Assessment of Bycatch in the Great Australian Bight Trawl Fishery

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Project No. 2000/169

State Government Victoria Department of Natural Resources and Environment

Fisheries Research & Development Corporation

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2002

ISBN: 1 74106 273 X

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NON-TECHNICAL SUMMARY

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Objectives:

1. Design an onboard sampling strategy that will provide a representative sample of the spatial and temporal dynamics of the total catch composition (retained and discarded) in the GABTF.
2. Undertake onboard sampling of commercial vessels and collect information on the quantity and species composition of the total catch (retained and discarded) in the GABTF.
3. Collect biological data on the main species retained in the GABTF (sex ratio, size, age, maturity and reproduction for Bight redfish and deepwater flathead, size and age for orange roughy) and length-frequency distributions for selected other species.
4. Based on the data collected during this project, provide industry, the GABMAC and stock assessment scientists with information on GABTF species biology and bycatch composition appropriate to their specific needs.
5. Investigate the potential for Environment Australia to fund data collection from commercial vessels working within the GAB Marine Park which can be used in conjunction with or comparison to the CSIRO research cruise.

Note: Objective 5 was not approved by Environment Australia and is not referred to again in this document.

Non Technical Summary

OUTCOMES ACHIEVED

Industry has recognised the need for, and strongly supported the assessment and quantification of bycatch in the GABTF and has been willing to have observers onboard for the duration of the project. The results of this study provide AFMA, industry and scientists with detailed information on the quantity and species composition of the retained and discarded catch in the Great Australian Bight Trawl Fishery, according to Zone (spatial) and Season (temporal). This information can now be assessed with a view to implementing appropriate mitigation actions to reduce bycatch and minimise the impact of fishing gear on non-target species and the marine environment. The results of

the study also provide biological data on the target species as well as length-frequency distribution data for target and non-target species in the GABTF. This information will add to current knowledge and will be incorporated into stock assessments and age-structured models, which are currently being developed.

As a result of this initial research project, the Great Australian Bight Industry Association has provided full funding to continue the monitoring program during 2001/02. Furthermore, with the results of the monitoring study available, GABTF Industry has requested to be part of the new FRDC project "Effects of Trawling Subprogram: Promoting Industry uptake of gear modifications to reduce bycatch in the South East and Great Australian Bight Trawl Fisheries" (Project 2001/006).

The Great Australian Bight Trawl Fishery (GABTF) covers an extensive area of southern Australian waters, from Cape Leeuwin in Western Australia to Cape Jervis in South Australia, and out to the edge of the Australian Fishing Zone (AFZ). It is comprised of a continental shelf/upper slope fishery mainly targeting Bight redfish (*Centroberyx gerrardi*) and deepwater flathead (*Neoplatycephalus conatus*) and a seasonal deepwater slope fishery for orange roughy (*Hoplostethus atlanticus*).

As a trawl fishery, the GABTF is generally considered to be a relatively non-selective fishery for which non-target species may represent a large component of the total catch. During 2000, the Commonwealth, through the Australian Fisheries Management Authority (AFMA) and stakeholders, developed a Bycatch Action Plan for the fishery. The aim of the Plan was to provide a strategic approach to reduce the impacts of fishing on bycatch species and the marine environment, ensure the ecological sustainability of the fishery, and to increase community awareness and industry support for the activities taken to address bycatch in the GABTF. An important component of the Plan was the collection of detailed information on the species composition of both the catch and bycatch. As a first step towards this, the present study was initiated in the GABTF to collect detailed spatial and temporal information on the amount and species composition of the targeted catch and bycatch together with biological data on the important species.

A stratified, representative sampling regime was determined from detailed analysis of logbook information from the GABTF. The fishery was divided into four Zones (Far West, West, Central and East), that were sampled over four seasons (Summer, Autumn, Winter and Spring). Implementation of the monitoring required onboard observers to work on commercial trawl vessels to collect operational (location, depth, time, gear type etc), catch (estimated weight of retained and discarded species) and biological data (length-frequency data for target and non-target species) for about 80 sea-days during the one-year study period. Length, weight, sex, and maturity of deepwater flathead and Bight redfish (bimonthly samples of 100 individuals) were recorded and otoliths were extracted from these species and from orange roughy for ageing purposes.

A total of 77 observer sea-days were undertaken during October 2000 to July 2001. Of these, 72 sea-days were directed at "market fishing" (targeting Bight redfish and deepwater flathead) and 5 sea-days were directed at orange roughy fishing. Most Zone and Season targets were met but there was some under-sampling of Winter market fishing due to the commencement of the project in October 2000. Overall, the percentage (by weight) of the catch that was retained in market shots varied from 44% in the Central Zone, 65% in the East Zone, to 67% in the West Zone. For orange roughy shots in Far West Zone, 99.6% of the catch was retained.

During market fishing, the retained catch was dominated by deepwater flathead, Bight redfish, blue grenadier, king dory, blue eye trevalla, orange roughy and large (>35cm TL) chinaman leatherjacket and ornate angel shark (>80cm TL). The discarded catch was dominated by latchet, wide stingaree, draughtboard shark, southern frostfish, sponge, hard coral and small chinaman leatherjacket (<35cm TL).

The biological data collected for deepwater flathead and Bight redfish built on information gained from previous studies. Length-weight relationships were determined for both sexes of both species. The present study showed that deepwater flathead had a protracted spawning season from October to February and Bight redfish spawned during early autumn. Both species may school by sex. There is sex dimorphism in deepwater flathead with females potentially growing larger than males but both sexes are reproductively mature at about 43 cm TL. Maturity ogives suggest male Bight redfish mature at 35.2 cm FL and female Bight redfish at 32.4 cm FL, but this needs to be confirmed using histology of gonads. Otoliths were collected for deepwater flathead, Bight redfish and orange roughy, but all ageing work is being undertaken as part of other research projects.

This research project has provided the data needed by AFMA and stakeholders to help assess the ecological sustainability of the GABTF and to address issues of bycatch and discarding. This data can now be assessed with a view to implementing strategies to reduce bycatch and minimise fishing impacts in the GAB. Information on the biology of target species and on the size distributions of non-target species will be made available to scientists and other users for incorporation into current stock assessments.

KEYWORDS: Great Australian Bight Trawl Fishery, bycatch, deepwater flathead, Bight redfish, orange roughy

Acknowledgments

The authors are grateful for the wide-spread support of the Great Australian Bight Trawl Fishing Industry. In particular, we would like to thank the owners, skippers and crews of the *Lucky S*, *Majestic Star, Noble Pearl, Sarriba, Southern Voyager* and *Territory Pearl* for their hospitality and allowing the research to be undertaken on their vessels. Ken Smith, Paul McCoy, Pam Oliviero and Sharon Berrie are thanked for their technical assistance. Anne Gason and Rhonda Flint are thanked for their computer programming support and Sonia Talman is acknowledged for her editorial comments on the final report. This research study was funded by the Fisheries Research and Development Corporation.

FINAL REPORT

2000/169 Assessment of Bycatch in the Great Australian Bight Fishery

Background

The Great Australian Bight Trawl Fishery (GABTF) is a multi-species fishery, worth approximately $7 million annually. It provides fresh fish for markets in south-eastern Australia and has a growing export market to Asia. As a Commonwealth fishery, the GABTF is managed by the Australian Fisheries Management Authority and it covers an extensive area of southern Australian waters, from Cape Leeuwin in Western Australia to Cape Jervis in South Australia. Over most of this region, the fishery extends from the Australian Fishing Zone (AFZ) into the 200 metre isobath, but it also includes shallower waters between 125?E and 132 ?E (Fig. 1). There are two general components to the GABTF: a continental shelf/upper slope fishery (<200m) for deepwater flathead (*Neoplatycephalus conatus*) and Bight redfish (*Centroberyx gerrardi*), and a seasonal deepwater slope fishery for orange roughy (*Hoplostethus atlanticus*). Only 10 vessels have statutory fishing rights in the GABTF.

Whilst trawling is often targeted towards species of high commercial value, it is generally considered to be a relatively non-selective method of fishing in which a lot of non-target species are captured. Some of this “bycatch” may be of commercial value and retained as “byproduct” but the remainder is usually discarded either because it has no commercial value or regulations preclude it from being landed. In addition, some organisms may be killed as a result of interaction with the fishing gear without being captured (unaccounted mortality).

Under Section 3 of the *Fisheries Management Act 1991 (Commonwealth)*, the Australian Fisheries Management Authority (AFMA) must ensure “that the exploitation of fisheries resources and the carrying on of any 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”. The issue of bycatch, which by definition includes discards and unaccounted mortality, is addressed more specifically in the Commonwealth Policy on Fisheries Bycatch. In an endeavour to reduce bycatch in fisheries, the Commonwealth, through AFMA and stakeholders, has developed and implemented fishery-specific bycatch action plans. One of these plans has been developed for the Great Australian Bight Trawl Fishery (AFMA 2001a,b).

The primary aims of the GABTF Bycatch Action Plan are to:

1. Reduce the impacts of fishing on bycatch species and the marine environment by minimising, to the greatest extent possible, the interaction and potential capture of bycatch species, including marine mammals and protected species, and the level of discarding of bycatch species.
2. Minimise the impacts of fishing gear on the benthos and marine environment and on non-landed catch.
3. Increase community awareness and industry support for the activities taken to address bycatch in the GABTF.

The first step in addressing these aims is to collect detailed information on the amount and species composition of the targeted and non-targeted catch in the GABTF. In the South East Fishery (SEF) this has been accomplished by the establishment of the Integrated Scientific Monitoring Program (ISMP) conducted by the Marine and Freshwater Resources Institute, Victoria (MAFRI). The ISMP uses on-board field scientists to collect information on the quantity, size and age composition of the retained and discarded catch taken by board trawler vessels working in the SEF (Knuckey and Sporcic, 1999; Knuckey *et al.*, 1999, 2000). Based on the ISMP, a one-year FRDC funded pilot study to monitor catches by the GAB trawl fleet was undertaken.

Need

Despite the GABTF being in its twelfth year of operation, information on bycatch was very limited. If the core objectives of the Commonwealth Policy on Fisheries Bycatch were to be implemented for the GABTF, there was an essential need for baseline data on amount and composition of bycatch. This project was designed to provide this information, so that it would be possible to address the aims of reducing bycatch and minimising fishing impacts in the GABTF.

Objectives

1. Design an onboard sampling strategy that will provide a representative sample of the spatial and temporal dynamics of the total catch composition (retained and discarded) in the GABTF.
2. Undertake onboard sampling of commercial vessels and collect information on the quantity and species composition of the total catch (retained and discarded) in the GABTF.
3. Collect biological data on the main species retained in the GABTF (sex ratio, size, age, maturity and reproduction for Bight redfish and deepwater flathead, size and age for orange roughy) and length-frequency distributions for selected other species.
4. Based on the data collected during this project, provide industry, the GABMAC and stock assessment scientists with information on GABTF species biology and bycatch composition appropriate to their specific needs.

Methods

The study was designed to provide comprehensive baseline information on the catch composition of demersal trawl vessels used throughout the Great Australian Bight Trawl Fishery. To achieve this, onboard observers identified and estimated (by weight) the retained and discarded species of the catch. In addition, biological information on targeted and other species was collected and interactions with wildlife were recorded.

Sampling design

A stratified, representative sampling regime was adopted for the onboard monitoring. Detailed analysis of logbook information from the GAB enabled the division of the fishery into the following strata: Zone (Far West, West, Central and East, with most effort being directed at the West and Central Zones) (Fig. 1), and Season (Summer, Autumn, Winter and Spring). Sampling levels within these strata were weighted to reflect the recent catches in the fishery. As a result, not all Zone x Season cells in the sampling design were sampled (Table 1).

Implementation of the design required onboard observers to work on commercial trawl vessels to collect catch and biological information for about 80 sea-days during the one-year study period. Within strata, observer trips were undertaken in a representative manner with attempts made to sample across the fishing fleet in line with the current state of the fishery. Due to the low numbers of vessels working in the fishery, multiple trips on individual vessels were required, which was supported by Industry.

Onboard sampling

The onboard component of the project was directed at obtaining the estimated weight and length-frequency distributions of the retained and discarded catches by strata. For each shot the observer collected operational data on the fishing activities (location, depth, time, gear type etc) and biological data on the catch. After capture, all fish were identified to species level where possible. Estimated weight of fish (retained and discarded) was recorded for each species and the length of a representative sub-sample of important fish species was measured (down to the nearest centimetre). Experience has shown that a smooth size distribution is obtained after measuring around 100 fish. The main species sampled for length-frequency information included deepwater flathead, Bight redfish, orange roughy, angel shark, chinaman leatherjacket, jackass morwong, western gemfish, blue grenadier, latchet and spotted warehou. Copy of the data sheets, indicating the range of operational and biological data collected, are included in Appendix 3.

Additional biological sampling

At regular intervals (at least bimonthly) during October 2000 and June 2001 comprehensive biological information was collected on deepwater flathead and Bight redfish. A randomly selected sample of about 100 fish of each species was collected from the last couple of shots of an observer trip. To ensure that the bimonthly sampling strategy was maintained, deepwater flathead and Bight redfish were occasionally purchased from GAB trawl vessels. Whole fish were taken to local fish processors or alternatively transported to MAFRI where details on length, weight, sex, maturity including gonad weight and developmental stage were recorded (see Appendix 3). Gonads were extracted and preserved for future histology and fecundity evaluation. Sagittal otoliths from deepwater flathead, Bight redfish and orange roughy were removed for routine ageing purposes.

Data storage

All onboard observer data is contained within a MS ACCESS database similar in design to the SEF ISMP database managed by MAFRI (Knuckey *et.al.*, 2000) (**file:gabtfs.mdb**). All biological data for deepwater flathead, Bight redfish and orange roughy is contained in a separate MS ACCESS database (**file:gabtfreprod.mdb**).

Results/Discussion

A total of 77 observer sea-days, 72 sea-days directed at market fishing and 5 sea-days directed at orange roughy fishing, were completed between October 2000 and July 2001 (Table 1). Eight observer trips, onboard five different vessels, resulted in all four Zones being sampled. With an emphasis on sampling in the West and Central Zones, most Zone and Season targets were met. There was some under-sampling in Winter due to the commencement of the project in October 2000 so only July 2001 was sampled. The Winter sampling shortfall has been overcome by increased Winter sampling as part of the AFMA funded project ‘ISMP – Monitoring of the Great Australian Bight Trawl Fishery during 2001/02’.

During the market fishing trips (10 to14 days in length), demersal trawls were, on average, in water depths of 100-150m for 4-5 hours duration. Across all Zones (excluding the Far West Zone), an average of 0.35t was landed for every hour trawled of which 55% was retained, resulting in 0.19t of retained catch per hour. Within Zone, the percentage retained catch (by weight) varied from 44% in the Central Zone, 65% in the East Zone, 67% in the West Zone to 99.6% in Far West Zone (Table 2). In terms of Season, the percentage retained catch varied from 42% in Spring, 55% in Autumn, 66% in Summer to 99.6% in Winter but this Winter value is based on a single Zone (Table 3). On closer examination the percentage retained catch per Season is dependent on a combination of Zone and Season (Table 3). In the Central Zone the percentage retained catch increased from 41% in Spring, to 49% in Summer and to 55% in Autumn. Whilst in the West Zone the percentage retained catch decreased from 67% in Summer to 58% in Autumn (no Spring data available). This variation in retained catch depends on catch composition which varies seasonally (i.e. the landed catch may be dominated by latchet in Spring, which is a discarded species, and dominated by deepwater flathead in Summer, which is retained).

Catch composition

General

During the one-year study, over 160 species were identified (usually to species level) in the landed catch (Table 4). Eighty-two species were retained while 137 species were discarded. The difference between total species identified and numbers of retained and discarded species arose because under-sized individuals of retained species were sometimes discarded. There were variations in the species composition in the different zones of the GABTF. The composition in the East Zone of the GABTF was similar to that of the western zone of the SETF (see Knuckey and Liggins 1999), comprising retained catches of blue grenadier, king dory, blue eye trevalla, spotted warehou and western gemfish (Fig. 2). The discarded catch consisted mainly of latchet, draughtboard shark dogfish and rubyfish (Fig. 2). The composition of Central and West Zones of the GABTF were similar to each other and reflected the "typical" GABTF catch of Bight redfish, deepwater flathead and ocean jackets, with latchet being the main discard species (Figs. 3 & 4). The catch composition in the Far West Zone was similar to other deepwater orange roughy fisheries, comprised almost entirely of orange roughy (Fig. 5).

An example of the on-board information (mean weight of the discarded and retained catch and size distributions) of the major species within each zone is shown in Figure 6. The size distributions of the main species caught in the GABTF are presented in Figures 7-17 for each of the zones. Size frequency distributions were similar across Zones for deepwater flathead (ranging 34 to 77cm TL) but the size distribution of Bight redfish was narrower in the West Zone compared to the Central Zone with fewer small fish (<30cm FL) observed. The size distribution of orange roughy in the Far West Zone ranged from 29 to 51cm SL, which is similar to the length-frequency distribution of spawning roughy in Eastern Tasmania (Knuckey *et al*., 2000).

Other species such as latchet (20 to 46cm LCF), chinaman leatherjacket (21 to 54cm TOT), ornate angel shark (43 to 129cm TOT), jackass morwong (22 to 44cm LCF) and western gemfish (40 to 110cm LCF) were caught in the East, Central and West Zones while blue grenadier (51 to 105cm STL), blue eye trevalla (41 to 61cm LCF) and spotted/silver warehou (30 to 54cm LCF) were only caught in the East Zone.

Examples of typical catches in the Great Australian Bight Trawl Fishery are presented in Appendix 3. With the exception of fiddler and smooth rays, most of the discarded catch was in poor condition or dead.

Detailed descriptions of the size distributions of the main retained and discarded species in each of the zones are given below.

East Zone

Over the year, 30 demersal trawls were monitored during 13 observer sea-days in the East Zone. Of the 24t of catch landed, 65% (by weight) was retained. The retained catch consisted of 44 species dominated by blue grenadier (16%), king dory (15%), blue eye trevella (11%) and spotted warehou (8%) (Fig. 2). The discarded catch was dominated by latchet (22%), draughtboard shark (13%), southern frostfish (12%) and green-eyed dogfish (9%) (Fig. 2). Only small quantities of deepwater flathead were retained (30 kg per shot) and Bight redfish were completely absent from the catch. The East Zone catch composition is more similar to that of the Western Victorian Zone of the SETF rather than the Central and West Zones of the GABTF.

The mean catch and length-frequency distributions of the East Zone retained species are similar to those of the Western Victorian Zone (Knuckey *et al.*, 2000) with the exception of blue grenadier (Fig. 15). The length-frequency distribution of blue grenadier in the East Zone shows a greater proportion of larger individuals (>70 cm STL) than in the Western Victorian Zone.

Central Zone

In the Central Zone, 97 demersal trawls were monitored during 35 observer sea-days undertaken during 2000/01. Of the 155t of catch landed, only 44% (by weight) was retained. The retained catch consisted of about 50 species dominated by deepwater flathead (48%), Bight redfish (11%), chinaman leatherjacket (11%) and ornate angel shark (6%) (Fig. 3). Latchet (51%) dominated the discarded catch with lesser amounts of wide stingaree (11%), sponge (9%) and chinaman leatherjacket (5%). (Fig. 3).

In the Central Zone the mean catches of deepwater flathead (retained) (Fig. 7) and latchet (discarded) (Fig.10) were similar (approx. 400 kg per shot), whilst the Bight redfish (retained) (Fig. 8) was about a quarter of this (approx. 100 kg per shot). Of the estimated 44 t of latchet landed, only 0.3% (> 35cm LCF) was retained (ie. 99.7% of the latchet catch was discarded because it was not of commercial size, Fig. 10). In the Central Zone, about a third of the chinaman leatherjacket landed catch was also discarded (Fig. 11). Small quantities of ornate angel shark were routinely landed with about a quarter of these discarded, ranging in length between 43 and 98 cm TL, whilst larger ornate angel shark, ranging in length between 87 and 129 cm TL, were retained (Fig. 12). The occurrence of sponge, rock and hard coral in the catches of this Zone may be attributed to the occasional trawling of virgin ground.

West Zone

Over the year, 57 demersal trawls were monitored during 24 observer sea-days in the West Zone. Of the 106t of catch landed, 67% (by weight) was retained. The retained catch consisted of 44 species dominated by deepwater flathead (51%), chinaman leatherjacket (12%), Bight redfish (11%) and ornate angel shark (3%) (Fig. 4). The discarded catch was again dominated by latchet (41%), with lesser amounts of chinaman leatherjacket (11%), sponge (8%) and wide stingaree (8%) (Fig. 4). The species composition of landed catches in the Central and West Zones are similar with both the retained and discarded catches comprising the same four or five major species.

In the West Zone the mean retained catch weight per shot of deepwater flathead almost doubled (700 kg per shot, Fig. 7) compared to that of the Central Zone (Fig. 7) whilst the mean discarded catch weight of latchet halved (250 kg per shot, Fig. 10). This increase in the average retained catch weight of deepwater flathead may be more indicative of season rather than zone, with almost all of the West Zone trawls monitored during the summer when deepwater flathead spawning aggregations are prevalent. The Bight redfish mean retained catch in the West Zone was greater than that of the Central Zone (Fig. 8). Occasional good catches of western gemfish were observed in the West Zone (Fig .14). In contrast to the western gemfish length-frequency distribution of the East Zone, which ranged from 39 to 83cm LCF, the West Zone distribution consisted of larger western gemfish, ranging from 51 to 110cm LCF.

Far West Zone

In the Far West Zone, 10 demersal trawls, targeting orange roughy, were monitored over 5 observer sea-days undertaken during July 2001. Of the 68,792 kg caught, 68,187 (99.6% by weight) was retained and 187 kg was discarded. The retained catch was dominated by orange roughy (99.6%), with some smooth oreo (Fig. 5). The small discarded catch consisted of hard coral (80%) with lesser amounts of spikey oreo (7%), whiptails (2%) and squid (2%). (Fig. 5).

Biological Parameters for deepwater flathead and Bight redfish

Comprehensive biological sampling of deepwater flathead and Bight redfish during the one year study allowed biological parameters to be updated and incorporated into current stock assessments. Many of the following parameter estimates support those estimates determined from a previous study during 1988-1990 (Newton *et al.,* 1994).

Sex ratio

Using data collected from the seven sampling periods undertaken between October 2000 and June 2001, deepwater flathead and Bight redfish sex ratios were determined (Table 5). For deepwater flathead the bimonthly proportion of females in the sample (female to male ratio) ranged between 0.35 and 0.67, whilst the proportion of females for the seven sampling periods separately ranged between 0.35 and 1.00. There is some concern over the random sampling nature of sample1 during Jan-Feb resulting in the occurrence of all deepwater flathead being female. Taking this into account, however, there was some evidence to suggest that deepwater flathead may school by sex. For Bight redfish the bimonthly proportion of females in the sample ranged between 0.36 and 0.55, whilst the proportion of females for the seven sampling periods separately ranged between 0.27 and 0.56. As with deepwater flathead, Bight redfish may school by sex, especially during the summer period. More extensive sampling and analyses needs to be undertaken to statistically evaluate the proportion female (sex ratio) of both deepwater flathead and Bight redfish.

Length-weight relationship

Using the comprehensive biological data collected during the year, length-weight relationships were determined for deepwater flathead and Bight redfish (sexes separately and combined) using the non-linear model procedure (NLIN) in SAS.

The deepwater flathead total length-weight relationships are consistent with those determined by Newton *et al*., 1994 (Table 6, Figs. 18 and 19). The relationships determined for this study are similar for the separate sexes, but it is important to note that weight can vary dramatically with gonad development (GSI), especially for larger female fish. In this study, the weight of 65cm-sized deepwater flathead ranged from 1.8kg for developing females to 2.8 kg for spawning females. Hence length-weight relationships between studies may differ depending on the composition of the sample, especially if the sample is dominated by a single gonad developmental stage.

Bight redfish length-weight relationships were determined for both Fork Length and Standard Length (sexes separately and combined) (Table 7, Figs. 20 to 23.) Fork Length was the preferred length measurement for this study. However to compare with previous studies (Newton *et al.,* 1994), the Standard Length-weight relationship was determined using a small number of Bight redfish measured in June 2001. Despite the small sample size (N=90), the length-weight relationships determined in this study for Standard Length are consistent with those determined by Newton *et al.* (1994).

Fork Length to Standard Length relationship for Bight redfish

During the May 2001 observer field trip Bight redfish were measured to develop a Fork Length (FL) to Standard Length (SL) conversion factor to be applied to length frequency data collected from a previous study. Using the linear regression procedure (REG) in SAS a highly significant relationship was determined, ($P<0.0001$, n = 192) (Table 8, Fig. 24).

Ageing

At the time of extensive biological data collection, the sagittal otoliths from 689 deepwater flathead and 595 Bight redfish were removed for ageing purposes. The otoliths were forwarded to the Central Ageing Facility (CAF) based at MAFRI and are currently awaiting routine ageing. In addition to these otoliths which were randomly collected from the commercial catch, 9 juvenile deepwater flathead, ranging from12.5 to 33 cm TL were collected from the discarded catch. These juveniles improve the estimation of growth parameters by increasing the number of age-length data points in the first few age classes which is almost non-existent as most data is collected from commercial sized fish (>35cm TL). Continued attempts will be made over the next year as part of the ISMP AFMA funded project to opportunistically collect otoliths from small deepwater flathead and Bight redfish.

In addition to the routine collection of deepwater flathead and Bight redfish otoliths, a total of 243 orange roughy otoliths were collected from the Albany area, Western Australia during onboard and port sampling in July 2001. These otoliths were also forwarded to the CAF for routine ageing.

Reproduction

Bimonthly gonad somatic indices (GSI) for deepwater flathead and Bight redfish were determined from biological data collected during October 2000 to June 2001. The deepwater flathead GSI was highest during spring and summer (October to February) (Figs. 25 and 26). These findings are consistent with the observations of Newton *et al.* (1994) who suggest that there is a protracted spawning season from October to February for deepwater flathead. However, whilst gonads were weighed and a development stage was assigned, further research, namely histology, needs to be undertaken to determine the correct spawning season as a high GSI does not necessarily imply spawning. There may be a temporal-spatial component to deepwater flathead spawning across the Great Australian Bight.

The Bight redfish GSI peaked between February and April indicating an early autumn spawning season (Figs. 27 and 28). These results are also consistent with the findings of Newton *et al.* (1994). As with deepwater flathead, histology of gonads needs to be undertaken to determine the correct spawning period of Bight redfish.

In addition to the proposed histological examination of preserved deepwater flathead and Bight redfish gonads, fecundity evaluation could be performed concurrently.

Maturity

Using the macroscopic gonad development stage data collected from the seven sampling periods (undertaken between October 2000 and June 2001), maturity ogives for deepwater flathead and Bight redfish were determined. Of the 310 male deepwater flathead examined, about 50% of these were deemed immature (Fig. 29). The maturity ogive suggests that male deepwater flathead are reproductively mature at about 43.1cm TL (size at which 50% are mature) (Fig. 30). Of the 379 female deepwater flathead examined, less than 20% of these were deemed immature (Fig. 31). As for males, the maturity ogive suggests that female deepwater flathead are reproductively mature at about 43.1cm TL (Fig. 32). These size at maturity estimates are consistent with those determined by Newton *et al.* (1994) (42 and 45 cm TL for males and females, respectively). The maturity ogives obtained in the present study may be further refined with the incorporation of histological information. Incorporating size at maturity estimates with the onboard commercial catch length-frequency data (Fig. 12), it appears that about 80% of the deepwater flathead commercial catch consisted of mature fish (i. e. TL > 43 cm).

Of the 311 male Bight redfish examined, about 55% of these were deemed immature (Fig. 33). The maturity ogive suggests that male Bight redfish are reproductively mature at about 35.2cm FL (Fig. 35). Of the 279 female Bight redfish examined, about 40% of these were deemed immature (Fig. 36). The maturity ogive suggests that female Bight redfish are reproductively mature at a smaller length than males (32.4 cm FL) (Fig. 37). These size at maturity estimates are greater than those determined by Newton *et al.* (1994), who estimated size at maturity as 26 cm SL (approx. 28 cm FL, using this study's conversion factor) for males and females combined. These differing estimates of size at maturity have major implications for the reproductive capacity of the fishery. A size at maturity of 28 cm FL infers that about 80% of the onboard commercial catch is deemed mature compared to about 25% when size at maturity is 35 cm FL (Fig. 8). Hence, Bight redfish maturity ogives need to be further refined with additional sampling, especially during the proposed early Autumn spawning period, and the implementation of histological techniques are needed to confirm macroscopic gonad developmental staging.

Sex dimorphism in deepwater flathead

The length-frequency distribution of deepwater flathead determined from the extensive biological sampling undertaken during October 2000 to June 2001 suggests sexual dimorphism with females growing larger than males. Males ranged in size from 35 to 57 cm TL (Fig. 29) whilst females ranged from 34 to 74 cm TL (Fig. 31). This potential difference in growth of the two sexes needs to be taken into consideration when evaluating length-frequency trends over time as a decrease in the occurrence of large fish in the commercial catch may be confounded by the sex ratio of the sample.

Wildlife interactions

Although seabirds, dolphins, seals and whales were observed, none were caught. The only direct interactions observed were seabirds feeding on the discarded catch including fish processing scraps. Unaccounted mortality (catch that is damaged and killed by the fishing gear but is not landed) was not assessed.

Benefits

This research has provided the data needed by AFMA and stakeholders to assess the biological sustainability of the GABTF and to address issues of bycatch and discarding. This data can now be assessed with a view to implementing appropriate mitigation actions to reduce bycatch and minimise the impact of fishing gear on non-target species and the marine environment. Such action has considerable benefits for industry as it reduces catch sorting times, the amount of excess fuel used to drag unwanted catch to deck, the profit lost due to target species being damaged by non-target species and future loss of profits when commercially valuable juvenile species are discarded. It also demonstrates to the community that industry is taking a pro-active approach to the issue of bycatch.

Information on the biology of target species and on the size distributions of non-target species will be made available to scientists and other users for incorporation into current databases and stock assessments.

Further Development

This report provides the data required to begin investigating and implementing species and/or size specific strategies for reducing bycatch and minimising fishing impacts (see conclusion). The results of this report show that large quantities of chinaman leatherjacket and latchet are landed and discarded, with their combined total catches equivalent (by weight) to that of the combined total catches of Bight redfish and deepwater flathead. It is therefore important that further research, in the form of stock assessments, be undertaken for these species. Whether chinaman leatherjacket and latchet stocks become increasingly commercially exploited or not, there needs to be some understanding of the impact of fishing operations on these stocks.

The biological data collected on deepwater flathead and Bight redfish generally supported the results of an earlier study (Newton *et al.,* 1994) with the exception of maturity ogives for Bight redfish. In the current study, a larger size at maturity (+ 7 cm) was determined, which has major implications for the reproductive capacity of the fishery. If this is the correct size at maturity, only 25% of the commercial catch in the GABTF is deemed mature. To further refine size at maturity for Bight redfish, intensive sampling needs to be undertaken during the autumn spawning season. The sampling should include the application of histological techniques to confirm macroscopic gonad development staging. A similar study could be done for deepwater flathead to determine if the spawning season is protracted (Oct to Mar) or if it has a sequential spatial component as mooted by some fishers (zone and/or depth effect).

A number of orange roughy otoliths were collected during the one-year study. At the August 2001 GABMAC meeting it was agreed that these otoliths be included in a stock discrimination study using otolith morphology techniques. It is proposed that the stock discrimination study compare orange roughy fishing grounds within the Great Australian Bight. At a later date they may also be used to discriminate between the Great Australian Bight fishery and orange roughy stocks from the east coast of Australia.

Planned Outcomes

Industry has recognised the need for, and strongly supported the assessment and quantification of bycatch in the GABTF and has been willing to have observers onboard for the duration of the project.

The results of this study provide AFMA, industry and scientists with detailed information on the quantity and species composition of the retained and discarded catch in the Great Australian Bight Trawl Fishery, according to Zone (spatial) and Season (temporal). This information can now be assessed with a view to implementing appropriate mitigation actions to reduce bycatch and minimise the impact of fishing gear on non-target species and the marine environment.

The results of the study also provide biological data on the target species as well as length-frequency distribution data for target and non-target species in the GABTF. This information will add to current knowledge and will be incorporated into stock assessments and age-structured models, which are currently being developed.

Conclusion

This study is the first step in the development of a comprehensive baseline data set on catch composition (both retained and discarded) in the Great Australian Bight Trawl Fishery. The results of the study show that about 45% of the landed catch is discarded and that this component is dominated by latchet, wide stingaree, draughtboard shark, southern frostfish, sponge, hard coral and chinaman leatherjacket (TL<35cm). With this knowledge, bycatch reduction targets may be set and possible strategies to meet these targets implemented.

The major bycatch species for consideration in setting bycatch targets are latchet <35 cm TL, chinaman leatherjacket <35 cm TL, wide stingaree and occasional large catches of sponge. Strategies to achieve these targets may include a combination of gear modification, the development of new markets, and temporal (seasonal) and/or spatial (area) closures.

Gear modification studies to reduce bycatch levels on otter board trawlers in the SEF have been successful (Knuckey and Ashby, 2002) and may be applicable to the Great Australian Bight Trawl Fishery. For example, increased cod end mesh size, braid thickness, and the incorporation of an escape mesh panel of square rather than diamond mesh may reduce the capture of small latchet, chinaman leatherjacket and immature deepwater flathead (< 43 cm TL). Field trials would need to be undertaken to evaluate the effectiveness of these modifications in reducing bycatch levels without undermining commercial catch weights (retained catch).

An alternate strategy for reducing bycatch levels is to utilise the bycatch (i. e. change the catch status from bycatch to byproduct). The industry may be able to develop new, economically viable markets for small latchet and chinaman leatherjacket. This may require the introduction of larger capacity fishing vessels with plate freezer facilities to handle the extra 5-10 tonne of product retained for each fishing trip. However, while this utilises a proportion of the catch that is otherwise returned to the sea dead, it does not alter the impact of fishing on these species.

The bycatch of sponge, rock and hard coral raises concerns over the adverse effects of trawling on benthic communities in the Great Australian Bight. These features are a major component of benthic habitat ‘structure’ which is important to marine species because of the associated quantity and variety of food resources, living spaces and refugia. Habitat structure provides refuge from competitors, unfavourable environmental conditions and predators, which is particularly important for the early life stages of fish (Persson and Eklov, 1995, Rooker *et al.*, 1998). Factors that affect juvenile survivorship influence the size, vitality and distribution of adult populations so habitat complexity has an important role in the sustainability of fish stocks. Reducing the bycatch of benthic features will reduce habitat degradation and this may help to ensure the healthy status of fish stocks in the GABTF. This may be achieved in the GABTF by closing areas of virgin ground to trawling and by prohibiting exploratory fishing under certain depths (<100m). Consideration may also be given to gear types or modifications that are less damaging to benthic environments.

There are no obvious strategies to reduce wide stingaree bycatch. It is highly likely that wide stingaree are attracted to trawled/disturbed ground to scavenge on discards. Numbers of stingaree increase over time to such an extent that often fishing operators are forced to move to new areas to avoid incidental capture.

In addition to the collection of bycatch data, comprehensive biological sampling of deepwater flathead and Bight redfish was undertaken. Length-weight relationships, GSI’s and maturity ogives were determined and otoliths collected for incorporation into current stock assessments carried out by the Bureau of Rural Sciences (Tilzey and Wise, 1999). Most of the current biological parameters are similar to those determined from a previous study in the early 1990’s (Newton *et al.*, 1994).

The exception being the maturity ogive for Bight redfish, with a larger size at maturity (+ 7 cm) determined for the current study.

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Tables

Table 1. Sampling design for onboard monitoring of GABTF vessels during 2000/01. Actual number of sea-days undertaken are presented in parentheses.

Table 2. Summary of total catch by Zone for on-board monitoring of GABTF vessels.

Table 3. Percentage catch retained by Zone and Season for on-board monitoring of GABTF.

Table 4. Species composition of the retained and discarded components of the catch by GAB trawl vessels.

Species	Scientific name	CAAB	No. shots	Mean catch /shot (kg)	
				Retained	Discarded
Orange roughy	*Hoplostethus atlanticus*	37 255009	12	5696.8	0.7
Deepwater flathead	*Neoplatycephalus conatus*	37 296002	162	420.6	0.0
Blue grenadier	*Macruronus novaezelandiae*	37 227001	15	167.0	0.0
Blue mackerel	*Scomber australasicus*	37 441001	18	155.0	54.8
King dory	*Cyttus traversi*	37 264001	15	152.4	0.8
Chinaman-leatherjacket	*Nelusetta ayraudi*	37 465006	125	128.6	71.3
Bight redfish	*Centroberyx gerrardi*	37 258004	130	119.8	0.4
Velvet leatherjacket	*Parika scaber*	37 465005	2	96.0	2.5
Blue eye trevalla	*Hyperoglyphe antarctica*	37 445001	22	79.6	0.0
Spotted warehou	*Seriolella punctata*	37 445006	17	69.5	0.2
Spiky oreo	*Neocyttus rhomboidalis*	37 266001	15	69.2	11.2
Smooth oreo	*Pseudocyttus maculatus*	37 266003	4	63.3	50.3
Squid	*Loligo sp*	37 600000	22	45.8	1.2
Ornate angel shark	*Squatina tergocellata*	37 024002	141	45.8	23.1
Wobbegong	*Orectolobus maculatus*	37 013003	16	45.6	0.0
Silver trevally	*Pseudocaranx dentex*	37 337062	55	44.5	0.3
Ling	*Genypterus blacodes*	37 228002	26	39.2	0.2
Endeavour dogfish	*Centrophorus moluccensis*	37 020001	26	37.8	0.1
Jackass morwong	*Nemadactylus macropterus*	37 377003	132	32.7	5.2
* Family * monacanthidae	*Monacanthidae*	37 465000	23	28.5	16.3
Gemfish	*Rexea solandri*	37 439002	96	27.9	2.1
Arrow squid	*Notodarus gouldi*	37 600001	92	25.6	0.7
Hammerhead shark	*Sphyrna lewini*	37 019001	4	25.5	0.0
Common saw shark	*Pristiophorus cirratus*	37 023002	100	25.1	0.3
Eagle ray	*Myliobatis australis*	37 039001	11	24.1	25.0
Queen snapper	*Nemadactylus valenciennesi*	37 377004	96	23.8	0.0
Green-eyed dogfish	*Squalus mitsukurii*	37 020007	96	22.0	38.1
Giant boarfish	*Paristiopterus labiosus*	37 367002	122	20.6	0.1
Southern calamari	*Sepioteuthis australis*	37 600003	26	20.2	0.1
Samsonfish	*Seriola hippos*	37 337007	3	20.0	0.0
Barracouta	*Thyrsites atun*	37 439001	53	18.9	41.4
Veilfin	*Metavelifer multiradiatus*	37 269001	21	15.1	0.0
Knifejaw	*Oplegnathus woodwardi*	37 369002	141	14.9	9.7
Brier shark	*Deania calcea*	37 020003	7	14.6	0.1
Gummy shark	*Mustelus antarcticus*	37 017001	75	14.2	0.0
Ribaldo	*Mora moro*	37 224002	10	12.4	1.5
School shark	*Galeorhinus galeus*	37 017008	11	11.5	0.0
Ocean perch - offshore	*Helicolenus barathri (offshore)*	37 287093	36	10.9	1.0
Purple stargazer	*Pleuroscopus sp. 1*	37 400017	8	10.8	0.0
Hapuku	*Polyprion oxygeneios*	37 311006	31	10.2	0.0
Bight ghost shark	*Hydrolagus lemures*	37 042003	3	9.3	0.0
Whitley's skate	*Raja whitleyi*	37 031006	21	8.6	30.3
Red gurnard	*Chelidonichthys kumu*	37 288001	108	7.0	0.3
Jack mackerel	*Trachurus declivis*	37 337002	76	6.4	17.6
Latchet	*Pterygotrigla polyommata*	37 288006	149	6.3	395.3
Southern conger eel	*Conger verreauxi*	37 067007	8	5.8	0.0
Southern chimaera	*Chimaera sp a*	37 042005	5	5.6	0.0
Snapper	*Pagrus auratus*	37 353001	12	5.6	0.0
Alfonsin	*Beryx splendens*	37 258002	1	5.0	0.0
Speckled stargazer	*Kathetostoma sp. 1*	37 400018	3	4.7	0.0
Rubyfish	*Plagiogeneion macrolepis*	37 345002	40	4.0	36.9
Whiskery shark	*Furgaleus macki*	37 017003	3	4.0	0.0
Yellow-eyed snapper	*Centroberyx australis*	37 258006	12	3.8	1.5
Long-finned eel	*Anguilla reinhardtii*	37 056002	23	3.7	0.2
Mirror dory	*Zenopsis nebulosus*	37 264003	15	3.7	0.0
John dory	*Zeus faber*	37 264004	50	3.1	0.6
Australian tusk	*Dannevigia tusca*	37 228001	43	3.0	0.2

Table 4. Continued.

Species	Scientific name	CAAB	No. shots	Mean catch /shot (kg)	
				Retained	Discarded
Elephant fish	*Callorhynchus milii*	37 043001	8	3.0	0.8
Owston's dogfish	*Centroscymnus owstoni*	37 020019	1	3.0	0.0
Black shark	*Dalatias licha*	37 020002	9	2.9	3.6
Pigfish	*Bodianus vulpinus*	37 384001	3	2.7	0.0
Blue warehou	*Seriolella brama*	37 445005	9	2.7	0.0
Silver dory	*Cyttus australis*	37 264002	13	2.6	0.2
Ocean perch- inshore	*Helicolenus percoides*	37 287001	44	2.5	8.5
Fiddler ray	*Trygonorrhina fasciata*	37 027002	73	2.2	37.5
Spiny gurnard	*Lepidotrigla papilio*	37 288002	1	2.0	0.0
* Family * labridae	*Labridae*	37 384000	1	2.0	0.0
Tuskfish	*Xiphocheilus typus*	37 384014	10	1.7	0.0
* Family * congridae	*Congridae*	37 067000	23	1.6	2.0
Cuttlefish	*Sepioids*	37 602000	23	1.4	1.1
Smooth stingray	*Dasyatis brevicaudata*	37 035001	44	1.4	39.0
Long-finned boarfish	*Zanclistius elevatus*	37 367005	87	1.3	3.9
Redbait	*Emmelichthys nitidus*	37 345001	15	1.0	15.1
Tiger flathead	*Neoplatycephalus richardsoni*	37 296001	2	1.0	0.0
Four-spined leatherjacket	*Eubalichthys quadrispinis*	37 465032	7	0.9	2.0
Piked dogfish	*Squalus megalops*	37 020006	40	0.8	43.4
Long-snouted boarfish	*Pentaceropsis recurvirostris*	37 367003	2	0.5	3.0
King crab (tasmanian giant)	*Pseudocarcinus gigas*	37 701001	20	0.5	2.0
Swallow-tail	*Centroberyx lineatus*	37 258005	50	0.4	37.5
Sharpnose seven-gill shark	*Heptranchias perlo*	37 005001	8	0.3	3.5
Deepwater burrfish	*Allomycterus pilatus*	37 469002	98	0.0	41.1
Bugs	*Ibacus cilatus*	37 700000	34	0.0	4.2
Wide stingaree	*Urolophus expansus*	37 038008	93	0.0	136.8
Southern frostfish	*Lepidopus caudatus*	37 440002	7	0.0	130.6
Sponge	*Porifera*	37 905T02	140	0.0	78.3
Residue	*Residue*	37 905406	9	0.0	49.4
Draughtboard shark	*Cephaloscyllium sp. A*	37 015013	24	0.0	43.5
Blue spotted stingray	*Dasyatis kuhlii*	37 035004	1	0.0	40.0
Black stingray	*Dasyatis thetidis*	37 035002	10	0.0	33.9
Hard coral	*Order gorgonacae*	37 905632	27	0.0	30.6
Broadnose seven-gill shark	*Notorynchus cepedianus*	37 005002	1	0.0	30.0
Porifera - fan sponge	*Porifera - fan sponge*	37 905636	1	0.0	25.0
* Family * dasyatididae	*Dasyatididae*	37 035000	7	0.0	24.4
Sunfish	*Mola ramsayi*	37 470001	1	0.0	20.0
Toothed whiptail	*Lepidorhynchus denticulatus*	37 232004	15	0.0	18.8
Serrulate whiptail	*Coryphaenoides serrulatus*	37 232015	2	0.0	17.5
* Family * skates	*Rajidae*	37 031000	34	0.0	14.7
Soft coral	*Order alcyonacea*	37 905630	5	0.0	12.2
Shovelnose ray	*Aptychotrema rostrata*	37 027009	13	0.0	12.1
Skates and/or rays	*Skates and/or rays*	37 900V01	15	0.0	12.0
Ringed toadfish	*Omegophora armilla*	37 467002	111	0.0	11.1
Thetis fish	*Neosebastes thetidis*	37 287006	60	0.0	10.3
Short boarfish	*Parazanclistius hutchinsi*	37 367010	8	0.0	10.1
Spotted swellshark	*Cephaloscyllium laticeps*	37 015001	2	0.0	10.0
Gulf gurnard perch	*Neosebastes panticus*	37 287004	41	0.0	8.9
Sandpaper fish	*Paratrachichthys sp. 1*	37 255003	11	0.0	8.6
PortJackson shark	*Heterodontus portusjacksoni*	37 007001	45	0.0	8.4
Banded bellowafish	*Centriscops obliquus*	37 279004	14	0.0	7.9
Southern whiptail	*Coelorinchus australis*	37 232001	8	0.0	7.9
Whiptails/rattails	*Macrouridae*	37 232000	24	0.0	7.5
New Zealand dory	*Cyttus novaezelandiae*	37 264005	3	0.0	7.0
Spiny flathead	*Hoplichthys haswelli*	37 297001	19	0.0	6.4
* Family * ostraciidae	*Ostraciidae*	37 466000	34	0.0	6.0
Sergeant baker	*Aulopus purpurissatus*	37 117001	36	0.0	5.5

Table 4. Continued.

Species	Scientific name	CAAB	No. shots	Mean catch /shot (kg)	
				Retained	Discarded
Thornback skate	*Raja lemprieri*	37 031007	2	0.0	5.5
Bight skate	*Raja gudgeri*	37 031010	2	0.0	5.0
Cucumber fish	*Chlorophthalmus nigripinnis*	37 120001	24	0.0	4.5
Notable whiptail	*Coelorinchus innotabilis*	37 232014	7	0.0	4.4
Mosaic leatherjacket	*Eubalichthys mosaicus*	37 465003	1	0.0	4.0
Black-spotted gurnard perch	*Neosebastes nigropunctatus*	37 287002	30	0.0	3.7
Ruddy gurnard perch	*Neosebastes scorpaenoides*	37 287005	13	0.0	3.7
Slender cod	*Halargyreus johnsonii*	37 224009	3	0.0	3.7
Spotted catshark	*Asymbolus analis*	37 015027	35	0.0	3.4
Western sea perch	*Lepidoperca occidentalis*	37 311052	3	0.0	3.3
White-barred boxfish	*Anoplocapros lenticularis*	37 466010	14	0.0	3.1
Deepwater stargazer	*Kathetostoma nigrofasciatum*	37 400004	72	0.0	3.0
Common sawbelly	*Hoplostethus intermedius*	37 255001	7	0.0	2.7
Electric rays	*Torpedinidae*	37 028900	5	0.0	2.6
Octopus	*Octopods*	37 601000	10	0.0	2.6
Holothurian	*Holothuriidae*	37 905602	13	0.0	2.5
Crabs	*Crabs*	37 702000	41	0.0	2.5
Spiny boxfish	*Capropygia unistriata*	37 466011	74	0.0	2.2
Rough flutemouth	*Fistularia petimba*	37 278002	1	0.0	2.0
Prickly dogfish	*Oxynotus bruniensis*	37 021001	1	0.0	2.0
Peacock skate	*Raja nitida*	37 031009	1	0.0	2.0
* Family * cardinalfishes	*Apogonidae*	37 327000	4	0.0	2.0
Gastropods	*Gastropods*	37 660000	6	0.0	1.8
Splendid sea perch	*Callanthias australis*	37 311055	6	0.0	1.8
Sea urchin	*Class echinoidea*	37 905607	7	0.0	1.8
* Family * clupeidae	*Clupeidae*	37 085000	12	0.0	1.7
Southern rock lobster	*Jasus edwardsii*	37 703014	3	0.0	1.7
Starfish	*Subclass asteroidea*	37 905610	31	0.0	1.6
Ascidian - sea squirts	*Ascidian - sea squirts*	37 905625	7	0.0	1.6
Sawtail shark	*Galeus boardmani*	37 015009	16	0.0	1.5
Common bellowsfish	*Macrorhamphosus scolopax*	37 279002	18	0.0	1.2
Pinocchiofish	*Rhinochimaera pacifica*	37 044002	1	0.0	1.0
* Family * lancetfishes	*Alepisauridae*	37 128000	1	0.0	1.0
* Family * lightfishes	*Gonostomatidae*	37 106000	1	0.0	1.0
* Family * loosejaws	*Malacosteidae*	37 110000	1	0.0	1.0
* Family * photichthyidae	*Photichthyidae*	37 106000	1	0.0	1.0
* Family * viperfishes	*Chauliodontidae*	37 111000	2	0.0	1.0
Blobfish	*Psychrolutes marcidus*	37 305001	1	0.0	1.0
Gulf catshark	*Asymbolus vincenti*	37 015003	2	0.0	1.0
Grooved and roundsnouted	*Cockies*	37 900V15	1	0.0	1.0
Red cod	*Pseudophycis bachus*	37 224006	6	0.0	1.0
Barred grubfish	*Parapercis allporti*	37 390001	5	0.0	1.0
Butterfly perch	*Caesioperca lepidoptera*	37 311002	1	0.0	1.0
* Family * soleidae	*Soleidae*	37 462000	3	0.0	1.0
* Family * anguillidae	*Anguillidae*	37 056000	4	0.0	0.9
Prawns	*Penaeidae*	37 701000	4	0.0	0.3

Table 5. Proportion female of deepwater flathead and Bight redfish within bi-monthly sampling period. Number of fish sexed are presented in parenthesis ( ).

Table 6. Estimates of length-weight parameters for deepwater flathead (where W, weight; L, length; $W = a L^{b}$).

Table 7. Estimates of length-weight parameters for Bight redfish (where W, weight; L, length; $W = a L^{b}$).

Table 8. Estimate of fork length-standard length parameters for Bight redfish (where FL, fork length; SL, standard length; FL = a SL).

Figures

Figure 1. Geographical extent of the Great Australian Bight Trawl Fishery, showing the four Zones used in the sampling strategy.

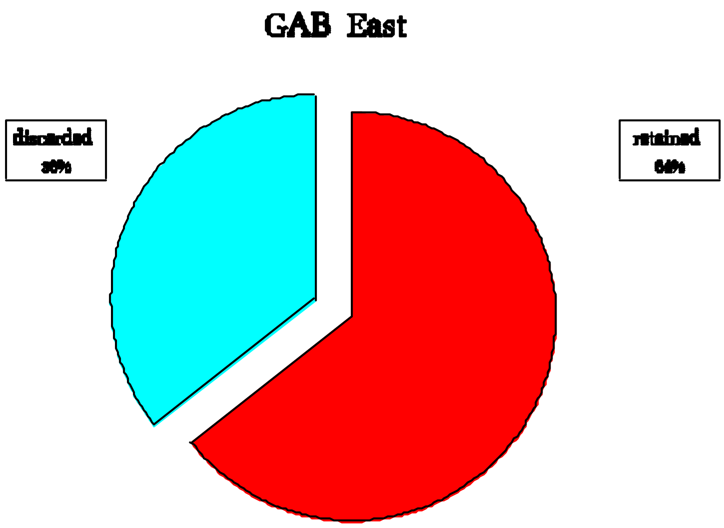


Figure 2. Percentage and species composition (by weight) of the retained and discarded catch for the East Zone across all seasons.

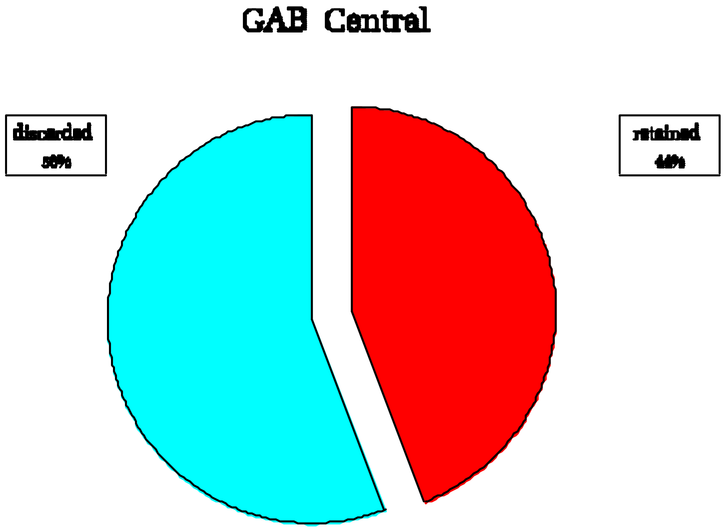


Figure 3. Percentage and species composition (by weight) of the retained and discarded catch for the Central Zone across all seasons.

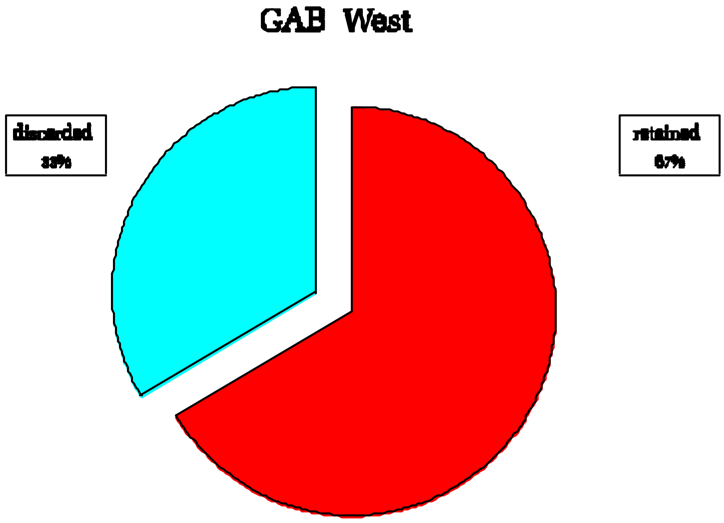


Figure 4. Percentage and species composition (by weight) of the retained and discarded catch for the West Zone across all seasons.

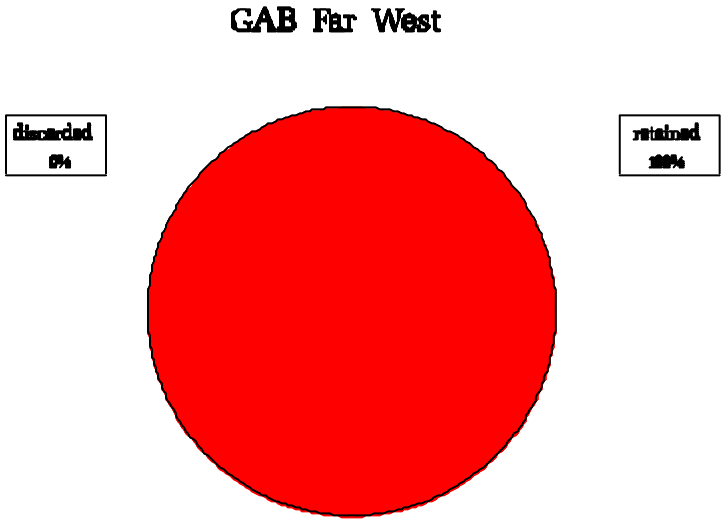


Figure 5. Percentage and species composition (by weight) of the retained and discarded catch for the Far West Zone across all seasons.

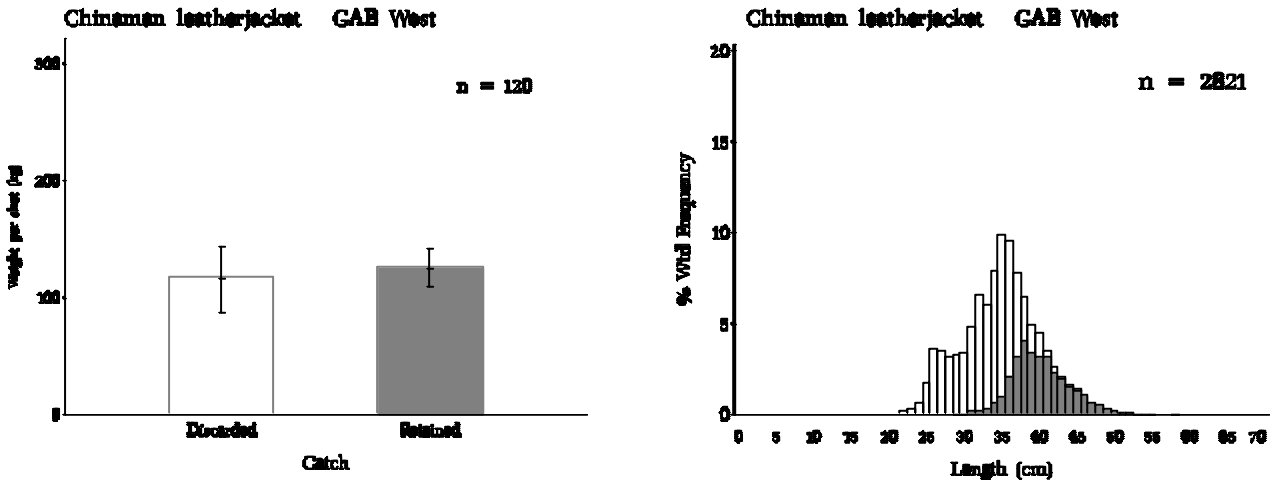
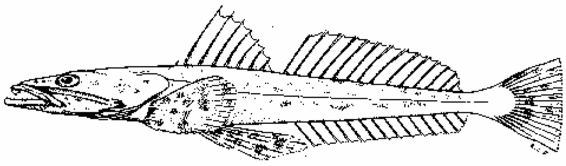
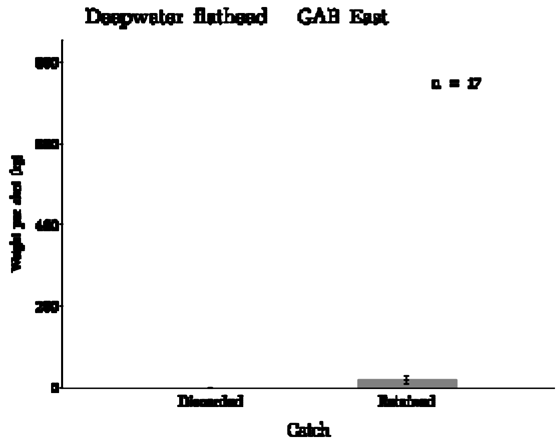
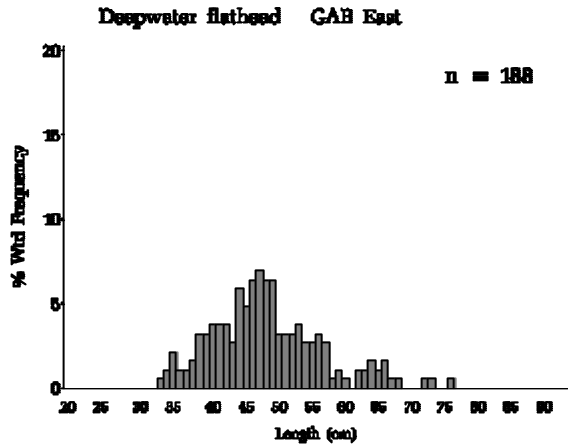


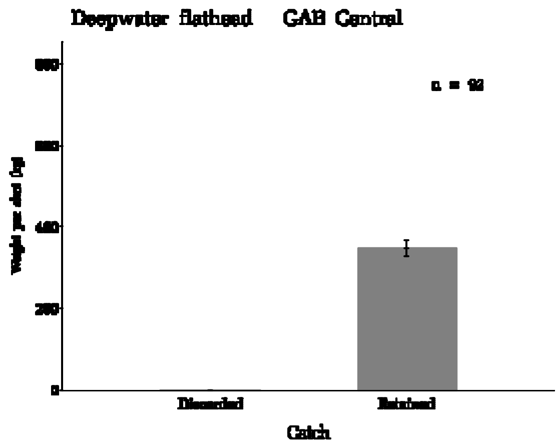
Figure 6. Example of on-board information presented for the major species in each Zone.

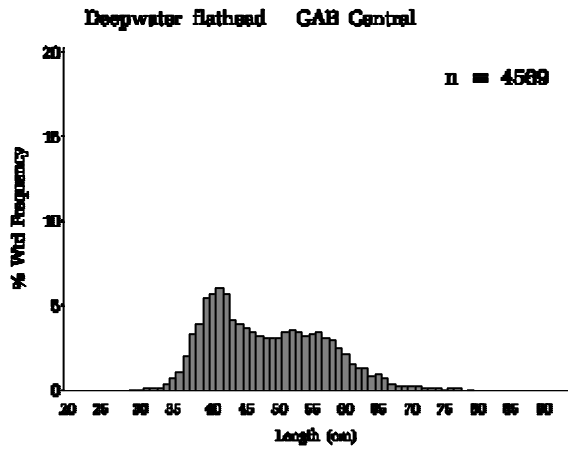
The diagram on the left presents the weight per shot of the discarded and retained catch (mean ? standard error, n = number of shots observed). The diagram on the right presents length frequencies of retained (grey bars) and discarded (white bars) fish (total number, n =number of fish measured).

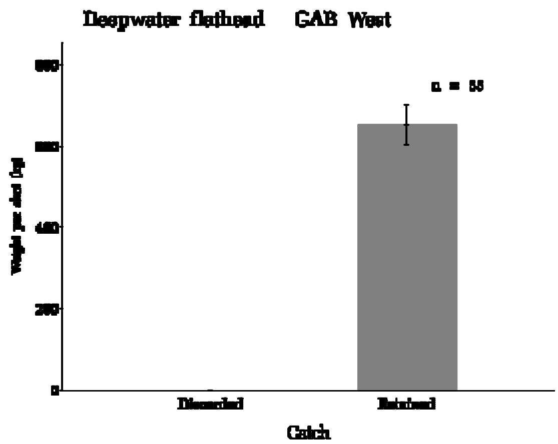
Species	Scientific name	CAAB
Deepwater flathead trawl flathead	*Neoplatycephalus conatus* 	296002 AFMA: FLK VIC: 616











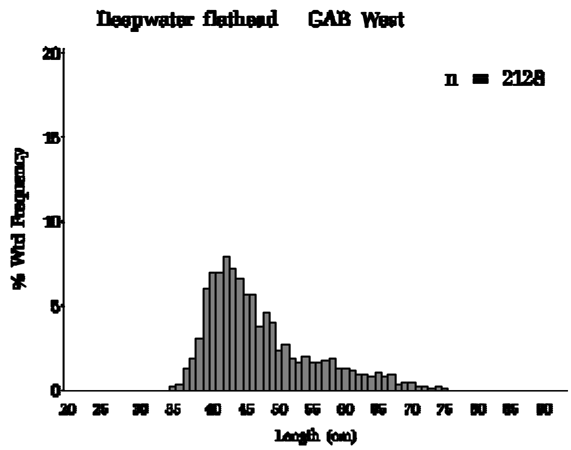
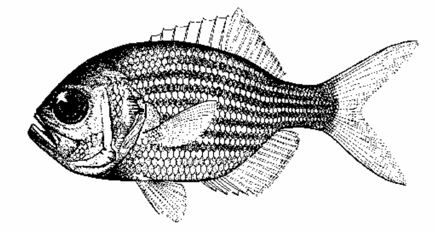


Figure 7. Mean catch and length-frequency distributions for deepwater flathead.

Species	Scientific name	CAAB
Bight redfish nannygai red snapper	*Centroberyx gerrardi* 	258004 AFMA: REB

Bight redfish GAB East

No catch data

Bight redfish GAB East

No length data

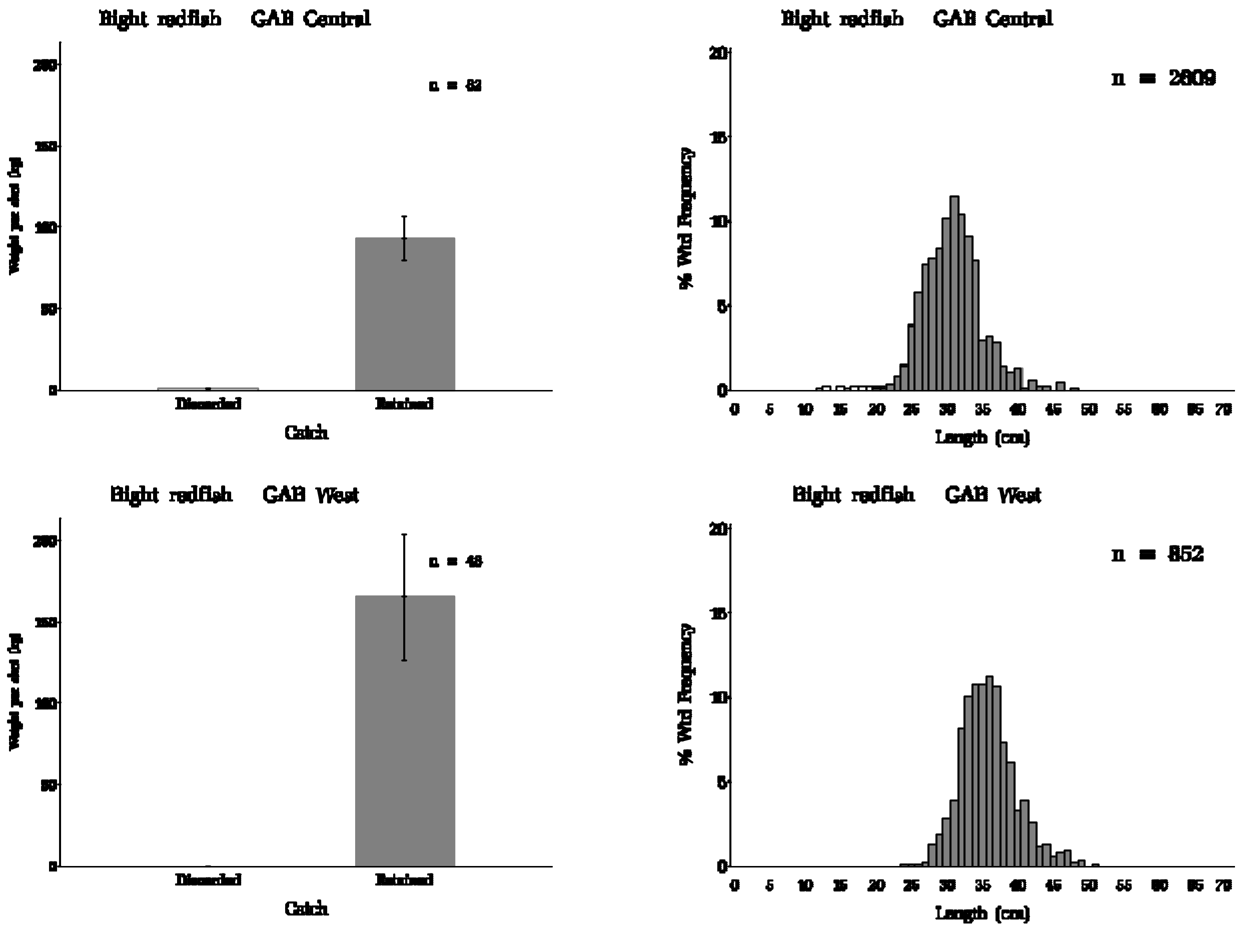
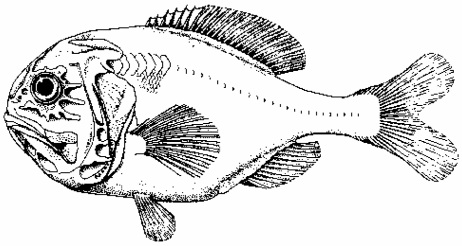
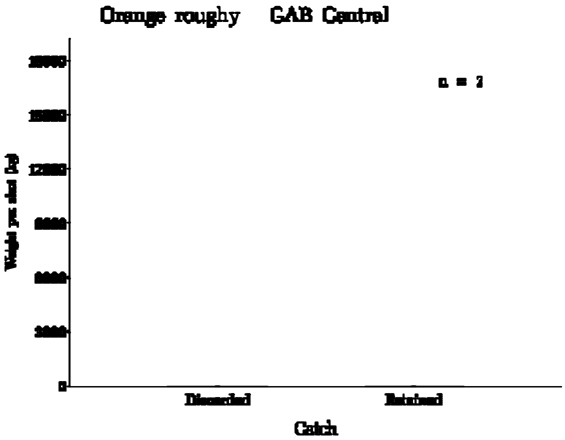


Figure 8. Mean catch and length-frequency distributions for Bight redfish.

Species	Scientific name	CAAB
Orange roughy deep sea perch sea perch	*Hoplostethus atlanticus* 	255009 AFMA: ORO VIC: 707



Orange roughy GAB Central

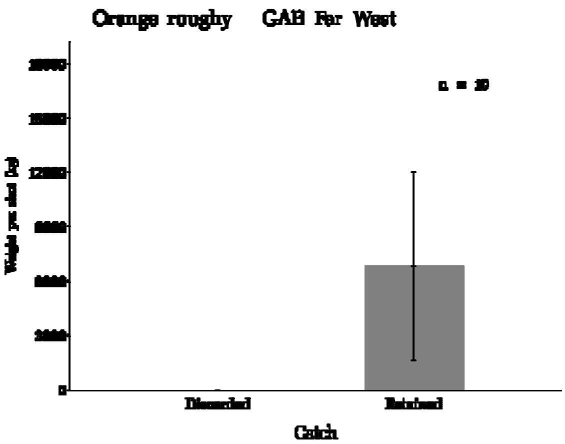
No length data

Orange roughy GAB West

No catch data

Orange roughy GAB West

No length data



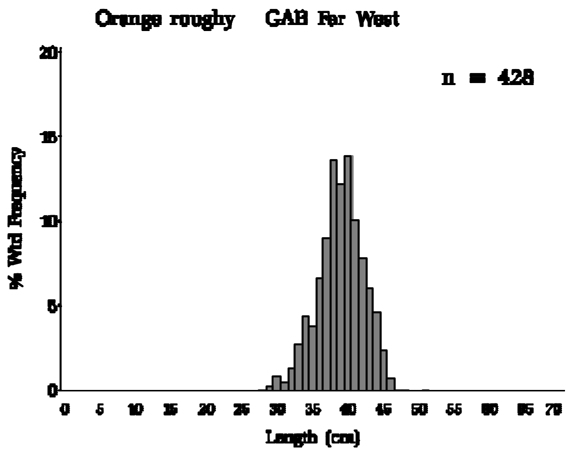
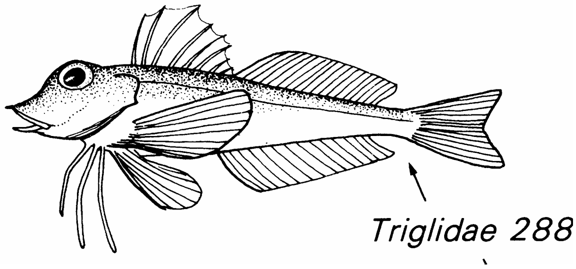


Figure 9. Mean catch and length-frequency distributions for orange roughy.

Species	Scientific name	CAAB
Latchet Sharp-beaked gurnard	*Pterygotrigla polyommata* 	288006 AFMA: LAT VIC:

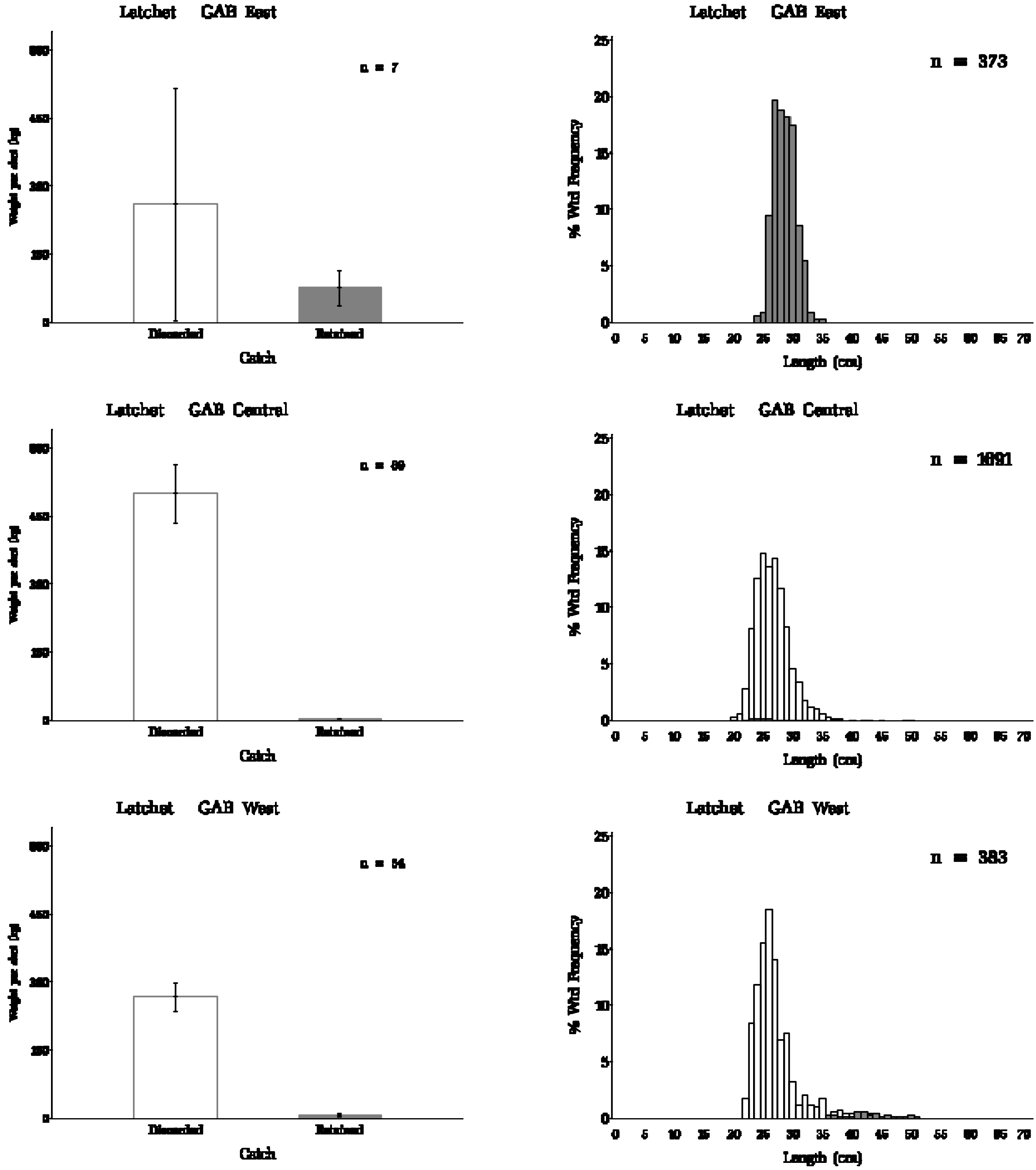
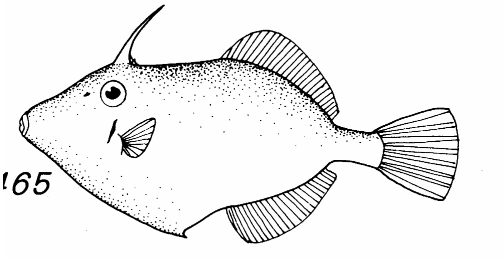


Figure 10. Mean catch and length-frequency distributions for latchet.

Species	Scientific name	CAAB
Chinaman – leatherjacket Ocean jacket		465006 AFMA: TRS VIC: 454

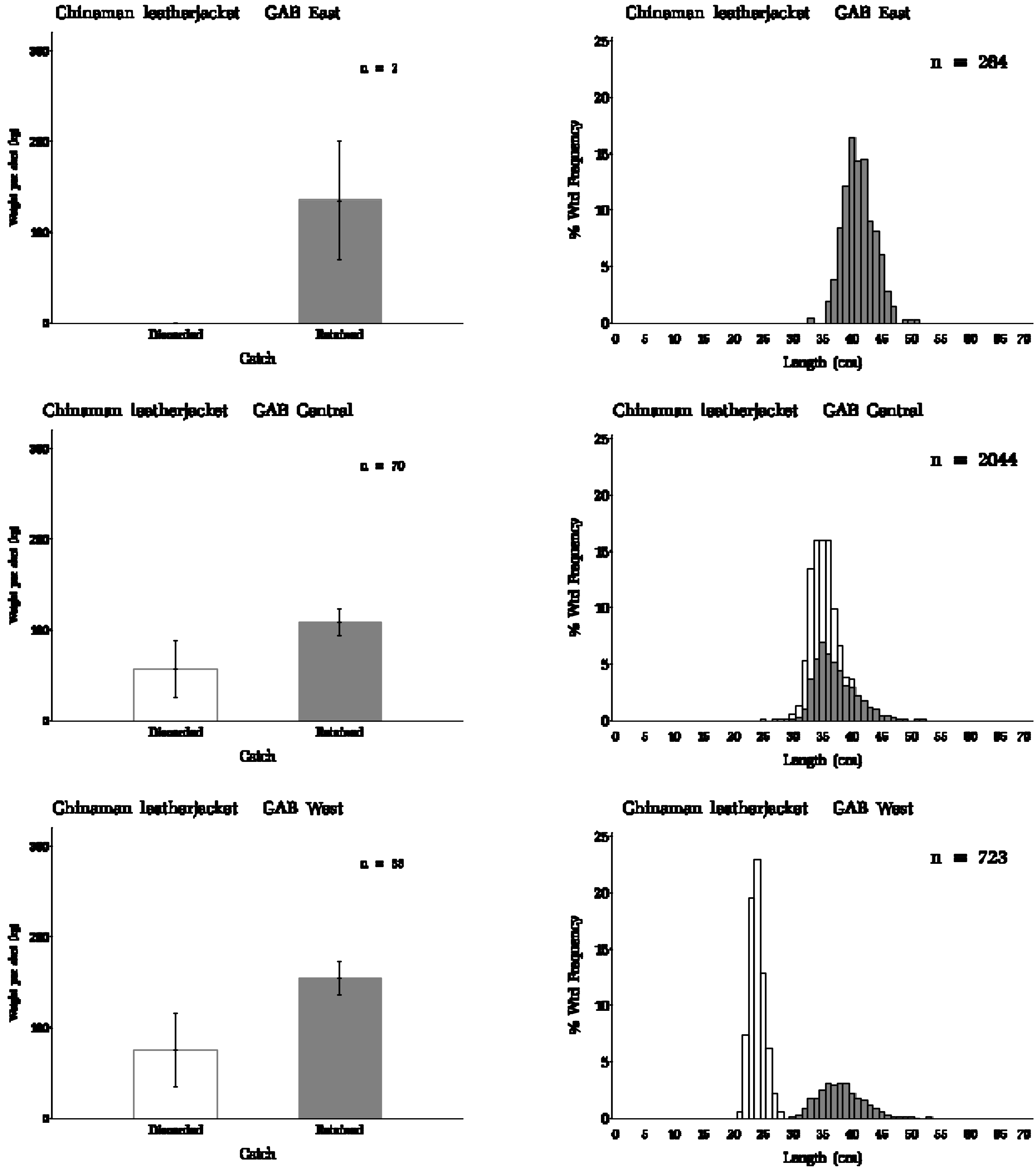
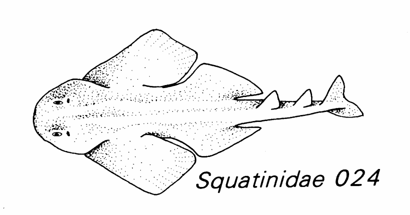
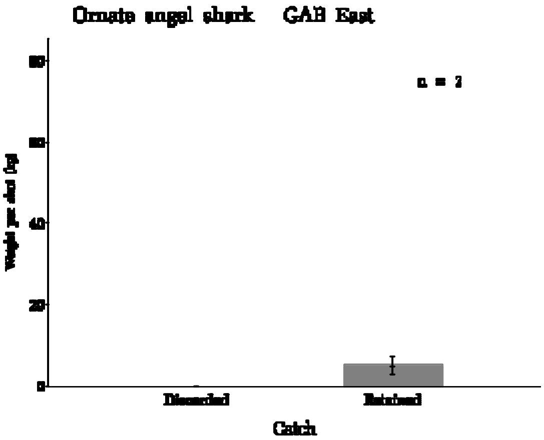


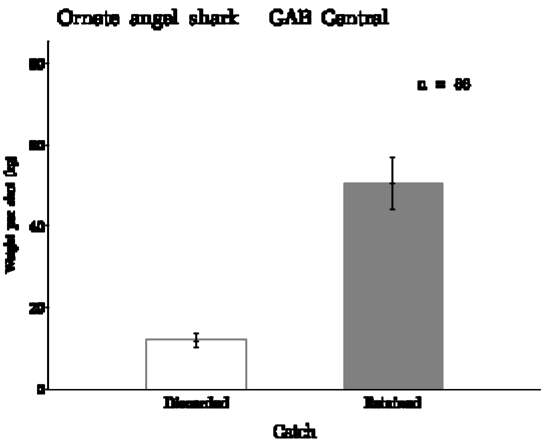
Figure 11. Mean catch and length-frequency distributions for chinaman leatherjacket.

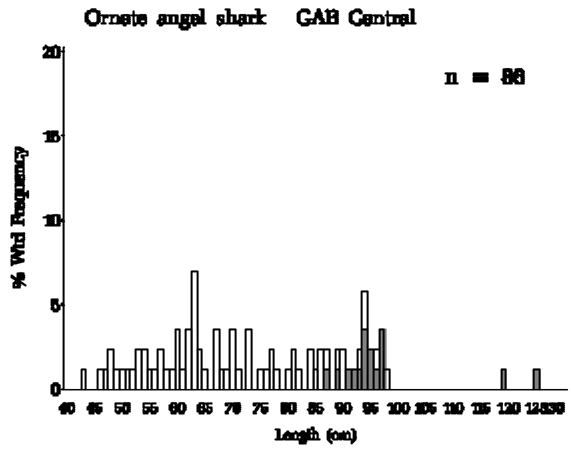
Species	Scientific name	CAAB
Ornate angel shark angel shark	*Squatina tergocellata* 	024002 AFMA: VIC:

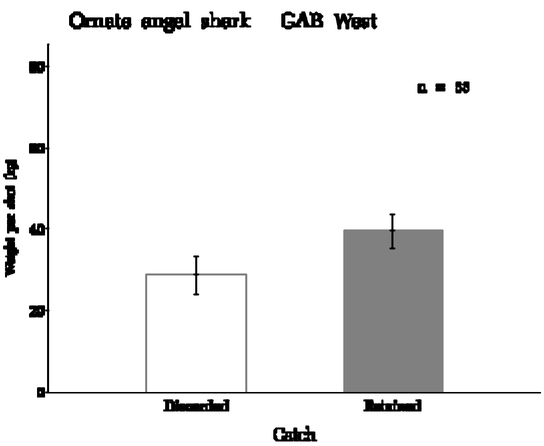


Ornate angel shark GAB East

No length data



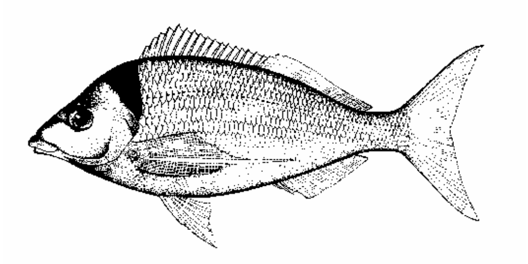




Ornate angel shark GAB West

No length data

Figure 12. Mean catch and length-frequency distributions for ornate angel shark.

Species	Scientific name	CAAB
Jackass morwong deepsea perch morwong mowie perch sea bream	*Nemadactylus macropterus* 	377003 AFMA: MOW VIC: 502

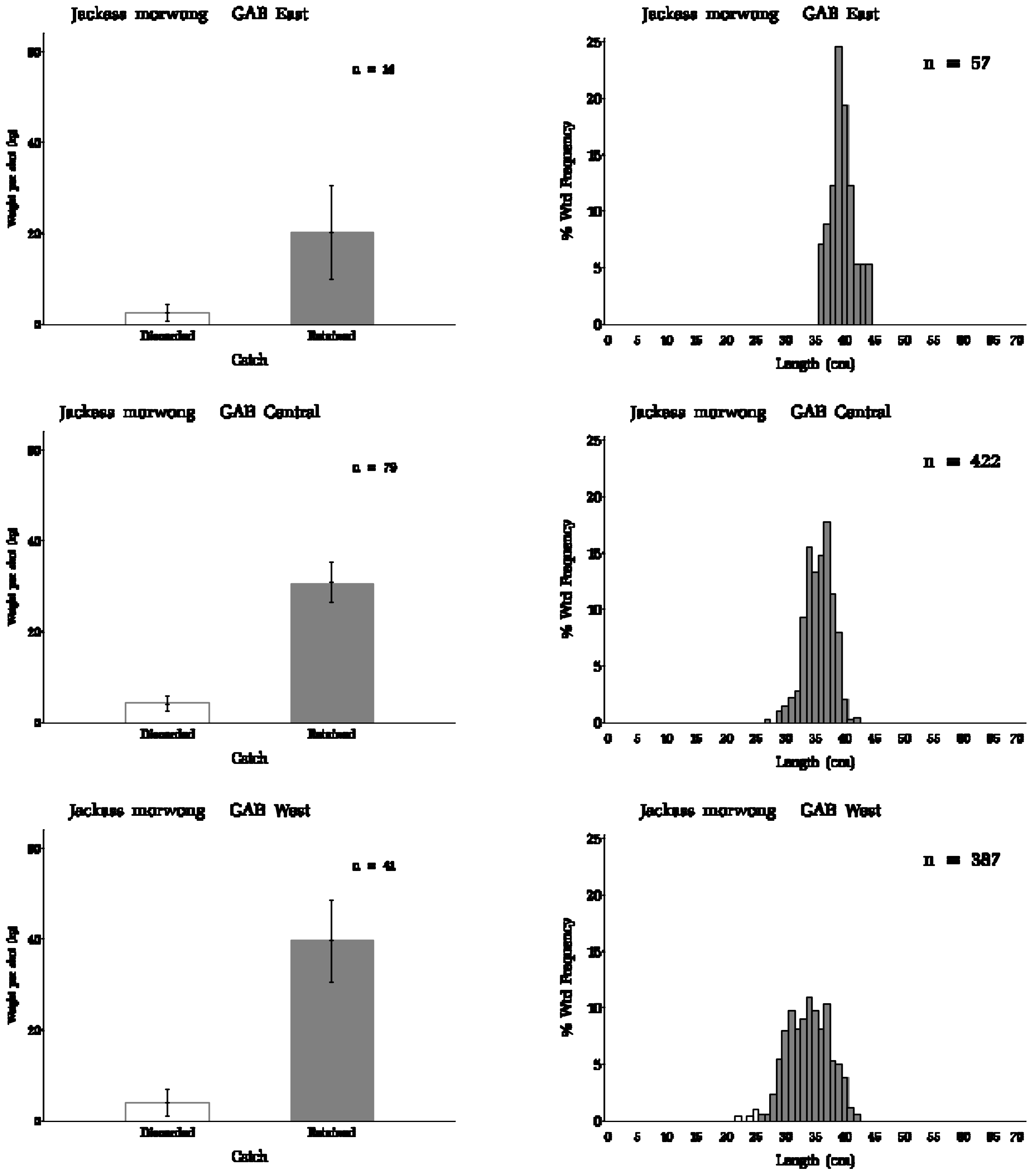
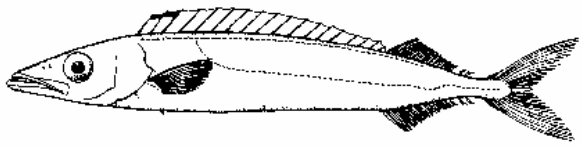


Figure 13. Mean catch and length-frequency distributions for jackass morwong.

Species	Scientific name	CAAB
Western Gemfish kingfish king couta	*Rexea solandri* 	439002 AFMA: GEM VIC: 336

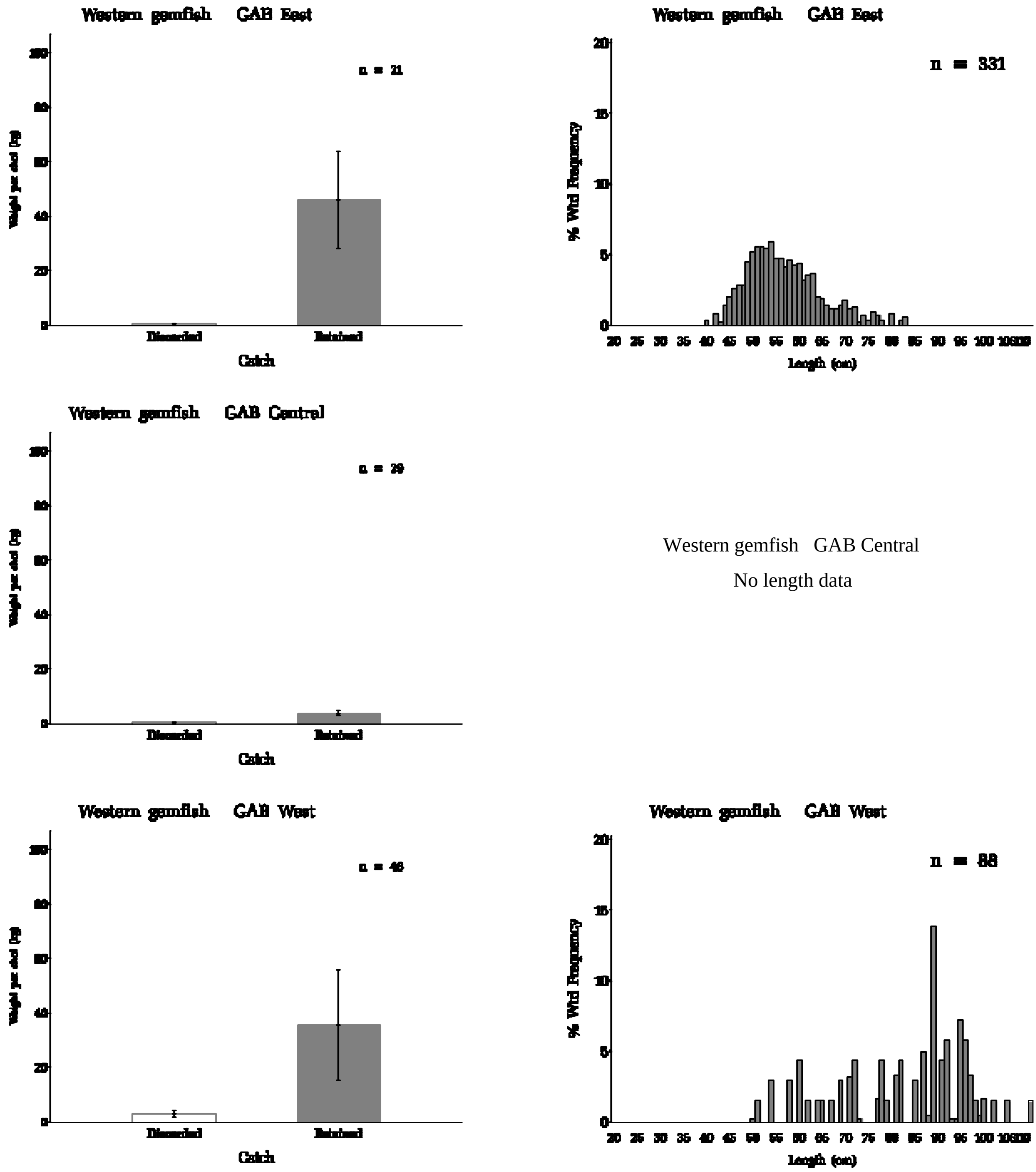
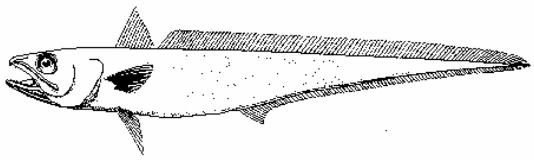
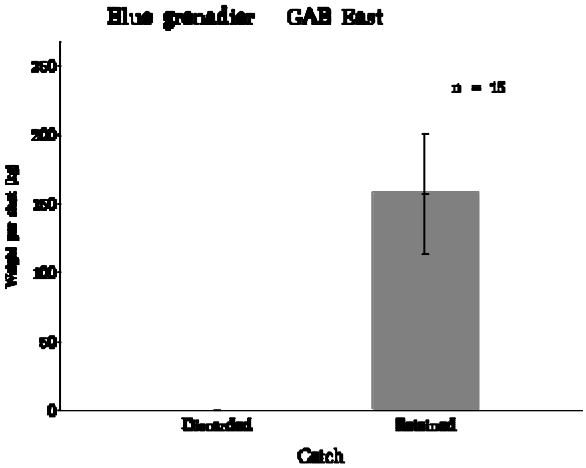
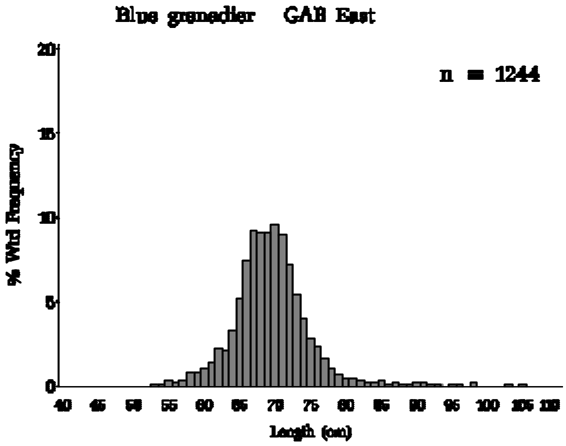


Figure 14. Mean catch and length-frequency distributions for western gemfish.

Species	Scientific name	CAAB
Blue grenadier whiptail hoki blue hake	*Macruronus novaezelandiae* 	227001 AFMA: GRE VIC: 226





Blue grenadier GAB Central

No catch data

Blue grenadier GAB Central

No length data

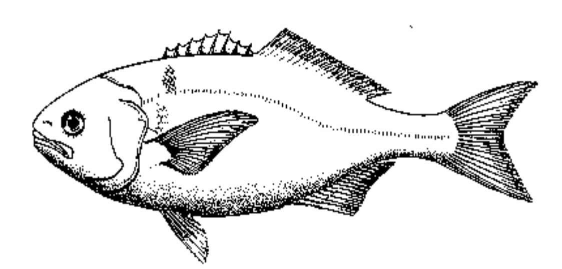
Blue grenadier GAB West

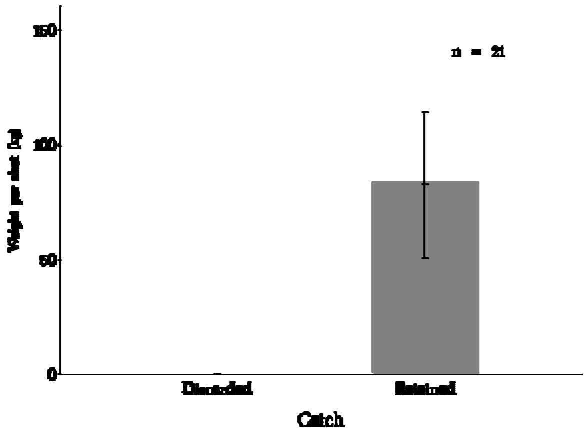
No catch data

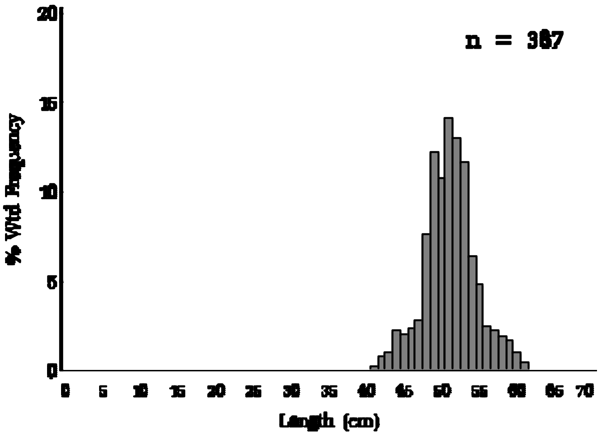
Blue grenadier GAB West

No length data

Figure 15. Mean catch and length-frequency distributions for blue grenadier.

Species	Scientific name	CAAB
Blue eye trevalla deep sea trevalla big eye	*Hyperoglyphe antarctica* 	445001 AFMA: TBE VIC: 451





Blue eye trevalla GAB Central

No catch data

Blue eye trevalla GAB Central

No length data

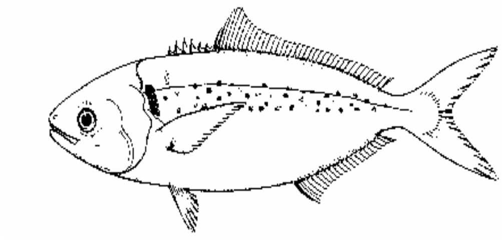
Blue eye trevalla GAB West

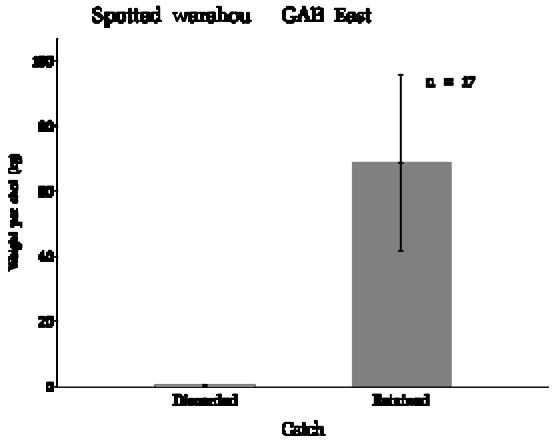
No catch data

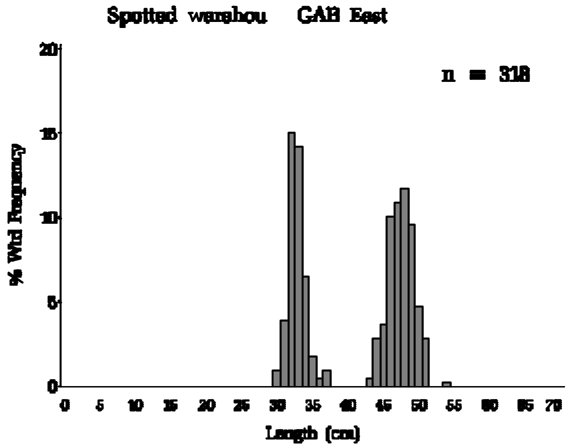
Blue eye trevalla GAB West

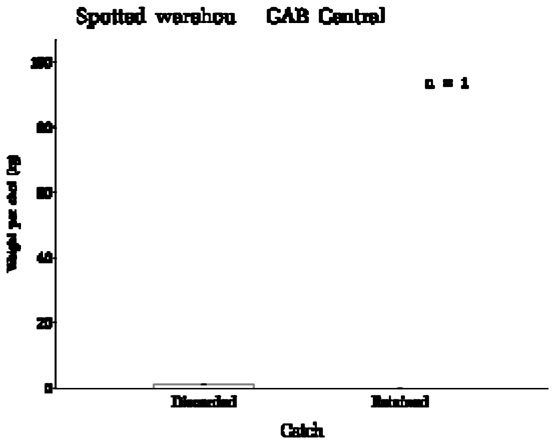
No length data

Figure 16. Mean catch and length-frequency distributions for blue eye trevella.

Species	Scientific name	CAAB
Spotted warehou spotted snotty silver warehou	*Seriolella punctata* 	445006 AFMA: TRS VIC: 454







Spotted warehou GAB Central

No length data

Spotted warehou GAB West

No catch data

Spotted warehou GAB West

No length data

Figure 17. Mean catch and length-frequency distributions for spotted warehou.

Figure 18. Length-weight relationships for male deepwater flathead.

Figure 19. Length-weight relationships for female deepwater flathead.

Figure 20. Fork length-weight relationships for male Bight redfish.

Figure 21. Fork length-weight relationships for female Bight redfish

Figure 22. Standard length-weight relationships for male Bight redfish.

Figure 23. Standard length-weight relationships for female Bight redfish.

Figure 24. Fork length-standard length relationship for Bight redfish.

Figure 25. Bimonthly GSI (Gonad Somatic Index) for male deepwater flathead.

Figure 26. Bimonthly GSI (Gonad Somatic Index) for female deepwater flathead.

Figure 27. Bimonthly GSI (Gonad Somatic Index) for male Bight redfish.

Figure 28. Bimonthly GSI (Gonad Somatic Index) for female Bight redfish.

Figure 29. Length frequency distributions of male deepwater flathead for biological parameter estimations.

Figure 30. Maturity ogive for male deepwater flathead.

Figure 31. Length frequency distributions of female deepwater flathead for biological parameter estimations.

Figure 32. Maturity ogive for female deepwater flathead.

Figure 33. Length frequency distributions of male Bight redfish for biological parameter estimations.

Figure 35. Maturity ogive for male Bight redfish.

Figure 36. Length frequency distributions of female Bight redfish for biological parameter estimations.

Figure 37. Maturity ogive for female Bight redfish.

Appendix 1. Intellectual Property

No patentable inventions or processes have been developed as part of this project. All results will be published in relevant scientific articles and other public domain literature.

Appendix 2. Staff

Dr Ian Knuckey	Principal Investigator
Ms Lauren Brown	Field Scientist

Appendix 3. Examples of datasheets and typical catch of the GABTF