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Catch Evaluation of Target, By-product, and By-catch Species Taken by Gillnets and Longlines in the Shark Fishery of South-eastern Australia

(Elasmobranch Fisheries – Oral)

by

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Abstract

Experimental demersal gillnets and demersal longlines were deployed from research vessels on grounds of *Mustelus antarcticus* during 1973–76. Gillnet mesh-size had major effects on catch composition and catch rate, whereas gillnet hanging ratio, hook-size, hook shank-length, and hook-spacing had minor effects. The gillnets and longlines were much more effective at catching chondrichthyans than teleosts, and catches of species of cephalopoda, bivalvia, gastropoda, mammalia, aves, and reptilia were negligible. Any reduction in the present legal minimum mesh-size of 6 inches in the shark fishery would markedly increase by-catch. In gillnets monitored by scientific observers aboard commercial vessels during 1998–01, the ratio of the number of chondrichthyan to teleost animals was 23.8:1 in Bass Strait and 4.5:1 in South Australia. In Bass Strait between 1973-76 and 1998-01, the catch rate by 6-inch mesh-sized gillnets of chondrichthyan fishes declined by one-third, whereas a change in the catch rate of teleost fishes was not statistically detectable. Most of this decline is explained by reductions of 54% by *Cephaloscyllium laticeps* and of 87% by *Galeorhinus galeus*, which were the only statistically detectable changes. The retained commercial catch was 74% of the chondrichthyan animals and 58% of the teleost animals caught; only 2% of the chondrichthyan animals and 11% of the teleost animals were discarded dead. There are occasional interactions with protected species - *Carcharodon carcharias* and marine mammals, but the fishery operates on fishing grounds away from depleted stocks of squalids and holocephalans on the continental slope and *Carcharias taurus* on the continental shelf.

Keywords: Australia, shark fishery, by-catch, gillnet, hook.

Introduction

Several initiatives taken in recent years have created a requirement to evaluate catch composition and catch rates in Australian fisheries. The requirement applies to both targeted and non-targeted species, and, of the non-targeted species, both the retained species (by-product) and discarded species (by-catch).

Australia's Commonwealth *Fisheries Management Act 1991* requires management arrangements to "ensure that the exploitation of fisheries resources and the carrying on of related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long-term sustainability of the marine environment". Hence, in accordance with these legislative obligations and Commonwealth Government policy prescribed under Australia's Ocean Policy regarding the impact of fishing activities on non-target species and the environment, the Australian Fisheries Management Authority recently developed by-catch action plans for major Australian fisheries.

More recently, the Commonwealth *Environment Protection and Biodiversity Conservation Act (EPBC) 1999* requires fisheries managed under Commonwealth jurisdiction or fisheries producing products for export to be

'strategically assessed'. This process involves assessing each fishery for ecological impacts on (a) target and by-product species, (b) by-catch species, (c) threatened, endangered and protected species, (d) marine habitats, and (e) marine food chains. The process requires collection of appropriate data, risk assessment, and appropriate management responses.

At a world level, concern for the condition of the stocks of chondrichthyan species led to the International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks), developed recently by the Food and Agriculture Organization of the United Nations. The IPOA-Sharks recognises that the life-history characteristics of chondrichthyan species can make for low 'biological productivity' and cause these animals to be generally more susceptible to overexploitation from fishing than teleost and invertebrate species. The IPOA-Sharks also recognises that these species require special management, research, and monitoring if they are to be harvested sustainably (Anon., 2000). As a signatory to the IPOA-Sharks, Australia has developed a National Plan of Action for the Conservation and Management of Shark (NPOA-Sharks).

The catches of most chondrichthyan species have not been reported and it is likely that many species, particularly those taken as by-catch, are already at high risk without it being recognised (Walker, 1998). 'Critical by-catches' are by-catches of species or populations that are in danger of extinction, and 'unsustainable by-catches' are by-catches of species or populations that are not currently at risk but will decline at current levels of by-catch (Hall, 1996).

Australia's NPOA-Sharks and various fisheries and environmental management agencies have already identified several species of shark on the continental shelf requiring special protection or management in southern Australia. The white shark (*Carcharodon carcharias*) is listed as vulnerable and the grey nurse shark (*Carcharias taurus*) east coast population is listed as critically endangered and the west coast population is listed as vulnerable under the *EPBC Act 1999*. The Commonwealth and various States have adopted, or are in the process of adopting, special protection for these species, and for the basking shark (*Cetorhinus maximus*). Current assessments indicate that the mature biomass of school shark (*Galeorhinus galeus*), which was a target species until recently, has been reduced to 12–18% of the pre-fishing levels (Punt *et al*., 2000), making the species one of Australia's most severely depleted, and now tightly controlled, species.

On the continental slope of southern Australia, several species of dogfishes (*Squalidae*) and holocephalans (*Holocephali*), taken as by-product by demersal trawl, gillnet or longline, have been identified as severely depleted and requiring special management. Species such as *Centrophorus harrissoni, C. uyato, and C. moluccensis* are being considered for listing under the *EPBC Act 1999*. The Australian Society for Fish Biology has listed *C. harrissoni* as 'endangered' and *C. uyato* as 'threatened'. Upper-slope dogfish species are more vulnerable to capture than mid-slope species, because they are targeted throughout their vertical distribution and most of their local geographic distribution. Demersal trawl surveys off central and southern New South Wales during 1977 and 1997 indicate a reduction in catch rates of *Centrophorus* spp of 98.4–99.7% (Andrew *et al*., 1997; Graham *et al*., 2001). Despite concerns, catches of these species have been unregulated to date.

High priority is being given to the development of methods that can be applied across species, communities and ecosystems for all Australian fisheries to enable a coordinated and comprehensive assessment strategy. Such an approach must be scientifically defensible, but also pragmatic by being applicable across a wide range of situations including type of fishery and varying availability of data. The shark fishery of southern Australia presently targets one species of shark—gummy shark (*Mustelus antarcticus*)—and takes a range of chondrichthyan and teleost species as by-product and by-catch. For this fishery, apart from the need to evaluate catches, there is a need to address public perceptions of discards associated with the use of demersal gillnets, which are often confused with surface-set driftnets. Hence there is also a need to provide better data for the purpose of managing public perceptions.

The present study is designed to evaluate the catch composition and catch rates in the shark fishery of southern Australia. The catch of each species was evaluated in terms of whether the animals were landed onboard 'live' or 'dead' and whether they were 'retained' or 'discarded'. The study addresses catches taken both by demersal monofilament gillnets and demersal longlines from data available for the two periods of 1973-76 and 1998-01.

Data utilized in the present study were collected opportunistically during three separate investigations. Data from the first of these investigations were collected on two research vessels during 1973-76, when the biology and the length-

selective characteristics of fishing gear were investigated for *Mustelus antarcticus* (Walker, 1983). Data from the second of these investigations were collected on two commercial fishing vessels during 1998 as part a pilot fixed-station fishery-independent survey designed to determine survey intensity for monitoring abundance of harvested species (Punt *et al*., 2002). Data from the third of these investigations were collected on eight fishing vessels during 1999-01 as part of a study of common sawshark (*Pristipohorus cirratus*), southern sawshark (*P. nudipinnis*), and elephant fish (*Callorhinchus milii*).

During 1973-76, most of the research sampling was undertaken in Bass Strait, with a small amount of sampling undertaken in waters off the east and south coasts of Tasmania and in waters off South Australia. Five separate experiments were undertaken during this period to test for the effects of gillnet mesh-size, gillnet hanging ratio, hook-size, hook shank-length, and hook-spacing on catch rate and length of fish. During 1998-01, sampling was undertaken during normal commercial fishing operations in Bass Strait and South Australia. For Bass Strait, comparisons of gillnet 6-inch mesh-size catch rates were made between 1973-76 and 1998-01. Catch rates for gillnet 7-inch mesh-size and longlines with Mustad 11/O long-shank hooks are also presented for Bass Strait during 1973-76, because these gears were used extensively by the fishing industry during this period. For Tasmania, similar data were presented for 1973-76, but there are no data to present for 1998-01. For South Australia, there are insufficient data to present for 1973-76, but gillnet 6-inch and 6½-inch mesh-size data are presented for 1998-01. During 1998-01, most of the fishing gear deployed in South Australia and Tasmania was 6½-inch mesh-size and most of the fishing gear deployed in Bass Strait was 6-inch mesh-size.

Materials and Methods

Field sampling 1973-76

During the period from 8 June 1973 to 29 November 1976, the FV *Moondara* and FRV *Sarda* were used for determining catch composition and catch rates. A total of 162 fishing sites were sampled during 155 fishing days at depths of 9-79 m on the continental shelf between Streaky Bay, South Australia; Gabo Island, Victoria; and Hobart, Tasmania. Most fishing sites were in Bass Strait (126 sites), but some were off eastern Tasmania, south of latitude 41° South (20 sites), and off South Australia (16 sites) (Fig. 1a).

The fishing gear consisted of 400 hooks attached to two separate longlines and of 12 gillnets. The hooks (2/O-10/O Mustad short-shank and 11/O Mustad long-shank) were clipped 5, 7.5, 10, or 20 m apart to a sinking super saran rope main line. Each hook was connected to one end of a 1-m long snood, constructed of 6-mm diameter braided polypropylene, by a 10-mm long monel wire trace. The other end of the snood was attached to the main-line by way of a snap-clip. Each gillnet was 250 m long and 1.7 m deep. Eight of the gillnets had a hanging ratio of 0.60 and mesh sizes ranging 2-9 inches (51-229 mm), in steps of 1 inch (25 mm). Two of the gillnets had a hanging ratio of 0.53 and mesh-sizes of 6 inches (152 mm) and 7 inches (178 mm), and two had a hanging ratio of 0.67 and mesh sizes of 6 and 7 inches.

The monofilament polyamide webbing used to construct the nets was green, double knotted, double selvedge, and of neutral buoyancy. The bridle and headline were made of 10-mm (diameter) polypropylene rope. The headline with attached webbing was 250 m long. Vinyl floats ('3TV-5' each with 128 g wt upthrust) were attached to the headline at 5-m intervals. The leadline was made of 6-mm diameter polyethylene rope, with eight 57-g lead weights per 5 m. The leadline was made 5% longer than the headline to reduce the incidence of tangling when setting of the nets. The number of meshes deep, the thickness of the filaments of the webbing (0.47-1.05 mm), and the breaking strain of the filaments varied with mesh-size (101-467 Newton) (Table 1).

The gillnets and longlines were set on the seabed mostly between the times of 0400 h and 0600 h; the nets were set first, followed by the longlines. Set as groups of two or three nets, the ends of the headlines of adjoining nets were connected and separated by 100-m lengths of 10-mm diameter polypropylene rope. Two lead anchor weights (each 12.5 kg) were attached to the bridles at the two ends of each net. Two buoy lines, with buoys, were attached to the headlines of the nets at the two free ends of each group of nets. Similar configurations of buoy lines, buoys, and anchor weights were adopted for each longline. The groups of nets and the two longlines were usually set in a line 100-300 m apart.

Five separate experiments were undertaken using various combinations of this fishing gear to determine the effects on the catch rate and total length of fish for each species. Experiment 1, 2, and 3 tested the effects of mesh-size of gillnets (2-9 inch), hanging ratio of gillnets (0.53, 0.60, and 0.67), and hook-size (short-shank Mustad 2/O-10/O), respectively. Experiments 4 and 5 together tested the effects of hook-size (short-shank Mustad 5/O and 10/O), hook shank-length (Mustad short-shank 10/O and long-shank 11/O), and hook spacing (Mustad long-shank 11/O 5, 10 and 20-m). Mean fishing times for the gears were 6.1 h for Experiment 1, 6.3 h for Experiment 2, 4.3 h for Experiment 3, 4.3 h for Experiment 4, and 3.2 h for Experiment 5.

Field sampling 1998–01

During the period from 10 November 1998 to 22 February 2001, nine different commercial vessels were used during 10 separate fishing trips for sampling at 153 fishing sites (91 sites in Bass Strait and 62 sites off South Australia) (Fig.1b). The vessels operated under normal commercial fishing conditions, where the fishing gear consisted of 6-inch or 6½-inch mesh-size gillnets. The vessels were all licensed to deploy gillnets up to a maximum of 4 200 m long and 20 meshes deep; each gillnet was ~2.4 m deep with a hanging ratio of ~0.60. The thickness and breaking strain of the filaments of the gillnet-webbing were ~0.90 mm and ~359 Newton, respectively. The gear was set on the seabed, mostly twice a day. Those set between the times of 2100 h and 0500 h were mostly hauled after sunrise, whereas those set between the times of 0800 h and 2 000 h were mostly hauled after sunset. Mean fishing time for the gear was 8.2 h. Depths at the fishing sites ranged 17-130 m; there were only 10 sites >79 m (all in South Australia), the maximum depth fished during 1973-76. The full length of gillnet was deployed at most fishing sites (4 200 m at 128 sites) or a little less was deployed when the gear was damaged (4 000 m at 21 sites). Half the available gillnets were set when searching for target species or when avoiding strong tidal flow or damage to the catch from predation (2 100 m at 2 sites, and 2 000 at 2 sites).

Data collection

When hauling the fishing gear, the catch was sorted for each of up to 22 fishing gear sampling units. All animals of chondrichthyes, teleostei, cephalopoda, mammalia, aves, and reptilia, and selected (large-sized) species of crustacea, bivalvia, gastropoda, were identified, counted, and, when practical, weighed, measured to the nearest millimetre, and sexed. No information was recorded for other invertebrate and chordate taxonomic groups. Common, scientific, and family name for each animal identified was assigned according to the Codes for Australian Aquatic Biota (CAAB) maintained by CSIRO Division of Marine Research as of June 2002. Chondrichthyan fishes were measured as total length (TL); the tail of each animal was first allowed to take a natural position and the top caudal lobe was then placed parallel to the body axis. Teleost fishes were measured as fork length (FL). In addition, during 1998-01 where practical, each animal caught was classed as 'live', 'dead', or 'unknown' when removed from the water, and classed as 'retained' or 'discarded'. Because 'sea lice' (isopods and copepods), and, off South Australia, leatherjackets (family *Monocanthidae*), can cause damage and loss of a portion of the catch, the proportion of each retained animal was recorded.

Data analysis

The data were managed and analysed using the statistical package SAS Version 8.1 (SAS Institute, North Carolina, USA). Catch rates were statistically tested for each of the five experiments separately and for each of three regions adopted for comparisons of the fishing gears used most widely in the shark fishery during 1973-76 and 1998-01. For each experiment separately, the data were pooled over all fishing sites, whereas, for inter-period and commercial gear comparisons, the data were separated into the three regions Bass Strait, Tasmania, and South Australia. For the purpose of the present study

A one-way analysis of variance was applied to test for the effect of each of several independent variables separately for each species and each major taxonomic group. For each analysis separately, the variance was appropriately tested for homogeneity and, where this was true, the following model was applied.

$$\text{Catch rate} = \text{Independent variable} + \varepsilon.$$

In the model, ε is the error term and catch rate is the number of animals caught divided by the fishing effort, where fishing effort was applied separately in the model for each of several alternative units. For gillnets, the units of fishing effort applied were 'metre-lifts' and 'metre-lift-hours', and, for longlines, the units of fishing effort applied were 'hook-lifts' (number of hooks), 'hook-lift-hours', hook-metre-lifts' (length of mainline), and hook-metre-lift-hours'. The independent variable in the model varied depending on experiment or on region for the inter-period or gear comparisons. The independent variable was mesh-size for Experiment 1, hanging ratio for Experiment 2, hook-size for Experiment 3, and the three independent variables were hook-size, hook shank-length, and hook-space for each of Experiments 4 and 5. For inter-period comparisons, the independent variable was sampling-period for gillnet 6-inch mesh-size in Bass Strait and, for commercial gear comparisons, the independent variable was mesh-size for gillnet 6-inch and 6½-inch mesh-size in South Australia during 1998–01. No statistical test was applied to the data presented for Tasmania during 1973-76.

Results

During the two sampling periods 1973-76 and 1998-01 combined, a total of 26 924 animals of 131 separate species were caught by gillnet and longline. A much higher number of animals and a higher number of species were caught by gillnets (22 918 animals, 124 species) than by longlines (4 006 animals, 54 species). The higher range of gillnet mesh-sizes and longline hook-sizes deployed caught both a higher number of animals and higher number of species during 1973-76 (16 657 animals, 112 species) than during 1998-01 (10 267 animals, 65 species), despite a much lower fishing effort during 1973-76 than during 1998-01. Some of the differences in numbers of animals and numbers of species caught between the two periods can be explained by longlines being used only during 1973-76 (4 006 animals, 54 species). However, most of the differences in the numbers caught can be explained by eight mesh-sizes (2-9 inches) used during 1973-76 (12 651 animals, 104 species) and only two mesh-sizes (6 and 6½ inches) during 1998-01 (10 267 animals, 65 species).

The catch was mostly species of chondrichthyes (21 633 animals, 33 species) and teleosts (5 118 animals, 87 species), with small quantities of species of cephalopoda (26 animals, 4 species), bivalvia (14 animals, 1 species), gastropoda (9 animals, 1 species), crustacea (121 animals, 3 species), and mammalia (3 animals, 2 species) (Table 2).

Catch rates for Experiments 1-5 undertaken during 1973-76 are presented in Tables 3-7, respectively. Catch rates for comparison between the 1973-76 and 1998-01 sampling periods in Bass Strait, and available data for 1973-76 in Tasmania and for 1998-01 in South Australia are presented in Table 8. In each table, the catch rates are presented by species categorised as Chondrichthyes, Teleostei, Cephalopoda, and Other. The category Other includes bivalvia, gastropoda, crustacea and mammalia. Within each taxonomic category, the species are ordered from the highest to lowest on the basis of the number of animals caught. The probability values for the effects of various variables tested by 'one-way analysis of variance' are presented where the condition of homogeneity of variance was met.

Experiment 1: Effect of gillnet mesh-size on catch rates

Results from Experiment 1 indicate that the effect of mesh-size of monofilament gillnets for the eight mesh-sizes 2-9 inches on catch rate is statistically highly significant for many of the species caught (Table 3). Overall the gillnets had much higher catch rates of chondrichthyan fishes than of teleost fishes for all mesh-sizes 3-9 inch, but the 2-inch mesh-size had a higher catch rate of teleost fishes than of chondrichthyan fishes. There is roughly a linear relationship between the ratio of the number of chondrichthyan fishes / the number of teleost fishes against mesh-size where the ratio increases with increasing mesh-size (Fig. 2).

Of the total catch of 7 356 animals across all species and mesh-sizes, more than two thirds were chondrichthyan fishes (5 038 animals, 68%) and most of the rest were teleost fishes (2 284 animals, 31%). Together species of cephalopoda (9 animals), bivalvia (14 animals), and crustacea (11 animals) were <1% of the catch. No animals were caught for species of gastropoda, mammalia, aves and reptilia. There were 25 species of chondrichthyes, 62 species of teleostei plus *Monacanthidae* (covering unidentified animals in this family), 3 species of cephalopoda, 1 species of bivalvia, and 1 species of crustacea.

The highest catch rates of chondrichthyan fishes were taken in larger mesh-sizes than the highest catch rates of teleost fishes. The highest catch rate of chondrichthyan fishes was in the 4-inch mesh-size (25%), followed by 3-

inch (20%), 5-inch (15%), 2-inch (11%), 6-inch (10%), 7-inch (10%), 8-inch (5%), and 9-inch mesh-sizes (4%). The highest catch rate of teleost fishes was in the 2-inch mesh-size (54%), followed by 3-inch (27%), 4-inch (12%), 5-inch (2%), 6-inch (1%), 7-inch (1%), 8-inch (1%), and 9-inch mesh-sizes (0%).

Over all eight mesh-sizes, the catch rates of chondrichthyan fishes varied widely between species, with two species providing more than half these animals and seven other species having similar catch rates and providing most of the rest of the animals. *Squalus megalops* (37%) provided the highest catch by number, followed by *Mustelus antarcticus* (17%), *Heterodontus portusjacksoni* (7%), *Galeorhinus galeus* (7%), *Callorhinchus milii* (7%), *Squalus acanthias* (6%), *Pristiophorus cirratus* (6%), *Cephaloscyllium laticeps* (6%), *Pristiophorus nudipinnis* (4%), *Asymbolis vincenti* (1%), and *Parascyllium ferruginem* (1%). A further 14 species together provided <2% of the catch (Table 3).

The catch rates of teleost fishes also varied widely between species, with one species providing more than one-third of these animals. This species along with nine other species provided three-quarters of the teleost animals. The order of predominance in the catch was *Platycephalus bassensis* (34%), *Trachuris novaezelandiae* (10%), *Neosebastes scorpaenoides* (7%), *Caesioperca lepidoptera* (7%), *Parequula melbournensis* (5%), *Neoplatycephalus aurimaculatus* (4%), *Dinolestes lewini* (2%), *Thyrsites atun* (2%), *Nemadactylus macropterus* (2%), and *Pictilabrus laticlavius* (2%). The remaining 25% of animals caught comprised 52 species and unidentified fishes of the family *Monocanthidae* (Table 3).

Most chondrichthyan and teleost species exhibited a pattern of a highest catch (mode) for a particular mesh-size and the catch falling progressively with both decreasing and increasing mesh-size. The modal catch was by 3-inch mesh-size for *Pristiophorus nudipinnis*, *Asymbolis vincenti*, and *Parascyllium ferrugineum*; 4-inch for *Squalus megalops*, *Galeorhinus galeus*, and *Squalus acanthias*; 5-inch for *Mustelus antarcticus*, *Callorhinchus milii*, and *Pristiophorus ciratus*; 7-inch for *Heterodontus portusjacksoni*, and *Cephaloscyllium laticeps*; and 9-inch for *Myliobatis australis*. Most of the *Platycephalus bassensis* catch, expressed as a percentage of the total number of teleost fishes caught, were taken by the 2-inch (21%), 3-inch (10%) and 4-inch (2%) mesh-sizes. Other teleost species taken predominantly by the 2-inch mesh-size include *Trachurus novaezelandiae* (10%), *Caesioperca lepidoptera* (7%), *Parequula melbournensis* (3%), *Neoplatycephalus aurimaculatus* (2%), and *Dinolestes lewini* (2%). *Nemadactylus macropterus was* was taken predominantly by 3-inch mesh-size (1%) and *Neosebastes scorpaenoides* by 4-inch mesh-size (3%). The 6- and 7-inch mesh-sizes, used commercially in the fishery, each took 10% of the chondricthyan animals and 1% of the teleost animals.

Experiment 2: Effect of gillnet hanging-ratio on catch rates

For Experiment 2 there were sufficient data to test 9 chonchrichthyan species and 11 teleost species for the effect on catch rate of hanging ratio of monofilament gillnets for the 6-inch and 7-inch mesh-sizes. The effect of hanging ratio was statistically not significant for any of these species (Table 4).

Experiment 3: Effect of hook-size on catch rates

Results from Experiment 3 indicate that the effect on catch rate of hook-size for the eight short-shank Mustad 2/O, 3/O, 4/O, 5/O, 7/O, 8/O, 9/O, and 10/O hooks with a 7.5-m hook-space is statistically significant for only one (*Heterodontus portusjacksoni*) of the 18 chondrichthyan species and for none of the 16 teleost species caught. Similarly, the effect of hook-size was not statistically significant for either the 18 chondrichthyan species pooled or the 16 teleost species pooled. (Table 5). Of the total catch of 1 856 animals across all species and hook-sizes, more than two thirds were chondrichthyan fishes (1 291 animals, 70%) and most of the rest were teleost fishes (561 animals, 30%). There was a small catch of three species of cephalopoda (4 animals, <1%), and zero catches of animals of bivalvia, gastropoda, crustacea, mammalia, aves, and reptilia (Table 5). The ratio of the number of chondrichthyan fishes / the number of teleost fishes against hook-size is fairly constant with increasing hook-size (Fig. 2).

For the species of chondrichthyes, the catch rates were similar for the three top species: *Squalus megalops* (27%), *Mustelus antarcticus* (24%), and *Cephaloscyllium laticeps* (22%). Other species caught include *Galeorhinus galeus*

(11%), *Asymbolis vincenti* (4%), *Parascyllium ferrigumeum* (2%), *Heterodontus portusjacksoni* (2%), *Raja whitleyi* (2%), *Trygonorrhina faciata* (2%), and a further 9 species provided the remaining 4% of the catch.

For the species of teleostei, the catch was dominated by two species: *Platycephalus bassensis* (47%) and *Neosebastes scorpaenoides* (37%). Other species include *Pseudophycis barbata* (4%), *Nemadactylus macropterus* (2%), *Scorpaena macropterus* (2%), *Chelidonichthys kumu* (2%), *Neoplatycephalus richardsoni* (2%), and a further 9 species provided the remaining 4% of the catch.

Experiments 4 and 5: Effects of hook-size, shank-length, and hook-space on catch rates

As would be expected, the catch rates for the top four or five chondrichthyan species and top two teleost species caught during Experiments 4 and 5 were similar to those caught during Experiment 3 (Tables 6 and 7). Across these two experiments, the effects of hook-size, shank-length, and hook-space on catch rates are not statististically significant, with one single exception. Shank-length of hook for the teleost *Neosebastes scorpaenoides* was statistically significant.

Effects of sampling period and commercial fishing gears on catch rates

Catch rates for commercial fishing gears are available from fishing aboard research vessels during 1973-76 and from commercial shark fishing vessels during 1998-01. These data are presented for Bass Strait, Tasmania, and South Australia separately. In Bass Strait, these data are for longline Mustad 11/O long-shank hooks and gillnet 6-inch and 7-inch mesh-sizes during 1973-76 and for gillnet 6-inch mesh-size only during 1998-01 (Table 8a). In Tasmania, these data are for longline Mustad 11/O long-shank hooks and gillnet 6-inch and 7-inch mesh-sizes during 1973-76 (Table 8b). In South Australia, these data are for gillnet 6-inch and 6½-inch mesh-sizes during 1998-01 (Table 8c). There are no data from Tasmania during 1998-01 to make comparisons with 1973-76 and there are insufficient data collected from South Australia during 1973-76 to make comparisons with 1998-01. Hence, comparison of catch rates between the two periods 1973-76 and 1998-01 can only be made for Bass Strait.

In Bass Strait, direct comparisons in catch rate between 1973-76 and 1998-01 can only be made for gillnet 6-inch mesh-size (Table 8a). These data indicate a statistically significant decrease in the catch rate for all chondrichthyan fishes, and no significant difference in the catch rate for all teleost fishes. Among the chondrichthyan species, *Cephaloscyllium laticeps* exhibits a statistically significant decrease (54%) and *Galeorhinus galeus* exhibits a highly statistically significant decrease (87%) between the two periods. One species - *Notorynchus cepedianus* - taken in low numbers during 1973-76 exhibits a statistically highly significant increase in catch. In addition, 10 chondrichthyan species and 17 teleost species exhibit zero catch rates during 1973-76 and low catch rates during 1998-01, while, conversely, only 3 chondrichthyan species and 5 teleost species exhibit low catch rates during 1973-76 and zero catch rates during 1998-01. These differences are interpreted as an artifact of the data where the probability of catching low numbers of animals of species that are either rare or of low catchability in the depth-range 0-79 m is higher during 1998-01 than during 1973-76. This is because the total fishing effort by the sampling fishing gear was 12.2 times higher during 1998-01 than during 1973-76. For these reasons the one-way analysis of variance was not applied for determining the probability of a sampling period effect for any species where the catch rate was zero during either 1973-76 or 1998-01 (Table 8a).

In Tasmania, there are too few data to properly characterise catch composition and catch rates. The data suggest that catch rates of *Squalus acanthias* in Tasmania are higher than in Bass Strait and South Australia (Table 8b).

In South Australia, the catch rate by gillnet was statistically significantly higher in 6-inch than in 6½-inch mesh-size for all chondrichthyan fishes combined, but the effect of mesh-size was not significant for teleost fishes. Most of the higher catch rate by the 6-inch mesh-size is from *Mustelus antarcticus* and *Notorynchus cepedianus*. As in Bass Strait and Tasmania, catch rates of teleost fishes is low compared with chondrichthyan species in South Australia (Table 8c).

There are some minor differences in catch rates between Bass Strait, Tasmania, and South Australia. Among the chondrichthyan species, the data suggest that the catch rates of *Cephaloscyllium laticeps*, *Pristiophorus cirratus*, *P. nudipinnis*, and *Callorhinchus milii* are higher in Bass Strait than in South Australia. Several minor species—

Myliobatis australis, *Carcharhinus brachyurus*, and *Alopias vulpinis*—are more common in South Australia than Bass Strait. Among the teleosts, several species appeared in the catch off South Australia that were absent or provided very low catch rates in Bass Strait and Tasmania. These species include *Centroberyx gerrardi*, *Kyphosus gibsoni*, and *Nemadactylus valenciennesi*. One species—*Platycephalus bassensis*—appears to be less common in South Australia than in Bass Strait and Tasmania.

Breakdown of total catch as retained and discarded, and live and dead

Percentages of the commercial catch taken as retained and discarded animals, broken down as live and dead, for 1998–01 are presented for Bass Strait (8 198 animals) and South Australia (2 069 animals) separately. The catches were taken by 6-inch mesh-size in Bass Strait and a combination of 6-inch and 6½-inch mesh-size in South Australia. The catch rate of chondrichthyan animals in Bass Strait was ~2.5 times higher than that in South Australia, whereas the catch rate of teleosts in Bass Strait was about half that in South Australia (Tables 9a, b).

Chondrichthyan fishes provided a higher proportion of the commercial catch in Bass Strait (95%) than in South Australia (82%), whereas teleost fishes provided a higher proportion of the catch in South Australia (18%) than in Bass Strait (4%). In Bass Strait, of the chondrichthyan fishes (7 761 animals), 74% (38% live and 36% dead) were retained and 26% (24% live and 2% dead) were discarded, and of the teleost fishes (337 animals), 54% were retained (40% live and 14% dead) and 46% were discarded (18% live and 28% dead). In South Australia, of the chondrichthyan fishes (1 675 animals), 72% (42% live and 30% dead) were retained and 28% (25% live and 3% dead) were discarded, and, of the teleost fishes (375 animals), 91% were retained (91% live and 0% dead) and 9% were discarded (7% live and 2% dead).

In Bass Strait, 48% the catch of chondrichthyan fishes was the target species—*Mustelus antarcticus*, 28% comprised by-product species (*Pristiophorus cirratus*, *Callorhinchus milii*, *P. nudipinnis*, *Galeorhinus galeus*, and *Notorynchus cepedianus*), and 24% comprised 10 by-catch species. The three principal chondrichthyan by-catch species—*Cephaloscyllium laticeps* (13%), *Heterodontus portusjacksoni* (7%), and *Squalus megalops* (3%)—were discarded live, except for 6% of *Squalus megalops* discarded dead. In South Australia, 55% of the catch of chondrichthyan fishes was *Mustelus antarcticus*, 19% comprised by-product species (*Pristiophorus cirratus*, *Callorhinchus milii*, *P. nudipinnis*, *Galeorhinus galeus*, *Sphyrna zygaena*, *Notorynchus cepedianus*, and *Furgaleus macki*), and 26% comprised 9 by-catch species. The three most caught by-catch species—*Heterodontus portusjacksoni* (15%), *Squalus megalops* (4%), and *Myliobatis australis* (3%)—were discarded live, except for 9% of *Myliobatis australis* discarded dead.

In Bass Strait, none of the 26 teleost species caught provide high catches; 54% of the animals were retained. Most of the catch of the top 4 species (*Seriolella brama*, *Pentaceropsis recurvirostris*, *Trachurus declivis*, and *Pseudocaranx dentex*), together providing 61% of the catch of teleost fishes, were retained, except for *T. declivis* which was discarded (68% live and 32% dead). In South Australia, most of the catch of 27 teleost species were retained (91%). The top 4 species (*Kyphosus gibsoni*, *Centroberyx gerrardi*, *Pentaceropsis recurvirostris*, and *Nemadactylus valenciennesi*) provided 58% of the catch.

Three wildlife interactions occurred during 1998-01 as part of the present study. Two Australian fur seals (*Arctocephalus pusillus dorfer*) were discarded dead in Bass Strait and one common dolphin (*Delphinus delphis*) was discarded dead in South Australia.

Discussion

In recent years, most of the fishing effort in the shark fishery of south-eastern Australia has been targeted at *Mustelus antarcticus*; the earlier practice of targeting *Galeorhinus galeus* has almost ceased completely. Of the total catch of this species produced from the fishery (1 651 tons, carcass weight), 91% was taken by demersal monofilament gillnet and 9% was taken by demersal longline (Walker *et al.*, 2001). The fishing effort was distributed in Bass Strait (55% of gillnet effort, 30% of longline effort), South Australia (40%, 64%), and Tasmania (5%, 6%), and most of the gillnet effort deployed in Bass Strait and Tasmania was 6-inch mesh-size, whereas most of that deployed in South Australia was 6½-inch mesh-size. Baited Mustad 11/O long-shank hooks were used on the longlines. Eleven important conclusions are drawn about the catch rates of gillnets and longlines deployed in the fishery on the continental shelf in the depth-range 9-130 m.

1. Both gillnets and longlines are much more effective at catching chondrichthyan than teleost fishes, and catches of species of cephalopoda, bivalvia, gastropoda, mammalia, aves and reptilia are negligible.
2. The effect of gillnet mesh-size on catch rates is strong, whereas the effects of gillnet hanging ratio, hook-size, hook shank-length, and hook-space are weak.
3. Overall catch rates of chondrichthyan and teleost fishes by mesh-size are very different. For chondrichthyans, the modal catch rate is by 4-inch mesh-size with decreasing catch rates for both increasing and decreasing mesh-size, whereas for teleosts the modal catch rate is by 2-inch mesh-size with decreasing catch rates as mesh-size increases.
4. For gillnets there is linear increase in the ratio of the number of chondrichthyan fishes divided by the number of teleost fishes with increasing mesh-size, whereas for hooks the ratio is approximately constant with increasing hook-size.
5. For chondrichthyes, the top four species taken by gillnet across 8 mesh-sizes (Experiment 1)—*Squalus megalops*, *Mustelus antarcticus*, *Heterodontus portusjacksoni*, and *Galeorhinus galeus*—are similar to the top four species taken by longline across 8 hook-sizes (Experiment 3)—*Squalus megalops*, *Mustelus antarcticus*, *Cephaloscyllium laticeps*, and *Galeorhinus galeus*. The only difference being that *H. portusjacksoni* is more prevalent than *C. laticeps* in the gillnet catch, whereas the converse occurs for the longline catch.
6. For teleost species, *Platycephalus bassensis* is the most prevalent species caught by both gillnets across 8 mesh-sizes (Experiment 1) and longlines across 8 hook-sizes (Experiment 3). *Neosebastes scorpaenoides* is the second most prevalent species caught by longline and the third most prevalent species caught by gillnet. The second most prevalent species taken by gillnet—*Trachurus novaezelandiae*—is not caught by longline.
7. For the Chondrichthyan species in Bass Strait, there has been about a one-third overall reduction in abundance across all species combined between 1973-76 and 1998-01. About half of this reduction is attributable to an 87% reduction in the abundance of *Galeorhinus galeus* and a 54% reduction in the catch of *Cephaloscyllium laticeps*.
8. Most of the commercial catch of Chondrichthyan fishes taken in demersal gillnets of 6-inch and 6½-inch mesh-size that is not retained is returned to the water live and only small amounts of teleost fishes are discarded dead. Most of the discarded animals are *Cephaloscyllium laticeps*, *Heterodontus portusjacksoni*, *Squalus megalops*, and *Myliobatis australis*.
9. Wildlife interactions occur occasionally with Australian fur seals (*Arctocephalus pusillus dorfer*) and common dolphin (*Delphinus delphis*).
10. Of the various chondrichthyan species on the continental shelf and continental slope identified as requiring special protection or special management, only two species are taken by the fishery. A by-catch of *Carcharodon carcharius* are taken occasionally and *Galeorhinus galeus*, once the primary target species, is presently taken as significant by-product.
11. The fishery does not impact on the populations grey nurse shark (*Carcharias taurus*), listed as critically endangered, or the depleted populations of *Centrophorus* spp or holocepahalans on the continental slope.

The 87% reduction in the abundance of *Galeorhinus galeus* detected in Bass Strait by the present study is consistent with the reduction determined from independent catch per unit effort data (Walker, 1999) and stock assessment models (Punt *et al.*, 2000; Punt and Walker, 1998). During the period from the mid-1920s when the fishery began until the early-1970s, G. galeus was the principal target species taken by baited hooks on longlines. Through the 1970s, 1980s, and 1990s, most of the catch was taken by gillnets and targeting switched rapidly from *G. galeus* to *Mustelus antarcticus* in Bass Strait, but switched gradually in South Australia and Tasmania, as the abundance of *G. galeus* continually declined. Since 2000, the catch of this species has been tightly regulated through implementation of a total allowable catch. Most fishing effort in the fishery is now targeted at *M. antarcticus*, which is a much more biologically productive species (Pribac *et al.*, submitted; Walker, 1998).

The 54% reduction in the catch of *Cephaloscyllium laticeps* is more difficult to explain. Fishing mortality of these animals is not expected to be high, because they are highly robust animals; they are mostly alive when removed from gillnets and returned to water. Part of the explanation for this observed reduction is that commercial fishers tend to avoid fishing grounds where these animals are known to be abundant. In addition, fishers often move away from fishing grounds where catch numbers of this species are high to avoid having to untangle large numbers of these animals from the gillnets. Some fishers claim that *Mustelus antarcticus* tend not to aggregate in regions inhabited by large numbers of *C. laticeps*. In Bass Strait, no attempt was made to avoid *C. laticeps* during 1973-76 (172 fishing sites) or during the pilot fixed-station fishery-independent survey in 1998 (24 fishing sites), but some of

the fishers operating under normal commercial conditions might have avoided such regions during 1999-01 (67 fishing sites).

Anecodotal information indicates that there is a small by-catch of *Carcharodon carcharias* taken by the fishery, which is consistent with the one animal caught by longline during 1973-76 as part of the present study. The species is now totally protected in all Australian waters and the unintentional fishing mortality of the species is being reduced as various waters are being closed to shark fishing. All Victorian waters (coastal waters out to 3 nm and all enclosed bays and inlets) have been closed to shark fishing since 1988. Smaller area closures are presently under consideration in South Australia and Tasmania.

There are no reported catches of *Carcharias taurus* from the Southern Shark Fishery. Whereas the distribution of *C. taurus* is reported to include Victoria, South Australia, and Tasmania (Last and Stevens, 1994), the species is extremely rare in these waters. The species occurs mainly in New South Wales and Western Australia (Pollard, 1996). In addition, because the fishery rarely operates outside depths of 75 m, the fishery does not impact the severely depleted populations of *Centrophorus* spp or holocepahalans on the continental slope, which occur in depths >200 m.

The small catch of marine mammals by gillnets during 1998–01—two Australian fur seals (*Arctocephalus pusillus dorfer*) and one common dolphin (*Delphinus delphis*)—is consistent with the anecdotal information of a small by-catch for these species. Several other species of seals (families *Otariidae* and *Phocidae*) and dolphins (family *Delphinidae*) that occur within the range of the fishery (Menkhorst, 1995) may be caught on rare occasions. The Victorian closure to shark fishing is likely to have reduced the unintentional fishing mortality of *Arctocephalus pusillus dorfer* around four major seal breeding colonies (Lady Julia Percy Island, Seal Rock, Kanowa Island and The Skerries) and other haul out sites. Closure of other important seal habitat is under consideration in other States.

Based on limited data, 27 million tons of material are estimated to be discarded annually from the world's fisheries. Most of this is from industrial rather than artisanal fisheries. The highest number of records of discards is from trawl fisheries (966), followed by drift net and gillnet fisheries (232), line fisheries (150), pot fisheries (83), and purse seine fisheries (82) (Alverson *et al*., 1994). Management of by-catch—particularly mammals, seabirds, and turtles—have become the key factors in the management strategies of some fisheries (Jennings *et al*. 2001).

For the shark fishery of southern Australia, most of the by-catch consists of a small number of chondrichthyan species that are discarded live. Only small quantities of teleost species are taken that are mostly retained and interactions with protected species are minimal. The main challenge for management of the fishery is to allow sustainable use of the highly productive resource of *Mustelus antarcticus*, while rebuilding the severely depleted stocks of *Galeorhinus galeus*.

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Table 1. Variable characteristics of the eight experimental gillnets

Mesh size (inch)	No. meshes deep	Filament thickness (mm)	Breaking strain (N)
2	42	0.47	101
3	28	0.57	146
4	21	0.66	193
5	17	0.74	240
6	14	0.81	285
7	12	0.87	326
8	10	0.90	348
9	9	1.05	467

Table 2. Number of animals and number of species caught by gillnet and longline during 1973–76 and 1998–01

Taxonomic group	Number of animals					Number of species				
	1973–76			1998–01	Total	1973–76			1998–01	Total
	Longline	Gillnet	Total	Gillnet		Longline	Gillnet	Total	Gillnet	
Chondrichthyes	3093	9104	12197	9436	21633	23	27	31	22	33
Teleostei	905	3501	4406	712	5118	28	70	74	35	87
Cephalopoda	8	14	22	4	26	3	4	4	2	4
Bivalvia	0	14	14	0	14	0	1	1	0	1
Gastropoda	0	0	0	9	9	0	0	0	1	1
Crustacea	0	18	18	103	121	0	2	2	3	3
Mammalia	0	0	0	3	3	0	0	0	2	2
Aves	0	0	0	0	0	0	0	0	0	0
Reptilia	0	0	0	0	0	0	0	0	0	0
Total	4006	12651	16657	10267	26924	54	104	112	65	131

Table 3. Experiment 1: Effect of gillnet mesh-size on number of animals caught off south-eastern australia during 1973–76

Eight fishing gear sampling units of gillnet, each 250 m long, of 8 mesh-sizes (2–9 inch) were set at each of 73 sites; s.e., standard error; P, probability value for an effect of mesh-size; * P<0.05, ** P<0.01, *** P

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 1				
		2-inch	3-inch	4-inch	5-inch	6-inch
Fishing effort (km-hours)		113	112	109	110	114
Number of fishing gear sampling units		73	73	73	73	73
Chondrichthyes						
Piked spurdog	*Squalus megalops*	3524(1363)	5915(2368)	5904(1959)	1181(445)	320(140)
Gummy shark	*Mustelus antarcticus*	221(102)	518(158)	1669(398)	1965(385)	1390(259)
Port Jackson shark	*Heterodontus portusjacksoni*	125(77)	141(60)	398(154)	404(112)	641(171)
School shark	*Galeorhinus galeus*	427(206)	559(235)	871(455)	723(385)	187(78)
Elephant fish	*Callorhinchus milii*	69(58)	334(165)	582(261)	996(503)	666(355)
White-spotted spurdog	*Squalus acanthias*	233(172)	139(129)	922(491)	517(359)	432(357)
Common sawshark	*Pristiophorus cirratus*	335(127)	510(169)	469(136)	774(291)	332(105)
Draughtboard shark	*Cephaloscyllium laticeps*	131(117)	113(56)	161(73)	179(52)	332(104)
Southern sawshark	*Pristiophorus nudipinnis*	269(72)	574(259)	448(178)	354(148)	99(45)
Gulf catshark	*Asymbolus vincenti*	157(99)	182(85)	78(78)	0	0
Rusty catshark	*Parascyllium ferrugineum*	28(21)	166(68)	87(44)	45(45)	24(24)
Southern eagle ray	*Myliobatis australis*	14(14)	0	0	7(7)	0
Broadnose sevengill shark	*Notorynchus cepedianus*	20(14)	0	36(29)	50(32)	14(12)
Varied catshark	*Parascyllium variolatum*	26(18)	66(61)	5(5)	10(10)	0
Australian angel shark	*Squatina australis*	42(42)	0	0	10(10)	0
Bronze whaler	*Carcharhinus brachyurus*	0	0	0	33(33)	0
Longnose skate	*Raja sp A*	0	0	0	8(8)	15(11)
Southern dogfish	*Centrophorus uyato*	0	0	0	57(57)	0
Sparsely-spotted stingaree	*Urolophus paucimaculatus*	0	0	0	9(9)	0
Whiskery shark	*Furgaleus macki*	0	0	0	0	0
Shortfin mako	*Isurus oxyrinchus*	0	0	0	0	0
Thresher shark	*Alopias vulpinus*	0	0	0	0	0
Ornate wobbegong	*Orectolobus ornatus*	0	0	0	8(8)	0
Smooth hammerhead	*Sphyrna zygaena*	0	0	0	0	0
Melbourne skate	*Raja whitleyi*	0	9(9)	0	0	0
Sub-total	*Chondrichthyes*	5621(1475)	9227(2516)	11628(2632)	7329(1361)	4451(770)
Teleostei						
Sand flathead	*Platycephalus bassensis*	7433(4106)	2173(488)	368(101)	94(54)	135(113)
Yellowtail scad	*Trachurus novaezelandiae*	2316(1774)	12(9)	9(9)	0	0
Ruddy gurnard perch	*Neosebastes scorpaenoides*	315(134)	495(146)	741(268)	39(23)	35(26)
Butterfly perch	*Caesioperca lepidoptera*	1420(749)	0	6(6)	0	0
Silverbelly	*Parequula melbournensis*	637(419)	259(238)	6(6)	0	0
Goldspot flathead	*Neoplatycephalus aurimaculatus*	524(307)	360(191)	91(32)	26(15)	0
Unspecified leatherjacket	*Family Monacanthidae*	15(15)	626(378)	0	25(25)	8(8)
Long-finned pike	*Dinolestes lewini*	366(298)	11(11)	0	13(13)	0
Barracouta	*Thyrsites atun*	7(7)	69(50)	359(235)	5(5)	0

Table 3. (continued)

Jackass morwong	*Nemadactylus macropterus*	0	161(83)	131(101)	62(44)	0
Senator fish	*Pictilabrus laticlavius*	464(464)	122(122)	0	0	0
Tiger flathead	*Neoplatycephalus richardsoni*	458(293)	137(80)	25(18)	41(32)	0
Bastard trumpeter	*Latridopsis forsteri*	0	8(8)	156(148)	112(70)	0
Queen snapper	*Nemadactylus valenciennesi*	0	13(13)	109(76)	54(46)	36(28)
Southern goatfish	*Upeneichthys vlamingii*	65(29)	199(79)	11(11)	0	0
Barber perch	*Caesioperca rasor*	308(221)	44(38)	0	0	0
White trevally	*Pseudocaranx dentex*	231(198)	35(17)	25(18)	9(9)	0
Bearded rock cod	*Pseudophycis barbata*	59(29)	101(58)	167(108)	0	9(9)
Yank flathead	*Platycephalus speculator*	1155(1143)	131(87)	40(31)	8(8)	0
Saddled wrasse	*Notolabrus fucicola*	28(28)	61(33)	123(78)	13(13)	0
Herring cale	*Odax cyanomelas*	70(63)	61(61)	7(7)	0	0
Globefish	*Diodon nicthemerus*	143(132)	0	13(13)	0	0
Red gurnard	*Chelidonichthys kumu*	41(27)	24(17)	114(62)	0	0
Velvet leatherjacket	*Meuschenia scaber*	22(16)	213(170)	0	0	0
Long-snouted boarfish	*Pentaceropsis recurvirostris*	0	0	0	75(32)	17(12)
Magpie perch	*Cheilodactylus nigripes*	10(10)	8(8)	8(8)	76(38)	30(21)
Chinaman-leatherjacket	*Nelusetta ayraudi*	0	190(183)	9(9)	17(17)	0
Brown Spotted wrasse	*Notolabrus parilus*	0	61(61)	26(26)	5(5)	0
Brown-striped leatherjacket	*Meuschenia australis*	0	94(71)	0	10(10)	0
Butterfly gurnard	*Lepidotrigla vanessa*	0	69(37)	41(24)	0	0
Blue-throated wrasse	*Notolabrus tetricus*	14(14)	0	10(10)	57(29)	6(6)
Blue warehou	*Seriolella brama*	11(11)	21(21)	21(15)	38(32)	0
Rough gurnard perch	*Neosebastes pandus*	24(24)	58(58)	0	0	0
Sergeant baker	*Aulopus purpurissatus*	0	27(16)	47(26)	0	0
Redfish	*Centroberyx affinis*	0	85(85)	0	0	0
Bight redfish	*Centroberyx gerrardi*	0	0	0	8(8)	0
Sandpaper fish	*Paratrachichthys sp 1*	75(75)	0	0	0	0
Rosy wrasse	*Pseudolabrus psittaculus*	43(24)	0	0	0	0
Jewfish	*Argyrosomus japonicus*	0	0	0	8(8)	0
Rock ling	*Genypterus tigerinus*	11(11)	22(16)	0	10(10)	0
Silver dory	*Cyttus australis*	0	0	14(14)	0	16(11)
Eastern school whiting	*Sillago flindersi*	23(16)	5(5)	0	0	0
Marblefish	*Aplodactylus arctidens*	0	0	7(7)	19(19)	0
King George whiting	*Sillaginodes punctata*	32(22)	18(18)	0	0	0
Common bullseye	*Pempheris multiradiatus*	19(13)	10(10)	0	0	0
Toothbrush leatherjacket	*Acanthaluteres vittiger*	0	31(18)	0	0	0
Snapper	*Pagrus auratus*	0	0	0	0	0
Sea sweep	*Scorpis aequipinnis*	0	0	0	16(16)	0
Striped trumpeter	*Latris lineata*	0	0	0	0	0
Horse-shoe leatherjacket	*Meuschenia hippocrepis*	0	0	17(17)	0	0
Ornate cowfish	*Aracana ornata*	11(11)	0	9(9)	0	0
John dory	*Zeus faber*	12(12)	0	0	0	0
Harlequin fish	*Othos dentex*	0	0	0	8(8)	0
Blue devil	*Paraplesiops meleagris*	0	17(17)	0	0	0

Table 3. (continued)

Southern cardinalfish	*Vincentia conspersa*	15(15)	0	0	0	0
Tailor	*Pomatomus saltatrix*	11(11)	0	0	0	0
Eastern Australian salmon	*Arripis trutta*	0	0	0	15(15)	0
Zebra fish	*Girella zebra*	0	0	14(14)	0	0
Old wife	*Enoplosus armatus*	0	0	10(10)	0	0
Dusky morwong	*Dactylophora nigricans*	0	0	10(10)	0	0
Western blue groper	*Achoerodus gouldii*	0	0	0	17(17)	0
Speckled stargazer	*Kathetostoma canaster*	9(9)	0	0	0	0
Six-Spined leatherjacket	*Meuschenia freycineti*	7(7)	0	0	0	0
Sub-total	*Teleostei*	16401(5423)	6031(1020)	2746(585)	881(185)	293(123)
Cephalopoda						
Gould's squid	*Nototodarus gouldi*	15(15)	35(18)	0	0	0
Giant cuttlefish	*Sepia apama*	24(18)	0	0	0	0
Octopus	*Octopus pallidus*	0	0	0	10(10)	0
Sub-total	*Cephalopoda*	40(24)	35(18)	0	10(10)	0
Other						
Commercial scallop	*Pecten fumatus*	0	0	0	0	136(136)
Swollen spider crab	*Leptomithrax gaimardii*	0	0	0	0	0

		2-inch	3-inch	4-inch	5-inch	6-inch
Sub-total	Chondrichthyes	5621(1475)	9227(2516)	11628(2632)	7329(1361)	4451(770)
Sub-total	Teleostei	16401(5423)	6031(1020)	2746(585)	881(185)	293(123)
Sub-total	Cephalopoda	40(24)	35(18)	0	10(10)	0
Commercial scallop	Pecten fumatus	0	0	0	0	136(136)
Swollen spider crab	Leptomithrax gaimardii	0	0	0	0	0

Table 4. Experiment 2: Effect of gillnet hanging ratio on number of animals caught by 6-inch and 7-inch gillnets off south-eastern Australia during 1973–76

HR, hanging ratio; 6 fishing gear sampling units of gillnet, each 250 m long, of 2 mesh-sizes (6 and 7 inch) x 3 HRs (0.53, 0.60, and 0.67) were set at each of 32 sites; s.e., standard error; P, p
HR; s.e., standard error; P, probalility of an effect of hook-size; * P<0.05, ** P<0.01, *** P<0.001.

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 1000 km-hours				
		6-inch mesh-size			7-inch mesh-size	
		0.53 HR	0.60 HR	0.67 HR	0.53 HR	0.60 HR
Fishing effort (km-hours)		52	53	51	49	49
Number of fishing gear sampling units		32	32	32	32	32
Chondrichthyes						
Gummy shark	*Mustelus antarcticus*	2010(562)	1671(349)	2266(486)	1552(362)	1270(393)
Draughtboard shark	*Cephaloscyllium laticeps*	663(290)	475(184)	631(218)	502(168)	1151(502)
Elephant fish	*Callorhinchus milii*	481(274)	447(177)	611(245)	342(184)	387(217)
Common sawshark	*Pristiophorus cirratus*	571(276)	560(193)	292(109)	88(57)	82(49)
Port Jackson shark	*Heterodontus portusjacksoni*	0	0	230(105)	504(177)	587(214)
School shark	*Galeorhinus galeus*	204(71)	91(56)	151(80)	121(46)	78(49)
Piked spurdog	*Squalus megalops*	142(88)	158(95)	188(115)	0	13(13)
White-spotted spurdog	*Squalus acanthias*	45(45)	53(53)	18(18)	71(71)	27(27)
Southern sawshark	*Pristiophorus nudipinnis*	25(25)	26(26)	60(34)	14(14)	62(36)
Broadnose sevengill shark	*Notorynchus cepedianus*	0	0	21(21)	0	0
Longnose skate	*Raja sp A*	0	35(25)	0	0	0
Melbourne skate	*Raja whitleyi*	0	0	0	26(26)	0
Sparsely-spotted stingaree	*Urolophus paucimaculatus*	20(20)	0	0	0	0
Southern eagle ray	*Myliobatis australis*	0	0	0	25(25)	0
Sub-total	*Chondrichthyes*	4161(810)	3516(622)	4468(657)	3244(566)	3656(955)
Teleostei						
Sand flathead	*Platycephalus bassensis*	1783(1740)	255(255)	18(18)	0	0
Queen snapper	*Nemadactylus valenciennesi*	89(89)	0	0	0	81(81)
Jackass morwong	*Nemadactylus macropterus*	47(47)	0	30(30)	23(23)	38(38)
Yank flathead	*Platycephalus speculator*	0	0	0	0	34(34)
Blue warehou	*Seriolella brama*	0	0	0	130(130)	0
Long-snouted boarfish	*Pentaceropsis recurvirostris*	28(28)	0	41(41)	29(29)	35(35)
Striped trumpeter	*Latris lineata*	16(16)	0	0	18(18)	17(17)
Silver dory	*Cyttus australis*	18(18)	36(25)	0	0	0
Snapper	*Pagrus auratus*	0	0	21(21)	0	0
Magpie perch	*Cheilodactylus nigripes*	0	0	17(17)	0	22(22)
Blue-throated wrasse	*Notolabrus tetricus*	0	0	17(17)	0	0
Bearded rock cod	*Pseudophycis barbata*	0	21(21)	0	0	0
Redfish	*Centroberyx affinis*	0	0	0	0	22(22)
Ruddy gurnard perch	*Neosebastes scorpaenoides*	0	0	0	0	19(19)
Red gurnard	*Chelidonichthys kumu*	0	0	18(18)	0	0
Unspecified leatherjacket	*Family Monacanthidae*	0	19(19)	0	0	0
Sub-total	*Teleostei*	1981(1737)	331(257)	162(65)	200(134)	268(105)
Other						
Commercial scallop	*Pecten fumatus*	0	311(311)	0	0	0

Table 5. Experiment 3: Effects of hook-size on the number of animals caught off south-eastern Australia during during 1973_76

Eight fishing gear sampling units of 50 hooks for each of 8 Mustad hook-sizes, with short-shank and 7.5-m hook-space, were set at each of 39 sites; s.e., standard error; P, probability value for a

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 100,000 hook-h				
		2/O	3/O	4/O	5/O	7/O
Fishing effort (100 hook-hours)		83	83	84	83	83
Number of fishing gear sampling units		39	39	39	39	39
Chondrichthyes						
Piked spurdog	*Squalus megalops*	988(420)	1061(652)	1181(607)	1048(540)	753(325)
Gummy shark	*Mustelus antarcticus*	273(91)	555(151)	536(137)	406(104)	482(140)
Draughtboard shark	*Cephaloscyllium laticeps*	619(186)	487(141)	520(131)	401(127)	463(124)
School shark	*Galeorhinus galeus*	118(52)	198(84)	395(187)	487(208)	403(222)
Gulf catshark	*Asymbolus vincenti*	114(60)	181(82)	117(45)	147(69)	147(94)
Rusty catshark	*Parascyllium ferrugineum*	38(28)	142(116)	17(17)	65(45)	38(30)
Port Jackson shark	*Heterodontus portusjacksoni*	0	19(14)	8(8)	45(22)	63(24)
Melbourne skate	*Raja whitleyi*	18(18)	0	0	12(12)	0
Southern fiddler ray	*Trygonorrhina fasciata*	0	28(28)	0	41(41)	43(33)
Common sawshark	*Pristiophorus cirratus*	9(9)	14(14)	31(21)	37(21)	48(23)
White-spotted spurdog	*Squalus acanthias*	59(59)	0	0	40(25)	11(11)
Broadnose sevengill shark	*Notorynchus cepedianus*	15(15)	0	47(35)	0	0
Longnose skate	*Raja sp A*	0	0	22(15)	43(30)	11(11)
Elephant fish	*Callorhinchus milii*	29(29)	14(14)	13(13)	12(12)	0
Southern sawshark	*Pristiophorus nudipinnis*	37(37)	0	0	0	0
Shortfin mako	*Isurus oxyrinchus*	0	12(12)	0	0	0
Smooth stingray	*Dasyatis brevicaudata*	0	0	8(8)	0	0
Sandyback stingaree	*Urolophus bucculentus*	0	9(9)	0	0	0
Sub-total	*Chondrichthyes*	2319(468)	2722(665)	2895(687)	2782(631)	2462(474)
Teleostei						
Sand flathead	*Platycephalus bassensis*	455(105)	571(167)	684(200)	447(152)	351(116)
Ruddy gurnard perch	*Neosebastes scorpaenoides*	264(105)	493(235)	407(241)	477(216)	622(326)
Bearded rock cod	*Pseudophycis barbata*	51(35)	54(32)	26(18)	26(18)	39(22)
Jackass morwong	*Nemadactylus macropterus*	28(28)	13(13)	0	62(51)	24(24)
Red rock cod	*Scorpaena papillosa*	50(50)	0	12(12)	11(11)	0
Red gurnard	*Chelidonichthys kumu*	70(49)	0	0	13(13)	0
Tiger flathead	*Neoplatycephalus richardsoni*	0	11(11)	23(23)	32(24)	44(44)
Yank flathead	*Platycephalus speculator*	9(9)	0	9(9)	28(20)	0
Blue-throated wrasse	*Notolabrus tetricus*	0	0	11(11)	0	11(11)
Silverbelly	*Parequula melbournensis*	0	51(39)	0	0	0
Goldspot flathead	*Neoplatycephalus aurimaculatus*	9(9)	0	12(12)	0	0
Sergeant baker	*Aulopus purpurissatus*	0	0	0	11(11)	10(10)
Butterfly gurnard	*Lepidotrigla vanessa*	0	0	36(27)	0	0
Senator fish	*Pictilabrus laticlavius*	13(13)	0	0	0	0
Rosy wrasse	*Pseudolabrus psittaculus*	12(12)	0	0	0	0
Velvet leatherjacket	*Meuschenia scaber*	10(10)	0	0	0	0
Sub-total	*Teleostei*	971(194)	1193(332)	1221(352)	1107(285)	1101(462)
Cephalopoda						
Giant cuttlefish	*Sepia apama*	0	12(12)	0	0	0
Gould's squid	*Nototodarus gouldi*	0	0	11(11)	0	0
Octopus	*Octopus pallidus*	0	0	0	7(7)	0
Sub-total	*Cephalopoda*	0	12(12)	11(11)	7(7)	0

Table 6. Experiment 4: Effects of hook-size, hook-space and hook-shank-length on number of animals caught off south-eastern Australia during 1973–76

Four fishing gear sampling units of 50 Mustad hooks each of short-shank (SS) hook-sizes 5/O and 10/O, with 10-m hook-space, and of long-shank (LS) hook-size 11/O, with each of 10-m and 20-m hook-spac
41 sites; s.e., standard error; P_1, probability value for an effect of hook-size; P_2, probability value for an effect of shank-length; P_3, probability value for an effect of hook-space; * P<0.05, ** P<0.01, *** P<

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 100,000 hook-hours				Number caught	P_1
		10-m hook-space			20-m hook-space		
		5/O SS	10/O SS	11/O LS	11/O LS		
Fishing effort (100 hook-hours)		87	89	88	90		
Number of fishing gear sampling units		41	41	41	41		
Chondrichthyes							
Gummy shark	*Mustelus antarcticus*	992(294)	1153(264)	1052(243)	1217(243)	343	.6845
School shark	*Galeorhinus galeus*	769(270)	872(228)	841(228)	1183(447)	294	.7710
Draughtboard shark	*Cephaloscyllium laticeps*	347(166)	174(68)	131(50)	175(75)	61	.3373
Piked spurdog	*Squalus megalops*	251(150)	52(42)	99(55)	54(47)	59	.2053
Port Jackson shark	*Heterodontus portusjacksoni*	114(84)	55(28)	126(65)	101(85)	28	.5054
Southern sawshark	*Pristiophorus nudipinnis*	93(61)	53(37)	60(30)	178(68)	27	.5771
Broadnose sevengill shark	*Notorynchus cepedianus*	16(16)	47(27)	25(20)	84(47)	11	.3282
White shark	*Carcharodon carcharias*	0	0	0	7(7)	1	
Rusty catshark	*Parascyllium ferrugineum*	0	0	13(13)	0	1	
Whiskery shark	*Furgaleus macki*	0	20(20)	0	0	1	
Melbourne skate	*Raja whitleyi*	0	13(13)	0	0	1	
Sub-total	*Chondrichthyes*	2582(564)	2439(449)	2348(345)	3000(607)	827	.8430
Teleostei							
Sand flathead	*Platycephalus bassensis*	433(206)	240(100)	120(52)	201(82)	62	.4013
Ruddy gurnard perch	*Neosebastes scorpaenoides*	110(63)	247(81)	73(42)	49(38)	30	.1871
Blue-throated wrasse	*Notolabrus tetricus*	48(28)	6(6)	0	0	5	.1466
Saddled wrasse	*Notolabrus fucicola*	32(32)	38(38)	0	0	4	.9020
Barracouta	*Thyrsites atun*	41(24)	0	0	0	3	
Bearded rock cod	*Pseudophycis barbata*	0	19(19)	0	0	1	
Bight redfish	*Centroberyx gerrardi*	0	14(14)	0	0	1	
Barber perch	*Caesioperca rasor*	17(17)	0	0	0	1	
Snapper	*Pagrus auratus*	0	7(7)	0	0	1	
Velvet leatherjacket	*Meuschenia scaber*	0	14(14)	0	0	1	
Sub-total	*Teleostei*	682(237)	586(148)	193(75)	250(101)	109	.7315
Cephalopoda							
Giant cuttlefish	*Sepia apama*	26(26)	0	13(13)	0	3	

Table E5. Experiment 5: Effects of hook-size, hook-space and hook-shank-length on number of animals caught off south-eastern Australia during 1973_76

Four fishing gear sampling units of 50 Mustad hooks of each of short-shank (SS) hook-sizes 5/O and 10/O, with 5-m hook-space, and of long-shank (LS) hook-size 11/O, with each of 5-m and 10-m hook-spac
sites; s.e., standard error; P_1, probability value for an effect of hook-size; P_2, probability value for an effect of shank-length; P_3, probability value for an effect of hook-space; * P<0.05, ** P<0.01, *** P<0.

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 100,000 hook-hours				Number caught	P_1
		5-m hook-space			10-m hook-space		
		5/O SS	10/O SS	11/O LS	11/O LS		
Fishing effort (100 hook-hours)		35	36	36	37		
Number of fishing gear sampling units		22	22	22	22		
Chondrichthyes							
Gummy shark	Mustelus antarcticus	1332(412)	1654(433)	865(354)	1399(284)	175	.5939
Draughtboard shark	Cephaloscyllium laticeps	536(202)	506(217)	438(145)	558(218)	63	.9207
White-spotted spurdog	Squalus acanthias	473(147)	581(174)	207(100)	421(148)	59	.6355
School shark	Galeorhinus galeus	52(37)	248(119)	111(54)	189(82)	22	.1229
Port Jackson shark	Heterodontus portusjacksoni	50(34)	189(115)	129(61)	107(70)	16	.2499
Piked spurdog	Squalus megalops	106(79)	228(128)	28(28)	52(36)	14	.4219
Melbourne skate	Raja whitleyi	80(58)	77(55)	78(55)	29(29)	10	.9680
Southern sawshark	Pristiophorus nudipinnis	0	27(27)	0	52(36)	3	
Elephant fish	Callorhinchus milii	0	29(29)	0	16(16)	2	
Longnose skate	Raja sp A	30(30)	0	0	0	1	
Southern eagle ray	Myliobatis australis	0	0	0	28(28)	1	
Sub-total	*Chondrichthyes*	2659(459)	3540(663)	1857(432)	2850(353)	366	.2804
Teleostei							
Sand flathead	Platycephalus bassensis	647(228)	204(141)	377(209)	103(61)	46	.1056
Ruddy gurnard perch	Neosebastes scorpaenoides	160(89)	124(72)	79(56)	69(48)	16	.7559
Blue-throated wrasse	Notolabrus tetricus	90(64)	146(88)	163(81)	28(28)	16	.6098
Snapper	Pagrus auratus	0	0	24(24)	0	1	
Speckled stargazer	Kathetostoma canaster	0	24(24)	0	0	1	
Sub-total	*Teleostei*	897(237)	498(191)	643(221)	200(75)	80	.1966

Table 8a. Comparison of number of animals caught by various fishing gears in Bass Strait between 1973–76 and 1998–01

s.e., standard error; P, probability value for a difference in catch between 1973–76 and 1998–01 for 6-inch mesh-size; * P<0.05, ** P<0.01, *** P<0.001

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 100,000 hook-hours or 1000 km-hours				Number caught
		1973–76			1998–01	
		Hooks	7-inch	6-inch	6-inch	
Fishing effort (100 hook-hours or km-hours)		631	220	271	3317	
Number of fishing gear sampling units		148	139	172	91	
Chondrichthyes						
Gummy shark	*Mustelus antarcticus*	1059(120)	1105(153)	1457(197)	1220(118)	4797
Draughtboard shark	*Cephaloscyllium laticeps*	293(49)	1063(217)	660(112)	305(53)	1609
Common sawshark	*Pristiophorus cirratus*	6(2)	171(34)	381(76)	292(35)	1145
Elephant fish	*Callorhinchus milii*	3(2)	515(261)	340(154)	229(57)	910
Port Jackson shark	*Heterodontus portusjacksoni*	68(18)	684(154)	269(63)	160(41)	794
School shark	*Galeorhinus galeus*	528(134)	360(78)	246(47)	32(8)	425
Piked spurdog	*Squalus megalops*	59(21)	46(26)	115(53)	71(26)	326
Southern sawshark	*Pristiophorus nudipinnis*	74(22)	57(21)	151(42)	68(11)	299
Broadnose sevengill shark	*Notorynchus cepedianus*	28(14)	15(11)	1(1)	17(6)	71
White-spotted spurdog	*Squalus acanthias*	97(29)	61(52)	46(26)	0	65
Southern eagle ray	*Myliobatis australis*	4(4)	11(8)	7(7)	11(3)	45
Sparsely-spotted stingaree	*Urolophus paucimaculatus*	0	0	7(5)	12(4)	43
Australian angel shark	*Squatina australis*	0	23(19)	4(4)	8(2)	31
Melbourne skate	*Raja whitleyi*	17(9)	6(6)	0	>0(>0)	9
Gulf catshark	*Asymbolus vincenti*	3(1)	0	0	0	5
Western shovelnose ray	*Aptychotrema vincentiana*	0	0	0	1(1)	5
Shortfin mako	*Isurus oxyrinchus*	0	0	0	1(1)	4
Rusty catshark	*Parascyllium ferrugineum*	4(4)	5(5)	10(10)	0	4
Varied catshark	*Parascyllium variolatum*	2(2)	0	0	0	3
Longnose skate	*Raja sp A*	1(1)	0	0	>0(>0)	2
Smooth stingray	*Dasyatis brevicaudata*	1(1)	0	0	0	2
Thresher shark	*Alopias vulpinus*	0	0	0	>0(>0)	1
Bronze whaler	*Carcharhinus brachyurus*	0	0	4(4)	0	1
Thornback skate	*Raja lemprieri*	>0(>0)	0	0	0	1
Skates	*Raja spp*	0	0	0	>0(>0)	1
Sub-total	*Chondrichthyes*	2249(215)	4121(467)	3699(349)	2429(144)	10598
Teleostei						
Sand flathead	*Platycephalus bassensis*	183(43)	40(24)	86(70)	3(1)	126
Long-snouted boarfish	*Pentaceropsis recurvirostris*	1(1)	42(17)	62(19)	17(3)	73
Blue warehou	*Seriolella brama*	0	30(30)	0	15(5)	60
Jack mackerel	*Trachurus declivis*	0	0	0	16(12)	53
White trevally	*Pseudocaranx dentex*	0	12(12)	0	11(8)	46
Latchet	*Pterygotrigla polyommata*	0	0	0	7(5)	23
Blue-throated wrasse	*Notolabrus tetricus*	29(13)	8(6)	8(5)	4(2)	22
Ruddy gurnard perch	*Neosebastes scorpaenoides*	57(19)	4(4)	15(11)	0	20

Table 8a. (continued)

Magpie perch	*Cheilodactylus nigripes*	0	5(5)	8(6)	4(2)	17
Goldspot flathead	*Neoplatycephalus aurimaculatus*	0	0	47(47)	0	14
Queen snapper	*Nemadactylus valenciennesi*	0	19(19)	17(17)	1(1)	14
Bight redfish	*Centroberyx gerrardi*	0	0	0	4(2)	12
Red gurnard	*Chelidonichthys kumu*	>0(>0)	0	3(3)	2(1)	10
Bearded rock cod	*Pseudophycis barbata*	3(3)	0	11(8)	1(1)	12
Barracouta	*Thyrsites atun*	0	0	0	3(2)	8
Deepsea trevalla	*Hyperoglyphe antarctica*	0	0	0	2(2)	6
Swallow-tail	*Centroberyx lineatus*	0	0	0	1(1)	5
Sergeant baker	*Aulopus purpurissatus*	>0(>0)	0	0	1(1)	4
Silver dory	*Cyttus australis*	0	0	13(7)	0	4
Giant boarfish	*Paristiopterus labiosus*	0	0	0	2(1)	4
Knifejaw	*Oplegnathus woodwardi*	0	0	0	1(1)	4
Pink ling	*Genypterus blacodes*	0	0	0	1(1)	3
Tiger flathead	*Neoplatycephalus richardsoni*	1(1)	0	0	1(>0)	3
Snapper	*Pagrus auratus*	4(4)	0	4(4)	>0(>0)	3
Jackass morwong	*Nemadactylus macropterus*	0	19(11)	0	1(1)	6
Stargazer	*Uranoscopidae spp*	>0(>0)	0	0	1(>0)	3
Leatherjacket	*Family Monacanthidae*	0	0	3(3)	1(1)	3
Bastard trumpeter	*Latridopsis forsteri*	0	0	10(7)	0	2
Greenback flounder	*Rhombosolea tapirina*	0	0	0	1(>0)	2
Red cod	*Pseudophycis bachus*	>0(>0)	0	0	0	1
Redfish	*Centroberyx affinis*	0	5(5)	0	0	1
Tailor	*Pomatomus saltatrix*	0	4(4)	0	0	1
Marblefish	*Aplodactylus arctidens*	0	0	3(3)	0	1
Western blue groper	*Achoerodus gouldii*	0	0	0	>0(>0)	1
Saddled wrasse	*Notolabrus fucicola*	0	6(6)	0	0	1
Common stinkfish	*Synchiropus calauropomus*	0	0	4(4)	0	1
Sub-total	*Teleostei*	279(51)	195(49)	294(130)	102(18)	569
Cephalopoda						
Octopus	*Octopus pallidus*	0	0	0	1(1)	3
Giant cuttlefish	*Sepia apama*	4(4)	0	0	0	2
Gould's squid	*Nototodarus gouldi*	0	0	0	>0(>0)	1
Sub-total	*Cephalopoda*	4(4)	0	0	1(1)	6
Other						
Swollen spider crab	*Leptomithrax gaimardii*	0	0	0	24(13)	83
Southern rock lobster	*Jasus edwardsii*	0	0	0	1(1)	2
False bailer shell	*Livonia mammilla*	0	0	0	3(1)	9
Australian fur seal	*Arctocephalus pusillus dorifer*	0	0	0	1(>0)	2

Table 8b. Comparison of number of animals caught by various fishing gears in Tasmania during 1973_76

s.e., standard error

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 100,000 hook-hours or 1000 km-hours			Number caught
		Hooks	7-inch	6-inch	
Fishing effort (100 hook-hours or km-hours)		49	35	36	
Number of fishing gear sampling units		4	23	23	
Chondrichthyes					
Gummy shark	*Mustelus antarcticus*	317(112)	846(349)	1962(486)	117
White-spotted spurdog	*Squalus acanthias*	20(20)	689(556)	1288(1124)	78
Elephant fish	*Callorhinchus milii*	0	480(224)	911(332)	50
Piked spurdog	*Squalus megalops*	122(41)	19(19)	759(280)	36
Draughtboard shark	*Cephaloscyllium laticeps*	62(21)	220(92)	214(122)	19
School shark	*Galeorhinus galeus*	163(4)	59(44)	18(18)	11
Southern sawshark	*Pristiophorus nudipinnis*	0	79(47)	197(89)	10
Port Jackson shark	*Heterodontus portusjacksoni*	0	135(80)	83(83)	6
Common sawshark	*Pristiophorus cirratus*	0	0	120(56)	4
Broadnose sevengill shark	*Notorynchus cepedianus*	40(40)	0	37(37)	3
Longnose skate	*Raja sp A*	0	0	48(34)	2
Sub-total	*Chondrichthyes*	724(152)	2527(716)	5637(1534)	336
Teleostei					
Jackass morwong	*Nemadactylus macropterus*	0	0	107(76)	5
Striped trumpeter	*Latris lineata*	0	73(40)	22(22)	4
Sand flathead	*Platycephalus bassensis*	20(20)	0	37(37)	2
Bearded rock cod	*Pseudophycis barbata*	21(21)	0	0	1
Red rock cod	*Scorpaena papillosa*	22(22)	0	0	1
Tiger flathead	*Neoplatycephalus richardsoni*	21(21)	0	0	1
Sub-total	*Teleostei*	83(34)	73(40)	166(100)	14
Other					
Commercial scallop	*Pecten fumatus*	0	0	432(432)	14

Table 8c. Comparison of number of animals caught by various fishing gears in South Australia during 1998_01

s.e., standard error; P, probability value for a difference in catch between 6 and 6½-inch mesh-size during 1998_01; * P<0.05, ** P<0.01, *** P<0.001.

Common name or effort	Scientific name	Mean (s.e.) number of animals caught per 100,000 hook-hours or 1000 km-hours		Number caught	P
		6-inch	6½-inch		
Fishing effort (100 hook-hours or km-hours)		531	1335		
Number of fishing gear sampling units		14	48		
Chondrichthyes					
Gummy shark	*Mustelus antarcticus*	1150(202)	253(44)	939	.0000***
Port Jackson shark	*Heterodontus portusjacksoni*	61(15)	141(53)	315	.4232
School shark	*Galeorhinus galeus*	0	94(50)	139	
Smooth hammerhead	*Sphyrna zygaena*	2(2)	75(30)	77	.2011
Piked spurdog	*Squalus megalops*	4(3)	62(37)	71	.3962
Southern eagle ray	*Myliobatis australis*	62(19)	20(7)	53	.0145*
Bronze whaler	*Carcharhinus brachyurus*	2(2)	45(19)	45	.2152
Common sawshark	*Pristiophorus cirratus*	2(2)	40(13)	43	.1190
Southern sawshark	*Pristiophorus nudipinnis*	18(7)	14(7)	29	.7411
Broadnose sevengill shark	*Notorynchus cepedianus*	37(13)	2(1)	27	.0000***
Elephant fish	*Callorhinchus milii*	16(5)	9(4)	23	.3896
Thresher shark	*Alopias vulpinus*	25(13)	10(7)	19	.2930
Australian angel shark	*Squatina australis*	9(4)	16(10)	19	.7146
Spotted wobbegong	*Orectolobus maculatus*	0	4(2)	4	
Whiskery shark	*Furgaleus macki*	0	1(1)	2	
Skates	*Raja spp*	0	2(1)	2	
Sparsely-spotted stingaree	*Urolophus paucimaculatus*	3(3)	0	2	
White shark	*Carcharodon carcharias*	0	0	1	
Draughtboard shark	*Cephaloscyllium laticeps*	0	0	1	
White-spotted spurdog	*Squalus acanthias*	2(2)	0	1	
Western shovelnose ray	*Aptychotrema vincentiana*	0	1(1)	1	
Sub-total	*Chondrichthyes*	1394(208)	788(110)	1813	.0116*
Teleostei					
Bight redfish	*Centroberyx gerrardi*	10(10)	43(20)	64	.3789
Southern drummer	*Kyphosus gibsoni*	0	36(26)	62	.4496
Long-snouted boarfish	*Pentaceropsis recurvirostris*	36(13)	29(11)	61	.7483
Queen snapper	*Nemadactylus valenciennesi*	12(8)	31(14)	48	.4888
Snapper	*Pagrus auratus*	42(32)	12(7)	36	.1772
Dusky morwong	*Dactylophora nigricans*	0	17(9)	24	
Western blue groper	*Achoerodus gouldii*	6(4)	14(7)	21	.5701

Table 8c. (continued)

Red gurnard	*Chelidonichthys kumu*	33(10)	0	18	
Jewfish	*Argyrosomus japonicus*	10(7)	3(2)	14	.1943
Magpie perch	*Cheilodactylus nigripes*	8(7)	5(3)	13	.5919
Yellow-Spotted boarfish	*Paristiopterus gallipavo*	0	3(2)	6	
Leatherjacket	*Family Monacanthidae*	0	6(4)	6	
Latchet	*Pterygotrigla polyommata*	0	4(2)	5	
Sand flathead	*Platycephalus bassensis*	8(3)	1(1)	5	.0378*
Tiger flathead	*Neoplatycephalus richardsoni*	5(4)	0	3	
Sergeant baker	*Aulopus purpurissatus*	0	1(1)	2	
Blue-throated wrasse	*Notolabrus tetricus*	4(4)	0	2	
Pink ling	*Genypterus blacodes*	2(2)	0	1	
Mirror dory	*Zenopsis nebulosus*	0	>0(>0)	1	
Ruddy gurnard perch	*Neosebastes scorpaenoides*	0	0	1	
Jack mackerel	*Trachurus declivis*	0	1(1)	1	
Samsonfish	*Seriola hippos*	0	1(1)	1	
Bumpnose trevally	*Carangoides hedlandensis*	0	2(2)	1	
Sweep	*Scorpis lineolatus*	0	1(1)	1	
Old wife	*Enoplosus armatus*	0	1(1)	1	
Wrasse	*Labridae spp*	0	1(1)	1	
Greenback flounder	*Rhombosolea tapirina*	2(2)	0	1	
Toadfish	*Tetraodon erythrotaenia*	0	1(1)	1	
Sub-total	*Teleostei*	179(58)	212(67)	401	.7952
Other					
Swollen spider crab	*Leptomithrax gaimardii*	7(7)	14(11)	13	.7404
Southern rock lobster	*Jasus edwardsii*	0	3(2)	4	
Southern bay lobster	*Ibacus peronii*	2(2)	0	1	
Common dolphin	*Delphinus delphis*	2(2)	0	1	

Table 9a. Breakdown of total catch as retained, discarded, live, and dead animals for each species in Bass Strait during 1998_01

Catch per unit effort (CPUE) is measured as number of animals per 1000 km-hours.

Common name or effort	Scientific name	CPUE	Total catch (%)				Total catch (%)		Total ca
			Retained		Discarded		Live	Dead	Retained
			Live	Dead	Live	Dead			
Fishing effort (km-hours)		3317							
Chondrichthyes									
Gummy shark	Mustelus antarcticus	1114	40	59	0	1	40	60	99
Draughtboard shark	Cephaloscyllium laticeps	312	0	0	100	0	100	0	0
Common sawshark	Pristiophorus cirratus	304	77	22	0	1	77	23	99
Elephant fish	Callorhinchus milii	223	70	28	1	1	71	29	98
Port Jackson shark	Heterodontus portusjacksoni	157	0	0	100	0	100	0	0
Piked spurdog	Squalus megalops	77	0	0	94	6	94	6	0
Southern sawshark	Pristiophorus nudipinnis	67	78	20	0	2	78	22	98
School shark	Galeorhinus galeus	32	29	68	1	2	30	70	97
Broadnose sevengill shark	Notorynchus cepedianus	18	17	83	0	0	17	83	100
Sparsely-spotted stingaree	Urolophus paucimaculatus	12	0	0	77	23	77	23	0
Southern eagle ray	Myliobatis australis	12	0	0	79	21	79	21	0
Australian angel shark	Squatina australis	7	0	17	67	16	67	33	17
Western shovelnose ray	Aptychotrema vincentiana	2	0	0	80	20	80	20	0
Shortfin mako	Isurus oxyrinchus	1	0	25	25	50	25	75	25
Thresher shark	Alopias vulpinus	0	100	0	0	0	100	0	100
Longnose skate	Raja sp A	0	0	0	100	0	100	0	0
Melbourne skate	Raja whitleyi	0	0	0	100	0	100	0	0
Skates	Raja spp	0	0	0	100	0	100	0	0
Sub-total	*Chondrichthyes*	2339	38	36	24	2	62	38	74
Teleostei									
Blue warehou	Seriolella brama	17	25	33	0	42	25	75	58
Long-snouted boarfish	Pentaceropsis recurvirostris	16	92	6	0	2	92	8	98
Jack mackerel	Trachurus declivis	16	0	0	68	32	68	32	0
White trevally	Pseudocaranx dentex	13	43	57	0	0	43	57	100
Latchet	Pterygotrigla polyommata	7	0	0	0	100	0	100	0
Magpie perch	Cheilodactylus nigripes	4	0	0	64	36	64	36	0
Bight redfish	Centroberyx gerrardi	4	67	25	0	8	67	33	92
Sand flathead	Platycephalus bassensis	3	9	0	36	55	45	55	9
Blue-throated wrasse	Notolabrus tetricus	3	33	23	11	33	44	56	56
Red gurnard	Chelidonichthys kumu	2	25	0	0	75	25	75	25
Barracouta	Thyrsites atun	2	0	0	0	100	0	100	0
Deepsea trevalla	Hyperoglyphe antarctica	2	0	100	0	0	0	100	100
Swallow-tail	Centroberyx lineatus	2	100	0	0	0	100	0	100
Bearded rock cod	Pseudophycis barbata	1	0	0	0	100	0	100	0

Table 9a. (continued)

Giant boarfish	Paristiopterus labiosus	1	100	0	0	0	100	0	100
Knifejaw	Oplegnathus woodwardi	1	100	0	0	0	100	0	100
Queen snapper	Nemadactylus valenciennesi	1	50	50	0	0	50	50	100
Sergeant baker	Aulopus purpurissatus	1	0	0	0	100	0	100	0
Pink ling	Genypterus blacodes	1	33	67	0	0	33	67	100
Jackass morwong	Nemadactylus macropterus	1	33	0	0	67	33	67	33
Tiger flathead	Neoplatycephalus richardsoni	1	50	50	0	0	50	50	100
Stargazer	Uranoscopidae spp	1	0	0	100	0	100	0	0
Greenback flounder	Rhombosolea tapirina	1	100	0	0	0	100	0	100
Leatherjacket	Family Monacanthidae	1	0	0	50	50	50	50	0
Snapper	Pagrus auratus	0	100	0	0	0	100	0	100
Western blue groper	Achoerodus gouldii	0	0	0	100	0	100	0	0
Sub-total	*Teleostei*	102	40	14	18	28	58	42	54
Cephaplopoda									
Octopus	Octopus pallidus	1	33	0	67	0	100	0	33
Gould's squid	Nototodarus gouldi	0	100	0	0	0	100	0	100
Sub-total	*Cephalopoda*	1	50	0	50	0	100	0	50
Other									
Swollen spider crab	Leptomithrax gaimardii	25	0	0	70	30	70	30	0
Southern rock lobster	Jasus edwardsii	1	100	0	0	0	100	0	100
False bailer shell	Livonia mammilla	3	67	0	33	0	100	0	67
Australian fur seal	Arctocephalus pusillus dorifer	1	0	0	0	100	0	100	0

Table 9b. Breakdown of total catch as retained, discarded, live, and dead animals for each species in South Australia during 1998_01

Catch per unit effort (CPUE) is measured as number of animals per 1000 km-hours.

Common name or effort	Scientific name	CPUE	Total catch (%)				Total catch (%)		Total ca
			Retained		Discarded		Live	Dead	Retained
			Live	Dead	Live	Dead			
Fishing effort (km-hours)		1865							
Chondrichthyes									
Gummy shark	Mustelus antarcticus	497	47	52	0	1	47	53	99
Port Jackson shark	Heterodontus portusjacksoni	138	0	0	100	0	100	0	0
School shark	Galeorhinus galeus	44	94	2	4	0	98	2	96
Smooth hammerhead	Sphyrna zygaena	41	97	2	0	1	97	3	99
Piked spurdog	Squalus megalops	38	0	0	100	0	100	0	0
Southern eagle ray	Myliobatis australis	28	2	0	89	9	91	9	2
Common sawshark	Pristiophorus cirratus	23	91	7	2	0	93	7	98
Bronze whaler	Carcharhinus brachyurus	23	100	0	0	0	100	0	100
Southern sawshark	Pristiophorus nudipinnis	14	63	30	4	3	67	33	93
Broadnose sevengill shark	Notorynchus cepedianus	13	21	0	0	79	21	79	21
Elephant fish	Callorhinchus milii	12	68	14	9	9	77	23	82
Thresher shark	Alopias vulpinus	10	5	0	32	63	37	63	5
Australian angel shark	Squatina australis	10	21	0	68	11	89	11	21
Spotted wobbegong	Orectolobus maculatus	2	100	0	0	0	100	0	100
Skates	Raja spp	1	0	0	100	0	100	0	0
Sparsely-spotted stingaree	Urolophus paucimaculatus	1	0	0	50	50	50	50	0
Whiskery shark	Furgaleus macki	1	100	0	0	0	100	0	100
White-spotted spurdog	Squalus acanthias	1	0	0	100	0	100	0	0
Western shovelnose ray	Aptychotrema vincentiana	1	0	0	100	0	100	0	0
Sub-total	*Chondrichthyes*	898	42	30	25	3	67	33	72
Teleostei									
Southern drummer	Kyphosus gibsoni	33	100	0	0	0	100	0	100
Bight redfish	Centroberyx gerrardi	31	98	0	2	0	100	0	98
Long-snouted boarfish	Pentaceropsis recurvirostris	30	98	0	0	2	98	2	98
Queen snapper	Nemadactylus valenciennesi	23	98	0	2	0	100	0	98
Snapper	Pagrus auratus	19	100	0	0	0	100	0	100
Dusky morwong	Dactylophora nigricans	13	58	0	42	0	100	0	58
Western blue groper	Achoerodus gouldii	11	100	0	0	0	100	0	100
Red gurnard	Chelidonichthys kumu	10	56	0	22	22	78	22	56
Jewfish	Argyrosomus japonicus	5	90	0	0	10	90	10	90
Magpie perch	Cheilodactylus nigripes	5	100	0	0	0	100	0	100

Table 9b. (continued)

Yellow-Spotted boarfish	Paristiopterus gallipavo	3	100	0	0	0	100	0	100
Leatherjacket	Family Monacanthidae	3	100	0	0	0	100	0	100
Latchet	Pterygotrigla polyommata	3	40	0	60	0	100	0	40
Sand flathead	Platycephalus bassensis	3	60	0	20	20	80	20	60
Tiger flathead	Neoplatycephalus richardsoni	2	100	0	0	0	100	0	100
Sergeant baker	Aulopus purpurissatus	1	0	0	100	0	100	0	0
Blue-throated wrasse	Notolabrus tetricus	1	100	0	0	0	100	0	100
Pink ling	Genypterus blacodes	1	100	0	0	0	100	0	100
Mirror dory	Zenopsis nebulosus	1	100	0	0	0	100	0	100
Jack mackerel	Trachurus declivis	1	100	0	0	0	100	0	100
Samsonfish	Seriola hippos	1	100	0	0	0	100	0	100
Bumpnose trevally	Carangoides hedlandensis	1	0	0	100	0	100	0	0
Sweep	Scorpis lineolatus	1	100	0	0	0	100	0	100
Old wife	Enoplosus armatus	1	0	0	100	0	100	0	0
Wrasse	Labridae spp	1	100	0	0	0	100	0	100
Greenback flounder	Rhombosolea tapirina	1	100	0	0	0	100	0	100
Toadfish	Tetraodon erythrotaenia	1	0	0	100	0	100	0	0
Sub-total	*Teleostei*	201	91	0	7	2	98	2	91
Other									
Swollen spider crab	Leptomithrax gaimardii	7	0	0	69	31	69	31	0
Southern rock lobster	Jasus edwardsii	2	100	0	0	0	100	0	100
Southern bay lobster	Ibacus peronii	1	0	0	100	0	100	0	0
Common dolphin	Delphinus delphis	1	0	0	0	100	0	100	0

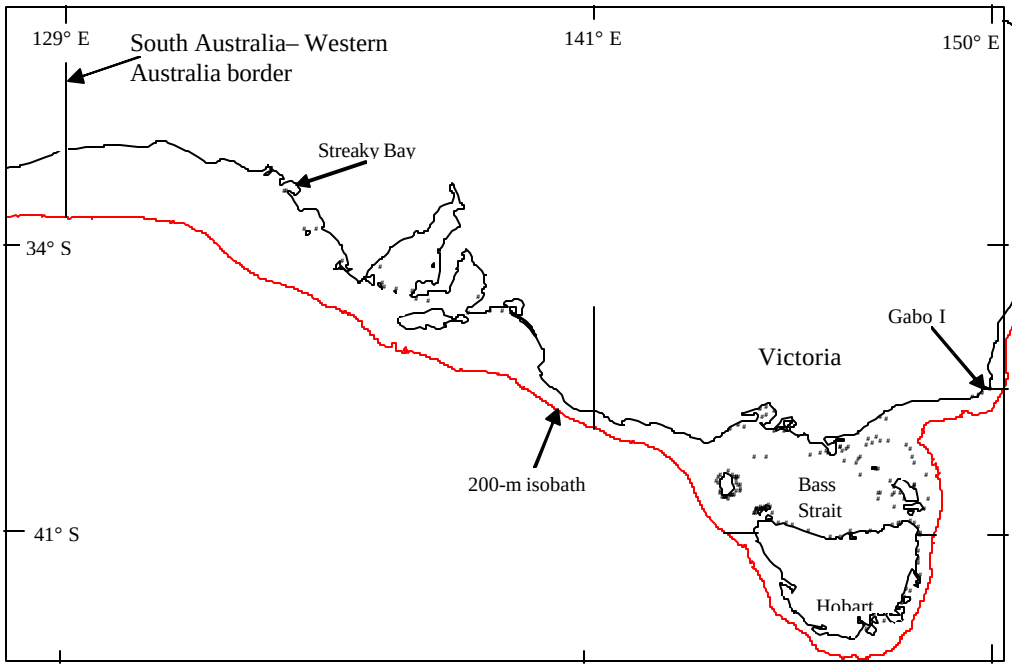

Figure 1a. Fishing sites during 1973–76.

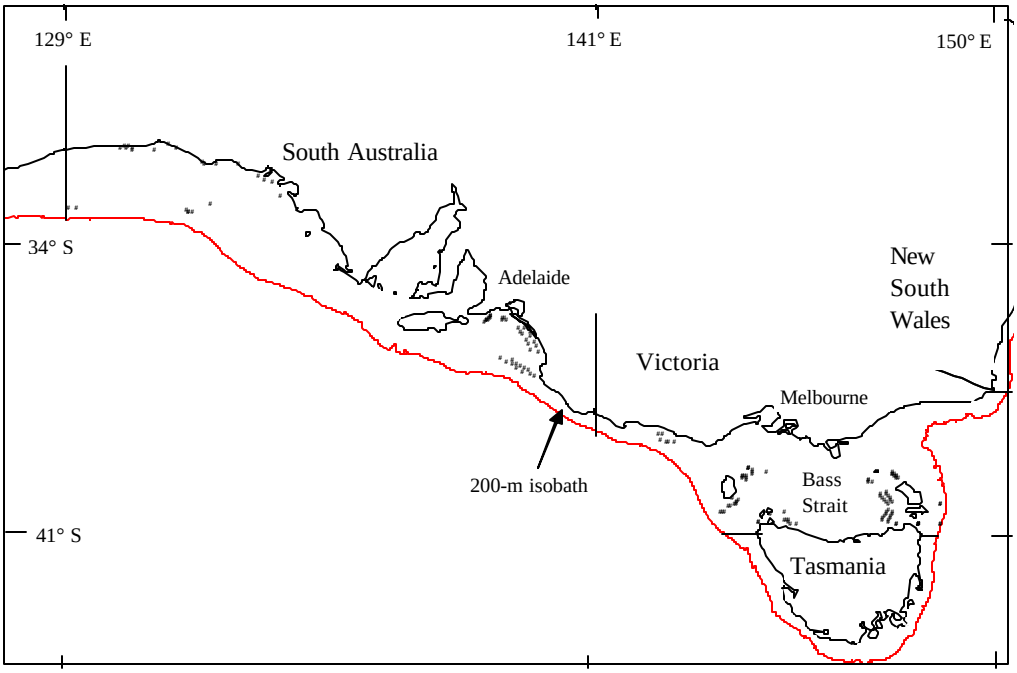

Figure 1b. Fishing sites during 1998–01.

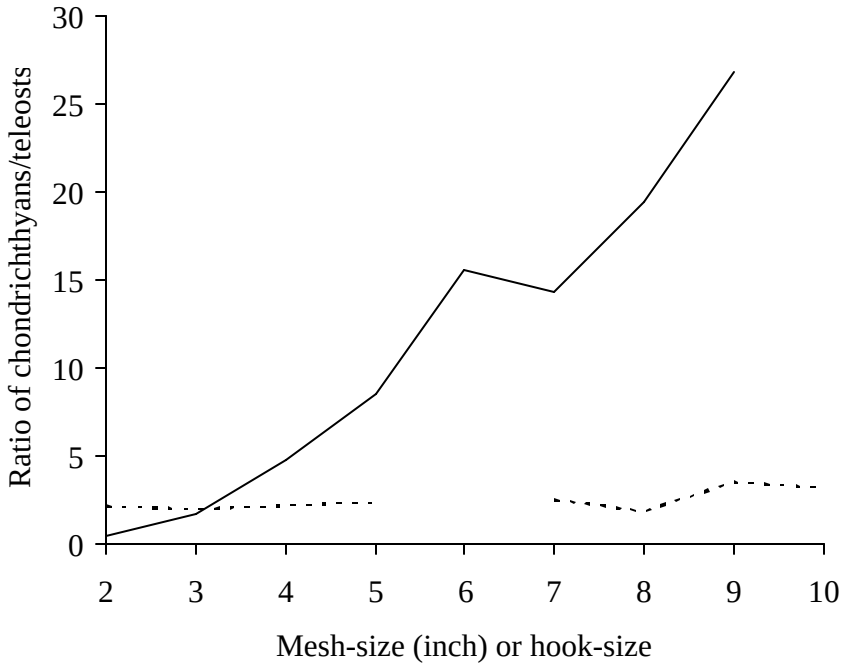

Figure 2. Ratio of number of animals of chondrichthyes / number of animals of teleostei against gillnet mesh-size or hook-size.

Mesh-sizes range 2–9 inches and hook-sizes Mustad 2/O–5/O and Mustad 7/O–10/O.