthic and sessile invertebrates, suggesting lighter contact with the seabed. Overall, the fauna described here is indicative of the gear used for its capture, and represents that portion of the biota that is vulnerable to the gear and ultimately retained by the codend.

It therefore follows that species diversity on the Sydney whiting grounds is probably best represented by the composition of catches from the control codend which, because of its small mesh, would be expected to retain the greatest number of organisms and taxa. This was demonstrated by the (pooled) total-catch in the control codend being almost three times the number and twice the weight of the catch in the 90-mm meshed treatments (Appendix 4), and the mean numbers of species per tow being greatest in the control catches (Tables 8.1, 8.2). However, despite the difference in mesh-size between the two codends, the control caught only four more species than the treatments (combined) over the respective 75 and 77 tows by each. This suggests that given sufficient sampling, the larger-meshed commercial trawls will catch a high proportion of the available species, albeit with small taxa being captured less frequently and in lower numbers. For most species, frequency of capture was consistent with their relative abundance with the 13 most numerous species in the control codends and the 9 most numerous in the treatments being caught in more than 80% of tows. The initially fast rate of capture of species (50% after 4 – 6 tows) and the high incidence of single captures (21%) was very similar to that reported for a study of prawn-trawl bycatch in northern Australia (Tonks *et al.* 2008) where 58% of taxa had been identified after less than 10% of samples had been sorted, while 28% of species were found only once across the total catch.

The different selectivity characteristics of the five treatment codends were described in composite catch terms in Chapters 4 – 6, and the trends shown are also apparent at the species level. The T4mm100 and T3mm200 were the most selective of the codends and captured the lowest numbers of taxa, while the less selective 4- and 5-mm twine, 200-mesh treatment codends each accumulated almost as many species as their controls. Catch numbers and weights of individual species are listed for the most selective (T4mm100) and least selective (T5mm200) codends (Tables 8.3, 8.4) to highlight the differences in catch composition between the two; comparisons with the control catches show, in relative terms, which species readily escaped through the 90-mm treatment-codend meshes. In absolute terms, the T4mm100 codend caught the least number of organisms of any codend, and only one fifth the catch number and half the weight of its corresponding control. Although school whiting, longfin gurnard, longspine flathead and yellowtail scad were among the most numerous fish in the catches of both codends, their combined catch number in the 100-mesh codend was almost ten fold less than was taken in the control trawls (see also Chapter 4). In addition, small non-commercial teleosts prominent in the control catches, such as *Gnathophis* eels, Whitley's gurnard perch, violet roughy, crested flounder and three-spined cardinalfish, were retained only in very low numbers by the T4mm100 codend. This greatly reduced catch of small teleosts resulted in elasmobranchs (44%) and southern calamari and cuttlefish (8%) contributing much higher proportions of the total-catch weight.

In contrast, the less selective T5mm200 codend caught more than double the number of organisms taken by the T4mm100 codend, a total that was almost half that of its control and, like the control catches, was dominated by teleost fishes (77% of the catch weight) with elasmobranchs just 12% of the weight (Table 8.4). While this lower proportion of elasmobranchs in the T5mm200 codend (when compared with the T4mm100 codend) was partially because of its greater retention of small teleosts, particularly school whiting, lower mean catch rates of elasmobranchs such as Port Jackson sharks, shovelnose rays and banjo rays during Experiment 2 also contributed (see Appendix 6). The only taxa that were relatively abundant in the control but largely absent from the treatment codend were very small and/or slender species, consistent with the non-selective characteristics of the T5mm200 codend.

8.4. Summary

- A total of 173 species of demersal fauna were identified from catches, with teleost fishes (94 species) the dominant taxonomic group.
- The total and mean numbers of species retained by the different codends was relative to the selectivity characteristics of each; mean number of species ranged from 31 (T4mm100 and T3mm200) to 39 – 43 (controls).
- The frequency of capture was low for most species: only 7 species were caught in more than 90% of tows, while 50% of species were caught in fewer than 10% of tows, and 35 species (21%) were taken only once.
- Species frequency of capture was relative to their overall abundance: seven of the eight most abundant species were taken in 90% or more trawls.
- All catches were dominated by a small number of species; overall, 10 species (9 teleosts and southern calamari) contributed more than 90% of the total catch number and 70% of total catch weight.
- School whiting, longfin gurnard and longspine flathead were the most abundant species in the 40-mm control codend contributing respectively 46%, 15% and 11% of total catch numbers, and 39%, 9% and 9% of total catch weight.
- In all codends, elasmobranchs were relatively few in number (< 7%) but as high as 44% of catch weight in the most selective codend (T4mm100).

Table 8.1. Total and mean numbers of species recorded from the 90-mm mesh treatment (T) and 40-mm mesh control (C) codends in Experiments 1 and 2, and results of t-test comparisons of mean number of species between the treatments and corresponding control catches (n = no. of tows; ns = not significant; * $p < 0.05$; ** $p < 0.01$).

Experiment 1		Elasmobranchs			Teleosts			Molluscs			Crustaceans			All species		
Codends	**n**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**
Total treatment codends	45	23	5.8	0.3	66	17.4	0.9	20	6.4	0.3	17	2.9	0.3	126	32.5	1.2
T4mm200	16	20	5.9	0.4	51	19.0	1.4	18	6.8	0.4	11	3.1	0.4	100	34.8	1.8
T4mm200X	14	16	5.6	0.4	56	17.1	1.2	17	6.8	0.4	11	2.6	0.3	100	32.1	1.5
T4mm100	15	18	5.9	0.6	50	16.3	1.0	15	5.7	0.5	8	2.9	0.5	91	30.7	1.4
Total control catches	45	21	5.4	0.4	69	23.3	0.8	21	8.0	0.4	16	3.3	0.3	127	40.1	1.3
C200	15	15	5.7	0.6	59	25.1	1.2	20	8.5	0.5	10	3.5	0.4	104	42.9	2.2
C200X	15	15	5.3	0.6	57	22.6	1.2	20	7.9	0.5	12	3.1	0.2	104	38.9	1.5
C100	16	20	5.4	0.5	60	22.6	1.0	20	7.7	0.6	9	3.4	0.4	109	39.0	1.5
Comparisons																
T4mm200 – T4mm200X			ns			ns			ns			ns			ns	
T4mm200 – T4mm100			ns			ns			ns			ns			ns	
T4mm200X – T4mm100			ns			ns			ns			ns			ns	
T4mm200 – C200			ns			**			*			ns			*	
T4mm200X – C200X			ns			**			ns			ns			**	
T4mm100 – C100			ns			**			*			ns			**	
Experiment 2		**Elasmobranchs**			**Teleosts**			**Molluscs**			**Crustaceans**			**All species**		
Codends		**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**	**Total**	**Mean**	**SE**
Total treatment codends	32	21	4.3	0.4	61	18.6	0.7	21	6.9	0.4	9	3.0	0.2	112	32.8	1.0
T3mm200	16	14	4.4	0.4	52	16.9	0.8	18	6.3	0.5	8	2.9	0.4	92	30.6	1.0
T5mm200	16	19	4.1	0.6	57	20.4	1.0	21	7.6	0.6	7	3.0	0.3	104	35.1	1.6
Total control catches	30	20	4.5	0.4	70	24.1	0.6	21	7.1	0.3	11	3.8	0.3	122	39.5	0.9
C3mm	15	18	4.3	0.5	58	24.4	0.9	19	7.3	0.5	10	3.9	0.5	105	39.9	1.3
C5mm	15	18	4.7	0.6	63	24.3	0.9	21	6.8	0.4	11	3.7	0.3	113	39.4	1.4
Comparisons																
T3mm200 – T5mm200			ns			*			ns			ns			*	
T3mm200 – C3mm			ns			**			ns			ns			**	
T5mm200 – C5mm			ns			**			ns			ns			*	

Table 8.2. Top 20 species by number and weight, pooled for all catches taken by the treatment and control codends. [%No. and %Wt: species total no. and species total weight as % of total-catch number and total-catch weight; R = rank].

Treatment codends (n = 77)		**%No**	**R**	**%Wt**	**R**	**Control codend catches (n = 75)**		**%No**	**R**	**%Wt**	**R**
S. flindersi	School whiting	32.3	*1*	19.5	*1*	*S. flindersi*	School whiting	46.7	*1*	40.7	*1*
L. argus	Gurnard-longfin	26.2	*2*	11.7	*2*	*L. argus*	Gurnard-longfin	14.5	*2*	9.2	*2*
C. affinis	Redfish	13.0	*3*	8.3	*4*	*P. longispinus*	Flathead-longspine	10.7	*3*	9.1	*3*
N. ayraudi	Ocean jacket	6.5	*4*	8.4	*3*	*C. affinis*	Redfish	6.1	*4*	4.8	*4*
P. longispinus	Flathead-longspine	4.9	*5*	3.2	*9*	*T. novaezelandiae*	Yellowtail scad	3.6	*5*	1.6	*12*
T. novaezelandiae	Yellowtail scad	2.7	*6*	1.7	*12*	*Gnathophis* spp.	*Gnathophis* congers	3.0	*6*	2.8	*9*
S. australis	Southern calamari	2.1	*7*	5.6	*7*	*L. gallus*	Crested flounder	2.8	*7*	0.3	*25*
P. caeruleopunctatus	Flathead-bluespotted	1.3	*8*	5.9	*6*	*O. agastos*	Violet roughy	1.8	*8*	0.3	*26*
S. rozella	Rosecone cuttlefish	1.1	*9*	1.5	*13*	*N. ayraudi*	Ocean jacket	1.8	*9*	3.3	*7*
O. agastos	Violet roughy	0.9	*10*	0.1	*54*	*M. whitleyi*	Whitley's gurnard perch	1.6	*10*	0.1	*58*
Pagrus auratus	Snapper	0.7	*11*	0.9	*18*	*S. australis*	Southern calamari	0.9	*11*	3.7	*5*
P. richardsoni	Flathead-tiger	0.6	*12*	1.5	*14*	*O. australis*	Southern octopus	0.6	*12*	0.8	*16*
A. inermis	Smooth boxfish	0.5	*13*	1.0	*17*	*S. rozella*	Rosecone cuttlefish	0.5	*13*	1.1	*13*
T. testacea	Stingaree-common	0.5	*14*	3.0	*10*	*A. anomalus*	3 spined cardinalfish	0.5	*14*	<0.1	*67*
A. rostrata	Ray-shovelnose	0.5	*15*	5.3	*8*	*P. caeruleopunctatus*	Flathead-bluespotted	0.4	*15*	3.3	*8*
P. tenuirastrum	Slender flounder	0.4	*16*	0.6	*21*	*P. richardsoni*	Flathead-tiger	0.3	*16*	0.8	*15*
U. kapalensis	Stingaree-Kapala	0.4	*17*	1.4	*15*	*G. greyi*	Beaked salmon	0.2	*17*	0.4	*23*
I. peronii	Balmain bug	0.4	*18*	0.4	*24*	*A. inermis*	Smooth boxfish	0.2	*18*	0.7	*18*
C. kumu	Gurnard-red	0.4	*19*	0.7	*20*	*O. genyopus*	Ravenous cusk	0.2	*19*	<0.1	*73*
O. australis	Southern octopus	0.3	*20*	0.2	*35*	*Z. scalaris*	Manyband sole	0.2	*20*	0.3	*27*
Trygonorrhina sp A	Ray-banjo	0.2	*22*	2.5	*11*	*A. rostrata*	Ray-shovelnose	0.1	*27*	2.6	*10*
H. portusjacksoni	Shark-Port Jackson	0.2	*24*	6.5	*5*	*M. australis*	Ray-southern eagle	0.1	*28*	1.0	*14*
M. australis	Ray-southern eagle	0.2	*25*	0.9	*19*	*C. kumu*	Gurnard-red	0.1	*29*	0.4	*20*
C. brachyurus	Shark-bronze whaler	<0.1	*108*	1.1	*16*	*U. kapalensis*	Stingaree-Kapala	0.1	*30*	0.6	*19*
						Trygonorrhina sp A	Ray-banjo	0.1	*32*	2.0	*11*
						H. portusjacksoni	Shark-Port Jackson	0.1	*33*	3.5	*6*
						T. testacea	Stingaree-common	0.1	*34*	0.7	*17*
Totals:	Elasmobranchs	2.4		24.2		**Totals:**	Elasmobranchs	0.7		12.0	
	Teleosts	92.6		66.4			Teleosts	96.2		81.0	
	Molluscs	4.2		8.6			Molluscs	2.4		6.5	
	Crustaceans	0.8		0.8			Crustaceans	0.7		0.5	
	Total No. & Wt (kg)	**127691**		**15240**			**Total No. & Wt (kg)**	**348827**		**25987**	

Table 8.3. Top 20 species by number and weight taken by the T4mm100 and control codends during Experiment 1. [%No. and %Wt: species total no. and species total weight as % of total-catch number and total-catch weight; R = rank].

T4mm100 codend (n = 15)		**%No**	**R**	**%Wt**	**R**	**Control codend (n = 16)**		**%No**	**R**	**%Wt**	**R**
L. argus	Gurnard-longfin	28.9	*1*	9.2	*3*	*S. flindersi*	School whiting	43.7	*1*	37.7	*1*
C. affinis	Redfish	18.2	*2*	7.1	*6*	*L. argus*	Gurnard-longfin	14.2	*2*	9.5	*3*
S. flindersi	School whiting	10.6	*3*	4.1	*9*	*P. longispinus*	Flathead-longspine	13.6	*3*	11.2	*2*
N. ayraudi	Ocean jacket	6.9	*4*	3.8	*10*	*T. novaezelandiae*	Yellowtail scad	8.4	*4*	3.2	*8*
P. longispinus	Flathead-longspine	3.9	*5*	1.8	*15*	*C. affinis*	Redfish	5.0	*5*	4.2	*5*
S. rozella	Rosecone cuttlefish	3.6	*6*	3.1	*11*	*L. gallus*	Crested flounder	2.0	*6*	0.3	*25*
Pagrus auratus	Snapper	3.3	*7*	2.7	*14*	*Gnathophis* spp.	*Gnathophis* congers	2.0	*7*	1.8	*13*
P. caeruleopunctatus	Flathead-bluespotted	2.8	*8*	8.3	*5*	*M. whitleyi*	Whitley's gurnard perch	1.2	*8*	<0.1	*59*
S. australis	Southern calamari	2.4	*9*	4.3	*8*	*N. ayraudi*	Ocean jacket	1.2	*9*	1.8	*11*
T. testacea	Stingaree-common	2.0	*10*	8.6	*4*	*O. agastos*	Violet roughy	1.1	*10*	0.2	*33*
P. richardsoni	Flathead-tiger	1.8	*11*	2.7	*13*	*S. rozella*	Rosecone cuttlefish	0.9	*11*	1.7	*14*
A. strigatus	Mado	1.7	*12*	0.6	*23*	*A. anomalus*	3 spined cardinalfish	0.7	*12*	0.1	*54*
A. rostrata	Ray-shovelnose	1.6	*13*	11.8	*1*	*S. australis*	Southern calamari	0.6	*13*	1.8	*10*
M. australis	Ray-southern eagle	1.1	*14*	2.7	*12*	*P. caeruleopunctatus*	Flathead-bluespotted	0.6	*14*	4.0	*6*
T. novaezelandiae	Yellowtail scad	0.9	*15*	0.5	*26*	*P. richardsoni*	Flathead-tiger	0.4	*15*	1.1	*15*
I. peronii	Balmain bug	0.9	*16*	0.6	*25*	*G. greyi*	Beaked salmon	0.3	*16*	0.5	*20*
L. mulhalli	Gurnard-roundsnout	0.8	*17*	0.2	*33*	*M. australis*	Ray-southern eagle	0.3	*17*	2.3	*9*
A. inermis	Smooth boxfish	0.8	*18*	1.0	*17*	*A. inermis*	Smooth boxfish	0.3	*18*	0.7	*17*
U. kapalensis	Stingaree-Kapala	0.8	*19*	1.6	*16*	*P. tenuirastrum*	Slender flounder	0.3	*19*	0.5	*21*
P. tenuirastrum	Slender flounder	0.7	*20*	0.6	*21*	*S. undosquamis*	Largescale grinner	0.1	*20*	0.1	*53*
C. kumu	Gurnard-red	0.7	*21*	0.8	*19*	*A. rostrata*	Ray-shovelnose	0.2	*21*	4.2	*4*
Trygonorrhina sp A	Ray-banjo	0.7	*22*	5.0	*7*	*T. testacea*	Stingaree-common	0.1	*28*	0.9	*16*
H. portusjacksoni	Shark-Port Jackson	0.3	*27*	10.8	*2*	*Trygonorrhina* sp A	Ray-banjo	0.1	*33*	1.8	*12*
M. antarcticus	Shark-gummy	0.1	*35*	0.9	*18*	*H. portusjacksoni*	Shark-Port Jackson	<0.1	*40*	3.7	*7*
H. galeatus	Shark-crested horn	0.1	*25*	0.8	*20*	*S. apama*	Giant cuttlefish	<0.1	*59*	0.6	*18*
						S. albipunctata	Shark-eastern angel	<0.1	*85*	0.6	*19*
Totals:	Elasmobranchs	6.8		43.9		**Totals:**	Elasmobranchs	0.9		14.9	
	Teleosts	84.4		46.4			Teleosts	96.4		79.5	
	Molluscs	7.4		8.6			Molluscs	2.2		5.1	
	Crustaceans	1.4		1.1			Crustaceans	0.6		0.5	
	Total No. & Wt (kg)	**14148**		**2618**			**Total No. & Wt (kg)**	**70900**		**5197**	

Table 8.4. Top 20 species by number and weight taken by the T5mm200 and control codends during Experiment 2. [%No. and %Wt: species total no. and species total weight as % of total-catch number and total-catch weight; R = rank].

T5mm200 codend (n = 16)		%No	R	%Wt	R	**Control codend (n = 15)**		%No	R	%Wt	R
S. flindersi	School whiting	34.2	*1*	25.3	*1*	*S. flindersi*	School whiting	37.1	*1*	37.5	*1*
L. argus	Gurnard-longfin	29.1	*2*	12.8	*3*	*L. argus*	Gurnard-longfin	23.1	*2*	13.7	*2*
N. ayraudi	Ocean jacket	11.1	*3*	18.5	*2*	*P. longispinus*	Flathead-longspine	8.6	*3*	7.5	*4*
P. longispinus	Flathead-longspine	7.1	*4*	4.8	*5*	*Gnathophis* spp.	*Gnathophis* congers	4.3	*4*	4.1	*6*
C. affinis	Redfish	6.0	*5*	4.5	*6*	*N. ayraudi*	Ocean jacket	4.1	*5*	8.7	*3*
S. australis	Southern calamari	2.2	*6*	7.1	*4*	*L. gallus*	Crested flounder	4.0	*6*	0.4	*21*
T. novaezelandiae	Yellowtail scad	1.3	*7*	1.1	*14*	*T. novaezelandiae*	Yellowtail scad	3.7	*7*	1.2	*12*
O. agastos	Violet roughy	1.2	*8*	0.2	*34*	*C. affinis*	Redfish	3.5	*8*	3.1	*7*
O. australis	Southern octopus	0.7	*9*	0.7	*18*	*O. agastos*	Violet roughy	2.3	*9*	0.4	*22*
P. caeruleopunctatus	Flathead-bluespotted	0.6	*10*	3.2	*7*	*M. whitleyi*	Whitley's gurnard perch	1.6	*10*	0.1	*56*
P. richardsoni	Flathead-tiger	0.5	*11*	1.5	*12*	*S. australis*	Southern calamari	1.2	*11*	5.8	*5*
A. inermis	Smooth boxfish	0.5	*11*	1.0	*15*	*O. australis*	Southern octopus	1.0	*12*	1.5	*9*
Gnathophis spp.	*Gnathophis* congers	0.5	*13*	0.4	*23*	*M. plebejus*	King prawn	0.5	*13*	0.1	*40*
U. kapalensis	Stingaree-Kapala	0.4	*14*	2.1	*9*	*O. genyopus*	Ravenous cusk	0.5	*14*	0.1	*54*
M. plebejus	King prawn	0.3	*15*	<0.1	*61*	*G. greyi*	Beaked salmon	0.4	*15*	0.5	*18*
L. gallus	Crested flounder	0.3	*16*	<0.1	*73*	*T. recurvirostris*	Hardback prawn	0.4	*16*	<0.1	*73*
C. kumu	Gurnard-red	0.2	*17*	0.6	*19*	*A. inermis*	Smooth boxfish	0.3	*17*	0.7	*15*
P. tenuirastrum	Slender flounder	0.2	*18*	0.3	*27*	*S. undosquamis*	Largescale grinner	0.3	*18*	0.3	*24*
S. rozella	Rosecone cuttlefish	0.2	*19*	0.3	*27*	*P. caeruleopunctatus*	Flathead-bluespotted	0.2	*19*	2.1	*8*
I. peronii	Balmain bug	0.2	*20*	0.3	*30*	*Z. scalaris*	Manybanded sole	0.2	*20*	0.3	*23*
P. pelagicus	Crab-blue swimmer	0.2	*22*	0.5	*20*	*P. richardsoni*	Flathead-tiger	0.2	*21*	0.8	*14*
T. testacea	Stingaree-common	0.2	*23*	2.2	*8*	*C. kumu*	Gurnard-red	0.2	*22*	0.4	*19*
A. rostrata	Ray-shovelnose	0.1	*29*	1.6	*11*	*U. kapalensis*	Stingaree-Kapala	0.1	*30*	0.7	*16*
H. portusjacksoni	Shark-Port Jackson	0.1	*34*	1.7	*10*	*A. rostrata*	Ray-shovelnose	0.1	*33*	1.4	*10*
Trygonorrhina sp A	Ray-banjo	0.1	*37*	1.2	*13*	*Trygonorrhina* sp A	Ray-banjo	<.1	*35*	1.2	*11*
H. monopterygium	Ray-coffin	<0.1	*47*	0.9	*17*	*T. testacea*	Stingaree-common	<0.1	*37*	0.6	*17*
D. brevicaudata	Smooth stingray	<0.1	*85*	1.0	*16*	*M. australis*	Ray-southern eagle	<0.1	*45*	0.4	*20*
						H. portusjacksoni	Shark-Port Jackson	<0.1	*58*	1.2	*13*
Totals:	Elasmobranchs	1.1		12.4		**Totals:**	Elasmobranchs	0.5		7.0	
	Teleosts	94.3		77.1			Teleosts	95.7		84.1	
	Molluscs	3.8		9.6			Molluscs	2.6		8.2	
	Crustaceans	0.8		0.9			Crustaceans	1.2		0.7	
	Total No. & Wt (kg)	**30643**		**3153**			**Total No. & Wt (kg)**	**65096**		**4718**	

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10. APPENDICES

Appendix 1a. Operational data for tows by FV *Kirrawa* codends for Experiment 1 during 2005 (* preliminary tow).

Tow No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
*250101	1-3-05	1945	2115	33°36'	151°24'	33°32'	151°27'	N		24-26	43-48	T4mm100	90	NE	20-25	4
*250102	1-3-05	2220	2350	33°34'	151°26'	33°38'	151°23'	S		22-26	41-48	control	42	NE	15-20	4
*250103	2-3-05	0115	0245	33°37'	151°23'	33°34'	151°26'	N		26-28	48-51	T4mm100	90	NE	10-15	3
*250104	2-3-05	0400	0530	33°34'	151°25'	33°38'	151°22'	S		24-25	43-45	control	42	NE	0-5	1
*250201	7-3-05	2040	2220	33°25'	151°33'	33°21'	151°35'	N		26-29	48-53	control	42	NE	15-20	3
*250202	7-3-05	2300	0030	33°21'	151°35'	33°17'	151°38'	N		26-28	48-51	T4mm200X	90	NE	10-15	2
*250203	8-3-05	0115	0245	33°18'	151°38'	33°21.3'	151°36.3'	S		27-29	50-53	control	42	NE	5-10	2
*250204	8-3-05	0345	0515	33°22.3'	151°35.1'	33°25'	151°32'	S		25-27	45-50	T4mm200X	90	NE	0-5	1
250301	14-3-06	1900	2030	33°28.5'	151°31.2'	33°25.2'	151°33.6'	N	3.8	27-28	50-51	control	42	NE	20-25	4
250302	14-3-07	2150	2320	33°26.8'	151°32.3'	33°31.3'	151°28.7'	S	5.5	28-30	51-55	T4mm200	90	NE	15-20	3
250303	15-3-08	0045	0215	33°32.4'	151°27.9'	33°29.2'	151°30.8'	N	4.0	27-28	50-51	control	42	NE	10-15	2
250304	15-3-09	0330	0500	33°30.4'	151°28.7'	33°35.5'	151°25.2'	S	5.9	26-27	48-50	T4mm200	90	NE	0-5	2
250401	6-4-05	1800	1930	33°21.8'	151°35.5'	33°18.0'	151°38.1'	N	4.4	25-27	45-50	T4mm200X	90	ESE	0-5	2
250402	6-4-05	2020	2155	33°19.0'	151°37.3'	33°22.8'	151°35.0'	S	4.3	25-27	45-50	control	42	ESE	0-5	2
250403	6-4-05	2255	0035	33°24.4'	151°33.9'	33°28.6'	151°31.1'	S	4.8	26-28	48-51	T4mm200X	90	SW	0-5	2
250404	7-4-05	0130	0300	33°28.2'	151°31.4'	33°24.9'	151°33.3'	N	4.0	26-28	48-51	control	42	WSW	0-5	2
250501	13-4-05	1807	1937	33°33.7'	151°26.9'	33°30.0'	151°29.8'	N	4.4	27-28	50-51	control	42	ENE	5-10	2
250502	13-4-05	2025	2200	33°29.4'	151°30.5'	33°25.6'	151°33.1'	N	4.6	28-29	51-53	T4mm100	90	NW	0-5	1
250503	13-4-05	2250	0020	33°26.5'	151°32.5'	33°29.8'	151°29.9'	S	4.0	27-29	50-53	control	42	W	0-5	1
250504	14-4-05	0115	0245	33°30.5'	151°29.3'	33°33.7'	151°26.2'	S	4.2	26-28	48-51	T4mm100	90	W	0-5	2
250601	17-4-05	1835	2005	33°36.0'	151°25.4'	33°32.4'	151°27.8'	N	4.2	26-28	48-51	T4mm200	90	NE	20-25	4
250602	17-4-05	2105	2235	33°31.9'	151°28.1'	33°28.8'	151°30.4'	N	3.7	26-28	48-51	control	42	NE	15-20	3
250603	17-4-05	2340	0110	33°29.5'	151°30.5'	33°32.9'	151°27.8'	S	4.3	26-28	48-51	T4mm200	90	NE	10-15	2
250604	18-4-05	0210	0340	33°34.3'	151°26.6'	33°37.5'	151°23.9'	S	4.0	26-28	48-51	control	42	NE	0-5	2
250701	18-4-05	1740	1910	33°33.1'	151°26.9'	33°29.7'	151°29.6'	N	4.2	26-28	48-51	control	42	NE	10-15	4
250702	18-4-05	2000	2130	33°28.9'	151°30.2'	33°25.4'	151°32.5'	N	4.0	26-28	48-51	T4mm200X	90	NE	5-10	3
250703	18-4-05	2230	2400	33°26.1'	151°32.7'	33°29.7'	151°29.9'	S	4.2	26-28	48-51	control	42	NE	0-5	2
250704	19-4-05	0055	0235	33°30.8'	151°29.6'	33°34.6'	151°26.4'	S	4.6	27-29	50-53	T4mm200X	90	SW	5-15	2

Appendix 1a (continued). Operational data for tows by FV *Kirrawa* for Experiment 1 during 2005 (**+** tow not used for catch data analyses).

Tow No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
250801	21-4-05	1730	1900	33°39.9'	151°22.7'	33°35.9'	151°24.8'	N	4.4	26-28	48-51	T4mm100	90	ENE	5-10	2
250802	21-4-05	1945	2115	33°35.1'	151°25.1'	33°31.3'	151°28.3'	N	4.6	26-28	48-51	control	42	NW	0-5	1
250803	21-4-05	2205	2335	33°31.3'	151°28.4'	33°35.1'	151°25.6'	S	4.4	26-28	48-51	T4mm100	90	W	0-5	1
250804	22-4-05	30	215	33°36.1'	151°25.2'	33°40.2'	151°22.7'	S	4.5	26-28	48-51	control	42	W	0-5	2
250901	25-4-05	1845	2015	33°32.8'	151°27.6'	33°29.1'	151°30.3'	N	4.2	27-29	50-53	control	42	NE	5-10	2
250902	25-4-05	2120	2250	33°29.1'	151°30.9'	33°25.3'	151°33.2'	N	4.2	27-30	50-55	T4mm200X	90	NW	1	1
250903	25-4-05	2345	115	33°26.0'	151°32.7'	33°30.0'	151°30.0'	S	4.4	27-29	50-53	control	42	-	-	1
250904	26-4-05	230	400	33°29.3'	151°30.0'	33°33.5'	151°27.3'	S	4.8	27-28	50-52	T4mm200X	90	-	-	1
251001	26-4-05	1720	1850	33°33.3'	151°27.5'	33°29.6'	151°30.1'	N	4.4	27-29	50-53	T4mm200	90	NE	5-10	2
251002	26-4-05	1940	2110	33°29.0'	151°30.7'	33°25.5'	151°33.3'	N	4.2	27-29	50-53	control	42	NW	1	1
251003	26-4-05	2205	2335	33°26.3'	151°32.9'	33°29.8'	151°30.0'	S	4.2	28-29	51-53	T4mm200	90	-	-	1
+251004	27-4-05	25	155	33°31.1'	151°29.2'	33°34.7'	151°26.7'	S	4.1	27-29	50-53	control	42	-	-	1
+251101	3-5-05	1750	1920	33°32.4'	151°27.2'	33°28.9'	151°30.2'	N	4.2	26-28	48-51	control	42	NW	5	1
+251102	3-5-05	2015	2145	33°27.6'	151°31.7'	33°23.8'	151°34.3'	N	4.3	26-28	48-51	T4mm100	90	NW	1	1
+251103	3-5-05	2245	15	33°26.5'	151°31.6'	33°30.1'	151°29.5'	S	4.1	25-28	45-51	control	42	-	-	1
+251104	4-5-05	120	250	33°29.5'	151°29.1'	33°33.2'	151°26.4'	S	4.3	25-27	45-50	T4mm100	90	-	-	1
251201	4-5-05	1730	1900	33°38.0'	151°27.3'	33°34.3'	151°29.9'	N	4.2	35-37	64-68	T4mm200	90	N	5	1
251202	4-5-05	2000	2130	33°34.0'	151°29.6'	33°37.4'	151°27.4'	S	4.0	34-36	62-66	control	42	NW	1	1
251203	4-5-05	2225	2355	33°37.5'	151°27.3'	33°33.5'	151°29.9'	N	4.3	35-37	64-68	T4mm200	90	-	-	1
251204	5-5-05	100	230	33°33.9'	151°29.4'	33°37.6'	151°26.9'	S	4.3	33-35	60-64	control	42	-	-	1
251301	9-5-05	1730	1900	33°38.7'	151°26.5'	33°34.8'	151°29.2'	N	4.5	34-36	62-66	control	42	NE	5	1
251302	9-5-05	2000	2130	33°34.0'	151°29.3'	33°37.7'	151°27.0'	S	4.2	33-34	60-62	T4mm200X	90	NW	10	1
251303	9-5-05	2240	10	33°34.3'	151°26.4'	33°30.6'	151°28.8'	N	4.2	27-28	50-52	control	42	NW	5	1
251304	10-5-05	130	300	33°29.8'	151°29.5'	33°33.6'	151°26.8'	S	4.3	26-28	48-51	T4mm200X	90	NW	5	1
+251401	10-5-05	1650	1820	33°34.2'	151°26.8'	33°33.1'	151°29.7'	N	4.2	27-28	50-52	T4mm100	90	NE	8	1
+251402	10-5-05	1915	2045	33°29.5'	151°30.4'	33°26.2'	151°32.8'	N	4.0	28-29	51-53	control	42	NE	8	1
+251403	10-5-05	2150	2330	33°26.5'	151°31.5'	33°30.5'	151°28.4'	S	4.5	25-27	45-50	T4mm100	90	NW	5	1
+251404	11-5-05	45	215	33°32.8'	151°28.6'	33°36.6'	151°25.6'	S	4.4	28-30	51-55	control	42	NW	5	1

Appendix 1a (continued). Operational data for tows by FV *Kirrawa* for Experiment 1 during 2005 (**+** tow not used for catch data analyses).

No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
251501	14-6-05	1830	2000	33°32.3'	151°30.4'	33°28.8'	151°31.8'	N	4.0	31-32	57-59	control	42	NW	15	1
251502	14-6-05	2045	2215	33°28.2'	151°32.4'	33°24.7'	151°34.7'	N	4.0	30-33	55-60	T4mm200	90	NW	10	1
251503	14-6-05	2330	0100	33°23.6'	151°36.0'	33°27.6'	151°33.3'	S	5.2	32-35	59-64	control	42	NW	15	1
251504	15-6-05	0150	0330	33°27.4'	151°33.9'	33°23.5'	151°35.8'	N	4.2	31-35	57-64	T4mm200	90	NW	10	1
251601	15-6-05	1700	1830	33°28.5'	151°32.2'	33°32.6'	151°30.9'	S	4.3	33-35	60-64	T4mm200X	90	W	2	1
251602	15-6-05	1930	2100	33°32.3'	151°27.7'	33°29.0'	151°30.2'	N	4.0	27-28	50-51	control	42	W	5	1
251603	15-6-05	2215	2345	33°32.5'	151°30.3'	33°36.6'	151°28.1'	S	4.2	32-34	59-62	T4mm200X	90	W	10	1
251604	16-6-05	0100	0240	33°33.8'	151°29.7'	33°37.8'	151°27.0'	S	4.6	33-35	60-64	control	42	W	5	1
251701	19-7-05	1700	1830	33°28.3'	151°32.3'	33°24.9'	151°34.8'	N	4.0	31-33	57-60	control	42	SE	15	2/3
251702	19-7-05	2030	2200	33°23.7'	151°35.8'	33°20.1'	151°38.4'	N	4.1	31-33	57-60	T4mm100	90	SE	15	2/3
251703	19-7-05	2340	0110	33°20.1'	151°38.2'	33°23.7'	151°36.2'	S	4.2	31-33	57-60	control	42	SE	10	2/3
251704	20-7-05	0230	0400	33°24.3'	151°36.1'	33°27.7'	151°32.3'	S	4.2	33-34	60-62	T4mm100	90	SE	10	2/3
+251801	27-7-05	2000	2130	33°27.7'	151°32.9'	33°24.2'	151°35.7'	N	4.5	31-34	57-62	T4mm200	90	N	5	1
+251802	27-7-05	2230	0000	33°23.1'	151°36.0'	33°19.1'	151°39.4'	N	4.5	31-33	57-60	control	42	N	5	1
+251803	28-7-05	0130	0300	33°18.4'	151°39.7'	33°22.2'	151°36.8'	S	4.6	31-34	57-62	T4mm200	90	NW	5	1
+251804	28-7-05	0430	0600	33°21.9'	151°37.1'	33°26.0'	151°35.2'	S	4.6	32-34	59-62	control	42	W	5	1
+251901	28-7-05	1700	1830	33°40.1'	151°27.0'	33°36.2'	151°29.3'	N	4.5	38-43	70-79	control	42	W	5	1
+251902	28-7-05	1920	2050	33°36.7'	151°28.9'	33°40.8'	151°26.5'	S	4.3	39-45	71-82	T4mm200X	90	W	5	1
+252001	9-8-05	2000	2130	33°19.6'	151°38.9'	33°16.1'	151°40.9'	N	4.2	30-33	55-60	control	42	NW	10	1
+252002	9-8-05	2230	2400	33°17.0'	151°40.5'	33°20.9'	151°38.1'	S	4.0	32-34	59-62	T4mm200X	90	NW	15	1
+252003	10-8-05	0150	0330	33°30.3'	151°31.7'	33°34.6'	151°30.1'	S	4.2	32-38	59-70	T4mm100	90	NW	15	1
+252004	10-8-05	0430	0600	33°36.5'	151°29.3'	33°40.5'	151°26.8'	S	4.3	37-43	68-79	control	42	NW	20	2
+252101	17-8-05	0020	0150	33°21.8'	151°36.1'	33°17.7'	151°38.3'	N	4.4	26-28	48-51	control	42	W	5	1
+252102	17-8-05	0300	0430	33°18.0'	151°38.4'	33°22.7'	151°35.5'	S	4.5	28-29	51-53	T4mm200X	90	W	5	1

Appendix 1b. Operational data for tows by FV *May Bell II* for Experiment 1 during 2005 (**+** tow not used for catch data analyses).

Tow No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
+252201	17-8-05	1740	1910	33°23.3'	151°34.4'	33°19.6'	151°37.3'	N	4.4	27-29	49-53	T4mm200X	90	NE	5	1
+252202	17-8-05	2000	2130	33°18.5'	151°37.8'	33°14.6'	151°40.5'	N	4.5	26-28	48-51	control	42	NW	5	1
+252203	17-8-05	2205	2335	33°15.1'	151°40.3'	33°19.1'	151°37.8'	S	4.5	27-29	49-53	control	42	W	5	1
+252204	18-8-05	30	200	33°20.1'	151°37.2'	33°24.0'	151°34.3'	S	4.4	26-29	48-53	T4mm100	90	W	5	1
+252301	5-10-05	1730	1900	33°28.6'	151°30.6'	33°24.9'	151°34.0'	N	4.2	26-29	48-53	control	42	NE	15	2
+252302	5-10-05	1950	2120	33°23.9'	151°34.5'	33°20.2'	151°36.8'	N	4.2	27-29	49-53	T4mm200	90	NW	10	2
+252303	5-10-05	2300	30	33°28.2'	151°31.2'	33°32.0'	151°28.2'	S	4.5	28-29	51-53	control	42	SW	5	1
+252304	6-10-05	110	240	33°32.8'	151°28.1'	33°37.1'	151°25.2'	S	4.5	28-29	51-53	T4mm200	90	S	15	2
252401	12-10-05	1815	1945	33°34.3'	151°28.0'	33°30.4'	151°30.0'	N	4.2	29-31	53-57	T4mm100	90	ENE	5	2
252402	12-10-05	2030	2200	33°29.4'	151°30.0'	33°26.0'	151°33.3'	N	4.5	28-30	51-55	control	42	NE	10	2
252403	12-10-05	2300	30	33°24.4'	151°33.2'	33°20.9'	151°36.2'	N	4.4	25-27	45-49	T4mm100	90	N	10	2
252404	13-10-05	125	255	33°20.0'	151°36.9'	33°15.8'	151°38.8'	N	4.4	25-28	45-51	control	42	N	5	2
252501	26-10-05	1830	2000	33°34.2'	151°25.4'	33°37.3'	151°23.0'	S	4.2	24-27	43-50	control	42	N	5	2
252502	26-10-05	2110	2240	33°37.8'	151°23.2'	33°33.4'	151°25.7'	N	4.7	23-26	42-48	T4mm200	90	NW	10	1
252503	27-10-05	5	135	33°34.4'	151°25.4'	33°38.2'	151°23.1'	S	4.6	25-27	45-50	control	42	W	10	1
252504	27-10-05	250	420	33°37.7'	151°23.2'	33°33.8'	151°25.5'	N	4.6	24-27	43-50	T4mm200	90	SE	10	1
252601	29-10-05	1745	1915	33°39.0'	151°22.8'	33°34.9'	151°24.3'	N	4.4	23-28	42-51	control	42	NE	5	1
252602	29-10-05	2030	2200	33°34.5'	151°24.1'	33°38.6'	151°22.9'	S	4.2	23-27	42-50	T4mm200X	90	NE	5	1
252603	29-10-05	2300	30	33°38.5'	151°23.2'	33°33.9'	151°25.5'	N	4.9	24-27	43-50	control	42	NE	5	1
252604	30-10-05	200	330	33°34.0'	151°25.4'	33°38.7'	151°23.0'	S	5.0	24-28	43-51	T4mm200X	90	SE	5	1
252701	31-10-05	1810	1940	33°37.6'	151°22.9'	33°33.6'	151°25.6'	N	4.5	25-26	45-48	control	42	NE	5	2
252702	31-10-05	2040	2210	33°33.2'	151°26.1'	33°29.4'	151°28.0'	N	4.5	25-26	45-48	T4mm100	90	NE	10	2
252703	31-10-05	2310	40	33°30.9'	151°28.3'	33°34.8'	151°25.4'	S	4.2	25-28	45-51	control	42	NE	15	2
252704	1-11-05	140	310	33°34.7'	151°25.5'	33°30.9'	151°28.3'	N	4.4	25-26	45-48	T4mm100	90	NE	10	2

Appendix 2. Operational data for tows by FV *May Bell II* for Experiment 2 during 2006 (**+** tow not used for catch data analyses).

Tow No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
260101	7-3-06	1945	2115	33°30.6'	151°29.1'	33°27.3'	151°30.0'	N	4.0	27-29	49-53	control	42	SE	15	2
260102	7-3-06	2200	2330	33°26.2'	151°32.6'	33°23.1'	151°35.9'	N	4.2	27-30	49-55	T3mm200	90	SE	15	2
260103	8-3-06	0020	0150	33°23.1'	151°35.6'	33°26.5'	151°33.0'	S	4.0	27-30	49-55	control	42	SE	15	2
260104	8-3-06	0300	0430	33°27.2'	151°31.9'	33°31.0'	151°29.2'	S	4.2	27-31	49-57	T3mm200	90	SE	10	2
260201	8-3-06	1950	2120	33°34.4'	151°26.9'	33°31.0'	151°29.4'	N	4.0	28-30	51-55	T5mm200	90	NE	10	2
260202	8-3-06	2210	2340	33°30.2'	151°29.5'	33°26.2'	151°31.8'	N	4.2	24-29	44-53	control	42	NE	15	2
260203	9-3-06	0050	0220	33°26.9'	151°31.4'	33°30.2'	151°29.2'	S	4.2	25-28	46-51	T5mm200	90	N	5	1
260204	9-3-06	0315	0450	33°31.8'	151°28.0'	33°35.8'	151°25.0'	S	4.5	26-28	48-51	control	42	N	5	1
260301	21-3-06	1905	2035	33°33.7	151°26.4'	33°30.6'	151°29.1'	N	4.0	25-29	46-53	T3mm200	90	SE	10	2
260302	21-3-06	2125	2300	33°29.0'	151°29.9'	33°25.6'	151°33.2'	N	4.0	27-29	49-53	control	42	SE	10	2
260303	21-3-06	2350	0120	33°25.5'	151°33.1'	33°29.0'	151°30.5'	S	4.0	28-29	51-53	T3mm200	90	SE	10	2
260304	22-3-06	0215	0345	33°29.5'	151°29.7'	33°32.9'	151°26.6'	S	4.0	26-29	48-53	control	42	SE	10	2
260401	22-3-06	2020	2150	33°27.6'	151°31.9'	33°24.6'	151°35.1'	N	4.2	28-31	51-57	control	42	SE	10	2
260402	22-3-06	2245	0015	33°23.2'	151°35.7'	33°19.2'	151°37.4'	N	4.2	27-30	49-55	T5mm200	90	SE	10	2
260403	23-3-06	0115	0245	33°19.3'	151°37.4'	33°23.4'	151°35.4'	S	4.2	28-29	51-53	control	42	SE	10	2
260404	23-3-06	0400	0530	33°24.6'	151°34.9'	33°27.5'	151°31.9'	S	4.2	28-31	51-57	T5mm200	90	SE	10	2
+260501	23-3-06	1910	2040	33°38.1'	151°24.0'	33°34.9'	151°26.8'	N	4.0	28-29	51-53	control	42	SE	5	2
260502	23-3-06	2135	2305	33°33.9'	151°27.0'	33°30.3'	151°29.3'	N	4.0	27-29	49-53	T3mm200	90	SE	10	2
260503	23-3-06	2355	0125	33°30.5'	151°28.9'	33°34.8'	151°26.5'	S	4.0	27-29	49-53	control	42	SE	10	2
260504	24-3-06	0225	0355	33°35.5'	151°24.0'	33°39.7'	151°22.7'	S	4.0	27-29	49-53	T3mm200	90	SE	10	2
260601	17-4-06	1810	1940	33°34.8'	151°25.3'	33°32.1'	151°28.4'	N	3.8	25-29	46-53	T5mm200	42	NE	20	3
260602	17-4-06	2035	2205	33°31.5'	151°29.5'	33°28.1'	151°31.3'	N	3.9	28-31	51-57	control	90	N	20	3
260603	17-4-06	2300	0030	33°27.7'	151°31.6'	33°31.2'	151°28.5'	S	4.3	27-29	49-53	T5mm200	42	NW	15	2
260604	18-4-06	0125	0255	33°31.5'	151°28.4'	33°34.9'	151°25.9'	S	4.2	26-29	48-53	control	90	NW	10	2
260701	18-4-06	1800	1930	33°31.1'	151°28.9'	33°27.6'	151°31.4'	N	4.1	26-29	48-53	control	42	W	10	1
260702	18-4-06	2015	2145	33°27.2'	151°32.1'	33°23.6'	151°34.7'	N	4.1	27-29	49-53	T3mm200	90	W	10	1

Appendix 2 (continued). Operational data for tows by FV *May Bell II* for Experiment 2 during 2006 (**+** tow not used for catch data analyses).

Tow No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
260703	18-4-06	2235	2400	33°24.4'	151°34.5'	33°27.7'	151°32.0'	S	4.0	28-30	51-55	control	42	W	5	1
260704	19-4-06	0050	0220	33°29.1'	151°31.1'	33°32.6'	151°27.6'	S	4.5	27-31	49-57	T3mm200	90	W	5	1
260801	19-4-06	1800	1930	33°32.0'	151°28.0'	33°28.8'	151°31.0'	N	4.1	27-29	49-53	T5mm200	90	NE	15	3
260802	19-4-06	2005	2135	33°27.9'	151°32.2'	33°24.8'	151°34.0'	N	4.1	27-29	49-53	control	42	NE	10	2
260803	19-4-06	2210	2340	33°25.3'	151°33.7'	33°28.9'	151°30.8'	S	4.2	29-30	53-55	T5mm200	90	NW	5	1
260804	20-4-06	0020	0150	33°30.0'	151°29.8'	33°33.5'	151°27.1'	S	4.0	27-30	49-55	control	42	W	5	1
260901	28-4-06	1840	2010	33°35.1'	151°25.7'	33°31.8'	151°28.4'	N	4.0	27-30	49-55	control	42	NE	5	2
260902	28-4-06	2100	2230	33°30.9'	151°28.4'	33°27.8'	151°31.1'	N	4.0	27-28	49-51	T3mm200	90	NE	5	2
260903	28-4-06	2325	0055	33°27.7'	151°31.9'	33°31.1'	151°29.4'	S	4.0	28-31	51-57	control	42	NW	5	2
260904	29-4-06	0200	0330	33°31.2'	151°29.0'	33°34.7'	151°26.4'	S	4.0	27-30	49-55	T3mm200	90	NW	5	2
261001	29-4-06	1720	1850	33°32.5'	151°27.9'	33°29.3'	151°30.5'	N	4.0	28-30	51-55	T5mm200	90	N	10	2
261002	29-4-06	1930	2100	33°28.8'	151°30.8'	33°25.3'	151°32.6'	N	4.0	25-29	46-53	control	42	N	5	2
261003	29-4-06	2145	2315	33°25.6'	151°32.3'	33°28.8'	151°30.3'	S	4.5	25-28	46-51	T5mm200	90	N	10	2
261004	29-4-06	2355	0125	33°29.8'	151°29.6'	33°32.5'	151°27.1'	S	4.3	26-29	48-53	control	42	S	10	2
+261101	30-4-06	1645	1815	33°31.7'	151°27.5'	33°28.4'	151°29.6'	N	4.0	25-26	46-48	control	42	NW	5	1
+261102	30-4-06	1850	2020	33°27.8'	151°30.1'	33°24.5'	151°33.0'	N	4.0	25-27	46-49	T3mm200	90	NW	5	1
+261103	30-4-06	2100	2230	33°24.8'	151°32.9'	33°28.3'	151°30.5'	S	4.2	26-28	48-51	control	42	W	5	1
+261104	30-4-06	2310	0040	33°29.3'	151°29.9'	33°32.6'	151°27.2'	S	4.2	26-29	48-53	T3mm200	90	W	5	1
+261201	13-5-06	1635	1805	33°30.3'	151°27.8'	33°28.4'	151°26.8'	N	4.3	25-28	46-51	control	42	NE	5	1
+261202	13-5-06	1850	2020	33°25.9'	151°32.2'	33°23.2'	151°35.8'	N	4.1	26-30	48-55	T5mm200	90	NE	5	1
+261203	13-5-06	2350	0120	33°28.8'	151°30.7'	33°31.7'	151°28.7'	S	4.2	28-30	51-55	control	42	NW	5	1
+261204	14-5-06	0220	0400	33°32.8'	151°27.0'	33°35.0'	151°23.0'	S	4.3	22-27	40-49	T5mm200	90	SW	5	1
261301	15-5-06	1945	2115	33°20.5'	151°37.1'	33°17.0'	151°39.2'	N	4.0	27-30	49-55	T3mm200	90	NE	5	1
261302	15-5-06	2200	2330	33°16.5'	151°39.5'	33°13.0'	151°41.7'	N	4.0	26-29	48-53	control	42	NE	5	1
261303	16-5-06	0010	0140	33°12.5'	151°41.5'	33°08.8'	151°43.3'	N	4.0	26-29	48-53	T3mm200	90	NE	5	1
261304	16-5-06	0220	0350	33°08.1'	151°43.6'	33°04.7'	151°45.1'	N	4.0	25-27	46-49	control	42	NE	5	1
261401	16-5-06	1630	1800	33°03.8'	151°45.5'	33°08.6'	151°43.3'	S	5.0	26-27	48-49	control	42	NE	5	1

Appendix 2 (continued). Operational data for tows by FV *May Bell II* for Experiment 2 during 2006.

Tow No.	Date	Start Time	Finish Time	Start Position		Finish Position		Tow dir.	Dist. (nm)	Depth fm	Depth m	Codend	Mesh (mm)	Wind Dir.	Wind Speed	Sea State
261402	16-5-06	1850	2020	33°10.4'	151°43.1'	33°15.5'	151°40.6'	S	5.0	28-31	51-57	T5mm200	90	NE	5	1
261403	16-5-06	2115	2245	33°17.4'	151°39.1'	33°21.7'	151°36.0'	S	4.5	28-29	51-53	control	42	NE	5	1
261404	16-5-06	2345	0115	33°23.0'	151°35.4'	33°26.5'	151°32.4'	S	4.5	28-29	51-53	T5mm200	90	NE	5	1
261501	27-6-06	1715	1845	33°34.8'	151°28.6'	33°31.4'	151°30.7'	N	3.4	33-35	60-64	T5mm200	90	W	<5	1
261502	27-6-06	1940	2110	33°32.3'	151°30.9'	33°28.3'	151°32.5'	N	4.0	33-34	60-62	control	42	W	<5	1
261503	27-6-06	2200	2330	33°29.2'	151°32.2'	33°33.2'	151°30.6'	S	4.0	34-35	62-64	T5mm200	90	W	10	1
261504	28-6-06	0030	0200	33°31.3'	151°31.3'	33°34.8'	151°29.8'	S	3.6	33-36	60-66	control	42	W	10	1
261601	29-6-06	1635	1805	33°35.0'	151°28.5'	33°31.9'	151°30.5'	N	3.1	32-34	59-62	control	42	NE	5	1
261602	29-6-06	1845	2015	33°31.9'	151°30.5'	33°28.3'	151°32.5'	N	3.6	32-34	59-62	T3mm200	90	NE	10	1
261603	29-6-06	2050	2220	33°29.4'	151°32.2'	33°33.7'	151°29.8'	S	4.4	33-34	60-62	control	42	W	5	1
261604	29-6-06	2330	0100	33°31.0'	151°31.0'	33°35.0'	151°29.0'	S	4.0	32-36	59-66	T3mm200	90	W	5	1

Appendix 3a. List of all commercially harvested species caught during Experiments 1 & 2. Data are the number of times each species was caught in the treatment (90 mm mesh) codends (T) and control codends (C); CAAB Nos are the Codes for Australian Aquatic Biota; CR = % capture rate for all trawls.

				Expt 1		Expt 2		
			Codends:	**T**	**C**	**T**	**C**	**CR**
CAAB No.			**Total no. of tows:**	**45**	**45**	**32**	**30**	**152**
Elasmobranchs								
37	13003	*Orectolobus maculatus*	Shark-spotted wobbegong	2	2	1	2	4.6
37	17001	*Mustelus antarcticus*	Shark-gummy	16	10	0	3	19.1
37	18001	*Carcharhinus brachyurus*	Shark-bronze whaler	1	0	1	0	1.3
37	18023	*Carcharhinus brevipinna*	Shark-spinner	0	0	1	0	0.7
37	24001	*Squatina australis*	Shark-southern angel	0	0	0	1	0.7
37	24004	*Squatina albipunctata*	Shark-eastern angel	2	2	0	0	2.6
37	27006	*Trygonorrhina* sp. A	Ray-banjo	33	31	16	19	65.1
37	27009	*Aptychotrema rostrata*	Ray-eastern shovelnose	44	43	23	22	86.8
37	38001	*Urolophus bucculentus*	Stingaree-sandyback	6	7	0	0	8.6
37	39001	*Myliobatis australis*	Ray-southern eagle	20	19	9	13	40.1
Teleosts								
37	67007	*Conger verreauxi*	Conger-southern	3	2	2	2	5.9
37	224003	*Pseudophycis barbata*	Redcod-bearded	1	0	0	0	0.7
37	258003	*Centroberyx affinis*	Redfish	39	43	31	28	92.8
37	264004	*Zeus faber*	John dory	11	13	6	9	25.7
37	288001	*Chelidonichthys kumu*	Gurnard-red	40	39	26	29	88.2
37	288006	*Pterygotrigla polyommata*	Latchet	3	2	0	0	3.3
37	296001	*Platycephalus richardsoni*	Flathead-tiger	24	22	5	8	38.8
37	296004	*Platycephalus fuscus*	Flathead-dusky	1	0	3	1	3.3
37	296007	*P. caeruleopunctatus*	Flathead-bluespotted (sand)	45	45	29	30	98.0
37	296038	*Platycephalus marmoratus*	Flathead-marbled	25	38	22	19	68.4
37	296011	*Ratabulus diversidens*	Flathead-freespine	2	5	1	0	5.3
37	311147	*Epinephelus ergastularius*	Banded (bar) cod	2	1	1	2	3.9
37	327002	*Dinolestes lewini*	Longfin pike	6	5	2	13	17.1
37	330010	*Sillago ciliata*	Whiting-sand	0	0	1	1	1.3
37	330014	*Sillago flindersi*	Whiting-eastern school	45	45	31	30	99.3
37	334002	*Pomatomus saltatrix*	Tailor	0	1	12	6	12.5
37	337003	*Trachurus novaezelandiae*	Scad-yellowtail	37	41	27	30	88.8
37	337007	*Seriola hippos*	Samsonfish	0	0	0	1	0.7
37	337062	*Pseudocaranx georgianus*	Trevally-silver	7	5	8	11	20.4
37	353001	*Pagrus auratus*	Snapper	12	14	11	11	31.6
37	353013	*Rhabdosargus sarba*	Tarwhine	6	3	3	4	10.5
37	354001	*Argyrosomus hololepidotus*	Mulloway	0	0	1	0	0.7
37	354020	*Atractoscion aequidens*	Teraglin	0	0	2	3	3.3
37	355001	*Upeneichthys lineatus*	Goatfish-bluestriped	14	20	15	17	43.4
37	355018	*Parupeneus spilurus*	Goatfish-blackspot	0	0	1	0	0.7
37	367002	*Paristiopterus labiosus*	Boarfish-giant	8	11	13	10	27.6
37	376002	*Crinodus lophodon*	Rock cale	1	0	0	1	1.3
37	377002	*Nemadactylus douglasii*	Grey morwong	11	9	1	2	15.1
37	378002	*Latridopsis forsteri*	Bastard trumpeter	0	0	0	1	0.7
37	400002	*Ichthyscopus barbatus*	Stargazer-fringed	3	5	3	1	7.9
37	400003	*Kathetostoma laeve*	Stargazer-banded	13	19	8	9	32.2
37	441001	*Scomber australasicus*	Blue mackerel	1	9	2	1	8.6
37	460002	*Pseudorhombus jenynsii*	Flounder-smalltooth	1	1	1	0	2.0
37	460031	*Pseudorhombus tenuirastrum*	Flounder-slender (smoothback)	33	29	19	21	67.1
37	465003	*Eubalichthys mosaicus*	Leatherjacket-mosaic	5	7	3	3	11.8
37	465005	*Meuschenia scaber*	Leatherjacket-velvet	3	3	1	0	4.6
37	465006	*Nelusetta ayraudi*	Ocean jacket	45	42	32	30	98.0
37	465022	*Aluterus monoceros*	Leatherjacket-unicorn	1	0	0	3	2.6
37	465036	*Meuschenia freycineti*	Leatherjacket-sixspine	1	4	0	1	3.9
37	465059	*Meuschenia trachylepis*	Leatherjacket-yellowfin	12	9	9	8	25.0

Appendix 3a (continued). List of all commercially harvested species caught during Experiments 1 & 2.

				Expt 1		Expt 2		
			Codends:	**T**	**C**	**T**	**C**	**CR**
CAAB No.			**Total no. of tows:**	**45**	**45**	**32**	**30**	**152**
Molluscs								
23	207062	*Cymbiolena magnifica*	Volute-magnificent	10	6	8	5	19.1
23	617005	*Sepioteuthis australis*	Southern calamari	45	45	32	30	100.0
23	617901	*Uroteuthis* cf. *etheridgei*	Squid-estuary	0	0	5	5	6.6
23	617903	*Uroteuthis* sp.	Squid-slender	8	11	6	7	21.1
23	607001	*Sepia apama*	Cuttlefish-giant	6	10	4	6	17.1
23	607010	*Sepia rozella*	Cuttlefish-rosecone	43	41	22	22	84.2
23	636004	*Nototodarus gouldi*	Squid-Gould’s	28	32	5	7	47.4
23	659001	*Octopus australis*	Octopus-southern	23	41	30	30	81.6
23	659003	*Octopus maorum*	Octopus-Maori	3	6	3	1	8.6
23	659006	*Octopus tetricus*	Octopus-gloomy	4	11	8	12	23.0
23	659991	*Octopus* cf. *kagoshimensis*	Octopus-eyecross	1	4	13	15	21.7
Crustaceans								
28	711029	*Metapenaeus macleayi*	Prawn-school	0	0	1	0	0.7
28	711052	*Melicertus plebejus*	Prawn-king	13	30	12	26	53.3
28	821004	*Ibacus peronii*	Bug-Balmain	38	38	28	26	85.5
28	821019	*Ibacus chacei*	Bug-smooth	15	13	7	8	28.3
28	911005	*Portunus pelagicus*	Crab-blue swimmer	25	25	26	23	65.1
28	911006	*Portunus sanguinolentis*	Crab-3 spot swimmer	0	1	0	0	0.7

Appendix 3b. List of all non-commercial species caught during Experiments 1 & 2. Data are the number of times each species was caught in the treatment (90 mm mesh) codends (T) and control codends (C); CAAB Nos are the Codes for Australian Aquatic Biota; CR = % capture rate for all trawls. [* *Gnathophis* spp. = mainly *G. longicaudus* with small numbers of *G. grahami* & *G. umbrellabius* in deeper tows]

				Expt 1		Expt 2		
			Codends:	**T**	**C**	**T**	**C**	**CR**
CAAB No.			**Total no. of tows:**	**45**	**45**	**32**	**30**	**152**
Elasmobranchs								
37	7001	*Heterodontus portusjacksoni*	Shark-Port Jackson	33	30	13	12	57.9
37	7003	*Heterodontus galeatus*	Shark-crested horn	7	6	4	2	12.5
37	13002	*Parascyllium collare*	Shark-collared carpet	3	1	1	3	5.3
37	13007	*Brachaelurus waddi*	Shark-blind	3	4	5	6	11.8
37	15027	*Asymbolus analis*	Catshark-grey spotted	4	6	4	6	13.2
37	28001	*Hypnos monopterygium*	Ray-coffin	9	17	17	8	33.6
37	28003	*Torpedo mcneilli*	Ray-torpedo	0	0	1	0	0.7
37	31002	*Dipturus australis*	Skate-Sydney	7	7	3	2	12.5
37	35001	*Dasyatis brevicaudata*	Stingray-smooth	1	1	1	0	2.0
37	35002	*Dasyatis thetidis*	Stingray-Thetis	1	0	0	1	1.3
37	35004	*Neotrygon kuhlii*	Maskray-bluespotted	0	0	1	0	0.7
37	38006	*Trygonoptera testacea*	Stingaree-common	26	24	9	7	43.4
37	38013	*Trygonoptera imitata*	Stingaree-east. shovelnose	3	4	11	14	21.1
37	38004	*Urolophus paucimaculatus*	Stingaree-spotted	9	8	3	4	15.8
37	38005	*Urolophus sufflavus*	Stingaree-yellowback	3	3	1	1	5.3
37	38007	*Urolophus viridis*	Stingaree-greenback	2	1	0	1	2.6
37	38018	*Urolophus kapalensis*	Stingaree-Kapala	23	20	12	7	40.8
Teleosts								
37	63001	*Oxyconger leptognathus*	Bigeye pike eel	0	5	0	1	3.9
37	67901	*Gnathophis* spp.*	Congers-misc. *Gnathophis*	14	43	19	29	69.1
37	67002	*Gnathophis longicaudus*	Little conger					*
37	67016	*Gnathophis umbrellabius*	Umbrella conger					*
37	67028	*Gnathophis grahami*	Graham's conger					*
37	67019	*Poeciloconger kapala*	Conger-mottled	0	7	0	2	5.9
37	67020	*Scalanago lateralis*	Ladder eel	0	1	0	0	0.7
37	68001	*Ophisurus serpens*	Serpent eel	0	0	1	1	1.3
37	117001	*Aulopus purpurissatus*	Sergeant baker	7	6	0	1	9.2
37	118001	*Saurida undosquamis*	Largescale grinner	1	10	16	24	33.6
37	118002	*Trachinocephalus myops*	Painted grinner	2	6	4	4	10.5
37	141001	*Gonorynchus greyi*	Beaked salmon	5	28	6	25	42.1
37	210009	*Antennarius striatus*	Striped anglerfish	1	0	0	0	0.7
37	210014	*Kuiterichthys furcipilis*	Rough angler	0	0	0	1	0.7
37	224011	*Pseudophycis breviuscula*	Redcod-bastard	2	13	3	4	14.5
37	228048	*Ophidion genyopus*	Ravenous cusk	2	19	6	17	28.9
37	255007	*Optivus agastos*	Violet sawbelly	27	40	23	27	77.0
37	259001	*Cleidopus gloriamaris*	Pineapple fish	2	1	1	0	2.6
37	278002	*Fistularia petimba*	Red flutemouth	1	0	3	8	7.9
37	279002	*Macroramphosus scolopax*	Common bellows	0	0	1	1	1.3
37	287045	*Maxillicosta whitleyi*	Whitley's gurnard perch	18	43	14	27	67.1
37	288002	*Lepidotrigla papilio*	Gurnard-spiny	6	8	4	4	14.5
37	288003	*Lepidotrigla vanessa*	Gurnard-butterfly	1	0	0	0	0.7
37	288008	*Lepidotrigla mulhalli*	Gurnard-roundsnout	3	2	1	1	4.6
37	288032	*Lepidotrigla argus*	Gurnard-longfin (eye)	45	45	32	30	100.0
37	292001	*Petaecus fronto*	Red Indian fish	0	1	0	0	0.7
37	296036	*Platycephalus longispinis*	Flathead-longspine	43	42	32	30	96.7
37	296041	*Ambiserrula jugosa*	Flathead-mud	0	1	0	0	0.7
37	311053	*Apogonops anomalus*	Three-spined cardinal	8	14	0	0	14.5
37	321005	*Pelates sexlineatus*	Striped grunter	1	3	1	4	5.9
37	337011	*Carangoides chrysophrys*	Trevally-longnose	0	0	0	1	0.7
37	337017	*Decapterus macrosoma*	Scad-slender	0	1	0	0	0.7
37	355014	*Upeneus tragula*	Goatfish-bartail	1	3	0	4	5.3
37	357001	*Pempheris multiradiata*	Bigscale bullseye	5	4	1	2	7.9

Appendix 3b (continued). List of all non-commercial species caught during Experiments 1 & 2.

CAAB No.			Codends:	Expt 1 T	Expt 1 C	Expt 2 T	Expt 2 C	CR
			Total no. of tows:	45	45	32	30	152
Teleosts (cont.)								
37	361005	*Microcanthus strigatus*	Stripey	0	0	4	1	3.3
37	361010	*Atypichthys strigatus*	Mado	4	5	5	8	14.5
37	366001	*Enoplosus armatus*	Old wife	0	0	0	2	1.3
37	367005	*Zanclistius elevatus*	Boarfish-blackspot	0	1	1	0	1.3
37	382003	*Sphyraena acutipinnis*	Sharpfin barracuda	0	4	0	2	3.9
37	390001	*Parapercis allporti*	Grubfish-barred	0	1	0	0	0.7
37	390027	*Simipercis trispinosa*	Grubfish-3spine	0	1	0	0	0.7
37	400001	*Xenocephalus armatus*	Stargazer-bulldog	1	0	0	0	0.7
37	401000	*Champsodon* sp.	Gaper	0	0	0	1	0.7
37	427001	*Foetorepus calauropomus*	Common stinkfish	2	8	0	1	7.2
37	427015	*Repomucenus calcaratus*	Spotted dragonet	2	5	0	0	4.6
37	460001	*Lophonectes gallus*	Flounder-crested	21	44	15	26	69.7
37	462010	*Zebrias scalaris*	Sole-manyband	6	36	7	25	48.7
37	462018	*Synclidopus macleayana*	Sole-narrowband	6	22	5	16	32.2
37	462029	*Pardachirus hedleyi*	Sole-peacock	0	0	0	1	0.7
37	466002	*Anoplocapros inermis*	Smooth boxfish	39	30	28	24	79.6
37	466008	*Tetrasomus reipublicae*	Cowfish	0	0	4	0	2.6
37	467005	*Arothron firmamentum*	Puffer-starry	1	1	0	0	1.3
37	467065	*Lagocephalus cheesemanii*	Puffer-green	15	17	15	10	37.5
37	469002	*Allomycterus pilatus*	Porcupinefish-Australian	24	26	8	9	44.1
37	469013	*Dicotylichthys punctulatus*	Porcupinefish-threebar	8	8	3	4	15.1
Molluscs								
23	171020	*Semicassis labiata*	Helmet shell-smooth	6	6	17	12	27.0
23	171024	*Semicassis thomsoni*	Helmet shell-Thomson's	25	20	8	6	38.8
23	177001	*Tonna cerevisina*	Cask shell	19	18	14	8	38.8
23	202025	*Penion maximus*	Whelk-giant	21	19	12	5	37.5
23	207007	*Amoria undulata*	Volute-wavy	0	2	1	0	2.0
23	207039	*Cymbiolista hunteri*	Volute-Hunter's	28	34	23	18	67.8
23	208027	*Ancillista velesiana*	Olive shell	9	19	5	8	27.0
23	222093	*Conus papilliferus*	Cone shell	0	0	1	0	0.7
23	270001	*Amusium balloti*	Saucer scallop	1	0	0	0	0.7
23	607024	*Sepia limata*	Cuttlefish-pygmy	4	15	3	4	17.1
23	608001	*Sepioloidea lineolata*	Striped dumpling squid	1	19	0	8	18.4
23	609001	*Euprymna tasmanica*	Southern dumpling squid	0	2	0	2	2.6
23	659014	*Hapalochlaena fasciata*	Octopus-blue-lined	2	3	0	0	3.3
23	659992	*Octopus* cf. *bunurong*	Octopus-spotted	0	0	2	0	1.3
23	659993	*Octopus* sp.	Octopus-twospot	0	0	0	1	0.7
Crustaceans								
28	37001	*Hemisquilla australiensis*	Mantis shrimp-smooth	1	0	0	0	0.7
28	46001	*Lysiosquilla colemani*	Mantis shrimp-banded	1	0	0	0	0.7
28	51003	*Belosquilla laevis*	Mantis shrimp-pinkspine	0	1	0	0	0.7
28	51009	*Anchisquilloides mcneilli*	Mantis shrimp-yellowspine	1	1	0	0	1.3
28	711055	*Trachypenaeus curvirostris*	Prawn-hardback	4	16	9	11	26.3
28	875005	*Calappa lophos*	Boxcrab-redstreaked	1	0	0	0	0.7
28	875003	*Mursia curtispina*	Boxcrab-spined	0	1	0	0	0.7
28	876003	*Bellidilia undecimspinosa*	Crab-smooth pebble	1	0	0	0	0.7
28	880002	*Leptomithrax tuberculata*	Spidercrab-knobbed	9	5	10	7	20.4
28	880024	*Leptomithrax waitei*	Spidercrab-Waite's	1	0	0	2	2.0
28	880991	*Leptomithrax* sp.	Spidercrab-red armed	0	0	0	1	0.7
28	880143	*Naxioides robillardi*	Spidercrab-horned	1	0	0	0	0.7
28	911018	*Charybdis bimaculata*	Swimmercrab-brown	1	2	0	3	3.9
28	911019	*Charybdis miles*	Swimmercrab-angry	1	1	0	0	1.3
28	911063	*Portunus orbitosinus*	Swimmercrab-paddlespot	0	2	0	0	1.3
28	911026	*Portunus rubromarginatus*	Swimmercrab-pinkedged	0	1	0	0	0.7
28	922000	*Exopheticus insignis*	Crab-redmoon	0	1	0	0	0.7
28	926991	*Pilumnus* sp.	Crab-hairy	15	12	1	3	20.4

Appendix 4a. List of all species caught in treatment codends (77 tows) with total catch number and weight (kg), % total number and weight, and rank (R); for full species name, refer to CAAB No. in Appendix 3.

CAAB No.	Species		No.	%No.	R	Wt	%Wt	R
37 330014	*Sillago flindersi*	School whiting	41196	32.3	1	2969.4	19.5	1
37 288032	*Lepidotrigla argus*	Gurnard-longfin	33486	26.2	2	1781.1	11.7	2
37 258003	*Centroberyx affinis*	Redfish	16578	13.0	3	1265.8	8.3	4
37 465006	*Nelusetta ayraudi*	Ocean jacket	8344	6.5	4	1273.9	8.3	3
37 296036	*P. longispinis*	Flathead-longspine	6240	4.9	5	483.6	3.2	9
37 337003	*T. novaezelandiae*	Yellowtail scad	3470	2.7	6	266.4	1.7	12
23 617005	*S. australis*	Southern calamari	2671	2.1	7	852.3	5.6	7
37 296007	*P. caeruleopunctatus*	Flathead-bluespotted	1639	1.3	8	901.6	5.9	6
23 607010	*Sepia rozella*	Cuttle-rosecone	1451	1.1	9	228.3	1.5	13
37 255007	*Optivus agastos*	Violet sawbelly	1125	0.9	10	15.6	0.1	55
37 353001	*Pagrus auratus*	Snapper	898	0.7	11	142.0	0.9	18
37 296001	*P. richardsoni*	Flathead-tiger	807	0.6	12	224.6	1.5	14
37 466002	*A. inermis*	Smooth boxfish	677	0.5	13	148.2	1.0	17
37 38006	*T. testacea*	Stingaree-common	645	0.5	14	456.3	3.0	10
37 27009	*A. rostrata*	Ray-shovelnose	630	0.5	15	815.2	5.3	8
37 460031	*P. tenuirastrum*	Flounder-slender	573	0.4	16	85.4	0.6	21
37 38018	*Urolophus kapalensis*	Stingaree-Kapala	568	0.4	17	215.2	1.4	15
28 821004	*Ibacus peronii*	Bug-Balmain	479	0.4	18	56.5	0.4	25
37 288001	*Chelidonichthys kumu*	Gurnard-red	461	0.4	19	99.3	0.7	20
23 659001	*Octopus australis*	Octopus-southern	355	0.3	20	37.1	0.2	35
37 67000	*Gnathophis* spp.	Congers-*Gnathophis*	292	0.2	21	24.7	0.2	43
37 27006	*Trygonorrhina* sp.A	Ray-banjo	278	0.2	22	388.5	2.5	11
23 207039	*Cymbiolista hunteri*	Volute-Hunter's	278	0.2	22	29.3	0.2	40
37 7001	*H. portusjacksoni*	Shark-Port Jackson	270	0.2	23	983.9	6.4	5
37 39001	*Myliobatis australis*	Ray-southern eagle	261	0.2	24	137.4	0.9	19
37 361010	*Atypichthys strigatus*	Mado	261	0.2	24	0.5	<0.1	107
28 911005	*Portunus pelagicus*	Crab-blue swimmer	221	0.2	27	58.9	0.4	24
37 467065	*L. cheesemanii*	Puffer-Cheeseman's	216	0.2	28	43.6	0.3	32
37 311053	*Apogonops anomalus*	Three-spined cardinal	176	0.1	29	0.9	<0.1	99
23 636004	*Nototodarus gouldi*	Squid-Goulds	158	0.1	30	22.9	0.2	46
37 460001	*Lophonectes gallus*	Flounder-crested	155	0.1	31	1.6	<0.1	88
37 288008	*Lepidotrigla mulhalli*	Gurnard-roundsnout	152	0.1	32	8.4	0.1	61
37 287045	*Maxillicosta whitleyi*	Whitley's gurn. perch	141	0.1	33	0.4	<0.1	108
37 353013	*Rhabdosargus sarba*	Tarwhine	136	0.1	34	23.8	0.2	44
37 296038	*P. marmoratus*	Flathead-marbled	134	0.1	35	38.4	0.3	34
37 355001	*Upeneichthys lineatus*	Goatfish-bluestriped	133	0.1	36	22.7	0.1	47
37 357001	*P. multiradiata*	Bigscale bullseye	124	0.1	37	3.3	<0.1	77
28 211052	*Melicertus plebejus*	Prawn-king	122	0.1	38	2.9	<0.1	81
37 469002	*Allomycterus pilatus*	Porcupinefish-Aust’n	120	0.1	39	53.2	0.3	28
37 377002	*N. douglasii*	Grey morwong	103	0.1	40	17.9	0.1	50
23 171024	*Semicassis thomsoni*	Helmitshell-Thomson	95	0.1	41	4.8	<0.1	71
37 38005	*Urolophus sufflavus*	Stingaree-yellowback	80	0.1	42	34.8	0.2	37
23 202025	*Penion maximus*	Whelk-giant	77	0.1	43	16.8	0.1	52
37 288002	*Lepidotrigla papilio*	Gurnard-spiny	74	0.1	44	1.7	<0.1	86
23 177001	*Tonna cerevisina*	Cask shell	73	0.1	45	15.9	0.1	54
23 171020	*Semicassis labiata*	Helmitshell-smooth	59	<0.1	46	3.0	<0.1	80
37 118001	*Saurida undosquamis*	Largescale grinner	58	<0.1	47	5.3	<0.1	69
23 617000	*Uroteuthis* sp.	Squid-slender	57	<0.1	48	7.2	<0.1	64
23 207062	*Cymbiolena magnifica*	Volute-magnificent	56	<0.1	49	44.8	0.3	31
28 711055	*T. recurvirostris*	Prawn-hardback	50	<0.1	50	0.3	<0.1	115
37 38013	*Trygonoptera imitata*	Stingaree-east. shovel.	45	<0.1	51	37.0	0.2	36
37 31002	*Dipturus australis*	Skate-Sydney	41	<0.1	52	29.6	0.2	39
37 264004	*Zeus faber*	John dory	38	<0.1	53	23.3	0.2	45
37 334002	*Pomatomus saltatrix*	Tailor	38	<0.1	53	9.2	0.1	59
37 465059	*M. trachylepis*	L'jacket-yellowfin	37	<0.1	55	13.4	0.1	56

Appendix 4a. (continued) List of all species caught in treatment codends.

CAAB No.	Species		No.	%No.	R	Wt	%Wt	R
37 28001	*H. monopterygium*	Ray-coffin	36	<0.1	56	69.7	0.5	22
37 367002	*P. labiosus*	Boarfish-giant	35	<0.1	57	27.0	0.2	41
28 821019	*Ibacus chacei*	Bug-smooth	35	<0.1	57	3.8	<0.1	72
28 926099	*Pilumnus* sp.	Crab-hairy	34	<0.1	59	0.3	<0.1	115
37 462010	*Zebrias scalaris*	Sole-manyband	33	<0.1	60	3.3	<0.1	77
37 17001	*Mustelus antarcticus*	Shark-gummy	30	<0.1	61	55.9	0.4	26
37 337062	*P. georgianus*	Silver trevally	30	<0.1	61	5.6	<0.1	67
37 141001	*Gonorynchus greyi*	Beaked salmon	29	<0.1	63	3.8	<0.1	72
37 400003	*Kathetostoma laeve*	Stargazer-banded	28	<0.1	64	26.9	0.2	42
23 208027	*Ancillista velesiana*	Olive shell	28	<0.1	64	0.7	<0.1	102
23 659000	*O.* cf. *kagoshimensis*	Octopus-eyecross	27	<0.1	66	2.1	<0.1	82
37 38004	*U. paucimaculatus*	Stingaree-spotted	26	<0.1	67	11.8	0.1	57
28 880002	*L. tuberculata*	Spidercrab-knobbed	26	<0.1	67	0.3	<0.1	115
37 228000	*Ophidion genyopus*	Ravenous cusk	24	<0.1	69	0.2	<0.1	120
23 659006	*Octopus tetricus*	Octopus-gloomy	21	<0.1	70	11.0	0.1	58
37 13007	*Brachaelurus waddi*	Shark-blind	20	<0.1	71	59.8	0.4	23
37 462018	*S. macleayana*	Sole-narrowbanded	20	<0.1	71	1.2	<0.1	90
37 38001	*U. bucculentus*	Stingaree-sandyback	19	<0.1	73	51.5	0.3	29
37 118002	*T. myops*	Painted grinner	18	<0.1	74	2.1	<0.1	82
23 607001	*Sepia apama*	Cuttle-giant	17	<0.1	75	55.3	0.4	27
37 7003	*Heterodontus galeatus*	Shark-crested horn	16	<0.1	76	32.0	0.2	38
37 117001	*Aulopus purpurissatus*	Sergeant baker	16	<0.1	76	6.0	<0.1	66
37 441001	*Scomber australasicus*	Blue mackerel	16	<0.1	76	1.0	<0.1	92
37 427015	*R. calcaratus*	Stinkfish-spotted	15	<0.1	79	0.6	<0.1	106
37 469013	*D. punctulatus*	Porcupine-threebar	15	<0.1	79	19.0	0.1	49
37 224011	*P. breviuscula*	Redcod-bastard	13	<0.1	81	0.4	<0.1	108
37 15027	*Asymbolus analis*	Catshark-grey spotted	12	<0.1	82	7.8	0.1	62
37 327002	*Dinolestes lewini*	Longfin pike	12	<0.1	82	3.6	<0.1	75
23 607024	*Sepia limata*	Cuttle-pigmy	12	<0.1	82	0.1	<0.1	126
37 278002	*Fistularia petimba*	Red flutemouth	9	<0.1	85	0.7	<0.1	102
37 465003	*Eubalichthys mosaicus*	Leatherjacket-mosaic	8	<0.1	86	5.1	<0.1	70
23 617000	*U.* cf. *etheridgi*	Squid-estuary	8	<0.1	86	1.1	<0.1	91
37 296011	*Ratabulus diversidens*	Flathead-freespine	7	<0.1	88	0.9	<0.1	95
37 466008	*T. reipublicae*	Cowfish	7	<0.1	88	0.4	<0.1	108
37 354020	*A. aequidens*	Teraglin	6	<0.1	90	6.7	<0.1	65
37 400002	*Ichthyscopus barbatus*	Stargazer-fringed	6	<0.1	90	2.1	<0.1	82
37 465005	*Meuschenia scaber*	Leatherjacket-velvet	6	<0.1	90	1.3	<0.1	89
23 659003	*Octopus maorum*	Octopus-Maori	6	<0.1	90	5.5	<0.1	68
37 13002	*Parascyllium collare*	Shark-collared carpet	5	<0.1	94	3.8	<0.1	72
37 13003	*O. maculatus*	Wobbegong-spotted	5	<0.1	94	20.5	0.1	48
37 67007	*Conger verreauxi*	Conger-southern	5	<0.1	94	9.1	0.1	60
37 361005	*M. strigatus*	Stripey	5	<0.1	94	16.0	0.1	53
23 659000	*Octopus* cf. *bunurong*	Octopus-spotted	5	<0.1	94	0.3	<0.1	115
37 296004	*Platycephalus fuscus*	Flathead-dusky	4	<0.1	99	7.4	<0.1	63
37 427001	*F. calauropomus*	Stinkfish-common	4	<0.1	99	0.2	<0.1	120
28 880024	*Leptomithrax waitei*	Spidercrab-Waite's	4	<0.1	99	0.4	<0.1	108
37 24004	*Squatina albipunctata*	Shark-eastern angel	3	<0.1	102	41.0	0.3	33
37 259001	*Cleidopus gloriamaris*	Pineapple fish	3	<0.1	102	0.8	<0.1	100
37 288006	*P. polyommata*	Latchet	3	<0.1	102	0.9	<0.1	95
37 311147	*E. ergastularius*	Banded rockcod	3	<0.1	102	0.9	<0.1	95
37 321005	*Pelates sexlineatus*	Striped grunter	3	<0.1	102	0.1	<0.1	126
28 911018	*Charybdis bimaculata*	Swimmercrab-brown	3	<0.1	102	0.1	<0.1	126
37 18001	*C. brachyurus*	Shark-bronze whaler	2	<0.1	108	170.0	1.1	16
37 35001	*Dasyatis brevicaudata*	Stingray-smooth	2	<0.1	108	45.0	0.3	30
37 35004	*Neotrygon kuhlii*	Maskray-bluespotted	2	<0.1	108	1.6	<0.1	87
37 38007	*Urolophus viridis*	Stingaree-greenback	2	<0.1	108	0.9	<0.1	95

Appendix 4a. (continued) List of all species caught in treatment codends.

CAAB No.	Species		No.	%No.	R	Wt	%Wt	R
37 279002	*M. scolopax*	Common bellowsfish	2	<0.1	108	<0.1	<0.1	138
37 460002	*P. jenynsii*	Flounder-smalltooth	2	<0.1	108	0.4	<0.1	108
28 865002	*L.tridentifer*	Frog crab	2	<0.1	108	<0.1	<0.1	138
37 18023	*C. brevipinna*	Shark-spinner	1	<0.1	115	3.0	<0.1	79
37 28003	*Torpedo mcneilli*	Ray-torpedo	1	<0.1	115	17.0	0.1	51
37 35002	*Dasyatis thetidis*	Stingray-Thetis	1	<0.1	115	3.5	<0.1	76
37 68001	*Ophisurus serpens*	Serpent eel	1	<0.1	115	1.0	<0.1	92
37 210009	*Antennarius striatus*	Striped anglerfish	1	<0.1	115	0.1	<0.1	126
37 224003	*Pseudophycis barbata*	Redcod-bearded	1	<0.1	115	2.0	<0.1	85
37 288003	*Lepidotrigla vanessa*	Gurnard-butterfly	1	<0.1	115	0.2	<0.1	120
37 330010	*Sillago ciliata*	Whiting-sand	1	<0.1	115	0.2	<0.1	120
37 354001	*A. hololepidotus*	Mulloway	1	<0.1	115	0.4	<0.1	108
37 355014	*Upeneus tragula*	Goatfish-bartail	1	<0.1	115	<0.1	<0.1	138
37 355018	*Parupeneus spilurus*	Blackspot goatfish	1	<0.1	115	0.8	<0.1	100
37 367005	*Zanclistius elevatus*	Boarfish-blackspot	1	<0.1	115	0.3	<0.1	115
37 376002	*Crinodus lophodon*	Rock cale	1	<0.1	115	0.4	<0.1	108
37 400001	*Xenocephalus armatus*	Stargazer-bulldog	1	<0.1	115	0.1	<0.1	126
37 465022	*Aluterus monoceros*	Leatherjacket-unicorn	1	<0.1	115	1.0	<0.1	92
37 465036	*Meuschenia freycineti*	Leatherjacket-sixspine	1	<0.1	115	0.7	<0.1	102
37 467005	*A. firmamentum*	Puffer-starry	1	<0.1	115	0.7	<0.1	102
23 207007	*Amoria undulata*	Volute-striped	1	<0.1	115	0.1	<0.1	126
23 222093	*Conus papilliferus*	Cone shell	1	<0.1	115	0.1	<0.1	126
23 270001	*Amusium ballotae*	Saucer scallop	1	<0.1	115	0.2	<0.1	120
23 608001	*Sepioloidea lineolata*	Squid-striped	1	<0.1	115	<0.1	<0.1	138
28 37001	*H. australiensis*	Mantis-smooth	1	<0.1	115	0.1	<0.1	126
28 46001	*L.ysiosquilla colemani*	Mantis-banded	1	<0.1	115	0.1	<0.1	126
28 51009	*A. mcneilli*	Mantis-yellowspined	1	<0.1	115	0.1	<0.1	126
28 711000	*Metapaeneopsis* sp.	Prawn – coral	1	<0.1	115	<0.1	<0.1	138
28 711029	*Metapenaeus macleayi*	Prawn – school	1	<0.1	115	<0.1	<0.1	138
28 875005	*Calappa lophos*	Boxcrab-redstreaked	1	<0.1	115	0.1	<0.1	126
28 876003	*B. undecimspinosa*	Crab-smooth pebble	1	<0.1	115	<0.1	<0.1	138
28 880143	*Naxoides robillardi*	Spidercrab-horned	1	<0.1	115	0.1	<0.1	126
28 911019	*Charybdis miles*	Swimmercrab-angry	1	<0.1	115	0.1	<0.1	126
		Total:	**127714**			**15266**		

Appendix 4b. List of all species caught in the control codend (75 tows) with total-catch number and weight (kg), % total number and weight, and rank (R); for full species name, refer to CAAB No. in Appendix 3.

CAAB No.	Species		No.	%No.	R	Wt	%Wt	R
37 330014	*Sillago flindersi*	School whiting	162807	46.7	1	10585.1	40.7	1
37 288032	*Lepidotrigla argus*	Gurnard-longfin	50566	14.5	2	2401.6	9.2	2
37 296036	*P. longispinis*	Flathead-longspine	37301	10.7	3	2376.5	9.1	3
37 258003	*Centroberyx affinis*	Redfish	21219	6.1	4	1249.5	4.8	4
37 337003	*T. novaezelandiae*	Yellowtail scad	12712	3.6	5	425.7	1.6	12
37 67000	*Gnathophis* spp.	Congers-*Gnathophis*	10431	3.0	6	735.0	2.8	9
37 460001	*Lophonectes gallus*	Flounder-crested	9598	2.8	7	89.6	0.3	25
37 255007	*Optivus agastos*	Violet sawbelly	6270	1.8	8	78.4	0.3	26
37 465006	*Nelusetta ayraudi*	Ocean jacket	6177	1.8	9	848.0	3.3	7
37 287045	*Maxillicosta whitleyi*	Whitley's gurn. perch	5627	1.6	10	14.1	<0.1	58
23 617005	*Sepioteuthis australis*	Southern calamari	3138	0.9	11	950.2	3.7	5
23 659001	*Octopus australis*	Octopus-sand	1925	0.6	12	216.2	0.8	16
23 607010	*Sepia rozella*	Cuttle-rosecone	1841	0.5	13	277.9	1.1	13
37 311053	*Apogonops anomalus*	3-spined cardinalfish	1741	0.5	14	8.7	<0.1	67
37 296007	*P. caeruleopunctatus*	Flathead-bluespotted	1527	0.4	15	844.6	3.3	8
37 296001	*P. richardsoni*	Flathead-tiger	916	0.3	16	218.4	0.8	15
37 141001	*Gonorynchus greyi*	Beaked salmon	834	0.2	17	91.5	0.4	23
37 466002	*Anoplocapros inermis*	Smooth boxfish	754	0.2	18	171.0	0.7	18
37 228000	*Ophidion genyopus*	Ravenous cusk	745	0.2	19	7.5	<0.1	73
37 462010	*Zebrias scalaris*	Sole-manybanded	743	0.2	19	74.3	0.3	27
28 711055	*T. recurvirostris*	Prawn-hardback	714	0.2	21	3.6	<0.1	86
37 118001	*Saurida undosquamis*	Largescale grinner	674	0.2	22	34.1	0.1	38
28 211052	*Melicertus plebejus*	Prawn-king	671	0.2	23	18.5	<0.1	53
37 462018	*S. macleayana*	Sole-narrowbanded	667	0.2	24	40.0	0.2	37
37 460031	*P. tenuirastrum*	Flounder-slender	658	0.2	25	92.0	0.4	23
28 821004	*Ibacus peronii*	Bug-Balmain	496	0.1	26	58.8	0.2	30
37 27009	*Aptychotrema rostrata*	Ray-shovelnose	481	0.1	27	667.5	2.6	10
37 39001	*Myliobatis australis*	Ray-southern eagle	425	0.1	28	249.1	1.0	14
37 288001	*Chelidonichthys kumu*	Gurnard-red	398	0.1	29	104.4	0.4	20
37 38018	*Urolophus kapalensis*	Stingaree-Kapala	340	0.1	30	145.1	0.6	19
37 361010	*Atypichthys strigatus*	Mado	324	<0.1	31	10.4	<0.1	63
37 27006	*Trygonorrhina* sp.A	Ray-banjo	323	<0.1	32	517.0	2.0	11
37 38006	*Trygonoptera testacea*	Stingaree-common	309	<0.1	33	176.0	0.7	17
37 7001	*H. portusjacksoni*	Shark-Port Jackson	308	<0.1	34	910.7	3.5	6
23 636004	*Nototodarus gouldi*	Squid-Gould's	294	<0.1	35	28.6	0.1	43
37 296038	*P. marmoratus*	Flathead-marbled	287	<0.1	36	55.2	0.2	31
37 353001	*Pagrus auratus*	Snapper	280	<0.1	37	49.8	0.2	33
37 441001	*Scomber australasicus*	Blue mackerel	248	<0.1	38	8.2	<0.1	69
23 207039	*Cymbiolista hunteri*	Volute-Hunter's	243	<0.1	39	29.0	0.1	41
37 467065	*L. cheesemanii*	Puffer-Cheeseman's	242	<0.1	40	54.6	0.2	32
37 469002	*Allomycterus pilatus*	Porcupinefish-Aust'n	232	<0.1	41	94.8	0.4	21
23 607024	*Sepia limata*	Cuttle-pigmy	211	<0.1	42	1.1	<0.1	104
37 355001	*Upeneichthys lineatus*	Goatfish-bluestriped	199	<0.1	43	25.6	<0.1	45
37 224011	*P. breviuscula*	Redcod-bastard	194	<0.1	44	7.9	<0.1	71
28 911005	*Portunus pelagicus*	Crab-blue swimmer	187	<0.1	45	48.8	0.2	33
37 288002	*Lepidotrigla papilio*	Gurnard-spiny	169	<0.1	46	4.1	<0.1	82
23 608001	*Sepioloidea lineolata*	Squid-striped bottle	140	<0.1	47	0.7	<0.1	110
37 427001	*F. calauropomus*	Stinkfish-common	123	<0.1	48	10.6	<0.1	62
37 382003	*Sphyraena acutipinnis*	Sharpfin barracuda	115	<0.1	49	6.2	<0.1	77
23 208027	*Ancillista velesiana*	Olive shell	97	<0.1	50	2.7	<0.1	99
23 171024	*Semicassis thomsoni*	Helmitshell-knobbed	96	<0.1	51	4.8	<0.1	79
37 353013	*Rhabdosargus sarba*	Tarwhine	74	<0.1	52	14.2	<0.1	57
37 38013	*Trygonoptera imitata*	Stingaree-shovelnose	67	<0.1	53	25.3	<0.1	46
23 617000	*Uroteuthis* sp.	Squid-slender	67	<0.1	53	6.9	<0.1	75

Appendix 4b. (continued) List of all species caught in the control codend.

CAAB No.	Species		No.	%No.	R	Wt	%Wt	R
37 465005	*Meuschenia scaber*	Leatherjacket-velvet	66	<0.1	55	8.1	<0.1	70
37 31002	*Dipturus australis*	Skate-Sydney	63	<0.1	56	49.8	0.2	33
23 171020	*Semicassis labiata*	Helmitshell-smooth	61	<0.1	57	3.1	<0.1	92
37 296011	*Ratabulus diversidens*	Flathead-freespine	53	<0.1	58	7.9	<0.1	71
37 337062	*P. georgianus*	Silver trevally	53	<0.1	58	7.0	<0.1	74
37 38004	*U. paucimaculatus*	Stingaree-spotted	50	<0.1	60	24.5	<0.1	48
23 177001	*Tonna cerevisina*	Cask shell	49	<0.1	61	10.4	<0.1	63
37 377002	*N. douglasii*	Grey morwong	47	<0.1	62	9.1	<0.1	66
23 202025	*Penion maximus*	Whelk-giant	46	<0.1	63	9.5	<0.1	65
37 327002	*Dinolestes lewini*	Longfin pike	44	<0.1	64	11.2	<0.1	61
23 659000	*O. cf. kagoshimensis*	Octopus-eyecross	44	<0.1	64	2.8	<0.1	97
28 880002	*L. tuberculata*	Spidercrab-knobbed	44	<0.1	64	<0.1	<0.1	129
28 926099	*Pilumnus* sp.	Crab-hairy	43	<0.1	67	0.1	<0.1	130
23 659006	*Octopus tetricus*	Octopus-gloomy	41	<0.1	68	18.3	<0.1	54
37 357001	*P. multiradiata*	Bigscale bullseye	39	<0.1	69	1.1	<0.1	104
37 288008	*Lepidotrigla mulhalli*	Gurnard-roundsnout	38	<0.1	70	2.3	<0.1	100
37 367002	*P. labiosus*	Boarfish-giant	37	<0.1	71	24.8	<0.1	47
37 118002	*T. myops*	Painted grinner	36	<0.1	72	1.0	<0.1	108
37 279002	*M. scolopax*	Common bellowsfish	36	<0.1	72	0.2	<0.1	121
37 465059	*M. trachylepis*	L'jacket-yellowfin	35	<0.1	74	13.5	<0.1	59
37 28001	*H. monopterygium*	Ray-coffin	34	<0.1	75	61.9	0.2	29
37 400003	*Kathetostoma laeve*	Stargazer-banded	33	<0.1	76	28.0	0.1	44
37 38005	*Urolophus sufflavus*	Stingaree-yellowback	32	<0.1	77	16.1	<0.1	55
37 264004	*Zeus faber*	John dory	32	<0.1	77	23.5	<0.1	49
28 911018	*Charybdis bimaculata*	Swimmercrab-brown	31	<0.1	79	0.6	<0.1	111
28 821019	*Ibacus chacei*	Bug-smooth	27	<0.1	80	3.2	<0.1	91
37 355014	*Upeneus tragula*	Goatfish-bartail	25	<0.1	81	1.1	<0.1	104
23 607001	*Sepia apama*	Cuttle-giant	25	<0.1	81	93.7	0.4	22
23 617000	*U.* cf. *etheridgi*	Squid-estuary	25	<0.1	81	3.0	<0.1	93
37 15027	*Asymbolus analis*	Catshark-grey spotted	24	<0.1	84	12.4	<0.1	60
37 17001	*Mustelus antarcticus*	Shark-gummy	24	<0.1	84	47.6	0.2	36
37 38001	*U. bucculentus*	Stingaree-sandyback	23	<0.1	86	69.0	0.3	28
37 469013	*D. punctulatus*	Porcupine-threebar	23	<0.1	86	33.5	0.1	39
37 321005	*Pelates sexlineatus*	Striped grunter	20	<0.1	88	1.0	<0.1	108
37 427015	*R. calcaratus*	Stinkfish-spotted	19	<0.1	89	0.6	<0.1	111
23 207062	*Cymbiolena magnifica*	Volute-magnificent	19	<0.1	89	15.2	<0.1	56
28 711000	*Metapaeneopsis* sp.	Prawn-coral	19	<0.1	89	<0.1	<0.1	129
37 67019	*Poeciloconger kapala*	Conger-mottled	18	<0.1	92	4.0	<0.1	84
37 117001	*Aulopus purpurissatus*	Sergeant baker	16	<0.1	93	8.7	<0.1	67
23 609001	*Euprymna tasmanica*	Squid-sthn dumpling	15	<0.1	94	0.1	<0.1	129
37 13007	*Brachaelurus waddi*	Shark-blind	14	<0.1	95	29.0	0.1	41
37 465003	*Eubalichthys mosaicus*	Leatherjacket-mosaic	14	<0.1	95	6.0	<0.1	78
37 334002	*Pomatomus saltatrix*	Tailor	13	<0.1	97	4.1	<0.1	82
37 7003	*Heterodontus galeatus*	Shark-crested horn	12	<0.1	98	19.5	<0.1	52
37 278002	*Fistularia petimba*	Red flutemouth	12	<0.1	98	2.0	<0.1	102
37 63001	*O. leptognathus*	Bigeye pike eel	11	<0.1	100	0.5	<0.1	114
37 400002	*Ichthyscopus barbatus*	Stargazer-fringed	10	<0.1	101	4.6	<0.1	81
37 38007	*Urolophus viridis*	Stingaree-greenback	8	<0.1	102	3.6	<0.1	86
23 659003	*Octopus maorum*	Octopus-Maori	8	<0.1	102	2.9	<0.1	96
37 311147	*E. ergastularius*	Banded rockcod	5	<0.1	104	1.1	<0.1	104
37 465036	*Meuschenia freycineti*	Leatherjacket-sixspine	5	<0.1	104	3.4	<0.1	89
37 13002	*Parascyllium collare*	Shark-collared carpet	4	<0.1	106	3.5	<0.1	88
37 13003	*O. maculatus*	Wobbegong-spotted	4	<0.1	106	22.5	<0.1	50
37 67007	*Conger verreauxi*	Conger-southern	4	<0.1	106	3.4	<0.1	89
37 337017	*D. macrosoma*	Slender scad	4	<0.1	106	0.1	<0.1	129
37 354020	*A. aequidens*	Teraglin	4	<0.1	106	4.8	<0.1	79
37 462029	*Pardachirus hedleyi*	Sole-peacock	4	<0.1	106	0.2	<0.1	121

Appendix 4b. (continued) List of all species caught in the control codend.

CAAB No.	Species		No.	%No.	R	Wt	%Wt	R
23 659014	*H. fasciata*	Octopus-bluelined	4	<0.1	106	0.1	<0.1	129
37 366001	*Enoplosus armatus*	Old wife	3	<0.1	113	0.5	<0.1	114
37 465022	*Aluterus monoceros*	Leatherjacket-unicorn	3	<0.1	113	2.8	<0.1	97
23 207007	*Amoria undulata*	Volute-striped	3	<0.1	113	0.4	<0.1	117
28 911063	*Portunus orbitosinus*	Swimcrab-paddlespot	3	<0.1	113	<0.1	<0.1	146
37 24004	*Squatina albipunctata*	Shark-eastern angel	2	<0.1	117	29.3	0.1	40
37 67020	*Scalanago lateralis*	Ladder eel	2	<0.1	117	0.2	<0.1	121
37 288006	*P. polyommata*	Latchet	2	<0.1	117	0.3	<0.1	119
37 361005	*M. strigatus*	Stripey	2	<0.1	117	0.2	<0.1	121
37 376002	*Crinodus lophodon*	Rock cale	2	<0.1	117	2.3	<0.1	100
37 467005	*A. firmamentum*	Puffer-starry	2	<0.1	117	3.0	<0.1	93
28 880024	*Leptomithrax waitei*	Spidercrab-Waite's	2	<0.1	117	0.4	<0.1	117
37 24001	*Squatina australis*	Shark-southern angel	1	<0.1	124	6.8	<0.1	76
37 35001	*Dasyatis brevicaudata*	Stingray-smooth	1	<0.1	124	20.0	<0.1	51
37 35002	*Dasyatis thetidis*	Stingray-Thetis	1	<0.1	124	4.0	<0.1	84
37 68001	*Ophisurus serpens*	Serpent eel	1	<0.1	124	0.5	<0.1	114
37 210014	*K. furcipilis*	Rough angler	1	<0.1	124	<0.1	<0.1	146
37 259001	*Cleidopus gloriamaris*	Pineapple fish	1	<0.1	124	0.3	<0.1	119
37 292001	*Petaecus fronto*	Red Indian fish	1	<0.1	124	0.2	<0.1	121
37 296004	*Platycephalus fuscus*	Flathead-dusky	1	<0.1	124	3.0	<0.1	93
37 296041	*Ambiserrula jugosa*	Flathead-mud	1	<0.1	124	0.1	<0.1	129
37 330010	*Sillago ciliata*	Whiting-sand	1	<0.1	124	0.2	<0.1	121
37 337007	*Seriola hippos*	Samsonfish	1	<0.1	124	0.6	<0.1	111
37 337011	*C. chrysophrys*	Longnose trevally	1	<0.1	124	0.1	<0.1	129
37 367005	*Zanclistius elevatus*	Boarfish-blackspot	1	<0.1	124	0.2	<0.1	121
37 378002	*Latridopsis forsteri*	Bastard trumpeter	1	<0.1	124	1.7	<0.1	103
37 390001	*Parapercis allporti*	Grubfish-barred	1	<0.1	124	0.1	<0.1	129
37 390027	*Simipercis trispinosa*	Grubfish-pink	1	<0.1	124	<0.1	<0.1	146
37 401000	*Champsodon* sp.	Gaper	1	<0.1	124	<0.1	<0.1	146
37 460002	*P. jenynsii*	Flounder-smalltooth	1	<0.1	124	0.2	<0.1	121
23 659000	*Octopus* sp.	Octopus-twospots	1	<0.1	124	0.1	<0.1	129
28 51003	*Belosquilla laevis*	Mantis-common	1	<0.1	124	0.1	<0.1	129
28 51009	*A. mcneilli*	Mantis-yellowspined	1	<0.1	150	0.1	<0.1	129
28 875003	*Mursia curtispina*	Boxcrab-spined	1	<0.1	124	0.1	<0.1	129
28 880000	Majidae sp.	Masked crab-red arms	1	<0.1	124	0.1	<0.1	129
28 911006	*P. sanguinolentis*	Crab-3 spot swimmer	1	<0.1	124	0.1	<0.1	141
28 911019	*Charybdis miles*	Swimmercrab-angry	1	<0.1	124	0.1	<0.1	129
28 911026	*P. rubromarginatus*	Swimmercrab-pink	1	<0.1	124	0.1	<0.1	129
28 922099	*Exopheticus insignis*	Crab-redmoon	1	<0.1	124	0.1	<0.1	129
		Total:	**348827**			**25986**		

Appendix 5. Mean catch rates (no. per tow) with standard error (s.e.) of all species caught in each treatment codend and the corresponding control codend during Experiment 1; for species name, see Appendix 3 (N = no. of tows species was caught).

Codend:	**T4mm200**			**T4mm200X**			**T4mm100**			**Control C200**			**Control C200X**			**Control C100**		
	N	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.
N max. :	**16**			**14**			**15**			**15**			**14**			**16**		
Elasmobranchs – commercial																		
Shark-spotted wobbegong	**0**			**2**	0.4	0.3	**0**			**0**			**0**			**2**	0.1	0.1
Shark-gummy	**7**	1.0	0.4	**2**	0.1	0.1	**7**	0.8	0.3	**4**	0.3	0.1	**5**	1.1	0.7	**1**	0.1	0.1
Shark-bronze whaler	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Shark-eastern angel	**1**	0.1	0.1	**1**	0.1	0.1	**0**			**0**			**0**			**2**	0.1	0.1
Ray-eastern shovelnose	**16**	10.1	3.3	**14**	12.6	2.3	**14**	15.1	4.7	**15**	8.5	2.2	**13**	7.9	1.6	**15**	9.7	2.0
Ray-banjo	**10**	4.0	1.7	**12**	4.3	1.3	**11**	6.4	1.8	**11**	7.9	3.8	**8**	6.0	2.2	**12**	3.8	1.4
Stingaree-sandyback	**4**	1.1	0.7	**0**			**2**	0.1	0.1	**1**	0.1	0.1	**4**	1.3	1.0	**2**	0.3	0.2
Ray-southern eagle	**8**	2.4	1.0	**5**	3.2	2.5	**7**	10.2	5.2	**6**	6.9	4.4	**6**	5.1	3.0	**7**	12.7	7.7
Teleosts – commercial																		
Conger-southern	**2**	0.1	0.1	**1**	0.1	0.1	**0**			**1**	0.1	0.1	**0**			**1**	0.1	0.1
Redcod-bearded	**0**			**0**			**1**	0.1	0.1	**0**			**0**			**0**		
Redfish	**14**	344.0	140.5	**13**	324.7	108.4	**11**	170.5	90.8	**14**	399.7	128.0	**14**	434.4	149.4	**15**	220.8	77.8
John dory	**4**	1.2	0.9	**4**	0.4	0.2	**3**	0.3	0.2	**6**	0.4	0.1	**6**	1.0	0.5	**1**	0.1	0.1
Gurnard-red	**15**	6.5	1.9	**11**	4.9	1.2	**14**	6.7	2.0	**13**	3.4	0.7	**12**	3.6	0.7	**14**	5.2	1.1
Latchet	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**0**		
Flathead-tiger	**11**	15.0	7.4	**7**	9.5	6.1	**6**	16.5	9.5	**9**	11.6	6.1	**6**	17.6	14.1	**7**	16.6	13.9
Flathead-bluespotted	**16**	30.2	5.0	**14**	24.2	5.4	**15**	26.1	4.1	**15**	27.8	4.5	**14**	28.3	6.1	**16**	24.4	3.9
Flathead-dusky	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Flathead-marbled	**12**	3.2	0.8	**8**	1.5	0.6	**5**	0.5	0.4	**13**	8.4	2.8	**13**	4.2	1.2	**12**	2.3	0.5
Flathead-freespine	**1**	0.1	0.1	**1**	0.2	0.2	**0**			**1**	0.3	0.3	**2**	1.9	1.8	**2**	1.4	1.2
Banded (bar) cod	**0**			**1**	0.1	0.1	**1**	0.1	0.1	**0**			**0**			**1**	0.1	0.1
Longfin pike	**3**	0.4	0.3	**2**	0.1	0.1	**1**	0.1	0.1	**3**	0.3	0.2	**0**			**2**	0.8	0.7
Eastern school whiting	**16**	1063	338.8	**14**	501.1	139.4	**15**	100.1	23.7	**15**	3478	805.7	**14**	2153	316.0	**16**	1936	476.7
Tailor	**0**			**0**			**0**			**0**			**1**	0.2	0.2	**0**		
Silver trevally	**0**			**3**	0.3	0.2	**4**	0.5	0.2	**3**	0.7	0.5	**0**			**2**	1.1	1.1
Yellowtail scad	**13**	39.8	32.5	**14**	142.4	110.2	**10**	8.7	3.9	**15**	105.9	31.7	**12**	136.5	36.0	**14**	373.8	295.8
Snapper	**7**	24.7	14.3	**2**	1.1	0.7	**3**	31.3	31.0	**6**	5.1	3.1	**6**	4.7	4.2	**2**	0.3	0.3
Tarwhine	**3**	4.9	3.3	**1**	0.1	0.1	**2**	3.1	3.0	**2**	2.1	1.6	**1**	0.5	0.5	**0**		
Goatfish-bluestriped	**6**	2.7	1.1	**5**	1.9	1.4	**3**	0.6	0.4	**9**	2.9	0.8	**7**	1.4	0.6	**4**	1.3	0.9
Boarfish-giant	**4**	0.6	0.3	**3**	0.2	0.1	**1**	0.2	0.2	**5**	0.6	0.3	**4**	0.4	0.2	**2**	0.1	0.1
Rock cale	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Grey morwong	**6**	5.2	4.1	**2**	1.1	0.8	**3**	0.2	0.1	**4**	1.7	1.1	**3**	1.0	0.9	**2**	0.1	0.1

Appendix 5 (continued). Mean catch rates with standard error of all species caught in each treatment codend and control during Experiment 1.

Codend:	T4mm200			T4mm200X			T4mm100			Control C200			Control C200X			Control C100		
	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.
N max. :	**16**			**14**			**15**			**15**			**14**			**16**		
Teleosts – commercial																		
Stargazer-fringed	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**2**	0.2	0.1	**1**	0.2	0.2	**2**	0.2	0.1
Stargazer-banded	**3**	0.2	0.1	**4**	0.3	0.1	**7**	0.7	0.2	**5**	0.3	0.1	**5**	0.4	0.2	**9**	0.7	0.2
Blue mackerel	**1**	0.9	0.9	**2**	0.3	0.2	**0**			**5**	4.1	2.7	**4**	8.3	6.8	**4**	5.4	4.1
Flounder-smalltooth	**0**			**0**			**1**	0.1	0.1	**0**			**0**			**1**	0.1	0.1
Flounder-slender	**12**	10.4	4.1	**9**	14.2	5.0	**12**	7.0	2.6	**10**	11.5	4.8	**8**	12.8	5.3	**11**	11.6	4.9
Leatherjacket-unicorn	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Leatherjacket-mosaic	**1**	0.1	0.1	**1**	0.1	0.1	**3**	0.2	0.1	**2**	0.1	0.1	**2**	0.2	0.2	**3**	0.2	0.1
Leatherjacket-sixspine	**0**			**0**			**1**	0.1	0.1	**1**	0.1	0.1	**2**	0.1	0.1	**1**	0.1	0.1
Leatherjacket-velvet	**2**	0.3	0.2	**0**			**1**	0.1	0.1	**2**	0.4	0.3	**1**	4.3	4.3	**0**		
Leatherjacket-yellowfin	**4**	0.6	0.3	**2**	0.2	0.2	**6**	0.8	0.3	**4**	0.6	0.3	**2**	0.4	0.4	**3**	0.3	0.1
Ocean jacket	**16**	92.9	33.5	**14**	39.4	12.8	**14**	64.0	40.5	**13**	32.8	10.3	**14**	88.2	34.8	**15**	52.3	15.7
Invertebrates – commercial																		
Southern calamari	**16**	27.0	3.9	**14**	29.5	7.1	**15**	22.8	5.8	**15**	33.1	6.8	**14**	35.7	8.1	**16**	26.3	4.8
Squid-slender	**2**	0.7	0.5	**3**	0.6	0.4	**3**	1.1	0.6	**3**	1.5	1.1	**3**	0.4	0.3	**5**	1.3	0.8
Squid-Gould's	**9**	3.9	1.6	**9**	2.5	0.8	**10**	1.7	0.5	**12**	9.7	3.4	**10**	4.1	2.1	**10**	4.6	2.2
Cuttlefish-giant	**3**	0.4	0.3	**1**	0.1	0.1	**2**	0.3	0.2	**3**	0.2	0.1	**4**	0.4	0.2	**3**	0.6	0.4
Cuttlefish-rosecone	**15**	21.9	8.8	**14**	32.4	9.7	**14**	34.0	12.3	**14**	42.0	16.3	**13**	28.8	9.8	**14**	38.4	13.8
Octopus-southern	**11**	1.5	0.4	**8**	2.0	0.8	**4**	0.3	0.1	**15**	13.3	2.1	**13**	14.6	3.0	**13**	9.6	1.7
Octopus-eyecross	**1**	0.1	0.1	**0**			**0**			**1**	0.2	0.2	**0**	0	0	**3**	0.2	0.1
Octopus-gloomy	**2**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**6**	0.7	0.3	**3**	0.5	0.4	**2**	0.3	0.2
Octopus-Maori	**0**			**2**	0.1	0.1	**1**	0.1	0.1	**2**	0.2	0.1	**3**	0.2	0.1	**1**	0.1	0.1
Volute-magnificent	**3**	0.4	0.2	**4**	0.5	0.3	**0**			**3**	0.3	0.2	**4**	0.4	0.2	**3**	0.3	0.1
Prawn-king	**5**	0.3	0.1	**3**	0.4	0.2	**5**	0.8	0.4	**10**	5.0	2.1	**8**	6.9	2.1	**12**	5.1	1.4
Bug-smooth	**5**	0.6	0.3	**5**	0.4	0.2	**5**	0.5	0.2	**4**	0.3	0.1	**4**	0.4	0.2	**5**	0.4	0.2
Bug-Balmain	**14**	6.3	1.2	**12**	8.2	3.3	**12**	8.3	2.5	**14**	10.5	3.3	**12**	5.9	1.7	**12**	7.7	2.3
Crab-blue swimmer	**8**	1.8	0.7	**8**	1.2	0.4	**9**	2.7	0.9	**8**	1.7	0.6	**8**	1.1	0.4	**9**	1.9	0.6
Crab-3 spot swimmer	**0**			**0**			**0**			**1**	0.1	0.1	**0**			**0**		

Appendix 5 (continued). Mean catch rates with standard error of all species caught in each treatment codend and control during Experiment 1.

Codend:	**T4mm200**			**T4mm200X**			**T4mm100**			**Control C200**			**Control C200X**			**Control C100**		
	N	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.
N max. :	**16**			**14**			**15**			**15**			**14**			**16**		
Elasmobranchs – non-commercial																		
Shark-Port Jackson	**12**	6.9	2.6	**10**	5.5	2.8	**11**	2.8	0.9	**12**	6.8	2.6	**7**	9.3	7.0	**11**	2.3	0.6
Shark-crested horn	**2**	0.2	0.1	**0**			**5**	0.6	0.3	**4**	0.4	0.2	**0**			**2**	0.2	0.1
Shark-collared carpet	**2**	0.1	0.1	**0**			**1**	0.1	0.1	**0**			**0**			**1**	0.1	0.1
Shark-blind	**1**	0.1	0.1	**2**	0.2	0.2	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1
Catshark-grey spotted	**1**	0.1	0.1	**3**	0.4	0.2	**0**			**2**	0.2	0.1	**1**	0.1	0.1	**3**	0.3	0.2
Ray-coffin	**3**	0.2	0.1	**4**	0.5	0.3	**2**	0.2	0.1	**6**	0.6	0.2	**6**	0.5	0.2	**5**	0.4	0.2
Skate-Sydney	**2**	1.0	0.8	**3**	1.1	0.6	**2**	0.4	0.3	**3**	2.4	1.6	**2**	1.5	1.1	**2**	0.3	0.2
Stingray-smooth	**0**			**0**			**1**	0.1	0.1	**0**			**1**	0.1	0.1	**0**		
Stingray-Thetis	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Stingaree-east. shovelnose	**1**	0.1	0.1	**0**			**2**	0.2	0.1	**2**	0.2	0.1	**0**			**2**	0.3	0.3
Stingaree-common	**8**	1.2	0.4	**8**	11.3	6.5	**10**	19.0	14.2	**10**	2.1	0.5	**7**	5.9	3.2	**7**	5.3	2.2
Stingaree-Kapala	**8**	3.3	1.2	**7**	18.6	9.2	**8**	7.3	3.2	**7**	4.7	2.1	**7**	11.6	7.4	**6**	1.8	0.9
Stingaree-spotted	**4**	0.4	0.3	**3**	0.7	0.4	**2**	0.4	0.3	**1**	0.3	0.3	**4**	0.7	0.4	**3**	0.7	0.4
Stingaree-yellowback	**2**	4.4	4.4	**1**	0.3	0.3	**1**	0.3	0.3	**0**			**2**	0.2	0.2	**1**	0.8	0.8
Stingaree-greenback	**1**	0.1	0.1	**0**			**1**	0.1	0.1	**0**			**0**			**1**	0.4	0.4
Teleosts – non-commercial																		
Bigeye pike eel	**0**			**0**			**0**			**2**	0.1	0.1	**1**	0.4	0.3	**2**	0.2	0.1
Congers-*Gnathophis*	**9**	4.1	1.9	**4**	4.6	4.3	**2**	0.1	0.1	**15**	99.9	23.6	**14**	95.6	18.5	**14**	87.4	30.5
Conger-mottled	**0**			**0**			**0**			**3**	0.6	0.3	**1**	0.1	0.1	**3**	0.4	0.3
Ladder eel	**0**			**0**			**0**			**1**	0.1	0.1	**0**			**0**		
Sergeant baker	**3**	0.7	0.4	**2**	0.2	0.2	**2**	0.1	0.1	**4**	0.8	0.4	**0**			**2**	0.2	0.1
Largescale grinner	**1**			**0**			**1**	0.1	0.1	**3**	5.1	4.3	**2**	1.1	0.9	**5**	10.1	5.8
Painted grinner	**1**	0.1	0.1	**1**	0.1	0.1	**0**			**3**	0.7	0.4	**1**	1.3	1.3	**2**	0.1	0.1
Beaked salmon	**2**	0.4	0.3	**1**	0.3	0.3	**2**	0.1	0.1	**10**	7.7	2.0	**6**	4.6	2.1	**12**	14.5	6.4
Striped anglerfish	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Redcod-bastard	**1**	0.1	0.1	**1**	0.1	0.1	**0**			**6**	4.7	2.3	**4**	1.4	0.6	**3**	2.6	1.6
Ravenous cusk	**0**			**1**	0.1	0.1	**1**	0.1	0.1	**9**	8.8	4.0	**3**	4.2	2.8	**7**	3.2	2.0
Violet sawbelly	**14**	10.8	3.6	**8**	13.6	7.6	**5**	4.1	2.0	**13**	96.9	40.4	**13**	80.7	39.3	**14**	48.8	15.5
Pineapple fish	**0**			**0**			**2**	0.1	0.1	**0**			**1**	0.1	0.1	**0**		
Red flutemouth	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Whitley's gurnard perch	**8**	2.2	1.1	**6**	2.4	1.8	**4**	0.8	0.4	**15**	112.5	23.9	**14**	118.3	30.2	**14**	52.8	15.5

Appendix 5 (continued). Mean catch rates with standard error of all species caught in each treatment codend and control during Experiment 1.

Codend:	**T4mm200**			**T4mm200X**			**T4mm100**			**Control C200**			**Control C200X**			**Control C100**		
	N	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.	**N**	mean	s.e.
N max. :	**16**			**14**			**15**			**15**			**14**			**16**		
Teleosts – non-commercial																		
Gurnard-longfin	**16**	457.5	87.0	**14**	331.0	98.2	**15**	272.7	64.5	**15**	474.1	88.9	**14**	648.9	121.0	**16**	627.9	110.8
Gurnard-roundsnout	**1**	0.1	0.1	**1**	0.1	0.1	**1**	7.7	7.7	**1**	0.1	0.1	**0**			**1**	0.4	0.4
Gurnard-spiny	**2**	1.8	1.2	**3**	1.6	1.0	**1**	0.1	0.1	**2**	2.5	1.7	**4**	6.4	3.4	**2**	0.9	0.8
Gurnard-butterfly	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Red Indian fish	**0**			**0**			**0**			**0**			**0**			**1**	0.1	0.1
Flathead-mud	**0**			**0**			**0**			**0**			**1**	0.1	0.1	**0**		
Flathead-longspine	**15**	100.1	21.3	**13**	79.3	22.6	**15**	36.8	7.9	**14**	400.5	73.6	**13**	738.0	118.6	**15**	603.8	86.8
Three-spined cardinal	**2**	3.8	3.1	**1**	3.6	3.6	**5**	4.4	3.3	**5**	72.9	45.1	**5**	9.1	4.8	**4**	32.5	20.3
Striped grunter	**0**			**1**	0.1	0.1	**0**			**0**			**1**	0.1	0.1	**2**	0.4	0.3
Slender scad	**0**			**0**			**0**			**0**			**1**	0.3	0.3	**0**		
Goatfish-bartail	**0**			**1**	0.1	0.1	**0**			**0**			**1**	0.6	0.6	**2**	0.2	0.1
Bigscale bullseye	**4**	2.8	2.0	**1**	2.4	2.4	**0**			**3**	1.3	0.8	**1**	0.4	0.4	**0**		
Mado	**2**	0.8	0.6	**0**			**2**	15.7	15.3	**2**	6.9	6.7	**0**			**3**	2.4	2.2
Boarfish-blackspot	**0**			**0**			**0**			**1**	0.1	0.1	**0**			**0**		
Sharpfin barracuda	**0**			**0**			**0**			**2**	4.9	4.7	**1**	1.1	1.1	**1**	0.1	0.1
Grubfish-barred	**0**			**0**			**0**			**0**			**0**			**1**	0.1	0.1
Grubfish-pink	**0**			**0**			**0**			**0**			**0**			**1**	0.1	0.1
Stargazer-bulldog	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Common stinkfish	**0**			**0**			**0**			**2**	0.5	0.3	**0**			**1**	0.1	0.1
Spotted dragonet	**0**			**1**	0.7	0.7	**1**	0.3	0.3	**3**	0.3	0.2	**2**	0.5	0.4	**1**	0.3	0.3
Flounder-crested	**9**	2.7	0.8	**5**	1.0	0.5	**7**	0.7	0.3	**15**	164.4	46.3	**14**	175.6	45.2	**15**	90.3	26.3
Sole-narrowbanded	**2**	0.6	0.4	**2**	0.3	0.2	**2**	0.1	0.1	**7**	8.5	4.3	**6**	14.9	7.5	**9**	7.9	3.8
Sole-manyband	**4**	1.1	0.6	**1**	0.1	0.1	**1**	0.1	0.1	**11**	12.9	4.9	**11**	12.7	5.0	**14**	7.2	1.5
Smooth boxfish	**13**	12.4	5.1	**12**	3.0	0.7	**14**	7.5	3.0	**12**	8.8	4.4	**6**	4.1	2.1	**12**	11.8	5.2
Puffer-Cheeseman’s	**5**	1.3	0.8	**6**	6.6	4.0	**4**	1.6	0.9	**5**	2.8	1.9	**7**	4.3	2.0	**5**	4.3	2.3
Puffer-starry	**1**	0.1	0.1	**0**			**0**			**0**			**1**	0.1	0.1	**0**		
Porcupinefish-Australian	**10**	1.8	0.5	**7**	1.6	0.7	**7**	2.3	1.0	**8**	2.1	0.7	**8**	5.9	2.5	**10**	3.4	1.2
Porcupinefish-threebar	**4**	0.3	0.1	**1**	0.1	0.1	**3**	0.2	0.1	**1**	0.1	0.1	**3**	0.3	0.2	**4**	0.7	0.4
Invertebrates – non-commercial																		
Squid-striped dumpling	**1**	0.1	0.1	**0**			**0**			**8**	2.6	1.1	**4**	1.2	0.6	**7**	2.6	1.0
Squid-southern dumpling	**0**			**0**			**0**			**0**			**1**	0.4	0.4	**1**	0.5	0.5
Cuttlefish-pygmy	**2**	0.4	0.3	**1**	0.1	0.1	**1**	0.1	0.1	**6**	5.9	2.7	**3**	1.9	1.1	**6**	2.3	1.4
Octopus-blue-lined	**0**			**2**	0.1	0.1	**0**			**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1

Appendix 5 (continued). Mean catch rates with standard error of all species caught in each treatment codend and control during Experiment 1.

Codend:	T4mm200			T4mm200X			T4mm100			Control C200			Control C200X			Control C100		
	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.	N	mean	s.e.
N max.:	**16**			**14**			**15**			**15**			**14**			**16**		
Invertebrates – non-commercial																		
Helmetshell-smooth	**3**	0.3	0.1	**2**	0.2	0.2	**1**	0.1	0.1	**2**	0.3	0.2	**3**	0.5	0.4	**1**	0.1	0.1
Helmetshell-Thomson’s	**11**	2.2	0.5	**7**	1.0	0.4	**7**	2.0	0.8	**9**	2.7	0.8	**6**	1.2	0.5	**5**	1.5	0.9
Whelk-giant	**9**	1.3	0.3	**7**	1.3	0.4	**4**	0.7	0.4	**8**	0.8	0.2	**6**	1.1	0.5	**5**	0.8	0.4
Cask shell	**6**	0.5	0.2	**7**	1.5	0.6	**6**	1.3	0.5	**6**	0.7	0.3	**4**	0.7	0.5	**8**	1.1	0.3
Volute-wavy	**0**			**0**			**0**			**1**	0.1	0.1	**1**	0.1	0.1	**0**		
Volute-Hunter’s	**11**	3.5	1.3	**7**	3.1	1.1	**12**	4.5	1.4	**9**	2.5	0.7	**8**	4.0	1.5	**11**	3.5	1.1
Olive shell	**3**	0.4	0.3	**2**	0.3	0.2	**4**	0.5	0.2	**4**	1.1	0.5	**7**	1.8	0.7	**8**	1.9	0.6
Saucer scallop	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Mantis shrimp-yellowspine	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**1**	0.1	0.1
Mantis shrimp-pinkspine	**0**			**0**			**0**			**0**			**1**	0.1	0.1	**0**		
Mantis shrimp-smooth	**0**			**0**			**1**	0.1	0.1	**0**			**0**			**0**		
Mantis shrimp-banded	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Prawn-hardback	**2**	0.3	0.2	**0**			**2**	0.3	0.2	**6**	5.4	2.1	**2**	1.6	1.2	**8**	9.4	6.2
Frog crab	**2**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Boxcrab-redstreaked	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Boxcrab-spined	**0**			**0**			**0**			**0**			**0**			**1**	0.1	0.1
Crab-smooth pebble	**1**	0.1	0.1	**0**			**0**			**0**			**0**			**0**		
Spidercrab-knobbed	**3**	0.2	0.1	**2**	0.2	0.2	**4**	0.3	0.1	**2**	0.2	0.1	**3**	0.8	0.5	**0**		
Spidercrab-Waite’s	**0**			**1**	0.3	0.3	**0**			**0**			**0**			**0**		
Spidercrab-horned	**0**			**1**	0.1	0.1	**0**			**0**			**0**			**0**		
Swimmercrab-brown	**0**			**1**	0.2	0.2	**0**			**0**			**1**	0.7	0.7	**1**	0.6	0.6
Swimmercrab-angry	**0**			**1**	0.1	0.1	**0**			**0**			**1**	0.1	0.1	**0**		
Swimmercrab-paddlespot	**0**			**0**			**0**			**1**	0.1	0.1	**1**	0.1	0.1	**0**		
Swimmercrab-pinkedged	**0**			**0**			**0**			**1**	0.1	0.1	**0**			**0**		
Crab-redmoon	**0**			**0**			**0**			**0**			**1**	0.1	0.1	**0**		
Crab-hairy	**7**	1.1	0.4	**2**	0.2	0.2	**6**	0.7	0.3	**6**	0.6	0.2	**1**	1.1	1.1	**5**	0.6	0.2

Appendix 6. Mean catch rates (no. per tow) with standard error (s.e.) of all species caught in each treatment codend and the corresponding control during Experiment 2; for species name, see Appendix 3 (N = no. of tows each species was caught).

Codend:	**T5mm200**			**T3mm200**			**C5mm control**			**C3mm control**		
	N	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**
N max.:	**16**			**16**			**15**			**15**		
Elasmobranchs – commercial												
Shark-spotted wobbegong	**1**	0.1	0.1	**0**			**1**	0.1	0.1	**1**	0.1	0.1
Shark-gummy	**0**			**0**			**1**	0.1	0.1	**2**	0.1	0.1
Shark-bronze whaler	**0**			**1**	0.1	0.1	**0**			**0**		
Shark-spinner	**1**	0.1	0.1	**0**			**0**			**0**		
Shark-southern angel	**0**			**0**			**0**			**1**	0.1	0.1
Ray-eastern shovelnose	**12**	2.2	0.8	**11**	1.9	0.5	**12**	2.8	0.7	**10**	3.1	0.9
Ray-banjo	**6**	1.3	0.7	**10**	2.3	0.9	**12**	2.4	0.6	**7**	1.7	1.0
Ray-southern eagle	**4**	0.9	0.5	**5**	0.6	0.3	**8**	1.6	0.7	**5**	1.1	0.7
Teleosts – commercial												
Conger-southern	**1**	0.1	0.1	**1**	0.1	0.1	**2**	0.1	0.1	**0**		
Redfish	**15**	113.9	39.9	**16**	133.6	35.0	**13**	152.3	47.1	**15**	221.7	54.3
John dory	**4**	0.4	0.2	**2**	0.1	0.1	**3**	0.3	0.2	**6**	0.5	0.2
Gurnard-red	**12**	4.7	1.4	**14**	6.9	1.2	**14**	7.1	1.9	**15**	7.1	1.2
Flathead-tiger	**3**	9.4	5.7	**2**	2.2	1.9	**5**	7.9	5.2	**3**	7.5	5.0
Flathead-bluespotted (sand)	**15**	12.1	2.3	**14**	14.6	4.4	**15**	10.8	1.9	**15**	10.7	1.9
Flathead-dusky	**1**	0.1	0.1	**2**	0.1	0.1	**0**			**1**	0.1	0.1
Flathead-marbled	**11**	2.4	0.7	**11**	1.0	0.2	**11**	2.9	1.0	**8**	1.6	0.6
Flathead-freespine	**1**	0.1	0.1	**0**			**0**			**0**		
Banded (bar) cod	**0**			**1**	0.1	0.1	**2**	0.2	0.1	**0**		
Longfin pike	**1**	0.1	0.1	**1**	0.1	0.1	**6**	0.9	0.4	**7**	0.9	0.4
Whiting-sand	**1**	0.1	0.1	**0**			**1**	0.1	0.1	**0**		
Whiting-eastern school	**15**	654.8	110.8	**16**	324.9	69.6	**15**	1610.3	578.8	**15**	1691.5	479.3
Tailor	**7**	2.1	0.9	**5**	0.3	0.1	**2**	0.1	0.1	**4**	0.5	0.3
Silver trevally	**4**	0.8	0.6	**4**	0.4	0.2	**6**	0.7	0.3	**5**	0.9	0.4
Samsonfish	**0**			**0**			**0**			**1**	0.1	0.1
Yellowtail scad	**14**	24.7	6.6	**13**	19.7	8.5	**15**	159.7	117.4	**15**	55.8	10.6
Snapper	**7**	0.5	0.2	**4**	0.7	0.4	**6**	1.5	0.7	**5**	7.3	7.0
Tarwhine	**1**	0.4	0.4	**2**	0.3	0.2	**1**	0.1	0.1	**3**	2.3	1.5
Mulloway	**1**	0.1	0.1	**0**			**0**			**0**		
Teraglin	**1**	0.3	0.3	**1**	0.1	0.1	**2**	0.1	0.1	**1**	0.1	0.1
Goatfish-blackspot	**0**			**1**	0.1	0.1	**0**			**0**		
Goatfish-bluestriped	**7**	2.0	0.9	**8**	1.4	0.7	**8**	2.8	1.5	**9**	4.9	2.4

Appendix 6 (continued). Mean catch rates with standard error (s.e.) of all species caught in each treatment codend and control during Experiment 2.

Codend:	T5mm200			T3mm200			C5mm control			C3mm control		
	N	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**
Teleosts – commercial												
Boarfish-giant	**5**	0.6	0.2	**8**	0.7	0.2	**4**	0.5	0.2	**6**	0.9	0.4
Rock cale	**0**			**0**			**1**	0.1	0.1	**0**		
Grey (rubberlip) morwong	**1**	0.1	0.1	**0**			**1**	0.3	0.3	**1**	0.1	0.1
Bastard trumpeter	**0**			**0**			**1**	0.1	0.1	**0**		
Stargazer-banded	**5**	0.4	0.2	**3**	0.3	0.2	**5**	0.4	0.2	**4**	0.3	0.2
Stargazer-fringed	**2**	0.1	0.1	**1**	0.1	0.1	**0**			**1**	0.1	0.1
Blue mackerel	**2**	0.1	0.1	**0**			**1**	6.7	6.7	**0**		
Flounder-slender	**10**	4.4	2.0	**9**	1.9	0.6	**12**	3.8	0.9	**9**	4.3	2.0
Jacket-ocean	**16**	212.6	66.2	**16**	120.9	39.0	**15**	179.7	50.2	**15**	61.3	14.6
Leatherjacket-unicorn	**0**			**0**			**1**	0.1	0.1	**2**	0.1	0.1
Leatherjacket-mosaic	**2**	0.1	0.1	**1**	0.1	0.1	**2**	0.3	0.2	**1**	0.1	0.1
Leatherjacket-sixspine	**0**			**0**			**1**	0.1	0.1	**0**		
Leatherjacket-velvet	**0**			**1**	0.1	0.1	**0**			**0**		
Leatherjacket-yellowfin	**4**	0.3	0.1	**5**	0.5	0.2	**5**	0.7	0.3	**3**	0.4	0.2
Invertebrates – commercial												
Sthn calamari	**16**	41.9	6.4	**16**	50.8	8.1	**15**	50.6	9.6	**15**	64.1	13.1
Squid-estuary	**2**	0.1	0.1	**3**	0.4	0.2	**3**	0.8	0.4	**2**	0.9	0.7
Squid-slender	**3**	0.8	0.5	**3**	0.6	0.3	**3**	0.8	0.7	**4**	0.4	0.2
Squid-Gould’s	**4**	2.1	1.6	**1**	0.1	0.1	**2**	0.5	0.4	**5**	0.5	0.3
Cuttlefish-giant	**2**	0.1	0.1	**2**	0.2	0.1	**1**	0.1	0.1	**5**	0.4	0.2
Cuttlefish-rosecone	**12**	4.4	2.4	**10**	4.1	2.0	**11**	6.3	3.7	**11**	6.5	2.8
Octopus-southern	**15**	13.1	4.9	**15**	5.6	1.4	**15**	42.9	6.5	**15**	48.3	10.0
Octopus-Maori	**3**	0.2	0.1	**0**			**1**	0.1	0.1	**0**		
Octopus-gloomy	**5**	0.6	0.3	**3**	0.5	0.4	**7**	0.9	0.4	**5**	0.3	0.1
Octopus-eyecross	**6**	0.8	0.4	**7**	0.8	0.3	**8**	1.4	0.4	**7**	1.1	0.4
Volute-magnificent	**5**	0.3	0.1	**3**	0.3	0.1	**4**	0.3	0.2	**1**	0.1	0.1
Prawn-king	**7**	5.4	3.2	**5**	0.9	0.5	**11**	22.5	13.6	**15**	5.3	1.9
Prawn-school	**0**			**1**	0.1	0.1	**0**			**0**		
Bug-Balmain	**14**	4.3	1.0	**14**	4.4	1.3	**13**	4.8	1.0	**13**	4.1	0.8
Bug-smooth	**4**	0.4	0.2	**3**	0.3	0.2	**5**	0.4	0.2	**3**	0.3	0.2
Crab-blue swimmer	**12**	3.8	1.0	**14**	4.6	1.2	**11**	3.4	1.1	**12**	4.3	1.1

Appendix 6 (continued). Mean catch rates with standard error (s.e.) of all species caught in each treatment codend and control during Experiment 2.

Codend:	T5mm200			T3mm200			C5mm control			C3mm control		
	N	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**
Elasmobranchs – non-commercial												
Shark-Port Jackson	**6**	1.5	0.6	**7**	1.1	0.5	**5**	0.8	0.4	**7**	1.8	0.8
Shark-crested horn	**2**	0.1	0.1	**2**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1
Shark-collared carpet	**1**	0.1	0.1	**0**			**1**	0.1	0.1	**2**	0.1	0.1
Shark-blind	**1**	0.4	0.4	**4**	0.5	0.2	**2**	0.2	0.1	**4**	0.5	0.3
Catshark-grey spotted	**1**	0.1	0.1	**3**	0.3	0.2	**5**	0.9	0.4	**1**	0.1	0.1
Ray-coffin	**9**	0.7	0.2	**8**	0.8	0.2	**4**	0.3	0.2	**4**	0.5	0.3
Ray-torpedo	**0**			**1**	0.1	0.1	**0**			**0**		
Skate-Sydney	**2**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1	**1**	0.1	0.1
Stingray-smooth	**1**	0.1	0.1	**0**			**0**			**0**		
Maskray-bluespotted	**1**	0.1	0.1	**0**			**0**			**0**		
Stingray-Thetis	**0**			**0**			**1**	0.1	0.1	**0**		
Stingaree-eastern shovelnose	**3**	0.3	0.2	**8**	2.3	0.8	**7**	2.1	1.0	**7**	1.8	1.0
Stingaree-common	**5**	3.8	2.5	**4**	7.7	5.3	**3**	2.1	1.4	**4**	5.3	3.6
Stingaree-Kapala	**6**	8.4	6.4	**6**	0.7	0.3	**4**	3.3	2.7	**3**	2.0	1.7
Stingaree-spotted	**3**	0.2	0.1	**0**			**1**	1.4	1.4	**3**	0.2	0.1
Stingaree-yellowback	**1**	0.1	0.1	**0**			**1**	1.1	1.1	**0**		
Stingaree-greenback	**0**			**0**			**0**			**1**	0.1	0.1
Teleosts – non-commercial												
Bigeye pike eel	**0**			**0**			**0**			**1**	0.1	0.1
Congers- *Gnathophis*	**12**	9.0	2.7	**7**	1.1	0.4	**14**	186.6	52.5	**15**	226.4	68.4
Conger-mottled	**0**			**0**			**0**			**2**	0.1	0.1
Serpent eel	**0**			**1**	0.1	0.1	**0**			**1**	0.1	0.1
Sergeant baker	**0**			**0**			**1**	0.1	0.1	**0**		
Painted grinner	**2**	0.8	0.5	**2**	0.1	0.1	**2**	0.2	0.1	**2**	0.2	0.1
Largescale grinner	**10**	2.4	0.7	**6**	1.2	0.5	**13**	12.1	5.0	**11**	15.9	7.9
Beaked salmon	**4**	0.9	0.6	**2**	0.1	0.1	**12**	19.1	6.1	**13**	9.1	2.4
Rough anglerfish	**0**			**0**			**1**	0.1	0.1	**0**		
Bastard redcod	**1**	0.3	0.3	**2**	0.4	0.4	**2**	2.0	1.6	**2**	2.1	1.7
Ravenous cusk	**5**	1.3	0.7	**1**	0.1	0.1	**8**	20.4	8.8	**9**	13.1	9.9
Violet sawbelly	**12**	22.4	5.6	**11**	21.4	13.6	**14**	99.4	34.1	**13**	94.3	29.5
Pineapple fish	**0**			**1**	0.1	0.1	**0**			**0**		
Red flutemouth	**2**	0.4	0.3	**1**	0.1	0.1	**4**	0.5	0.3	**4**	0.3	0.1
Common bellowsfish	**1**	0.1	0.1	**0**			**1**	2.4	2.4	**0**		
Whitley's gurnard perch	**10**	2.8	1.0	**4**	1.0	0.6	**14**	68.4	38.5	**14**	27.5	9.4

Appendix 6 (continued). Mean catch rates with standard error (s.e.) of all species caught in each treatment codend and control during Experiment 2.

Codend:	T5mm200			T3mm200			C5mm control			C3mm control		
	N	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**
Teleosts – non-commercial												
Gurnard-longfin	**16**	556.8	120.6	**16**	533.3	146.0	**15**	1002.6	430.5	**15**	619.0	186.5
Gurnard-roundsnout	**1**	2.1	2.1	**0**			**1**	2.0	2.0	**0**		
Gurnard-spiny	**3**	1.4	1.0	**1**	0.1	0.1	**3**	1.3	0.7	**1**	0.5	0.5
Flathead-longspine	**16**	136.6	20.3	**16**	49.4	9.9	**15**	374.9	76.0	**15**	378.5	60.0
Striped grunter	**1**	0.1	0.1	**0**			**1**	0.1	0.1	**3**	0.6	0.4
Longnose trevally	**0**			**0**			**0**			**1**	0.1	0.1
Goatfish-bartail	**0**			**0**			**1**	0.3	0.3	**3**	0.7	0.4
Bigscale bullseye	**0**			**1**	2.8	2.8	**2**	0.9	0.8	**0**		
Mado	**2**	0.2	0.1	**3**	0.7	0.4	**4**	1.7	1.2	**4**	10.4	8.2
Stripey	**2**	0.1	0.1	**2**	0.2	0.1	**0**			**1**	0.1	0.1
Old wife	**0**			**0**			**1**	0.1	0.1	**1**	0.1	0.1
Boarfish-blackspot	**1**	0.1	0.1	**0**			**0**			**0**		
Sharpfin barracuda	**0**			**0**			**1**	1.7	1.7	**1**	0.1	0.1
Gaper	**0**			**0**			**0**			**1**	0.1	0.1
Common stinkfish	**0**			**0**			**1**	0.1	0.1	**0**		
Flounder-crested	**11**	4.9	1.4	**4**	0.6	0.3	**13**	173.7	102.6	**14**	41.5	11.0
Sole-peacock	**0**			**0**			**0**			**1**	0.3	0.3
Sole-narrowbanded	**4**	0.3	0.1	**1**	0.1	0.1	**9**	6.8	1.9	**7**	6.9	3.0
Sole-manyband	**6**	0.7	0.3	**1**	0.1	0.1	**12**	9.6	2.4	**13**	7.5	1.2
Smooth boxfish	**14**	9.4	6.1	**14**	10.8	3.2	**10**	13.7	7.1	**14**	11.4	3.4
Cowfish	**2**	0.1	0.1	**2**	0.3	0.2	**0**			**0**		
Cheeseman’s puffer	**9**	3.0	1.1	**6**	2.0	0.8	**5**	3.3	1.6	**5**	1.5	0.7
Porcupinefish-Australian	**4**	0.9	0.6	**4**	1.3	0.7	**3**	1.5	1.1	**6**	2.7	1.4
Porcupinefish-threebar	**3**	0.4	0.3	**0**			**1**	0.1	0.1	**3**	0.4	0.2

Appendix 6 (continued). Mean catch rates with standard error (s.e.) of all species caught in each treatment codend and control during Experiment 2.

Codend:	**T5mm200**			**T3mm200**			**C5mm control**			**C3mm control**		
	N	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**	**N**	**mean**	**s.e.**
Invertebrates – non-commercial												
Squid-striped dumpling	**0**			**0**			**2**	0.9	0.7	**6**	1.9	1.0
Squid-southern dumpling	**0**			**0**			**1**	0.1	0.1	**1**	0.1	0.1
Cuttlefish-pigmy	**2**	0.1	0.1	**1**	0.1	0.1	**2**	1.9	1.3	**2**	2.1	1.7
Octopus-spotted	**1**	0.1	0.1	**1**	0.1	0.1	**0**			**0**		
Octopus-twospot	**0**			**0**			**1**	0.1	0.1	**0**		
Volute-wavy	**1**	0.1	0.1	**0**			**0**			**0**		
Volute-Hunter’s	**13**	3.9	1.0	**10**	2.8	0.7	**9**	3.3	1.0	**9**	3.0	1.0
Whelk-giant	**5**	0.9	0.4	**7**	0.8	0.3	**2**	0.1	0.1	**3**	0.2	0.1
Cask shell	**5**	0.5	0.2	**9**	1.1	0.3	**3**	0.3	0.1	**5**	0.5	0.2
Helmetshell-smooth	**12**	2.6	0.7	**5**	0.6	0.2	**6**	2.1	0.8	**6**	1.1	0.5
Helmetshell-Thomson’s	**4**	0.3	0.2	**4**	0.8	0.5	**3**	0.7	0.4	**3**	0.3	0.2
Olive shell	**4**	0.6	0.3	**1**	0.1	0.1	**3**	0.6	0.3	**5**	1.1	0.5
Cone shell	**1**	0.1	0.1	**0**			**0**			**0**		
Prawn-hardback	**4**	1.4	1.2	**5**	1.2	0.7	**5**	16.2	10.4	**6**	14.5	6.5
Prawn-school	**0**			**1**	0.1	0.1	**0**			**0**		
Swimmercrab-brown	**0**			**0**			**2**	0.7	0.5	**1**	0.1	0.1
Spidercrab-Waite’s	**0**			**0**			**1**	0.1	0.1	**1**	0.1	0.1
Spidercrab-knobbed	**6**	0.6	0.2	**4**	0.4	0.2	**3**	1.0	0.5	**4**	1.0	0.5
Spidercrab-red arms	**0**			**0**			**1**	0.1	0.1	**0**		
Crab-hairy	**1**			**0**			**2**	0.5	0.4	**1**	0.1	0.1

Appendix 7. Draft of paper submitted to *Fisheries Research*.

Effects of codend circumference and twine diameter on selection in southeastern Australian fish trawls

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Abstract

Two experiments, done in a south-eastern Australian trawl fishery targeting eastern school whiting (*Sillago flindersi*: Sillaginidae), examined the relative efficiencies and selectivities of five codends and extension sections made from double-twine 90-mm (inside stretched length) mesh netting. All extension sections were made from 3-mm diameter twine and were 100 meshes long and 100 meshes in circumference, while the codends were 25 meshes in length. The first experiment tested three codends made from 4-mm diameter twine: one with a circumference of 100 meshes, and two of 200-mesh circumferences with one of the latter incorporating two cross-sectional joins in its extension piece. The second experiment compared two 200-mesh circumference codends, one constructed from 3-mm diameter twine and the other from 5-mm diameter twine. The codends were alternately fished with a small-meshed control. Results showed a general trend of reduced selection by the 200-mesh circumference and thicker-twined codends, and especially by the industry-preferred 200-mesh circumference codend constructed from 5-mm diameter twine. Experiment 1 found that the 100-mesh codend caught significantly fewer school whiting, retained catch and total catch than did the two 200-mesh codends, and the 200-mesh codend with the modified extension section caught significantly fewer school whiting and retained catch than did the 200-mesh codend with the straight extension. In the second experiment, the 200 mesh 5-mm twine codend caught significantly more total and retained catch, school whiting, and longspine flathead (*Platycephalus longispinis*: Platycephalidae) than did the 200 mesh, 3-mm twine codend. Across all codends, the smallest lengths at 50% probability of retention (L_{50}) were estimated for school whiting, longspine flathead, redfish (*Centroberyx affinis*: Berycidae) and longfin gurnard (*Lepidotrigla argus*: Triglidae) in the 5-mm 200-mesh codend. From the school whiting data, it was estimated that an increase of twine diameter from 4 to 5 mm in the 200-mesh codends reduced the average lateral mesh opening from ~27 to ~17% of the stretched mesh length. While this design retained commercial quantities of school whiting, it seems far from optimal. It is suggested that a more efficient codend comprising possibly smaller, square-shaped meshes should be developed and used in conjunction with temporal, spatial and catch restrictions.

Key words: species selection, size selection, codend selection, multi-species, fisheries management

Introduction

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

In recent years, a number of such modifications have been incorporated into the nets towed by central New South Wales (NSW) fish trawlers. These vessels are 15 – 24 m in length, powered by 135 – 450 kW main engines and tow single otter trawls with headline lengths of between 25 and 45 m; sweeps and bridles are approximately 200 m in length and most use steel vee-shaped otter boards. Generally, the wings and body of the trawls are constructed from light-weight netting (stretched mesh size between 90 and 110 mm) joined to an extension (100 meshes in length or normal direction – N, and 100 meshes in circumference or transverse direction – T) constructed from 3 – 4 mm diameter twine, and a codend (33 N x 100 T) made from 3 – 6 mm diameter double-twine. Both of the latter sections comprise a minimum legal mesh size of 90 mm. This generic trawl configuration has been used over the past 20 years to target more than 20 species across a range of depths between 25 and 600 m, but mostly in depths greater than 75 m.

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

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

Materials and methods

The objectives were addressed during two experiments done off the NSW coast between March 2005 and June 2006 with the chartered trawler towing a standard single-rigged trawl constructed from 100-mm polyethylene (PE) mesh in the wings and 90-mm mesh in the remainder. The trawl had a general plan similar to that described by Broadhurst and Kennelly (1996), with a headline length of 33 m attached to 195 m sweeps and bridles, and 2.0 m vee-shaped boards. All hauls were for 90 minutes at night in depths between 40 and 80 m at between 1.4 and 1.7 ms^{-1} (2.8 – 3.3 knots).

Codends

A control and five treatment codend and extension sections were constructed for use with the trawl (Fig. 1). All codends and their extensions were made from dark PE netting, and were respectively about 2.8 and 11.0 m in length. The five treatment extensions and codends were constructed throughout from double-braided twine, 90-mm mesh netting; all extensions were made from 3-mm diameter (ø) twine and were 99 N x 100 T (Fig. 1a – e). The first treatment (termed 4mm100) had a codend (4-mm ø twine) measuring 25 N x 100 T that was joined at a ratio of 1:1 to its extension (Fig. 1a). The other four treatments (termed 4mm200X, 4mm200, 3mm200, and 5mm200) had 25 N x 200 T codends that were joined at a ratio of 2:1 to their extensions (Fig. 1b – e). The 4mm200X codend was identical to the 4mm200 codend, but its extension included two additional joins (at 33 and 66 N from the end), designed to restrict lateral mesh openings (Fig. 1b). The 3mm200, 4mm200, and 5mm200 treatments were identical, except for different twine diameters in the codend (3, 4 and 5 mm, respectively) (Fig. 1c – e). The control consisted of a 239 N x 225 T extension made from 43 mm mesh (2-mm ø braided twine), attached to a 61 N x 450 T codend made from 40 mm mesh (3-mm ø twisted twine) (Fig. 1f). The control had the same fishing circumference and joining ratio as the four 200 T codends.

Experiment 1: effects of codend circumference

Experiment 1 was done over 27 nights between March and November 2005 (in depths between 42 and 79 m) using the 4mm100, 4mm200X and 4mm200 treatments and control (Fig. 1a – c, f). On each night of fishing, we attempted two pairs of alternate hauls, each pair consisting of a haul with the treatment codend (selected for use that night) and one with the control codend. It was not always possible to complete two pairs of alternate hauls each night but, overall, 16 pairs of alternate hauls were completed for each treatment, and for all treatments there were at least six nights on which the two replicate pairs of hauls were completed.

Experiment 2: effects of twine diameter

Experiment 2 was done between February and June 2006 (in depths between 44 and 66 m) using only the 3mm200 and 5mm200 treatment and control codends (Fig. 1d – f). As above, on each night we aimed to complete two replicate pairs of alternate hauls with the selected treatment codend and control. Over 16 nights, we completed 16 and 15 alternate hauls with each of the 3mm200 and 5mm200 treatment codends and the control codend. Two replicate pairs of alternate hauls with each treatment codend were done on seven nights.

Data collected and statistical analyses

For all trawls, the numbers and weights of each species were recorded. Commercial species were divided into categories of retained and discarded (usually by size), and overall retained, discarded, and total catch were then determined. The most abundant (or commercially-important) teleosts and squid (calamari) were sampled for length data (see Table 1). Fishes with forked or emarginate caudal fins were measured to the centre of the fork or fin margin (FL), while those with truncate or rounded fins were recorded as TL. Calamari measurements were mantle length (ML). All measurements were to the nearest 0.5 cm below actual length. In experiment 1, the weights of the retained and discarded components of catches of some commercial species were estimated from length-weight relationships derived by Graham (1999) and Broadhurst *et al.* (2006a). The collected data were analysed separately for each experiment using two general parametric approaches: (i) univariate analyses of the numbers and weights of the total catches and individually abundant key species and (ii) size selectivity analyses of the latter.

Analyses of variance (ANOVA) was used to examine differences in the total, retained and discarded catches from the treatment codends, and differences in the numbers and weights of retained and discarded key species where there were sufficient data (defined as at least 1 individual in each of 10 hauls). To provide balanced analyses, data were only considered from the nights for which there were two replicate pairs of hauls for each treatment: six nights in experiment 1 and seven nights in experiment 2. For both experiments, data were ln(x+1) transformed (so that effects would be on the multiplicative scale), tested for heterogeneous variances and analysed by one-nested factor ANOVA (nights and treatment codend were considered random and fixed factors, respectively). To increase power for the main effect of treatment codend, where the nested term (nights) was non-significant at $p < 0.25$, it was pooled with the residual. All significant effects of treatment codend were investigated using Student-Newman-Keuls (SNK) multiple comparisons. Figures showing mean numbers and weights are shown for composite totals and for species where significant differences were detected; otherwise, only figures showing mean numbers are presented.

Where there were sufficient data, size frequencies of key species were combined across all hauls for the treatment codends and their associated controls within each experiment. Logistic selection curves were fitted to these data using maximum likelihood and REP corrected for overdispersion arising from between-haul variation (Millar *et al.* 2004). These fits used the SELECT methodology and were done with both equal and estimated-split models (Millar and Walsh 1992), which were assessed for goodness-of-fit by comparing model deviances and through inspection of residuals.

Results

Overall, 137 species (26 elasmobranchs, 77 teleosts, 23 molluscs and 11 crustaceans) were recorded from the treatment codends, of which 58 were marketable. Each codend averaged 30 to 35 species per haul but, for most hauls, more than 80% of the total catch (by number) comprised the commercially-important school whiting, redfish (*Centroberyx affinis*), and ocean jacket (*Nelusetta ayraudi*), and the non-commercial longfin gurnard (*Lepidotrigla argus*) and longspine flathead (*Platycephalus longispinis*). In total, only 10 species (8 commercial and 2 non-commercial) were consistently caught in sufficient quantities for analyses (Table 1). Almost all school whiting, bluespotted flathead (*Platycephalus caeruleopunctatus*), southern calamari (*Sepioteuthis australis*) and rosecone cuttlefish (*Sepia rozella*) were larger than minimum legal (MLL) or marketable (MML) lengths, but high proportions of redfish, red gurnard (*Chelidonichthys kumu*), yellowtail scad (*Trachurus novaezelandiae*) and ocean jacket were below marketable size and, along with all the non-commercial longfin gurnard and longspine flathead, were therefore discarded (Table 1).

The mean (± SE) weights of total catch caught in the commercially preferred 4- and 5mm200 codends (between 204.7 ± 20.0 and 273.0 ± 96.8 kg per 90-min haul) were within the range expected in the fishery. Across the 200-mesh codends, mean retained catch numbers were between 34 and 54% of the total catch, and mean retained catch weights were 47 – 58% of the total. The highest mean catch rate of school whiting was 87 kg per haul by the 4mm200 codend, while the lowest was 7 kg per haul by the 4mm100 codend – both during experiment 1 (Fig. 2 h).

Experiment 1: effects of codend circumference

There were sufficient numbers of retained school whiting, bluespotted flathead, southern calamari and rose-cone cuttlefish, and discarded redfish, yellowtail scad, longfin gurnard and longspine flathead to test for differences among nights and treatment codends using ANOVA. All variables except for numbers of bluespotted flathead and southern calamari showed significant differences among the nested factor of nights ($p < 0.05$). The main effect of treatment codends had significant F-ratios for the numbers of total ($F_{2, 33} = 9.41$, $p < 0.01$) and retained ($F_{2, 15} = 10.64$, $p < 0.01$) catch, and for the numbers ($F_{2, 15} = 15.66$, $p < 0.01$) and weights ($F_{2, 15} = 16.31$, $p < 0.01$) of school whiting (Fig. 2 a, b, d and h). SNK tests of these means showed that the 4mm100 codend caught a significantly lower mean number of total catch than each of the 4mm200 and 4mm200X codends which, in turn, were not significantly different to each other (Fig. 2 a). Compared to the 4mm200 codend, the numbers of retained catch and the numbers and weights of school whiting were significantly and incrementally lower in the 4mm200X and 4mm100 codends (Fig. 2 b, d and h). No other main effects were detected, but there was some trend for lower catches by the 4mm100 codend, in particular for the weight of retained catch and the numbers of discarded catch, redfish, longfin gurnard, longspine flathead and yellowtail scad (Fig. 2 c, f, j-m).

Sufficient quantities and appropriate sizes of school whiting, redfish, longfin gurnard, bluespotted flathead, longspine flathead and southern calamari were caught to enable attempts at modelling their selectivities in the three treatment codends. With the exception of bluespotted flathead caught in the 4mm200 codend, logistic selection curves were successfully converged for all species across all treatment codends (Table 2). The estimated-split model provided significantly better fits in all cases, except for school whiting in the 4mm200X and 4mm100 codends, and longspine flathead in the 4mm200X codend ($p < 0.05$; Table 2). Excluding school whiting, which escaped across nearly all sizes in all three treatment gears, the remaining commercially-important species (bluespotted flathead, redfish and southern calamari) had lengths at 50% probability of retention (L_{50}) in all three treatment codends that were similar to, or less than, their MLL or MML (Tables 1 and 2; Fig. 3). Further, the L_{50}s and their associated selection ranges (SR) for school whiting, bluespotted flathead and southern calamari were greater in the 4mm100 codend than in either of the 200-mesh codends; however, less clear differences in parameter vectors were observed between the two 200-mesh codends (Table 2 and Fig. 3).

Experiment 2: effects of twine diameter

ANOVA was done for retained and discarded catches of ocean jacket and redfish, retained school whiting, southern calamari and bluespotted flathead, and discarded longfin gurnard, longspine flathead and yellowtail scad. Significant effects of night were detected for the catches of retained southern calamari ($p < 0.05$) and discarded longspine flathead ($p < 0.01$). Compared to the 5mm200 codend, the 3mm200 codend caught significantly fewer numbers of total ($F_{1,\ 26} = 5.88$; $p < 0.05$) and retained ($F_{1,\ 26} = 4.76$; $p < 0.05$) catches, weights of retained school whiting ($F_{1,\ 26} = 7.61$; $p < 0.05$), and numbers ($F_{1,\ 14} = 7.43$; $p < 0.05$) and weights ($F_{1,\ 14} = 6.20$; $p < 0.05$) of longspine flathead (Fig. 4 a, b, h, q and r). No other significant differences were detected, although the same trends as above were observed for the weights of total, retained and discarded catches, and the numbers of discarded catch, school whiting, retained redfish, yellowtail scad and ocean jacket (Fig. 4b, d, e-g, l-o).

Logistic selection curves were converged for eight species, but the fits for bluespotted flathead, red gurnard and ocean jacket were not significantly different from the non-selective null model ($p > 0.05$) in which length has no effect on selectivity and hence are not presented (Table 3; Fig. 5). Estimated split models provided significantly better fits for all species (Table 3). Compared to the 5mm200 codend, there was a clear trend of greater L_{50}s for school whiting, longfin gurnard and longspine flathead in the 3mm200 codend (Table 3; Fig. 5a, c and d). The remaining commercially-important species had L_{50}s that were less than their MLL and MML in both treatment codends (Tables 1 and 3; Fig. 5).

Discussion

This study confirms that codends made from diamond-shaped mesh, large enough to allow the escape of fish smaller than minimum commercial or legal size, can be constructed in such a way as to grossly circumvent the intent of minimum mesh-size regulations (Reeves *et al.* 1992; Broadhurst and Kennelly 1996). It is well established that forces created by drag during fishing elongate diamond meshes, and restrict their lateral openings (Robertson and Stewart 1988; Reeves *et al.* 1992). The extent to which this occurs depends on numerous factors, including the type of codend attachments (e.g., Kynoch *et al.*, 2004), twine material (e.g., Tokaç *et al.* 2004) and thickness (e.g., Lowry and Robertson 1996; Özbilgin and Tosunoğlu, 2003; Herrmann and O'Neill 2006), catch weight (e.g., Erickson *et al.*, 1996; Campos *et al.* 2003; Hermann 2005), and especially codend circumference (e.g., Reeves *et al.* 1992; Broadhurst and Kennelly 1996; Lok *et al.* 1997). The 5mm200 codend developed by NSW fishers to successfully harvest school whiting uses a combination of some of these variables to significantly reduce overall trawl selectivity, the effectiveness of which can be discussed according to species-specific differences in morphology, size and behaviour.

The extent to which lateral mesh openings were reduced is best illustrated by the results for school whiting, which was the most abundant fusiform species (width-to-height ratio of 1.4) and is known to readily escape from codends at high numbers if openings are sufficient (Broadhurst and Kennelly 1996; Broadhurst *et al.* 2006b). Apart from a single fish of 27.5 cm FL, all school whiting were less than 26.0 cm FL. Based on morphological relationships provided by Broadhurst *et al.* (2006a), 26-cm FL school whiting have a maximum width of 31 mm, height of 43 mm and girth of 148 mm. Even allowing for the inside perimeter of a 90-mm mesh to be, in practice, about 20 mm less than the theoretical perimeter of 180 mm (because of the effects of large knots in double-twine netting), the girths of 26 cm FL and smaller school whiting were sufficiently small to easily pass through the 90-mm mesh, and this clearly occurred for many fish in the 4mm100 codend tested during experiment 1. Doubling the circumference in the 4mm200 codend reduced the estimated L_{50} from 28.2 to 18.7 cm FL, the latter corresponding to a maximum width of 24.1 mm. Assuming fish escaped in a normal swimming plane and were unable to penetrate meshes narrower than their width (which is reasonable given the thickness and stiffness of the twine), the lateral mesh openings were therefore approximately 27 % of the stretched mesh length (i.e., (24.1 ÷ 90) x 100). Applying the same logic, increasing the twine diameter by 1 mm in the 5mm200 codend further narrowed mesh openings to an average of 15.3 mm (for an L_{50} of 12.18 cm FL) or approximately 17 % of the stretched mesh length.

These estimated lateral mesh openings are within the ranges suggested for diamond-mesh extensions and codends by Robertson (1986) and Broadhurst *et al.* (1999), but were by no means consistent throughout all deployments. The large variances around the selection parameter vectors for the 5mm200 codend indicate the variable retention of a range of sizes of school whiting, and so other factors known to influence codend selectivity probably had ancillary impacts. For example, it is likely that at least some larger fish escaped during hauling when drag was reduced and meshes were under less tension (Watson 1989). Further, fishers also report markedly reduced catches of school whiting when items such as tree branches, logs or large sharks are caught, presumably because these also force meshes open at strategic locations.

The significantly smaller catch of school whiting in the 4mm200X codend (see Fig. 2g, h) may have resulted from the modification to the extension section that was intended to further constrict the transverse spread of meshes. This modification (developed by the operator of the chartered trawler) comprised two joins in the extension, similar in principal to the fixed codend restrictors or “round straps” described by Herrmann *et al.* (2006). However it is possible that, instead of the desired effect, the constrictions inadvertently created slack or more open meshes at their junctures thereby allowing school whiting of all sizes to escape. That the mean numbers of other retained species less affected by codend modifications were only slightly lower (e.g., bluespotted flathead) or even greater (e.g., southern calamari and rosecone cuttlefish), and the mean total, retained and discarded catch weights were almost identical (see Fig. 2), suggests otherwise similar overall efficiencies between the 4mm200X and 4mm200 codends. Subsequently to this experiment, the trawler operator ceased using the 4mm200X codend arrangement after independently concluding that it gave no catch benefits.

While there was a general trend of reduced selection by the larger circumference and thicker twine codends for most species, it was most acute for school whiting. The lesser effects on other taxa probably reflected differences among body profiles, sizes and/or behaviour. For example, other fish such as the fusiform red gurnard and the dorso-ventrally compressed bluespotted flathead were mostly caught at sizes too large to escape from any of the treatments (see Broadhurst *et al.* 2006a). Conversely, while redfish and ocean jacket encompassed the same length range as school whiting, these species are laterally compressed and ovate in profile so their retention would depend less on mesh width and more on mesh height (which would not vary greatly among the examined configurations). Also, owing to their deeper body shape, both of these species, and especially ocean jacket, are unlikely to swim as strongly or be as manoeuvrable as the more streamlined school whiting (e.g., Ohlberger *et al.*, 2006), which may have reduced their probability of encountering open meshes. Similar morphologically-dependant differences in selectivity are common among most multispecies trawl fisheries (e.g., Lök *et al.*, 1997; Özbilgin and Tosunoğlu, 2003; Tokaç *et al.* 2004; Broadhurst *et al.* 2006b).

Like redfish and ocean jacket, the benthic-dwelling flatheads would not be expected to maintain sustained swimming once in the trawl (Piasente *et al.* 2004), and their wide, ventrally compressed heads may limit their opportunities to push through meshes and escape. The respective widths and heights of the smallest bluespotted flathead (29.5 cm FL) were approximately 57 and 23 mm (Broadhurst *et al.* 2006a). Clearly, irrespective of the treatment codend, the size of these fish means that any escapees would have had to orientate sideways to pass through meshes and so, as for redfish and ocean jacket, their retention was probably more dependent on vertical opening. Similar behaviour was probably displayed by longspine flathead, although, given their smaller sizes (7 – 31 cm TL), many individuals would have been able to penetrate meshes at nearly all angles and escape; the probability of which (like for school whiting) was significantly and negatively correlated with increases in codend circumference and twine thickness.

While the 5mm200 codend allows fishers to significantly reduce trawl selectivity within current legal regulations, this configuration may not be the most appropriate or efficient means of harvesting school whiting. Although the estimated L_{50} of 12.18 FL for school whiting was well below the MML of about 15 cm FL, the SR (2.69 cm) was calculated with high error (± 3.48) and so conceivably could be much greater. Any major increase in SR would manifest as varying proportions of commercial-sized individuals escaping, presumably with some associated mortality. Conversely, individuals below MML would also be caught and subsequently discarded with mortalities approaching 100%. A more suitable codend design to target school whiting might involve smaller, square-shaped meshes. For example, Broadhurst *et al.* (2005, 2006b) demonstrated that penaeid-trawl codends made from < 3-mm diameter single twine netting of 35 – 40 mm diamond mesh hung on the bar selected school and the similar stout (*Sillago robusta*) whiting at L_{50}s between ~14 and 18 cm TL, and across selection ranges typically less than 2 cm (and with low associated SE). Although there is some concern that the use of such small-meshed codends by fish trawlers would result in more discards, most of the significant impacts of the modifications examined here were restricted to the retained species, and so any differences between the current and specifically-developed gears may not be extreme. In any case, appropriate spatial and temporal restrictions on the use of a specific school whiting trawl might be applied to further control selection (Broadhurst *et al.* 2005). Such configurations warrant testing on fish trawlers, although the difficulty remains to alter the existing management paradigm concerning the utility of mesh size as an independent mechanism for controlling the exploitation rate of trawls, and encourage the investigation of more holistic strategies.

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Table 1. The family, species and common names of taxa caught in the treatment codends in sufficient numbers for analyses. The method for measuring length during the study, and minimum legal (MLL[1]) or approximate minimum marketable (MML[2]) lengths (cm) are given for cephalopods (ML = mantle length) and commercial teleosts (FL = fork length; TL = total length; na = not applicable).

Family	Species	Common name	Length measured	MLL[1] / MML[2]
Cephalopods				
Loliginidae	*Sepioteuthis australis*	Southern calamari	ML	12.0 [2]
Sepiidae	*Sepia rozella*	Rosecone cuttlefish	ML	8.0 [2]
Teleosts				
Berycidae	*Centroberyx affinis*	Redfish	FL	15.0 [2]
Carangidae	*Trachurus novaezelandiae*	Yellowtail scad	FL	10.0 [2]
Monacanthidae	*Nelusetta ayraudi*	Ocean jacket	TL	28.0 [2]
Platycephalidae	*Platycephalus caeruleopunctatus*	Bluespotted flathead	FL	32.5 [1]
	Platycephalus longispinis	Longspine flathead	TL	na
Sillaginidae	*Sillago flindersi*	School whiting	FL	15.0 [2]
Triglidae	*Chelidonichthys kumu*	Red gurnard	FL	28.0 [2]
	Lepidotrigla argus	Longfin gurnard	TL	na

Table 2. Lengths (cm) at 50% probability of retention (L_{50}), selection ranges (SR) and relative fishing efficiencies (p) for the key species caught in the 4mm200, 4mm200X and 4mm100 codends. Standard errors are given in parentheses. Sixteen treatment and control hauls were used in the models; ns, non-selective for the sizes caught.

Species	Codend	L_{50}	SR	p
School whiting	4mm200	18.69 (3.27)	6.46 (4.79)	0.42 (0.13)
	4mm200X	20.54 (0.21)	4.51 (0.32)	0.50
	4mm100	28.20 (1.01)	8.03 (0.85)	0.50
Redfish	4mm200	12.40 (0.83)	3.48 (0.54)	0.78 (0.03)
	4mm200X	10.21 (0.39)	1.90 (0.40)	0.56 (0.02)
	4mm100	10.51 (0.52)	2.35 (0.67)	0.53 (0.03)
Longfin gurnard	4mm200	12.24 (0.26)	2.98 (0.34)	0.53 (0.01)
	4mm200X	12.52 (0.24)	2.14 (0.31)	0.47 (0.01)
	4mm100	12.39 (0.80)	4.88 (1.22)	0.38 (0.03)
Longspine flathead	4mm200	21.16 (0.63)	3.63 (0.63)	0.33 (0.03)
	4mm200X	27.68 (0.56)	7.19 (0.62)	0.5
	4mm100	24.81 (2.33)	6.19 (1.29)	0.27 (0.08)
Bluespotted flathead	4mm200	ns	ns	ns
	4mm200X	32.87 (0.73)	2.41 (0.95)	0.51 (0.02)
	4mm100	35.00 (2.20)	9.62 (6.10)	0.57 (0.05)
Southern calamari	4mm200	7.90 (0.30)	1.00 (0.48)	0.48 (0.02)
	4mm200X	7.51 (0.00)	0.10 (0.00)	0.47 (0.00)
	4mm100	10.53 (0.52)	3.43 (0.68)	0.55 (0.02)

Table 3. Lengths (cm) at 50% probability of retention (L_{50}), selection ranges (SR) and relative fishing efficiencies (p) for the key species caught in the 3mm200 and 5mm200 codends. Standard errors are given in parentheses. Sixteen (3mm200) and 15 (5mm200) treatment and control hauls were used in the models; ns, non-selective for the sizes caught.

Species	Codend	L_{50}	SR	p
School whiting	3mm200	18.98 (0.64)	3.85 (0.63)	0.30 (0.03)
	5mm200	12.18 (1.54)	2.69 (3.48)	0.31 (0.02)
Redfish	3mm200	9.22 (0.38)	1.77 (0.51)	0.44 (0.02)
	5mm200	8.62 (1.20)	4.12 (2.53)	0.44 (0.02)
Longfin gurnard	3mm200	10.90 (0.40)	2.31 (0.67)	0.49 (0.02)
	5mm200	7.69 (0.48)	1.55 (0.78)	0.37 (0.01)
Red gurnard	3mm200	ns	ns	ns
	5mm200	ns	ns	ns
Longspine flathead	3mm200	24.48 (1.10)	4.67 (0.64)	0.30 (0.06)
	5mm200	17.52 (0.38)	2.75 (0.66)	0.29 (0.01)
Bluespotted flathead	3mm200	ns	ns	ns
	5mm200	ns	ns	ns
Ocean jacket	3mm200	ns	ns	ns
	5mm200	ns	ns	ns
Southern calamari	3mm200	7.67 (1.71)	2.61 (2.70)	0.46 (0.02)
	5mm200	8.50 (0.56)	1.64 (1.11)	0.45 (0.02)

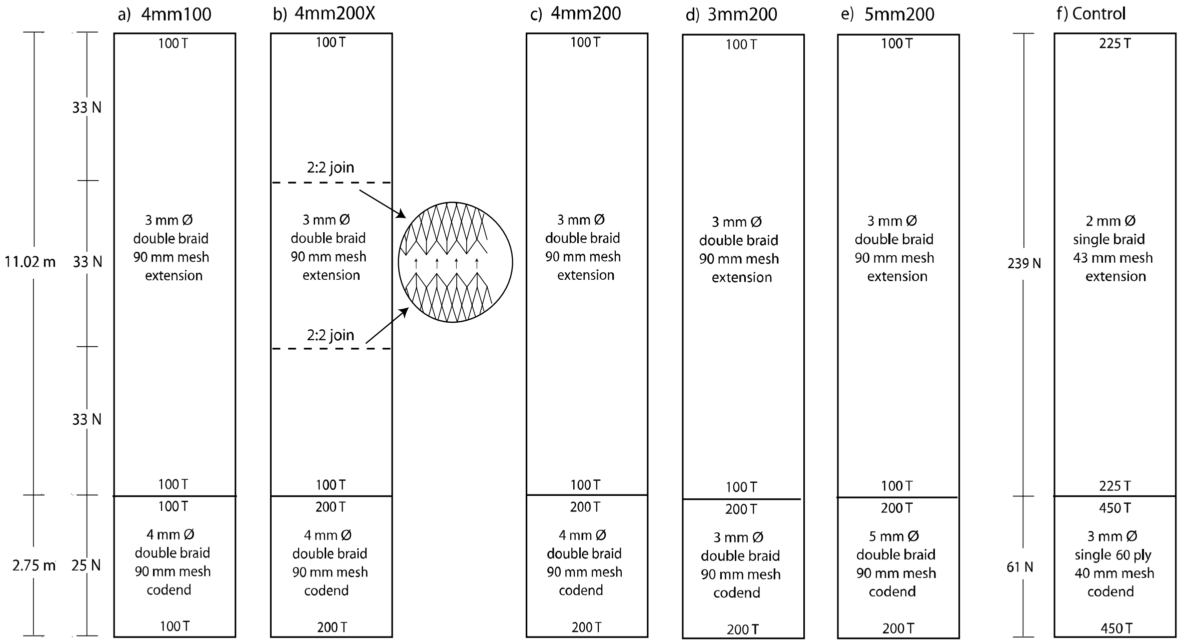

Figure 1. Plans of the (a) 4mm100, (b) 4mm200X, (c) 4mm200, (d) 3mm200, (e) 5mm200 treatment extension and codend arrangements, and (f) control extension and codend.

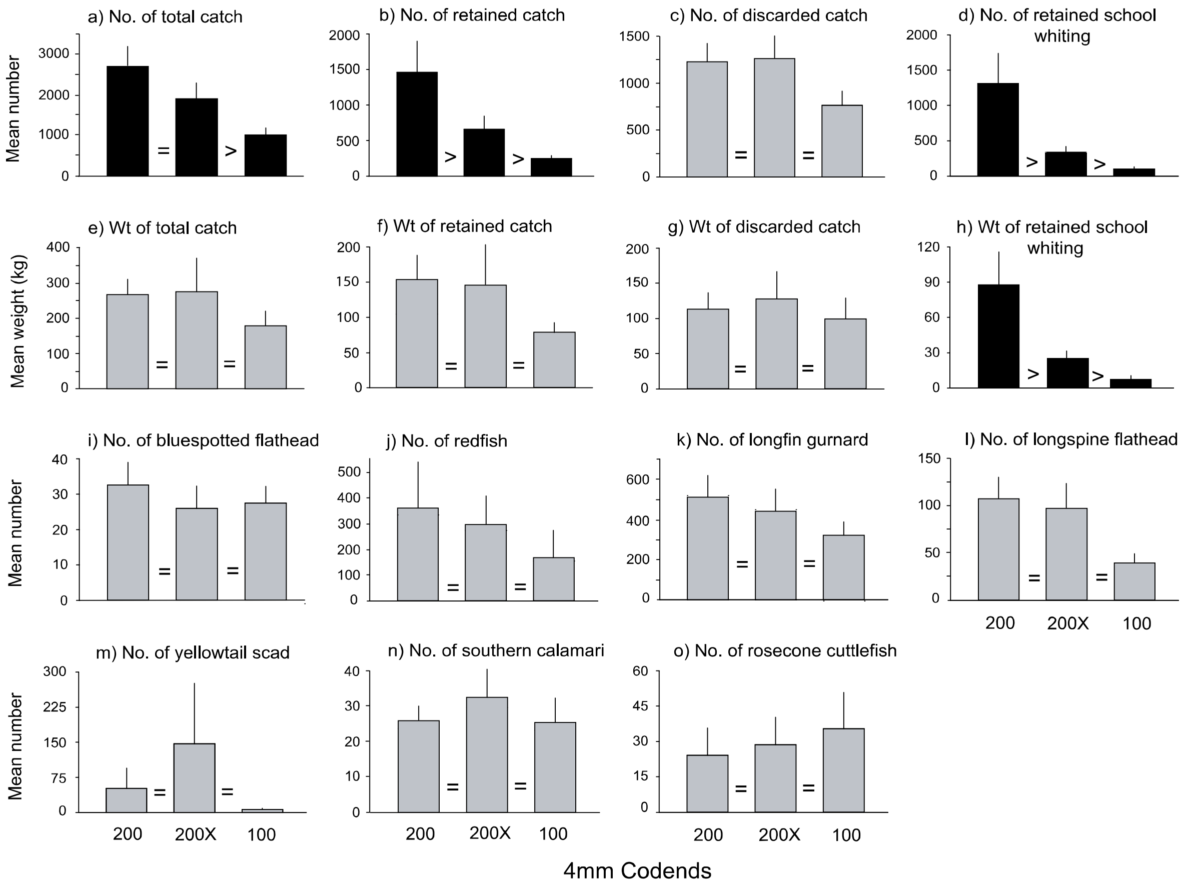

Figure 2. Mean catch numbers and weights (+ SE) for the 4mm200, 4mm200X and 4mm100 codends: a) number, and e) weight of total catch; b) number, and f) weight of retained catch; c) number, and g) weight of discarded catch; d) number, and h) weight of retained school whiting; and the numbers of i) bluespotted flathead, j) redfish, k) longfin gurnard, l) longspine flathead, m) yellowtail scad, n) southern calamari, and o) rosecone cuttlefish.

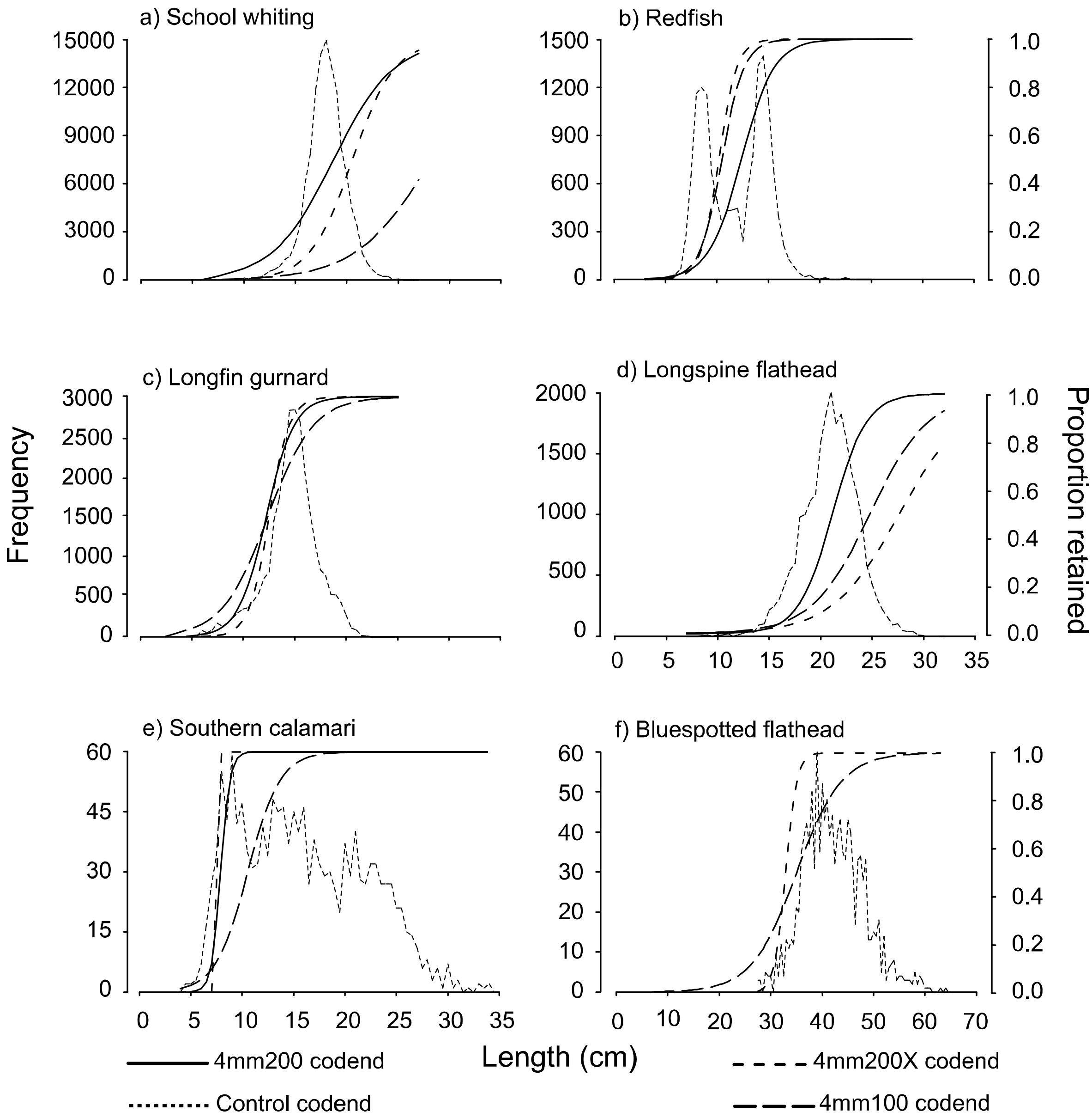

Figure 3. Size-frequency distributions pooled across deployments of the control codend and, where converged, selection curves for the 4mm200, 4mm200X and 4mm100 codends for a) school whiting, b) redfish, c) longfin gurnard, d) longspine flathead, e) southern calamari and f) bluespotted flathead.

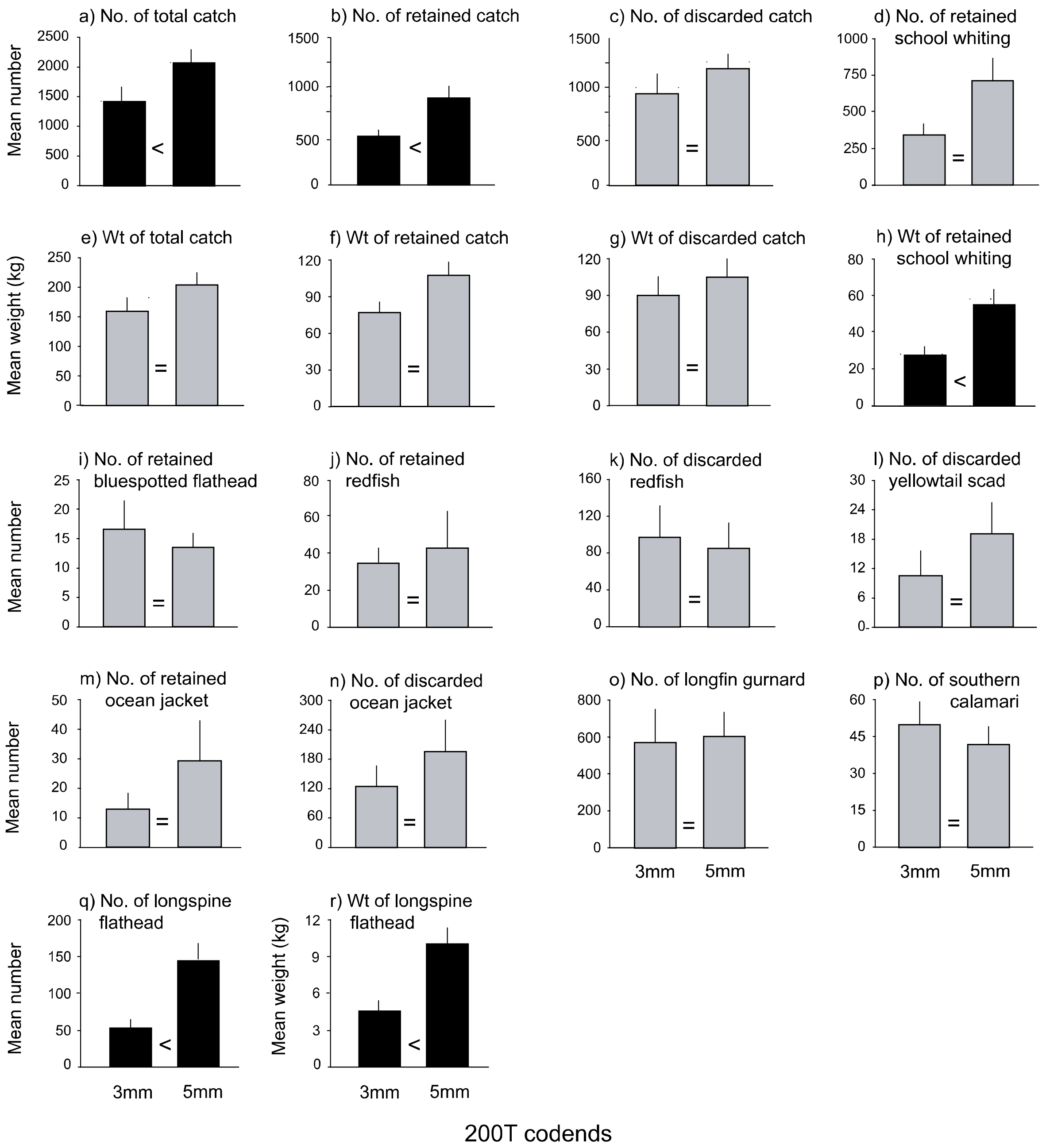

Figure 4. Mean catch numbers and weights (+ SE) for the 3mm200 and 5mm200 codends: a) number, and e) weight of total catch; b) number, and f) weight of retained catch; c) number, and g) weight of discarded catch; d) number, and h) weight of retained school whiting; and numbers of i) retained bluespotted flathead, j) retained redfish, k) discarded redfish, l) discarded yellowtail scad, m) retained ocean jacket, n) discarded ocean jacket, o) longfin gurnard, p) southern calamari, and q) number and r) weight of longspine flathead.

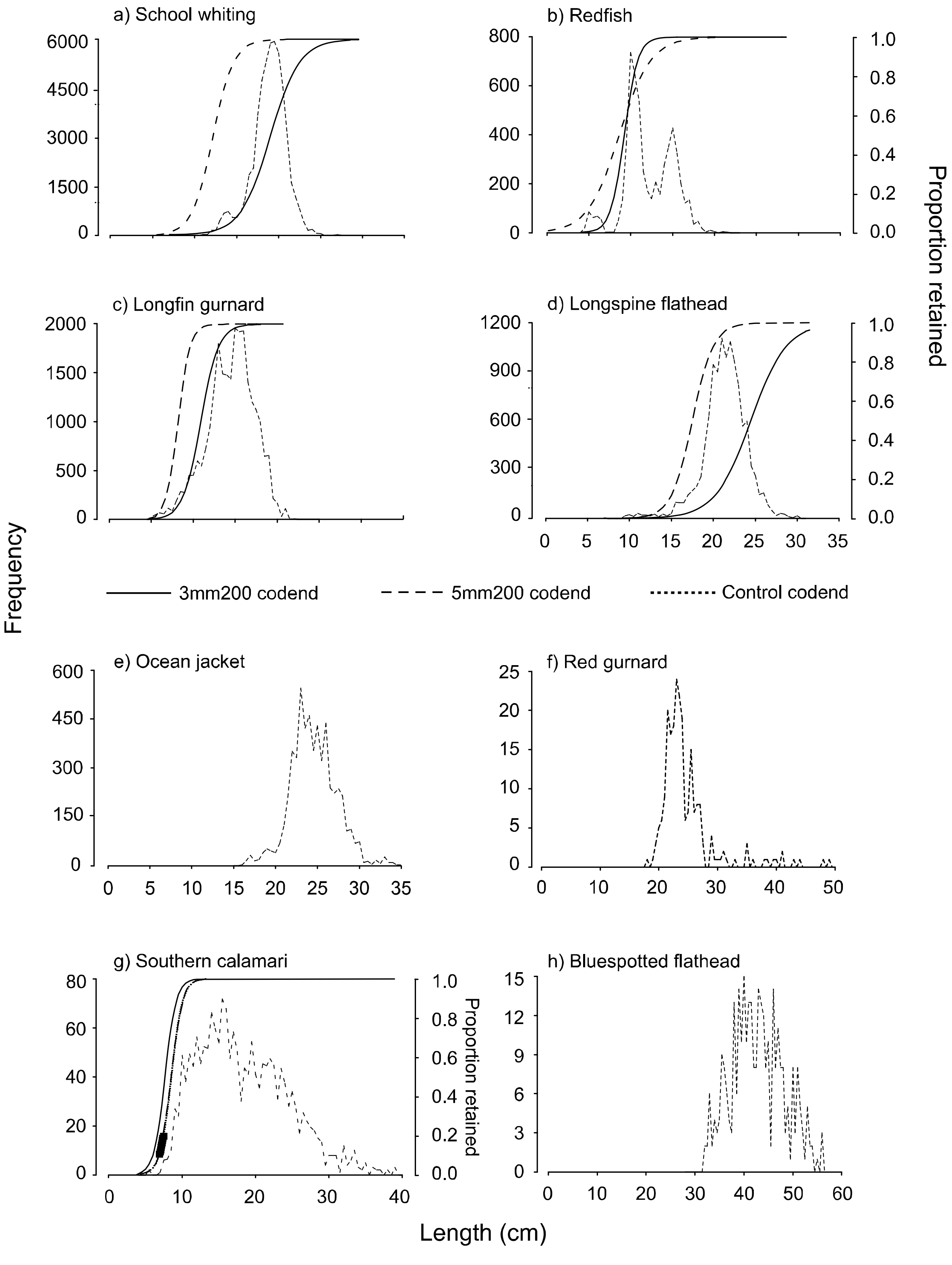

Figure 5. Size-frequency distributions pooled across deployments of the control codend and, where converged, selection curves for the 3mm200 and 5mm200 codends for a) school whiting, b) redfish, c) longfin gurnard, d) longspine flathead, e) ocean jacket, f) red gurnard, g) southern calamari, and h) bluespotted flathead.

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